



杉数科技
Cardinal Operations

Cardinal Optimizer (COPT) User Guide

Ver 7.2.6

Cardinal Operations

D. Ge, Q. Huangfu, Z. Wang, J. Wu and Y. Ye

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Chapter 1

Introduction to Cardinal Optimizer

Cardinal Optimizer is a high-performance mathematical programming solver for efficiently solving large-scale optimization problem. This documentation provides basic introduction to the Cardinal Optimizer, including:

- *How to install Cardinal Optimizer*
- *How to setup license files*
- *How to use Cardinal Optimizer in interactive shell*

We suggest that all users to read the first two sections carefully before using the Cardinal Optimizer.

Once the installation and license setup are done, we recommend users who want to do a quick experiment on the Cardinal Optimizer to read the *COPT Interactive Shell* chapter for details. Users who already have preferred programming language can select from available **Application Programming Interfaces (APIs)**, including:

- *C interface*
- *C++ interface*
- *C# interface*
- *Java interface*
- *Python interface*
- *AMPL interface*
- *Pyomo interface*
- *PuLP interface*
- *CVXPY interface*

1.1 Overview

Cardinal Optimizer supports solving Linear Programming (LP) problems, Second-Order-Cone Programming (SOCP) problems, Convex Quadratic Programming (QP) problems, Convex Quadratically Constrained Programming (QCP) problems, Semidefinite Programming problems (SDP), General Nonlinear Programming (NLP) problems, and Mixed Integer Programming (MIP) problems, which include Mixed Integer Linear Programming (MILP), Mixed Integer Second-Order-Cone Programming (MISOCP), Mixed Integer Convex Quadratic Programming (MIQP), Mixed Integer Convex Quadratically Constrained Programming (MIQCP).

We will support more problem types in the future. The supported problem types and available algorithms are summarized in [Table 12.1](#)

Table 1.1: Supported problem types and available algorithms

Problem type	Available algorithms
Linear Programming (LP)	Dual simplex; Barrier; First-Order Method
Second-Order-Cone Programming (SOCP)	Barrier
Exponential Cone Programming (ExpCone)	Barrier
Convex Quadratic Programming (QP)	Barrier
Convex Quadratically Constrained Programming (QCP)	Barrier
Semidefinite Programming (SDP)	Barrier; ADMM
General Nonlinear Programming (NLP)	Barrier
Mixed Integer Linear Programming (MILP)	Branch-and-Cut
Mixed Integer Second-Order-Cone Programming (MISOCP)	Branch-and-Cut
Mixed Integer Convex Quadratic Programming (MIQP)	Branch-and-Cut
Mixed Integer Convex Quadratically Constrained Programming (MIQCP)	Branch-and-Cut

Cardinal Optimizer supports all major 64-bit operating systems including Windows, Linux (including ARM64 platform) and MacOS (including ARM64 platform), and currently provides programming interfaces shown below:

- C interface
- C++ interface
- C# interface
- Java interface
- Python interface
- AMPL interface
- AIMMS interface
- Pyomo interface
- PuLP interface
- CVXPY interface
- GAMS interface
- Julia interface

We are going to develop more programming interfaces to suit various needs of users and situations.

1.2 Licenses

Now, we provides 4 types of license, which are Personal License, Server License, Floating License, and Cluster License. They are listed in table below (Table 1.2) :

Table 1.2: License Type

License Type	Detail
Personal License	It is tied to personal computers by username. Only approved user can run COPT on his devices. No limitations on CPU cores and threads.
Server License	It is tied to a single server computer by its hardware info (MAC and CPUID). An arbitrary number of users and programs can run COPT simultaneously. No limitations on CPU cores as well.
Floating License	It is tied to a server machine running COPT floating token service, by its hardware info (MAC and CPUID). Any COPT floating client connected to server can borrow and use the floating license, thus run one process for optimization jobs simultaneously. The token number is max number of clients who can use floating licenses simultaneously.
Cluster License	It is tied to a server machine running COPT compute cluster service, by its hardware info (MAC and CPUID). Any COPT compute cluster client connected to server can offload optimization computations. That is, clients are allowed to do modelling locally, execute optimization jobs remotely, and then obtain results interactively. Although server can have multiple clients connected, each connection must run optimization jobs sequentially. No limitations on CPU cores.

1.3 How to Cite

If you used COPT in your research work, please mention us in your publication. For example:

- We used COPT [1] in our project.
- To solve the integer problem, we used Cardinal Optimizer [1].

with the following entry in the Reference section:

[1] D. Ge, Q. Huangfu, Z. Wang, J. Wu and Y. Ye. Cardinal Optimizer (COPT) user guide.
 → <https://guide.coap.online/copt/en-doc>, 2023.

The corresponding BiBTeX citation is:

```
@misc{copt,
  author={Dongdong Ge and Qi Huangfu and Zizhuo Wang and Jian Wu and Yinyu Ye},
  title={Cardinal {O}ptimizer {(COPT)} user guide},
  howpublished={https://guide.coap.online/copt/en-doc},
  year=2023
}
```

1.4 Contact Information

Cardinal Optimizer is developed by Cardinal Operations, users who want any further help can contact us using information provided in Table 6.1

Table 1.3: Contact information

Type	Information	Description
Website	https://www.shanshu.ai/	
Phone	400-680-5680	
Email	coptsales@shanshu.ai	business support
Email	coptsupport@shanshu.ai	technical support

Chapter 2

Installation Guide

This chapter introduces how to install **Cardinal Optimizer** on all supported operating systems, and how to obtain and setup license correctly. We recommend all users read this chapter carefully before using Cardinal Optimizer.

2.1 Registration

Before using Cardinal Optimizer, users need to register online and then install the COPT package on your machine. If this is not done yet, please visit official [COPT page](#) and fill the registration form following the guidelines.

The online registration is for personal license application. Specifically, users only need to provide user-name of machine, besides basic information.

Upon approval, you will receive a letter from coptsales@shanshu.ai. It gives both link to download COPT software package, a license key tied with registration information, and also two attached license files. You may refer to *Software Installation* below and *Setting Up License* for further steps.

If you encountered any problems, please contact coptsupport@shanshu.ai for help.

2.2 Software Installation

2.2.1 Windows

We provide two types of installation packages for Windows operating systems. The user needs to **choose one of the two options**. One is an executable installer (Download link name contains **installer**) for most of users and the other one is a zip-format archive specialized for expert users.

The executable installer provides a visual installation prompt window and automatically configures environment variables. Users only need to follow the instructions and click to complete the installation steps in sequence; The ZIP format installation package requires the user to decompress the installation package first and manually configure the environment variables.

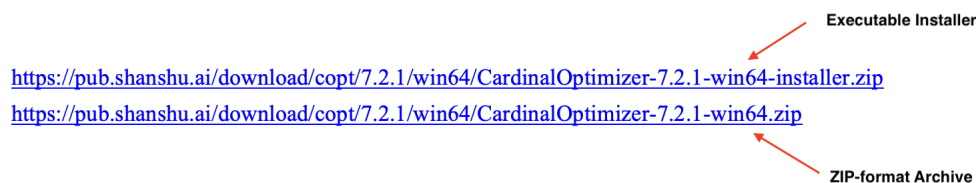


Fig. 2.1: Two different installation package download links for Windows system

We recommend users to download the executable installer.

Executable installer

If you download the executable installer for Windows from our website, e.g. CardinalOptimizer-7.2.1-win64-installer.exe for 64-bit version of COPT 7.2.1, just double-click it and follow the following guidance:

- Step 1: Click the installer and select the installation language. The default installation language is **English**, users can change it by select from the drop-down menu, see Fig. 2.2. Here we use the default setting.

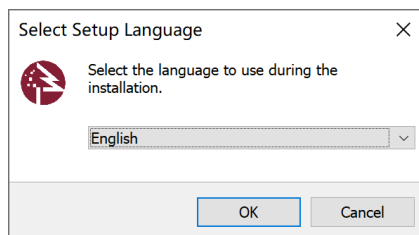


Fig. 2.2: Select installation language

- Step 2: If you agree with the 'End-User License Agreement (EULA)', just choose 'I accept the agreement' and then click 'Next'. The software won't install if you disagree with the EULA, see Fig. 2.3.

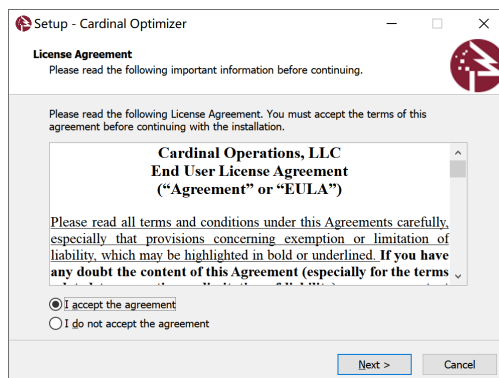


Fig. 2.3: License agreement page

- Step 3: By default, the installer will place all files into directory C:\Program Files\copt72, you may change it to any directories. If you have decided the install directory, just click 'Next', see Fig. 2.4.

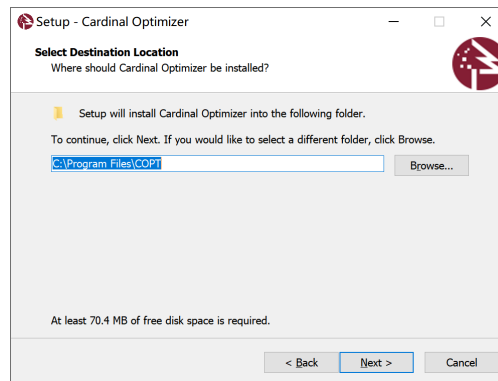


Fig. 2.4: Choose install directory

- Step 4: To select the start menu folder, you can simply use the default setting and click 'Next', see Fig. 2.5.

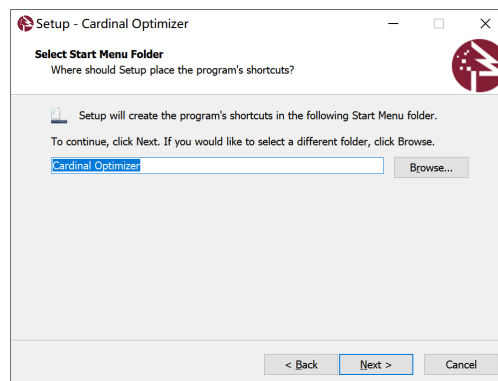


Fig. 2.5: Select start menu folder

- Step 5: By now, the software is ready to install, just click 'Install', see Fig. 2.6.

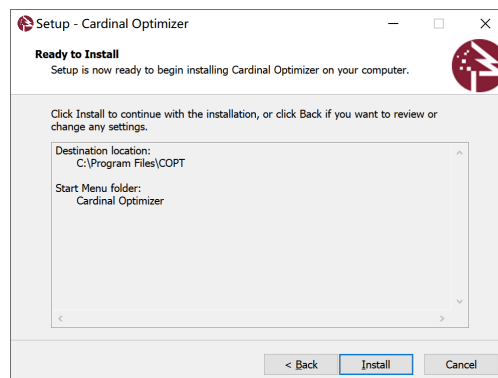


Fig. 2.6: Ready to install

- Step 6: When installation completed, the software requires restart of your machine since the installer has automatically made the required modifications to environment variables for you. Be sure to save your working files and close other running applications before restart, and then click 'Finish', see Fig. 2.7.



Fig. 2.7: Installation completed and restart your machine

Zip-format installer archive

If you downloaded the zip-format installer archive, just uncompress it to any directories with any unarchiver and set up environment variables as follows. Here we assumed the installation directory to be C:\Program Files\copt72:

- Step 1: Open Command Prompt (cmd) with **administrator privilege** and execute the following command to pop-up the environment variables setting panel.

```
rundll32 sysdm.cpl,EditEnvironmentVariables
```

- Step 2: Add directory C:\Program Files\copt72\bin to system environment variable PATH.
- Step 3: Create a new system environment variable named COPT_HOME, whose value is C:\Program Files\copt72.
- Step 4: Create a new system environment variable named COPT_LICENSE_DIR, whose value is C:\Program Files\copt72.

Up to now, you have already setup the required modifications to the environment variables. If you accept the copt-eula_en.pdf in installation directory, then please go to *Setting Up License* for license issues.

2.2.2 MacOS

We provide two types of installation packages for MacOS, one is a DMG-format installer for most of users and the other is a gzip-format archive for expert users. The user need to **choose one of the two options**.

In addition, for MacOS systems, we provide the MacOS-Universal installation package, which is universal to both Apple Silicon and old Intel chips (the installation package suffix is `universal_mac`).

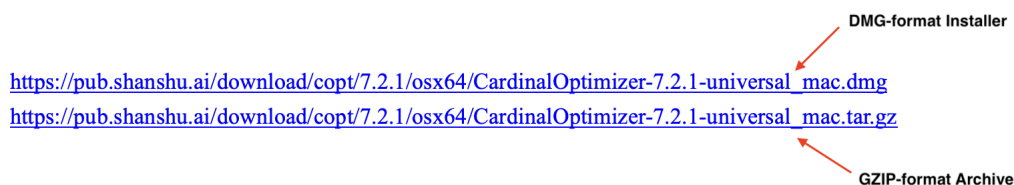


Fig. 2.8: Two different installation package download links for MacOS system

We recommend users to download the DMG-format installer.

DMG installer

If you download the DMG-format installer for MacOS-Universal from our website, e.g. CardinalOptimizer-7.2.1-universal_mac.dmg of COPT 7.2.1, please follow the following guidance to install the software:

- Step 1: Double-click the DMG-format installer, waiting for the OS to mount the DMG installer automatically.
- Step 2: Simply drag the copt72 folder into 'Applications' folder, see Fig. 2.9:

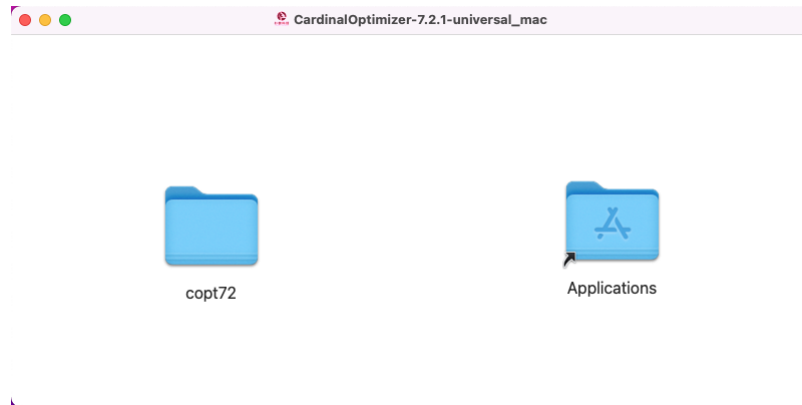


Fig. 2.9: Drag copt72 into 'Applications'

After the above steps are completed, the necessary environment variables need to be configured. Please continue to read: *Environment variable configuration* section.

GZIP installer

If you download the gzip-format installer archive, just uncompress it to any directories with commands:

```
tar -xzf CardinalOptimizer-7.2.1-universal_mac.tar.gz
```

You will get a folder named copt72 in current directory, you can move it to any other directories as you want. We recommend users move it to the 'Applications' folder by executing commands below:

```
mv copt72 /Applications/
```

After the above steps are completed, the necessary environment variables need to be configured. Please continue to read: *Environment variable configuration* section.

Environment variable configuration

The next step for both DMG-format and gzip-format installer is to setup the environment variables.

First, please execute the following command on the terminal to determine the current Shell version:

```
echo $SHELL
```

If the output is: `/bin/bash`, it means that the current terminal is **bash**; if the output is: `/bin/zsh`, It means that the current terminal is **zsh**.

Next, please open the terminal and confirm that you are in the user directory (if not, you need to execute the following command to switch to the user directory):

```
cd ~/
```

Please refer to the corresponding environment variable configuration guide according to the terminal.

- *BASH terminal*
- *ZSH terminal*

After the environment variable is configured, you can verify whether the configuration is successful, refer to *Verify the environment variable*.

BASH terminal

There are three main steps to configure environment variables under the BASH terminal:

1. Check 'bash_profile' file

Enter the following command to output all files in the user directory and check whether there is a '.bash_profile' hidden file:

```
ls -a
```

If the file does not exist, execute the following command to create an empty '.bash_profile' file at your own (if the file already exists, please ignore this step):

```
touch ~/.bash_profile
```

2. Add environment variables

First, please execute the following command to open the '.bash_profile' file.

```
open ~/.bash_profile
```

Next, please add the following content to the '.bash_profile' using any editors that you preferred:

```
export COPT_HOME=/Applications/copt72
export COPT_LICENSE_DIR=/Applications/copt72
export PATH=$COPT_HOME/bin:$PATH
export DYLD_LIBRARY_PATH=$COPT_HOME/lib:$DYLD_LIBRARY_PATH
```

Note: There can be no spaces on both sides of the equal sign.

3. Check the environment variables to take effect

Save the above modification and exit, the user can execute the following command in the terminal to view the modified '.bash_profile' file:

```
cat ~/.bash_profile
```

If the modification is successful, the content of the file output should include the newly added information above.

Then, the user needs to execute the following command on the terminal to make the above modification take effect.

```
source ~/.bash_profile
```

ZSH terminal

Likewise, there are three main steps to configure environment variables under the ZSH terminal:

1. Check 'zshrc' file

Enter the following command to output all files in the user directory and check whether there is a '.zshrc' hidden file:


```
ls -a
```

If the file does not exist, execute the following command to create an empty '.zshrc' file at your own (if the file already exists, please ignore this step):

```
touch ~/.zshrc
```

2. Add environment variables

First, please execute the following command to open the '.zshrc' file.

```
open ~/.zshrc
```

Next, please add the following content to the '.zshrc' using any editors that you preferred:

```
export COPT_HOME=/Applications/copt72
export COPT_LICENSE_DIR=/Applications/copt72
export PATH=$COPT_HOME/bin:$PATH
export DYLD_LIBRARY_PATH=$COPT_HOME/lib:$DYLD_LIBRARY_PATH
```

3. Check the environment variables to take effect

Save the above modification and exit, the user can execute the following command in the terminal to view the modified '.zshrc' file:

```
cat ~/.zshrc
```

If the modification is successful, the content of the file output should include the newly added information above.

Then, the user needs to execute the following command on the terminal to make the above modification take effect.

```
source ~/.zshrc
```

Verify environment variable configuration

Now open a new terminal to check if the previous modifications work by executing commands below respectively:

```
echo $COPT_HOME
echo $COPT_LICENSE_DIR

echo $PATH
echo $DYLD_LIBRARY_PATH
```

If the terminal outputs respectively:

```
/Applications/copt72
/Applications/copt72
/Applications/copt72/bin:$PATH
/Applications/copt72/lib:$DYLD_LIBRARY_PATH
```

It means that the COPT-related environment variables are configured successfully.

Notes: The environment variables \$PATH and \$DYLD_LIBRARY_PATH may display different contents on different computers. However, the set COPT-related environment variables should be displayed normally to indicate that the configuration is successful.

If the user checks that the COPT-related environment variables have been successfully added, please carefully read the user agreement document '[copt-eula_cn.pdf](#)' in the installation directory. If you accept the the agreement, please go to [Setting Up License](#) for license issues.

MacOS Security Checkup

For MacOS 10.15 (Catalina), if users received error message below:

```
"libcopt.dylib" cannot be opened because the developer cannot be verified.  
macOS cannot verify that this app is free from malware.
```

or

```
"libcopt_cpp.dylib": dlopen(libcopt_cpp.dylib,6): no suitable image found.  
Did find: libcopt_cpp.dylib: code signature in (libcopt_cpp.dylib) not valid  
for use in process using Library Validation: library load disallowed by  
system policy.
```

Then execute the following commands:

```
xattr -d com.apple.quarantine CardinalOptimizer-7.2.1-universal_mac.dmg  
xattr -d com.apple.quarantine CardinalOptimizer-7.2.1-universal_mac.tar.gz
```

or

```
xattr -dr com.apple.quarantine /Applications/copt72
```

to disable security check of MacOS.

2.2.3 Linux

For Linux platform, we support X86 and ARM64 architectures and provide packages in GZIP format. The installation package names differ from different architectures:

Linux-X86:

<https://pub.shanshu.ai/download/copt/7.2.1/linux64/CardinalOptimizer-7.2.1-lnx64.tar.gz>

Linux-ARM64:

https://pub.shanshu.ai/download/copt/7.2.1/aarch64/CardinalOptimizer-7.2.1-aarch64_lnx.tar.gz

Fig. 2.10: Installation package download links for Linux system

If you download the software, e.g. CardinalOptimizer-7.2.1-lnx64.tar.gz for 64-bit version of COPT 7.2.1, just type commands below in shell to extract it to any directories:

```
tar -xzf CardinalOptimizer-7.2.1-lnx64.tar.gz
```

You will get a folder named copt72 in current directory, you can move it to any other directories as you like. We recommend users move it to '/opt' directory by typing commands below in shell:

```
sudo mv copt72 /opt/
```

Note that the above command requires **root privilege** to execute.

The next step users need to do is to set the required environment variables, by adding the following commands to the `'.bashrc'` file in your `$HOME` directory using any editors that you preferred:

Remember to save your modifications to the `'.bashrc'` file, and open a new terminal to check if it works by executing commands below respectively:

```
echo $COPT_HOME
echo $COPT_LICENSE_DIR

echo $PATH
echo $LD_LIBRARY_PATH
```

If you accept the `copt-eula_en.pdf` in installation directory, then please go to [Setting Up License](#) for license issues.

2.3 Setting Up License

The Cardinal Optimizers requires a valid license to work properly. We offer different types of licenses most suitable for user's needs. All users should read this section carefully. If you encounter any problem about license, feel free to contact coptsupport@shanshu.ai.

The license specifically includes: `license.dat` and `license.key` two files. Starting from COPT 6.5, if you apply for personal license applications via our official website, we will send both files directly as attachments (no need to obtain it yourself).

Users can **directly download two license files to the local computer, skip the following steps of obtaining and verifying the license**, and can go straight to the [Install license](#) step.

The configuration of the license mainly includes the following three steps:

- [Obtaining License \(skippable\)](#)
- [Verifying License \(skippable\)](#)
- [Installing License](#)

2.3.1 Obtaining License

Once the registration is done, a license key is sent to users. It is a unique token binding with user's registration information. Afterwards, users may run the `copt_licgen` tool, shipped with Cardinal Optimizer, to obtain license files from COPT licensing server (Internet connection required).

Note: If the user has already obtained the two files `license.dat` and `license.key`, there is no need to repeat the following steps to obtain them again.

The following notes show you how to play with the `copt_licgen` tool.

For Windows system, open a new cmd window. The current path is the user directory, and the path is as follows: `"C:\Users\shanshu"`.

For MacOS and Linux systems, open a new terminal. The current path is the user directory, represented by the symbol `~`.

To obtain COPT license files, execute the following command using the option `'-key'` and the license key as argument. Below is an example, assuming the license key is `'19200817f147gd9f60abc791def047fb'`:

```
copt_licgen -key 19200817f147gd9f60abc791def047fb
```

If the license key is saved to `key.txt` file in format of `'KEY=xxx'`, which resides in the same place as `copt_licgen`, execute the following command using the option `'-file'` and `'key.txt'` as argument.

```
copt_licgen -file key.txt
```

We recommend to use the **first way** to get your license files.

If the authorization server verifies the license, then it generates `license.dat` and `license.key` and download it to the user's computer. The default download directory is the current working directory.

```
copt_licgen -key 19200817f147gd9f60abc791def047fb
[Info] Cardinal Optimizer   COPT v7.2.1 20240304
[Info] Use specific key 19200817f147gd9f60abc791def047fb
[Info] * get new COPT license from licensing server *
[Info] Write to license.dat
[Info] Write to license.key
[Info] Received new license files from server
[Info] Done !!!
```

Note: Users do not need to have internet connection to run COPT. However, obtaining license itself requires internet connection. If you encounter any problem, please feel free to contact coptsupport@shanshu.ai.

2.3.2 Verifying License

If the license key binding to registration information is verified by COPT license server, two license files, `license.dat` and `license.key`, are downloaded to the current working directory. To double check two license files are valid in current version of COPT, execute the following command with the option `'-v'`. Note that this command requires both `license.dat` and `license.key` existing in the current working directory.

```
copt_licgen -v
```

If you see log information similar to the following, you have obtained and verified the license files successfully.

```
copt_licgen -v
[Info] Cardinal Optimizer   COPT v7.2.1 20240304
[Info] Run local validation
[Info] Read license.dat
[Info] Read license.key
[Info] Expiry : Tue 2030-12-31 00:00:00 +0800
[Info] Local validation result: Succeeded
[Info] Done !!!
```

2.3.3 Installing License

Once you obtained the `license.dat` and `license.key` files from COPT license server and verified they work as expected, setting up them is just as simple as moving them to the same directory as the COPT dynamic library or *COPT Command-Line*. Note this installation is applied only to current COPT.

The following two ways of installation applied to all versions of COPT on your machine.

Via HOME directory method (recommended)

The simplest way to install COPT license is to create a folder of `copt` in your HOME directory, and move the authenticated license files `license.dat` and `license.key` to the new folder `copt`.

Note: The folder name "`copt`" is case sensitive and it must be lowercase.

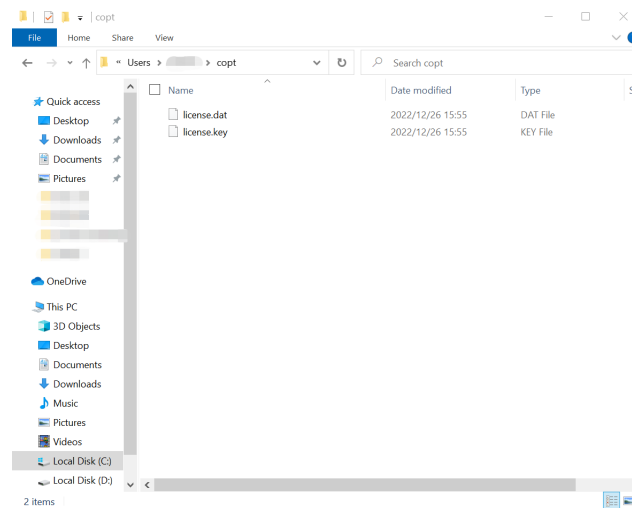
The HOME directory names are slightly different under different systems, please refer to the corresponding license installation steps according to your operating system:

- *Windows*
- *MacOS*
- *Linux*

Windows

The HOME directory looks like "`C:\Users\username\`" on Windows. User can manually move the two license files `license.dat` and `license.key` to the directory "`C:\Users\username\copt`".

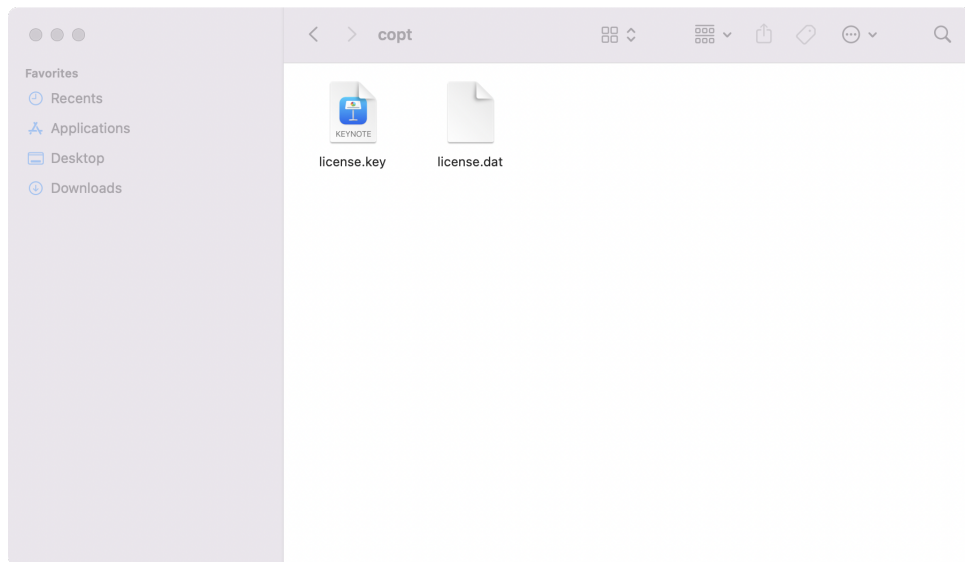
Finally, please check whether the license files `license.dat` and `license.key` are located in this directory, as shown in the figure below, indicating that the license has been installed correctly:



MacOS

The HOME directory looks like "`/home/your username/`" on MacOS. User can manually move the two license files to "`/home/your username/copt/`".

Finally, please check whether the license files `license.dat` and `license.key` are located in this directory, as shown in the figure below, indicating that the license has been installed correctly:



Linux

The HOME directory looks like `"/home/your_username/"` on Linux.

User can execute the following command in the terminal to move the two license files `license.dat` and `license.key` to the directory `"/home/your_username/copt"`.

```
mv license.* ~/copt/
```

Next, please check that the license files `license.dat` and `license.key` are located in `"/home/username/copt"` directory, the command is:

```
ls ~/copt/
```

If the terminal output shows that there are two files `license.dat` and `license.key`, it means that the license has been installed correctly, otherwise the installation fails.

Via environment variable method

Alternatively, for users who prefer having licenses in a customized folder, they can set environment variable `COPT_LICENSE_DIR` to the customized folder. You may refer to [Software Installation](#) for how to set environment variable on Windows, Linux and MacOS.

In addition, please double check that if license files `license.dat` and `license.key` locate in path specified by environmental variable `COPT_LICENSE_DIR`.

The viewing and operation of environment variables are slightly different under different systems, please refer to the following installation steps for your own operating system:

- [Windows](#)
- [MacOS](#)
- [Linux](#)

Windows

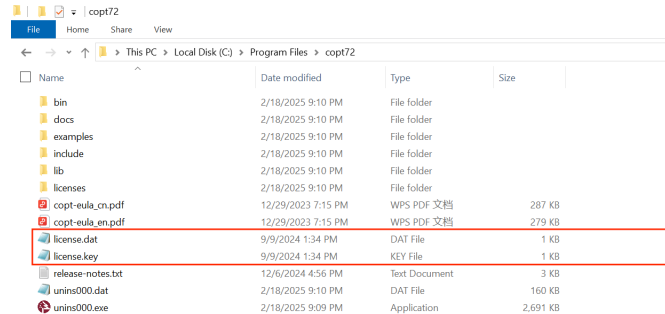
For Windows systems, execute the following command to view the path pointed to by the environment variable `COPT_LICENSE_DIR` :

```
echo %COPT_LICENSE_DIR%
```

Note: If there is no output on the terminal, it means that the COPT-related environment variables have not been configured, please check [Software installation](#).

Then move the license files `license.dat` and `license.key` to the path `COPT_LICENSE_DIR` points to.

Here we assume that the environment variable `COPT_LICENSE_DIR` points to the default installation directory of COPT. As shown in the figure, it means that the license has been installed correctly:



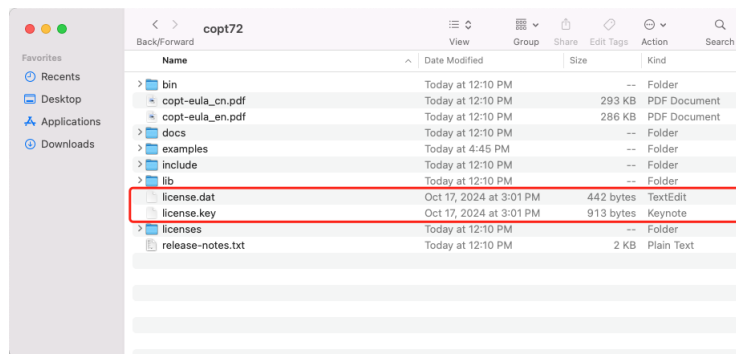
MacOS

For MacOS system, you can use the following command to view the path pointed to by the environment variable `COPT_LICENSE_DIR`:

```
echo $COPT_LICENSE_DIR
```

Then move the license files `license.dat` and `license.key` to the path `COPT_LICENSE_DIR` points to.

Here we assume that the environment variable `COPT_LICENSE_DIR` points to the default installation directory of COPT. As shown in the figure, it means that the license has been installed correctly:



Linux

For Linux systems, user can use the following command to view the path pointed to by the environment variable `COPT_LICENSE_DIR`:

```
echo $COPT_LICENSE_DIR
```

Then user can execute the following command to move the license files `license.dat` and `license.key` to to the path `COPT_LICENSE_DIR` points to.

```
mv license.* $COPT_LICENSE_DIR/
```

Note: For Linux systems, if the path pointed to by the environment variable `COPT_LICENSE_DIR` is `/opt/copt72`, user need to perform the move operation with **root authority** , and the command is:

```
sudo mv license.* $COPT_LICENSE_DIR/
```

In addition, please double check that if license files `license.dat` and `license.key` locate in path specified by environmental variable `COPT_LICENSE_DIR` , and the command is:

```
ls $COPT_LICENSE_DIR/
```

If the terminal displays the files `license.dat` and `license.key`, it means that the license has been installed correctly, otherwise the license installation fails.

Note: If there are license files `license.dat` and `license.key` in the `copt` folder of the user directory and the directory pointed to by the environment variable, the former will be checked and used the former.

2.3.4 Others

Basically, each type of licenses includes two license files: `license.dat` and `license.key`, each of which has digital signature to protect its content. When invoking COPT command-line or loading COPT dynamic library to solve an optimization problem, the public RSA key stored in '`license.key`' is used to verify signature in '`license.dat`'.

Afterwards, license data in format of key-value pair is parsed to verify whether it is a legal license. Below is a sample of license data.

```
## SHANSHU LICENSE FILE ##
```

```
USER = Trial User
MAC = 44:05:99:31:41:C2
CPUID = BFEBFBFF000706E5
EXPIRY = 2030-12-31
VERSION = 7.2.1
NOTE = Free For Trial
```

Note: Please make sure that the `VERSION` field in the license file is the same major version as the software installed on the machine. Otherwise, it may cause error: `Invalid signature in public key file .`

2.4 Verify the installation and configuration

After the user completes the above steps of software installation and license configuration, please enter the COPT command line tool to verify whether the installation is successful.

In MacOS and Linux systems, please open the terminal (in Windows system, please open the cmd window), and enter the `copt_cmd` command to use the COPT command line tool.

If the user sees the output as shown below (without any error message), the COPT command line tool can be entered normally, which means that the previous software and license configuration has been successfully completed.

```
Cardinal Optimizer v7.2.1. Build date Oct 17 2024
Copyright Cardinal Operations 2024. All Rights Reserved

COPT>
```

If you fail to enter the COPT command line tool normally, please refer to [FAQ](#) according to the error message and check whether the above steps of installation and license configuration are completed correctly.

After the installation is successfully completed, according to the interface of COPT as needed, please continue to refer to [Quick Start](#), and check the installation and applying methods of each interface.

2.5 Upgrade

The upgrade steps of COPT mainly include two parts: 1. Software upgrade; 2. License file update.

1. Uninstall the old version of COPT

Firstly, if the user does not need to run multiple versions at the same time, the old version of the software can be uninstalled first.

For different operating systems, the methods of uninstalling COPT are slightly different:

In Windows system, please open the old COPT installation package (named like `copt72`), please double-click to run `unins000.exe`, and then the software can be uninstalled automatically. In MacOS and Linux systems, please delete the old version of the COPT installation package directly to complete the software uninstallation.

2. Install the new version of COPT

If it is an upgrade between major versions (for example: COPT 6.5 -> COPT 7.0), the user needs to re-apply for new version license. Next, the user needs to reinstall the new version of COPT. For the same steps, please refer to [Software Installation](#).

3. Update the license files

In addition, after the software update is complete, the license file needs to be updated. We recommend that the user configure the license file via [user directory](#). The user only needs to delete the license file of the old version under the `copt` folder and move the new license file into it to complete the license update.

After completing the above steps, users can refer to [Verify installation and configuration completion](#) to observe whether the version number in the banner information output by the COPT command line tool is a new version.

Notes

1. For the Python interface of COPT, users also need to **upgrade its corresponding interface `coptpy` at the same time**. If Python is an Anaconda distribution, it can be conducted via `pip install --upgrade coptpy`.
 2. The above are the upgrade steps for major version iterations (for example: COPT 6.5 -> COPT 7.0). In addition, on the basis of each major version, COPT will also provide patch release (eg: COPT 7.2.1 -> COPT 7.2.2), for some feature fixes and updates. For upgrades between minor versions, there is no need to update the license files.
-

Chapter 3

COPT Command-Line

The **Cardinal Optimizer** ships with `copt_cmd` executable on all supported platforms, which let users solve optimization models in an interactive way. Before running COPT command-line, please make sure that you have valid license installed.

3.1 Overview

COPT command-line is a COPT API interpreter that executes commands read from the standard input or from a script file. COPT command-line interprets the following options when it is invoked:

- **-c**: If the '`-c`' option is present, it reads from an inline scripts, which is a quoted string and specified by the second argument.
- **-i**: If the '`-i`' option is present, it reads from an input script file, whose path is specified by the second argument.
- **-o**: If the '`-o`' option is present, it reads from standard input, while each **valid** command line is written to an output script file, whose path is specified by the second argument.

Regardless of arguments, the tool is interactive. Besides wrapping COPT API calls, it offers various features to help users move cursor around and edit lines. We try to provide as much user experience as standard command prompt (Windows console and Unix terminal).

3.2 Edit mode

This tool defines a number of commands to position the cursor, edit lines with combination keys on a standard keyboard. The following notes show you how to use the most important ones.

- **Basic commands**

1. **<Insert>**: Toggle between inserting characters and replacing the existing ones.
2. **<Esc>**: Discard inputs and move the cursor to the beginning of line. Press **<ESC>** twice on Linux/Mac platform to do the same thing.

- **Moving around**

1. **<Home>/<End>**: Jump to the beginning/end of line.
2. **<Left>/<Right>** Arrow: Move the cursor one character to the left/right.
3. **<CTRL>+<Left>/<Right>** Arrow: Move the cursor one word to the left/right.

- **Cut and Paste**

An internal paste buffer is available for the following cut operations.

1. <Delete>: Cut the character under the cursor.
2. <Backspace>: Cut the character before the cursor.
3. <CTRL>+<H>: Cut from the cursor to the beginning of line.
4. <CTRL>+<E>: Cut from the cursor to the end of line.
5. <CTRL>+<Y>: Paste text in paste buffer at the cursor position.

Each of cut operations defines cut direction: cut forward or cut backward. Obviously, <Delete> and <CTRL>+<E> cut forward; <Backspace> and <CTRL>+<H> cut backward. When two consecutive cut operations have the same cut direction, the cutting text is appended the paste buffer. Otherwise, the paste buffer is overwritten by the latest chopped text.

- **Command history**

1. <Up>/<Down>: Move through the history of command lines in the older/newer direction. The tool remembers the history entry if the last executed line is in history.
2. <CTRL>+<R> or <F8>: If you know what a previously executed line starts with, and you want to run it again, type prefix characters and then press <CTRL>+<R>, or <F8> on Windows platform, to iterate through the history of commands with matching prefix.

- **Tab completion**

Use <Tab> to complete shell commands, COPT parameters/attributes, or files under specified path. To cycle through multiple matches, just repeat pressing <Tab>.

1. If the cursor is over or right after the first word on the current command line, press <Tab> to complete available shell commands with matching prefix (from the cursor to the first character of word).
2. Otherwise, press <Tab> to complete COPT parameters/attributes, or file names under path with matching prefix. Specifically, if the prefix matches with COPT parameters as well as file under current working directory, only COPT parameters will be listed. In this case, to iterate file names, add relative path './' to start with.
3. For convenience, tab completion ignores case and support asterisk (*) as wildcard to match file and directory pattern.
4. <Shift>+<Tab>: Complete the next one in an opposite direction.

3.3 Script mode

There are two approaches to run scripts, a batch of commands, in COPT command-line. One is to save scripts as a text file. The other is called **inline scripts**, that is, a quoted string of commands separated by ';'. Both of them can be loaded when COPT command-line is invoked, or loaded on fly in the edit mode (see shell command 'load'). Below describes more details about loading scripts as arguments.

This tool allows users to load a script file to do a batch job automatically. As mentioned in [Overview](#), a script file is read when its file path is specified as arguments of the option '-i'.

- When reading a script file, COPT command-line double checks whether the first non-blank line starts with special text: '#COPT script file'. This is to make sure users do not load an invalid script file by mistake. Indeed, only '#COPT' is verified. In addition, any line in scripts is commented out if its first non-blank character is '#'.
- After a script file is loaded, the tool keeps reading it as standard inputs, until reaching end of file or a special character '?'. Here, we use question mark '?' to pause scripts on purpose. To continue, users can type 'load' in command line. Afterwards, the tool picks whatever left in scripts and start to run from there, until reaching end of file or another question mark '?'. Once current scripts finish, users can load any other script file on fly.

It also allows users to load special scripts, called **inline scripts**. The only difference from a script file is that commands are separated by ';', instead of '\n'. So inline scripts can be read by using arguments of the option '-c', or loaded on fly by specifying a quoted string, and special character '?' works in the same way.

In addition, this tool provides a feature of recording **valid** command lines sequentially to a script file, if users specify an output script file as argument of the option '-o'. Here, **valid** command must use known shell commands and do not exceed number of allowed parameters.

In particular, if users load a script file or inline scripts on fly, all commands in scripts are written to the output script file. Note that command 'load' itself is not written to output script file on purpose. Because we've expanded and written all commands in scripts. On the other hand, it may trigger infinity loop if the script file loaded is actually itself.

3.4 Shell commands

COPT command-line supports the following shell commands for users to manipulate optimization models. Moreover, shell commands are case-insensitive and support tab-completion.

3.4.1 General shell commands

The shell commands below are in support of interactions.

- **cd**: This shell command works similar to DOS command 'cd'. That is, it changes **current working directory**, if its argument is valid relative or absolute path of a directory. Note that **current working directory** is the base directory for relative path and tab completion. It is initialized to current binary folder where `copt_cmd` exist. Users can change it by shell command 'cd <dirpath>'. For example, if users change working directory to a folder having mps files, reading model becomes much easier because only filename is needed.
- **dir/ls**: This shell command works similar to DOS command 'dir' or Bash command 'ls'. That is, it lists all files and directories under given relative or absolute path. To see files under current working directory, type 'dir' or 'ls'; To see files under parent folder, type 'dir ../'; To see files under home path, type 'dir ~/ ', etc. In addition, wildcard (*) is supported as well. That is, 'dir net' lists all file names starting with 'net' under current working directory; 'dir /home/user/*.gz' lists all files of type of '.gz' under path of '/home/user/'.
- **exit/quit**: Leave COPT command-line.
- **help**: It provides information on all shell commands. Typing 'help' followed by a shell command name gives you more details on shell commands. In particular, typing 'help' without arguments lists all shell commands with short descriptions. Right after overview of shell commands, the text 'help' with additional whitespace appear in the new prompt line. So users can directly type, or possibly <Tab> complete, actual shell command to read more details.
- **load**: Load a script file or inline scripts on fly and then execute a batch of commands. The syntax of 'load' command should be followed by either relative/absolute path of a script file, or quoted string of inline scripts. One special scenario is when current script is paused, that is, hit question mark ('?') during execution. In this case, type 'load' will continue the paused scripts. If users forgot having scripts in progress and try to load another scripts, it works as command 'load' and any additional argument is ignored. This behavior is back to normal after reaching the end of current scripts.
- **pwd**: This shell command works similar to Bash command 'pwd'. That is, display current working directory to let users know where they are.
- **status**: COPT command-line has a state machine on status of problem solving (see Fig. 3.1). This is used to guide users through steps. Typing 'status' shows you current interactive status. The status exposed to users are as follows:
 - **Initial**, initial status, either right after the tool is invoked, or shell command **reset** is called.

- **Read**, read an optimization model in format of mps successfully.
- **SetParam**, set value of any COPT parameter successfully.
- **Optimize**, shell command **opt** is called to solve current optimization model.

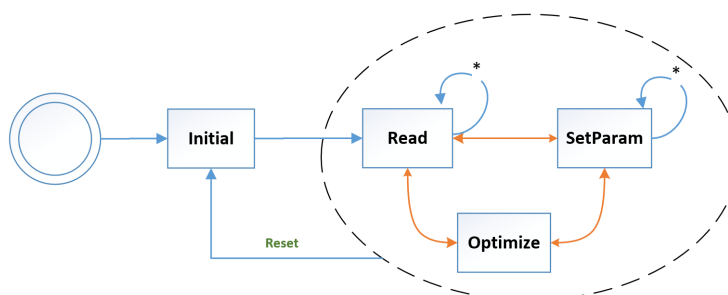


Fig. 3.1: Status of COPT command-line

3.4.2 COPT shell commands

The shell commands below are related to COPT API calls.

- **display/get**: Display current setting of any COPT parameter or attribute. Typing 'display' followed by COPT parameter or attribute name shows its current value. Typing 'display' only lists all COPT parameters and attributes with short descriptions. Right after overview of COPT parameters/attributes, the text 'display' with additional whitespace appear in the new prompt line. So users can directly type, or possibly <Tab> complete, actual parameter/attribute name to see its current value.
- **opt/optimize**: Solve optimization model and display results on screen. This command requires no parameter and its interactive status is set to 'Optimize'.
- **optlp/optimizelp**: Solve optimization model as LP model. This command requires no parameter and its interactive status is set to 'Optimize'.
- **iis**: Compute IIS for the loaded model.
- **feasrelax**: Do feasible relaxation for infeasible problem. Note that an optimization problem must exist before calling 'feasrelax'. 'feasrelax' or 'feasrelax all' means to relax all bounds of variables and constraints with penalty 1, while 'feasrelax vars' means to only relax bounds of variables with penalty 1, and 'feasrelax cons' means to only relax bounds of constraints with penalty 1.
- **tune**: Tuning parameter automatically of the loaded model.
- **loadtuneparam**: Loads the specified tuning results into the currently loaded model. The calling command is 'loadtuneparam idx', where 'idx' is the specified tuning result's number. Use the command 'get TuneResults' to get the number of tuning results obtained after the current tuning.
- **read**: Read optimization model, MIP solution, LP basis, MIP initial solution and COPT parameters from file under given relative/absolute path. It supports files including optimization problem file of type '.mps' and compressed format '.mps.gz', problem file of type '.lp' and compressed format '.lp.gz', problem file of type '.dat-s' and compressed format '.dat-s.gz', problem file of type '.cbf' and compressed format '.cbf.gz', problem file of type '.bin' and compressed format '.bin.gz', basis file of type '.bas', solution file of type '.sol', MIP initial solution file of type '.mst', parameter file of type '.par' and tuning file of type '.tune'.
- **readmps**: Read optimization model in format of '.mps' or '.mps.gz' from file. Note this command does not require file type '.mps' or '.mps.gz'. That is, it is fine to have content in format of MPS, regardless of its file name. In addition, the interactive status is set to 'Read'.

- **readlp**: Read optimization model in format of `'.lp'` or `'.lp.gz'` from file. Note this command does not require file type `'.lp'` or `'.lp.gz'`. That is, it is fine to have content in format of LP, regardless of its file name. In addition, the interactive status is set to `'Read'`.
- **readsdpa**: Read an optimization problem in format of `'.dat-s'` or `'.dat-s.gz'` from file. Note that this command is similar to `'read'` when the file type is `'.dat-s'`. However, `'readsdpa'` does not require the file has type `'.dat-s'`. It parses the file as SDPA format, no matter what file type it is.
- **readcbf**: Read an optimization problem in format of `'.cbf'` or `'.cbf.gz'` from a file. Note that this command is similar to `'read'` when the file type is `'.cbf'`. However, `'readcbf'` does not require the file has type `'.cbf'`. It parses the file as CBF format, no matter what file type it is.
- **readbin**: Read optimization model in format of `'.bin'` or `'.bin.gz'` from file. Note this command does not require file type `'.bin'`. That is, it is fine to have content in format of COPT binary format, regardless of its file name. In addition, the interactive status is set to `'Read'`.
- **readsol**: Read MIP solution from file. Note this command does not require file type of `'.sol'`. That is, it is fine to have content of solution, regardless of its file name.
- **readbasis**: Read optimal basis from file. Note this command does not require file type of `'.bas'`. That is, it is fine to have content of basis, regardless of its file name.
- **readmst**: Read MIP initial solution from file. Note this command does not require file type of `'.mst'`. That is, it is fine to have content of solution, regardless of its file name.
- **readparam**: Read COPT parameters from file and set corresponding values. Note this command does not require file type of `'.par'`. That is, it is fine to have content of COPT parameters, regardless of its file name.
- **readtune**: Read the parameter file under the given relative or absolute path. Note this command does not require file type of `'.tune'`. That is, it is fine that the file conforms to the COPT parameter tuning file format, regardless of its file name.
- **reset**: Reset current optimization model and all parameters/attributes to defaults. In addition, the interactive status is set to `'Initial'`.
- **set**: Set value of any COPT parameter. The syntax of this command should be `'set'`, followed by COPT parameter name and an integer/double number. Moreover, Typing `'set'` only lists all COPT parameters with short descriptions. Right after overview of COPT parameters, the text `'set'` with additional whitespace appears in the new prompt line. So users can directly type, or possibly <Tab> complete, actual parameter name to complete as partial command. If so, its current value, default value, min value, max value of given COPT parameter are displayed on screen. Now users know how to add correct value to complete the full command of `'set'`. One tip of saving typing here is to get last history entry by pressing <Up>. At last, the interactive status is set to `'SetParam'`.
- **write**: Output MPS/LP/CBF format model, COPT binary format model, IIS model, FeasRelax model, LP/MIP solution, optimal basis, settings of modified COPT parameters to file under given relative/absolute path. This command detects file types. For an instance, `'write diet.sol'` outputs LP solution to file `'diet.sol'`. An error message will be shown to users if file type do not match. Supported file types are: `'.mps'`, `'.lp'`, `'.bin'`, `'.cbf'`, `'.iis'`, `'.relax'`, `'.sol'`, `'.bas'`, `'.mst'` and `'.par'`.
- **writemps**: Output current optimization model to a file of type `'.mps'`. Note `'.mps'` is appended to the file name, if users do not add it.
- **writelp**: Output current optimization model to a file of type `'.lp'`. Note `'.lp'` is appended to the file name, if users do not add it.
- **writecbf**: Output problem to a file of type `'.cbf'`. Note `'.cbf'` is appended to the file name, if users do not add it.
- **writebin**: Output current optimization model to a file of type `'.bin'`. Note `'.bin'` is appended to the file name, if users do not add it.

- **writeiis**: Output computed IIS model to a file of type `'.iis'`. Note `'.iis'` is appended to the file name, if users do not add it.
- **writerelax**: Output feasibility relaxation problem to a file of type `'.relax'`. Note `'.relax'` is appended to the file name, if users do not add it.
- **writesol**: Output LP solution of problem to a file of type `'.sol'`. Note `'.sol'` is appended to the file name, if users do not add it.
- **writepoolsol**: For the current problem, save the solution with the specified number in the solution pool to the result file under the given relative or absolute path. If the file extension is not `''sol''`, the suffix `'.sol'` is automatically added. The calling command is `'writepoolsol idx pool_idx.sol'`, where `'idx'` is the specified solution number in solution pool. Use the command `'get PoolSols'` to get the current number of solution pool results.
- **writebasis**: Output optimal basis to a file of type `'.bas'`. Note `'.bas'` is appended to the file name, if users do not add it.
- **writemst**: Output current best MIP solution to a file of type `'.mst'`. Note `'.mst'` is appended to the file name, if users do not add it.
- **writeparam**: Output modified COPT parameters to a file of type `'.par'`. Note `'.par'` is appended to the file name, if users do not add it.
- **writetuneparam**: Save the specified tuning result to the parameter setting file under the given relative or absolute path. The calling command is `'writetuneparam idx tune_idx.par'`, where `'idx'` is the specified tuning result number. Use the command `'get TuneResults'` to get the number of tuning results obtained after the current tuning.

3.5 Example Usage

This section shows how to use COPT command-line to interactively solve a well-known problem, called “Diet Problem”. Please refer to [AMPL Interface - Example Usage](#) for problem description in more detail.

With valid license, COPT command-line should run as follows, after entering `copt_cmd` in command prompt.

```
copt_cmd
```

If users are new to COPT command-line, always start with shell command `'help'`.

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COPT>

Suppose diet model has mps format and exits in the current working directory. In this way, we just type its file name to read, without worrying about its path.

```
COPT> read diet.mps
Reading from '/home/username/copt/diet.mps'
Reading finished (0.00s)
```

Before solving it, users are free to tune any COPT parameter. Below is an example to set value of double parameter `TimeLimit` to 10s.

If users are not familiar with COPT parameters, just type `'set'` to list all public COPT parameters and attributes with short description. Furthermore, `'set'` with parameter name, for example `'set TimeLimit'`, displays its current value, default value, min value and max value of the given parameter.


```
COPT> set timelimit 10

Setting parameter 'TimeLimit' to 10
```

After tuning parameters, it is time to solve the model. The messages during problem solving are shown as follows.

```
COPT> opt
Model fingerprint: 129c032d

Hardware has 4 cores and 8 threads. Using instruction set X86_NATIVE (1)
Minimizing an LP problem

The original problem has:
    4 rows, 8 columns and 31 non-zero elements
The presolved problem has:
    4 rows, 8 columns and 31 non-zero elements

Starting the simplex solver using up to 8 threads
```

Method	Iteration	Objective	Primal.NInf	Dual.NInf	Time
Dual	0	0.0000000000e+00	4	0	0.01s
Dual	1	8.8201991646e+01	0	0	0.01s
Postsolving					
Dual	1	8.8200000000e+01	0	0	0.01s

```

Solving finished
Status: Optimal  Objective: 8.8200000000e+01  Iterations: 1  Time: 0.01s
```

After solving the model, users might check results by using shell command 'get' with a parameter name. Note that, similar to 'set', type 'get' to list all public parameters and attributes. In particular, 'get all' shows all parameters/attributes and their current value.

```
COPT> get TimeLimit
  DblParam: [Current] 10s
COPT> get LpObjval
  DblAttr:  [Current] 88.2
COPT> get LpStatus
  IntAttr:  [Current] 1 optimal
```

Before leaving COPT command-line, users might output the model in format of mps, optimal basis, modified parameters, or LP solution to files. Below is an example to write LP solution to current directory.

```
COPT> writesol diet
  Writing solutions to /home/username/copt/diet.sol
COPT> quit
  Leaving COPT...
```

Below is the script file `diet.in` by putting everything together, see [Listing 3.1](#):

Listing 3.1: `diet.in`

```
1 #COPT script-in file
2
3 read diet.mps
4 set timelimit 10
5 opt
```

(continues on next page)

(continued from previous page)

```
6 writesol diet
7 quit
```

which is loaded by using the option '-i' when starting `copt_cmd`:

```
copt_cmd -i diet.in
```

or executing shell command `load` on fly.

```
COPT> load diet.in
```

Chapter 4

COPT Floating Licensing service

The **Cardinal Optimizer** provides COPT Floating Token Server on all supported platforms, who serve license tokens to COPT client applications over local network.

Once you have floating license properly installed, server owns a set of license tokens up to number described in the license file. Any properly configured COPT client of the same version can request a token from server and release it whenever quit.

4.1 Server Setup

The application of COPT Floating Token server includes `copt_flserver` executable and a configuration file `fls.ini`. The very first thing to do when server starts is to verify floating license locally, whose location is specified in `fls.ini`. If local validation passes, server connects to remote COPT licensing server for further validation, including machine IP, which is supposed to match IP range that user provided during registration. This means the machine running COPT Floating Token Server should have internet access in specified area. For details, please see descriptions below or refer to *[How to obtain and setup license](#)*.

4.1.1 Installation

The **Cardinal Optimizer** provides a separate package for remote services, which include COPT floating token server. Users may apply for remote package from customer service. Afterwards, unzip the remote package and move to any folder on your computer. The software is portable and does not change anything in the system it runs on. Below are details of installation.

Windows

Please unzip the remote package and move to any folder. Though, it is common to move to folder under `C:\Program Files`.

Linux

To unzip the remote package, enter the following command in terminal:

```
tar -xzf CardinalOptimizer-Remote-7.2.1-lnx64.tar.gz
```

Then, the following command moves folder `copt_remote72` in current directory to other path. For an example, admin user may move it to folder under `/opt` and standard user may move it to `$HOME`.

```
sudo mv copt_remote72 /opt
```

Note that it requires `root` privilege to execute this command.

MacOS

To unzip the remote package, enter the following command in terminal:

```
tar -xzf CardinalOptimizer-Remote-7.2.1-universal_mac.tar.gz
```

Then, the following command moves folder `copt_remote72` in current directory to other path. For an example, admin user may move it to folder under `/Applications` and standard user may move it to `$HOME`.

```
mv copt_remote72 /Applications
```

4.1.2 Floating License

After installing COPT remote package, it requires floating license to run. It is preferred to save floating license files, `license.dat` and `license.key`, to `floating` folder in path of remote package.

The following explains how to obtain the license file via the `copt_licgen` tool and the license credential information `key` under different systems.

Note

If the user has already obtained the two license files `license.dat` and `license.key`, there is no need to obtain them again. You can skip the following steps to obtain the license file and refer to [Configuration](#) directly.

Windows

If the COPT remote package is installed under "`C:\Program Files`", execute the following command to enter `floating` folder in path of remote package.

```
cd "C:\Program Files\copt_remote72\floating"
```

Note that the tool `copt_licgen` creating license files exists under `tools` folder in path of remote package. The following command creates floating license files in current directory, given a floating license key, such as `7483dff0863ffdae9fff697d3573e8bc`.

```
..\tools\copt_licgen -key 7483dff0863ffdae9fff697d3573e8bc
```

Linux and MacOS

If the COPT remote package is installed under "`/Applications`", execute the following command to enter `floating` folder in path of remote package on MacOS system.

```
cd /Applications/copt_remote72/floating
```

The following command creates floating license files in current directory, given a floating license key, such as `7483dff0863ffdae9fff697d3573e8bc`.

```
../tools/copt_licgen -key 7483dff0863ffdae9fff697d3573e8bc
```

In addition, if users run the above command when current directory is different than `floating` folder in path of remote package, it is preferred to move them to `floating`. The following command does so.

```
mv license.* /Application/copt_remote72/floating
```

4.1.3 Configuration

Below is a typical configuration file, `fls.ini`, of COPT Floating Token Server.

```
[Main]
Port = 7979

# password is case-sensitive and default is empty
# it applies to both copt clients and managing tool
PassWd =

[SSL]
# needed if connecting using SSL
CaFile =
CertFile =
CertkeyFile =

[Licensing]
# if empty or default license name, it is from binary folder
# to get license files from cwd, add prefix "./"
# full path is supported as well
LicenseFile = license.dat
PubkeyFile = license.key

[WLS]
# WebServer have a default host and no need to edit in most scenarios
# Must specify WebLicenseId and WebAccesskey to trigger web licensing
WebServer =
WebLicenseId =
WebAccessKey =
WebTokenDuration = 300

[Filter]
# default policy 0 indicates accepting all connections, except for ones in blacklist
# otherwise, denying all connections except for ones in whitelist
DefaultPolicy = 0
UseBlackList = true
UseWhiteList = true
FilterListFile = flsfilters.ini

[Logs]
LogsFolder = ./logs
```

The **Main** section specifies port number, through which COPT clients connect to server and then obtain the license token. The **Licensing** section specifies location of floating license. As described in comments above, if empty string or default license file name is specified, floating license files are read from the binary folder where the server executable reside.

It is possible to run COPT Floating Token server, even if floating license files do not exist in the same folder as the server executive. One solution is to set `LicenseFile = ./license.dat` and `PubkeyFile = ./license.key`. By doing so, server read floating license from the current working directory. That is, user could execute server application at the path where floating license files exist.

The other solution is to set full path of license files in configuration. As mentioned before, Cardinal Optimizer allows users to set environment variable `COPT_LICENSE_DIR` for license files. For details, please refer to *How to install Cardinal Optimizer*. If user prefers the way of environment variable, the configuration file should have the full path to floating license.

In the **Filter** section, `DefaultPolicy` has default value 0, meaning all connections are accepted except for those in black lists; if it is set to non-zero value, then all connection are blocked except for those

in white lists. In addition, black list is enabled if `UseBlackList` is true and white list is enabled if `UseWhiteList` is true. The filter configuration file is specified by `FilterListFile`. Below is an example of the filter configuration file.

```
[BlackList]
# 127.0.*.* + user@machine*

[WhiteList]
# 127.0.1.2/16 - user@machine*

[ToolList]
# only tool client at server side can access by default
127.0.0.1/32
```

It has three sections and each section has its own rules. In section of `BlackList`, one may add rules to block others from connection. In section of `WhiteList`, one may add rules to grant others for connection, even if the default policy is to block all connections. Only users listed in section of `ToolList` are able to connect to floating token server by Floating Token Server Managing Tool (see below for details).

Specifically, rules in filter configuration have format of starting with IP address. To specify IP range, you may include wildcard (*) in IP address, or use CIDR notation, that is, a IPv4 address and its associated network prefix. In addition, a rule may include (+) or exclude (-) given user at given machine, such as `127.0.1.2/16 - user@machine`. Here, `user` refers to `username`, which can be queried by `whoami` on Linux/MacOS platform; `machine` refers to `computer name`, which can be queried by `hostname` on Linux/MacOS platform.

4.1.4 Web License for Floating Server

Besides local floating license above, users may use web license for floating server to run floating service. This requires that the machine running floating server must have internet access. However, hardware info are not required any more. That is, users are free to deploy floating server to any cloud machine or container, as long as they have internet access. Please refer to [COPT Web Licenses](#) for details.

Below are brief steps:

- Follow steps to register an account and apply for trial of web license for floating server.
- Once approved, *Web License ID* is generated for users
- On page of *API Keys*, create *Web Access Key* using given *Web License ID*

Afterwards, users edit configuration file *fls.ini* and add values of both *Web License ID* and *Web Access Key* to related keywords in section of *WLS*. For instance,

```
[WLS]
# WebServer have a default host and no need to edit in most scenarios
# Must specify WebLicenseId and WebAccesskey to trigger web licensing
WebServer =
WebLicenseId =
WebAccessKey =
WebTokenDuration = 300
```

As of now, floating server talks to [COPT Web Licenses](#) for licensing. Users are able to monitor its token usage and other informations online.

4.1.5 Example Usage

Suppose that floating license exists in the same folder where the server executable reside. To start the COPT Floating Token Server, just execute the following command at any directory in Windows console, or Linux/Mac terminal.

```
copt_flserver
```

If you see log information as follows, the Floating Token Server has been successfully started. Server monitors any connection from COPT clients, manages approved clients as well as requests in queue. User can stop Floating Token Server anytime when entering `q` or `Q`.

```
> copt_flserver
[ Info] Floating Token Server, COPT v7.2.1 20240304
[ Info] server started at port 7979
```

If failed to verify local floating license, or something is wrong on remote COPT license server, you might see error logs as follows.

```
> copt_flserver
[ Info] Floating Token Server, COPT v7.2.1 20240304
[Error] Invalid signature in public key file
[Error] Fail to verify local license
```

and

```
> copt_flserver
[ Info] Floating Token Server, COPT v7.2.1 20240304
[Error] Error to connect license server
[Error] Fail to verify floating license by server
```

4.2 Client Setup

COPT Clients can be COPT command-line tool, or any application which solve problems using COPT api, such as COPT python interface. Floating licensing is a better approach in terms of flexibility and efficiency. Different from stand-alone license, any machine having properly configured COPT client can legally run Cardinal Optimizer, as long as peak number of connected clients does not exceed the token number.

4.2.1 Configuration

Via the configuration file

Before running COPT as floating client, please make sure that you have installed COPT locally. For details, please refer to [How to install Cardinal Optimizer](#). Users can skip obtaining local licenses by adding a floating configuration file `client.ini`.

Below is a typical configuration file, `client.ini`, of COPT floating clients.

```
Host = 192.168.1.11
Port = 7979
QueueTime = 600
```

As configured above, COPT floating client tries to connect to `192.168.1.11` at port `7979` with wait time in queue up to `600` seconds. Here, `Host` is set to `localhost` if empty or not specified; `QueueTime` is set to `0` if empty or not specified. Specifically, empty `QueueTime` means client does not wait and should quit immediately, if COPT Floating Token Server have no tokens available. Port number must be great than zero and should be the same as that specified in server configuration file. Note that keywords in the client configuration file are case insensitive.

Without local license files, a COPT application still works if client configuration file, `client.ini`, exists in one of the following three locations in order, that is, current working directory, environment directory by `COPT_LICENSE_DIR` and binary directory where COPT executable is located.

By design, COPT application reads local license files instead of client configuration file, if they both exist in the same location. On the other hand, if local license files are under the environment directory, to activate approach of floating licensing, user can simply add a configuration file, `client.ini`, under the current working directory (different from the environment directory).

If a COPT application calls COPT API to solve problems, such as COPT python interface, license is checked as soon as COPT environment object is created. If there exists proper client configuration file, `client.ini`, a license token is granted to COPT client. This license token is released and sent back to token server, as soon as last COPT environment object in the same process destroys.

Via API Functions

In addition to the method using the `client.ini` file mentioned above, users can also configure the client in their code through API functions. Taking the COPT Python interface as an example, the corresponding class is *EnvrConfig Class*, and similar approaches apply to other programming languages. The configuration is as follows:

```
# Set client configuration parameters
envconfig.set(COPT.CLIENT_FLOATING, "192.168.1.11")
envconfig.set(COPT.CLIENT_PORT, "7979")
envconfig.set(COPT.CLIENT_WAITTIME, "600")
```

4.2.2 High Availability

In the case of multiple floating license servers, the client can achieve high availability by configuring multiple server IP addresses in the `Host` field of the `client.ini` file, as shown in the table below:

```
Host = 192.168.1.11; 192.168.1.22; 192.168.1.33
Port = 7979
WaitTime = 600
```

Here, the `Host` field contains the IP addresses of each floating license server. If the port number of a server is not 7979, the port can be specified after the IP address.

The above configuration indicates that the client will first attempt to connect to the server 192.168.1.11:7979. If that server is unavailable, the client will try connecting to 192.168.1.22:7979, and so on, until a successful connection to one of the floating servers is made.

If a floating server fails during token issuance or management, the client will reassign to another available floating license server as specified in the configuration file. This setup ensures that the floating license service has disaster recovery capabilities, thereby improving the high availability of the COPT floating license service.

4.2.3 Example Usage

Suppose that we've set client configuration file `client.ini` properly and have no local license, below is an example of obtaining a floating token by COPT command-line tool `copt_cmd`. Execute the following command in Windows console, or Linux/Mac terminal.

```
copt_cmd
```

If you see log information as follows, the COPT client, `copt_cmd`, has obtained the floating token successfully. COPT command-line tool is ready to solve optimization problems.


```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] initialize floating client: ./client.ini

[ Info] connecting to server ...
[ Info] connection established
COPT>
```

If you see log information as follows, the COPT client, `copt_cmd`, has connected to COPT Floating Token Server. But due to limited number of tokens, client waits in queue of size 1.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] Initialize floating client: ./client.ini

[ Info] connecting to server ...
[Error] empty license and queue size 1
[ Info] Wait for license in 2 / 39 secs
[ Info] Wait for license in 4 / 39 secs
[ Info] Wait for license in 6 / 39 secs
[ Info] Wait for license in 8 / 39 secs
[ Info] Wait for license in 10 / 39 secs
[ Info] Wait for license in 20 / 39 secs
[ Info] Wait for license in 30 / 39 secs
```

If you see log information as follows, the COPT client, `copt_cmd`, has connected to COPT Floating Token Server. But client refused to wait in queue, as Queue time is 0.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] Initialize floating client: ./client.ini

[ Info] connecting to server ...
[Error] Server error: "no more token available", code = 2
[Error] Fail to open: ./license.dat

[Error] Fail to initialize cmdline
```

If you see log information as follows, the COPT client, `copt_cmd`, fails to connect to COPT Floating Token Server. Finally, client quits after time limit.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] initialize floating client: ./client.ini

[ Info] connecting to server ...
[ Info] wait for license in 2 / 10 secs
[ Info] wait for license in 4 / 10 secs
[ Info] wait for license in 6 / 10 secs
[ Info] wait for license in 8 / 10 secs
[ Info] wait for license in 10 / 10 secs
[Error] timeout at waiting for license
[Error] fail to open: ./license.dat
```

[Error] Fail to initialize cmdline

In addition, users can start the COPT command-line tool on the client side to connect to the specified floating server IP address as follows:

```
> copt_cmd -floating <ip>
```

4.3 Floating Token Server Managing Tool

COPT floating token service ships with a tool `copt_flstool`, for retrieving information and tune parameters of floating token server on fly.

4.3.1 Tool Usage

Execute the following command in Windows console, Linux or MacOS terminal:

```
> ./copt_flstool
```

Below displays help messages of this tool:

```
> ./copt_flstool
COPT Floating Token Server Managing Tool

copt_flstool [-s server ip] [-p port] [-x passwd] command <param>

commands are:  addblackrule <127.0.0.1/20[-user@machine]>
               addwhiterule <127.0.*.*[+user@machine]>
               getfilters
               getinfo
               resetfilters
               setpasswd <xxx>
               toggleblackrule <n-th>
               togglewhiterule <n-th>
               writefilters
```

If the `-s` and `-p` option are present, tool connects to floating token server with given server IP and port. Otherwise, tool connections to localhost and default port 7979. If floating token server sets a password, tool must provide password string after the `-x` option.

This tool provides the following commands:

- **AddBlackRule:** Add a new rule in black filters. each rule has format starting with non-empty IP address, which may have wildcard to match IPs in the scope. In addition, it is optional to be followed by including (+) or excluding (-) user name at machine name.
- **AddWhiteRule:** Add a new rule in white filters. Note that a white rule has the same format as a black rule.
- **GetFilters:** Get all rules of black filters, white filters and tool filters, along with relative sequence numbers, which are parameters for command ToggleBlackRule and ToggleWhiteRule.
- **GetInfo:** Get general information of floating token server, including token usage, connected clients, and all COPT versions in support.
- **ResetFilters:** Reset filter lists in memory to those on filter config file.
- **SetPasswd:** Update password of target floating token server on fly.

- **ToggleBlackRule:** Toggle between enabling and disabling a black rule, given its sequence number by GetFilters.
- **ToggleWhiteRule:** Toggle between enabling and disabling a white rule, given its sequence number by GetFilters.
- **WriteFilters:** Write filter lists in memory to filter config file.

4.3.2 Example Usage

The following command lists general information on local machine.

```
> ./copt_flstool GetInfo
```

```
[ Info] COPT Floating Token Server Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to localhost:7979
[ Info] [command] wait for connecting to floating token server
[ Info] [floating] general info
# of available tokens is 3 / 3, queue size is 0
# of active clients is 0
```

To run managing tool on other machine, its IP should be added to a rule in ToolList section in filter configuration file flsfilters.ini. The following command from other machine lists information of server 192.168.1.11.

```
> ./copt_flstool -s 192.168.1.11 GetInfo
```

```
[ Info] COPT Floating Token Server Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to floating token server
[ Info] [floating] general info
# of available tokens is 3 / 3, queue size is 0
# of active clients is 0
```

The following command shows all filter lists of server 192.168.1.11, including those in BlackList section, WhiteList section and ToolList section.

```
> ./copt_flstool -s 192.168.1.11 GetFilters
```

```
[ Info] COPT Floating Token Server Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to floating token server
[ Info] [floating] filters info
[BlackList]

[WhiteList]

[ToolList]
[1] 127.0.0.1
```

The following command added user of IP 192.168.3.13 to black list.

```
> ./copt_flstool -s 192.168.1.11 AddBlackRule 192.168.3.133
```

```
[ Info] COPT Floating Token Server Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to floating token server
[ Info] [floating] server added new black rule (succeeded)
```

The following command shows that a new rule in BlackList section is added.

```
> ./copt_flstool -s 192.168.1.11 GetFilters
```

```
[ Info] COPT Floating Token Server Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to floating token server
[ Info] [floating] filters info
[BlackList]
  [1] 192.168.3.133

[WhiteList]

[ToolList]
  [1] 127.0.0.1
```

The following command disable a rule in BlackList section.

```
> ./copt_flstool -s 192.168.1.11 ToggleBlackRule 1
```

```
[ Info] COPT Floating Token Server Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to floating token server
[ Info] [floating] server toggle black rule [1] (succeeded)
```

4.4 Running as service

To run COPT floating token server as a system service, follow steps described in `readme.txt` under floating folder, and set config file `copt_flserver.service` properly.

Below is `readme.txt`, which lists installing steps in both Linux and MacOS platforms.

```
[Linux] To run copt_flserver as a service with systemd

Add a systemd file
  cp copt_flserver.service to /lib/systemd/system/
  sudo systemctl daemon-reload

Enable new service
  sudo systemctl start copt_flserver.service
  or
  sudo systemctl enable copt_flserver.service

Restart service
  sudo systemctl restart copt_flserver.service

Stop service
  sudo systemctl stop copt_flserver.service
  or
  sudo systemctl disable copt_flserver.service

Verify service is running
  sudo systemctl status copt_flserver.service

[MacOS] To run copt_flserver as a service with launchctl

Add a plist file
  cp copt_flserver.plist to /Library/LaunchAgents as current user
  or
  cp copt_flserver.plist to /Library/LaunchDaemons with the key 'UserName'
```

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```

Enable new service
    sudo launchctl load -w /Library/LaunchAgents/copt_flserver.plist
or
    sudo launchctl load -w /Library/LaunchDaemons/copt_flserver.plist

Stop service
    sudo launchctl unload -w /Library/LaunchAgents/copt_flserver.plist
or
    sudo launchctl unload -w /Library/LaunchDaemons/copt_flserver.plist

Verify service is running
    sudo launchctl list shanshu.copt.flserver

```

4.4.1 Linux

Below are steps in details of how to run COPT floating token server as a system service in Linux platform.

For instance, assume that COPT remote service is installed under '/home/eleven'. In your terminal, type the following command to enter the root directory of floating service.

```
cd /home/eleven/copt_remote72/floating
```

modify template of the service config file `copt_flserver.service` in text format:

```

[Unit]
Description=COPT Floating Token Server

[Service]
WorkingDirectory=/path/to/service
ExecStart=/path/to/service/copt_flserver
Restart=always
RestartSec=1

[Install]
WantedBy=multi-user.target

```

That is, update template path in keyword `WorkingDirectory` and `ExecStart` to actual path where the floating service exists.

```

[Unit]
Description=COPT Floating Token Server

[Service]
WorkingDirectory=/home/eleven/copt_remote72/floating
ExecStart=/home/eleven/copt_remote72/floating/copt_flserver
Restart=always
RestartSec=1

[Install]
WantedBy=multi-user.target

```

Afterwards, copy `copt_flserver.service` to system service folder `/lib/systemd/system/` (see below).

```
sudo cp copt_flserver.service /lib/systemd/system/
```

The following command may be needed if you add or update service config file. It is not needed if service unit has been loaded before.

```
sudo systemctl daemon-reload
```

The following command starts the new floating service.

```
sudo systemctl start copt_flserver.service
```

To verify the floating service is actually running, type the following command

```
sudo systemctl status copt_flserver.service
```

If you see logs similar to below, COPT floating server is running successfully as a system service.

```
copt_flserver.service - COPT Floating Token Server
Loaded: loaded (/lib/systemd/system/copt_flserver.service; enabled; vendor preset:
➔enabled)
Active: active (running) since Tue 2021-06-29 11:46:10 CST; 3s ago
Main PID: 3054 (copt_flserver)
Tasks: 6 (limit: 4915)
CGroup: /system.slice/copt_flserver.service
└─3054 /home/eleven/copt_remote72/floating/copt_flserver
```

```
eleven-ubuntu systemd[1]: Started COPT Floating Token Server.
eleven-ubuntu COPTCLS[3054]: LWS: 4.1.4-b2011a00, loglevel 1039
eleven-ubuntu COPTCLS[3054]: NET CLI SRV H1 H2 WS IPv6-absent
eleven-ubuntu COPTCLS[3054]: server started at port 7979
```

To stop the floating service, type the following command

```
sudo systemctl stop copt_flserver.service
```

4.4.2 MacOS

Below are steps in details of how to run COPT floating token server as a system service in MacOS platform.

For instance, assume that COPT remote service is installed under '/Applications'. In your terminal, type the following command to enter the root directory of floating service.

```
cd /Applications/copt_remote72/floating
```

modify template of the service config file `copt_flserver.plist` in xml format:

```
<?xml version="1.0" encoding="UTF-8"?>
<plist version="1.0">
  <dict>
    <key>Label</key>
    <string>shanshu.copt.flserver</string>
    <key>Program</key>
    <string>/path/to/service/copt_flserver</string>
    <key>RunAtLoad</key>
    <true/>
    <key>KeepAlive</key>
    <true/>
  </dict>
</plist>
```

That is, update template path in Program tag to actual path where the floating service exists.

```
<?xml version="1.0" encoding="UTF-8"?>
<plist version="1.0">
```

```

<dict>
  <key>Label</key>
  <string>shanshu.copt.flserver</string>
  <key>Program</key>
  <string>/Applications/copt_remote72/floating/copt_flserver</string>
  <key>RunAtLoad</key>
  <true/>
  <key>KeepAlive</key>
  <true/>
</dict>
</plist>

```

Afterwards, copy `copt_flserver.plist` to system service folder `/Library/LaunchAgents` (see below).

```
sudo cp copt_flserver.plist /Library/LaunchAgents
```

The following command starts the new floating service.

```
sudo launchctl load -w /Library/LaunchAgents/copt_flserver.plist
```

To verify the floating service is actually running, type the following command

```
sudo launchctl list shanshu.copt.flserver
```

If you see logs similar to below, COPT floating server is running successfully as a system service.

```

{
  "LimitLoadToSessionType" = "System";
  "Label" = "shanshu.copt.flserver";
  "OnDemand" = false;
  "LastExitStatus" = 0;
  "PID" = 16406;
  "Program" = "/Applications/copt_remote72/floating/copt_flserver";
};

```

To stop the floating service, type the following command

```
sudo launchctl unload -w /Library/LaunchAgents/copt_flserver.plist
```

If the floating service should be run by a specific user, add `UserName` tag to config file. Below adds a user `eleven`, who has privilege to run the floating service.

```

<?xml version="1.0" encoding="UTF-8"?>
<plist version="1.0">
  <dict>
    <key>Label</key>
    <string>shanshu.copt.flserver</string>
    <key>Program</key>
    <string>/Applications/copt_remote72/floating/copt_flserver</string>
    <key>UserName</key>
    <string>eleven</string>
    <key>RunAtLoad</key>
    <true/>
    <key>KeepAlive</key>
    <true/>
  </dict>
</plist>

```

Then copy new `copt_flserver.plist` to system service folder `/Library/LaunchDaemons` (see below).

```
sudo cp copt_flserver.plist /Library/LaunchDaemons
```

The following command starts the new floating service.

```
sudo launchctl load -w /Library/LaunchDaemons/copt_flserver.plist
```

To stop the floating service, type the following command

```
sudo launchctl unload -w /Library/LaunchDaemons/copt_flserver.plist
```


Chapter 5

COPT Compute Cluster Service

The **Cardinal Optimizer** provides COPT compute cluster service on all supported platforms, which allows you to offload optimization computations from COPT client applications over local network.

Once COPT compute cluster server runs at local network, any COPT client application with matching COPT version can connect to server and offload optimization computations. That is, COPT compute cluster clients are allowed to do modelling locally, execute optimization jobs remotely, and then obtain results interactively.

Note that the more computing power server has, the more optimization jobs can run simultaneously. Furthermore, COPT compute cluster service has functionality to cluster multiple servers together and therefore serve more COPT compute cluster clients over local network.

5.1 Server Setup

The COPT compute cluster service includes `copt_cluster` executable and a configuration file `cls.ini`. The very first thing to do when cluster server starts is to verify cluster license locally, whose path is specified in `cls.ini`. If local validation passes, cluster server might connect remotely to COPT licensing server for further validation, such as verifying machine IP, which is supposed to match IP range that user provided during registration. This means the server running COPT compute cluster service should have internet access in specified area, such as campus network. For details, please see descriptions below or refer to *How to obtain and setup license*.

5.1.1 Installation

The **Cardinal Optimizer** provides a separate package for remote services, which include COPT compute cluster. Users may apply for remote package from customer service. Afterwards, unzip the remote package and move to any folder on your computer. The software is portable and does not change anything in the system it runs on. Below are details of installation.

Windows

Please unzip the remote package and move to any folder. Though, it is common to move to folder under `C:\Program Files`.

Linux

To unzip the remote package, enter the following command in terminal:

```
tar -xzf CardinalOptimizer-Remote-7.2.1-lnx64.tar.gz
```

Then, the following command moves folder `copt_remote72` in current directory to other path. For an example, admin user may move it to folder under `/opt` and standard user may move it to `$HOME`.

```
sudo mv copt_remote72 /opt
```

Note that it requires **root** privilege to execute this command.

MacOS

To unzip the remote package, enter the following command in terminal:

```
tar -xzf CardinalOptimizer-Remote-7.2.1-universal_mac.tar.gz
```

Then, the following command moves folder `copt_remote72` in current directory to other path. For an example, admin user may move it to folder under `/Applications` and standard user may move it to `$HOME`.

```
mv copt_remote72 /Applications
```

If you see errors below or similar signature problem of COPT lib during installation,

```
"libcopt.dylib" cannot be opened because the developer cannot be verified.  
macOS cannot verify that this app is free from malware.
```

run the following command as root user, to bypass check of loading dynamic lib on MacOS.

```
xattr -d com.apple.quarantine CardinalOptimizer-Remote-7.2.1-universal_mac.tar.gz
```

or

```
xattr -dr com.apple.quarantine /Applications/copt_remote72
```

5.1.2 Cluster License

After installing COPT remote package, it requires cluster license to run. It is preferred to save cluster license files, `license.dat` and `license.key`, to `cluster` folder in path of remote package.

The following explains how to obtain the license file via the `copt_licgen` tool and the license credential information `key` under different systems.

Note

If the user has already obtained the two license files `license.dat` and `license.key`, there is no need to obtain them again. You can skip the following steps to obtain the license file and refer to [Configuration](#) directly.

Windows

If the COPT remote package is installed under "`C:\Program Files`", execute the following command to enter `cluster` folder in path of remote package.

```
cd "C:\Program Files\copt_remote72\cluster"
```

Note that the tool `copt_licgen` creating license files exists under `tools` folder in path of remote package. The following command creates cluster license files in current directory, given a cluster license key, such as `7483dff0863ffdae9fff697d3573e8bc`.

```
..\tools\copt_licgen -key 7483dff0863ffdae9fff697d3573e8bc
```

Linux and MacOS

If the COPT remote package is installed under `/Applications`, execute the following command to enter `cluster` folder in path of remote package on MacOS system.

```
cd /Applications/copt_remote72/cluster
```

The following command creates cluster license files in current directory, given a cluster license key, such as `7483dff0863ffdae9fff697d3573e8bc`.

```
../tools/copt_licgen -key 7483dff0863ffdae9fff697d3573e8bc
```

In addition, if users run the above command when current directory is different than `cluster` folder in path of remote package, it is preferred to move them to `cluster`. The following command does so.

```
mv license.* /Application/copt_remote72/cluster
```

5.1.3 Configuration

Below is a typical configuration file, `cls.ini`, of COPT compute cluster.

```
[Main]
Port = 7878
# number of total tokens, which copt jobs can run simultaneously up to
NumToken = 3
# password is case-sensitive and default is empty
# it applies to both copt clients and cluster nodes
PassWd =
# data folder of cluster relative to its binary folder,
# where various of copt libraries and temporary job files reside.
DataFolder = ./data

[SSL]
# needed if connecting using SSL
CaFile =
CertFile =
CertkeyFile =

[Licensing]
# if empty or default license name, it is from binary folder
# to get license files from cwd, add prefix "./"
# full path is supported as well
LicenseFile = license.dat
PubkeyFile = license.key

[WLS]
# WebServer have a default host and no need to edit in most scenarios
# Must specify WebLicenseId and WebAccesskey to trigger web licensing
# If specified, ignore settings in Licensing section
WebServer =
WebLicenseId =
WebAccessKey =
WebTokenDuration = 300

[FLS]
# Lease token from floating server
# If specified, ignore settings in Licensing section and WLS section
TokenServer =
TPort = 7979

[Cluster]
# host name and port of parent node in cluster
# If specified or changed on fly, connect to parent node
Parent =
PPort = 7878

[Filter]
```

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```
# default policy 0 indicates accepting all connections, except for ones in blacklist
# otherwise, denying all connections except for ones in whitelist
DefaultPolicy = 0
UseBlackList = true
UseWhiteList = true
FilterListFile = clsfilters.ini

[Logs]
LogsFolder = ./logs
```

The **Main** section specifies port number, through which COPT compute cluster clients connect to server; token number, the number of optimization jobs that server can run simultaneously up to; password string, if specified, cluster clients should send the same password when requesting for service.

Main:

In the **[Main]** section of the configuration file, users can set the following connection information:

- **Port** : Specifies the connection port for the cluster server, through which COPT compute cluster clients connect to server;
- **NumToken** : Defines the number of optimization jobs that the COPT cluster server can run simultaneously up to. This number can be estimated based on the server's hardware resource capacity and is user-configurable. The default value is 3, with no concurrency limit.
- **PassWd** : Sets the password for client connections to the cluster server. The default is empty, meaning no password is required. If specified, clients should send the same password when requesting for cluster service. For a more secure connection, users can enable encrypted communication using RSA certificates in the **[SSL]** section.
- **DataFolder** : Specifies the path where the COPT solver is installed on the server.

The COPT compute cluster may install multiple versions of COPT to subfolder of **DataFolder**. Only clients with matching version (major and minor) will get approved and then offload optimization jobs at server side. Note that the COPT compute cluster pre-installs a COPT solver of the same version as server itself, which illustrate how to install other versions of COPT.

For instance, the COPT compute cluster has default COPT v7.2.1 installed and users plan to install COPT of other version v4.0.7. Users may create a folder `./data/copt/4.0.7/` and copy a COPT C lib of the same version to it. Specifically, on Linux platform, copy C dynamic library `libcopt.so` from the binary folder `$COPT_HOME/lib/` of COPT v4.0.7 to subfolder `./data/copt/4.0.7/` of the COPT compute cluster.

Furthermore, users are allowed to install newer version of COPT than cluster server version, such as COPT v7.5.0. To do so, follow the same step of copying a C lib of COPT v7.5.0 to `./data/copt/7.5.0/`. In addition, users need a personal license of v7.5.0 to load C lib of COPT v7.5.0 at server side. That is, copy valid personal license files to folder `./data/copt/7.5.0/` as well. However, this simple procedure may break if the newer COPT solver has significant updates. In this case, it is necessary to upgrade the COPT compute cluster to newer version, that is, v7.5.0.

Below is an example of directory structure of cluster server on Linux platform. It includes pre-installed COPT v7.2.1, COPT of previous version v4.0.7, and COPT of newer version v7.5.0.

```
~/copt_remote72/cluster
├── cls.ini
├── copt_cluster
├── license.dat -> cluster license v7.2.1
├── license.key
└── data
    └── copt
        └── 4.0.7
```

```

    libcopt.so
└─7.2.1
    libcopt.so
└─7.5.0
    libcopt.so
    license.dat -> license v7.5.0
    license.key

```

Licensing:

The **Licensing** section specifies location of cluster license files. As described in comments above, if empty string or default license file name (`license.dat` or `license.key`) is specified, cluster license files are read from the binary folder where the cluster executive reside.

It is possible to run COPT compute cluster service, even if cluster license files do not exist in the same folder as the cluster executive. One option is to set `LicenseFile = ./license.dat` and `PubkeyFile = ./license.key`. By doing so, the COPT compute cluster reads cluster license files from the current working directory. That is, user could execute command at the path where cluster license files exist to run service.

The other option is to set full path of license files in configuration. As mentioned before, Cardinal Optimizer allows user to set environment variable `COPT_LICENSE_DIR` for license files. For details, please refer to [How to install Cardinal Optimizer](#). If user prefers the way of environment variable, `cls.ini` should have the full path to cluster license files.

Cluster:

In the **[Cluster]** section of the configuration file, users can set the parent node (IP and port) for the current cluster server connection. By default, this is empty, indicating no connection to other nodes.

- **Parent:** The IP address of the parent node within the local network.
- **PPort:** The port number of the parent node.

If there is only one cluster server or if the current server is the root node, this section does not need to be configured.

For multiple cluster servers, specifying a parent node allows users to form a tree-structured network topology for the COPT computing cluster. The current server can join the parent node's cluster through this configuration.

Filter:

In the **[Filter]** section of the configuration file, users can configure the filtering policy for the cluster server.

- **DefaultPolicy:** Default is set to 0, meaning all clients are allowed to connect to the cluster server, except those on the blacklist. If it is set to non-zero value, then all connection are blocked except for those in white lists.
- **UseBlackList:** If set to `True`, the blacklist will be enabled.
- **UseWhiteList:** If set to `True`, the whitelist will be enabled.
- **FilterListFile:** Specifies the name of the filtering configuration file for the cluster server, default is `clsfilters.ini`. Below is an example of the filter configuration file:

```

[BlackList]
# 127.0.*.* + user@machine*

[WhiteList]
# 127.0.1.2/16 - user@machine*

[ToolList]
# only tool client at server side can access by default
127.0.0.1/32

```

It has three sections and each section has its own rules. In section of **BlackList**, one may add rules to block others from connection. In section of **WhiteList**, one may add rules to grant others for connection, even if the default policy is to block all connections. Only users listed in section of **ToolList** are able to connect to cluster server by Cluster Managing Tool (see below for details).

Specifically, rules in filter configuration have format of starting with IP address. To specify IP range, users may include wildcard (*) in IP address, or use CIDR notation, that is, a IPv4 address and its associated network prefix. In addition, a rule may include (+) or exclude (-) given user at given machine, such as `127.0.1.2/16 - user@machine`. Here, **user** refers to **username**, which can be queried by `whoami` on Linux/MacOS platform; **machine** refers to **computer name**, which can be queried by `hostname` on Linux/MacOS platform.

Note that after modifying the configuration file `clsfilters.ini`, users can use the `ResetFilters` command to reset the current rules to those in the filter configuration document. Users can also use the `WriteFilters` command to output the current rules to the filter configuration document.

Logs:

In the `[Logs]` section of the configuration file, users can set the log file path for the cluster server, which is by default stored in the `./logs` path under the cluster server installation directory.

5.1.4 Web License for Compute Cluster

Besides local cluster license above, users may use web license for compute cluster to run compute cluster service. This requires that machines running compute cluster server must have internet access. However, hardware info are not required any more. That is, users are free to deploy compute cluster servers to any cloud machine or container, as long as they have internet access. Please refer to [COPT Web Licenses](#) for details.

Below are brief steps:

- Follow steps to register an account and apply for trial of web license for compute cluster.
- Once approved, **Web License ID** is generated for users
- On page of **API Keys**, create **Web Access Key** using given **Web License ID**

Afterwards, users edit configuration file `cls.ini` and add values of both **Web License ID** and **Web Access Key** to related keywords in section of **WLS**. For instance,

```
[WLS]
# WebServer have a default host and no need to edit in most scenarios
# Must specify WebLicenseId and WebAccesskey to trigger web licensing
WebServer =
WebLicenseId =
WebAccessKey =
WebTokenDuration = 300
```

As of now, compute cluster server talks to [COPT Web Licenses](#) for licensing. Users are able to monitor its token usage and other information online.

5.1.5 Example Usage

Suppose that cluster license files exist in the same folder where the cluster executable reside. To start the COPT compute cluster, just execute the following command at any directory in Windows console, or Linux/Mac terminal.

```
./copt_cluster
```

If you see log information as follows, the COPT compute cluster has been successfully started. Server monitors any connection from COPT compute cluster clients, manages client requests in queue as well as approved clients. User may stop cluster server anytime when entering **q** or **Q**.

```
> ./copt_cluster
[ Info] start COPT Compute Cluster, COPT v7.2.1 20240304
[ Info] [NODE] node has been initialized
[ Info] server started at port 7878
```

If failed to verify local cluster license, or something is wrong on remote COPT licensing server, you might see error logs as follows.

```
> ./copt_cluster
[ Info] start COPT Compute Cluster, COPT v7.2.1 20240304
[Error] Invalid signature in public key file
[Error] Fail to verify local license
```

and

```
> ./copt_cluster
[ Info] start COPT Compute Cluster, COPT v7.2.1 20240304
[Error] Error to connect license server
[Error] Fail to verify cluster license by server
```

5.2 Client Setup

The COPT compute cluster client can be COPT command-line, or any application which solves problems by COPT API, such as COPT cpp/java/csharp/python interface. The COPT compute cluster service is a better approach in terms of flexibility and efficiency. Any COPT compute cluster client can legally run Cardinal Optimizer without local license.

5.2.1 Configuration

Via the configuration file

Before running COPT as cluster client, please make sure that you have installed COPT locally. For details, please refer to [How to install Cardinal Optimizer](#). Users can skip obtaining local licenses by adding a cluster configuration file **client.ini**.

Below is a typical configuration file, **client.ini**, of COPT compute cluster client.

```
Cluster = 192.168.1.11
Port = 7878
WaitTime = 600
Passwd =
```

As configured above, COPT compute cluster client tries to connect to 192.168.1.11 at port 7878 with waiting time in queue up to 600 seconds. Here, the default value of **Cluster** is localhost. **WaitTime** (or **QueueTime**) is set to 0 if empty or not specified. Specifically, empty **WaitTime** means client does not wait and should quit immediately, if the COPT compute cluster have no more token available. **Port**

default number is 7878. It must be great than zero if specified and should be the same as that specified in cluster configuration file `cls.ini`. Note that keywords in the configuration file are case insensitive.

In addition, users can set the password for connecting the remote server through `Passwd`. The `Priority` can be used to set the priority of cluster optimization jobs. Possible values range from 0 to 99, with higher values indicating higher priority. If jobs are queued, the priority setting will ensure that the next task is processed first, but it will not affect tasks that are already running.

To run as a COPT compute cluster client, an application must have configuration file, `client.ini`, in one of the following three locations, that is, current working directory, environment directory by `COPT_LICENSE_DIR` and binary directory where COPT executable resides.

By design, COPT application reads local license files instead of `client.ini`, if they both exist in the same location. However, if local license files are under the environment directory, to connect to cluster server, user could simply add a configuration file, `client.ini`, under the current working directory (different from the environment directory).

If a COPT application calls COPT API to solve problems, such as COPT python interface, license is checked as soon as COPT environment object is created. If there only exists proper configuration file, `client.ini`, the application works as a COPT compute cluster client and obtains token to offload optimization jobs. As soon as COPT environment object is destroyed, the COPT compute cluster server is notified to release token and thus to approve more requests waiting in queue.

Via API Functions

In addition to the method using the `client.ini` file mentioned above, users can also configure the client in their code through API functions. Taking the COPT Python interface as an example, the corresponding class is *EnvrConfig Class*, and similar approaches apply to other programming languages. The configuration is as follows:

```
# Set client configuration parameters
envconfig.set(COPT.CLIENT_CLUSTER, "192.168.1.11")
envconfig.set(COPT.CLIENT_PORT, "7878")
envconfig.set(COPT.CLIENT_WAITTIME, "600")
```

5.2.2 High Availability

When there are multiple cluster servers, the client can achieve high availability by configuring multiple Cluster server IP addresses in the `Cluster` field of `client.ini`, as shown in the following table:

```
Cluster = 192.168.1.11; 192.168.1.22; 192.168.1.33
Port = 7878
WaitTime = 600
Passwd =
```

According to the above configuration, the first IP in the `Cluster` field is the root node IP of the cluster. If the port of other child nodes of the cluster is not 7878, it could be added after the IP address. The above configuration file indicates that the client will first try to connect to the root node 192.168.1.11:7878. If the root node is not available, it will try to connect to the child node of 192.168.1.22:7878, and so on, until the connection with the cluster server is successful.

If a cluster node fails when performing a computing task, the client will reallocate the available cluster nodes according to the backup nodes in the configuration file. This can enable the cluster service to have a certain disaster recovery capability, thereby improving the high availability of the COPT computing cluster service.

5.2.3 Example Usage

Suppose that we've set configuration file `client.ini` properly and have no local license, below is an example of connecting to cluster server by COPT command-line tool `copt_cmd`. Execute the following command in Windows console, or Linux/Mac terminal.

```
copt_cmd
```

If you see log information as follows, the COPT compute cluster client, `copt_cmd`, has connected to cluster server successfully. COPT command-line tool is ready to do modelling locally and then offload optimization jobs to server.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] initialize cluster client with ./client.ini

[ Info] wait for server in 0 / 39 secs
[ Info] connecting to cluster server 192.168.1.11:7878
COPT>
```

If you see log information as follows, the COPT compute cluster client, `copt_cmd`, has connected to cluster server. However, due to limited number of tokens, it waits in queue of size 5, until timeout.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] initialize cluster client with ./client.ini

[ Info] wait for server in 0 / 39 secs
[ Info] connecting to cluster server 192.168.1.11:7878

[ Warn] wait in queue of size 5
[ Info] wait for license in 2 / 39 secs
[ Info] wait for license in 4 / 39 secs
[ Info] wait for license in 6 / 39 secs
[ Info] wait for license in 8 / 39 secs
[ Info] wait for license in 10 / 39 secs
[ Info] wait for license in 20 / 39 secs
[ Info] wait for license in 30 / 39 secs
[Error] timeout at waiting for server approval
[Error] Fail to initialize copt command-line tool
```

If you see log information as follows, the COPT compute cluster client, `copt_cmd`, has connected to cluster server. But it refused to wait in queue, as QueueTime was set to 0. Therefore, client quits with error immediately.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] initialize cluster client with ./client.ini

[ Info] wait for server in 0 / 9 secs
[ Info] connecting to cluster server 192.168.1.11:7878
[ Warn] server error: "no more token available", code = 129
[Error] Fail to initialize copt command-line tool
```

If you see log information as follows, the COPT compute cluster client, `copt_cmd`, fails to connect to

cluster server. Finally, client quits after timeout.

```
> copt_cmd
Cardinal Optimizer v7.2.1. Build date Mar 04 2024
Copyright Cardinal Operations 2024. All Rights Reserved

[ Info] initialize cluster client with ./client.ini

[ Info] wait for server in 0 / 39 secs
[ Info] connecting to cluster server 192.168.1.11:7878
[ Info] wait for license in 2 / 39 secs
[ Info] wait for license in 4 / 39 secs
[ Info] wait for license in 6 / 39 secs
[ Info] wait for license in 8 / 39 secs
[ Info] wait for license in 10 / 39 secs
[ Info] wait for license in 20 / 39 secs
[ Info] wait for license in 30 / 39 secs
[Error] timeout at waiting for server approval
[Error] Fail to initialize copt command-line tool
```

In addition, users can start the COPT command-line tool on the client side to connect to the specified cluster server IP address as follows:

```
> copt_cmd -cluster <ip>
```

5.3 COPT Cluster Managing Tool

COPT cluster service ships with a tool `copt_clstool`, for retrieving information and tune parameters of cluster servers on fly.

5.3.1 Tool Usage

Execute the following command in Windows console, Linux or MacOS terminal:

```
> ./copt_clstool
```

Below displays help messages of this tool:

```
> ./copt_clstool
COPT Cluster Managing Tool

copt_clstool [-s server ip] [-p port] [-x passwd] command <param>

commands are:  addblackrule <127.0.0.1/20[-user@machine]>
               addwhiterule <127.0.*.*[+user@machine]>
               getfilters
               getinfo
               getnodes
               getjobs
               interrupt
               reload
               resetfilters
               setparent <xxx:7878>
               setpasswd <xxx>
               settoken <num>
               toggleblackrule <n-th>
```

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```
togglewhiterule <n-th>
writefilters
```

If the **-s** and **-p** option are present, tool connects to cluster server with given server IP and port. Otherwise, tool connections to localhost and default port 7878. If cluster server sets a password, tool must provide password string after the **-x** option.

This tool provides the following commands:

- **AddBlackRule**: Add a new rule in black filters. each rule has format starting with non-empty IP address, which may have wildcard to match IPs in the scope. In addition, it is optional to be followed by including (+) or excluding (-) user name at machine name.
- **AddWhiteRule**: Add a new rule in white filters. Note that a white rule has the same format as a black rule.
- **GetFilters**: Get all rules of black filters, white filters and tool filters, along with relative sequence numbers, which are parameters for command ToggleBlackRule and ToggleWhiteRule.
- **GetInfo**: Get general information of cluster server, including token usage, connected clients, and all COPT versions in support.
- **GetNodes**: Get information of nodes in cluster, including parent address and status, all children nodes.
- **Reload**: Reload available token information of all child nodes, in case it is not consistent for various reasons.
- **GetJobs**: Retrieves all currently running tasks on the server, including the task ID (TID), runtime (in seconds), and client ID.
- **Interrupt**: Terminates the specified task (TID) on the current server (cluster server). After executing this command, the task running on the client will be stopped, and the optimization status will return **stopped (user interrupt)**.
- **ResetFilters**: Reset filter lists in memory to those on filter config file.
- **SetParent**: Change parent node address on fly and then connecting to new parent. In this way, it avoids draining operation when stopping a node for maintenance purpose.
- **SetPasswd**: Update password of target cluster server on fly.
- **SetToken**: Change token number of target cluster server on fly.
- **ToggleBlackRule**: Toggle between enabling and disabling a black rule, given its sequence number by GetFilters.
- **ToggleWhiteRule**: Toggle between enabling and disabling a white rule, given its sequence number by GetFilters.
- **WriteFilters**: Write filter lists in memory to filter config file.

5.3.2 Example Usage

The following command lists general information on local machine.

```
> ./copt_clstool GetInfo
```

```
[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to localhost:7878
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] general info
# of available tokens is 3 / 3, queue size is 0
# of active clients is 0
```

```
# of installed COPT versions is 1
COPT v7.2.1
```

To run managing tool on other machine, its IP should be added to a rule in ToolList section in filter configuration file clsfilters.ini. The following command from other machine lists cluster information of server 192.168.1.11.

```
> ./copt_clstool -s 192.168.1.11 GetNodes

[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7878
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] node info
[Parent] (null):7878 (Lost)
[Child] Node_192.168.1.12:7878_N0001, v2.0=3
Total num of child nodes is 1
```

The following command changes token number of server 192.168.1.11 from 3 to 0.

```
> ./copt_clstool -s 192.168.1.11 SetToken 0

[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7878
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] total token was 3 and now set to 0
```

The following command shows all filter lists of server 192.168.1.11, including those in BlackList section, WhiteList section and ToolList section.

```
> ./copt_clstool -s 192.168.1.11 GetFilters

[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] filters info
[BlackList]

[WhiteList]

[ToolList]
[1] 127.0.0.1
```

The following command added user of IP 192.168.3.13 to black list.

```
> ./copt_clstool -s 192.168.1.11 AddBlackRule 192.168.3.133

[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] server added new black rule (succeeded)
```

The following command shows that a new rule in BlackList section is added.

```
> ./copt_clstool -s 192.168.1.11 GetFilters

[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] filters info
[BlackList]
[1] 192.168.3.133

[WhiteList]
```

```
[ToolList]
[1] 127.0.0.1
```

The following command disable a rule in BlackList section.

```
> ./copt_clstool -s 192.168.1.11 ToggleBlackRule 1
```

```
[ Info] COPT Cluster Managing Tool, COPT v7.2.1 20240304
[ Info] connecting to 192.168.1.11:7979
[ Info] [command] wait for connecting to cluster
[ Info] [cluster] server toggle black rule [1] (succeeded)
```

5.4 Running as service

To run COPT compute cluster server as a system service, follow steps described in `readme.txt` under `cluster` folder, and set config file `copt_cluster.service` properly.

Below is `readme.txt`, which lists installing steps in both Linux and MacOS platforms.

```
[Linux] To run copt_cluster as a service with systemd

Add a systemd file
cp copt_cluster.service to /lib/systemd/system/
sudo systemctl daemon-reload

Enable new service
sudo systemctl start copt_cluster.service
or
sudo systemctl enable copt_cluster.service

Restart service
sudo systemctl restart copt_cluster.service

Stop service
sudo systemctl stop copt_cluster.service
or
sudo systemctl disable copt_cluster.service

Verify service is running
sudo systemctl status copt_cluster.service

[MacOS] To run copt_cluster as a service with launchctl

Add a plist file
cp copt_cluster.plist to /Library/LaunchAgents as current user
or
cp copt_cluster.plist to /Library/LaunchDaemons with the key 'UserName'

Enable new service
sudo launchctl load -w /Library/LaunchAgents/copt_cluster.plist
or
sudo launchctl load -w /Library/LaunchDaemons/copt_cluster.plist

Stop service
sudo launchctl unload -w /Library/LaunchAgents/copt_cluster.plist
or
```

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```
sudo launchctl unload -w /Library/LaunchDaemons/copt_cluster.plist
```

Verify service is running

```
sudo launchctl list shanshu.copt.cluster
```

5.4.1 Linux

Below are steps in details of how to run COPT compute cluster server as a system service in Linux platform.

For instance, assume that COPT remote service is installed under '/home/eleven'. In your terminal, type the following command to enter the root directory of cluster service.

```
cd /home/eleven/copt_remote72/cluster
```

modify template of the service config file `copt_cluster.service` in text format:

```
[Unit]
Description=COPT Compute Cluster Server

[Service]
WorkingDirectory=/path/to/service
ExecStart=/path/to/service/copt_cluster
Restart=always
RestartSec=1

[Install]
WantedBy=multi-user.target
```

That is, update template path in keyword `WorkingDirectory` and `ExecStart` to actual path where the cluster service exists.

```
[Unit]
Description=COPT Compute Cluster Server

[Service]
WorkingDirectory=/home/eleven/copt_remote72/cluster
ExecStart=/home/eleven/copt_remote72/cluster/copt_cluster
Restart=always
RestartSec=1

[Install]
WantedBy=multi-user.target
```

Afterwards, copy `copt_cluster.service` to system service folder `/lib/systemd/system/` (see below).

```
sudo cp copt_cluster.service /lib/systemd/system/
```

The following command may be needed if you add or update service config file. It is not needed if service unit has been loaded before.

```
sudo systemctl daemon-reload
```

The following command starts the new cluster service.

```
sudo systemctl start copt_cluster.service
```

To verify the cluster service is actually running, type the following command

```
sudo systemctl status copt_cluster.service
```

If you see logs similar to below, COPT compute cluster server is running successfully as a system service.

```
copt_cluster.service - COPT Cluster Server
Loaded: loaded (/lib/systemd/system/copt_cluster.service; enabled; vendor preset:
➔enabled)
Active: active (running) since Sat 2021-08-28 11:46:10 CST; 3s ago
Main PID: 3054 (copt_cluster)
Tasks: 6 (limit: 4915)
CGroup: /system.slice/copt_cluster.service
        └─3054 /home/eleven/copt_remote72/cluster/copt_cluster

eleven-ubuntu systemd[1]: Started COPT Cluster Server.
eleven-ubuntu COPTCLS[3054]: LWS: 4.1.4-b2011a00, loglevel 1039
eleven-ubuntu COPTCLS[3054]: NET CLI SRV H1 H2 WS IPv6-absent
eleven-ubuntu COPTCLS[3054]: server started at port 7878
eleven-ubuntu COPTCLS[3054]: LWS: 4.1.4-b2011a00, loglevel 1039
eleven-ubuntu COPTCLS[3054]: NET CLI SRV H1 H2 WS IPv6-absent
eleven-ubuntu COPTCLS[3054]: [NODE] node has been initialized
```

To stop the cluster service, type the following command

```
sudo systemctl stop copt_cluster.service
```

5.4.2 MacOS

Below are steps in details of how to run COPT Compute Cluster server as a system service in MacOS platform.

For instance, assume that COPT remote service is installed under `"/Applications"`. In your terminal, type the following command to enter the root directory of cluster service.

```
cd /Applications/copt_remote72/cluster
```

modify template of the service config file `copt_cluster.plist` in xml format:

```
<?xml version="1.0" encoding="UTF-8"?>
<plist version="1.0">
  <dict>
    <key>Label</key>
    <string>shanshu.copt.cluster</string>
    <key>Program</key>
    <string>/path/to/service/copt_cluster</string>
    <key>RunAtLoad</key>
    <true/>
    <key>KeepAlive</key>
    <true/>
  </dict>
</plist>
```

That is, update template path in `Program` tag to actual path where the cluster service exists.

```
<?xml version="1.0" encoding="UTF-8"?>
<plist version="1.0">
  <dict>
    <key>Label</key>
    <string>shanshu.copt.cluster</string>
    <key>Program</key>
    <string>/Applications/copt_remote72/cluster/copt_cluster</string>
```

```
<key>RunAtLoad</key>
<true/>
<key>KeepAlive</key>
<true/>
</dict>
</plist>
```

Afterwards, copy `copt_cluster.plist` to system service folder `/Library/LaunchAgents` (see below).

```
sudo cp copt_cluster.plist /Library/LaunchAgents
```

The following command starts the new cluster service.

```
sudo launchctl load -w /Library/LaunchAgents/copt_cluster.plist
```

To verify the cluster service is actually running, type the following command

```
sudo launchctl list shanshu.copt.cluster
```

If you see logs similar to below, COPT compute cluster server is running successfully as a system service.

```
{
  "LimitLoadToSessionType" = "System";
  "Label" = "shanshu.copt.cluster";
  "OnDemand" = false;
  "LastExitStatus" = 0;
  "PID" = 16406;
  "Program" = "/Applications/copt_remote72/cluster/copt_cluster";
};
```

To stop the cluster service, type the following command

```
sudo launchctl unload -w /Library/LaunchAgents/copt_cluster.plist
```

If the cluster service should be run by a specific user, add `UserName` tag to config file. Below adds a user `eleven`, who has privilege to run the cluster service.

```
<?xml version="1.0" encoding="UTF-8"?>
<plist version="1.0">
  <dict>
    <key>Label</key>
    <string>shanshu.copt.cluster</string>
    <key>Program</key>
    <string>/Applications/copt_remote72/cluster/copt_cluster</string>
    <key>UserName</key>
    <string>eleven</string>
    <key>RunAtLoad</key>
    <true/>
    <key>KeepAlive</key>
    <true/>
  </dict>
</plist>
```

Then copy new `copt_cluster.plist` to system service folder `/Library/LaunchDaemons` (see below).

```
sudo cp copt_cluster.plist /Library/LaunchDaemons
```

The following command starts the new cluster service.

```
sudo launchctl load -w /Library/LaunchDaemons/copt_cluster.plist
```

To stop the cluster service, type the following command


```
sudo launchctl unload -w /Library/LaunchDaemons/copt_cluster.plist
```


Chapter 6

COPT Web Licensing Service

COPT's Web Licensing Service provides users with remote licensing services. Regardless of whether the client is located in the cloud or in a container, as long as it can access the Internet through the HTTPS protocol, it can obtain the Token from COPT's Web License server to run COPT without binding any hardware information.

Therefore, compared with traditional authorization methods, Web License is not limited to fixed hardware environments, flexibly supporting multiple users, and is suitable for container deployment (such as Docker) and cloud deployment (Internet environment is required). Its characteristics are summarized as follows:

1. It does not bind to any hardware information, flexibly supporting scenarios such as cloud and container deployment (hardware do not need to be fixed);
2. No version restrictions, support cross-version usage;
3. At least one machine needs to be connected to the Internet (remote communication with the web server);
4. Provide a [Web License Page](#) for users to obtain and manage licenses by themselves, which is user-friendly and convenient.

At the same time, corresponding to the traditional authorization method, Web License also includes three subcategories: Web License, Web License for Floating Server, and Web License for Compute Cluster.

Web License

It supports the deployment of servers running COPT in the cloud development environment (without binding any machine hardware information), and supports multiple modeling and solving tasks on the server at the same time.

Web License for Floating Server

It supports deploying a floating token server in a cloud development environment (the server needs to connect to the Internet and obtain remote authorization via Web License), and then use the floating token server to authorize other machines (clients) within the local network to run COPT.

Web License for Compute Cluster

It supports setting up one or more computing cluster servers in the cloud development environment. Modeling can be performed on the local machine (client) within the local network while optimization can be conducted on the remote cluster server machine (server), so that the powerful computing resources of the server can be efficiently utilized.

Users need to register on the [COPT Web License web page](#) first. After logging in, they can **apply directly on the page** to obtain the above three types of Web licenses, create new API Keys, obtain license files, and manage token occupancy and usage.

For more information on Web License or installation and usage tutorials, please refer to the [Web License web help documentation](#). If you have any further questions about web licensing, please contact us as follows:

Table 6.1: Contact information

Email	Description
coptsales@shanshu.ai	Business Support
coptsupport@shanshu.ai	Technical Support

Chapter 7

COPT Quick Start

7.1 C Interface

This chapter illustrates the use of C interface of Cardinal Optimizer through a simple C example. The problem to solve is shown in Eq. 7.1:

$$\begin{aligned} &\text{Maximize:} \\ &\quad 1.2x + 1.8y + 2.1z \\ &\text{Subject to:} \\ &\quad 1.5x + 1.2y + 1.8z \leq 2.6 \\ &\quad 0.8x + 0.6y + 0.9z \geq 1.2 \\ &\text{Bounds:} \\ &\quad 0.1 \leq x \leq 0.6 \\ &\quad 0.2 \leq y \leq 1.5 \\ &\quad 0.3 \leq z \leq 2.8 \end{aligned} \tag{7.1}$$

7.1.1 Example details

The source code for solving the above problem using C API of Cardinal Optimizer is shown in Listing 7.1:

Listing 7.1: lp_ex1.c

```
1  /*
2   * This file is part of the Cardinal Optimizer, all rights reserved.
3   */
4
5  /*
6   * The problem to solve:
7   *
8   * Maximize:
9   *   1.2 x + 1.8 y + 2.1 z
10  *
11  * Subject to:
12  *   1.5 x + 1.2 y + 1.8 z <= 2.6
13  *   0.8 x + 0.6 y + 0.9 z >= 1.2
14  *
15  * where:
16  *   0.1 <= x <= 0.6
```

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```

17  *    0.2 <= y <= 1.5
18  *    0.3 <= z <= 2.8
19  */
20
21  #include "copt.h"
22
23  #include <stdio.h>
24  #include <stdlib.h>
25
26  int main(int argc, char* argv[])
27  {
28      int errcode = 0;
29
30      copt_env* env = NULL;
31      copt_prob* prob = NULL;
32
33      // Create COPT environment
34      errcode = COPT_CreateEnv(&env);
35      if (errcode)
36          goto COPT_EXIT;
37
38      // Create COPT problem
39      errcode = COPT_CreateProb(env, &prob);
40      if (errcode)
41          goto COPT_EXIT;
42
43      /*
44       * Add variables
45       *
46       *   obj: 1.2 C0 + 1.8 C1 + 2.1 C2
47       *
48       *   var:
49       *       0.1 <= C0 <= 0.6
50       *       0.2 <= C1 <= 1.5
51       *       0.3 <= C2 <= 2.8
52       *
53       */
54      int ncol = 3;
55      double colcost[] = {1.2, 1.8, 2.1};
56      double collb[] = {0.1, 0.2, 0.3};
57      double colub[] = {0.6, 1.5, 1.8};
58
59      errcode = COPT_AddCols(prob, ncol, colcost, NULL, NULL, NULL, NULL, NULL, collb,
60      ↪ colub, NULL);
61      if (errcode)
62          goto COPT_EXIT;
63
64      /*
65       * Add constraints
66       *
67       *   r0: 1.5 C0 + 1.2 C1 + 1.8 C2 <= 2.6
68       *   r1: 0.8 C0 + 0.6 C1 + 0.9 C2 >= 1.2
69       */
70      int nrow = 2;
71      int rowbeg[] = {0, 3};
72      int rowcnt[] = {3, 3};

```

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```

72  int rowind[] = {0, 1, 2, 0, 1, 2};
73  double rowelem[] = {1.5, 1.2, 1.8, 0.8, 0.6, 0.9};
74  char rowsen[] = {COPT_LESS_EQUAL, COPT_GREATER_EQUAL};
75  double rowrhs[] = {2.6, 1.2};
76
77  errcode = COPT_AddRows(prob, nrow, rowbeg, rowcnt, rowind, rowelem, rowsen, rowrhs,
78  ↪NULL, NULL);
79  if (errcode)
80      goto COPT_EXIT;
81
82  // Set parameters and attributes
83  errcode = COPT_SetDblParam(prob, COPT_DBLPARAM_TIMELIMIT, 10);
84  if (errcode)
85      goto COPT_EXIT;
86  errcode = COPT_SetObjSense(prob, COPT_MAXIMIZE);
87  if (errcode)
88      goto COPT_EXIT;
89
90  // Solve problem
91  errcode = COPT_SolveLp(prob);
92  if (errcode)
93      goto COPT_EXIT;
94
95  // Analyze solution
96  int lpstat = COPT_LPSTATUS_UNSTARTED;
97  double lpobjval;
98  double* lpsol = NULL;
99  int* colstat = NULL;
100
101  errcode = COPT_GetIntAttr(prob, COPT_INTATTR_LPSTATUS, &lpstat);
102  if (errcode)
103      goto COPT_EXIT;
104
105  if (lpstat == COPT_LPSTATUS_OPTIMAL)
106  {
107      lpsol = (double*)malloc(ncol * sizeof(double));
108      colstat = (int*)malloc(ncol * sizeof(int));
109
110      errcode = COPT_GetLpSolution(prob, lpsol, NULL, NULL, NULL);
111      if (errcode)
112          goto COPT_EXIT;
113
114      errcode = COPT_GetBasis(prob, colstat, NULL);
115      if (errcode)
116          goto COPT_EXIT;
117
118      errcode = COPT_GetDblAttr(prob, COPT_DBLATTR_LPOBJVAL, &lpobjval);
119      if (errcode)
120          goto COPT_EXIT;
121
122      printf("\nObjective value: %.6f\n", lpobjval);
123
124      printf("Variable solution: \n");
125      for (int i = 0; i < ncol; ++i)
126          printf("  x[%d] = %.6f\n", i, lpsol[i]);

```

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```

127     printf("Variable basis status: \n");
128     for (int i = 0; i < ncol; ++i)
129         printf("  x[%d]: %d\n", i, colstat[i]);
130
131     free(lpsol);
132     free(colstat);
133 }
134
135 // Write problem, solution and modified parameters to files
136 errcode = COPT_WriteMps(prob, "lp_ex1.mps");
137 if (errcode)
138     goto COPT_EXIT;
139 errcode = COPT_WriteBasis(prob, "lp_ex1.bas");
140 if (errcode)
141     goto COPT_EXIT;
142 errcode = COPT_WriteSol(prob, "lp_ex1.sol");
143 if (errcode)
144     goto COPT_EXIT;
145 errcode = COPT_WriteParam(prob, "lp_ex1.par");
146 if (errcode)
147     goto COPT_EXIT;
148
149 // Error handling
150 COPT_EXIT:
151 if (errcode)
152 {
153     char errmsg[COPT_BUFFSIZE];
154
155     COPT_GetRetcodeMsg(errcode, errmsg, COPT_BUFFSIZE);
156     printf("ERROR %d: %s\n", errcode, errmsg);
157
158     return 0;
159 }
160
161 // Delete problem and environment
162 COPT_DeleteProb(&prob);
163
164 COPT_DeleteEnv(&env);
165
166 return 0;
167 }

```

We will explain how to use the C API step by step based on code above, please refer to *C API Reference* for detailed usage of C API.

Creating the environment

To solve any problem with Cardinal Optimizer, users are required to create optimization environment first, and check if it was created successfully by checking the return value:

```

// Create COPT environment
errcode = COPT_CreateEnv(&env);
if (errcode)
    goto COPT_EXIT;

```

If non-zero value was returned, it will jump to error reporting code block for detailed information and

exit.

Creating the problem

Once the optimization environment was successfully created, users will need to create problem then, the problem is the main structure that consists of variables, constraints etc. Users need to check the return value too.

```
// Create COPT problem
errcode = COPT_CreateProb(env, &prob);
if (errcode)
    goto COPT_EXIT;
```

If non-zero value was returned, it will jump to error reporting code block for detailed information and exit.

Adding variables

For linear problem, C API allows users to specify costs of variables in objective, and lower and upper bound simultaneously. For the problem above, we use code below to create variables:

```
/*
 * Add variables
 *
 *   obj: 1.2 C0 + 1.8 C1 + 2.1 C2
 *
 *   var:
 *       0.1 <= C0 <= 0.6
 *       0.2 <= C1 <= 1.5
 *       0.3 <= C2 <= 2.8
 *
 */
int ncol = 3;
double colcost[] = {1.2, 1.8, 2.1};
double collb[] = {0.1, 0.2, 0.3};
double colub[] = {0.6, 1.5, 1.8};

errcode = COPT_AddCols(prob, ncol, colcost, NULL, NULL, NULL, NULL, NULL, collb,
↪colub, NULL);
if (errcode)
    goto COPT_EXIT;
```

The argument `ncol` specify that the number of variables to create is 3, while the argument `colcost`, `collb` and `colub` specify the costs in objective, lower and upper bound respectively. Regarding other arguments of `COPT_AddCols` for specifying variables types and names, we just pass `NULL` to them, which means all variables are continuous and names are automatically generated by the Cardinal Optimizer. For the remaining arguments, we passed `NULL` too for further action.

Similarly, if non-zero value was returned, it will jump to error reporting code block for detailed information and exit.

Adding constraints

The next step to do after adding variables successfully is to add constraints to problem. For the problem above, the implementation is shown below:

```
/*
 * Add constraints
 *
 *   r0: 1.5 C0 + 1.2 C1 + 1.8 C2 <= 2.6
 *   r1: 0.8 C0 + 0.6 C1 + 0.9 C2 >= 1.2
 */
int nrow = 2;
int rowbeg[] = {0, 3};
int rowcnt[] = {3, 3};
int rowind[] = {0, 1, 2, 0, 1, 2};
double rowelem[] = {1.5, 1.2, 1.8, 0.8, 0.6, 0.9};
char rowsen[] = {COPT_LESS_EQUAL, COPT_GREATER_EQUAL};
double rowrhs[] = {2.6, 1.2};

errcode = COPT_AddRows(prob, nrow, rowbeg, rowcnt, rowind, rowelem, rowsen, rowrhs,
→NULL, NULL);
if (errcode)
    goto COPT_EXIT;
```

The argument `nrow` specifies that the number of constraints to create is 2, while argument `rowbeg`, `rowcnt`, `rowind` and `rowelem` define the coefficient matrix in CSR format. The argument `rowsen` represents the sense of constraints, while argument `rowrhs` specifies the right hand side of constraints. For remaining arguments in `COPT_AddRows`, we simply pass `NULL` to them.

If the return value is non-zero, then it jump to error reporting code block for detailed information and exit.

Setting parameters and attributes

Users are allowed to set parameters and attributes of problem before solving. For example, to set the time limit to 10 seconds, and to set the optimization direction to maximization, the code is shown below:

```
// Set parameters and attributes
errcode = COPT_SetDb1Param(prob, COPT_DBLPARAM_TIMELIMIT, 10);
if (errcode)
    goto COPT_EXIT;
errcode = COPT_SetObjSense(prob, COPT_MAXIMIZE);
if (errcode)
    goto COPT_EXIT;
```

If non-zero value was returned, then it will jump to error reporting code block for detailed information and exit.

Solve the problem

The next step to do is to solve the problem using code below:

```
// Solve problem
errcode = COPT_SolveLp(prob);
if (errcode)
    goto COPT_EXIT;
```

Non-zero return value indicates unsuccessful solve and jump to error reporting code block for detailed information and exit.

Analyze the solution

Once the solving process was finished, check the solution status first. If it claimed to have found the optimal solution, then use code below to obtain objective value, variables' solution and basis status:

```
// Analyze solution
int lpstat = COPT_LPSTATUS_UNSTARTED;
double lpobjval;
double* lpsol = NULL;
int* colstat = NULL;

errcode = COPT_GetIntAttr(prob, COPT_INTATTR_LPSTATUS, &lpstat);
if (errcode)
    goto COPT_EXIT;

if (lpstat == COPT_LPSTATUS_OPTIMAL)
{
    lpsol = (double*)malloc(ncol * sizeof(double));
    colstat = (int*)malloc(ncol * sizeof(int));

    errcode = COPT_GetLpSolution(prob, lpsol, NULL, NULL, NULL);
    if (errcode)
        goto COPT_EXIT;

    errcode = COPT_GetBasis(prob, colstat, NULL);
    if (errcode)
        goto COPT_EXIT;

    errcode = COPT_GetDblAttr(prob, COPT_DBLATTR_LPOBJVAL, &lpobjval);
    if (errcode)
        goto COPT_EXIT;

    printf("\nObjective value: %.6f\n", lpobjval);

    printf("Variable solution: \n");
    for (int i = 0; i < ncol; ++i)
        printf("  x[%d] = %.6f\n", i, lpsol[i]);

    printf("Variable basis status: \n");
    for (int i = 0; i < ncol; ++i)
        printf("  x[%d]: %d\n", i, colstat[i]);

    free(lpsol);
    free(colstat);
}
```

Write problem and solution

Users are allowed not only to save the problem to solve to standard MPS file, but also the solution, basis status and modified parameters to files:

```
// Write problem, solution and modified parameters to files
errcode = COPT_WriteMps(prob, "lp_ex1.mps");
if (errcode)
    goto COPT_EXIT;
errcode = COPT_WriteBasis(prob, "lp_ex1.bas");
if (errcode)
    goto COPT_EXIT;
errcode = COPT_WriteSol(prob, "lp_ex1.sol");
if (errcode)
    goto COPT_EXIT;
errcode = COPT_WriteParam(prob, "lp_ex1.par");
if (errcode)
    goto COPT_EXIT;
```

Error handling

The error handling block report error code and message by checking if the return value was non-zero:

```
// Error handling
COPT_EXIT:
if (errcode)
{
    char errmsg[COPT_BUFFSIZE];

    COPT_GetRetcodeMsg(errcode, errmsg, COPT_BUFFSIZE);
    printf("ERROR %d: %s\n", errcode, errmsg);

    return 0;
}
```

Delete environment and problem

Before exiting, delete problem and environment respectively:

```
// Delete problem and environment
COPT_DeleteProb(&prob);

COPT_DeleteEnv(&env);
```

7.1.2 Build and run

To ease the work for running the example for users on different operating systems, we provide Visual Studio project and Makefile for Windows, Linux and MacOS respectively, details are shown below.

Windows

For users on Windows platform, we provide Visual Studio project, all users are required to install Visual Studio 2017 beforehand. Assume that the installation directory is: '<instdir>', users that install the Cardinal Optimizer with executable installer can change directory to '<instdir>\examples\c\vsprojects' and open the Visual Studio project `lp_ex1.vcxproj` to build the solution. Users that install the Cardinal Optimizer using ZIP-format archive should make sure that all required environment variables are set correctly, see *Install Guide for Cardinal Optimizer* for details.

In addition, for Windows systems, COPT also supports the MinGW-w64 toolchain. Please refer to the corresponding instructions in the Makefile under the path '<instdir>\examples\c' for usage.

Linux and MacOS

For users on Linux or MacOS, we provide Makefile to build the example. Please install GCC toolchain for Linux and Clang toolchain for MacOS, together with the `make` utility beforehand. What's more, users should make sure also that all required environment variables are set correctly, see *Install Guide for Cardinal Optimizer* for details. Let's assume that the installation directory of Cardinal Optimizer is '<instdir>', then users need to change directory to '<instdir>\examples\c' and execute command `make` in terminal.

7.2 C++ Interface

This chapter walks through a simple C++ example to illustrate the use of the COPT C++ interface. In short words, the example creates an environment, builds a model, add variables and constraints, optimizes it, and then outputs the optimal objective value.

The example solves the following linear problem:

$$\begin{aligned}
 &\text{Maximize:} \\
 &\quad 1.2x + 1.8y + 2.1z \\
 &\text{Subject to:} \\
 &\quad 1.5x + 1.2y + 1.8z \leq 2.6 \\
 &\quad 0.8x + 0.6y + 0.9z \geq 1.2 \\
 &\text{Bounds:} \\
 &\quad 0.1 \leq x \leq 0.6 \\
 &\quad 0.2 \leq y \leq 1.5 \\
 &\quad 0.3 \leq z \leq 2.8
 \end{aligned} \tag{7.2}$$

Note that this is the same problem that was modelled and optimized in chapter of *C Interface*.

7.2.1 Example details

Below is the source code solving the above problem using COPT C++ interface.

Listing 7.2: `lp_ex1.cpp`

```

1  /*
2   * This file is part of the Cardinal Optimizer, all rights reserved.
3   */
4  #include "coptcpp_pch.h"
5
6  using namespace std;
7

```

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```

8  /*
9  * This example solves the following LP model:
10 *
11 * Maximize:
12 *   1.2 x + 1.8 y + 2.1 z
13 *
14 * Subject to:
15 *   R0: 1.5 x + 1.2 y + 1.8 z <= 2.6
16 *   R1: 0.8 x + 0.6 y + 0.9 z >= 1.2
17 *
18 * Where:
19 *   0.1 <= x <= 0.6
20 *   0.2 <= y <= 1.5
21 *   0.3 <= z <= 2.8
22 */
23 int main(int argc, char* argv[])
24 {
25     try
26     {
27         Envr env;
28         Model model = env.CreateModel("lp_ex1");
29
30         // Add variables
31         Var x = model.AddVar(0.1, 0.6, 0.0, COPT_CONTINUOUS, "x");
32         Var y = model.AddVar(0.2, 1.5, 0.0, COPT_CONTINUOUS, "y");
33         Var z = model.AddVar(0.3, 2.8, 0.0, COPT_CONTINUOUS, "z");
34
35         // Set objective
36         model.SetObjective(1.2 * x + 1.8 * y + 2.1 * z, COPT_MAXIMIZE);
37
38         // Add linear constraints using linear expression
39         model.AddConstr(1.5 * x + 1.2 * y + 1.8 * z <= 2.6, "R0");
40
41         Expr expr(x, 0.8);
42         expr.AddTerm(y, 0.6);
43         expr += 0.9 * z;
44         model.AddConstr(expr >= 1.2, "R1");
45
46         // Set parameters
47         model.SetDbLParam(COPT_DBLPARAM_TIMELIMIT, 10);
48
49         // Solve problem
50         model.Solve();
51
52         // Output solution
53         if (model.GetIntAttr(COPT_INTATTR_HASLPSOL) != 0)
54         {
55             cout << "\nFound optimal solution:" << endl;
56             VarArray vars = model.GetVars();
57             for (int i = 0; i < vars.Size(); i++)
58             {
59                 Var var = vars.GetVar(i);
60                 cout << " " << var.GetName() << " = " << var.Get(COPT_DBLINFO_VALUE) << endl;
61             }
62             cout << "Obj = " << model.GetDbLAttr(COPT_DBLATTR_LPOBJVAL) << endl;
63         }

```

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```

64     }
65     catch (CoptException e)
66     {
67         cout << "Error Code = " << e.GetCode() << endl;
68         cout << e.what() << endl;
69     }
70     catch (...)
71     {
72         cout << "Unknown exception occurs!";
73     }
74 }

```

Let's now walk through the example, line by line, to understand how it achieves the desired result of optimizing the model. Note that the example must include header `coptcpp_pch.h`.

Creating environment and model

Essentially, any C++ application using Cardinal Optimizer should start with a COPT environment, where user could add one or more models. Note that each model encapsulates a problem and corresponding data.

Furthermore, to create multiple problems, one can load them one by one in the same model, besides the naive option of creating multiple models in the environment.

```

Envr env;
Model model = env.CreateModel("lp_ex1");

```

The above call instantiates a COPT environment and a model with name "lp_ex1".

Adding variables

The next step in our example is to add variables to the model. Variables are added through `AddVar()` or `AddVars()` method on the model object. A variable is always associated with a particular model.

```

// Add variables
Var x = model.AddVar(0.1, 0.6, 0.0, COPT_CONTINUOUS, "x");
Var y = model.AddVar(0.2, 1.5, 0.0, COPT_CONTINUOUS, "y");
Var z = model.AddVar(0.3, 2.8, 0.0, COPT_CONTINUOUS, "z");

```

The first and second arguments to the `AddVar()` call are the variable lower and upper bounds, respectively. The third argument is the linear objective coefficient (zero here - we'll set the objective later). The fourth argument is the variable type. Our variables are all continuous in this example. The final argument is the name of the variable.

The `AddVar()` method has been overloaded to accept several different argument lists. Please refer to [C++ API Reference](#) for further details.

The objective is built here using overloaded operators. The C++ API overloads the arithmetic operators to allow you to build linear expressions by COPT variables. The second argument indicates that the sense is maximization.

Adding constraints

The next step in the example is to add the linear constraints. As with variables, constraints are always associated with a specific model. They are created using `AddConstr()` or `AddConstrs()` methods on the model object.

```
// Add linear constraints using linear expression
model.AddConstr(1.5 * x + 1.2 * y + 1.8 * z <= 2.6, "R0");

Expr expr(x, 0.8);
expr.AddTerm(y, 0.6);
expr += 0.9 * z;
model.AddConstr(expr >= 1.2, "R1");
```

The first constraint is to use overloaded arithmetic operators to build the linear expression. The comparison operators are also overloaded to make it easier to build constraints.

The second constraint is created by building a linear expression incrementally. That is, an expression can be built by constructor of a variable and its coefficient, by `AddTerm()` method, and by overloaded operators.

Setting parameters and attributes

The next step in the example is to set parameters and attributes of the problem before optimization.

```
// Set parameters
model.SetDbiParam(COPT_DBLPARAM_TIMELIMIT, 10);
```

The `SetDbiParam()` call here with `COPT_DBLPARAM_TIMELIMIT` argument sets solver to optimize up to 10 seconds.

Solving problem

Now that the model has been built, the next step is to optimize it:

```
// Solve problem
model.Solve();
```

This routine performs the optimization and populates several internal model attributes (including the status of the optimization, the solution, etc.).

Outputting solution

After solving the problem, one can query the values of the attributes for various of purposes.

```
// Output solution
if (model.GetIntAttr(COPT_INTATTR_HASLPSOL) != 0)
{
    cout << "\nFound optimal solution:" << endl;
    VarArray vars = model.GetVars();
    for (int i = 0; i < vars.Size(); i++)
    {
        Var var = vars.GetVar(i);
        cout << "  " << var.GetName() << " = " << var.Get(COPT_DBLINFO_VALUE) << endl;
    }
    cout << "Obj = " << model.GetDbLAttr(COPT_DBLATTR_LPOBJVAL) << endl;
}
```


Specifically, one can query the COPT_INTATTR_HASLPSOL attribute on the model to know whether we have optimal LP solution; query the COPT_DBLINFO_VALUE attribute of a variable to obtain its solution value; query the COPT_DBLATTR_LPOBJVAL attribute on the model to obtain the objective value for the current solution.

The names and types of all model, variable, and constraint attributes can be found in [Attributes](#) of C API reference.

Error handling

Errors in the COPT C++ interface are handled through the C++ exception mechanism. In the example, all COPT statements are enclosed inside a try block, and any associated errors would be caught by the catch block.

```
catch (CoptException e)
{
    cout << "Error Code = " << e.GetCode() << endl;
    cout << e.what() << endl;
}
catch (...)
{
    cout << "Unknown exception occurs!";
}
```

7.2.2 Build and Run

To build and run the example, users may refer to files under \$COPT_HOME/examples/cpp. Specifically, We provide visual studio project on Windows, as well as makefile project on Linux and Mac platforms.

Windows

1. Visual Studio project

For Windows platform, Visual Studio project is located at \$COPT_HOME/examples/cpp/vsprojects. Double-clicking the project file lp_ex1.vcxproj will bring Visual Studio. Note that it requires Visual studio 2017 or 2019 installed on Windows 10 to build.

The Visual Studio project has dependency on COPT cpp shared library copt_cpp.dll, which is referred in project file, along with its import library copt_cpp.lib. The required headers are copt.h, coptcpp.h and coptcpp.idl.h, which declare COPT constants, interfaces and methods exported from copt_cpp.dll. In addition, the example provides class header files under \$COPT_HOME/include/coptcpp_inc, which wraps COPT cpp interfaces and redefines overloaded operators.

In simple terms, users only need to include the header file coptcpp_pch.h as shown in the example, configure additional dependencies as copt_cpp.lib, and set the directory of additional link libraries as \$(COPT_HOME)/lib, and make sure that the dynamic library copt_cpp.dll has been installed in the appropriate path, and can be loaded at runtime.

To run the example, users should have COPT installed. Specifically, it requires COPT cpp library, copt_cpp.dll, and valid license files to run. Please refer to [Install Guide for Cardinal Optimizer](#) for further details.

In addition, on Windows systems, the Clang and Intel compilers, like the aforementioned MSVC compiler, all support compiling the C++ examples of COPT.

2. MinGW-w64 Toolchain

For Windows systems, COPT also supports the MinGW-w64 toolchain. For the two variants of the MinGW-w64, we provide the dynamic library `copt_mmingwcpp.dll` supporting MSVCRT and the dynamic library `copt_umingwcpp.dll` supporting UCRT. Please refer to the corresponding instructions in the Makefile under the path `$COPT_HOME/examples/cpp` for usage.

We recommend using `copt_mmingwcpp.dll` supporting MSVCRT by default, and trying the UCRT if any issues arise.

Linux and MacOS

We provide Makefile to build the example for Linux and MacOS platforms. Please make sure tools, `gcc` and `make`, are already installed on the platforms. To build the example, change directory to `$COPT_HOME/examples/cpp` and execute command `'make'` on unix terminal.

The project has dependency on COPT cpp shared library, that is, `libcopt_cpp.so` on Linux platform and `libcopt_cpp.dylib` on MacOS. Similar to Windows VS project, user should refer to `coptcpp_pch.h` under `$COPT_HOME/include/coptcpp_inc` to include all necessary headers, as shown in the example.

To run the example, users should have COPT installed. Specifically, it requires COPT cpp library, `libcopt_cpp.so` on Linux, `libcopt_cpp.dylib` on MacOS, and valid license files to run. Alternatively, user might set `LD_LIBRARY_PATH` and `COPT_LICENSE_DIR` properly to work around. Please refer to [Install Guide for Cardinal Optimizer](#) for further details.

7.3 C# Interface

This chapter walks through a simple C# example to illustrate the use of the COPT C# interface. In short words, the example creates an environment, builds a model, add variables and constraints, optimizes it, and then outputs the optimal objective value.

The example solves the following linear problem:

$$\begin{aligned} &\text{Maximize:} \\ &\quad 1.2x + 1.8y + 2.1z \\ &\text{Subject to:} \\ &\quad 1.5x + 1.2y + 1.8z \leq 2.6 \\ &\quad 0.8x + 0.6y + 0.9z \geq 1.2 \\ &\text{Bounds:} \\ &\quad 0.1 \leq x \leq 0.6 \\ &\quad 0.2 \leq y \leq 1.5 \\ &\quad 0.3 \leq z \leq 2.8 \end{aligned} \tag{7.3}$$

Note that this is the same problem that was modelled and optimized in chapter of [C Interface](#).

7.3.1 Example details

Below is the source code solving the above problem using COPT C# interface.

Listing 7.3: `lp_ex1.cs`

```
1  /*
2   * This file is part of the Cardinal Optimizer, all rights reserved.
3   */
4  using Copt;
5  using System;
6
```

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```

7  /*
8  * This C# example solves the following LP model:
9  *
10 *
11 * Maximize:
12 * 1.2 x + 1.8 y + 2.1 z
13 *
14 * Subject to:
15 * 1.5 x + 1.2 y + 1.8 z <= 2.6
16 * 0.8 x + 0.6 y + 0.9 z >= 1.2
17
18 * where:
19 * 0.1 <= x <= 0.6
20 * 0.2 <= y <= 1.5
21 * 0.3 <= z <= 2.8
22 */
23 public class lp_ex1
24 {
25     public static void Main()
26     {
27         try
28         {
29             Envr env = new Envr();
30             Model model = env.CreateModel("lp_ex1");
31
32             /*
33              * Add variables x, y, z
34              *
35              * obj: 1.2 x + 1.8 y + 2.1 z
36              *
37              * var:
38              * 0.1 <= x <= 0.6
39              * 0.2 <= y <= 1.5
40              * 0.3 <= z <= 2.8
41              */
42             Var x = model.AddVar(0.1, 0.6, 0.0, Copt.Consts.CONTINUOUS, "x");
43             Var y = model.AddVar(0.2, 1.5, 0.0, Copt.Consts.CONTINUOUS, "y");
44             Var z = model.AddVar(0.3, 2.8, 0.0, Copt.Consts.CONTINUOUS, "z");
45
46             model.SetObjective(1.2 * x + 1.8 * y + 2.1 * z, Copt.Consts.MAXIMIZE);
47
48             /*
49              * Add two constraints using linear expression
50              *
51              * r0: 1.5 x + 1.2 y + 1.8 z <= 2.6
52              * r1: 0.8 x + 0.6 y + 0.9 z >= 1.2
53              */
54             model.AddConstr(1.5 * x + 1.2 * y + 1.8 * z <= 2.6, "r0");
55
56             Expr expr = new Expr(x, 0.8);
57             expr.AddTerm(y, 0.6);
58             expr += 0.9 * z;
59             model.AddConstr(expr >= 1.2, "r1");
60
61             // Set parameters
62             model.SetDblParam(Copt.DblParam.TimeLimit, 10);

```

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```

63
64 // Solve problem
65 model.Solve();
66
67 // Output solution
68 if (model.GetIntAttr(Copt.IntAttr.LpStatus) == Copt.Status.OPTIMAL)
69 {
70     Console.WriteLine("\nFound optimal solution:");
71     VarArray vars = model.GetVars();
72     for (int i = 0; i < vars.Size(); i++)
73     {
74         Var xi = vars.GetVar(i);
75         Console.WriteLine(" {0} = {1}", xi.GetName(), xi.Get(Copt.DblInfo.Value));
76     }
77     Console.WriteLine("Obj = {0}", model.GetDblAttr(Copt.DblAttr.LpObjVal));
78 }
79
80 Console.WriteLine("\nDone");
81 }
82 catch (CoptException e)
83 {
84     Console.WriteLine("Error Code = {0}", e.GetCode());
85     Console.WriteLine(e.Message);
86 }
87 }
88 }

```

Let's now walk through the example, line by line, to understand how it achieves the desired result of optimizing the model.

Creating environment and model

Essentially, any C# application using Cardinal Optimizer should start with a COPT environment, where user could add one or more models. Note that each model encapsulates a problem and corresponding data.

Furthermore, to create multiple problems, one can load them one by one in the same model, besides the naive option of creating multiple models in the environment.

```

Envr env = new Envr();
Model model = env.CreateModel("lp_ex1");

```

The above call instantiates a COPT environment and a model with name "lp_ex1".

Adding variables

The next step in our example is to add variables to the model. Variables are added through AddVar() or AddVars() method on the model object. A variable is always associated with a particular model.

```

/*
 * Add variables x, y, z
 *
 * obj: 1.2 x + 1.8 y + 2.1 z
 *
 * var:

```

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```

    * 0.1 <= x <= 0.6
    * 0.2 <= y <= 1.5
    * 0.3 <= z <= 2.8
    */
    Var x = model.AddVar(0.1, 0.6, 0.0, Copt.Consts.CONTINUOUS, "x");
    Var y = model.AddVar(0.2, 1.5, 0.0, Copt.Consts.CONTINUOUS, "y");
    Var z = model.AddVar(0.3, 2.8, 0.0, Copt.Consts.CONTINUOUS, "z");

    model.SetObjective(1.2 * x + 1.8 * y + 2.1 * z, Copt.Consts.MAXIMIZE);

```

The first and second arguments to the `AddVar()` call are the variable lower and upper bounds, respectively. The third argument is the linear objective coefficient (zero here - we'll set the objective later). The fourth argument is the variable type. Our variables are all continuous in this example. The final argument is the name of the variable.

The `AddVar()` method has been overloaded to accept several different argument lists. Please refer to `chapCSharpApiRef_Model` of C# API reference for further details.

The objective is built here using overloaded operators. The C# API overloads the arithmetic operators to allow you to build linear expressions by COPT variables. The second argument indicates that the sense is maximization.

Adding constraints

The next step in the example is to add the linear constraints. As with variables, constraints are always associated with a specific model. They are created using `AddConstr()` or `AddConstrs()` methods on the model object.

```

    /*
    * Add two constraints using linear expression
    *
    * r0: 1.5 x + 1.2 y + 1.8 z <= 2.6
    * r1: 0.8 x + 0.6 y + 0.9 z >= 1.2
    */
    model.AddConstr(1.5 * x + 1.2 * y + 1.8 * z <= 2.6, "r0");

    Expr expr = new Expr(x, 0.8);
    expr.AddTerm(y, 0.6);
    expr += 0.9 * z;
    model.AddConstr(expr >= 1.2, "r1");

```

The first constraint is to use overloaded arithmetic operators to build the linear expression. The comparison operators are also overloaded to make it easier to build constraints.

The second constraint is created by building a linear expression incrementally. That is, an expression can be built by constructor of a variable and its coefficient, by `AddTerm()`, and by overloaded operators.

Setting parameters and attributes

The next step in the example is to set parameters and attributes of the problem before optimization.

```
// Set parameters
model.SetDbiParam(Copt.DblParam.TimeLimit, 10);
```

The `SetDbiParam()` call here with `Copt.DblParam.TimeLimit` argument sets solver to optimize up to 10 seconds.

Solving problem

Now that the model has been built, the next step is to optimize it:

```
// Solve problem
model.Solve();
```

This routine performs the optimization and populates several internal model attributes (including the status of the optimization, the solution, etc.).

Outputting solution

After solving the problem, one can query the values of the attributes for various of purposes.

```
// Output solution
if (model.GetIntAttr(Copt.IntAttr.LpStatus) == Copt.Status.OPTIMAL)
{
    Console.WriteLine("\nFound optimal solution:");
    VarArray vars = model.GetVars();
    for (int i = 0; i < vars.Size(); i++)
    {
        Var xi = vars.GetVar(i);
        Console.WriteLine(" {0} = {1}", xi.GetName(), xi.Get(Copt.DblInfo.Value));
    }
    Console.WriteLine("Obj = {0}", model.GetDbAttr(Copt.DblAttr.LpObjVal));
}

Console.WriteLine("\nDone");
```

Specifically, one can query the `Copt.IntAttr.LpStatus` attribute of the model to determine whether we have found optimal LP solution; query the `Copt.DblInfo.Value` attribute of a variable to obtain its solution value; query the `Copt.DblAttr.LpObjVal` attribute on the model to obtain the objective value for the current solution.

The names and types of all model, variable, and constraint attributes can be found in *Constants* of C# API reference.

Error handling

Errors in the COPT C# interface are handled through the C# exception mechanism. In the example, all COPT statements are enclosed inside a try block, and any associated errors would be caught by the catch block.

```
catch (CoptException e)
{
    Console.WriteLine("Error Code = {0}", e.GetCode());
    Console.WriteLine(e.Message);
}
```

7.3.2 Build and Run

To build and run csharp example, users may refer to project under \$COPT_HOME/examples/csharp. Specifically, We provide a csharp project file in cross-platform framework of dotnet core 2.0. This example shows a single project working on Windows, as well as Linux and Mac platforms.

First of all, download and install [dotnet core 2.0](#) on your platform. To get started, follow [instructions](#) in the dotnet core docs.

Dotnet core 2.0 project

The dotnet core 2.0 project file `example.csproj` example locates in folder \$COPT_HOME/examples/csharp/dotnetprojects. Copy example file `lp_ex1.cs` to this folder and change directory to there by Windows command line prompt, then run with command '`dotnet run --framework netcoreapp2.0`'. For users of dotnet core 3.0, just run with '`dotnet run --framework netcoreapp3.0`' instead will work too.

This csharp project has dependency on COPT dotnet 2.0 shared library `copt_dotnet20.dll`, which is referred in the project file and defines all managed classes of COPT solver. In addition, `copt_dotnet20.dll` loads two shared libraries, that is, `coptcswrap.dll` and `copt_cpp.dll` on Windows, `libcoptcswrap.so` and `libcopt_cpp.so` on Linux, `libcoptcswrap.dylib` and `libcopt_cpp.dylib` on Mac respectively. Note that `coptcswrap` library is a bridge between managed COPT library and native library `copt_cpp.dll`, which declares and implements COPT constants, interfaces and methods. So users should make sure they are installed properly on runtime search paths.

In summary, to run csharp example, users should have COPT installed properly. Specifically, it requires three related COPT shared libraries existing on runtime search paths, and valid license files to run. Please refer to *Install Guide for Cardinal Optimizer* for further details.

7.4 Java Interface

This chapter walks through a simple Java example to illustrate the use of the COPT Java interface. In short words, the example creates an environment, builds a model, add variables and constraints, optimizes it, and then outputs the optimal objective value.

The example solves the following linear problem:

$$\begin{aligned} &\text{Maximize:} \\ &\quad 1.2x + 1.8y + 2.1z \\ &\text{Subject to:} \\ &\quad 1.5x + 1.2y + 1.8z \leq 2.6 \\ &\quad 0.8x + 0.6y + 0.9z \geq 1.2 \\ &\text{Bounds:} \\ &\quad 0.1 \leq x \leq 0.6 \\ &\quad 0.2 \leq y \leq 1.5 \\ &\quad 0.3 \leq z \leq 2.8 \end{aligned} \tag{7.4}$$

Note that this is the same problem that was modelled and optimized in chapter of *C Interface*.

7.4.1 Example details

Below is the source code solving the above problem using COPT Java interface.

Listing 7.4: Lp_ex1.java

```
1  /*
2   * This file is part of the Cardinal Optimizer, all rights reserved.
3   */
4  import copt.*;
5
6  /*
7   * This Java example solves the following LP model:
8   *
9   * Maximize:
10  * 1.2 x + 1.8 y + 2.1 z
11  *
12  * Subject to:
13  * 1.5 x + 1.2 y + 1.8 z <= 2.6
14  * 0.8 x + 0.6 y + 0.9 z >= 1.2
15  *
16  * where:
17  * 0.1 <= x <= 0.6
18  * 0.2 <= y <= 1.5
19  * 0.3 <= z <= 2.8
20  */
21 public class Lp_ex1 {
22     public static void main(final String argv[]) {
23         try {
24             Envr env = new Envr();
25             Model model = env.createModel("lp_ex1");
26
27             /*
28              * Add variables x, y, z
29              *
30              * obj: 1.2 x + 1.8 y + 2.1 z
31              *
32              * var:
33              * 0.1 <= x <= 0.6
34              * 0.2 <= y <= 1.5
35              * 0.3 <= z <= 2.8
36              */
```

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```

37 Var x = model.addVar(0.1, 0.6, 1.2, copt.Consts.CONTINUOUS, "x");
38 Var y = model.addVar(0.2, 1.5, 1.8, copt.Consts.CONTINUOUS, "y");
39 Var z = model.addVar(0.3, 2.8, 2.1, copt.Consts.CONTINUOUS, "z");
40
41 /*
42  * Add two constraints using linear expression
43  *
44  * r0: 1.5 x + 1.2 y + 1.8 z <= 2.6
45  * r1: 0.8 x + 0.6 y + 0.9 z >= 1.2
46  */
47 Expr e0 = new Expr(x, 1.5);
48 e0.addTerm(y, 1.2);
49 e0.addTerm(z, 1.8);
50 model.addConstr(e0, copt.Consts.LESS_EQUAL, 2.6, "r0");
51
52 Expr e1 = new Expr(x, 0.8);
53 e1.addTerm(y, 0.6);
54 e1.addTerm(z, 0.9);
55 model.addConstr(e1, copt.Consts.GREATER_EQUAL, 1.2, "r1");
56
57 // Set parameters and attributes
58 model.setDblParam(copt.DblParam.TimeLimit, 10);
59 model.setObjSense(copt.Consts.MAXIMIZE);
60
61 // Solve problem
62 model.solve();
63
64 // Output solution
65 if (model.getIntAttr(copt.IntAttr.HasLpSol) != 0) {
66     System.out.println("\nFound optimal solution:");
67     VarArray vars = model.getVars();
68     for (int i = 0; i < vars.size(); i++) {
69         Var xi = vars.getVar(i);
70         System.out.println("  " + xi.getName() + " = " + xi.get(copt.DblInfo.
↪Value));
71     }
72     System.out.println("Obj = " + model.getDblAttr(copt.DblAttr.LpObjVal));
73 }
74
75 System.out.println("\nDone");
76 } catch (CoptException e) {
77     System.out.println("Error Code = " + e.getCode());
78     System.out.println(e.getMessage());
79 }
80 }
81 }

```

Let's now walk through the example, line by line, to understand how it achieves the desired result of optimizing the model.

Import COPT class

To use the Java interface of COPT, users need to import the Java interface class of COPT first.

```
import copt.*;
```

Creating environment and model

Essentially, any Java application using Cardinal Optimizer should start with a COPT environment, where user could add one or more models. Note that each model encapsulates a problem and corresponding data.

Furthermore, to create multiple problems, one can load them one by one in the same model, besides the naive option of creating multiple models in the environment.

```
Envr env = new Envr();  
Model model = env.createModel("lp_ex1");
```

The above call instantiates a COPT environment and a model with name "lp_ex1".

Adding variables

The next step in our example is to add variables to the model. Variables are added through addVar() or addVars() method on the model object. A variable is always associated with a particular model.

```
/*  
 * Add variables x, y, z  
 *  
 * obj: 1.2 x + 1.8 y + 2.1 z  
 *  
 * var:  
 * 0.1 <= x <= 0.6  
 * 0.2 <= y <= 1.5  
 * 0.3 <= z <= 2.8  
 */  
Var x = model.addVar(0.1, 0.6, 1.2, copt.Consts.CONTINUOUS, "x");  
Var y = model.addVar(0.2, 1.5, 1.8, copt.Consts.CONTINUOUS, "y");  
Var z = model.addVar(0.3, 2.8, 2.1, copt.Consts.CONTINUOUS, "z");
```

The first and second arguments to the addVar() call are the variable lower and upper bounds, respectively. The third argument is the linear objective coefficient. The fourth argument is the variable type. Our variables are all continuous in this example. The final argument is the name of the variable.

The addVar() method has been overloaded to accept several different argument lists. Please refer to *Java Modeling Classes* of Java API reference for further details.

Adding constraints

The next step in the example is to add the linear constraints. As with variables, constraints are always associated with a specific model. They are created using addConstr() or addConstrs() methods on the model object.

```
/*  
 * Add two constraints using linear expression  
 *  
 * r0: 1.5 x + 1.2 y + 1.8 z <= 2.6
```

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```

    * r1: 0.8 x + 0.6 y + 0.9 z >= 1.2
    */
Expr e0 = new Expr(x, 1.5);
e0.addTerm(y, 1.2);
e0.addTerm(z, 1.8);
model.addConstr(e0, copt.Consts.LESS_EQUAL, 2.6, "r0");

Expr e1 = new Expr(x, 0.8);
e1.addTerm(y, 0.6);
e1.addTerm(z, 0.9);
model.addConstr(e1, copt.Consts.GREATER_EQUAL, 1.2, "r1");

```

Two constraints here are created by building linear expressions incrementally. That is, an expression can be built by constructor of a variable and its coefficient, and then by addTerm() method.

Setting parameters and attributes

The next step in the example is to set parameters and attributes of the problem before optimization.

```

// Set parameters and attributes
model.setDblParam(copt.DblParam.TimeLimit, 10);
model.setObjSense(copt.Consts.MAXIMIZE);

```

The setDblParam() call here with copt.DblParam.TimeLimit argument sets solver to optimize up to 10 seconds. The setObjSense() call with copt.Consts.MAXIMIZE argument sets objective sense as maximization.

Solving problem

Now that the model has been built, the next step is to optimize it:

```

// Solve problem
model.solve();

```

This routine performs the optimization and populates several internal model attributes (including the status of the optimization, the solution, etc.).

Outputting solution

After solving the problem, one can query the values of the attributes for various of purposes.

```

// Output solution
if (model.getIntAttr(copt.IntAttr.HasLpSol) != 0) {
    System.out.println("\nFound optimal solution:");
    VarArray vars = model.getVars();
    for (int i = 0; i < vars.size(); i++) {
        Var xi = vars.getVar(i);
        System.out.println("  " + xi.getName() + " = " + xi.get(copt.DblInfo.
↪Value));
    }
    System.out.println("Obj = " + model.getDblAttr(copt.DblAttr.LpObjVal));
}

System.out.println("\nDone");

```

Specifically, one can query the `copt.IntAttr.HasLpSol` attribute on the model to know whether we have optimal LP solution; query the `copt.DblInfo.Value` attribute of a variable to obtain its solution value; query the `copt.DblAttr.LpObjVal` attribute on the model to obtain the objective value for the current solution.

The names and types of all model, variable, and constraint attributes can be found in [Constants](#) of Java API reference.

Error Handling

Errors in the COPT Java interface are handled through the Java exception mechanism. In the example, all COPT statements are enclosed inside a try block, and any associated errors would be caught by the catch block.

```
} catch (CoptException e) {  
    System.out.println("Error Code = " + e.getCode());  
    System.out.println(e.getMessage());  
}
```

7.4.2 Build and Run

To build and run java example, users may refer to files under `$COPT_HOME/examples/java`. Specifically, We provide an example file in java and a script file to build. This single example runs on all platforms that support Java.

First of all, download and install *Java 8 or above* on your platform.

Java example detail

In the java example folder `$COPT_HOME/examples/java`, the easiest way to run the example is to enter the java example folder in console or terminal and then execute command `'sh run.sh'`.

This java project has dependency on COPT java package `copt_java.jar`, which defines all java classes of COPT solver. In addition, `copt_java.jar` loads two shared libraries, that is, `coptjniwrap.dll` and `copt_cpp.dll` on Windows, `libcoptjniwrap.so` and `libcopt_cpp.so` on Linux, `libcoptjniwrap.dylib` and `libcopt_cpp.dylib` on Mac respectively. Note that `coptjniwrap` library is a JNI swig wrapper and acts as a bridge between COPT java package and native library `copt_cpp`, which declares and implements COPT constants, interfaces and methods. So users should make sure they are installed properly on runtime search paths.

In summary, to run java example, users should have COPT installed properly. Specifically, it requires two related COPT shared libraries existing on runtime search paths, and valid license files to run. Please refer to [Install Guide for Cardinal Optimizer](#) for further details.

7.5 Python Interface

7.5.1 Installation guide

Currently, the Python interface of Cardinal Optimizer supports Python versions 2.7, 3.6-3.13. Among them, for Python 3.8-3.13 versions, COPT's MacOS-Universal can provide support. For Python 2.7, 3.6-3.7 versions, only MacOS-X86 is available.

Before using the Python interface, please ensure that COPT has been installed and configured correctly. For details, please refer to [How to install the Cardinal Optimizer](#). Users can download Python from [Anaconda distribution](#) or [Python official distribution](#). We recommend users install the Anaconda distribution, because it is more user-friendly and convenient for Python novices (For Windows, please

don't install Python via Microsoft Store). If you use official Python distribution or Python shipped with system, then make sure you have installed the `pip` and `setuptools` Python packages beforehand.

Note

We recommend using versions 3.8-3.13 because the minimum version requirement for Matrix Modeling function of the COPT-Python interface is 3.8. Versions 2.7 and 3.6-3.7 are not recommended unless necessary.

Windows

Method 1: via pip install (recommended)

Open the cmd command window (if Python is an Anaconda distribution, open the Anaconda command line window) and enter the following command:

```
pip install coptpy
```

If an older version of the `coptpy` package has been installed, please open the cmd command window (if Python is an Anaconda distribution, open the Anaconda command line window) and enter the following command to upgrade to the latest version of the `coptpy` package:

```
pip install --upgrade coptpy
```

Method 2: via COPT installation package

For Windows, assuming the installation path of COPT is: "C:\Program Files\COPT", please switch to the directory "C:\Program Files\COPT\lib\python" and execute the following commands on command line:

```
python setup.py install
```

Note that if COPT is installed on the system disk, you need to **execute with administrator privileges** to open the command prompt. To test whether the Python interface is installed correctly, users can switch to the directory "C:\Program Files\COPT\examples\python" and execute the following commands on the command line:

```
python lp_ex1.py
```

If the model is solved correctly, it means that the Python interface of COPT has been installed correctly.

Note If you use the official release of Python 3.8, assume that its installation path is: "C:\Program Files\Python38", you need to copy the `copt_cpp.dll` file in the "bin" subdirectory of the COPT installation path to "C:\Program Files\Python38\Lib\site-packages\coptpy" to solve the problem of dynamic library dependency.

Currently, `coptpy` supports type hints. After `coptpy` is successfully installed, when you code in Python IDE, variable name completion and function prototype information will be automatically prompted.

Linux

Method 1: via pip install (recommended)

Open the terminal and enter the following command:

```
pip install coptpy
```

If an older version of the `coptpy` package has been installed, please open the terminal and enter the following command to upgrade to the latest version of the `coptpy` package:

```
pip install --upgrade coptpy
```

Method 2: via COPT installation package

For Linux, suppose the installation path of COPT is: `/opt/copt72`, please switch to the directory `/opt/copt72/lib/python` and execute the following commands on terminal:

```
sudo python setup.py install
```

For users using Python from Anaconda distribution, if above commands fails, assuming the installation path of Anaconda is: `"/opt/anaconda3"`, please execute the following commands instead on terminal to install the Python interface of COPT:

```
sudo /opt/anaconda3/bin/python setup.py install
```

To test whether the Python interface is installed correctly, users can switch to the directory `/opt/copt72/examples/python` and execute the following commands on terminal:

```
python lp_ex1.py
```

If the model solved correctly, it means that the Python interface of COPT has been installed correctly. Currently, `coptpy` supports type hints. After `coptpy` is successfully installed, when you code in Python IDE, variable name completion and function prototype information will be automatically prompted.

MacOS

Method 1: via pip install (recommended)

Open the terminal and enter the following command:

```
pip install coptpy
```

If an older version of the `coptpy` package has been installed, please open the terminal and enter the following command to upgrade to the latest version of the `coptpy` package:

```
pip install --upgrade coptpy
```

Method 2: via COPT installation package

For MacOS, assuming that the installation path of COPT is: `/Applications/copt72`, please switch the directory to `/Applications/copt72/lib/python` and execute the following commands on terminal:

```
sudo python setup.py install
```

To test whether the Python interface is installed correctly, users can switch to the directory `/Applications/copt72/examples/python` and execute the following commands on terminal:

```
python lp_ex1.py
```

If the model solved correctly, it means that the Python interface of COPT has been installed correctly. Currently, `coptpy` supports type hints. After `coptpy` is successfully installed, when you code in Python IDE, variable name completion and function prototype information will be automatically prompted.

7.5.2 Example details

This chapter illustrates the use of C interface of Cardinal Optimizer through a simple Python example. The problem to solve is shown in Eq. 7.5:

$$\begin{aligned}
 &\text{Maximize:} \\
 &\quad 1.2x + 1.8y + 2.1z \\
 &\text{Subject to:} \\
 &\quad 1.5x + 1.2y + 1.8z \leq 2.6 \\
 &\quad 0.8x + 0.6y + 0.9z \geq 1.2 \\
 &\text{Bounds:} \\
 &\quad 0.1 \leq x \leq 0.6 \\
 &\quad 0.2 \leq y \leq 1.5 \\
 &\quad 0.3 \leq z \leq 2.8
 \end{aligned} \tag{7.5}$$

The source code for solving the above problem using Python API of Cardinal Optimizer is shown in Listing 7.5:

Listing 7.5: `lp_ex1.py`

```

1  #
2  # This file is part of the Cardinal Optimizer, all rights reserved.
3  #
4
5  """
6  The problem to solve:
7
8  Maximize:
9      1.2 x + 1.8 y + 2.1 z
10
11 Subject to:
12     1.5 x + 1.2 y + 1.8 z <= 2.6
13     0.8 x + 0.6 y + 0.9 z >= 1.2
14
15 where:
16     0.1 <= x <= 0.6
17     0.2 <= y <= 1.5
18     0.3 <= z <= 2.8
19 """
20
21 import coptpy as cp
22 from coptpy import COPT
23
24 # Create COPT environment
25 env = cp.Envr()
26
27 # Create COPT model
28 model = env.createModel("lp_ex1")
29
30 # Add variables: x, y, z
31 x = model.addVar(lb=0.1, ub=0.6, name="x")

```

(continues on next page)

(continued from previous page)

```

32 y = model.addVar(lb=0.2, ub=1.5, name="y")
33 z = model.addVar(lb=0.3, ub=2.8, name="z")
34
35 # Add constraints
36 model.addConstr(1.5*x + 1.2*y + 1.8*z <= 2.6)
37 model.addConstr(0.8*x + 0.6*y + 0.9*z >= 1.2)
38
39 # Set objective function
40 model.setObjective(1.2*x + 1.8*y + 2.1*z, sense=COPT.MAXIMIZE)
41
42 # Set parameter
43 model.setParam(COPT.Param.TimeLimit, 10.0)
44
45 # Solve the model
46 model.solve()
47
48 # Analyze solution
49 if model.status == COPT.OPTIMAL:
50     print("Objective value: {}".format(model.objval))
51     allvars = model.getVars()
52
53     print("Variable solution:")
54     for var in allvars:
55         print(" x[{}]: {}".format(var.index, var.x))
56
57     print("Variable basis status:")
58     for var in allvars:
59         print(" x[{}]: {}".format(var.index, var.basis))
60
61 # Write model, solution and modified parameters to file
62 model.write("lp_ex1.mps")
63 model.write("lp_ex1.bas")
64 model.write("lp_ex1.sol")
65 model.write("lp_ex1.par")

```

We will explain how to use the Python API step by step based on code above, please refer to [C API Reference](#) for detailed usage of Python API.

Import Python interface

To use the Python interface of COPT, users need to import the Python interface library first.

```

import coptpy as cp
from coptpy import COPT

```


Create environment

To solve any problem with COPT, users need to create optimization environment before creating any model.

```
# Create COPT environment
env = cp.Envr()
```

Create model

If the optimization environment was created successfully, users need to create the model to solve, which includes variables and constraints information.

```
# Create COPT model
model = env.createModel("lp_ex1")
```

Add variables

Users can specify information such as objective costs, lower and upper bounds of variables when creating them. In this example, we just set the lower and upper bounds of variables and their names.

```
# Add variables: x, y, z
x = model.addVar(lb=0.1, ub=0.6, name="x")
y = model.addVar(lb=0.2, ub=1.5, name="y")
z = model.addVar(lb=0.3, ub=2.8, name="z")
```

Add constraints

After adding variables, we can then add constraints to the model.

```
# Add constraints
model.addConstr(1.5*x + 1.2*y + 1.8*z <= 2.6)
model.addConstr(0.8*x + 0.6*y + 0.9*z >= 1.2)
```

Set objective function

After adding variables and constraints, we can further specify objective function for the model.

```
# Set objective function
model.setObjective(1.2*x + 1.8*y + 2.1*z, sense=COPT.MAXIMIZE)
```

Set parameters

Users can set optimization parameters before solving the model, e.g. set optimization time limit to 10 seconds.

```
# Set parameter
model.setParam(COPT.Param.TimeLimit, 10.0)
```

Solve model

Solve the model via `solve` method.

```
# Solve the model
model.solve()
```

Analyze solution

When solving finished, we should query the solution status first. If the solution status is optimal, then we can retrieve objective value, solution and basis status of variables.

```
# Analyze solution
if model.status == COPT.OPTIMAL:
    print("Objective value: {}".format(model.objval))
    allvars = model.getVars()

    print("Variable solution:")
    for var in allvars:
        print(" x[{}]: {}".format(var.index, var.x))

    print("Variable basis status:")
    for var in allvars:
        print(" x[{}]: {}".format(var.index, var.basis))
```

Write files

Users can write current model to MPS format file, and write solution, basis status and modified parameters to file.

```
# Write model, solution and modified parameters to file
model.write("lp_ex1.mps")
model.write("lp_ex1.bas")
model.write("lp_ex1.sol")
model.write("lp_ex1.par")
```

7.5.3 Best Practice

Upgrade to the newer version

If users have COPT Python Interface `coptpy` installed and need to upgrade latest version, it is recommended to remove previous version before installing new version. To remove previous version, it is as simple as deleting the folder `coptpy` at `site-package`.

If the user is accessible to the Internet, we recommend using `pip` to uninstall or upgrade `coptpy`.

Uninstall the old package

```
pip uninstall coptpy
```

Upgrade to the new package

```
pip install --upgrade coptpy
```

If the user installed `coptpy` from the offline COPT installation package by `python setup.py install`, please refer to the following steps to uninstall and upgrade:

1. Firstly, please confirm the installation location of `coptpy`, which can be viewed through `pip show coptpy`, and the output is as follows:

```
Name: coptpy
Version: |COPT_version|
Summary: The Python interface of the Cardinal Optimizer
Home-page: www.shanshu.ai
Author: Cardinal Operations, LLC
Author-email: coptsales@shanshu.ai
License: Cardinal Operations, LLC
End User License Agreement
Location: /Users/user/anaconda3/lib/python3.11/site-packages
Requires:
Required-by:
```

2. Secondly, please manually delete the `coptpy-*.egg-info` and `coptpy` under the `site-packages` directory of the Location above.

3. Finally, please install the new version of `coptpy`: enter the COPT installation package directory (such as `copt72/lib/python`), and execute:

```
python setup.py install
```

Multi-Thread Programming

COPT does not guarantee thread safe and modelling APIs are not reentrant in general. It is safe to share COPT Envr objects among threads. However, it is not recommended to share Model objects among threads, unless you understand what you are doing. For instance, if you share the same model between two threads. One thread is responsible for modelling and solving. The other thread is used to monitor the progress and may interrupt at some circumstances, such as running out of time.

Dictionary order guaranteed after Python 3.7

As you know, Python dictionaries did not preserve the order in which items were added to them. For instance, you might type `{'fruits': ['apple', 'orange'], 'veggies': ['carrot', 'pea']}` and get back `{'veggies': ['carrot', 'pea'], 'fruits': ['apple', 'orange']}`.

However, the situation is changed. Standard dict objects preserve order in the implementation of Python 3.6. This order-preserving property is becoming a language feature in Python 3.7.

If your program has dependency on dictionary orders, please install COPT Python Interface `coptpy` for Python 3.7 or later version. For instance, if your model is implemented in Python 2.7 as follows:

```
m = Envr().createModel("customized model")
vx = m.addVars(['hello', 'world'], [0, 1, 2], nameprefix = "X")
# add a constraint for each var in tupledict 'vx'
m.addConstrs(vx[key] >= 1.0 for key in vx)
```

Your model might end up with rows `{R(hello,1), R(hello,0), R(world,1), R(world,0), R(hello,2), R(world,2)}`.

Use quicksum and psdquicksum when possible

The Python interface of COPT supports building linear expression, quadratic expression and PSD expression in natural way. For linear and quadratic expression, it is recommended to use `quicksum()` to build expression objects. For linear and PSD expression, it is recommended to use `psdquicksum()` to build expression objects. Both of them implement inplace summation, which is much faster than standard plus operator.

Operate the model in batch

The Python interface of COPT supports performing batch operations on the models, such as:

- Add multiple variables or constraints: `Model.addVars()/Model.addConstrs()` .
- Set the coefficients of multiple variables in the linear constraints: `Model.setCoeffs()` (**Note:** The index pairs of variables and constraints cannot appear repeatedly).
- Set the names of multiple variables or constraintss: `Model.setNames()` .

Please refer to *Python API Reference: Model Class* for function descriptions.

7.6 AMPL Interface

AMPL is an algebraic modeling language for describing large-scale complex mathematical problems, it was hooked to many commercial and open-source mathematical optimizers, with various data interfaces and extensions, and received high popularity among both industries and institutes, see [Who uses AMPL?](#) for more information. The solver `coptampl` (located in the "`\bin`" directory of the COPT installation package) uses **Cardinal Optimizer** to solve linear programming, convex quadratic programming, convex quadratic constrained programming and mixed integer programming problems. Normally `coptampl` is invoked by AMPL's solve command, which gives the invocation:

```
coptampl stub -AMPL
```

in which `stub.nl` is an AMPL generic output file (possibly written by '`ampl -obstub`' or '`ampl -ogstub`'). After solving the problem, `coptampl` writes a `stub.sol` file for use by AMPL's solve and solution commands. When you run AMPL, this all happens automatically if you give the AMPL commands:

```
ampl: option solver coptampl;  
ampl: solve;
```

7.6.1 Installation Guide

To use `coptampl` in AMPL, you must have a valid AMPL license and make sure that you have installed Cardinal Optimizer and setup its license properly, see [How to install Cardinal Optimizer](#) for details. Be sure to check if it satisfies the following requirements for different operating systems.

Windows

On Windows platform, the `coptampl.exe` utility and the `copt.dll` dynamic library contained in the Cardinal Optimizer must appear somewhere in your user or system `PATH` environment variable (or in the current directory).

To test if your setting meets the above requirements, you can check it by executing commands below in command prompt:

```
coptampl -v
```

And you are expected to see output similar to the following on screen:

```
AMPL/x-COPT Optimizer [7.2.1] (windows-x86), driver(20220526), MP(20220526)
```

If the commands failed, then you should recheck your settings.

Linux

On Linux platform, the `coptampl` utility must appears somewhere in your `$PATH` environment variable, while the `libcopt.so` shared library must appears somewhere in your `$LD_LIBRARY_PATH` environment variable.

Similarly, to test if your setting meets the above requirements, just execute commands below in shell:

```
coptampl -v
```

And you are expected to see output similar to the following on screen:

```
AMPL/x-COPT Optimizer [7.2.1] (linux-x86), driver(20220526), MP(20220526)
```

If the commands failed, please recheck your settings.

MacOS

On MacOS platform, the `coptampl` utility must appears somewhere in your `$PATH` environment variable, while the `libcopt.dylib` dynamic library must appears somewhere in your `$DYLD_LIBRARY_PATH` environment variable.

You can execute commands below in shell to see if your settings meets the above requirements:

```
coptampl -v
```

And you are expected to see output similar to the following on screen:

```
AMPL/x-COPT Optimizer [7.2.1] (macos-x86), driver(20220526), MP(20220526)
```

If the commands failed, then please recheck your settings.

7.6.2 Solver Options and Exit Codes

The `coptampl` utility offers some options to customize its behavior. Users can control it by setting the environment variable `copt_options` or use AMPL's `option` command. To see all available options, please invoke:

```
coptampl ==
```

The supported parameters and their interpretation for current version are shown in [Table 7.1](#):

Table 7.1: Parameters of `coptampl`

Parameter	Interpretation
barhomogeneous	whether to use homogeneous self-dual form in barrier
bariterlimit	iteration limit of barrier method
barthreads	number of threads used by barrier
basis	whether to use or return basis status
bestbound	whether to return best bound by suffix
conflictnanalysis	whether to perform conflict analysis
crossoverthreads	number of threads used by crossover
cutlevel	level of cutting-planes generation
divingheurlevel	level of diving heuristics
dualize	whether to dualize a problem before solving it
dualperturb	whether to allow the objective function perturbation
dualprice	specifies the dual simplex pricing algorithm
dualtol	the tolerance for dual solutions and reduced cost
feastol	the feasibility tolerance
heurlevel	level of heuristics
iisfind	whether to compute IIS and return result
iismethod	specify the IIS method
inttol	the integrality tolerance for variables
logging	whether to print solving logs
logfile	name of log file
exportfile	name of model file to be exported
lpmethod	method to solve the LP problem
matrixtol	input matrix coefficient tolerance
mipstart	whether to use initial values for MIP problem
miptasks	number of MIP tasks in parallel
nodecutrounds	rounds of cutting-planes generation of tree node
odelimit	node limit of the optimization
objno	objective number to solve
count	whether to count the number of solutions
stub	name prefix for alternative MIP solutions written
presolve	level of presolving before solving a problem
relgap	the relative gap of optimization
absgap	the absolute gap of optimization
return_mipgap	whether to return absolute/relative gap by suffix
rootcutlevel	level of cutting-planes generation of root node
rootcutrounds	rounds of cutting-planes generation of root node
roundingheurlevel	level of rounding heuristics
scaling	whether to perform scaling before solving a problem
simplexthreads	number of threads used by dual simplex
sos	whether to use ‘.sosno’ and ‘.ref’ suffix
sos2	whether to use SOS2 to represent piecewise linear terms
strongbranching	level of strong branching
submipheurlevel	level of Sub-MIP heuristics
threads	number of threads to use
timelimit	time limit of the optimization
treecutlevel	level of cutting-planes generation of search tree
wantsol	whether to generate ‘.sol’ file

Please refer to *COPT Parameters* for details.

AMPL uses suffix to store or pass model and solution information, and also some extension features, such as support for SOS constraints. Currently, `coptampl` support suffix information as shown in *Suffix supported by coptampl* :

Table 7.2: Suffix supported by `coptampl`

Suffix	Interpretation
absmipgap	absolute gap for MIP problem
bestbound	best bound for MIP problem
iis	store IIS status of variables or constraints
nsol	number of pool solutions written
ref	weight of variable in SOS constraint
relmipgap	relative gap for MIP problem
sos	store type of SOS constraint
sosno	type of SOS constraint
sosref	store variable weight in SOS constraint
sstatus	basis status of variables and constraints

Users who want to know how to use SOS constraints in AMPL, please refer to resources in AMPL's website: [How to use SOS constraints in AMPL](#).

When solving finished, `coptampl` will display a status message and return exit code to AMPL. The exit code can be displayed by:

```
ampl: display solve_result_num;
```

If no solution was found or something unexpected happened, `coptampl` will return non-zero code to AMPL from [Table 7.3](#):

Table 7.3: Exit codes of `coptampl`

Exit Code	Interpretation
0	optimal solution
200	infeasible
300	unbounded
301	infeasible or unbounded
600	user interrupted

7.6.3 Example Usage

The following section will illustrate the use of AMPL by a well-known example called “Diet problem”, which finds a mix of foods that satisfies requirements on the amounts of various vitamins, see [AMPL book](#) for details.

Suppose the following kinds of foods are available for the following prices per unit, see [Table 7.4](#):

Table 7.4: Prices of foods

Food	Price
BEEF	3.19
CHK	2.59
FISH	2.29
HAM	2.89
MCH	1.89
MTL	1.99
SPG	1.99
TUR	2.49

These foods provide the following percentages, per unit, of the minimum daily requirements for vitamins A, C, B1 and B2, see [Table 7.5](#):

Table 7.5: Nutrition of foods (%)

	A	C	B1	B2
BEEF	60%	20%	10%	15%
CHK	8	0	20	20
FISH	8	10	15	10
HAM	40	40	35	10
MCH	15	35	15	15
MTL	70	30	15	15
SPG	25	50	25	15
TUR	60	20	15	10

The problem is to find the cheapest combination that meets a week's requirements, that is, at least 700% of the daily requirements for each nutrient.

To summarize, the mathematical form for the above problem can be modeled as shown in Eq. 7.6:

Minimize:

$$\sum_{j \in J} cost_j \cdot buy_j$$

Subject to:

$$n_min_i \leq \sum_{j \in J} amt_{i,j} \cdot buy_j \leq n_max_i \quad \forall i \in I$$

$$f_min_j \leq buy_j \leq f_max_j \quad \forall j \in J$$

(7.6)

The AMPL model for above problem is shown in `diet.mod`, see Listing 7.6:

Listing 7.6: `diet.mod`

```

1  # The code is adopted from:
2  #
3  # https://github.com/Pyomo/pyomo/blob/master/examples/pyomo/amplbook2/diet.mod
4  #
5  # with some modification by developer of the Cardinal Optimizer
6
7  set NUTR;
8  set FOOD;
9
10 param cost {FOOD} > 0;
11 param f_min {FOOD} >= 0;
12 param f_max {j in FOOD} >= f_min[j];
13
14 param n_min {NUTR} >= 0;
15 param n_max {i in NUTR} >= n_min[i];
16
17 param amt {NUTR, FOOD} >= 0;
18
19 var Buy {j in FOOD} >= f_min[j], <= f_max[j];
20
21 minimize Total_Cost:
22     sum {j in FOOD} cost[j] * Buy[j];
23
24 subject to Diet {i in NUTR}:
25     n_min[i] <= sum {j in FOOD} amt[i, j] * Buy[j] <= n_max[i];

```

The data file for above problem is shown in `diet.dat`, see Listing 7.7:

Listing 7.7: diet.dat

```

1  # The data is adopted from:
2  #
3  # https://github.com/Pyomo/pyomo/blob/master/examples/pyomo/amplbook2/diet.dat
4  #
5  # with some modification by developer of the Cardinal Optimizer
6
7  data;
8
9  set NUTR := A B1 B2 C ;
10 set FOOD := BEEF CHK FISH HAM MCH MTL SPG TUR ;
11
12 param: cost f_min f_max :=
13 BEEF 3.19 0 100
14 CHK 2.59 0 100
15 FISH 2.29 0 100
16 HAM 2.89 0 100
17 MCH 1.89 0 100
18 MTL 1.99 0 100
19 SPG 1.99 0 100
20 TUR 2.49 0 100 ;
21
22 param: n_min n_max :=
23 A 700 10000
24 C 700 10000
25 B1 700 10000
26 B2 700 10000 ;
27
28 param amt (tr):
29 A C B1 B2 :=
30 BEEF 60 20 10 15
31 CHK 8 0 20 20
32 FISH 8 10 15 10
33 HAM 40 40 35 10
34 MCH 15 35 15 15
35 MTL 70 30 15 15
36 SPG 25 50 25 15
37 TUR 60 20 15 10 ;

```

To solve the problem with `coptampl` in AMPL, just type commands in command prompt on Windows or shell on Linux and MacOS:

```

ampl: model diet.mod;
ampl: data diet.dat;
ampl: option solver coptampl;
ampl: option copt_options 'logging 1';
ampl: solve;

```

`coptampl` solve it quickly and display solving log and status message on screen:

```

x-COPT 5.0.1: optimal solution; objective 88.2
1 simplex iterations

```

So `coptampl` claimed it found the optimal solution, and the minimal cost is 88.2 units. You can further check the solution by:

```
ampl: display Buy;
```

And you will get:

```
Buy [*] :=
BEEF    0
  CHK    0
FISH    0
  HAM    0
  MCH   46.6667
  MTL    0
  SPG    0
  TUR    0
;
```

So if we buy 46.667 units of MCH, we will have a minimal cost of 88.2 units.

7.7 Pyomo Interface

[Pyomo](#) is a Python based, open source optimization modeling language with a diverse set of optimization capabilities. It is used by researchers to solve complex real-world applications, see [Who uses Pyomo?](#) for more introduction. The following documentation explains how to use the **Cardinal Optimizer**.

7.7.1 Installation Guide

To use the Cardinal Optimizer in Pyomo, you should setup Pyomo and Cardinal Optimizer correctly first. Pyomo currently supports Python 2.7, 3.6-3.9, you can install Python from [Anaconda Distribution of Python](#) or from [Official Python](#). We recommend install Python from Anaconda since it is much more friendly and convenient for fresh users.

Using conda

The recommended way to install Pyomo in Anaconda Distribution of Python is to use `conda` which is built-in supported. Just execute the following commands in command prompt on Windows or shell on Linux and MacOS:

```
conda install -c conda-forge pyomo
```

Pyomo also has conditional dependencies on a variety of third-party Python packages, they can be installed using `conda` with commands:

```
conda install -c conda-forge pyomo.extras
```

Using pip

The alternative way to install Pyomo is to use the standard `pip` utility, just execute the following commands in command prompt on Windows or shell on Linux and MacOS:

```
pip install pyomo
```

If you encounter any problems when installing Pyomo, please refer to [How to install Pyomo](#) for details. To install Cardinal Optimizer and setup its license properly, please refer to [How to install Cardinal Optimizer](#) for details.

7.7.2 Example Usage

We are going to make a simple introduction on how to use the Cardinal Optimizer in Pyomo by solving the example described in *AMPL Interface - Example Usage*. Users who want to learn more information about Pyomo may refer to [Pyomo documentation](#) for details.

Abstract Model

Pyomo provides two major approaches to construct any supported model types, here we show the **Abstract Model** approach to solve the above problem.

The source code `pydiet_abstract.py` is shown below, see [Listing 7.8](#):

Listing 7.8: `pydiet_abstract.py`

```

1  # The code is adopted from:
2  #
3  # https://github.com/Pyomo/pyomo/blob/master/examples/pyomo/amplbook2/diet.py
4  #
5  # with some modification by developer of the Cardinal Optimizer
6
7  from pyomo.core import *
8
9  model = AbstractModel()
10
11  model.NUTR = Set()
12  model.FOOD = Set()
13
14  model.cost = Param(model.FOOD, within=NonNegativeReals)
15  model.f_min = Param(model.FOOD, within=NonNegativeReals)
16
17  model.f_max = Param(model.FOOD)
18  model.n_min = Param(model.NUTR, within=NonNegativeReals)
19  model.n_max = Param(model.NUTR)
20  model.amt = Param(model.NUTR, model.FOOD, within=NonNegativeReals)
21
22  def Buy_bounds(model, i):
23      return (model.f_min[i], model.f_max[i])
24  model.Buy = Var(model.FOOD, bounds=Buy_bounds)
25
26  def Objective_rule(model):
27      return sum_product(model.cost, model.Buy)
28  model.totalcost = Objective(rule=Objective_rule, sense=minimize)
29
30  def Diet_rule(model, i):
31      expr = 0
32
33      for j in model.FOOD:
34          expr = expr + model.amt[i, j] * model.Buy[j]
35
36      return (model.n_min[i], expr, model.n_max[i])
37  model.Diet = Constraint(model.NUTR, rule=Diet_rule)

```

And the data file `pydiet_abstract.dat` in [Listing 7.9](#):

Listing 7.9: pydiet_abstract.dat

```

1  # The data is adopted from:
2  #
3  # https://github.com/Pyomo/pyomo/blob/master/examples/pyomo/amplbook2/diet.dat
4  #
5  # with some modification by developer of the Cardinal Optimizer
6
7  data;
8
9  set NUTR := A B1 B2 C ;
10 set FOOD := BEEF CHK FISH HAM MCH MTL SPG TUR ;
11
12 param: cost f_min f_max :=
13     BEEF 3.19 0 100
14     CHK 2.59 0 100
15     FISH 2.29 0 100
16     HAM 2.89 0 100
17     MCH 1.89 0 100
18     MTL 1.99 0 100
19     SPG 1.99 0 100
20     TUR 2.49 0 100 ;
21
22 param: n_min n_max :=
23     A 700 10000
24     C 700 10000
25     B1 700 10000
26     B2 700 10000 ;
27
28 param amt (tr):
29     A C B1 B2 :=
30     BEEF 60 20 10 15
31     CHK 8 0 20 20
32     FISH 8 10 15 10
33     HAM 40 40 35 10
34     MCH 15 35 15 15
35     MTL 70 30 15 15
36     SPG 25 50 25 15
37     TUR 60 20 15 10 ;

```

To solve the problem using Pyomo and the Cardinal Optimizer, just type commands below in command prompt on Windows or Bash shell on Linux and MacOS.

```
pyomo solve --solver=coptampl pydiet_abstract.py pydiet_abstract.dat
```

When solving the problem, Pyomo write log information to the screen:

```

[ 0.00] Setting up Pyomo environment
[ 0.00] Applying Pyomo preprocessing actions
[ 0.00] Creating model
[ 0.01] Applying solver
[ 0.05] Processing results
Number of solutions: 1
Solution Information
    Gap: None
    Status: optimal
    Function Value: 88.19999999999999

```

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```

Solver results file: results.yml
[ 0.05] Applying Pyomo postprocessing actions
[ 0.05] Pyomo Finished

```

Upon completion, you can check the solution summary in `results.yml`:

```

# =====
# = Solver Results                                     =
# =====
# -----
# Problem Information
# -----
Problem:
- Lower bound: -inf
  Upper bound: inf
  Number of objectives: 1
  Number of constraints: 4
  Number of variables: 8
  Sense: unknown
# -----
# Solver Information
# -----
Solver:
- Status: ok
  Message: COPT-AMPL\x3a optimal solution; objective 88.2, iterations 1
  Termination condition: optimal
  Id: 0
  Error rc: 0
  Time: 0.03171110153198242
# -----
# Solution Information
# -----
Solution:
- number of solutions: 1
  number of solutions displayed: 1
- Gap: None
  Status: optimal
  Message: COPT-AMPL\x3a optimal solution; objective 88.2, iterations 1
  Objective:
    totalcost:
      Value: 88.19999999999999
  Variable:
    Buy[MCH]:
      Value: 46.666666666666664
  Constraint: No values

```

So the minimal total cost is about 88.2 units when buying 46.67 units of MCH.

Concrete Model

The other approach to construct model in Pyomo is to use **Concrete Model**, we will show how to model and solve the above problem in this way.

Concrete models can be solved using the "Direct" and "Persistent" interface methods. This method relies on the Pyomo plugin file "copt_pyomo.py" of COPT, which is located in the "lib/pyomo" subfolder of the installation package.

To use this plugin, you need to copy the "copt_pyomo.py" file to the same directory of your program, and have correctly installed the corresponding version of the Python interface of COPT(`coptpy`).

The source code `pydiet_concrete.py` is shown in Listing 7.10:

Listing 7.10: `pydiet_concrete.py`

```

1  # The code is adopted from:
2  #
3  # https://github.com/Pyomo/pyomo/blob/master/examples/pyomo/amplbook2/diet.py
4  #
5  # with some modification by developer of the Cardinal Optimizer
6
7  from __future__ import print_function, division
8
9  import pyomo.environ as pyo
10 import pyomo.opt as pyopt
11
12 from copt_pyomo import *
13
14 # Nutrition set
15 NUTR = ["A", "C", "B1", "B2"]
16 # Food set
17 FOOD = ["BEEF", "CHK", "FISH", "HAM", "MCH", "MTL", "SPG", "TUR"]
18
19 # Price of foods
20 cost = {"BEEF": 3.19, "CHK": 2.59, "FISH": 2.29, "HAM": 2.89, "MCH": 1.89,
21         "MTL": 1.99, "SPG": 1.99, "TUR": 2.49}
22 # Nutrition of foods
23 amt = {"BEEF": {"A": 60, "C": 20, "B1": 10, "B2": 15},
24        "CHK": {"A": 8, "C": 0, "B1": 20, "B2": 20},
25        "FISH": {"A": 8, "C": 10, "B1": 15, "B2": 10},
26        "HAM": {"A": 40, "C": 40, "B1": 35, "B2": 10},
27        "MCH": {"A": 15, "C": 35, "B1": 15, "B2": 15},
28        "MTL": {"A": 70, "C": 30, "B1": 15, "B2": 15},
29        "SPG": {"A": 25, "C": 50, "B1": 25, "B2": 15},
30        "TUR": {"A": 60, "C": 20, "B1": 15, "B2": 10}}
31
32 # The "diet problem" using ConcreteModel
33 model = pyo.ConcreteModel()
34
35 model.NUTR = pyo.Set(initialize=NUTR)
36 model.FOOD = pyo.Set(initialize=FOOD)
37
38 model.cost = pyo.Param(model.FOOD, initialize=cost)
39
40 def amt_rule(model, i, j):
41     return amt[i][j]
42 model.amt = pyo.Param(model.FOOD, model.NUTR, initialize=amt_rule)
43

```

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```

44 model.f_min = pyo.Param(model.FOOD, default=0)
45 model.f_max = pyo.Param(model.FOOD, default=100)
46
47 model.n_min = pyo.Param(model.NUTR, default=700)
48 model.n_max = pyo.Param(model.NUTR, default=10000)
49
50 def Buy_bounds(model, i):
51     return (model.f_min[i], model.f_max[i])
52 model.buy = pyo.Var(model.FOOD, bounds=Buy_bounds)
53
54 def Objective_rule(model):
55     return pyo.sum_product(model.cost, model.buy)
56 model.totalcost = pyo.Objective(rule=Objective_rule, sense=pyo.minimize)
57
58 def Diet_rule(model, j):
59     expr = 0
60
61     for i in model.FOOD:
62         expr = expr + model.amt[i, j] * model.buy[i]
63
64     return (model.n_min[j], expr, model.n_max[j])
65 model.Diet = pyo.Constraint(model.NUTR, rule=Diet_rule)
66
67 # Reduced costs of variables
68 model.rc = pyo.Suffix(direction=pyo.Suffix.IMPORT)
69
70 # Activities and duals of constraints
71 model.slack = pyo.Suffix(direction=pyo.Suffix.IMPORT)
72 model.dual = pyo.Suffix(direction=pyo.Suffix.IMPORT)
73
74 # Use 'copt_direct' solver to solve the problem
75 solver = pyopt.SolverFactory('copt_direct')
76
77 # Use 'copt_persistent' solver to solve the problem
78 # solver = pyopt.SolverFactory('copt_persistent')
79 # solver.set_instance(model)
80
81 results = solver.solve(model, tee=True)
82
83 # Check result
84 print("")
85 if results.solver.status == pyopt.SolverStatus.ok and \
86     results.solver.termination_condition == pyopt.TerminationCondition.optimal:
87     print("Optimal solution found")
88 else:
89     print("Something unexpected happened: ", str(results.solver))
90
91 print("")
92 print("Optimal objective value:")
93 print("  totalcost: {0:6f}".format(pyo.value(model.totalcost)))
94
95 print("")
96 print("Variables solution:")
97 for i in FOOD:
98     print("  buy[{0:4s}] = {1:9.6f} (rc: {2:9.6f})".format(i, \
99                                                         pyo.value(model.buy[i]), \

```

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```

100                                     model.rc[model.buy[i]])
101
102 print("")
103 print("Constraint solution:")
104 for i in NUTR:
105     print("  diet[{0:2s}] = {1:12.6f} (dual: {2:9.6f})".format(i, \
106                                                         model.slack[model.Diet[i]], \
107                                                         model.dual[model.Diet[i]]))

```

To solve the problem using Pyomo and the Cardinal Optimizer, just execute commands below:

```
python pydiet_concrete.py
```

Up completion, you should see solution summary on screen as below:

```

Optimal solution found
Objective:
  totalcost: 88.200000
Variables:
  buy[BEEF] = 0.000000
  buy[CHK ] = 0.000000
  buy[FISH] = 0.000000
  buy[HAM ] = 0.000000
  buy[MCH ] = 46.666667
  buy[MTL ] = 0.000000
  buy[SPG ] = 0.000000
  buy[TUR ] = 0.000000

```

So the Cardinal Optimizer found the optimal solution, which is about 88.2 units when buying about 46.67 units of MCH.

7.8 PuLP Interface

PuLP is an open source modeling tool based on Python, it is mainly used for modeling integer programming problems. This chapter introduces how to use the Cardinal Optimizer (COPT) in PuLP.

7.8.1 Installation guide

Before calling COPT in PuLP to solve problem, users need to setup PuLP and COPT correctly. PuLP currently supports Python 2.7 and later versions of Python. Users can download Python from [Anaconda distribution](#) or [Python official distribution](#) . We recommend users install the Anaconda distribution, because it is more user-friendly and convenient for Python novices.

Install via conda

We recommend that users who have installed the Anaconda distribution of Python use its own **conda** tool to install PuLP. Execute the following commands in Windows command prompt or terminal on Linux and MacOS:

```
conda install -c conda-forge pulp
```


Install via pip

Users can also install PuLP through the standard `pip` tool, execute the following command in Windows command prompt or Linux and MacOS terminal:

```
pip install pulp
```

Setup PuLP interface

For PuLP V2.8.0 and above, COPT can be applied directly. After installing and configuring the COPT, users can proceed with the following steps:

```
from pulp import *
```

In the solving function `solve`, specify the solver to COPT to solve:

```
solver = COPT()
result = prob.solve(solver)
```

Notes:

1. Calling COPT in PuLP via `solver = COPT()` relies on the Python interface of COPT so `coptpy` needs to be installed first.
 2. By specifying: `solver = COPT_DLL()` , `solver = COPT_CMD()` , you can also call COPT, depending on COPT installation package.
-

7.8.2 Introduction of features

The PuLP interface of COPT provides two methods: command line and dynamic library, which are introduced as follows:

Command line

The command-line method actually calls the interactive tool `copt_cmd` of COPT to solve problems. In this way, PuLP generates the MPS format file corresponding to the model, and combines the parameter settings passed by the user to generate the solving commands. Upon finish of solving, COPT writes and reads the result file, and assigns values to the corresponding variables and return them to PuLP.

Functions of the command line method are encapsulated as class `COPT_CMD`. Users can set parameters when creating the object of the class and provides the following parameters:

- `keepFiles`

This option controls whether to keep the generated temporary files. The default value is 0, which means no temporary files are kept.

- `mip`

This option controls whether to support solving integer programming models. The default value is `True`, which means support solving integer programming models.

- `msg`

This option controls whether to print log information on the screen. The default value is `True`, that is, print log information.

- **mip_start**

This option controls whether to use initial solution information for integer programming models. The default value is **False**, that is, the initial solution information will not be used.

- **logfile**

This option specifies the solver log. The default value is **None**, which means no solver log will be generated.

- **params**

This option sets optimization parameters in the form of **key=value**. Please refer to the chapter [Parameters](#) for currently supported parameters.

Dynamic library

The dynamic library method directly calls COPT C APIs to solve problems. In this way, PuLP generates problem data and call COPT APIs to load the problem and parameters set by the user. When optimization finishes, the solution is obtained by calling COPT APIs, and then assigned to the corresponding variables and constraints, and passed back to PuLP.

Functions of the dynamic library method are encapsulated as class **COPT_DLL**. Users can set parameters when creating the object of the class and provides the following parameters:

- **mip**

This option controls whether to support solving integer programming models. The default value is **True**, which means support solving integer programming models.

- **msg**

This option controls whether to print log information on the screen. The default value is **True**, that is, print log information.

- **mip_start**

This option controls whether to use initial solution information for integer programming models. The default value is **False**, that is, the initial solution information will not be used.

- **logfile**

This option specifies the solver log. The default value is **None**, which means no solver log will be generated.

- **params**

This option sets optimization parameters in the form of **key=value**. Please refer to the chapter [Parameters](#) for currently supported parameters.

In addition, the following methods are provided:

- **setParam(self, name, val)**

Set optimization solution parameters.

- **getParam(self, name)**

Obtain optimized solution parameters.

- **getAttr(self, name)**

Get the attribute information of the model.

- **write(self, filename)**

Output MPS/LP format model file, COPT binary format model file, result file, basic solution file, initial solution file and parameter setting file.

7.9 CVXPY Interface

CVXPY is an open source Python-embedded modeling language for convex optimization problems. It lets you express your problem in a natural way that follows the math, which is quite flexible and efficient. This chapter introduces how to use the Cardinal Optimizer (COPT) in CVXPY.

7.9.1 Installation guide

Before calling COPT in CVXPY to solve problem, users need to setup CVXPY and COPT correctly. CVXPY currently supports Python 3.7 and later versions of Python. Users can download Python from [Anaconda distribution](#) or [Python official distribution](#). We recommend users install the Anaconda distribution, because it is more user-friendly and convenient for Python novices.

Install via conda

We recommend that users who have installed the Anaconda distribution of Python use its own **conda** tool to install CVXPY. Execute the following commands in Windows command prompt or terminal on Linux and MacOS:

```
conda install -c conda-forge cvxpy
```

Install via pip

Users can also install CVXPY through the standard **pip** tool, execute the following command in Windows command prompt or Linux and MacOS terminal:

```
pip install cvxpy
```

Setup CVXPY interface

CVXPY V1.3 and its above versions support calling COPT directly. users need to install and configure COPT in advance and then:

```
import cvxpy as cp
```

In CVXPY's solving function **solve**, specify the parameter **solver="COPT"** to use the COPT solver to solve:

```
prob.solve(solver="COPT")
```

7.9.2 Introduction of features

The CVXPY interface of COPT supports Linear Programming (LP), Mixed Integer Programming (MIP), Convex Quadratic Programming (QP), Second-Order-Cone Programming (SOCP), Semi-definite Programming (SDP), Mixed Integer Convex Quadratic Programming (MIQP) and Mixed Integer Second-Order-Cone Programming (MISOCP), common used parameters are:

- **verbose**

CVXPY builtin parameter, which controls whether to display solving log to the screen. The default value is **False**, which means no log to be displayed.

- `params`

This option sets optimization parameters in the form of `key=value`. Please refer to the chapter [Parameters](#) for currently supported parameters.

Chapter 8

General Constants

There are three types of constants.

1. Constructing models, such as optimization directions, constraint senses or variable types.
2. Accessing solution results, such as API return code, basis status and LP status.
3. Monitoring optimization progress, such as callback context.

8.1 Version information

- `VERSION_MAJOR`

The major version number.

- `VERSION_MINOR`

The minor version number.

- `VERSION_TECHNICAL`

The technical version number.

8.2 Optimization directions

For different optimization scenarios, it may be required to either maximize or minimize the objective function. There are two optimization directions:

- `MINIMIZE`

For minimizing the objective function.

- `MAXIMIZE`

For maximizing the objective function.

The optimization direction is automatically set when reading in a problem from file. Besides, COPT provides relevant functions, allowing user to explicitly set. Functions for different APIs are listed below:

Table 8.1: Functions for setting optimization directions

Programming API	Function
C	<code>COPT_SetObjSense</code>
C++	<code>Model::SetObjSense()</code>
C#	<code>Model.SetObjSense()</code>
Java	<code>Model.setObjSense()</code>
Python	<code>Model.setObjSense()</code>

NOTE: The function names, calling methods and parameter names in different programming interfaces are slightly different. For details, please refer to the API parameters of each programming language.

8.3 Infinity and undefined value

Infinity

In COPT, the infinite bound is represented by a large value, whose default value is also available as a constant:

- INFINITY

The default value (1e30) of the infinite bound.

Undefined Value

In COPT, the undefined value is represented by another large value. For example, the default solution value of MIP start is set to a constant:

- UNDEFINED

Undefined value(1e40`).

8.4 Constraint senses

Traditionally, for optimization models, constraints are defined using **senses**. The most common constraint senses are:

- LESS_EQUAL

For constraint in the form of $g(x) \leq b$

- GREATER_EQUAL

For constraint in the form of $g(x) \geq b$

- EQUAL

For constraint in the form of $g(x) = b$

In addition, there are two less used constraint senses:

- FREE

For unconstrained expression

- RANGE

For constraints with both lower and upper bounds in the form of $l \leq g(x) \leq u$.

NOTE: Using constraint senses is supported by COPT but not recommended. We recommend defining constraints using explicit lower and upper bounds.

8.5 Variable types

Variable types are used for defining whether a variable is continuous or integral.

- CONTINUOUS
Non-integer continuous variables
- BINARY
Binary variables
- INTEGER
Integer variables

8.6 SOS constraint types

SOS constraint (Special Ordered Set) is a kind of special constraint that places restrictions on the values that a set of variables can take. COPT currently support two types of SOS constraints:

- SOS_TYPE1
SOS1 constraint
At most one variable in the constraint is allowed to take a non-zero value.
- SOS_TYPE2
SOS2 constraint
At most two variables in the constraint are allowed to take non-zero value, and those non-zero variables must be contiguous.

NOTE: Variables in SOS constraints are allowed to be continuous, binary and integer.

8.7 Indicator constraint types

Indicator constraint is a kind of logical constraints in COPT, used to describe the relationship between the value of the binary variable y and whether the linear constraint $a^T x \leq b$ is satisfied. Currently, COPT supports three types of indicator constraints:

- INDICATOR_IF
If-Then:
If $y = f$, then the linear constraint $a^T x \leq b$ is satisfied.
If $y \neq f$, then the linear constraint $a^T x \leq b$ is invalid (may be violated).

$$\begin{aligned} y = f &\rightarrow a^T x \leq b \\ f &\in \{0, 1\} \end{aligned} \tag{8.1}$$
- INDICATOR_ONLYIF
Only-If:
If the linear constraint $a^T x \leq b$ is satisfied, then $y = f$.
If the linear constraint $a^T x \leq b$ is not satisfied, then y can be 0 or 1.

$$\begin{aligned} a^T x \leq b &\rightarrow y = f \\ f &\in \{0, 1\} \end{aligned} \tag{8.2}$$

- INDICATOR_IFANDONLYIF

If-and-Only-If:

The linear constraint $a^T x \leq b$ and $y = f$ must be satisfied simultaneously or not satisfied simultaneously.

$$\begin{aligned} a^T x \leq b &\leftrightarrow y = f \\ f &\in \{0, 1\} \end{aligned} \quad (8.3)$$

8.8 SOC constraint types

The Second-Order-Cone (SOC) constraint is a special type of quadratic constraints. COPT supports two types of SOC constraints:

- CONE_QUAD : Regular Second-Order-Cone

$$Q^n = \left\{ x \in \mathbb{R}^n \mid x_0 \geq \sqrt{\sum_{i=1}^{n-1} x_i^2}, x_0 \geq 0 \right\} \quad (8.4)$$

- CONE_RQUAD : Rotated Second-Order-Cone

$$Q_r^n = \left\{ x \in \mathbb{R}^n \mid 2x_0x_1 \geq \sum_{i=2}^{n-1} x_i^2, x_0 \geq 0, x_1 \geq 0 \right\} \quad (8.5)$$

8.9 Exponential Cone type

COPT supports two types of exponential cone constraints:

- EXPCONE_PRIMAL : Primal exponential cone

$$\text{cl}(S_1) = S_1 \cup S_2 \quad (8.6)$$

$$\begin{aligned} S_1 &= \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid s > 0, t \geq s \exp\left(\frac{r}{s}\right) \right\}, \\ S_2 &= \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid s = 0, t \geq 0, r \leq 0 \right\} \end{aligned} \quad (8.7)$$

- EXPCONE_DUAL : Dual exponential cone

$$\text{cl}(S_1) = S_1 \cup S_2 \quad (8.8)$$

$$\begin{aligned} S_1 &= \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid r < 0, t \geq -r \exp\left(\frac{s}{r} - 1\right) \right\}, \\ S_2 &= \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid r = 0, t \geq 0, s \geq 0 \right\} \end{aligned} \quad (8.9)$$

8.10 Quadratic objective function

Besides linear objective function, COPT also supports general convex quadratic objective function.

The mathematical form is:

$$x^T Q x + c^T x \quad (8.10)$$

Where, x is an array of variables, Q is the quadratic part of the quadratic objective function and c is the linear part.

8.11 Quadratic constraint

Besides the special type of quadratic constraint, Second-Order-Cone (SOC) constraint, COPT also supports general convex quadratic constraint.

The mathematical form is:

$$x^T Q x + c^T x \leq b \quad (8.11)$$

Where, x is an array of variables, Q is the quadratic part of the quadratic constraint and c is the linear part.

8.12 Basis status

For an LP problem with n variables and m constraints, the constraints are treated as slack variables *internally*, resulting in $n + m$ variables. When solving an LP problem using the simplex method, the simplex method fixes n variables at one of their bounds, and then computes solutions for the other m variables. The m variables with computed solution are called *basic* variables, and the other n variables are called *non-basic* variables. The simplex progress and its final solution can be defined using the basis status of all the variables and constraints. The basis status supported by COPT are listed below:

Table 8.2: Basis status values and descriptions

Basis status codes	Value	Description
BASIS_LOWER	0	The variable is non-basic at its lower bound
BASIS_BASIC	1	The variable is basic
BASIS_UPPER	2	The variable is non-basic at its upper bound
BASIS_SUPERBASIC	3	The variable is non-basic but not any of its bounds
BASIS_FIXED	4	The variable is non-basic and fixed at its bound

8.13 Solution status

Possible solution status values are listed below:

Table 8.3: Solution Status

Status Codes	Value	Description
UNSTARTED	0	The solving process is not started yet
OPTIMAL	1	Optimal values founded
INFEASIBLE	2	The model is infeasible
UNBOUNDED	3	The objective is unbounded
INF_OR_UNB	4	The model is infeasible or unbounded
NUMERICAL	5	Numerical trouble encountered
NODELIMIT	6	Solving process not finished within node limit
IMPRECISE	7	The solution is imprecise
TIMEOUT	8	Solving process not finished within time limit
UNFINISHED	9	The solving process is stopped but solver cannot provide a solution because of numerical issues
INTERRUPTED	10	The solving process is stopped by user interrupt

Notes

- In the Python API, solution status are defined in COPT's General Constants Class. They can be accessed via the "COPT." prefix or `Model.status` ;
 - In the Constant class of the Java API and C# API, the constants about the solution status are defined in the `Status` class;
 - The linear programming solution status can be obtained through the attribute "LpStatus" , and the integer programming solution status can be obtained through the attribute "MipStatus" .
 - The LP-relaxation status of the current node can be obtained through the Callback information "NodeStatus" . The return value is as above, except for NODELIMIT, UNSTARTED, INF_OR_UNB .
-

8.14 Client configuration

For floating, cluster and Web License, the user can set client configuration parameters by calling API functions. The available parameters are:

- **CLIENT_CAFILE**
Path to the CA public certificate file for configuring SSL proxy.
- **CLIENT_CERTFILE**
Path to the client certificate file for configuring SSL proxy.
- **CLIENT_CERTKEYFILE**
Path to the client private key file for configuring SSL proxy.
- **CLIENT_CLUSTER**
IP address of the remote cluster server.
- **CLIENT_FLOATING**
IP address of the remote floating token server.
- **CLIENT_PASSWORD**
Password for accessing the remote server.
- **CLIENT_PORT**
Connection port of the remote server.

- **CLIENT_PRIORITY**
Task priority for the remote cluster server. Possible values range from 0 to 99, with higher values indicating higher priority.
- **CLIENT_WAITTIME**
Wait time of the client connection .
- **CLIENT_WEBSERVER**
Domain name of the COPT Web License server.
- **CLIENT_WEBLICENSEID**
Unique identifier for the Web License.
- **CLIENT_WEBACCESSKEY**
Each Web License can have multiple API keys, with each API key having a unique WebAccessKey.
- **CLIENT_WEBTOKENDURATION**
Validity period for each authorization from the Web License.

Notes:

The above client configuration related parameters should be set within the API function `EnvrConfig` .

8.15 Callback context

- **CBCONTEXT_INCUMBENT**
Invokes the callback after a new incumbent was found.
- **CBCONTEXT_MIPRELAX**
Invokes the callback when a new LP-relaxation solution is found.
- **CBCONTEXT_MIPSOL**
Invokes the callback when a new MIP candidate solution is found.
- **CBCONTEXT_MIPNODE**
Invokes the callback when a MIP node is finished and LP-relaxation has been solved.

8.16 API function return code

When an API function finishes, it returns an integer **return code**, which indicates whether the API call was finished okay or failed. In case of failure, it specifies the reason of the failure.

Possible COPT API function return codes are listed below:

Table 8.4: COPT API Function Return Codes

Return Codes	Value	Description
OK	0	The API call finished successfully
MEMORY	1	The API call failed because of memory allocation failure
FILE	2	The API call failed because of file input or output failure
INVALID	3	The API call failed because of invalid data
LICENSE	4	The API call failed because of license validation failure
INTERNAL	5	The API call failed because of internal error
THREAD	6	The API call failed because of thread error
SERVER	7	The API call failed because of remote server error
NONCONVEX	8	The API call failed because of problem is nonconvex”

8.17 Client configuration

For floating and cluster clients, users are allowed to set client configuration parameters, currently available settings are:

- `COPT_CLIENT_CLUSTER`
IP address of cluster server.
- `COPT_CLIENT_FLOATING`
IP address of token server.
- `COPT_CLIENT_PASSWORD`
Password of cluster server.
- `CLIENT_PORT`
Connection port of token server.
- `COPT_CLIENT_WAITTIME`
Wait time of client.

8.18 Methods for accessing constants

In different programming interfaces, the ways of accessing constants are slightly different. In the C language interface, the constant name is prefixed with "COPT_" (like `COPT_MAXIMIZE`). For details, please refer to the corresponding chapters for each programming language API:

- C API: *C API Reference: Constants*
- C++ API: *C++ API Reference: Constants*
- C# API: *C# API Reference: General Constants*
- Java API: *Java API Reference: General Constants*
- Python API: *Python API Reference: General Constants*

Chapter 9

Attributes

To query and modify properties of a COPT model is through the attribute interface. A variety of different attributes are available, and they can be associated with solutions, or the model.

9.1 Problem related

Problem related attributes provide the relevant information of the model composition and description. The names and descriptions of these attributes are summarized below.

Table 9.1: Problem related attributes

Name	Type	Description
<i>Cols</i>	Integer	Number of variables (columns) in the problem
<i>PSDCols</i>	Integer	Number of PSD variables in the problem
<i>Rows</i>	Integer	Number of constraints (rows) in the problem
<i>Elms</i>	Integer	Number of non-zero elements in the coefficient matrix
<i>QElms</i>	Integer	Number of non-zero quadratic elements in the quadratic objective function
<i>PSDElms</i>	Integer	Number of PSD terms in objective function
<i>SymMats</i>	Integer	Number of symmetric matrices in the problem
<i>Bins</i>	Integer	Number of binary variables
<i>Ints</i>	Integer	Number of integer variables
<i>Soss</i>	Integer	Number of SOS constraints
<i>Cones</i>	Integer	Number of Second-Order-Cone constraints
<i>ExpCones</i>	Integer	Number of exponential cone constraints
<i>AffineCones</i>	Integer	Number of affine cone constraints
<i>QConstrs</i>	Integer	Number of quadratic constraints
<i>PSDConstrs</i>	Integer	Number of PSD constraints
<i>LMIconstrs</i>	Integer	Number of LMI constraints
<i>Indicators</i>	Integer	Number of indicator constraints
<i>ObjSense</i>	Integer	The optimization direction
<i>ObjConst</i>	Double	The constant part of the objective function
<i>HasQObj</i>	Integer	Whether the problem has quadratic objective function
<i>HasPSDObj</i>	Integer	Whether the problem has PSD terms in objective function
<i>IsMIP</i>	Integer	Whether the problem is a MIP

- **Cols**

Integer attribute.

Number of variables (columns) in the problem.

- **PSDCols**
Integer attribute.
Number of PSD variables in the problem.
- **Rows**
Integer attribute.
Number of constraints (rows) in the problem.
- **Elms**
Integer attribute.
Number of non-zero elements in the coefficient matrix.
- **QElms**
Integer attribute.
Number of non-zero quadratic elements in the quadratic objective function.
- **PSDElems**
Integer attribute.
Number of PSD terms in objective function.
- **SymMats**
Integer attribute.
Number of symmetric matrices in the problem.
- **Bins**
Integer attribute.
Number of binary variables.
- **Ints**
Integer attribute.
Number of integer variables.
- **Soss**
Integer attribute.
Number of SOS constraints.
- **Cones**
Integer attribute.
Number of Second-Order-Cone constraints.
- **ExpCones**
Integer attribute.
Number of exponential cone constraints.
- **AffineCones**
Integer attribute.
Number of affine cone constraints.
- **QConstrs**
Integer attribute.
Number of quadratic constraints.

- **PSDConstrs**
Integer attribute.
Number of PSD constraints.
- **LMIconstrs**
Integer attribute.
Number of LMI (Linear Matrix Inequalities) constraints.
- **Indicators**
Integer attribute.
Number of indicator constraints.
- **ObjSense**
Integer attribute.
The optimization direction.
- **ObjConst**
Double attribute.
The constant part of the objective function.
- **HasQObj**
Integer attribute.
Whether the problem has quadratic objective function.
- **HasPSDObj**
Integer attribute.
Whether the problem has PSD terms in objective function.
- **IsMIP**
Integer attribute.
Whether the problem is a MIP.

9.2 Solution related

Solution related attributes provide the relevant information of the solution composition and description. The names and descriptions of these attributes are summarized below.

Table 9.2: Solution related attributes

Name	Type	Description
<i>LpStatus</i>	Integer	The LP status
<i>MipStatus</i>	Integer	The MIP status
<i>SimplexIter</i>	Integer	Number of simplex iterations performed
<i>BarrierIter</i>	Integer	Number of barrier iterations performed
<i>NodeCnt</i>	Integer	Number of explored nodes
<i>PoolSols</i>	Integer	Number of solutions in solution pool
<i>TuneResults</i>	Integer	Number of parameter tuning results
<i>HasLpSol</i>	Integer	Whether LP solution is available
<i>HasBasis</i>	Integer	Whether LP basis is available
<i>HasDualFarkas</i>	Integer	Whether the dual Farkas of an infeasible LP problem is available
<i>HasPrimalRay</i>	Integer	Whether the primal ray of an unbounded LP problem is available
<i>HasMipSol</i>	Integer	Whether MIP solution is available
<i>IISCols</i>	Integer	Number of bounds of columns in IIS
<i>IISRows</i>	Integer	Number of rows in IIS
<i>IISOSs</i>	Integer	Number of SOS constraints in IIS
<i>IISIndicators</i>	Integer	Number of indicator constraints in IIS
<i>HasIIS</i>	Double	Whether IIS is available
<i>HasFeasRelaxSol</i>	Integer	Whether feasibility LP-relaxation solution is available
<i>IsMinIIS</i>	Integer	Whether the computed IIS is minimal
<i>LpObjval</i>	Double	The LP objective value
<i>BestObj</i>	Double	Best integer objective value for MIP
<i>BestBnd</i>	Double	Best bound for MIP
<i>BestGap</i>	Double	Best relative gap for MIP
<i>FeasRelaxObj</i>	Double	Feasibility relaxation objective value
<i>SolvingTime</i>	Double	The time spent for the optimization (in seconds)

- **LpStatus**

Integer attribute.

The LP status. Please refer to *General Constants: Solution Status* for possible values.

- **MipStatus**

Integer attribute.

The MIP status. Please refer to *General Constants: Solution Status* for possible values.

- **SimplexIter**

Integer attribute.

Number of simplex iterations performed.

- **BarrierIter**

Integer attribute.

Number of barrier iterations performed.

- **NodeCnt**

Integer attribute.

Number of explored nodes.

- **PoolSols**

Integer attribute.

Number of solutions in solution pool.

- **TuneResults**

Integer attribute.

Number of parameter tuning results

- **HasLpSol**

Integer attribute.

Whether LP solution is available.

- **HasBasis**

Integer attribute.

Whether LP basis is available.

- **HasDualFarkas**

Integer attribute.

Whether the dual Farkas of an infeasible LP problem is available.

- **HasPrimalRay**

Integer attribute.

Whether the primal ray of an unbounded LP problem is available.

- **HasMipSol**

Integer attribute.

Whether MIP solution is available.

- **IISCols**

Integer attribute.

Number of bounds of columns in IIS.

- **IISRows**

Integer attribute.

Number of rows in IIS.

- **IISOSs**

Integer attribute.

Number of SOS constraints in IIS.

- **IISIndicators**

Integer attribute.

Number of indicator constraints in IIS.

- **HasIIS**

Integer attribute.

Whether IIS is available.

- **HasFeasRelaxSol**

Integer attribute.

Whether feasibility LP-relaxation solution is available.

- **IsMinIIS**

Integer attribute.

Whether the computed IIS is minimal.

- **LpObjval**

Double attribute.

The LP objective value.

- **BestObj**

Double attribute.

Best integer objective value for MIP.

- **BestBnd**

Double attribute.

Best bound for MIP.

- **BestGap**

Double attribute.

Best relative gap for MIP.

- **FeasRelaxObj**

Double attribute.

Feasibility relaxation objective value.

- **SolvingTime**

Double attribute.

The time spent for the optimization (in seconds).

9.3 Methods for accessing attributes

In different programming interfaces, the ways to access attributes are slightly different. For details, please refer to the corresponding chapters for each programming language API:

- C API: *C API Functions: Accessing attributes*
- C++ API: *C++ API Reference: Attributes*
- C# API: *C# API Reference: Attributes*
- Java API: *Java API Reference: Attributes*
- Python API: *Python API Reference: Attributes*

Chapter 10

Information

The information constants describe the relevant information of the model components (objective function, constraints and variables), solution results, and feasibility relaxation calculation results. This chapter will introduce the information constants provided by COPT and their meanings.

Table 10.1: COPT Information

Name	Type	Description
<i>Obj</i>	Double	Objective cost of columns
<i>LB</i>	Double	Lower bounds of columns or rows
<i>UB</i>	Double	Upper bounds of columns or rows
<i>Value</i>	Double	Solution of columns
<i>Slack</i>	Double	Solution of slack variables, also known as activities of constraints. Only available for LP problem
<i>Dual</i>	Double	Solution of dual variables. Only available for LP problem
<i>RedCost</i>	Double	Reduced cost of columns. Only available for LP problem
<i>DualFarkas</i>	Double	The dual Farkas for constraints of an infeasible LP problem
<i>PrimalRay</i>	Double	The primal ray for variables of an unbounded LP problem
<i>RelaxLB</i>	Double	Feasibility relaxation values for lower bounds of columns or rows
<i>RelaxUB</i>	Double	Feasibility relaxation values for upper bounds of columns or rows
<i>RelaxValue</i>	Double	Solutions for the original model variables (columns) in the feasibility relaxation model

Table 10.2: COPT Callback Information

Name	Type	Description
<i>BestObj</i>	Double	Current best objective
<i>BestBnd</i>	Double	Current best objective bound
<i>HasIncumbent</i>	Integer	Whether an incumbent is available
<i>Incumbent</i>	Double	Current best feasible solution
<i>MipCandObj</i>	Double	Objective value for current feasible solution candidate
<i>MipCandidate</i>	Double	Current feasible solution candidate
<i>RelaxSolObj</i>	Double	Current Objective of LP-relaxation
<i>RelaxSolution</i>	Double	Current solution of LP-relaxation
<i>NodeStatus</i>	Integer	The solution status of the LP-relaxation problem at the current node

10.1 Problem information

- Obj
 - Double information.
 - Objective cost of columns.
- LB
 - Double information.
 - Lower bounds of columns or rows.
- UB
 - Double information.
 - Upper bounds of columns or rows.

10.2 Solution information

- Value
 - Double information.
 - Solution of columns.
- Slack
 - Double information.
 - Solution of slack variables, also known as activities of constraints. Only available for LP problem.
- Dual
 - Double information.
 - Solution of dual variables. Only available for LP problem.
- RedCost
 - Double information.
 - Reduced cost of columns. Only available for LP problem.

10.3 Dual Farkas and primal ray

Advanced topic. When an LP is infeasible or unbounded, the solver can return the dual Farkas or primal ray to prove it.

- DualFarkas
 - Double information.
 - The dual Farkas for constraints of an infeasible LP problem. Please enable the parameter "ReqFarkasRay" to ensure that the dual Farkas is available when the LP is infeasible.
 - Without loss of generality, the concept of the dual Farkas can be conveniently demonstrated using an LP problem with general variable bounds and equality constraints: $Ax = 0$ and $l \leq x \leq u$. When the LP is infeasible, a dual Farkas vector y can prove that the system has conflict that $\max y^T Ax < y^T b = 0$. Computing $\max y^T Ax$: with the vector $\hat{a} = y^T A$, choosing variable bound $x_i = l_i$ when $\hat{a}_i < 0$ and $x_i = u_i$ when $\hat{a}_i > 0$ gives the maximal possible value of $y^T Ax$ for any x within their bounds.

Some application relies on the alternate conflict $\min \bar{y}^T Ax > \bar{y}^T b = 0$. This can be achieved by negating the dual Farkas, i.e. $\bar{y} = -y$ returned by the solver.

In very rare cases, the solver may fail to return a valid dual Farkas. For example when the LP problem slightly infeasible by tiny amount, which We recommend to study and to repair the infeasibility using FeasRelax instead.

- **PrimalRay**

Double information.

The primal ray for variables of an unbounded LP problem. Please enable the parameter "ReqFarkasRay" to ensure that the primal ray is available when an LP is unbounded.

For a minimization LP problem in the standard form: $\min c^T x, Ax = b$ and $x \geq 0$, a primal ray vector r satisfies that $r \geq 0, Ar = 0$ and $c^T r < 0$.

10.4 Feasibility relaxation information

- **RelaxLB**

Double information.

Feasibility relaxation values for lower bounds of columns or rows.

- **RelaxUB**

Double information.

Feasibility relaxation values for upper bounds of columns or rows.

- **RelaxValue**

Double information.

Solutions for the original model variables (columns) in the feasibility relaxation model.

10.5 Callback information

- **BestObj**

Double information.

Current best objective.

- **BestBnd**

Double information.

Current best objective bound.

- **HasIncumbent**

Integer information.

Whether an incumbent is available.

- **Incumbent**

Double information.

Current best feasible solution.

- **MipCandObj**

Double information.

Objective value for current feasible solution candidate.

- **MipCandidate**
Double information.
Current feasible solution candidate.
- **RelaxSolObj**
Double information.
Current Objective of LP-relaxation.
- **RelaxSolution**
Double information.
Current solution of LP-relaxation.
- **NodeStatus**
Integer information.
The solution status of the LP-relaxation problem at the current node. For possible values, please refer to: *General Constants Chapter: Solution Status (Part)*, except for NODELIMIT, UNSTARTED, INF_OR_UNB .

10.6 Methods for accessing information

In different programming interfaces, the ways to access and set information are slightly different. For details, please refer to the corresponding chapters for each programming language API:

- C API: *C API Functions: Accessing information of problem*
- C# API: *C# API Reference: Information*
- Java API: *Java API Reference: Information*
- Python API: *Python API Reference: Information*

Chapter 11

Parameters

Parameters control the operation of the **Cardinal Optimizer**. They can be modified before the optimization begins. Each parameter has its own default value and value range. Before starting the solution, user can set the parameters to different values, so as to put forward specific requirements on the solution algorithm and solution process. Of course, the default settings can also be maintained.

According to the task performed by the solver COPT and the optimization problem solved, it can be divided into different types of parameters.

This chapter will introduce the parameters constants provided by COPT and their meanings.

11.1 Limits and tolerances

Table 11.1: Limits and tolerances parameters

Name	Type	Description
<i>TimeLimit</i>	Double	Time limit of the optimization
<i>SolTimeLimit</i>	Double	Time limit if a primal feasible solution has been found
<i>NodeLimit</i>	Integer	Node limit of the optimization
<i>BarIterLimit</i>	Integer	Iteration limit of barrier method
<i>MatrixTol</i>	Double	Input matrix coefficient tolerance
<i>FeasTol</i>	Double	The feasibility tolerance
<i>DualTol</i>	Double	The tolerance for dual solutions and reduced cost
<i>IntTol</i>	Double	The integrality tolerance for variables
<i>RelGap</i>	Double	The relative gap of optimization
<i>AbsGap</i>	Double	The absolute gap of optimization

- **TimeLimit**

Double parameter.

Time limit of the optimization.

Default: 1e20

Minimal: 0

Maximal: 1e20

- **SolTimeLimit**

Double parameter.

Time limit if a primal feasible solution has been found.

Default: 1e20

Minimal: 0

Maximal: 1e20

- **NodeLimit**

Integer parameter.

Node limit of the optimization.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

- **BarIterLimit**

Integer parameter.

Iteration limit of barrier method.

Default: 500

Minimal: 0

Maximal: INT_MAX

- **MatrixTol**

Double parameter.

Input matrix coefficient tolerance.

Default: 1e-10

Minimal: 0

Maximal: 1e-7

- **FeasTol**

Double parameter.

The feasibility tolerance.

Default: 1e-6

Minimal: 1e-9.

Maximal: 1e-4

- **DualTol**

Double parameter.

The tolerance for dual solutions and reduced cost.

Default: 1e-6

Minimal: 1e-9

Maximal: 1e-4

- **IntTol**

Double parameter.

The integrality tolerance for variables.

Default: 1e-6

Minimal: 1e-9

Maximal: 1e-1

- **RelGap**

Double parameter.

The relative gap of optimization.

Default: 1e-4

Minimal: 0

Maximal: DBL_MAX

- AbsGap

Double parameter.

The absolute gap of optimization.

Default: 1e-6

Minimal: 0

Maximal: DBL_MAX

11.2 Presolving and scaling

Table 11.2: Presolving and scaling parameters

Name	Type	Description
<i>Presolve</i>	Integer	Level of presolving before solving a model
<i>Scaling</i>	Integer	Whether to perform scaling before solving a problem
<i>Dualize</i>	Integer	Whether to dualize a problem before solving it

- Presolve

Integer parameter.

Level of presolving before solving a model.

Default: -1

Possible values:

-1: Choose automatically.

0: Off.

1: Fast.

2: Normal.

3: Aggressive.

4: No Limitations, continues until the model cannot be modified (may be very time-consuming).

- Scaling

Integer parameter.

Whether to perform scaling before solving a problem.

Default: -1

Possible values:

-1: Choose automatically.

0: No scaling.

1: Apply scaling.

- Dualize

Integer parameter.

Whether to dualize a problem before solving it.

Default: -1

Possible values:

-1: Choose automatically.

0: No dualizing.

1: Dualizing the problem.

11.3 Linear programming related

Table 11.3: Linear programming related parameters

Name	Type	Description
<i>LpMethod</i>	Integer	Method to solve the LP problem
<i>DualPrice</i>	Integer	Specifies the dual simplex pricing algorithm
<i>DualPerturb</i>	Integer	Whether to allow the objective function perturbation when using the dual simplex method
<i>BarHomogeneous</i>	Integer	Whether to use homogeneous self-dual form in barrier
<i>BarOrder</i>	Integer	Ordering algorithm in barrier method
<i>BarStart</i>	Integer	Algorithm for finding initial points in barrier method
<i>Crossover</i>	Integer	Whether to use crossover
<i>ReqFarkasRay</i>	Integer	Advanced topic. Whether to compute the dual Farkas or primal ray when the LP is infeasible or unbounded

- **LpMethod**

Integer parameter.

Method to solve the LP problem.

Default: -1

Possible values:

-1: Choose automatically.

For Linear Programming, choose dual simplex method;

For Mixed Integer Linear Programming, choose dual simplex or barrier method.

1: Dual simplex.

2: Barrier.

3: Crossover.

4: Concurrent (Use simplex and barrier simultaneously).

5: Choose between simplex and barrier automatically (Based on features such as sparsity and/or coefficients ranges).

6: First-order method (PDLP).

Note:

Currently, COPT's GPU mode only supports solving Linear Programming problems using the first-order method (PDLP). To enable it, you need to set `LpMethod=6` first.

- **DualPrice**

Integer parameter.

Specifies the dual simplex pricing algorithm.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Using Devex pricing algorithm.
- 1: Using dual steepest-edge pricing algorithm.

- **DualPerturb**

Integer parameter.

Whether to allow the objective function perturbation when using the dual simplex method.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No perturbation.
- 1: Allow objective function perturbation.

- **BarHomogeneous**

Integer parameter.

Whether to use homogeneous self-dual form in barrier.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No.
- 1: Yes.

- **BarOrder**

Integer parameter.

Ordering algorithm in barrier method.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Approximate Minimum Degree (AMD).
- 1: Nested Dissection (ND).

- **BarStart**

Integer parameter.

Algorithm for finding initial points in barrier method.

Default: -1

Possible values:

-1: Choose automatically.

0: Simple.

1: Mehrotra.

2: Modified Mehrotra.

- Crossover

Integer parameter.

Whether to use crossover.

Default: 1

Possible values:

-1: Choose automatically.

Only run crossover when the LP solution is not primal-dual feasible.

0: No.

1: Yes.

- ReqFarkasRay

Integer parameter.

Advanced topic. Whether to compute the dual Farkas or primal ray when the LP is infeasible or unbounded.

Default: 0

Possible values:

0: No.

1: Yes.

11.4 Integer Programming related

Table 11.4: Integer programming related parameters

Name	Type	Description
<i>CutLevel</i>	Integer	Level of cutting-planes generation
<i>RootCutLevel</i>	Integer	Level of cutting-planes generation of root node
<i>TreeCutLevel</i>	Integer	Level of cutting-planes generation of search tree
<i>RootCutRounds</i>	Integer	Rounds of cutting-planes generation of root node
<i>NodeCutRounds</i>	Integer	Rounds of cutting-planes generation of search tree node
<i>HeurLevel</i>	Integer	Level of heuristics
<i>RoundingHeurLevel</i>	Integer	Level of rounding heuristics
<i>DivingHeurLevel</i>	Integer	Level of diving heuristics
<i>SubMipHeurLevel</i>	Integer	Level of Sub-MIP heuristics
<i>FAPHeurLevel</i>	Integer	Level of Fix-and-propagate heuristics
<i>StrongBranching</i>	Integer	Level of strong branching
<i>ConflictAnalysis</i>	Integer	Whether to perform conflict analysis
<i>MipStartMode</i>	Integer	Mode of MIP starts
<i>MipStartNodeLimit</i>	Integer	Limit of nodes for MIP start sub-MIPs

- CutLevel

Integer parameter.

Level of cutting-planes generation.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal
- 3: Aggressive

- **RootCutLevel**

Integer parameter.

Level of cutting-planes generation of root node.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal
- 3: Aggressive

- **TreeCutLevel**

Integer parameter.

Level of cutting-planes generation of search tree.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal
- 3: Aggressive

- **RootCutRounds**

Integer parameter.

Rounds of cutting-planes generation of root node.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

- **NodeCutRounds**

Integer parameter.

Rounds of cutting-planes generation of search tree node.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

- **HeurLevel**

Integer parameter.

Level of heuristics.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal
- 3: Aggressive

- **RoundingHeurLevel**

Integer parameter.

Level of rounding heuristics.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal
- 3: Aggressive

- **DivingHeurLevel**

Integer parameter.

Level of diving heuristics.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal
- 3: Aggressive

- **SubMipHeurLevel**

Integer parameter.

Level of Sub-MIP heuristics.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Off
- 1: Fast
- 2: Normal

3: Aggressive

- **FAPHeurLevel**

Integer parameter.

Level of Fix-and-propagate heuristics.

Default: -1

Possible values:

-1: Choose automatically.

0: Off

1: Fast

2: Normal

3: Aggressive

- **StrongBranching**

Integer parameter.

Level of strong branching.

Default: -1

Possible values:

-1: Choose automatically.

0: Off

1: Fast

2: Normal

3: Aggressive

- **ConflictAnalysis**

Integer parameter.

Whether to perform conflict analysis.

Default: -1

Possible values:

-1: Choose automatically.

0: No

1: Yes

- **MipStartMode**

Integer parameter.

Mode of MIP starts.

Default: -1

Possible values:

-1: Choose automatically.

0: Do not use any MIP starts.

1: Only load full and feasible MIP starts.

2: Only load feasible ones (complete partial solutions by solving subMIPs).

- **MipStartNodeLimit**

Integer parameter.

Limit of nodes for MIP start sub-MIPs.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

11.5 Semidefinite Programming related

- SDPMethod

Integer parameter.

Method to solve the SDP problem.

Default: -1

Possible values:

-1: Choose automatically.

0: Primal-Dual method.

1: ADMM method.

2: Dual method.

11.6 Nonlinear Programming related

Nonlinear programming parameters control the workflow of nonlinear programming solvers.

Table 11.5: Overview of Nonlinear Programming Parameters

Parameter	Type	Description
<i>NLPTol</i>	Double	Optimal relative tolerance for nonlinear programming
<i>NonConvex</i>	Integer	Handling strategy for nonconvex models
<i>NLPMuUpdate</i>	Integer	Barrier parameter update strategy of the nonlinear solver
<i>NLPLinScale</i>	Integer	Linear system scaling strategy of the nonlinear solver
<i>NLPIterLimit</i>	Integer	Iteration limit for the nonlinear solver

- NLPTol

Double parameter.

Optimal relative tolerance for nonlinear programming.

Default: 1e-8

Minimum: 1e-13

Maximum: 1e-3

- NonConvex

Integer parameter.

Handling strategy for nonconvex models.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Report nonconvexity and terminate.
- 1: Search for a local optimal solution.

- **NLPMuUpdate**

Integer parameter.

Barrier parameter update strategy of the nonlinear solver.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Monotonically decreasing.
- 1: Adaptive adjustment.

- **NLPLinScale**

Integer parameter.

Linear system scaling strategy of the nonlinear solver.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No scaling.
- 1: Always scale.

- **NLPIterLimit**

Integer parameter.

Iteration limit for the nonlinear solver.

Default: 1e4

Minimum: 0

Maximum: INT_MAX

11.7 Parallel computing related

Table 11.6: Parallel computing related parameters

Name	Type	Description
<i>Threads</i>	Integer	Number of threads to use
<i>BarThreads</i>	Integer	Number of threads used by barrier. If value is -1, the thread count is determined by parameter Threads
<i>SimplexThreads</i>	Integer	Number of threads used by dual simplex. If value is -1, the thread count is determined by parameter Threads
<i>CrossoverThreads</i>	Integer	Number of threads used by crossover. If value is -1, the thread count is determined by parameter Threads
<i>MipTasks</i>	Integer	Number of MIP tasks in parallel

- **Threads**

Integer parameter.

Number of threads to use.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 128

- BarThreads

Integer parameter.

Number of threads used by barrier. If value is -1, the thread count is determined by parameter **Threads**.

Default: -1

Minimal: -1

Maximal: 128

- SimplexThreads

Integer parameter.

Number of threads used by dual simplex. If value is -1, the thread count is determined by parameter **Threads**.

Default: -1

Minimal: -1

Maximal: 128

- CrossoverThreads

Integer parameter.

Number of threads used by crossover. If value is -1, the thread count is determined by parameter **Threads**.

Default: -1

Minimal: -1

Maximal: 128

- MipTasks

Integer parameter.

Number of MIP tasks in parallel.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 256

11.8 GPU computing related

- **GPUMode**

Integer parameter.

Usage mode of the GPU solver.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Force the use of CPU mode.
- 1: Utilize NVIDIA GPU.

Notes

1. The current GPU mode of COPT only supports Linear Programming problems, and the First-order method (PDLP) needs to be selected, that is, the GPU mode only works when **LpMethod=6** is set.
 2. For Windows and Linux-x86 systems, when **GPUMode** is set to the default value or 1, COPT will attempt to detect whether it can successfully load the CUDA library required for GPU solver and whether there is a GPU supporting device. If both checks succeed, the GPU mode of COPT will be used for computation. If it fails, the CPU mode of COPT will continue to be used. The printed information when COPT is started varies slightly between the two scenarios.
 3. For MacOS, Linux-aarch64 and other systems, only the CPU mode of COPT is available. Even if **GPUMode** is set to 1, COPT will still launch the CPU mode for computation. The printed information during COPT startup differs slightly between the two scenarios.
 4. Deploying the CUDA library is not the necessary dependency for running COPT. If **LpMethod=6** is not set (First-order method PDLP is not applied), the GPU mode will not be utilized, the installation of the CUDA library does not impact the functionality of COPT.
-

- **GPUDevice**

Integer parameter.

Utilize the GPU with the specified device ID (in cases where the running machine has multiple GPUs).

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

d .. **_PDLPTol:**

- **PDLPTol**

Double parameter.

Convergence tolerance for the first-order method (PDLP).

Default: 1e-6

Minimal: 1e-12

Maximal: 1e-4

11.9 IIS computation related

- **IISMethod**

Integer parameter.

Method for IIS computation.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Find smaller IIS.
- 1: Find IIS quickly.

11.10 Feasibility relaxation related

- **FeasRelaxMode**

Integer parameter.

Method for feasibility relaxation.

Default: 0

Possible values:

- 0: Minimize sum of violations.
- 1: Optimize original objective function under minimal sum of violations.
- 2: Minimize number of violations.
- 3: Optimize original objective function under minimal number of violations.
- 4: Minimize sum of squared violations.
- 5: Optimize original objective function under minimal sum of squared violations.

Notices:

- Either **FeasRelaxMode=4** or **FeasRelaxMode=5** does not support MILP but only LP. Other methods support both two types of problems.
-

11.11 Parameter Tuning related

Table 11.7: Tuner related parameters

Name	Type	Description
<i>TuneTimeLimit</i>	Double	Time limit for parameter tuning
<i>TuneTargetTime</i>	Double	Time target for parameter tuning
<i>TuneTargetRelGap</i>	Double	Optimal relative tolerance target for parameter tuning
<i>TuneMethod</i>	Integer	Method for parameter tuning
<i>TuneMode</i>	Integer	Mode for parameter tuning
<i>TuneMeasure</i>	Integer	Parameter tuning result calculation method
<i>TunePermutes</i>	Integer	Permutations for each trial parameter set
<i>TuneOutputLevel</i>	Integer	Parameter tuning log output intensity

- **TuneTimeLimit**

Double parameter.

Time limit for parameter tuning. If the parameter value is 0, it will automatically set by the solver.

Default: 0

Minimal: 0

Maximal: 1e20

- **TuneTargetTime**

Double parameter.

Time target for parameter tuning.

Default: 1e-2

Minimal: 0

Maximal: DBL_MAX

- **TuneTargetRelGap**

Double parameter.

Optimal relative tolerance target for parameter tuning.

Default: 1e-4

Minimal: 0

Maximal: DBL_MAX

- **TuneMethod**

Integer parameter.

Method for parameter tuning.

Default: -1

Possible values:

-1: Choose automatically.

0: Greedy search strategy.

1: Broader search strategy.

- **TuneMode**

Integer parameter.

Mode for parameter tuning.

Default: -1

Possible values:

-1: Choose automatically.

0: Solving time.

1: Optimal relative tolerance.

2: Objective function value.

3: The lower bound of the objective function value.

- **TuneMeasure**

Integer parameter.

Parameter tuning result calculation method.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Calculate the average value.
- 1: Calculate the maximum value.

- **TunePermutates**

Integer parameter.

Permutations for each trial parameter set. If the parameter value is 0, it will automatically set by the solver.

Default: 0

Minimal: 0

Maximal: INT_MAX

- **TuneOutputLevel**

Integer parameter.

Parameter tuning log output level.

Default: 2

Possible values:

- 0: No output of tuning log.
- 1: Output only a summary of the improved parameters.
- 2: Output a summary of each tuning attempt.
- 3: Output a detailed log of each tuning attempt.

11.12 Callback related

- **LazyConstraints**

Integer parameter.

Whether lazy constraints are part of the model.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No.
- 1: Yes.

Notes

- This parameter only affects MIP.
-

11.13 Other parameters

- Logging

Integer parameter.

Whether to print optimization logs.

Default: 1

Possible values:

0: No optimization logs.

1: Print optimization logs.

- LogToConsole

Integer parameter.

Whether to print optimization logs to console.

Default: 1

Possible values:

0: No optimization logs to console.

1: Print optimization logs to console.

11.14 Methods for accessing and setting parameters

In different programming interfaces, the ways to access and set parameters are slightly different. For details, please refer to the corresponding chapters for each programming language API:

- C API: *C API Functions: Accessing and setting parameters*
- C++ API: *C++ API Reference: Parameters*
- C# API: *C# API Reference: Parameters*
- Java API: *Java API Reference: Parameters*
- Python API: *Python API Reference: Parameters*

Chapter 12

Modeling and Solving Optimization Problems

This chapter will introduce how to model and solve different types of optimization problems using the COPT solver. The content of the chapter is structured as follows:

- *Linear Programming (LP)*
- *Second-Order Cone Programming (SOCP)*
- *Exponential Cone*
- *Semidefinite Programming (SDP)*
- *Quadratic Programming (QP)*
- *Quadratically Constrained Programming (QCP)*
- *Mixed-Integer Programming (MIP)*
- *Special Constraints*

The types of problems and corresponding optimization algorithms currently supported by the COPT solver are shown in Table 12.1:

Table 12.1: Types of Problems and Algorithms Supported by COPT

Problem type	Available algorithms
Linear Programming (LP)	Dual simplex; Barrier; First-Order Method
Second-Order-Cone Programming (SOCP)	Barrier
Exponential Cone Programming (ExpCone)	Barrier
Convex Quadratic Programming (QP)	Barrier
Convex Quadratically Constrained Programming (QCP)	Barrier
Semidefinite Programming (SDP)	Barrier; ADMM
Mixed Integer Linear Programming (MILP)	Branch-and-Cut
Mixed Integer Second-Order-Cone Programming (MISOCP)	Branch-and-Cut
Mixed Integer Convex Quadratic Programming (MIQP)	Branch-and-Cut
Mixed Integer Convex Quadratically Constrained Programming (MIQCP)	Branch-and-Cut

COPT supports three methods of inputting optimization problems: model file reader, programming interface, and third-party tools.

1. For model file input, please refer to *File Formats*.
2. The programming language interfaces supported by COPT include:

- C
 - Python
 - C++
 - C#
 - Java
 - Fortran
3. The main third-party tools interfaces currently supported by COPT include:
- AMPL
 - AIMMS
 - GAMS
 - Julia
 - Pyomo
 - PuLP
 - CVXPY

12.1 Linear Programming (LP)

Linear Programming, as the most fundamental and important branch of operations research, has a wide range of applications. The objective function and constraints of a linear programming problem are both linear.

12.1.1 Mathematical Model

The mathematical formulation is as follows:

$$\begin{aligned}
 \min \quad & \sum_{i=0}^{m-1} c_i x_i + c^f \\
 \text{s.t.} \quad & l_i^c \leq \sum_{j=0}^{n-1} a_{ij} x_j \leq u_i^c, \quad i = 1, 2, \dots, m-1 \\
 & l_j^v \leq x_j \leq u_j^v, \quad j = 1, 2, \dots, n-1
 \end{aligned} \tag{12.1}$$

Alternatively, the model can be concisely expressed using vectors and matrices:

$$\begin{aligned}
 \min \quad & c^T x + c^f \\
 \text{s.t.} \quad & l^c \leq A x \leq u^c \\
 & l^v \leq x \leq u^v
 \end{aligned} \tag{12.2}$$

The variables and parameters in the model have the following meanings:

- Problem size: m represents the number of constraints, and n represents the number of decision variables.
- Decision variables: $x = (x_j)_{j=0}^{n-1} \in \mathbb{R}^n$
- Variable bounds: $l^v, u^v \in \mathbb{R}^n$, where l^v represents the lower bounds and u^v represents the upper bounds of the variables.
- Constraint bounds: $l^c, u^c \in \mathbb{R}^m$, where l^c represents the lower bounds and u^c represents the upper bounds of the constraints.

- Coefficient matrix for linear constraints: $A = (a_{ij})_{m \times n} \in \mathbb{R}^{m \times n}$
- Coefficients of variables in the objective function: $c \in \mathbb{R}^n$ represents the coefficients of the variables in the objective function, and c^f represents the constant term in the objective function.

12.1.2 Modeling

The basic steps to build and solve a Linear Programming (LP) model in COPT are as follows:

1. Create the COPT environment and model.
2. Add required data.
3. Construct the linear programming model:
 - Add decision variables.
 - Add linear constraints.
 - Set the linear objective function.
4. Set optimization parameters and solve the model.
5. Retrieve the solution results.

Modeling: Adding Linear Constraints

The COPT provides three methods to add linear constraints:

1. Add a single linear constraint to the model.
2. Batch add a group of linear constraints.
3. Add a single linear constraint with lower and upper bounds.

When adding linear constraints to the model, the main parameters that can be specified are:

- **expr/ builder** : Linear constraint expression or linear constraint builder.
- **sense**: Type of constraint. For possible values, please refer to *Constants Section: Constraint Type*.
- **name**: Name of the linear constraint.

If adding a linear constraint with bounds, the following must also be specified:

- **lb**: Lower bound of the linear constraint.
- **ub**: Upper bound of the linear constraint.

The implementation methods in different programming interfaces are shown in [Table 12.2](#):

Table 12.2: Functions for Adding Linear Constraints

API	Add a single constraint	Add a group of constraints in batch
C	COPT_AddRow	COPT_AddRows
C++	Model::AddConstr()	Model::AddConstrs()
C#	Model.AddConstr()	Model.AddConstrs()
Java	Model.addConstr()	Model.addConstrs()
Python	Model.addConstr()	Model.addConstrs()

Notes

- For linear constraint operations, the function names, calling methods, and **argument names may vary slightly** across different programming interfaces, but the functionality and argument meanings are consistent.

- COPT supports defining constraints using constraint types, but we **recommend defining constraints directly using bounds**.
 - In the C API, linear constraints are added using the coefficient matrix as an input argument.
 - In the Python API, an additional method for adding linear constraints with bounds is provided: `Model.addBoundConstr()`.
-

Linear Programming Problem Example

Maximize:

$$1.2x + 1.8y + 2.1z$$

Subject to:

$$1.5x + 1.2y + 1.8z \leq 2.6$$

$$0.8x + 0.6y + 0.9z \geq 1.2 \quad (12.3)$$

Bounds:

$$0.1 \leq x \leq 0.6$$

$$0.2 \leq y \leq 1.5$$

$$0.3 \leq z \leq 2.8$$

For corresponding code implementations in different programming interfaces, please refer to: *COPT Quick Start Section*.

In the programming interfaces provided by COPT, except for the C language, the other object-oriented programming interfaces (C#, C++, Java, Python) offer classes related to linear constraints:

- Encapsulation of operations related to linear constraints:
 1. **Constraint** class: Encapsulation of operations related to linear constraints in COPT.
 2. **ConstrArray** class: Facilitates operations on a group of **Constraint** class objects.
- Encapsulation of linear constraint builders:
 1. **ConstrBuilder** class: Encapsulation of linear constraint builders in COPT.
 2. **ConstrBuilderArray** class: Facilitates operations on a group of **ConstrBuilder** class objects.
- C++ API: `<chapCppApiRef_Constraint>` , *ConstrArray* , *ConstrBuilder Class* , *ConstrBuilderArray Class*
- C# API: *Constraint Class* , *ConstrArray Class* , *ConstrBuilder Class* , *ConstrBuilderArray Class*
- Java API: *Constraint Class* , *ConstrArray Class* , *ConstrBuilder Class* , *ConstrBuilderArray Class*
- Python API: *Constraint Class* , *ConstrArray Class* , *ConstrBuilder Class* , *ConstrBuilderArray Class*

12.1.3 Solving

For linear programming problems, the COPT solver provides the Simplex method and Barrier method. The specific method can be selected by setting the optimization parameter "LpMethod". By configuring other related optimization parameters for linear programming, you can control the detailed workflow of the solving algorithm. For more details, please refer to Parameter: Linear Programming Related.

For the solving logs of linear programming problems, please refer to *Logging Section: Simplex Method* and *Interior Point Method*.

12.1.4 Related Attributes and Information

Linear Programming Related Attributes

Attributes for linear programming are shown in Table 12.3:

Table 12.3: Attributes for Linear Programming

Name	Type	Description
Cols	Integer	Number of variables (columns) in the problem
Rows	Integer	Number of constraints (rows) in the problem
Elms	Integer	Number of non-zero elements in the coefficient matrix
LpObjval	Double	The LP objective value
SimplexIter	Integer	Number of simplex iterations performed
BarrierIter	Integer	Number of barrier iterations performed

Attributes for results of a linear programming problem are shown in Table 12.4:

Table 12.4: Attributes for Linear Programming Results

Name	Type	Description
LpStatus	Integer	The LP status
HasLpSol	Integer	Whether LP solution is available
HasBasis	Integer	Whether LP basis is available
LpObjval	Double	The LP objective value

For the results of a linear programming problem, COPT also provides relevant information constants, as shown in Table 12.5:

Table 12.5: Information for Linear Programming

Name	Type	Description
Slack	Double	Solution of slack variables, also known as activities of constraints. Only available for LP problem
Dual	Double	Solution of dual variables. Only available for LP problem
RedCost	Double	Reduced cost of columns. Only available for LP problem

For different programming interfaces, please refer to *Attributes* and *Information* sections to see how to access these attributes and information.

12.2 Second-Order Cone Programming (SOCP)

Second-Order Cone Programming (SOCP) is an optimization problem where the objective function is linear, and the constraints include second-order cone.

12.2.1 Mathematical Model

Second-Order Cone (SOC):

$$\mathcal{Q}^{n+1} = \{(t, x) \in \mathbb{R} \times \mathbb{R}^n \mid t \geq \|x\|_2\} \quad (12.4)$$

Second-Order Cone Constraint:

When $t \in \mathbb{R}$ and $x \in \mathbb{R}^n$ are decision variables, a constraint of the form $t \geq \|x\|_2$ is called a second-order cone constraint.

The mathematical formulation is as follows:

$$\begin{aligned}
 \min \quad & c^T x + c^f \\
 \text{s.t.} \quad & l^c \leq Ax \leq u^c \\
 & l^v \leq x \leq u^v \\
 & Fx + g \in \mathcal{Q}
 \end{aligned} \tag{12.5}$$

The variables and arguments in the model have the following meanings:

- Decision variables: $x = (x_j)_{j=0}^{n-1} \in \mathbb{R}^n$
- Decision variable bounds: $l^v, u^v \in \mathbb{R}^n$, where l^v represents the lower bounds, and u^v represents the upper bounds of the variables.
- Constraint boundaries: $l^c, u^c \in \mathbb{R}^m$, where l^c represents the lower bounds, and u^c represents the upper bounds of the linear constraints.
- Coefficient matrix of linear constraints: $A = (a_{ij})_{m \times n} \in \mathbb{R}^{m \times n}$
- Coefficients in the objective function: $c \in \mathbb{R}^n$ represents the coefficients of the variables in the objective function, and c^f represents the constant term in the objective function.
- Problem size: m represents the number of linear constraints, n represents the number of decision variables, and k represents the number of second-order cone constraints.

The following are the meanings of arguments related to the cone constraints:

- F : $F \in \mathbb{R}^{k \times n}$ is the coefficient matrix of the cone constraints.
- g : $g \in \mathbb{R}^k$ is the constant vector in the cone constraints.
- \mathcal{Q} : Represents the Cartesian product of k sets, $\mathcal{Q} = \mathcal{Q}_1 \times \mathcal{Q}_2 \times \cdots \times \mathcal{Q}_p$, where p represents the number of second-order cone constraints, and each $\mathcal{Q}_i, i \in \{1, 2, \cdots, p\}$ represents a second-order cone.

12.2.2 Modeling

The basic steps to construct and solve a Second-Order Cone Programming (SOCP) model in COPT are as follows:

1. Create the COPT environment and model.
2. Add required data.
3. Construct the SOCP model:
 - Add decision variables.
 - Add constraints (second-order cone constraints, linear constraints).
 - Set the objective function.
4. Set solver parameters and solve.
5. Retrieve the solution results.

Modeling: Adding Second-Order Cone Constraints

COPT supports modeling the following two types of second-order cone constraints:

Standard Second-Order Cone

$$\mathcal{Q}^n = \left\{ x \in \mathbb{R}^n \mid x_0 \geq \sqrt{\sum_{i=1}^{n-1} x_i^2}, x_0 \geq 0 \right\} \tag{12.6}$$

Constant representation: CONE_QUAD

Rotated Second-Order Cone

$$Q_r^n = \left\{ x \in \mathbb{R}^n \mid 2x_0x_1 \geq \sum_{i=2}^{n-1} x_i^2, x_0 \geq 0, x_1 \geq 0 \right\} \quad (12.7)$$

Constant representation: CONE_RQUAD

When adding second-order cone constraints to the model, the main function arguments that can be specified by the user are:

- **ctype**: The type of second-order cone constraint.
 - CONE_QUAD : Standard second-order cone.
 - CONE_RQUAD: Rotated second-order cone.
- **cvars**: Variables that form the second-order cone constraint.
- **dim**: Dimension of the second-order cone constraint.

The implementation in different programming interfaces is shown in the table below:

Table 12.6: Functions for Adding Second-Order Cone

API	Function
C	COPT_AddCones
C++	Model::AddCone()
C#	Model.addCone()
Java	Model.addCone()
Python	Model.addCone()

Note

- The function names, calling methods, and **argument names differ slightly** in different programming interfaces for operations related to modeling second-order cone constraints, but the functionality and argument meanings are consistent.
- When providing variables that form the second-order cone constraint, please input them sequentially according to their order in the constraint expression.
- In the C API, the members of the second-order cone constraints are provided in compressed row storage format. For more information on sparse matrix compressed storage in the C API, please refer to the specific example in the relevant section.
- In the Python API, an additional member method `Model.addConeByDim()` is provided for specifying the dimension of the second-order cone.

Example of Second-Order Cone Constraints

A standard second-order cone formed by x_4, x_1, x_2, x_3 :

$$x_4 \geq \sqrt{x_1^2 + x_2^2 + x_3^2} \quad (12.8)$$

A rotated second-order cone formed by x_3, x_4, x_1, x_2 :

$$2x_3x_4 \geq x_1^2 + x_2^2 \quad (12.9)$$

Taking the standard second-order cone formed by x_4, x_1, x_2, x_3 as an example, the code implementation in different programming interfaces is as follows:

C Interface:

```
int ncone = 1;
int conetype[] = {COPT_CONE_QUAD};
int conebeg[] = {0};
int conecnt[] = {4};
int coneind[] = {3, 0, 1, 2};
COPT_AddCones(prob, ncone, conetype, conebeg, conecnt, coneind)
```

C++ Interface:

```
VarArray cvars;
cvars.PushBack(x4);
cvars.PushBack(x1);
cvars.PushBack(x2);
cvars.PushBack(x3);
model.AddCone(cvars, COPT_CONE_QUAD);
```

C# Interface:

```
VarArray cvars = new VarArray();
cvars.PushBack(x4);
cvars.PushBack(x1);
cvars.PushBack(x2);
cvars.PushBack(x3);
model.AddCone(cvars, Copt.Consts.CONE_QUAD);
```

Java Interface:

```
VarArray cvars = new VarArray();
cvars.PushBack(x4);
cvars.PushBack(x1);
cvars.PushBack(x2);
cvars.PushBack(x3);
model.addCone(cvars, copt.Consts.CONE_QUAD);
```

Python Interface:

```
model.addCone([x4, x1, x2, x3], COPT.CONE_QUAD)
```

In the programming interfaces provided by COPT, with the exception of the C language, object-oriented programming interfaces (C#, C++, Java, Python) provide classes related to second-order cone constraints:

- **Encapsulation of operations related to second-order cone constraints:**
 1. **Cone** class: Encapsulation of operations related to second-order cone constraints in COPT.
 2. **ConeArray** class: Conveniently allows users to operate on a group of **Cone** objects.
- **Encapsulation of second-order cone constraint builders:**
 1. **ConeBuilder** class: Encapsulation of builders for constructing second-order cone constraints in COPT.
 2. **ConeBuilderArray** class: Conveniently allows users to operate on a group of **ConeBuilder** objects.
- C++ API: *Cone Class* , *ConeArray Class* , *ConeBuilder Class* , *ConeBuilderArray Class*
- C# API: *Cone Class* , *ConeArray Class* , *ConeBuilder Class* , *ConeBuilderArray Class*
- Java API: *Cone Class* , *ConeArray Class* , *ConeBuilder Class* , *ConeBuilderArray Class*
- Python API: *Cone Class* , *ConeArray Class* , *ConeBuilder Class* , *ConeBuilderArray Class*

Attributes Related to Second-Order Cone Constraints

- COPT_INTATTR_CONES or "Cones"

Integer attribute. The number of second-order cone constraints in the model.

This attribute provides the count of second-order cone constraints that have been added to the model. It can be useful for monitoring or validating the structure of the model during or after the modeling process.

12.3 Exponential Cone

12.3.1 Mathematical Formulation

COPT supports two types of exponential cone constraints:

- EXPCONE_PRIMAL : Primal exponential cone

$$\text{cl}(S_1) = S_1 \cup S_2 \quad (12.10)$$

$$S_1 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid s > 0, t \geq s \exp\left(\frac{r}{s}\right) \right\}, \quad (12.11)$$

$$S_2 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid s = 0, t \geq 0, r \leq 0 \right\}$$

- EXPCONE_DUAL : Dual exponential cone

$$\text{cl}(S_1) = S_1 \cup S_2 \quad (12.12)$$

$$S_1 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid r < 0, t \geq -r \exp\left(\frac{s}{r} - 1\right) \right\}, \quad (12.13)$$

$$S_2 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid r = 0, t \geq 0, s \geq 0 \right\}$$

12.3.2 Exponential Cone Example

Take $(u_1, 1, u_3) \in K_{\text{exp}}$ for example, which mathematical form is $u_1 \geq e^{u_3}$. The code implementation is as follows:

C Interface:

Please refer to the example code in the installation package `expcone_gp.c`.

Python Interface:

```
u1 = model.addVar(lb=-COPT.INFINITY)
u2 = model.addVar(lb=1.0, ub=1.0)
u3 = model.addVar(lb=-COPT.INFINITY)
model.addExpCone([u1, u2, u3], COPT.EXPCONE_PRIMAL)
```

C++ Interface:

```
Var u1 = model.AddVar(-COPT.INFINITY, +COPT.INFINITY, 0.0, COPT.CONTINUOUS, "u1");
Var u2 = model.AddVar(1.0, 1.0, 0.0, COPT.CONTINUOUS, "u2");
Var u3 = model.AddVar(-COPT.INFINITY, +COPT.INFINITY, 0.0, COPT.CONTINUOUS, "u3");
```

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```

VertexArray uconevars;
uconevars.PushBack(u1);
uconevars.PushBack(u2);
uconevars.PushBack(u3);
model.AddExpCone(uconevars, COPT_EXPCONE_PRIMAL);

```

C# Interface:

```

VertexArray uconevars = new VarArray();
uconevars.PushBack(u1);
uconevars.PushBack(u2);
uconevars.PushBack(u3);
model.AddExpCone(uconevars, Copt.Consts.EXPCONE_PRIMAL);

Var u1 = model.AddVar(-Copt.Consts.INFINITY, +Copt.Consts.INFINITY, 0.0, Copt.Consts.
    ↪CONTINUOUS, "u1");
Var u2 = model.AddVar(1.0, 1.0, 0.0, Copt.Consts.CONTINUOUS, "u2");
Var u3 = model.AddVar(-Copt.Consts.INFINITY, +Copt.Consts.INFINITY, 0.0, Copt.Consts.
    ↪CONTINUOUS, "u3");

```

Java Interface:

```

Var u1 = model.addVar(-copt.Consts.INFINITY, +copt.Consts.INFINITY, 0.0, copt.Consts.
    ↪CONTINUOUS, "u1");
Var u2 = model.addVar(1.0, 1.0, 0.0, copt.Consts.CONTINUOUS, "u2");
Var u3 = model.addVar(-copt.Consts.INFINITY, +copt.Consts.INFINITY, 0.0, copt.Consts.
    ↪CONTINUOUS, "u3");

VertexArray uconevars = new VarArray();
uconevars.pushBack(u1);
uconevars.pushBack(u2);
uconevars.pushBack(u3);
model.addExpCone(uconevars, copt.Consts.EXPCONE_PRIMAL);

```

12.4 Semidefinite Programming (SDP)

Semidefinite Programming (SDP) consists semidefinite variables and cone constraints.

12.4.1 Mathematical Model

Positive Semidefinite Cone:

Let \mathcal{S}^n denote the set of n -dimensional symmetric matrices, the positive semidefinite cone is defined as:

$$\mathcal{S}_+^n = \{X \in \mathcal{S}^n \mid u^T X u \geq 0, \forall u \in \mathbb{R}^n\} \quad (12.14)$$

Positive Semidefinite (PSD) Variable:

In an SDP model, the decision variable $X \in \mathcal{S}_+^n$, can also be denoted as $X \succeq 0$. This decision variable is referred to as a semidefinite variable. Besides, the linear constraints of the model include semidefinite variables.

Semidefinite Cone Constraint

In an SDP model, $X \succeq 0$ is commonly referred to as the **semidefinite cone constraint**, while a constraint of the form $A \bullet X = b$, which involves a semidefinite variable, is referred to as a linear

constraint consisting of PSD variables. For simplicity, in the following chapter, we will refer to it as the **semidefinite constraint** and distinguish it from the semidefinite cone constraint (i.e., $X \succeq 0$).

The mathematical form of semidefinite programming is as follows:

$$\begin{aligned}
 \min \quad & \sum_{j=0}^{n-1} c_j x_j + \sum_{j=0}^{p-1} C_j \bullet X_j + c^f \\
 \text{s.t.} \quad & l_i^c \leq \sum_{j=0}^{n-1} a_{ij} x_j + \sum_{j=0}^{p-1} A_j \bullet X_j \leq u_i^c, \quad i = 0, 1, \dots, m-1 \\
 & l_j^v \leq x_j \leq u_j^v, \quad j = 0, 1, \dots, n-1 \\
 & X_j \succeq 0, \quad j = 0, 1, \dots, p-1
 \end{aligned} \tag{12.15}$$

Here, the operator \bullet denotes the matrix inner product operation:

Given two matrices $A = \{a_{ij}\} \in \mathbb{R}^{m \times n}$ and $B = \{b_{ij}\} \in \mathbb{R}^{m \times n}$, the inner product of matrix A and matrix B is defined as:

$$A \bullet B = \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} a_{ij} b_{ij} \tag{12.16}$$

The variables and arguments in the model have the following meanings:

- Problem size: m denotes the number of constraints, n denotes the number of non-semidefinite variables, and p denotes the number of semidefinite variables.
- Decision variables: non-semidefinite variables $x = (x_j)_{j=0}^{n-1} \in \mathbb{R}^n$, semidefinite variables $X_j \in \mathcal{S}_+^{r_j}$ (for $j = 0, \dots, p-1$).
- Non-semidefinite variable range: $l^v, u^v \in \mathbb{R}^n$, where l^v denotes the lower bounds and u^v denotes the upper bounds of the non-semidefinite variables.
- Constraint boundaries: $l^c, u^c \in \mathbb{R}^m$, where l^c denotes the lower bounds and u^c denotes the upper bounds of the constraints.
- Coefficient matrix of the linear constraints: $A = (a_{ij})_{m \times n} \in \mathbb{R}^{m \times n}$, $A_j \in \mathbb{R}^{r_j \times r_j}$.
- Coefficients in the objective function: $c \in \mathbb{R}^n$ represents the coefficients of the non-semidefinite variables, $C_j \in \mathbb{R}^{r_j \times r_j}$ represents the coefficients of the semidefinite variables, and c^f represents the constant term in the objective function.

12.4.2 Modeling

The basic steps to construct and solve a semidefinite programming (SDP) model in COPT are as follows:

1. Create the COPT environment and model.
2. Add required data.
3. Construct the semidefinite programming model:
 - Add decision variables (semidefinite and non-semidefinite variables).
 - Add constraints (including semidefinite constraints).
 - Set the objective function.
4. Set optimization parameters and solve.
5. Retrieve the solution.

Modeling: Adding Semidefinite Variables and Semidefinite Constraints

In COPT, semidefinite variables are added by specifying the dimension (`dim`) of the semidefinite variables:

1. Add a single semidefinite variable.
2. Add multiple semidefinite variables.

COPT provides two ways to add semidefinite constraints:

1. First construct the semidefinite constraint expression by combining the semidefinite terms (semidefinite variables and their corresponding coefficient matrices) and the linear terms, and then add them to the model.
2. Directly provide the semidefinite constraint expression (or semidefinite constraint builder) as a argument input, and add it to the model.

When adding semidefinite constraints to the model, the main arguments that can be specified are:

- **expr / builder** : The semidefinite constraint expression or semidefinite constraint builder.
- **rhs** : The right-hand side of the semidefinite constraint.
- **sense** : The constraint type. For possible values, refer to *Constants Chapter: Constraint Type*.
- **name** : The name of the semidefinite constraint.

The implementation in different programming interfaces is shown in [Table 12.7](#):

Table 12.7: Functions for Adding Semidefinite Variables/Constraints

API	Add Semidefinite Variable	Add Semidefinite Constraint
C	COPT_AddPSDCol / COPT_AddPSDCols	COPT_AddPSDConstr
C++	Model::AddPsdVar() / Model.AddPsdVars()	Model::AddPsdConstr()
C#	Model.AddPsdVar() / Model.AddPsdVars()	Model.AddPsdConstr()
Java	Model.addPsdVar() / Model.addPsdVars()	Model.addPsdConstr()
Python	Model.addPsdVar() / Model.addPsdVars()	Model.addPsdConstr()

Notes

- Regarding the operations for modeling semidefinite variables and semidefinite constraints, the function names, calling methods, and **argument names differ slightly** among different programming interfaces, but the functionality and argument meanings are consistent.
 - In the C API, when adding semidefinite constraints, arguments such as the indices of the non-zero linear term coefficients and the semidefinite variable indices need to be provided. For more details, refer to function `COPT_AddPSDConstr`.
 - In the Python API, `Model.addConstr()` can be used to add a linear constraint, a semidefinite constraint, or an indicator constraint to the model. For more details, please refer to *Python API Functions: Model Class*.
-

Examples of PSD variables and PSD constraints

$$\begin{aligned} A \bullet X + x_1 + x_2 &= 0.6 \\ x_1 \geq 0, x_2 \geq 0, X \succeq 0 \end{aligned} \tag{12.17}$$

where

$$A = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} \tag{12.18}$$

The code implementation in different programming interfaces is as follows:

C API:

```

{
    /* Matrix A */
    int ndim = 3;
    int nelelem = 6;
    int rows[] = {0, 1, 2, 1, 2, 2};
    int cols[] = {0, 0, 0, 1, 1, 2};
    double elems[] = {1.0, 1.0, 1.0, 1.0, 1.0, 1.0};
    retcode = COPT_AddSymMat(prob, ndim, nelelem, rows, cols, elems);
    if (retcode) goto exit_cleanup;
}

/* Add PSD columns */
int nPSDCol = 1;
int colDims[] = {3};
retcode = COPT_AddPSDCols(prob, nPSDCol, colDims, NULL);
if (retcode) goto exit_cleanup;
/* Add columns */
int nCol = 2;
retcode = COPT_AddCols(prob, nCol, NULL, NULL, NULL, NULL, NULL, NULL,
NULL, NULL, NULL);
if (retcode) goto exit_cleanup;
/* Add PSD constraints */
{
    int nRowMatCnt = 2;
    int rowMatIdx[] = {0, 1};
    double rowMatElem[] = {1.0, 1.0};
    int nColCnt = 1;
    int psdColIdx[] = {0};
    int symMatIdx[] = {2};
    char cRowSense = COPT_EQUAL;
    double dRowBound = 0.6;
    retcode = COPT_AddPSDConstr(prob, nRowMatCnt, rowMatIdx, rowMatElem, nColCnt,
        psdColIdx, symMatIdx, cRowSense, dRowBound, 0.0, NULL);
    if (retcode) goto exit_cleanup;
}

```

C++ API:

```

SymMatrix A = model.AddOnesMat(3);
Var x1 = model.AddVar(0.0, COPT_INFINITY, 0, COPT_CONTINUOUS, "x1");
Var x2 = model.AddVar(0.0, COPT_INFINITY, 0, COPT_CONTINUOUS, "x2");
PsdVar barX = model.AddPsdVar(3, "X");
model.AddPsdConstr(A * barX + x1 + x2 == 0.6, "PSD_R");

```

C# API:

```

SymMatrix A = model.AddOnesMat(3);
Var x1 = model.AddVar(0.0, Copt.Consts.INFINITY, 0, Copt.Consts.CONTINUOUS, "x1");
Var x2 = model.AddVar(0.0, Copt.Consts.INFINITY, 0, Copt.Consts.CONTINUOUS, "x2");
PsdVar barX = model.AddPsdVar(3, "X");
model.AddPsdConstr(A * barX + x1 + x2 == 0.6, "PSD_R");

```

Java API:

```

SymMatrix A = model.addOnesMat(3);
Var x1 = model.addVar(0.0, copt.Consts.INFINITY, 0, copt.Consts.CONTINUOUS, "x1");
Var x2 = model.addVar(0.0, copt.Consts.INFINITY, 0, copt.Consts.CONTINUOUS, "x2");
PsdVar barX = model.addPsdVar(3, "X");

```

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```
PsdExpr pexpr = new PsdExpr(x1, 1.0);  
pexpr.addTerm(x2, 1.0);  
pexpr.addTerm(barX, A);  
model.addPsdConstr(pexpr, copt.Consts.EQUAL, 0.6, "PSD_R");
```

Python API:

```
A = m.addOnesMat(3)  
x1 = m.addVar(lb=0.0, ub=COPT.INFINITY, name="x1")  
x2 = m.addVar(lb=0.0, ub=COPT.INFINITY, name="x2")  
X = m.addPsdVars(3, "BAR_X")  
psdc = model.addConstr(A * X + x1 + x2 == 0.6, name="PSD_C")
```

In the programming interfaces provided by COPT, except for the C language, other object-oriented programming interfaces (C#, C++, Java, Python) offer classes related to semidefinite constraints:

- Encapsulation of operations for constructing semidefinite expressions
 1. **PsdExpr** Class: Encapsulation of operations related to the combination of semidefinite variables when constructing semidefinite expressions in COPT.
- Encapsulation of operations related to semidefinite constraints
 1. **PsdConstraint** Class: Encapsulation of operations related to semidefinite constraints in COPT.
 2. **PsdConstrArray** Class: Facilitates user operations on a group of **PsdConstraint** class objects.
- Encapsulation of semidefinite constraint builders
 1. **PsdConstrBuilder** Class: Encapsulation for constructing semidefinite constraint builders in COPT.
 2. **PsdConstrBuilderArray** Class: Facilitates user operations on a group of **PsdConstrBuilder** class objects.
- C++ API: *PsdExpr Class* , *PsdConstrArray Class* , *PsdConstrBuilder Class* , *PsdConstrBuilderArray Class*
- C# API: *PsdExpr Class* , *PsdConstraint Class* , *PsdConstrArray Class* , *PsdConstrBuilder Class* , *PsdConstrBuilderArray Class*
- Java API: *PsdExpr Class* , *PsdConstraint Class* , *PsdConstrArray Class* , *PsdConstrBuilder Class* , *PsdConstrBuilderArray Class*
- Python API: *PsdExpr Class* , *PsdConstraint Class* , *PsdConstrArray Class* , *PsdConstrBuilder Class* , *PsdConstrBuilderArray Class*

12.4.3 Solving

For SDP problems, COPT provides the Barrier method and the ADMM method. You can specify the solving method by setting the optimization parameter **SDPMethod**.

For more details, please refer to Parameter Section: Semidefinite Programming Related.

12.4.4 Related Attributes

Attributes related to SDP model are as shown in Table 12.8:

Table 12.8: Attributes for Semidefinite Variables and Constraints

Name	Type	Description
PSDCols	Integer	Number of PSD variables in the problem
PSDElems	Integer	Number of PSD terms in objective function
SymMats	Integer	Number of symmetric matrices in the problem
PSDConstrs	Integer	Number of PSD constraints
HasPSDObj	Integer	Whether the problem has PSD terms in objective function

12.5 Quadratic Programming (QP)

12.5.1 Mathematical Formulation

Convex Quadratic Programming (QP) has a convex quadratic objective function and linear constraints. The mathematical formulation is as follows:

$$\begin{aligned}
 \min \quad & x^T Q x + c^T x + c^f \\
 \text{s.t.} \quad & l_i^c \leq \sum_{j=0}^{n-1} a_{ij} x_j \leq u_i^c, \quad i = 0, \dots, m-1 \\
 & l_j^v \leq x_j \leq u_j^v, \quad j = 0, 1, \dots, n-1
 \end{aligned} \tag{12.19}$$

The variables and arguments in the model are defined as follows:

- Decision variables: $x = (x_j)_{j=0}^{n-1} \in \mathbb{R}^n$;
- Variable bounds: $l^v, u^v \in \mathbb{R}^n$; where l^v denotes the lower bounds and u^v denotes the upper bounds of the variables;
- Constraint bounds: $l^c, u^c \in \mathbb{R}^m$; where l^c denotes the lower bounds and u^c denotes the upper bounds of the constraints;
- Coefficient matrix of linear constraints: $A = (a_{ij})_{m \times n} \in \mathbb{R}^{m \times n}$
- Coefficients in the objective function:
 - $Q \in \mathbb{R}^{n \times n}$ represents the coefficients of the quadratic term in the objective function
 - $c \in \mathbb{R}^n$ represents the coefficients of the linear term in the objective function, and c^f represents the constant term in the objective function
- Problem size: m denotes the number of constraints, and n denotes the number of decision variables.

12.6 Quadratically Constrained Programming (QCP)

Convex Quadratically Constrained Programming (QCP) consists of convex quadratic constraints.

12.6.1 Mathematical Model

The mathematical formulation is as follows:

$$\begin{aligned}
 \min \quad & \frac{1}{2}x^T Qx + c^T x + c^f \\
 \text{s.t.} \quad & \frac{1}{2}x^T P_i x + a_i^T x_j \leq u_i^c, \quad i = 0, \dots, m-1 \\
 & l^v \leq x_j \leq u^v, \quad j = 0, 1, \dots, n-1
 \end{aligned} \tag{12.20}$$

The variables and parameters in the model are defined as follows:

- Decision variables: $x = (x_j)_{j=0}^{n-1} \in \mathbb{R}^n$;
- Variable bounds: $l^v, u^v \in \mathbb{R}^n$, where l^v denotes the lower bounds and u^v denotes the upper bounds of the variables;
- Constraint bounds: $u^c \in \mathbb{R}^m$, where u^c denotes the upper bounds of the constraints;
- Coefficients in the quadratic constraints:
 - $P_i \in \mathbb{R}^{n \times n}$ (for $i = 0, \dots, m-1$),
 - $a_i = (a_{ij})_n \in \mathbb{R}^n$;
- Coefficients in the objective function:
 - $Q \in \mathbb{R}^{n \times n}$ represents the coefficients of the quadratic term in the objective function;
 - $c \in \mathbb{R}^n$ represents the coefficients of the linear term in the objective function, and c^f represents the constant term in the objective function.
- Problem size: m denotes the number of constraints, and n denotes the number of decision variables.

Notes

- The COPT solver currently supports solving convex quadratic programming and convex quadratically constrained programming problems. The matrices Q and P_i (for $i = 0, 1, \dots, m$) must be **positive semidefinite**.
 - When the constraint type is \geq (of the form $\frac{1}{2}x^T P_i x + \sum_{j=0}^{n-1} a_{ij}x_j \geq l_i^c$), the matrix Q must be **negative semidefinite**.
 - As seen from the mathematical formulation above, the quadratic constraint expression includes quadratic terms, linear terms, and constant terms.
-

12.6.2 Modeling

The basic steps to construct and solve a Quadratically Constrained Programming (QCP) model in COPT are as follows:

1. Create a COPT environment and model.
2. Add model parameters.
3. Construct the QCP model:
 - Add variables.
 - Add quadratic constraints.
 - Set the quadratic objective function.
4. Set solving parameters and solve.
5. Retrieve the solution.

Modeling: Adding Quadratic Constraints

COPT provides two ways to add quadratic constraints:

1. First, construct the quadratic constraint expression by combining the quadratic and linear terms, then add it to the model.
2. Directly provide the quadratic constraint expression (or a quadratic constraint builder) as a parameter input and add it to the model.

When adding quadratic constraints to the model, the following parameters can be specified by the user:

- **expr / builder**: The quadratic constraint expression or quadratic constraint builder.
- **rhs**: The right-hand side of the quadratic constraint.
- **sense**: The type of constraint, which can be COPT_LESS_EQUAL or COPT_GREATER_EQUAL.
- **name**: The name of the quadratic constraint.

The implementation in different programming interfaces is shown in [Table 12.9](#):

Table 12.9: Functions for Adding Quadratic Constraints

Programming Interface	Function
C	COPT_AddQConstr
C++	Model::AddQConstr()
C#	Model.AddQConstr()
Java	Model.addQConstr()
Python	Model.addQConstr()

Note:

- The operations related to quadratic constraint modeling may vary slightly in terms of function names, calling methods, and **parameter names** in different programming interfaces, but the functionality and parameter meanings are consistent.
- In the C API, when adding a quadratic constraint, non-zero linear term coefficient indices, quadratic term indices, and other parameters must be provided. For more details, please refer to [C API Functions: Constructing and Modifying the Model](#) under the function COPT_AddQConstr.
- In the Python API, Model.addQConstr() can be used to add a quadratic constraint to the model. For more details, please refer to [Python API Functions: Model Class](#).

Examples of quadratic constraints

$$x_1^2 + x_2^2 + x_1 + 2x_2 \leq 0 \quad (12.21)$$

The code implementation in different programming interfaces is as follows:

C API:

```
int nRowMatCnt = 2;
int rowMatIdx[] = {0, 1};
double rowMatElem[] = {1.0, 2.0};

int nQMatCnt = 2;
int qMatRow[] = {0, 1};
int qMatCol[] = {0, 1};
double qMatElem[] = {1.0, 1.0};
char cRowSense = COPT_LESS_EQUAL;
double dRowBound = 0.0;
char *name = "q1";
```

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```
errcode = COPT_AddQConstr(prob, nRowMatCnt, rowMatIdx, rowMatElem,  
                          nQMatCnt, qMatRow, qMatCol, qMatElem,  
                          cRowSense, dRowBound, name);
```

C++ API:

```
model.AddQConstr(x1*x1 + x2*x2 + x1 + 2*x2 <= 0, "q1");
```

C# API:

```
model.AddQConstr(x1*x1 + x2*x2 + x1 + 2*x2 <= 0, "q1");
```

Java API:

```
QuadExpr q1 = new QuadExpr(0.0);  
q1.addTerm(x1, x1, 1);  
q1.addTerm(x2, x2, 1);  
q1.addTerm(x1, 1);  
q1.addTerm(x2, 2);  
model.addQConstr(q1, copt.Consts.LESS_EQUAL, 0, "q1");
```

Python API:

```
model.addQConstr(x1*x1 + x2*x2 + x1 + 2*x2 <= 0, name="q1")
```

In the programming interfaces provided by COPT, except for C language, other object-oriented programming interfaces (C#, C++, Java, Python) offer classes related to quadratic constraints:

- Encapsulation of operations for constructing quadratic expressions
 1. **QuadExpr Class**: Encapsulation of operations related to combining variables when constructing quadratic expressions in the COPT.
- Encapsulation of operations related to quadratic constraints
 1. **QConstraint Class**: Encapsulation of operations related to quadratic constraints in the COPT.
 2. **QConstrArray Class**: Facilitates user operations on a group of **QConstraint** class objects.
- Encapsulation of quadratic constraint builders
 1. **QConstrBuilder Class**: Encapsulation of builders for constructing quadratic constraints in the COPT.
 2. **QConstrBuilderArray Class**: Facilitates user operations on a group of **QConstrBuilder** class objects.
- C++ API: *QuadExpr Class* , *QConstraint Class* , *QConstrArray Class* , *QConstrBuilder Class* , *QConstrBuilderArray Class*
- C# API: *QuadExpr Class* , *QConstraint Class* , *QConstrArray Class* , *QConstrBuilder Class* , *QConstrBuilderArray Class*
- Java API: *QuadExpr Class* , *QConstraint Class* , *QConstrArray Class* , *QConstrBuilder Class* , *QConstrBuilderArray Class*
- Python API: *QuadExpr Class* , *QConstraint Class* , *QConstrArray Class* , *QConstrBuilder Class* , *QConstrBuilderArray Class*

12.6.3 Related Attributes

Attributes for Quadratic Programming (QP) and Quadratically Constrained Programming (QCP) models are shown in Table 12.10:

Table 12.10: Attributes for QP and QCP

Name	Type	Description
QConstrs	Integer	Number of quadratic constraints
QElem	Integer	Number of non-zero quadratic elements in the quadratic objective function
HasQObj	Integer	Whether the problem has quadratic objective function

12.7 General Nonlinear Programming (NLP)

COPT has added support for General Nonlinear Programming (NLP). Currently, users can use it in the following ways:

- For nonconvex quadratic programming(QP) and nonconvex quadratic constrained programming(QCP), the user can set the optimization parameter "NonConvex"=1 to solve the model.
- For other general nonlinear programming problems, the user can model and solve the problem via C API interface or use `coptamp1` to read the NL format model file and solve.

COPT has introduced support for general nonlinear programming (NLP) in its C API. Currently, the supported nonlinear expressions include:

- Basic arithmetic operations (addition, subtraction, multiplication, division)
- Trigonometric functions (sin, cos, tan, etc.)
- Exponential function (exp), power function (pow), logarithmic function (log), and root function (sqrt)

Additionally, COPT supports functions such as ceiling (ceil), floor (floor), and absolute value (abs). All nonlinear expression types supported by COPT's C API can be found in *Nonlinear Expression Operator Constants*.

Below is an example of a nonlinear programming model, where both constraints and the objective function contain nonlinear expressions:

Objective Function

$$\min \quad x_1 x_4 \left(\sin(x_1 + x_2) + \cos(x_2 x_3) + \tan\left(\frac{x_3}{x_4}\right) \right) + x_3 \quad (12.22)$$

Constraints

$$\begin{aligned} x_1 x_2 x_3 x_4 + x_1 + x_2 &\geq 35 \\ \log(x_1) + 2\log(x_2) + 3\log(x_3) + 4\log(x_4) + x_3 + x_4 &\geq 15 \\ x_1^2 + x_2^2 + x_3^2 + x_4^2 + x_1 + x_3 &\geq 50 \end{aligned} \quad (12.23)$$

Variable Bounds

$$1 \leq x_1, x_2, x_3, x_4 \leq 5 \quad (12.24)$$

Currently, users can model and solve nonlinear programming problems using COPT's C API. Future updates will include support for other object-oriented APIs.

For reference, the above model is implemented in the example code "`\examples\c\nlp_ex1.c`" within the COPT installation package.

12.8 Mixed-Integer Programming (MIP)

12.8.1 Modeling

Mixed-Integer Programming (MIP) refers to optimization problems where some of the decision variables are restricted to integer values. Currently, COPT supports integer variables combined with linear programming, second-order cone programming, quadratic programming, and quadratically constrained programming.

MIP Problem Type	Solving Algorithm
MILP	Branch-and-Cut
MISOCP	Branch-and-Cut
MIQP	Branch-and-Cut
MIQCP	Branch-and-Cut

In COPT, the supported integer variable types and their corresponding constants are as follows:

- **BINARY**

Binary variable (0-1 variable)

- **INTEGER**

Integer variable

When adding decision variables to the model:

- Specify the parameter `vtype` as **BINARY** to add 0-1 variables;
- Specify the parameter `vtype` as **INTEGER** to add integer variables.

12.8.2 Solving

For integer programming problems, COPT provides the Branch-and-Cut algorithm, which can be specified by setting the optimization parameter "MipMethod". By configuring other related optimization parameters, you can control the specific workflow of the Branch-and-Cut algorithm. For more details, please refer to Parameter Section: Integer Programming Related.

For the solving logs of integer programming problems, please refer to *Logging Section: Branch-and-Cut*.

12.8.3 Related Attributes

Table 12.11: Overview of attributes for MIP

Name	Type	Description
Bins	Integer	Number of binary variables
Ints	Integer	Number of integer variables
Indicators	Integer	Number of indicator constraints
IsMIP	Integer	Whether the problem is a MIP
NodeCnt	Integer	Number of explored nodes
HasMipSol	Integer	Whether MIP solution is available
BestObj	Double	Best integer objective value for MIP
BestBnd	Double	Best bound for MIP
BestGap	Double	Best relative gap for MIP

12.9 Special Constraints

COPT supports the construction of two types of special constraints: SOS constraints and Indicator constraints.

12.9.1 SOS Constraints

SOS constraints (Special Ordered Set) are a special type of constraint that restricts the values of a group of variables. Currently, COPT supports two types of SOS constraints:

1. **SOS1 Constraint:** In this type of constraint, at most one variable in the specified group can take a non-zero value.
2. **SOS2 Constraint:** In this type of constraint, at most two variables in the specified group can take non-zero values, and the variables with non-zero values must be adjacent in the order.

These two types of SOS constraints correspond to the following constants in COPT, which can be specified when adding SOS constraints to the model:

- **SOS_TYPE1**
SOS1 Constraint
- **SOS_TYPE2**
SOS2 Constraint

When adding SOS constraints to the model, the following arguments can be specified by the user:

- **sostype:** Specifies the type of the SOS constraint.
- **vars:** The variables involved in the SOS constraint.
- **weights:** The weights of the variables involved in the SOS constraint; an optional argument, default is **None**.

Note

- The variables involved in the SOS constraint can be continuous variables, binary variables, or integer variables.
 - If the model includes SOS constraints, the model is an integer programming model.
 - The specific operations and usage of SOS constraints, including the function names, calling methods, and **argument names, may vary slightly** in different programming interfaces, but the functionality and argument meanings are consistent.
-

COPT provides related functions to support operations on SOS constraints. Below are the corresponding functions for adding and retrieving SOS constraints in different programming interfaces:

Table 12.12: Adding and Retrieving SOS Constraints

API	Add SOS Constraints	Retrieve All SOS Constraints in the Model
C	COPT_AddSOSs	COPT_GetSOSs
C++	Model::AddSos()	Model::GetSoss()
C#	Model.AddSos()	Model.GetSoss()
Java	Model.addSos()	Model.getSoss()
Python	Model.addSOS()	Model.getSOSs()

For operations related to SOS constraints, the function names, calling methods, and argument names may vary slightly in different programming interfaces, but the functionality and argument meanings are consistent. Please refer to the corresponding sections of each programming language's API reference manual for specific details:

- C API: *Building and modifying a problem*
- C++ API: *Model Class*
- C# API: *Model Class*
- Java API: *Model Class*
- Python API: *Model Class*

In the programming interfaces provided by COPT, except for the C language, other object-oriented programming interfaces (C#, C++, Java, Python) offer classes related to SOS constraints:

- Encapsulation of operations related to SOS constraints:
 1. **Sos Class**: Encapsulation of operations related to SOS constraints in COPT.
 2. **SosArray Class**: Facilitates user operations on a group of **Sos** class objects.
- Encapsulation of SOS constraint builders:
 1. **SosBuilder Class**: Encapsulation of builders for constructing SOS constraints in COPT, providing the following member methods:
 2. **SosBuilderArray Class**: Facilitates user operations on a group of **SosBuilder** class objects.

For more details on the member methods and specific descriptions of the above SOS constraint-related classes, please refer to the corresponding sections in the API reference manuals of each programming language.

- C++ API: *Sos Class* , *SosArray Class* , *SosBuilder Class* , *SosBuilderArray Class*
- C# API: *Sos Class* , *SosArray Class* , *SosBuilder Class* , *SosBuilderArray Class*
- Java API: *Sos Class* , *SosArray Class* , *SosBuilder Class* , *SosBuilderArray Class*
- Python API: *SOS Class* , *SOSArray Class* , *SOSBuilder Class* , *SOSBuilderArray Class*

12.9.2 Indicator Constraints

Indicator constraint is a type of logical constraint that uses a binary variable y as the indicator variable to determine the logical relationship between the value of y and whether the linear constraint $a^T x \leq b$ is satisfied. Currently, COPT supports three types of Indicator constraints: If-Then, Only-If, and If-and-Only-If.

- **INDICATOR_IF**

If-Then:

- If $y = f$, then the linear constraint is satisfied;
- If $y \neq f$, then the linear constraint can be violated.

$$\begin{aligned} y = f &\rightarrow a^T x \leq b \\ f &\in \{0, 1\} \end{aligned} \quad (12.25)$$

- **INDICATOR_ONLYIF**

Only-If:

- If the linear constraint $a^T x \leq b$ is satisfied, then $y = f$;
- If the linear constraint $a^T x \leq b$ is not satisfied, then y can take the value of 0 or 1.

$$\begin{aligned} a^T x \leq b &\rightarrow y = f \\ f &\in \{0, 1\} \end{aligned} \quad (12.26)$$

- **INDICATOR_IFANDONLYIF**

If-and-Only-If:

The linear constraint $a^T x \leq b$ and $y = f$ are equivalent. They must both be satisfied or both be unsatisfied.

$$\begin{aligned} a^T x \leq b &\leftrightarrow y = f \\ f &\in \{0, 1\} \end{aligned} \quad (12.27)$$

COPT provides two methods to add Indicator constraints:

1. By calling an API function (e.g., in Python: `Model.addGenConstrIndicator()`). The key parameters for constructing an Indicator constraint are:
 - **binVar**: The binary indicator variable.
 - **binval**: The value (**True** or **False**) of the indicator variable that is conditionally related to the satisfaction of the linear constraint.
 - **builder**: The linear constraint builder.
 - **type**: The type of Indicator constraint (possible values are listed in *Indicator constraint types*).
2. By overloading operators (for If-Then and Only-If constraints):
 - **>>**: Represents the If-Then logical relationship, corresponding to `INDICATOR_IF`;
 - **<<**: Represents the Only-If logical relationship, corresponding to `INDICATOR_ONLYIF`.

Here are examples of how to implement these methods in Python API:

1. Adding an If-Then type Indicator constraint where the linear constraint $y + 2z \geq 3$ is satisfied if x is true.

$$x = 1 \rightarrow y + 2z \geq 3 \quad (12.28)$$

```
model.addGenConstrIndicator(x, True, y + 2*z >= 3)
```

```
model.addConstr((x==1) >> (y + 2*z >= 3))
```

2. Adding an Only-If type Indicator constraint where x is false if the linear constraint $y + 2z \leq 3$ is satisfied.

$$x = 0 \leftarrow y + 2z \leq 3 \quad (12.29)$$

```
model.addGenConstrIndicator(x, False, y + 2*z <= 3, type=COPT.INDICATOR_
<math>\leftarrow</math>ONLYIF)
```

```
model.addConstr((x==0) << (y + 2*z <= 3))
```

3. Adding an If-and-Only-If type Indicator constraint where the binary variable x being true is equivalent to the linear constraint $y + 2z = 3$ being satisfied.

$$x = 1 \leftrightarrow y + 2z = 3 \quad (12.30)$$

```
model.addGenConstrIndicator(x, True, y + 2*z == 3, type=COPT.INDICATOR_
<math>\leftarrow</math>IFANDONLYIF)
```

Note

1. The general expression of the linear constraint given above, $a^T x \leq b$, can actually take the forms \leq , \geq , or $=$.
2. If the model includes Indicator constraints, it is considered an integer programming model.
3. COPT supports adding a batch of Indicator constraints to the model by calling an API function. In Python, the corresponding function is: `Model.addGenConstrIndicators()`.
4. The method of adding Indicator constraints by overloading operators only supports If-Then and Only-If constraints. If you need to add an If-and-Only-If constraint, you must use the API function and specify the `type` as `INDICATOR_IFANDONLYIF`.
5. The specific operations and usage of Indicator constraints, including function names, calling methods, and **parameter names, may vary slightly** in different programming interfaces, but the functionality and parameter meanings are consistent.

COPT provides related functions to support adding Indicator constraints and retrieving the corresponding Indicator constraint builders, as listed below:

Table 12.13: Adding and Retrieving Indicator Constraints in Different APIs

API	Add Indicator	Retrieve Indicator
C	<code>COPT_AddIndicator</code>	<code>COPT_GetIndicator</code>
C++	<code>Model::AddGenConstrIndicator()</code>	<code>Model::GetGenConstrIndicator()</code>
C#	<code>Model.AddSos()</code>	<code>Model.GetGenConstrIndicator()</code>
Java	<code>Model.addSos()</code>	<code>Model.getGenConstrIndicator()</code>
Python	<code>Model.addGenConstrIndicator()</code>	<code>Model.getGenConstrIndicator()</code>

For operations such as building and adding Indicator constraints, the function names, calling methods, and argument names may vary slightly in different programming interfaces, but the functionality and argument meanings are consistent. Please refer to the corresponding sections of each programming language's API reference manual for specific details:

- C API: *Constructing and Modifying the Model*
- C++ API: *Model Class*
- C# API: *Model Class*
- Java API: *Model Class*
- Python API: *Model Class*

In the programming interfaces supported by COPT, except for the C language, other object-oriented programming interfaces (C#, C++, Java, Python) offer classes related to Indicator constraints:

- Encapsulation of operations related to Indicator constraints:
 1. **GenConstr** Class: Encapsulation of operations related to Indicator constraints in COPT.
 2. **GenConstrArray** Class: Facilitates user operations on a group of **GenConstr** class objects.
- Encapsulation of Indicator constraint builders:
 1. **GenConstrBuilder** Class: Encapsulation of builders for constructing Indicator constraints in COPT.
 2. **GenConstrBuilderArray** Class: Facilitates user operations on a group of **GenConstrBuilder** class objects.

For more details on the member methods and specific descriptions of the above Indicator constraint-related classes, please refer to the corresponding sections in the API reference manuals of each programming language.

- C++ API: *GenConstr Class* , *GenConstrArray Class* , *GenConstrBuilder Class* , *GenConstrBuilderArray Class*

- C# API: *GenConstr Class* , *GenConstrArray Class* , *GenConstrBuilder Class* , *GenConstrBuilderArray Class*
- Java API: *GenConstr Class* , *GenConstrArray Class* , *GenConstrBuilder Class* , *GenConstrBuilderArray Class*
- Python API: *GenConstr Class* , *GenConstrArray Class* , *GenConstrBuilder Class* , *GenConstrBuilderArray Class*

12.9.3 Attributes for Special Constraints

COPT provides the following attributes to describe the number of special constraints in the model, as shown in Table 12.14.

For methods of retrieving these attributes in different programming interfaces, please refer to: *Attributes Section*.

Table 12.14: Overview of Special Constraints-Related Attributes

Attribute	Type	Description
Soss	Integer	Number of SOS constraints
Indicators	Integer	Number of indicator constraints
IISOSSs	Integer	Number of SOS constraints in IIS
IISIndicators	Integer	Number of indicator constraints in IIS

12.9.4 IIS Status of Special Constraints

Regarding the IIS (Irreducible Infeasible Set) calculation results for infeasible models, COPT provides related functions to obtain the IIS status of SOS constraints. Please refer to Handling Infeasible Models Section: Retrieving IIS Status of Special Constraints.

Chapter 13

MIP Starts

13.1 Utilities of MIP Starts

13.1.1 Set and Load MIP Starts

For MIP problems, COPT provides methods to specify initial solution value(s) for a single variable or set of variables and load it/them into model. The parameters that can be specified are:

- **vars** :variables
- **startvals** :variables' solution values

The functions in different APIs are shown in [Table 13.1](#):

Table 13.1: Functions for setting MIP starts

API	Function
C	<code>COPT_AddMipStart</code>
C++	<code>Model::SetMipStart()</code>
C#	<code>Model.SetMipStart()</code>
Java	<code>Model.setMipStart()</code>
Python	<code>Model.setMipStart(vars, startvals)</code>

Note

- Regarding the operations of MIP starts, their **function names**, **calling methods**, and **parameter names** are slightly different in different programming interfaces, but the implementation of functions and meanings of parameter are the same.
 - For more details on setting initial solutions in C, please refer to function `COPT_AddMipStart` in chapter *C API Function: MIP start utilities*.
 - You may want to call this method several times to input the MIP start. Please call `loadMipStart()` once when the input is done.
-

13.1.2 Read and Write MIP Starts

COPT provides functions for file read/write. It can read variable values from a MIP start file (".mst") as the initial solution values of variables, and write the solving results or existing initial solution to a MIP start file (".mst"). The functions for reading and writing MIP start file in different APIs are shown in Table 13.2:

Table 13.2: Functions for reading and writing MIP starts

API	read MIP starts	write MIP starts
C	COPT_ReadMst	COPT_WriteMst
C++	Model::ReadMst	Model::WriteMst
C#	Model.ReadMst()	Model.WriteMst()
Java	Model.readMst()	Model.writeMst()
Python	Model.readMst()	Model.writeMst()

13.2 Related Parameters

COPT provides the following parameters that control how MIP starts (initial solutions) are handled inside.

- **MipStartMode**

Integer parameter.

Mode of MIP starts, i.e. how MIP starts are handled.

Default -1

Possible values:

-1: Automatic.

0: Do not use any MIP starts.

1: Only load full and feasible MIP starts.

2: Only load feasible ones (complete partial solutions by solving subMIPs).

Note: If the provided initial solution is incomplete (partial), **MipStartMode=2** needs to be set, otherwise the initial solution will be rejected.

- **MipStartNodeLimit**

Integer parameter.

Limit of nodes for MIP start sub-MIPs.

Default: -1

Minimal: -1

Maximal: INT_MAX

13.3 Log of MIP starts

13.3.1 MIP starts are accepted

1.A (better) initial solution was provided

```
Initial MIP solution # 1 with objective value 9.73987 was accepted
```

2.A partial initial solution was provided, and set MipStartMode=2. (complete it by solving a subMIP)

```
Loading 1 initial MIP solution
Extending partial MIP solution # 1
Extending partial MIP solution # 1 succeed (0.2s)
Initial MIP solution # 1 with objective value 9.66566 was accepted
```

13.3.2 MIP starts are rejected

1.The provided initial solution was infeasible

```
Initial MIP solution # 1 was rejected: Primal Inf 1.00e+00 Int Inf 1.78e-15
```

2.The provided initial solution was not better than the current best one

```
Initial MIP solution # 2 with objective value 10.3312 was rejected (not better)
```

3.The provided initial solution was incomplete (partial), and not set MipStartMode=2

```
Loading 1 initial MIP solution
Initial MIP solution # 1 was rejected: partial
```

4.The provided initial solution was incomplete (partial), and COPT failed to find a feasible solution by solving subMIP

```
Loading 1 initial MIP solution
Extending partial MIP solution # 1
Extending partial MIP solution # 1 failed (infeasible)
Initial MIP solution # 1 was rejected: partial
```


Chapter 14

MIP Solution Pool

In general, the solver finds multiple feasible solutions in the process of solving a MIP problem with Branch-and-cut method. COPT provides a solution pool for MIP problem, from which users can obtain solutions and the corresponding objective function values. Supported optimization problem types are: MILP, MISOCP, MIQ(C)P.

COPT provides functions that users can get the `iSol` th solution's objective function value and solution values (of specified variables) by specifying the following parameters.

- `iSol`: Index of the solution to obtain. (0-based)
- `vars`: Variables

The functions in different APIs are shown in [Table 14.1](#):

Table 14.1: Get solutions and objective values from solution pool

API	Get solution	Get objective value
C	<code>COPT_GetSolution</code>	<code>COPT_GetPoolObjVal</code>
C++	<code>Model::GetPoolSolution()</code>	<code>Model.GetPoolSolution()</code>
C#	<code>Model.GetPoolSolution()</code>	<code>Model.GetPoolSolution()</code>
Java	<code>Model.getPoolSolution()</code>	<code>Model.getPoolObjVal()</code>
Python	<code>Model.getPoolSolution()</code>	<code>Model.getPoolObjVal()</code>

Note: Regarding the operations of solution pool, their **function names**, **calling methods**, and **parameter names** are slightly different in different programming interfaces, but the implementation of functions and meanings of parameter are the same.

Attributes of Solution Pool

- `PoolSols`
Integer attribute
Number of solutions in the solution pool.

Chapter 15

COPT Tuner

15.1 Introduction

The COPT Tuner is a tool designed for tuning performance automatically for all supported problem types.

- For MIP problems, it supports tuning for solving time, relative gap, best objective value and objective bound;
- For non-MIP problems, only solving time supported.

The workflow of the COPT tuning tool is as follows:

1. First, perform benchmark calculation and allow users to customize benchmark calculation parameters;
2. Next, generate tuning parameters one by one, and find parameter combinations that improve the solution performance through parameter tuning calculations.

15.2 Related parameters

Firstly, the tuner will do a baseline run, possibly with fixed parameters from users, then move to the improvement run, where the tuner will generate trial parameter sets and search for parameters that can improve the performance. To summarize, the COPT Tuner provides the following capabilities:

Table 15.1: Tuner related parameters

Name	Type	Description
<i>TuneTimeLimit</i>	Double	Time limit for parameter tuning
<i>TuneTargetTime</i>	Double	Time target for parameter tuning
<i>TuneTargetRelGap</i>	Double	Optimal relative tolerance target for parameter tuning
<i>TuneMethod</i>	Integer	Method for parameter tuning
<i>TuneMode</i>	Integer	Mode for parameter tuning
<i>TuneMeasure</i>	Integer	Parameter tuning result calculation method
<i>TunePermutates</i>	Integer	Permutations for each trial parameter set
<i>TuneOutputLevel</i>	Integer	Parameter tuning log output intensity

15.3 Provided capabilities

The COPT tuning tool provides the following capabilities:

15.3.1 Tuning method

Controlled by the parameter **TuneMethod**, options are: greedy search and aggressive search. The greedy method tries to find better parameter settings within limited number of trials, while the aggressive method search for more combinations and has much larger search space than the greedy one, and can potentially find even better parameter settings at the expense of more elapsed tuning time. Default setting is to choose automatically.

- Greedy search strategy: It is expected to optimize the calculation with fewer parameters and find better parameter settings;
- Broader search strategy: try more parameter combinations, have a larger search space, and are more likely to find better parameter settings, but also consume more tuning time.

The possible values and corresponding meanings of the parameter **TuneMethod** are as follows. By setting it to a different value, the search method can be selected. The default setting is automatic selection.

- -1: Automatic selection
- 0: Greedy search strategy
- 1: Broader search strategy

15.3.2 Tuning mode

Controlled by the parameter **TuneMode**, options are: solving time, relative gap, objective value and objective bound. For MIP problem, by default, if the baseline run is not solved to optimality within specified time limit, tuner will change tuning mode to relative gap automatically. Default setting is to choose automatically.

- 0: Solving time
- 1: Optimal relative tolerance
- 2: Objective function value
- 3: Lower bound of objective function value

Note: For integer programming problems, by default, if the benchmark calculation does not optimize the model within the given time limit, the tuning tool will automatically switch the tuning mode to the optimal relative tolerance.

15.3.3 Tuning permutations

Controlled by the parameter **TunePermutess**. Tuner allow users to run more permutations for each trial parameter set to evaluate performance variability. Default setting is to choose automatically.

15.3.4 Tuning measure

Controlled by the parameter **TuneMeasure**, options are: by average or maximum. When users run more permutations for each trial, tuner will compute the aggregated tuning value by this measure. Default setting is to choose automatically.

- 0: Calculate the average
- 1: Calculate the maximum value

15.3.5 Tuning targets

Controlled by the parameter **TuneTargetTime** and **TuneTargetRelGap**. Tuner enables users to specify target solving time or relative gap for tuning, when tuner finds out parameters that satisfy the specified target, it will stop tuning. For solving time, default value is 0.01 seconds, while for relative gap, default value is 1e-4.

15.3.6 Tuning output

Controlled by the parameter **TuneOutputLevel**, options are: no output, show summary for improved trials, show summary for each trial and show detailed log for each trial. Default setting is to show summary for each trial.

- 0: Do not output tuning log
- 1: Output only a summary of the improved parameters
- 2: Output a summary of each tuning attempt
- 3: Output a detailed log of each tuning attempt

15.3.7 TuneTimeLimit

Controlled by the parameter **TuneTimeLimit**. This parameter is used to control the overall time limit for the improvement run of tuning. Default setting is to choose automatically.

15.3.8 User defined parts

- User defined parameters

The tool enables users to set parameters for the baseline run, which will also be used as fixed parameters for each trial run. Tuner will not tune parameters in the fixed parameters.

- User defined MIP start

The COPT tuner enables users to set MIP start for the baseline run, which will also be used for each trial run also.

- User defined tuning file

The COPT tuner enables users to read tuning parameter sets from tuning file, if so, the tuner will try to tune from the given parameter sets, otherwise, tuner will generate tuning parameter sets automatically. The tuning file is similar to parameter file, with the difference that it allow multiple values for each parameter name.

Note: The COPT tuning file has a similar format to the COPT parameter file, except that the tuning file allows multiple values to be specified for a single parameter.

15.3.9 Load or writing tuning parameter

After the parameter tuning is completed, the number of parameter tuning results can be obtained through the attribute `TuneResults`, and the tuning results of the specified number can also be loaded into the model or written into the parameter file.

COPT can output the parameter tuning results of the specified number to the parameter file (".par"). The parameters that need to be specified are:

- `idx`: parameter tuning result number
- `filename`: file name

The corresponding functions in different programming interfaces are as follows:

Table 15.2: functions for writing parameter tuning results in different interfaces

API	function
C	<code>COPT_WriteTuneParam</code>
C++	<code>Model::WriteTuneParam()</code>
C#	<code>Model.WriteTuneParam()</code>
Java	<code>Model.writeTuneParam()</code>
Python	<code>Model.writeTuneParam()</code>

15.4 Example

For example, to tune model "foo.mps" from command line for solving time with COPT command line tool, the commands are:

```
copt_cmd -c "read foo.mps; tune; exit"
```

To use the tuner in API such as Python, the codes are:

```
env = Envr()
m = env.createModel()
m.read("foo.mps")
m.tune()
```

Chapter 16

Callbacks

COPT provides the callbacks utility, which supports users in obtaining information during the MIP solving process, e.g., the current best bound, the current optimal objective value, etc.; or controlling the solving process, e.g., by adding lazy constraints and cutting planes, or terminating the solving process. The problem types supporting the use of callbacks are MILP, MISOCP, MIQ(C)P.

A callback function is a user-provided function called by COPT during the solving process. The user can register one custom callback function via their preferred API for one or multiple callback contexts. Section *Using the callback utilities in different APIs* gives a detailed introduction to how to setup a callback function. The callback function will be invoked at certain moments during the solving process, depending on the callback contexts. When invoked, the user can *access information* and *control the solving process*, respectively. The available information and operations depend on the context. Currently, COPT supports four callback contexts:

- `CBCONTEXT_INCUMBENT`: Invokes the callback after a new incumbent was found.
- `CBCONTEXT_MIPNODE`: Invokes the callback after a MIP node was processed.
- `CBCONTEXT_MIPRELAX` : Invokes the callback when an LP-relaxation was solved.
- `CBCONTEXT_MIPSOL`: Invokes the callback when a new MIP candidate solution is found.

The content of this chapter is organized as follows:

- *Obtaining information during the solving process*
- *Controlling the MIP solving process*
- *Using the callback utilities in different APIs*

Notes

Only **one** callback function can be registered in COPT at a time. But one callback can be registered for multiple contexts. If a user wants to call different operations for different contexts (such as adding lazy constraints under `CBCONTEXT_MIPSOL` and adding user cuts under `CBCONTEXT_MIPRELAX`), they need to register one callback for all relevant contexts and have this callback call the respective operations based on the context in which it was called.

16.1 Obtaining information during the solving process

The information that can be obtained during the MIP solving process depends on the context the callback is invoked in, see the table below. Information is usually obtained by calling (an API dependent version of) `getInfo` / `GetCallbackInfo` from within the callback function, specifying the desired information via a string supplied as the function argument. For a detailed description of the available callback information arguments, please refer to [Callback information](#).

The following table lists information that can be obtained in different contexts:

Context	Callback Information
CBCONTEXT_MIPNODE	NodeStatus, RelaxSolution, RelaxSolObj, MipCandObj, MipCandidate
CBCONTEXT_MIPRELAX	RelaxSolution, RelaxSolObj
CBCONTEXT_MIPSOL	MipCandObj, MipCandidate
CBCONTEXT_INCUMBENT	

In addition to the corresponding Callback Context and Information listed above, `BestObj`, `BestBnd`, `HasIncumbent`, and `Incumbent` can be obtained in any context.

Notes

1. If `HasIncumbent == False`, then `Incumbent` cannot be obtained.
 2. The return value of the “NodeStatus” information is constant, representing the solving status of the current node’s LP relaxation. For possible values, please refer to [General Constants Section: Solution Status \(Partial\)](#).
 3. `Incumbent`, `RelaxSolution`, and `MipCandidate` are obtained through different methods in different interfaces:
 - C API: through the function `COPT_GetCallbackInfo`, the name of the intermediate information to be obtained is provided as arguments of the function;
 - In object-oriented programming languages (C++/C#/Java/Python), the `CallbackBase` class provides specialized functions to obtain the corresponding intermediate information. E.g., in Python/C++ `CallbackBase` provides `GetIncumbent`, `GetRelaxSol`, and `GetSolution`. Other programming language interfaces are similar, please refer to the `CallbackBase` class of each API.
-

16.2 Controlling the MIP solving process

COPT provides functions to allow the user to interactively add lazy constraints or cutting planes during the solving process of the MIP branch-and-cut to control the MIP solving process. There are three main types of operations:

1. Adding lazy constraints
2. Adding cutting planes
3. Adding feasible solutions

16.2.1 Adding lazy constraints

Lazy constraints are constraints that are added to the model only when they are violated. For some models with a large number of constraints, adding lazy constraints only when violated can effectively reduce the size of the model during the solution process and improve the efficiency of the solving process. A popular example of this is the TSP model, see "cb_ex1" in the examples directory in the installation package.

COPT supports two ways of adding lazy constraints. One is to explicitly add lazy constraints to the model **before** starting the solution process. The other is to add lazy constraints **during** the solving process through a user callback. For this purpose, each API provides two sets of methods, one for adding lazy constraints to the initial model and one for adding them from a callback. In the C API, the methods can be distinguished according to whether or not the function name contains "Callback", e.g., COPT_AddLazyConstr and COPT_AddCallbackLazyConstr. In object-oriented APIs, the two sets of functions correspond to the Model class and the CallbackBase class respectively. Taking python as an example:

- Before solving, a user can directly add lazy constraints to the model by calling Model.addLazyConstr() or Model.addLazyConstrs() respectively.
- During the solving process, a user can dynamically add lazy constraints (if supported by the current context, see below) from within the callback function via CallbackBase.addLazyConstr() or CallbackBase.addLazyConstrs().

In both cases, the added lazy constraints will be stored by COPT separately from the actual model and are only added to the model, when they are violated by a solution found during the solving process.

In order to ensure correctness, COPT will check whether any lazy constraints added so far are violated by any solution found during the solving process. This will increase the solving time, especially when many non-violated lazy constraints have been added. It is recommended that the user only adds lazy constraints when necessary, e.g. when they are violated by a solution.

Lazy constraints can **only** be added in the callback contexts CBCONTEXT_MIPSOL and CBCONTEXT_MIPRELAX. While it is not strictly necessary to check every LP relaxation solution for violated lazy constraints, a user has to check every solution provided in CBCONTEXT_MIPSOL for feasibility against the lazy constraints in order to not produce wrong results.

To avoid adding unnecessarily many lazy constraints, COPT has some simple redundancy checks for lazy constraints in place. Exact duplicates will be discarded. However, adding many, very similar but redundant lazy constraints will negatively affect COPT's performance. This should be avoided by the user.

Notes

- Registering a callback function for the CBCONTEXT_MIPSOL will make COPT believe that the user wants to add lazy constraints. As lazy constraints are not actually part of the model, this will lead to the deactivation of dual reductions during COPT's presolve, as dual arguments rely on the knowledge of all model rows. If the user does not intend to add lazy constraints but still wants to use the CBCONTEXT_MIPSOL, COPT provides the *LazyConstraints* parameter which enables the user to explicitly tell COPT whether or not lazy constraints will be added to the model. By default, this parameter is set to -1 meaning COPT will turn off dual presolve reductions if either lazy constraints are part of the model or a callback for context CBCONTEXT_MIPSOL has been installed. Explicitly setting the parameter to 0 will allow dual reductions during COPT's presolve even if lazy constraints or a callback for context CBCONTEXT_MIPSOL are present. This is useful only in very rare cases, e.g., if the callback only prints information about solution candidates but never adds lazy constraints. As soon as lazy constraints are added, this might lead to wrong results, however. For printing information about solutions, consider using the CBCONTEXT_INCUMBENT context instead.
- If a user invokes a function to add lazy constraints from a callback in the CBCONTEXT_MIPSOL context, the current MIP candidate solution will be rejected, no matter whether the added lazy constraint(s) are actually violated or not. This enables the user to reject arbitrary solutions by adding empty lazy constraints when an undesirable solution is found. Note however, that COPT

might find the same solution multiple times if no lazy constraint is provided. The LP relaxation solution will not necessarily be rejected if lazy constraints are added in `CBCONTEXT_MIPRELAX`, only when these are actually violated.

- It is invalid to call the any functions of the `Model` class for object-oriented languages (or their C equivalent) to add lazy constraints in a callback. More generally, the model cannot be changed during the solving process, except by adding lazy constraints or cutting planes.
-

16.2.2 Adding cutting planes

Cutting planes are added to the model during the solving process to strengthen the LP relaxation, e.g., cut off fractional LP solutions and improve the lower bound of the MIP problem.

COPT supports the addition of custom cutting planes to the model during the solving process. Similar to lazy constraints, cutting planes can be added to the model **before** and, via the callback, **during** the solving process. Each API provides two sets of methods, one for adding cutting planes to the initial model and one for adding them from a callback. In the C API, the methods can be distinguished according to whether or not the function name contains "Callback", e.g., `COPT_AddUserCut` and `COPT_AddCallbackUserCut`. In object-oriented APIs, the two sets of functions correspond to the `Model` class and the `CallbackBase` class respectively. Taking python as an example:

- Before solving, user can directly add cutting planes to the model by calling `Model.addUserCut()` or `Model.addUserCuts()`.
- During the solving process, a user can dynamically add cutting planes (if supported by the current context, see below) from within the callback function via `CallbackBase.addUserCut()` or `CallbackBase.addUserCuts()`.

Cutting planes can **only** be added in the `CBCONTEXT_MIPRELAX` context. Here, the user is provided with the current LP relaxation solution to separate their own cutting planes.

Notes

- Cutting planes that do not violate the current LP relaxation solution are discarded by COPT.
 - It is invalid to call any functions of the `Model` class (or their C equivalent) to add cutting planes in a callback. More generally, the model cannot be changed during the solution process, except by adding lazy constraints or cutting planes.
-

16.2.3 Adding feasible solutions

COPT supports adding feasible solutions during the MIP solving process. This enables the user to provide any feasible solution they found in parallel to the COPT solution process, e.g., in a self-implemented heuristic. Known solutions can either be supplied as starting solutions by calling `COPT_AddMipStart` (see [MIP Starts](#)) or from within a callback function. If a solution is know beforehand, supplying it as a MIP starting solution is preferred. For solutions found during the solving process, in the C API, a solution can be added by calling `COPT_AddCallbackSolution` inside the callback. In object-oriented APIs, the functions needed to add a solution are provided by the `CallbackBase` class and the workflow consists of calling two functions:

- Set the feasible solution: `CallbackBase.setSolution(vars, val)`
- Load a custom solution into the model: `CallbackBase.loadSolution()`

COPT will check any provided solution for feasibility and compute its objective value. The computed objective is return by `loadSolution` / `COPT_AddCallbackSolution`. If a solution is infeasible or worse than the current incumbent, it is discarded and the objective value returned by COPT is set to `1.0e+30`.

Solutions can be added in any callback context.

Notes

Currently, COPT only supports complete feasible solutions within callbacks.

16.3 Using the callback utilities in different APIs

For object oriented programming languages the basic steps of setting up a callback function are:

1. Implement a custom callback class, inheriting from the `CallbackBase` class.
2. Implement the `CallbackBase.callback()` function. This is the callback function that will be invoked by COPT. Here, the user can invoke the callback-specific functions for *obtaining information* or *controlling the solution process*.
3. Create an object of the custom callback class.
4. Register the callback in COPT through `Model.setCallback()`, and input the Callback Context as a parameter. For registering the callback function for multiple contexts, one can bitwise-or the desired contexts, e.g., `COPT.CBCONTEXT_MIPSOL | COPT.CBCONTEXT_MIPNODE`.

In the subsequent solving process, the user-supplied `CallbackBase.callback()` function will be called in each context registered. The currently invoked context can be obtained by calling the `CallbackBase` class method `where()`.

As already mentioned in the sections above, functions in `CallbackBase` class (or their corresponding C functions) can only be called in certain contexts. The following table lists for each callback context the allowed callback operations, using the Python API:

Context	Function
<code>CBCONTEXT_INCUMBENT</code>	<code>getInfo</code> , <code>getIncumbent</code> , <code>load/setSolution</code>
<code>CBCONTEXT_MIPNODE</code>	<code>getInfo</code> , <code>getIncumbent</code> , <code>getRelaxSol</code> , <code>load/setSolution</code>
<code>CBCONTEXT_MIPRELAX</code>	<code>addUserCut(s)</code> , <code>getIncumbent</code> , <code>getInfo</code> , <code>getRelaxSol</code> , <code>load/setSolution</code>
<code>CBCONTEXT_MIPSOL</code>	<code>addLazyConstr(s)</code> , <code>getIncumbent</code> , <code>getInfo</code> , <code>getSolution</code> , <code>load/setSolution</code>

Notes

- While `getInfo` can be called in all contexts, the information available depends on the context. See *Obtaining information during the solving process* for details.
 - In other APIs `getInfo` is often split into `getIntInfo` and `getDbInfo`.
 - The functions above may look slightly different for a certain API, but the presented relationships are the same.
-

While the above steps use Python as the reference API, the implementation in each object oriented programming language API is similar, and the user can refer to the provided sample code. For Python, "cb_ex1.py" is available in the examples directory in the installation package. For C, the main differences when implementing and registering a callback are as follows:

- The custom callback function can be any function using the signature `int COPT_CALL <function>(copt_prob* prob, void* cbdata, int cbctx, void* usrdata)` where `<function>` is arbitrary.
- Instead of using `Where()` for obtaining the current context, the callback context is supplied in `cbctx`.

- Callback-relevant information can be passed by defining a custom `struct` and passing it as the `usrdata` argument.

See `cb_ex1.c` in the C examples folder for a reference implementation.

The calling method and function name of the callback function in different programming interfaces are **slightly different**, but the supported functions and function meanings are the same. Please refer to the corresponding chapters of different programming interface API reference manuals for specific introductions:

- *C*
- *C++*
- *C#*
- *Java*
- *Python*

Chapter 17

Matrix Modeling Method

The COPT Python API provides matrix modeling, supports NumPy multi-dimensional array, a two-dimensional NumPy matrix, SciPy compressed sparse column matrix (`csc_matrix`) and compressed sparse row matrix (`csr_matrix`) operations and can be combined with ordinary (scalar) variables and constraints.

NumPy version should be 1.23 or above and Python minimum version requirement is 3.8. COPT mainly provides the following utilities:

1. Add multi-dimensional variables (`MVar`) and other related operations;
2. Construct multi-dimensional linear expressions (`MLinearExpr`), add multi-dimensional linear constraints (`MConstraint`) and other related operations;
3. Construct multi-dimensional quadratic expression (`MQuadExpr`), add multi-dimensional convex quadratic constraint (`QConstraint`) and other related operations.

17.1 Two different matrix modeling modes

The matrix modeling function provided by COPT currently supports two modes: original legacy mode and experimental mode. Among them, the legacy mode (by default) relies on Python's NumPy library. The experimental mode is based on the built-in matrix modeling class implementation of the COPT C++ interface. The modeling speed could be improved to a certain extent compared with the former.

In the Python interface, the two modes can be controlled and switched through `Model.matrixmodelmode`, and the default is the legacy mode. Please set according to your usage scenarios:

- `Model.matrixmodelmode = "legacy"` (default mode), depends on the NumPy library.
- `Model.matrixmodelmode = "experimental"`, C++ built-in matrix modeling class based on COPT (`NdArray`), no external dependencies.

The functions and operation types supported by the two modes are slightly different.

1.The order (storage) method of `MConstraint.reshape()`/`MVar.reshape()`, that is, the value of the function parameter `order`:

- Legacy mode: supports both 'C' (by row) and 'F' (by column)
- Experimental mode: only supports 'C' (by row)

2.Advanced indexing support:

Take the nqueen problem for example, only one queen can appear on each diagonal:

- Legacy mode: Compatible with NumPy's advanced index, which can be implemented as follows:

```

import coptpy as cp
import numpy as np

env = cp.Envir()
model = env.createModel()
model.matrixmodelmode = "legacy"
for i in range(1, 2*n):
    # At most one queen per diagonal
    diagn = (range(max(0, i-n), min(n, i)), range(min(n, i)-1, max(0, i-n)-1, -
→1))
    model.addConstrs(x[diagn].sum() <= 1, nameprefix="diag"+str(i))
    # At most one queen per anti-diagonal
    adiagn = (range(max(0, i-n), min(n, i)), range(max(0, n-i), min(n, 2*n-i)))
    model.addConstrs(x[adiagn].sum() <= 1, nameprefix="adiag"+str(i))

```

- Experimental mode: The above advanced indexing method is not supported and requires the built-in Python indexing method, which can be implemented as follows:

```

import coptpy as cp
import numpy as np

env = cp.Envir()
model = env.createModel()
model.matrixmodelmode = "experimental"
for i in range(-n+1, n):
    # At most one queen per diagonal
    model.addConstrs(x.diagonal(i).sum() <= 1, nameprefix="diag"+str(i))
    # At most one queen per anti-diagonal
    model.addConstrs(x[:, ::-1].diagonal(i).sum() <= 1, nameprefix="adiag
→"+str(i))

```

3.The relevant information obtained from matrix objects (objects such as MConstr and MVar), and the return value types are different:

- Legacy mode: `numpy.ndarray`
- Experimental mode: `coptcore.NdArray`

4.The supported dimensions are different:

- Legacy mode: There is no restriction on dimensions and can support higher-dimensional matrices.
- Experimental mode: The highest supported dimensions are three.

5.When adding multi-dimensional quadratic constraints, the support for variable dimensions participating in constraint formation and the type of return value are different:

- Legacy mode: The dimension of the variables involved in forming the quadratic constraint needs to be 1 (i.e. vector), higher dimensions are not supported, and the return value type is *QConstraint Class* object.

```

import coptpy as cp
import numpy as np

env = cp.Envir()
model = env.createModel()
model.matrixmodelmode = "legacy"
Q = np.full((3, 3), 1)
mx = model.addMVar(3, nameprefix="mx")
# mqc <coptpy.QConstraint: >
mqc = model.addQConstr(mx@Q@mx<=1)

```

- Experimental mode: The dimensions of variables participating in the quadratic constraints can be one or two-dimensional, and the return value type is *MQConstr Class* object.

```
import coptpy as cp
import numpy as np

env = cp.Envr()
model = env.createModel()
model.matrixmodelmode = "experimental"
Q = np.full((3, 3), 1)
mx = model.addMVar((3, 3), nameprefix="mx")
# mqc <coptpy.MQConstr: shape=(3, 3)>
mqc = model.addQConstr(mx@Q@mx <= 1)
```

17.2 Multi-dimensional Variables

1. Add multi-dimensional variable MVar

MVar contains operations related to multi-dimensional variables. Users can use **Model.addMVar()** to add a multi-dimensional variable **MVar** of any dimension and shape to the model. In addition to the need of specifying the argument **shape** (matrix shape), the rest of the arguments are consistent with ordinary variables, including: **lb**, **ub**, **vtype**, **nameprefix**.

- Add one-dimensional continuous multi-dimensional variables: `x = Model.addMVar(3)`
- Add two-dimensional 3x3 binary multi-dimensional variables: `y = Model.addMVar(shape(3,3), vtype=COPT.BINARY)`

In addition, the **MVar** multi-dimensional variables can also be sliced, such as: `y1 = y[:,0:2]`

2. Get multi-dimensional variable related attributes:

- Number of dimensions: **MVar.ndim**
- The shape of the multi-dimensional variable: **MVar.shape**
- Number of elements in the multi-dimensional variable: **MVar.size**

17.3 Multi-dimensional array operations and expressions

17.3.1 Multi-dimensional Linear Expressions

Multi-dimensional variables and their coefficients (can be **ndarray**) form a Multi-dimensional linear expression (**MLinExpr**), and the supported operations mainly include:

1. Matrix multiplication: `A @ x`

```
x = model.addMVar(3)
A = np.array([[1, 0, 1],[0, 0, 1]])
expr1 = A @ x
```

2. Vector inner product

```
x = model.addMVar(3)
c = np.array([1, 2, 3])
expr2 = c @ x
```

17.3.2 Multi-dimensional Quadratic Expression

Common multi-dimensional quadratic expressions and their corresponding mathematical forms are as follows:

- $x @ Q @ x$: $x^T Q x$
- $x @ x$: $x^T x$
- $x @ Q @ x + c @ x + b$: $x^T Q x + c^T x + b$

17.3.3 Other multi-dimensional array operations

1. Combine with regular linear variables, regular linear expressions, and constants:

```
x = model.addMVar(3)
y = model.addVar()
c = np.array([1, 2, 3])
Q = np.full((3, 3), 1)
expr3 = 2 * x @ Q @ x + c @ x + 2 * y + 1
```

2. Self-increment/self-subtraction/self-multiplication operations:

```
mx = m.addMVar((3, 3))
B = np.array([[1, 0, 1], [0, 1, 1]])
expr_add = B @ mx
expr_add += 1
expr_add *= 2
```

Notes

- When we directly print the multi-dimensional expression with `print(MLinExpr)/print(MQuadExpr)`, the `shape` of the expression will be output at the same time. When `shape=()`, it means that the expression is a scalar (single linear/quadratic expression), corresponding to `ndim=0`, `size=1`. The same is true for multi-dimensional variables `MVar`;
 - When performing matrix multiplication (`A@x`), the matrix multiplication algorithm needs to be satisfied, and the number of columns of A and the number of rows of X need to be the same;
 - COPT supports the combination of `MLinExpr` and `LinExpr`, but it should be noted that the `MLinExpr` needs `shape=()` at this time, and the final returned expression is `MLinExpr` with `shape=()`.
-

17.4 Matrix Constraints

17.4.1 Matrix linear Constraints

COPT supports two ways of adding multi-dimensional linear constraints, and the format provided by the function arguments is different:

1. `Model.addMConstr()` that specifically adds multi-dimensional linear constraints, the arguments that can be specified are:
 - **A** : coefficient matrix for linear constraints
 - **x** : decision variables (`MVar`)
 - **sense** : type of linear constraint, the possible values are: 'L' (\leq), 'G' (\geq), 'E' ($=$)

- **b** : right-hand-side of linear constraints (vector with dimensions equal to the number of rows of matrix A)
- **name** : name prefix for linear constraints

```
x = model.addMVar(shape=3, vtype=COPT.BINARY, nameprefix='x')
A = np.array([[1, 2, 3], [3, 2, 1]])
b = np.array([2, 5])
mconstrs = model.addMConstr(A, x, 'L', b, nameprefix='c')
obj = np.array([1, 2, 1])
model.setObjective(obj @ x, COPT.MINIMIZE)
```

2. Matrix linear constraints can be regarded as a set of linear constraints, so `Model.addConstrs()` can also add multi-dimensional linear constraints:

```
x = model.addMVar(shape=3, vtype=COPT.BINARY, nameprefix='x')
A = np.array([[1, 2, 3], [3, 2, 1]])
b = np.array([2, 5])
mconstrs = model.addConstrs(A @ x <= b, nameprefix='c')
obj = np.array([1, 2, 1])
model.setObjective(obj @ x, COPT.MINIMIZE)
```

17.4.2 Quadratic Constraints

COPT supports two ways of constructing multi-dimensional quadratic constraints, and the format provided by the function arguments is different:

1. `Model.addMQConstr()` that specifically adds multi-dimensional quadratic constraints, the arguments that can be specified are:
 - **Q** : quadratic coefficient matrix
 - **c** : vector of linear term coefficients, or `None` if there is no linear term
 - **sense** : type of quadratic constraint, the possible values are: 'L' (\leq), 'G' (\geq), 'E' ($=$)
 - **rhs** : right-hand-side of quadratic constraints
 - **xQ_L** : the left-hand variable of the quadratic coefficient matrix Q (vector whose length is consistent with the number of rows of the matrix Q)
 - **xQ_R** : right-hand variable of the quadratic coefficient matrix Q (vector whose length is consistent with the number of columns of the matrix Q)
 - **xc** : the variables for the linear term, or `None` if there is no linear term
 - **name** : name prefix for quadratic constraints

```
Q = np.diag([3, 2, 1])
x = model.addMVar(3)
c1 = model.addMQConstr(Q, None, 'L', 1.0, x, x)
```

2. `Model.addQConstr()`, directly gives the multi-dimensional quadratic expression

- **lhs** : multi-dimensional quadratic expression
- **sense** : constraint type
- **rhs** : right-hand-side of quadratic constraints

```
Q = np.diag([3, 2, 1])
x = model.addMVar(3)
c2 = model.addQConstr(x@Q@x<=1.0)
```

17.5 Objective function composed of multi-dimensional variables

COPT supports setting linear and quadratic objective functions, and provides two ways to set objective functions. The format of function arguments is different:

1. `Model.setMObjective()` that specifically sets the objective function composed of multi-dimensional variables, the arguments that can be specified are:
 - `Q` : quadratic coefficient matrix, or `None` if the objective function is linear
 - `c` : vector of linear term coefficients, or `None` if there is no linear term
 - `constant` : the constant term of the objective function
 - `xQ_L`: the left-hand variable of the quadratic term coefficient matrix `Q` (vector whose length is consistent with the number of rows of the matrix `Q`), or `None` if the objective function is linear
 - `xQ_R`: the right-hand variable of the quadratic coefficient matrix `Q` (vector, whose length is consistent with the number of columns in the matrix `Q`), or `None` if the objective function is linear
 - `xc`: the variable for the linear term, or `None` if there is no linear term
 - `sense`: direction of optimization, possible values are: `COPT.MINIMIZE` or `COPT.MAXIMIZE`
2. `Model.setObjective()` that directly gives the expression of the objective function
 - `expr`: Objective function expression, which can be linear or quadratic
 - `sense`: optimization direction, possible values are: `COPT.MINIMIZE` or `COPT.MINIMIZE`

```
x = model.addMVar(shape=3, vtype=COPT.BINARY, nameprefix="x")
obj = np. array([1, 2, 1])
model.setObjective(obj @ x, COPT.MINIMIZE)
```

Regarding the matrix modeling method, the COPT Python interface provides multi-dimensional variables, (linear and convex quadratic) expressions, and matrix constraint classes respectively, and contains related operations. For the methods and specific introductions included, please refer to the corresponding part of the Python API :

- Multi-dimensional variable: *MVar*
- Multi-dimensional linear expression: *MLinExpr*
- Multi-dimensional quadratic expressions: *MQuadExpr*
- Matrix constraints: *MConstr*

Chapter 18

Logging

Logging related parameters and functions are essential for users to control the display of solving logs of COPT. This chapter provides an interpretation of loggings for different algorithms, including the following sections:

- *Parameters and Functions for Logging*
- *Basic Information*
- *Simplex Method Logging*
- *Barrier Method Logging*
- *Branch-and-Cut Method Logging*
- *Logging for First-order method (PDLP) of GPU solver*

18.1 Parameters and Functions for Logging

Users can control the display of logs by setting related parameters.

- **Logging**

Integer parameter.

Whether to print optimization logs.

Default: 1

Possible values:

0: No optimization logs.

1: Print optimization logs.

- **LogToConsole**

Integer parameter.

Whether to print optimization logs to console.

Default: 1

Possible values:

0: No optimization logs to console.

1: Print optimization logs to console.

COPT provides operations related to logs, such as setting the logging file.

COPT provides functions to set the logging file, write the optimization logs into the specified file (with the file name suffix `.log`), allowing users to save and review the logs. The functions for different programming interfaces are shown in [Table 18.1](#):

Table 18.1: Functions for setting logging files in different programming interfaces

Programming Interface	Functions for setting logging files
C	<code>COPT_SetLogFile</code>
C++	<code>Model::SetLogFile()</code>
C#	<code>Model.SetLogFile()</code>
Java	<code>Model.setLogFile()</code>
Python	<code>Model.setLogFile()</code>

Note: When calling these functions, users should specify the file name for saving logs using the `logfile` parameter.

18.2 Basic Information

COPT outputs basic information before starting the solving process, depending on the problem types. The following information is typically displayed:

```
Model fingerprint: 2c27ab28

Hardware has 64 cores and 128 threads. Using instruction set X86_AVX512_E1 (14)
Minimizing a MIP problem
```

Here, `Model fingerprint` represents the unique code for the current model.

The next output provides information about the hardware used, including the number of CPU cores (`cores`) and threads (`threads`).

Finally, the problem type and optimization sense are displayed, such as:

Minimizing an LP problem, Minimizing a MIP problem, and Minimizing an SDP problem, etc.

18.3 Simplex Method Logging

Based on different stages of the optimization process, the logs for Simplex Method can be divided into three parts:

1. Presolve
2. Simplex iteration process
3. Summary of optimization results

This section uses the logs for example problem [afiro.mps](#) to interpret the information in the Simplex Method logging.

18.3.1 Presolve

By default, before starting the Simplex Method, the COPT performs presolve on the model to improve its quality. A preprocessed model will be transmitted to the solver.

The presolve part of the log outputs changes in the model size before and after presolve:

```
The original problem has:
    27 rows, 32 columns and 83 non-zero elements
The presolved problem has:
    7 rows, 10 columns and 28 non-zero elements
```

The description of the LP problem size includes the following information:

- Number of constraints (**rows**)
- Number of variables (**columns**)
- Number of non-zero elements in the coefficient matrix (**non-zero elements**)

In the example logs, after presolve, the number of constraints, variables, and non-zero elements in the coefficient matrix are all reduced.

18.3.2 Simplex iteration process

This part of the logs provides relevant information about the iteration process using the Simplex method.

```
Starting the simplex solver using up to 8 threads

Method   Iteration      Objective   Primal.NInf   Dual.NInf      Time
Dual            0   -4.8553789460e+02      3           0       0.00s
Dual            3   -4.6476735494e+02      0           0       0.00s
Postsolving
Dual            3   -4.6475314286e+02      0           0       0.00s
```

Here, the first line indicates that the current optimization algorithm is the Simplex method, and it uses 8 threads (**threads**) for computation.

The subsequent lines represent the simplex iteration process with 6 columns:

- **Method:** The optimization algorithm used, where "Dual" represents the dual simplex method.
- **Iteration:** The number of iterations.
- **Objective:** The objective function value.
- **Primal.NInf:** The number of primal infeasibilities in the primal problem.
- **Dual.NInf:** The number of dual infeasibilities in the dual problem.
- **Time:** The time taken for solving (in seconds).

18.3.3 Summary of Optimization Results

This part of the logs summarizes the results and the iteration process of the Simplex method after completing the solving process.

```
Solving finished
Status: Optimal   Objective: -4.6475314286e+02   Iterations: 3   Time: 0.00s
```

The included information consists of:

- Solving status (**Status**): If the model has an optimal solution, it is **Optimal**.

- Objective function value (**Objective**): If the model has an optimal solution, **Objective** displays the optimal objective function value.
- Total number of iterations (**Iterations**).
- Total solving time (**Time**).

If the model is infeasible, the corresponding log output is as follows:

```
Solving finished
Status: Infeasible  Objective: -  Iterations: 2  Time: 0.00s
```

18.4 Barrier Method Logging

Based on different stages of the optimization process, the solving logs for the Barrier Method can be divided into three parts:

1. Presolve
2. Barrier optimization process
3. Summary of Optimization Results

Note: By setting the optimization parameter "LpMethod = 2", you can choose the Barrier method as the algorithm for solving linear programming problems.

Similarly, using the example problem [afiro.mps](#), this section interprets the information in the logs for solving LP problems with the Barrier method.

18.4.1 Presolve

By default, before starting the Barrier Method, the COPT performs presolve to reduce the model size. A preprocessed model will be transmitted to the solver.

The presolve part of the log outputs changes in the model size before and after presolve:

```
The original problem has:
  27 rows, 32 columns and 83 non-zero elements
The presolved problem has:
  7 rows, 10 columns and 28 non-zero elements
```

18.4.2 Model Information

This part of the log presents relevant numerical information about the model:

```
Starting barrier solver using 64 threads

Problem info:
Dualized in presolve:          No
Range of matrix coefficients:   [4e-01,4e+00]
Range of rhs coefficients:      [8e+01,3e+02]
Range of bound coefficients:    [4e+01,1e+02]
Range of cost coefficients:     [2e-01,2e+00]

Factor info:
Number of free columns:        0
Number of dense columns:       0
Number of matrix entries:      2.800e+01
```

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Number of factor entries:	2.800e+01
Number of factor flops:	1.140e+02

Here, the first line indicates that the current optimization algorithm is Barrier Method, and it uses 64 threads (**threads**). The information includes:

- **Problem info** output, which includes: whether the dualized model is solved, the range of matrix coefficients, the range of RHS coefficients, the range of bound coefficients for constraint variables, and the range of cost coefficients for the objective function.
- **Factor info** output, which includes: the number of free columns, the number of dense columns, information related to the linear system matrix factorization.

18.5 Branch-and-Cut Method Logging

Based on different stages of the optimization process, the Branch-and-Cut logging can be divided into three parts:

1. Presolve
2. Branch-and-Cut Search Process
3. Summary of Results

Here, we'll use the example of *cutstock.mps.gz* in the *"/examples/data"* directory of COPT installation package to interpret the information of the MIP log,

18.5.1 Presolve

To simplify the model, the COPT solver performs presolve on the MIP model to eliminate redundant constraints or variable ranges. The information presented in the *Presolve* log includes the changes in model size before and after presolving.

```
The original problem has:
  404 rows, 1200 columns and 2598 non-zero elements
  200 binaries and 1000 integers

Presolving the problem

The presolved problem has:
  373 rows, 1169 columns and 2505 non-zero elements
  369 binaries and 800 integers
```

The description of MIP problem size includes

- the number of constraints (*rows*).
- the number of variables (*columns*).
- non-zero elements in the coefficient matrix (*non-zero elements*).
- the number of binary variables (*binaries*).
- the number of integer variables (*integers*).

Notes

- The variable count (*cols*) here includes all types of variables in the model, including continuous variables, integer variables, and 0-1 variables.

- In theory, 0-1 variables are a special case of integer variables, but they are counted separately in this context.

In the provided log example, the problem size (number of constraints and variables) is reduced after presolving.

18.5.2 Branch-and-Cut Search Process

This section of the log provides information about the Branch-and-Cut search process.

Starting the MIP solver with 8 threads and 32 tasks								
	Nodes	Active	LPit/n	IntInf	BestBound	BestSolution	Gap	Time
	0	1	--	0	3.100000e+01	--	Inf	0.05s
H	0	1	--	0	3.100000e+01	6.800000e+01	54.4%	0.70s
H	0	1	--	0	3.100000e+01	6.600000e+01	53.0%	0.70s
H	0	1	--	0	3.100000e+01	6.500000e+01	52.3%	0.71s
	0	1	--	86	5.591304e+01	6.500000e+01	14.0%	0.72s
H	0	1	--	86	5.591304e+01	6.200000e+01	9.82%	0.74s
	1	2	0.0	86	5.591304e+01	6.200000e+01	9.82%	0.76s
H	1	1	2129	6	6.000000e+01	6.000000e+01	0.00%	0.87s
	2	0	1064	6	6.000000e+01	6.000000e+01	0.00%	0.87s
	2	0	1064	6	6.000000e+01	6.000000e+01	0.00%	0.87s

Note: The presented log content is a partial representation of the optimization process due to space limitation, aiming to facilitating the interpretation of log content.

The Branch-and-Cut search log can be divided into three parts based on the meaning of each information item, and we'll interpret each part separately:

- Node search information (columns 1-4)
- Feasible solution interval information (columns 5-7)
- Solving time information (column 8)

Node search information (columns 1-4):

- **Nodes:** Number of nodes searched.
- **Active:** Number of leaf nodes yet to be searched.
- **LPit/n:** Average number of Simplex iterations per node.
- **IntInf:** Number of integer variables not taking integer values in the current linear relaxation (LP relaxation) solution.

Feasible solution interval information (columns 5-7):

- **BestBound:** Current best objective bound.
- **BestSolution:** Current best objective function value.
- **Gap:** Relative gap between upper and lower bounds. If less than the specified *RelGap* parameter, the solving process will stop.

Solving time information (column 8):

- **Time:** Time taken for solving.

Notes

- The markers (H/*) before **Nodes** in the first column indicate the discovery of a new feasible solution.
 - H: Found through heuristics.

- *: Found by solving subproblems through branching.
- Sometimes, **Nodes** stays 0 for an extended period, indicating that COPT is processing the root node. At the root node, COPT generates cutting planes and attempts various heuristic methods to obtain the optimal feasible solution, aiming to reduce the subsequent search scope.

18.5.3 Summary of Results

This part summarizes the final solving status of the MIP problem and the search process of the Branch-and-Cut method, including the model's solution and the workload of the solving process.

Best solution	:	60.000000000
Best bound	:	60.000000000
Best gap	:	0.0000%
Solve time	:	0.87
Solve node	:	2
MIP status	:	solved
Solution status	:	integer optimal (relative gap limit 0.0001)
Violations	:	absolute relative
bounds	:	0 0
rows	:	0 0
integrality	:	0

Results:

- Best objective function value (**Best solution**).
- Best lower bound (**Best bound**).
- Best gap (**Best gap**).
- Solving status (**Solution status**).

Solving Workload:

- Solving time (**Solve time**).
- Number of nodes searched (**Solve node**).

The section **Violations** indicates the extent to which the optimal solution satisfies the model's constraints and variable ranges. This includes conflict values for variables (**bounds**) and constraints (**rows**), as well as conflicts for integer solutions (*integrality*).

18.6 Logging for First-order method (PDLP) of GPU solver

For Linear Programming Problems, if the PDLP method is selected (setting the parameter **LpMethod=6**), GPU solver can be enabled. (The machine needs the compatible GPU and the necessary CUDA library needs to be configured).

The logging for GPU solver can be divided into the following sections, which are slightly different from the CPU solver, with the main distinction in the second section:

1. Presolve section
2. GPU hardware information of the machine
3. First-order method PDLP iteration process
4. Crossover section
5. Summary of optimization results

Taking the "thk_63" instance from public LP benchmark as an example, the following is the solving log for the GPU solver.

18.6.1 GPU hardware information of the machine

This section outputs information about the current machine's GPU information and CUDA version.

```
Hardware has 1 supported GPU device with CUDA 12.3
GPU 0: NVIDIA GeForce RTX 4090 (CUDA capability 8.9)
```

Notes

1. The "CUDA 12.3" mentioned in the log refers to the highest version of the CUDA Toolkit supported by the currently installed CUDA driver.
2. COPT's GPU solver requires a minimum CUDA Toolkit version of 11.7 (for Linux systems, the corresponding minimum CUDA Driver version is 525.60.13; for Windows systems, the corresponding minimum CUDA Driver version is 527.41). It is recommended to directly install CUDA version 12.0 or higher. If you need to use CUDA Toolkit 11.7, please install CUDA Toolkit and CUDA Driver separately. For details, please refer to the [FAQ section: GPU Usage](#).

18.6.2 3. First-order method PDLP iteration process

This section outputs the solving iteration process of the PDLP method, and the summary after the completion, including the iteration count of PDLP, and the optimal objective values, dual gaps for primal and dual problems.

```
Starting PDLP solver on GPU 0

Iterations      Primal.Obj      Dual.Obj      Gap      Primal.Inf      Dual.Inf      Time
      0      +6.00000000e+00      +6.00000000e+00      +0.00e+00      7.87e+00      0.00e+00      21.63s
    4000      +1.95436674e+03      -1.77166004e+03      +3.73e+03      2.09e-02      0.00e+00      33.37s
    8000      +1.90433201e+03      +1.55817851e+03      +3.46e+02      1.51e-02      0.00e+00      44.75s
   12000      +1.87801607e+03      +1.85689627e+03      +2.11e+01      1.74e-02      0.00e+00      56.27s
   16000      +1.86810632e+03      +1.86897715e+03      +8.71e-01      4.92e-03      0.00e+00      67.72s
   20000      +1.87022842e+03      +1.86994685e+03      +2.82e-01      3.42e-03      0.00e+00      79.18s
   23640      +1.87099459e+03      +1.87099144e+03      +3.15e-03      4.69e-05      0.00e+00      89.68s

PDLP status:                OPTIMAL
PDLP iterations:            23640
Primal objective:           1.87099459e+03
Dual objective:             1.87099144e+03
Primal infeasibility (abs/rel): 4.69e-05 / 6.20e-07
Dual infeasibility (abs/rel):  0.00e+00 / 0.00e+00
Duality gap (abs/rel):       3.15e-03 / 8.43e-07

Experimental: using crossover to find a basic solution after PDLP
Please set parameter Crossover to 0 if the basic solution is not required
Please set parameter PDLPTol to a smaller value if the crossover cleanup takes too
↔long

Starting crossover using up to 8 threads

50320 primal pushes remaining      92.09s
12495 primal pushes remaining      97.71s
```

(continues on next page)

(continued from previous page)

4124 primal pushes remaining 102s					
202 primal pushes remaining 104s					
0 primal pushes remaining 104s					
1480858 dual pushes remaining 104s					
589582 dual pushes remaining 106s					
0 dual pushes remaining 107s					
Method	Iteration	Objective	Primal.NInf	Dual.NInf	Time
Dual	986011	1.8710000000e+03	0	0	107.97s
Postsolving					
Dual	986011	1.8710000000e+03	0	0	110.56s
Unfolding					
Dual	1036742	1.8710000000e+03	0	0	157.25s
Solving finished					
Status: Optimal Objective: 1.8710000000e+03 Iterations: 1036742 Time: 157.69s					

Note: After solving with a First-order method (PDLP), if the solution reaches optimality (**Status: Optimal**), the default behavior is to perform the Crossover process to the basic solution. This process can also be disabled by setting the parameter *Crossover* to 0.

Chapter 19

File formats

19.1 File format list

The file formats currently supported by COPT are listed below:

Table 19.1: Supported file formats

Fileformat	File extension
MPS model file	.mps, .mps.gz
LP model file	.lp, .lp.gz
SDPA model file	.dat-s, .dat-s.gz
CBF model file	.cbf, .cbf.gz
model file in COPT binary format	.bin, .bin.gz
basis file	.bas
solution file	.sol
IIS file	.iis
FeasRelax file	.relax
MIP initial solution file	.mst
parameter file	.par
parameter tuning file	.tune

19.2 File I/O operations

By calling the relevant functions, users can input external model files to COPT for reading. At the same time, they can also save the output of the modeling and optimization results of COPT and output the files.

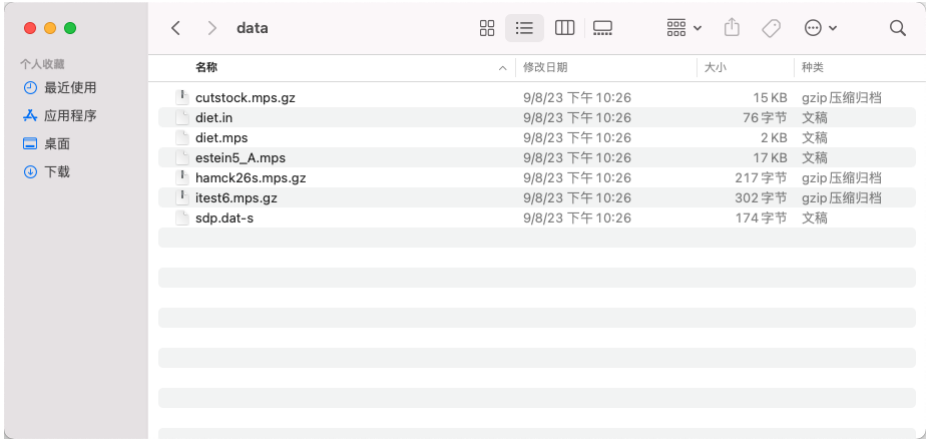
Let's take reading/writing the model in MPS format in the current directory as an example (similar operations are performed for other files). The implementation methods in different interfaces are as follows:

Table 19.2: Functions for input and output files

API	Input	Output
COPT cmd	read example.mps	write example.mps
C	COPT_ReadMps	COPT_WriteMps
Python	Model.read() / Model.readMps()	Model.write() / Model.writeMps()
C++	Model::read() / Model::readMps()	Model::write() / Model::writeMps()
C#	Model.Read() / Model.ReadMps()	Model.Write() / Model.WriteMps()
Java	Model.read() / Model.readMps()	Model.write() / Model.writeMps()

19.3 Model file introduction

Users can find the model file examples that come with COPT in the "examples/data" directory of the installation package. Here we introduce the specific contents of two common model file formats: MPS and LP.



MPS format

MPS is a universal model file standard format. Different types of optimization problems can be output and stored in mps format, which is widely used in optimization softwares.

The following is an example of a model file in MPS format:

NAME	COPTPROB	
OBJSENSE		
MAX		
ROWS		
N __OBJ__		
L R0000000		
G R0000001		
COLUMNS		
x __OBJ__	1.2	
x R0000000	1.5	
x R0000001	0.800000000000000004	
y __OBJ__	1.8	
y R0000000	1.2	
y R0000001	0.5999999999999998	
z __OBJ__	2.1000000000000001	
z R0000000	1.8	
z R0000001	0.9000000000000002	
RHS		
RHS R0000000	2.6000000000000001	
RHS R0000001	1.2	
BOUNDS		
LO BOUND x	0.10000000000000001	
UP BOUND x	0.5999999999999998	
LO BOUND y	0.20000000000000001	
UP BOUND y	1.5	
LO BOUND z	0.2999999999999999	
UP BOUND z	2.7999999999999998	
ENDATA		

This MPS format example mainly includes several parts: NAME, OBJSENSE, ROWS, COLUMNS, RHS, and BOUNDS.

1. NAME: The name of the model
2. OBJSENSE: Optimization direction of the objective function
3. ROWS: Constraints and their directions in the model (L means \leq constraints, G means \geq constraints, N means no boundaries)
4. COLUMNS: Variables and their coefficients in the model
5. RHS: The value of the right-hand term of the constraint
6. BOUNDS: Bounds of variables (LO means lower bound, UP means upper bound, FR means no bounds)

Notes

1. In the ROWS section, the first line `--OBJ--` represents the objective function.
 2. In the COLS part, the form `x --OBJ-- 1.2` indicates that the coefficient of variable x in the objective function is 1.2.
 3. In MPS format, integer variables will be identified by the following fields:
 - First integer variable: `MARKER 'MARKER' 'INTORG'`
 - Last integer variable: `MARKER 'MARKER' 'INTEND'`
-

LP format

The LP format is closer to the algebraic form. It is more readable than MPS, and can easily correspond to its original mathematical model.

The following is an example of a model file in LP format:

```
\Generated by Cardinal Operations

Maximize
1.2 x + 1.8 y + 2.1 z
Subject To
1.5 x + 1.2 y + 1.8 z <= 2.6
0.8 x + 0.6 y + 0.9 z >= 1.2
Bounds
0.1 <= x <= 0.6
0.2 <= y <= 1.5
0.3 <= z <= 2.8
END
```

This LP format mainly includes several parts: objective function (Maximize), constraints (Subject To), and variable scope (Bounds).

Notes

1. In some LP format file, we can see variable names in the form `x#1`, which marks x as the first variable. When the user does not specify a variable name, this is the name automatically generated when outputting the lp model file.
 2. If there is a binary type in the variable, it will be identified by the `Binaries` field.
-

Chapter 20

FAQs

20.1 Installation and Licensing Configuration Related

- **Q:** What is the reason for the error `invalid username` when configuring the license?

A: This error indicates that the username was incorrectly filled in when applying, and you can re-fill the form with the correct username to apply. For information on how to obtain username under different operating systems, please refer to the [Solver COPT application page](#), please remark in the application reason with **“The username is incorrectly filled in, reapply”**. we will issue new license for the correct username.

- **Q:** After downloading COPT, an antivirus software installed on the computer reports a virus and automatically isolates it.

A: The COPT software downloaded from the COPT official download link is the official version, which has not been developed with any suspicious virus behavior. It can be determined that the anti-virus software is falsely reporting. Please temporarily close the anti-virus software before downloading it.

- **Q:** After validating the license (executing `copt_licgen -v`), it reports an error: `Missing Files or Invalid Signature`.

A: This type of error indicates that the license file configuration fails. Please refer to [Installation Instructions: Configuring License File](#) to check whether the steps for configuring the license file are correctly followed. Common reasons are as follows:

1. The license file in the current working directory is not compatible with the version of COPT (for example: the license is version 4.0, while the COPT is version 5.0), please check the `VERSION` in `"license.dat"` to confirm whether the major version is the same, if not, please go to the [Solver COPT application page](#) to re-apply, and we will issue you the latest license.
2. In Windows system, if the COPT software is installed in the system disk (usually C) in a non-user directory (eg: the default installation path `"C:\Program Files\copt70"`), you need to **open the command line window with administrator privileges** and execute the license acquisition command `copt_licgen` again.

- **Q:** I have already installed an old version of the COPT Python interface (`coptpy`), how do I upgrade to the new version?

A: Please refer to [Python Interface Quick Start: Upgrade to the newer version](#) for detailed steps.

20.1.1 MacOS System

- **Q:** When calling `coptpy` on MacOS, an error is reported: `ImportError: from .coptpywrap import * symbol not found in flat namespace.`

A: This error may occur before COPT 6.5.12, since the architecture of `coptpy` and Anaconda do not match. For example, `coptpy` is the M chip version (arm64), and Anaconda is x86 version, you could install Anaconda that supports arm64 architecture to solve this problem.

However, from COPT 6.5.12, for MacOS systems, we provide universal package, so this problem could be resolved by upgrading COPT to the latest version.

- **Q:** When the license is configured in the MacOS system, the `copt_licgen` command is executed in the terminal, and an error is reported: `command not found: copt_licgen`.

A: This error is because the relevant environment variables of COPT are not configured. In the MacOS system, you need to configure the environment variables after installing COPT. Please refer to *Installation Instructions: MacOS System* chapter to obtain detailed installation instructions.

- **Q:** When manually configuring environment variables, I copy content directly from the document to `.zshrc` file or `.bash_profile` file, causing the configuration to fail.

A: Due to the document encoding problem, the above environment variables cannot be directly copied to the corresponding file, and the contents of the environment variables need to be manually entered.

20.1.2 Windows System

- **Q:** In Windows system, when executing `copt_licgen` to generate the license file, an error is reported that the license file cannot be written to the hard disk, and the error message is: `error opening file`.

A: If the COPT software is installed in the system disk (usually C) in a non-user directory (eg: the default installation path "C:\Program Files\copt70"), you need to **open the command line window with administrator privileges** and execute the license acquisition command `copt_licgen`, in order to normally write the license file to the C drive. Administrator privileges are not required to execute permission acquisition commands under user directories such as "C:\Users\shanshu".

- **Q:** In Windows system, when installing COPT Python interface via command `pip install coptpy`, an error is displayed: `could not find a version, no matching distribution`, what is the reason?

A: Please do not use Python installed through Microsoft Store, it is recommended to download from [Anaconda distribution](#) or [Python official distribution](#) Download Python.

- **Q:** In Windows system, when installing COPT Python interface through COPT installation package (`python setup.py install`), an error `could not create build: access denied` is reported.

A: If COPT is installed in the system disk (usually C) in a non-user directory (eg: the default installation path "C:\Program Files\copt70"), you need to first **Open the command line window with administrator privileges** and execute the command `python setup.py install`.

20.2 Modeling and Solving Functions Related

- **Q:** When creating a COPT solution environment, two lines of version information will be output. If I want to turn off this information, how should I do it?
- **A:** You can turn it off by setting "nobanner" to "1" in `EnvrConfig` before creating the solution environment. Taking the Python API as an example, the specific operations are as follows:

```
envconfig = coptpy.EnvrConfig()
envconfig.set('nobanner', '1')
env = coptpy.Envr(envconfig)
model = env.createModel()
```

- **Q:** How to deal with the situation where the model is infeasible?
A: COPT provides functions to calculate IIS and feasible relaxation to analyze the reasons for model infeasibility: Computing IIS will obtain the minimum set of infeasible constraints and variables, and feasibility relaxation attempts to make the model feasible with minimal changes.
- **Q:** Are there default value ranges for variables created in COPT?
A: Yes, the default lower bound of variables in COPT is 0, and the upper bound is `COPT.INFINITY`. Users can specify the lower bound of variables through the function argument *lb*, and the upper bound of variables through *ub*.
- **Q:** What is the reason for the error `ValueError: cannot create object arrays from iterator`. when adding matrix variables using the matrix modeling method of COPT?
A: The matrix modeling function supported by COPT Python has a minimum version requirement, the minimum version requirement for NumPy is 1.23, and the minimum version requirement for Python is 3.8 . NumPy can be upgraded to the latest version by `pip install --upgrade numpy`.
- **Q:** When adding constraints using Python interface, if the modeling efficiency is slow, are there any ways to improve the modeling process?
A: The Python interface of COPT supports building linear expression, quadratic expression and PSD expression in natural way. For linear and quadratic expression, it is recommended to use `quicksum()` to build expression objects. For linear and PSD expression, it is recommended to use `psdquicksum()` to build expression objects. Both of them implement inplace summation, which is much faster than standard plus operator.

20.3 GPU Usage Related

- **Q:** Are there any requirements for the CUDA library version when enabling COPT's GPU solver?
A: COPT requires a minimum version of 11.7 for the CUDA library. We recommend installing CUDA 12.0 or above, which can be directly installed via the official installer. If you need to install CUDA version 11, the best practice is to separately install CUDA Driver and CUDA Toolkit:
 1. Firstly, please download and install CUDA Driver separately (for Linux systems, CUDA Driver requires a minimum version of 525.60.13, for Windows systems, CUDA Driver requires a minimum version of 527.41).
 2. Secondly, please download the official CUDA installer with version 11.7 or above and only install the CUDA Toolkit, without selecting CUDA driver.
- **Q:** Are there any requirements for the GPU architecture when enabling GPU solver?
A: The GPU architecture needs to be at least the Maxwell architecture or above (Maxwell architecture is a GPU architecture introduced by NVIDIA in 2014, an upgrade from its previous Kepler architecture).

- **Q:** What are the common error messages and possible reasons when the machine cannot use GPU solver?

A: Common error messages and possible reasons are as follows:

1.Solving log indicates "NO CUDA libraries available" which suggests that necessary CUDA library functions are missing. You could try checking and setting the environment variable "LD_LIBRARY_PATH" to point to the directory where CUDA is installed. (Please follow the instructions provided after CUDA installation. Environment variables are automatically configured during installation on Windows systems. For Linux systems, manual configuration of environment variables is typically required. The directory will be like: "/usr/local/cuda/lib64").

2.Solving error message "Fail to solve problem" is usually due to the lower version of CUDA Driver. Please upgrade the COPT Driver (for Linux systems: 525.60.13 or above; for Windows systems: 527.41 or above) to resolve this issue.

3.Solving error message "sparse matrix format CUSPARSE_FORMAT_CSC is not supported" is usually caused by the lower version of CUDA Toolkit (typically occurring between CUDA V11.2 and V11.6). Please upgrade CUDA to version 11.7 or above to resolve this issue.

- **Q:** On a client machine with multiple GPUs, when setting the parameter *GPUDevice* to use a specific GPU number, why does it still detect only GPU with number 0 during solving?

A: Please check if the environment variable "CUDA_VISIBLE_DEVICES" has been manually set to specify the visible GPU devices for CUDA. Try not to set this environment variable so that COPT can detect all available GPUs on the current machine.

- **Q:** Why do I encounter errors when using COPT's GPU solver via Windows Subsystem for Linux (WSL) despite installing CUDA libraries that meet the version requirements (V12 or higher)?

A: Please check if the CUDA Driver version meets the requirements. WSL usually skips the Driver installation when installing CUDA and directly uses the Driver already installed in Windows. Please manually upgrade the CUDA Driver version and then restart WSL to resolve this issue.

Chapter 21

C API Reference

The **Cardinal Optimizer** provides a C API library for advanced usage. This section documents all the COPT constants, API functions, parameters and attributes listed in `copt.h`.

21.1 Constants

There are three types of constants.

1. Constructing models, such as optimization directions, constraint senses or variable types.
2. Accessing solution results, such as API return code, basis status and LP status.
3. Monitoring optimization progress, such as callback context.

21.1.1 Optimization directions

For different optimization scenarios, it may be required to either maximize or minimize the objective function. There are two optimization directions:

- `COPT_MINIMIZE`

For minimizing the objective function.

- `COPT_MAXIMIZE`

For maximizing the objective function.

The optimization direction is automatically set when reading in a problem from file. It can also be set explicitly using `COPT_SetObjSense`.

21.1.2 Infinity

In COPT, the infinite bound is represented by a large value, which can be set using the double parameter `COPT_DBLPARAM_INFBOUND`, whose default value is also available as a constant:

- `COPT_INFINITY`

The default value (`1e30`) of the infinite bound.

21.1.3 Undefined Value

In COPT, the undefined value is represented by another large value. For example, the default solution value of MIP start is set to a constant:

- COPT_UNDEFINED
Undefined value($1e40^+$).

21.1.4 Constraint senses

NOTE: Using constraint senses is supported by COPT but not recommended. We recommend defining constraints using explicit lower and upper bounds.

Traditionally, for optimization models, constraints are defined using **senses**. The most common constraint senses are:

- COPT_LESS_EQUAL
For constraint in the form of $g(x) \leq b$
- COPT_GREATER_EQUAL
For constraint in the form of $g(x) \geq b$
- COPT_EQUAL
For constraint in the form of $g(x) = b$

In addition, there are two less used constraint senses:

- COPT_FREE
For unconstrained expression
- COPT_RANGE
For constraints with both lower and upper bounds in the form of $l \leq g(x) \leq u$.
Please refer to documentation of COPT_LoadProb regarding how to use COPT_RANGE to define a constraints with both lower and upper bounds.

21.1.5 Variable types

Variable types are used for defining whether a variable is continuous or integral.

- COPT_CONTINUOUS
Non-integer continuous variables
- COPT_BINARY
Binary variables
- COPT_INTEGER
Integer variables

21.1.6 SOS-constraint types

SOS constraint (Special Ordered Set) is a kind of special constraint that places restrictions on the values that a set of variables can take.

COPT currently support two types of SOS constraints, one is SOS1 constraint, where at most one variable in the constraint is allowed to take a non-zero value, the other is SOS2 constraint, where at most two variables in the constraint are allowed to take non-zero value, and those non-zero variables must be contiguous. Variables in SOS constraints are allowed to be continuous, binary and integer.

- COPT_SOS_TYPE1
SOS1 constraint
- COPT_SOS_TYPE2
SOS2 constraint

21.1.7 Indicator constraint

Indicator constraint is a kind of logical constraints in COPT, used to describe the relationship between the value of the binary variable y and whether the linear constraint $a^T x \leq b$ is satisfied. Currently, COPT supports three types of indicator constraints:

- COPT_INDICATOR_IF

If-Then:

If $y = f$, then the linear constraint $a^T x \leq b$ is satisfied.

If $y \neq f$, then the linear constraint $a^T x \leq b$ is invalid (may be violated).

$$\begin{aligned} y = f &\rightarrow a^T x \leq b \\ f &\in \{0, 1\} \end{aligned} \tag{21.1}$$

- COPT_INDICATOR_ONLYIF

Only-If:

If the linear constraint $a^T x \leq b$ is satisfied, then $y = f$.

If the linear constraint $a^T x \leq b$ is not satisfied, then y can be 0 or 1.

$$\begin{aligned} a^T x \leq b &\rightarrow y = f \\ f &\in \{0, 1\} \end{aligned} \tag{21.2}$$

- COPT_INDICATOR_IFANDONLYIF

If-and-Only-If:

The linear constraint $a^T x \leq b$ and $y = f$ must be satisfied simultaneously or not satisfied simultaneously.

$$\begin{aligned} a^T x \leq b &\leftrightarrow y = f \\ f &\in \{0, 1\} \end{aligned} \tag{21.3}$$

21.1.8 SOC constraint type

The Second-Order-Cone (SOC) constraint is a special type of quadratic constraints. COPT supports two types of SOC constraints:

- COPT_CONE_QUAD : Regular Second-Order-Cone

$$Q^n = \left\{ x \in \mathbb{R}^n \mid x_0 \geq \sqrt{\sum_{i=1}^{n-1} x_i^2}, x_0 \geq 0 \right\} \quad (21.4)$$

- COPT_CONE_RQUAD : Rotated Second-Order-Cone

$$Q_r^n = \left\{ x \in \mathbb{R}^n \mid 2x_0x_1 \geq \sum_{i=2}^{n-1} x_i^2, x_0 \geq 0, x_1 \geq 0 \right\} \quad (21.5)$$

21.1.9 Exponential cone constraint type

COPT supports two types of exponential cone constraints:

- COPT_EXPCONE_PRIMAL : Primal exponential cone

$$\text{cl}(S_1) = S_1 \cup S_2 \quad (21.6)$$

$$S_1 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid s > 0, t \geq s \exp\left(\frac{r}{s}\right) \right\}, \quad (21.7)$$

$$S_2 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid s = 0, t \geq 0, r \leq 0 \right\}$$

- COPT_EXPCONE_DUAL : Dual exponential cone

$$\text{cl}(S_1) = S_1 \cup S_2 \quad (21.8)$$

$$S_1 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid r < 0, t \geq -r \exp\left(\frac{s}{r} - 1\right) \right\}, \quad (21.9)$$

$$S_2 = \left\{ \begin{pmatrix} t \\ s \\ r \end{pmatrix} \in \mathbb{R}^3 \mid r = 0, t \geq 0, s \geq 0 \right\}$$

21.1.10 Quadratic objective function

Besides linear objective function, COPT also supports general convex quadratic objective function.

The mathematical form is:

$$x^T Q x + c^T x \quad (21.10)$$

Where, x is an array of variables, Q is the quadratic part of the quadratic objective function and c is the linear part.

21.1.11 Quadratic constraint

Besides the special type of quadratic constraint, Second-Order-Cone (SOC) constraint, COPT also supports general convex quadratic constraint.

The mathematical form is:

$$x^T Q x + q^T x \leq b \quad (21.11)$$

Where, x is an array of variables, Q is the quadratic part of the quadratic constraint and c is the linear part.

21.1.12 Basis status

For an LP problem with n variables and m constraints, the constraints are treated as slack variables *internally*, resulting in $n + m$ variables. When solving an LP problem using the simplex method, the simplex method fixes n variables at one of their bounds, and then computes solutions for the other m variables. The m variables with computed solution are called *basic* variables, and the other n variables are called *non-basic* variables. The simplex progress and its final solution can be defined using the basis status of all the variables and constraints.

The basis status supported by COPT are:

- COPT_BASIS_LOWER
The variable is non-basic at its lower bound.
- COPT_BASIS_BASIC
The variable is basic.
- COPT_BASIS_UPPER
The variable is non-basic at its upper bound.
- COPT_BASIS_SUPERBASIC
The variable is non-basic but not any of its bounds.
- COPT_BASIS_FIXED
The variable is non-basic and fixed at its bound.

21.1.13 LP solution status

The solution status of an LP problem is called LP status, which can be obtained using integer attribute COPT_INTATTR_LPSTATUS.

Possible LP status values are:

- COPT_LPSTATUS_UNSTARTED
The LP optimization is not started yet.
- COPT_LPSTATUS_OPTIMAL
The LP problem is solved to optimality.
- COPT_LPSTATUS_INFEASIBLE
The LP problem is infeasible.
- COPT_LPSTATUS_UNBOUNDED
The LP problem is unbounded.
- COPT_LPSTATUS_NUMERICAL

Numerical trouble encountered.

- **COPT_LPSTATUS_TIMEOUT**

The LP optimization is stopped because of time limit.

- **COPT_LPSTATUS_UNFINISHED**

The LP optimization is stopped but the solver cannot provide a solution because of numerical difficulties.

- **COPT_LPSTATUS_IMPRECISE**

The solution is imprecise.

- **COPT_LPSTATUS_INTERRUPTED**

The LP optimization is stopped by user interrupt.

21.1.14 MIP solution status

The solution status of an MIP problem is called MIP status, which can be obtained using integer attribute **COPT_INTATTR_MIPSTATUS**.

Possible MIP status values are:

- **COPT_MIPSTATUS_UNSTARTED**

The MIP optimization is not started yet.

- **COPT_MIPSTATUS_OPTIMAL**

The MIP problem is solved to optimality.

- **COPT_MIPSTATUS_INFEASIBLE**

The MIP problem is infeasible.

- **COPT_MIPSTATUS_UNBOUNDED**

The MIP problem is unbounded.

- **COPT_MIPSTATUS_INF_OR_UNB**

The MIP problem is infeasible or unbounded.

- **COPT_MIPSTATUS_NODELIMIT**

The MIP optimization is stopped because of node limit.

- **COPT_MIPSTATUS_TIMEOUT**

The MIP optimization is stopped because of time limit.

- **COPT_MIPSTATUS_UNFINISHED**

The MIP optimization is stopped but the solver cannot provide a solution because of numerical difficulties.

- **COPT_MIPSTATUS_INTERRUPTED**

The MIP optimization is stopped by user interrupt.

21.1.15 Callback context

- **CBCONTEXT_INCUMBENT**
Invokes the callback after a new incumbent was found.
- **COPT_CBCONTEXT_MIPNODE**
Invokes the callback after a MIP node was processed.
- **COPT_CBCONTEXT_MIPRELAX**
Invokes the callback when an LP-relaxation was solved.
- **COPT_CBCONTEXT_MIPSOL**
Invokes the callback when a new MIP candidate solution is found.

21.1.16 Nonlinear Expression Operators

- **COPT_NL_PLUS**
Addition operator.
- **COPT_NL_MINUS**
Subtraction operator.
- **COPT_NL_MULT**
Multiplication operator.
- **COPT_NL_DIV**
Division operator.
- **COPT_NL_POW**
Power operator.
- **COPT_NL_SQRT**
Square root operator.
- **COPT_NL_EXP**
Exponential function operator.
- **COPT_NL_LOG**
Natural logarithm operator.
- **COPT_NL_LOG10**
Base-10 logarithm operator.
- **COPT_NL_NEG**
Unary negation operator.
- **COPT_NL_ABS**
Absolute value operator.
- **COPT_NL_FLOOR**
Floor function operator.
- **COPT_NL_CEIL**
Ceiling function operator.
- **COPT_NL_SIN**

Sine function operator.

- COPT_NL_COS

Cosine function operator.

- COPT_NL_TAN

Tangent function operator.

- COPT_NL_SINH

Hyperbolic sine function operator.

- COPT_NL_COSH

Hyperbolic cosine function operator.

- COPT_NL_TANH

Hyperbolic tangent function operator.

- COPT_NL_ASIN

Inverse sine (arcsin) function operator.

- COPT_NL_ACOS

Inverse cosine (arccos) function operator.

- COPT_NL_ATAN

Inverse tangent (arctan) function operator.

- COPT_NL_ASINH

Inverse hyperbolic sine (arsinh) function operator.

- COPT_NL_ACOSH

Inverse hyperbolic cosine (arcosh) function operator.

- COPT_NL_ATANH

Inverse hyperbolic tangent (artanh) function operator.

- COPT_NL_ATAN2

Two-argument inverse tangent function operator.

- COPT_NL_SUM

Summation operator.

- COPT_NL_GET

Constant retrieval operator.

21.1.17 API function return code

When an API function finishes, it returns an integer **return code**, which indicates whether the API call was finished okay or failed. In case of failure, it specifies the reason of the failure.

Possible COPT API function return codes are:

- COPT_RETCODE_OK

The API call finished successfully.

- COPT_RETCODE_MEMORY

The API call failed because of memory allocation failure.

- COPT_RETCODE_FILE

The API call failed because of file input or output failure.

- `COPT_RETCODE_INVALID`

The API call failed because of invalid data.

- `COPT_RETCODE_LICENSE`

The API call failed because of license validation failure. In this case, further information can be obtained by calling `COPT_GetLicenseMsg`.

- `COPT_RETCODE_INTERNAL`

The API call failed because of internal error.

- `COPT_RETCODE_THREAD`

The API call failed because of thread error.

- `COPT_RETCODE_SERVER`

The API call failed because of remote server error.

- `COPT_RETCODE_NONCONVEX`

The API call failed because of problem is nonconvex.

21.1.18 Client configuration

For floating and cluster clients, users are allowed to set client configuration parameters, currently available settings are:

- `COPT_CLIENT_CLUSTER`

IP address of cluster server.

- `COPT_CLIENT_FLOATING`

IP address of token server.

- `COPT_CLIENT_PASSWORD`

Password of cluster server.

- `COPT_CLIENT_PORT`

Connection port of token server.

- `COPT_CLIENT_WAITTIME`

Wait time of client.

21.1.19 Other constants

- `COPT_BUFFSIZE`

Defines the recommended buffer size when obtaining a C-style string message from COPT library. This can be used with, for example, `COPT_GetBanner`, `COPT_GetRetcodeMsg` etc.

21.2 Attributes

21.2.1 Problem information

- COPT_INTATTR_COLS or "Cols"
Integer attribute.
Number of variables (columns) in the problem.
- COPT_INTATTR_PSDCOLS or "PSDCols"
Integer attribute.
Number of PSD variables in the problem.
- COPT_INTATTR_ROWS or "Rows"
Integer attribute.
Number of constraints (rows) in the problem.
- COPT_INTATTR_ELEMS or "Elems"
Integer attribute.
Number of non-zero elements in the coefficient matrix.
- COPT_INTATTR_QELEMS or "QElems"
Integer attribute.
Number of non-zero quadratic elements in the quadratic objective function.
- COPT_INTATTR_PSDELEMS or "PSDElems"
Integer attribute.
Number of PSD terms in objective function.
- COPT_INTATTR_SYMMATS or "SymMats"
Integer attribute.
Number of symmetric matrices in the problem.
- COPT_INTATTR_BINS or "Bins"
Integer attribute.
Number of binary variables.
- COPT_INTATTR_INTS or "Ints"
Integer attribute.
Number of integer variables.
- COPT_INTATTR_SOSS or "Soss"
Integer attribute.
Number of SOS constraints.
- COPT_INTATTR_CONES or "Cones"
Integer attribute.
Number of Second-Order-Cone constraints.
- COPT_INTATTR_EXPCONES or "ExpCones"
Integer attribute.
Number of exponential cone constraints.

- COPT_INTATTR_AFFINECONES or "AffineCones"
Integer attribute.
Number of affine cone constraints.
- COPT_INTATTR_QCONSTRS or "QConstrs"
Integer attribute.
Number of quadratic constraints.
- COPT_INTATTR_PSDCONSTRS or "PSDConstrs"
Integer attribute.
Number of PSD constraints.
- COPT_INTATTR_LMICONSTRS or "LMIconstrs"
Integer attribute.
Number of LMI constraints.
- COPT_INTATTR_INDICATORS or "Indicators"
Integer attribute.
Number of indicator constraints.
- COPT_INTATTR_OBJSENSE or "ObjSense"
Integer attribute.
The optimization direction.
- COPT_DBLATTR_OBJCONST or "ObjConst"
Double attribute.
The constant part of the objective function.
- COPT_INTATTR_HASQOBJ or "HasQObj"
Integer attribute.
Whether the problem has quadratic objective function.
- COPT_INTATTR_HASPSDOBJ or "HasPSDObj"
Integer attribute.
Whether the problem has PSD terms in objective function.
- COPT_INTATTR_ISMIP or "IsMIP"
Integer attribute.
Whether the problem is a MIP.
- COPT_INTATTR_NLELEMS or "NLElems"
Integer attribute.
The number of nonlinear expression terms in the objective of the model.
- COPT_INTATTR_NLCONSTRS or "NLConstrs"
Integer attribute.
The number of nonlinear expression constraints in the model.
- COPT_INTATTR_HASNLOBJ or "HasNLObj"
Integer attribute.
Indicates whether the model has nonlinear expressions in the objective.

21.2.2 Solution information

- COPT_INTATTR_LPSTATUS or "LpStatus"
Integer attribute.
The LP status. Please refer to *Constants: LP solution status* for possible values.
- COPT_INTATTR_MIPSTATUS or "MipStatus"
Integer attribute.
The MIP status. Please refer to *Constants: MIP solution status* for possible values.
- COPT_INTATTR_SIMPLEXITER or "SimplexIter"
Integer attribute.
Number of simplex iterations performed.
- COPT_INTATTR_BARRIERITER or "BarrierIter"
Integer attribute.
Number of barrier iterations performed.
- COPT_INTATTR_NODECNT or "NodeCnt"
Integer attribute.
Number of explored nodes.
- COPT_INTATTR_POOLSOLS or "PoolSols"
Integer attribute.
Number of solutions in solution pool.
- COPT_INTATTR_TUNERESULTS or "TuneResults"
Integer attribute.
Number of parameter tuning results
- COPT_INTATTR_HASLPSOL or "HasLpSol"
Integer attribute.
Whether LP solution is available.
- COPT_INTATTR_HASBASIS or "HasBasis"
Integer attribute.
Whether LP basis is available.
- COPT_INTATTR_HASDUALFARKAS or "HasDualFarkas"
Integer attribute.
Whether the dual Farkas of an infeasible LP problem is available.
- COPT_INTATTR_HASPRIMALRAY or "HasPrimalRay"
Integer attribute.
Whether the primal ray of an unbounded LP problem is available.
- COPT_INTATTR_HASMIPSOL or "HasMipSol"
Integer attribute.
Whether MIP solution is available.
- COPT_INTATTR_IISCOLS or "IISCols"

Integer attribute.

Number of bounds of columns in IIS.

- COPT_INTATTR_IISROWS or "IISRows"

Integer attribute.

Number of rows in IIS.

- COPT_INTATTR_ISSOSS or "IISOSSs"

Integer attribute.

Number of SOS constraints in IIS.

- COPT_INTATTR_IISINDICATORS or "IISIndicators"

Integer attribute.

Number of indicator constraints in IIS.

- COPT_INTATTR_HASIIS or "HasIIS"

Integer attribute.

Whether IIS is available.

- COPT_INTATTR_HASFEASRELAXSOL or "HasFeasRelaxSol"

Integer attribute.

Whether feasibility LP-relaxation solution is available.

- COPT_INTATTR_ISMINIIS or "IsMinIIS"

Integer attribute.

Whether the computed IIS is minimal.

- COPT_DBLATTR_LPOBJVAL or "LpObjval"

Double attribute.

The LP objective value.

- COPT_DBLATTR_BESTOBJ or "BestObj"

Double attribute.

Best integer objective value for MIP.

- COPT_DBLATTR_BESTBND or "BestBnd"

Double attribute.

Best bound for MIP.

- COPT_DBLATTR_BESTGAP or "BestGap"

Double attribute.

Best relative gap for MIP.

- COPT_DBLATTR_FEASRELAXOBJ or FeasRelaxObj

Double attribute.

Feasibility relaxation objective value.

- COPT_DBLATTR_SOLVINGTIME or "SolvingTime"

Double attribute.

The time spent for the optimization (in seconds).

21.3 Information

21.3.1 Problem information

- COPT_DBLINFO_OBJ or "Obj"
Double information.
Objective cost of columns.
- COPT_DBLINFO_LB or "LB"
Double information.
Lower bounds of columns or rows.
- COPT_DBLINFO_UB or "UB"
Double information.
Upper bounds of columns or rows.

21.3.2 Solution information

- COPT_DBLINFO_VALUE or "Value"
Double information.
Solution of columns.
- COPT_DBLINFO_SLACK or "Slack"
Double information.
Solution of slack variables, also known as activities of constraints. Only available for LP problem.
- COPT_DBLINFO_DUAL or "Dual"
Double information.
Solution of dual variables. Only available for LP problem.
- COPT_DBLINFO_REDCOST or "RedCost"
Double information.
Reduced cost of columns. Only available for LP problem.

21.3.3 Dual Farkas and primal ray

Advanced topic. When an LP is infeasible or unbounded, the solver can return the dual Farkas or primal ray to prove it.

- COPT_DBLINFO_DUALFARKAS or "DualFarkas"

Double information.

The dual Farkas for constraints of an infeasible LP problem. Please enable the parameter "ReqFarkasRay" to ensure that the dual Farkas is available when the LP is infeasible.

Without loss of generality, the concept of the dual Farkas can be conveniently demonstrated using an LP problem with general variable bounds and equality constraints: $Ax = 0$ and $l \leq x \leq u$. When the LP is infeasible, a dual Farkas vector y can prove that the system has conflict that $\max y^T Ax < y^T b = 0$. Computing $\max y^T Ax$: with the vector $\hat{a} = y^T A$, choosing variable bound $x_i = l_i$ when $\hat{a}_i < 0$ and $x_i = u_i$ when $\hat{a}_i > 0$ gives the maximal possible value of $y^T Ax$ for any x within their bounds.

Some application relies on the alternate conflict $\min \bar{y}^T Ax > \bar{y}^T b = 0$. This can be achieved by negating the dual Farkas, i.e. $\bar{y} = -y$ returned by the solver.

In very rare cases, the solver may fail to return a valid dual Farkas. For example when the LP problem slightly infeasible by tiny amount, which We recommend to study and to repair the infeasibility using FeasRelax instead.

- COPT_DBLINFO_PRIMALRAY or "PrimalRay"

Double information.

The primal ray for variables of an unbounded LP problem. Please enable the parameter "ReqFarkasRay" to ensure that the primal ray is available when an LP is unbounded.

For a minimization LP problem in the standard form: $\min c^T x, Ax = b$ and $x \geq 0$, a primal ray vector r satisfies that $r \geq 0, Ar = 0$ and $c^T r < 0$.

21.3.4 Feasibility relaxation information

- COPT_DBLINFO_RELAXLB or "RelaxLB"

Double information.

Feasibility relaxation values for lower bounds of columns or rows.

- COPT_DBLINFO_RELAXUB or "RelaxUB"

Double information.

Feasibility relaxation values for upper bounds of columns or rows.

- COPT_DBLINFO_RELAXVALUE or "RelaxValue"

Double information.

Solutions for the original model variables (columns) in the feasibility relaxation model.

21.4 Callback information

- COPT_CBINFO_BESTOBJ or "BestObj"

Double information.

Current best objective.

- COPT_CBINFO_BESTBND or "BestBnd"

Double information.

Current best objective bound.

- COPT_CBINFO_HASINCUMBENT or "HasIncumbent"

Integer information.

Whether an incumbent is available.

- COPT_CBINFO_INCUMBENT or "Incumbent"

Double information.

Current best feasible solution.

- COPT_CBINFO_MIPCANDIDATE or "MipCandidate"

Double information.

Current feasible solution candidate.

- COPT_CBINFO_MIPCANDOBJ or "MipCandObj"

Double information.

Objective value for current feasible solution candidate.

- COPT_CBINFO_RELAXSOLUTION or "RelaxSolution"

Double information.

Current solution of LP-relaxation.

- COPT_CBINFO_RELAXSOLOBJ or "RelaxSolObj"

Double information.

Current objective of LP-relaxation.

- COPT_CBINFO_NODESTATUS or "NodeStatus"

Integer information.

The solution status of the LP-relaxation problem at the current node.

For possible values, please refer to: *General Constants Chapter: Solution Status (Part)*, except for NODELIMIT, UNSTARTED, INF_OR_UNB .

21.5 Parameters

21.5.1 Limits and tolerances

- COPT_DBLPARAM_TIMELIMIT or "TimeLimit"

Double parameter.

Time limit of the optimization.

Default: 1e20

Minimal: 0

Maximal: 1e20

- COPT_DBLPARAM_SOLTIMELIMIT or "SolTimeLimit"

Double parameter.

Time limit if a primal feasible solution has been found.

Default: 1e20

Minimal: 0

Maximal: 1e20

- COPT_INTPARAM_NODELIMIT or "NodeLimit"

Integer parameter.

Node limit of the optimization.

Default: -1

Minimal: -1

Maximal: INT_MAX

- COPT_INTPARAM_BARITERLIMIT or "BarIterLimit"

Integer parameter.

Iteration limit of barrier method.

Default: 500

Minimal: 0

Maximal: INT_MAX

- COPT_DBLPARAM_MATRIXTOL or "MatrixTol"

Double parameter.

Input matrix coefficient tolerance.

Default: 1e-10

Minimal: 0

Maximal: 1e-7

- COPT_DBLPARAM_FEASTOL or "FeasTol"

Double parameter.

The feasibility tolerance.

Default: 1e-6

Minimal: 1e-9.

Maximal: 1e-4

- COPT_DBLPARAM_DUALTOL or "DualTol"

Double parameter.

The tolerance for dual solutions and reduced cost.

Default: 1e-6

Minimal: 1e-9

Maximal: 1e-4

- COPT_DBLPARAM_INTTOL or "IntTol"

Double parameter.

The integrality tolerance for variables.

Default: 1e-6

Minimal: 1e-9

Maximal: 1e-1

- COPT_DBLPARAM_RELGAP or "RelGap"

Double parameter.

The relative gap of optimization.

Default: 1e-4

Minimal: 0

Maximal: DBL_MAX

- COPT_DBLPARAM_ABSGAP or "AbsGap"

Double parameter.

The absolute gap of optimization.

Default: 1e-6

Minimal: 0

Maximal: DBL_MAX

21.5.2 Presolving and scaling

- COPT_INTPARAM_PRESOLVE or "Presolve"

Integer parameter.

Level of presolving before solving a model.

Default: -1

Possible values:

-1: Automatic

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_SCALING or "Scaling"

Integer parameter.

Whether to perform scaling before solving a problem.

Default: -1

Possible values:

-1: Choose automatically.

0: No scaling.

1: Apply scaling.

- COPT_INTPARAM_DUALIZE or "Dualize"

Integer parameter.

Whether to dualize a problem before solving it.

Default: -1

Possible values:

-1: Choose automatically.

0: No dualizing.

1: Dualizing the problem.

21.5.3 Linear Programming related

- COPT_INTPARAM_LPMETHOD or "LpMethod"

Integer parameter.

Method to solve the LP problem.

Default: -1

Possible values:

-1: Choose automatically.

For Linear Programming, choose dual simplex method;

For Mixed Integer Linear Programming, choose dual simplex or barrier method.

- 1: Dual simplex.
- 2: Barrier.
- 3: Crossover.
- 4: Concurrent (Use simplex and barrier simultaneously).
- 5: Choose between simplex and barrier automatically (Based on features such as sparsity and/or coefficients ranges).
- 6: First-order method (PDLP).

Note:

Currently, COPT's GPU mode only supports solving Linear Programming problems using the first-order method (PDLP). To enable it, you need to set `LpMethod=6` first.

- `COPT_INTPARAM_DUALPRICE` or "DualPrice"

Integer parameter.

Specifies the dual simplex pricing algorithm.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Using Devex pricing algorithm.
- 1: Using dual steepest-edge pricing algorithm.

- `COPT_INTPARAM_DUALPERTURB` or "DualPerturb"

Integer parameter.

Whether to allow the objective function perturbation when using the dual simplex method.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No perturbation.
- 1: Allow objective function perturbation.

- `COPT_INTPARAM_BARHOMOGENEOUS` or "BarHomogeneous"

Integer parameter.

Whether to use homogeneous self-dual form in barrier.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No.
- 1: Yes.

- `COPT_INTPARAM_BARORDER` or "BarOrder"

Integer parameter.

Barrier ordering algorithm.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Approximate Minimum Degree (AMD).
- 1: Nested Dissection (ND).

- COPT_INTPARAM_BARSTART or "BarStart"

Integer parameter.

Algorithm for finding initial points in barrier method.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Simple.
- 1: Mehrotra.
- 2: Modified Mehrotra.

- COPT_INTPARAM_CROSSOVER or "Crossover"

Integer parameter.

Whether to use crossover.

Default: 1

Possible values:

- 1: Choose automatically.
 - Only run crossover when the LP solution is not primal-dual feasible.
- 0: No.
- 1: Yes.

- COPT_INTPARAM_REQFARKASRAY or "ReqFarkasRay"

Integer parameter.

Advanced topic. Whether to compute the dual Farkas or primal ray when the LP is infeasible or unbounded.

Default: 0

Possible values:

- 0: No.
- 1: Yes.

21.5.4 Semidefinite Programming related

- COPT_INTPARAM_SDPMETHOD or "SDPMethod"

Integer parameter.

Method to solve the SDP problem.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Primal-Dual method.
- 1: Alternating direction method of multipliers (ADMM).
- 2: Dual method.

21.5.5 Integer Programming related

- COPT_INTPARAM_CUTLEVEL or "CutLevel"
Integer parameter.
Level of cutting-planes generation.
Default: -1
Possible values:
 - 1: Choose automatically.
 - 0: Off
 - 1: Fast
 - 2: Normal
 - 3: Aggressive
- COPT_INTPARAM_ROOTCUTLEVEL or "RootCutLevel"
Integer parameter.
Level of cutting-planes generation of root node.
Default: -1
Possible values:
 - 1: Choose automatically.
 - 0: Off
 - 1: Fast
 - 2: Normal
 - 3: Aggressive
- COPT_INTPARAM_TREECUTLEVEL or "TreeCutLevel"
Integer parameter.
Level of cutting-planes generation of search tree.
Default: -1
Possible values:
 - 1: Choose automatically.
 - 0: Off
 - 1: Fast
 - 2: Normal
 - 3: Aggressive
- COPT_INTPARAM_ROOTCUTROUNDS or "RootCutRounds"

Integer parameter.

Rounds of cutting-planes generation of root node.

Default: -1 (Choose automatically)

Minimal: -1

Maximal: INT_MAX

- COPT_INTPARAM_NODECUTROUNDS or "NodeCutRounds"

Integer parameter.

Rounds of cutting-planes generation of search tree node.

Default: -1 (Choose automatically)

Minimal: -1

Maximal: INT_MAX

- COPT_INTPARAM_HEURLEVEL or "HeurLevel"

Integer parameter.

Level of heuristics.

Default: -1

Possible values:

-1: Choose automatically

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_ROUNDINGHEURLEVEL or "RoundingHeurLevel"

Integer parameter.

Level of rounding heuristics.

Default: -1

Possible values:

-1: Choose automatically

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_DIVINGHEURLEVEL or "DivingHeurLevel"

Integer parameter.

Level of diving heuristics.

Default: -1

Possible values:

-1: Choose automatically

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_TREECUTLEVEL or "SubMipHeurLevel"

Integer parameter.

Level of Sub-MIP heuristics.

Default: -1

Possible values:

-1: Choose automatically

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_FAPHEURLEVEL or "FAPHeurLevel"

Integer parameter.

Level of Fix-and-propagate heuristics.

Default: -1

Possible values:

-1: Choose automatically

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_STRONGBRANCHING or "StrongBranching"

Integer parameter.

Level of strong branching.

Default: -1

Possible values:

-1: Choose automatically

0: Off

1: Fast

2: Normal

3: Aggressive

- COPT_INTPARAM_CONFLICTANALYSIS or "ConflictAnalysis"

Integer parameter.

Whether to perform conflict analysis.

Default: -1

Possible values:

-1: Choose automatically.

0: No

1: Yes

- COPT_INTPARAM_MIPSTARTMODE or "MipStartMode"

Integer parameter.

Mode of MIP starts.

Default: -1

Possible values:

-1: Choose automatically.

0: Do not use any MIP starts.

1: Only load full and feasible MIP starts.

2: Only load feasible ones (complete partial solutions by solving subMIPs).

- COPT_INTPARAM_MIPSTARTNODELIMIT or "MipStartNodeLimit"

Integer parameter.

Limit of nodes for MIP start sub-MIPs.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

21.5.6 Nonlinear Programming related

- COPT_DBLPARAM_NLPTOL or "NLPTol"

Double parameter.

Relative optimality tolerance for nonlinear programming.

Default value: 1e-8

Minimum value: 1e-13

Maximum value: 1e-3

- COPT_INTPARAM_NONCONVEX or "NonConvex"

Integer parameter.

Handling strategy for nonconvex models.

Default value: -1

Possible values:

-1: Choose automatically.

0: Report model as nonconvex and terminate.

1: Search for a local optimal solution.

- COPT_INTPARAM_NLPMUUPDATE or "NLPMuUpdate"

Integer parameter.

Barrier parameter update strategy for the nonlinear solver.

Default value: -1

Possible values:

-1: Choose automatically.

0: Monotonic decrease.

1: Adaptive adjustment.

- COPT_INTPARAM_NLPLINSCALE or "NLPLinScale"

Integer parameter.

Scaling strategy for the linear system in the nonlinear solver.

Default value: -1

Possible values:

-1: Choose automatically.

0: No scaling.

1: Always scale.

- COPT_INTPARAM_NLPITERLIMIT or "NLPIterLimit"

Integer parameter.

Iteration limit for the nonlinear solver.

Default value: 1e4

Minimum value: 0

Maximum value: INT_MAX

21.5.7 Parallel computing related

- COPT_INTPARAM_THREADS or "Threads"

Integer parameter.

Number of threads to use.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 128

- COPT_INTPARAM_BARTHREADS or "BarThreads"

Integer parameter.

Number of threads used by barrier. If value is -1, the thread count is determined by parameter **Threads**.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 128

- COPT_INTPARAM_SIMPLEXTHREADS or "SimplexThreads"

Integer parameter.

Number of threads used by dual simplex. If value is -1, the thread count is determined by parameter **Threads**.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 128

- COPT_INTPARAM_CROSSOVERTHREADS or "CrossoverThreads"

Integer parameter.

Number of threads used by crossover. If value is -1, the thread count is determined by parameter **Threads**.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 128

- COPT_INTPARAM_MIPTASKS or "MipTasks"

Integer parameter.

Number of MIP tasks in parallel.

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: 256

21.5.8 IIS computation related

- COPT_INTPARAM_IISMETHOD or "IISMethod"

Integer parameter.

Method for IIS computation.

Default: -1

Possible values:

-1: Choose automatically.

0: Find smaller IIS.

1: Find IIS quickly.

21.5.9 Feasibility relaxation related

- COPT_INTPARAM_FEASRELAXMODE or "FeasRelaxMode"

Integer parameter.

Method for feasibility relaxation.

Default: 0

Possible values:

0: Minimize sum of violations.

1: Optimize original objective function under minimal sum of violations.

2: Minimize number of violations.

3: Optimize original objective function under minimal number of violations.

4: Minimize sum of squared violations.

5: Optimize original objective function under minimal sum of squared violations.

21.5.10 Tuner related

- COPT_DBLPARAM_TUNETIMELIMIT or "TuneTimeLimit"
 Double parameter.
 Time limit for parameter tuning. If the parameter value is 0, it will automatically set by the solver.
Default: 0
Minimal: 0
Maximal: 1e20
- COPT_DBLPARAM_TUNETARGETTIME or "TuneTargetTime"
 Double parameter.
 Time target for parameter tuning.
Default: 1e-2
Minimal: 0
Maximal: DBL_MAX
- COPT_DBLPARAM_TUNETARGETRELGAP or "TuneTargetRelGap"
 Double parameter.
 Optimal relative tolerance target for parameter tuning.
Default: 1e-4
Minimal: 0
Maximal: DBL_MAX
- COPT_INTPARAM_TUNEMETHOD or "TuneMethod"
 Integer parameter.
 Method for parameter tuning.
Default: -1
Possible values:
 - 1: Choose automatically.
 - 0: Greedy search strategy.
 - 1: Broader search strategy.
- COPT_INTPARAM_TUNEMODE or "TuneMode"
 Integer parameter.
 Mode for parameter tuning.
Default: -1
Possible values:
 - 1: Choose automatically.
 - 0: Solving time.
 - 1: Optimal relative tolerance.
 - 2: Objective function value.
 - 3: The lower bound of the objective function value.
- COPT_INTPARAM_TUNEMEASURE or "TuneMeasure"

Integer parameter.

Parameter tuning result calculation method.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: Calculate the average value.
- 1: Calculate the maximum value.

- COPT_INTPARAM_TUNEPERMUTES or "TunePermutates"

Integer parameter.

Permutations for each trial parameter set. If the parameter value is 0, it will automatically set by the solver.

Default: 0

Minimal: 0

Maximal: INT_MAX

- COPT_INTPARAM_TUNEOUTPUTLEVEL or "TuneOutputLevel"

Integer parameter.

Parameter tuning log output level.

Default: 2

Possible values:

- 0: Not displayed.
- 1: Display only improved parameter results.
- 2: Displays a summary of the results for each set of parameters.
- 3: Display each group of parameter results in detail.

21.5.11 Callback related

- COPT_INTPARAM_LAZYCONSTRAINTS or "LazyConstraints"

Integer parameter.

Whether lazy constraints are part of the model.

Default: -1

Possible values:

- 1: Choose automatically.
- 0: No.
- 1: Yes.

Notes

- This parameter only affects MIP.
-

21.5.12 GPU computing related

- COPT_INTPARAM_GPUMODE or "GPUMode"

Integer parameter.

Usage mode of the GPU solver.

Default: -1

Possible values:

-1: Choose automatically.

0: Force the use of CPU mode.

1: Utilize NVIDIA GPU.

- COPT_INTPARAM_GPUDEVICE or "GPUDevice"

Integer parameter.

Utilize the GPU with the specified device ID (in cases where the running machine has multiple GPUs).

Default: -1 (Choose automatically)

Minimal: -1 (Choose automatically)

Maximal: INT_MAX

- COPT_DBLPARAM_PDLPTOL or "PDLPTol"

Double parameter.

Convergence tolerance for the first-order method (PDLP).

Default: 1e-6

Minimal: 1e-12

Maximal: 1e-4

21.5.13 Other parameters

- COPT_INTPARAM_LOGGING or "Logging"

Integer parameter.

Whether to print optimization logs.

Default: 1

Possible values:

0: No optimization logs.

1: Print optimization logs.

- COPT_INTPARAM_LOGTOCONSOLE or "LogToConsole"

Integer parameter.

Whether to print optimization logs to console.

Default: 1

Possible values:

0: No optimization logs to console.

1: Print optimization logs to console.

21.6 API Functions

The documentations for COPT API functions are grouped by their purposes.

All the return values of COPT API functions are integers, and possible return values are documented in the constants section.

21.6.1 Creating the environment and problem

COPT_CreateEnvConfig

Synopsis

```
int COPT_CreateEnvConfig(copt_env_config **p_config)
```

Description

Create a COPT client configuration.

Arguments

`p_config`

Output pointer to COPT client configuration.

COPT_DeleteEnvConfig

Synopsis

```
int COPT_DeleteEnvConfig(copt_env_config **p_config)
```

Description

Delete COPT client configuration.

Arguments

`p_config`

Input pointer to COPT client configuration.

COPT_SetEnvConfig

Synopsis

```
int COPT_SetEnvConfig(copt_env_config *config, const char *name,  
const char *value)
```

Description

Set COPT client configuration.

Arguments

`config`

COPT client configuration.

`name`

Name of configuration parameter.

`value`

Value of configuration parameter.

COPT_CreateEnv

Synopsis

```
int COPT_CreateEnv(copt_env **p_env)
```

Description

Creates a COPT environment.

Calling this function is the first step when using the COPT library. It validates the license, and when the license is okay, the resulting environment variable will allow for creating COPT problems. When the license validation fails, more information can be obtained using `COPT_GetLicenseMsg` to help identify the issue.

Arguments

`p_env`

The output pointer to a variable holding COPT environment.

COPT_CreateEnvWithPath

Synopsis

```
int COPT_CreateEnvWithPath(const char *licDir, copt_env **p_env)
```

Description

Creates a COPT environment, directory of license files is specified by argument `licDir`.

Calling this function is the first step when using the COPT library. It validates the license, and when the license is okay, the resulting environment variable will allow for creating COPT problems. When the license validation fails, more information can be obtained using `COPT_GetLicenseMsg` to help identify the issue.

Arguments

`licDir`

Directory of license files.

`p_env`

Output pointer to a variable holding COPT environment.

COPT_CreateEnvWithConfig

Synopsis

```
int COPT_CreateEnvWithConfig(copt_env_config *config, copt_env **p_env)
```

Description

Creates a COPT environment, client configuration is specified by argument `config`.

Calling this function is the first step when using the COPT library. It validates the client configuration, and when the license is okay, the resulting environment variable will allow for creating COPT problems. When the license validation fails, more information can be obtained using `COPT_GetLicenseMsg` to help identify the issue.

Arguments

`config`

Client configuration.

`p_env`

Output pointer to a variable holding COPT environment.

COPT_DeleteEnv

Synopsis

```
int COPT_DeleteEnv(copt_env **p_env)
```

Description

Deletes the COPT environment created by `COPT_CreateEnv`.

Arguments

`p_env`

Input pointer to a variable holding COPT environment.

COPT_GetLicenseMsg

Synopsis

```
int COPT_GetLicenseMsg(copt_env *env, char *buff, int buffSize)
```

Description

Returns a C-style string regarding the license validation information. Please refer to this function when `COPT_CreateEnv` fails.

Arguments

`env`

The COPT environment.

`buff`

A buffer for holding the resulting string.

`buffSize`

The size of the above buffer.

COPT_CreateProb

Synopsis

```
int COPT_CreateProb(copt_env *env, copt_prob **p_prob)
```

Description

Creates an empty COPT problem.

Arguments

`env`

The COPT environment.

`p_prob`

Output pointer to a variable holding the COPT problem.

COPT_CreateCopy

Synopsis

```
int COPT_CreateCopy(copt_prob *src_prob, copt_prob **p_dst_prob)
```

Description

Create a deep-copy of an COPT problem.

Note: The parameter settings will be copied too. To solve the copied problem with different parameters, users should reset its parameters to default by calling `COPT_ResetParam` first, and then set parameters as needed.

Arguments

`src_prob`

The pointer to a variable holding the COPT problem to be copied.

`p_dst_prob`

Output pointer to a variable holding the copied COPT problem.

COPT_ClearProb

Synopsis

```
int COPT_ClearProb(copt_prob *prob)
```

Description

Clear COPT problem data (excluding callback function).

Arguments

`prob`

COPT problem.

COPT_DeleteProb

Synopsis

```
int COPT_DeleteProb(copt_prob **p_prob)
```

Description

Deletes the COPT problem created using `COPT_CreateProb`

Arguments

`p_prob`

Input pointer to a variable holding the COPT problem.

21.6.2 Building and modifying a problem

COPT_LoadProb

Synopsis

```
int COPT_LoadProb(  
    copt_prob *prob,  
    int nCol,  
    int nRow,  
    int iObjSense,  
    double dObjConst,  
    const double *obj,  
    const int *colMatBeg,  
    const int *colMatCnt,  
    const int *colMatIdx,  
    const double *colMatElem,  
    const char *colType,  
    const double *colLower,  
    const double *colUpper,  
    const char *rowSense,  
    const double *rowBound,  
    const double *rowUpper,  
    char const *const *colNames,  
    char const *const *rowNames)
```

Description

Loads a problem defined by arrays.

Arguments

prob

The COPT problem.

nCol

Number of variables (coefficient matrix columns).

nRow

Number of constraints (coefficient matrix rows).

iObjSense

The optimization sense, either COPT_MAXIMIZE or COPT_MINIMIZE.

dObjConst

The constant part of the objective function.

obj

Objective coefficients of variables.

colMatBeg, colMatCnt, colMatIdx and colMatElem

Defines the coefficient matrix in compressed column storage (CCS) format. Please see **other information** for an example of the CCS format.

If `colMatCnt` is NULL, `colMatBeg` will need to have length of `nCol+1`, and the begin and end pointers to the *i*-th matrix column coefficients are defined using `colMatBeg[i]` and `colMatBeg[i+1]`.

If `colMatCnt` is provided, the begin and end pointers to the *i*-th column coefficients are defined using `colMatBeg[i]` and `colMatBeg[i] + colMatCnt[i]`.

`colType`

Types of variables.

If `colType` is NULL, all variables will be continuous.

`colLower` and `colUpper`

Lower and upper bounds of variables.

If `colLower` is NULL, lower bounds will be 0.

If `colUpper` is NULL, upper bounds will be infinity.

`rowSense`

Senses of constraint.

Please refer to the list of all senses constants for all the supported types.

If `rowSense` is NULL, then `rowBound` and `rowUpper` will be treated as lower and upper bounds for constraints. This is the recommended method for defining constraints.

If `rowSense` is provided, then `rowBound` and `rowUpper` will be treated as RHS and **range** for constraints. In this case, `rowUpper` is only required when there are COPT_RANGE constraints, where the

lower bound is `rowBound[i] - fabs(rowUpper[i])`

upper bound is `rowBound[i]`

`rowBound`

Lower bounds or RHS of constraints.

`rowUpper`

Upper bounds or **range** of constraints.

`colNames` and `rowNames`

Names of variables and constraints. Can be NULL.

Other information

The compressed column storage (CCS) is a common format for storing sparse matrix. We demonstrate how to store the example matrix with 4 columns and 3 rows in the CCS format.

$$A = \begin{bmatrix} 1.1 & 1.2 & & \\ & 2.2 & 2.3 & \\ & & 3.3 & 3.4 \end{bmatrix} \quad (21.12)$$

```
// Compressed column storage using colMatBeg
colMatBeg[5] = { 0, 1, 3, 5, 6};
colMatIdx[6] = { 0, 0, 1, 1, 2, 2};
colMatElem[6] = {1.1, 1.2, 2.2, 2.3, 3.3, 3.4};
```

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```
// Compressed column storage using both colMatBeg and colMatCnt.  
// The * in the example represents unused spaces.  
colMatBeg[4] = { 0, 1, 5, 7};  
colMatCnt[4] = { 1, 2, 2, 1};  
colMatIdx[6] = { 0, 0, 1, 1, 2, *, *, 2};  
colMatElem[6] = {1.1, 1.2, 2.2, 2.3, 3.3, *, *, 3.4};
```

COPT_AddCol

Synopsis

```
int COPT_AddCol(  
    copt_prob *prob,  
    double dColObj,  
    int nColMatCnt,  
    const int *colMatIdx,  
    const double *colMatElem,  
    char cColType,  
    double dColLower,  
    double dColUpper,  
    const char *colName)
```

Description

Adds one variable (column) to the problem.

Arguments

prob

The COPT problem.

dColObj

The objective coefficient of the variable.

nColMatCnt

Number of non-zero elements in the column.

colMatIdx

Row index of non-zero elements in the column.

colMatElem

Values of non-zero elements in the column.

cColType

The type of the variable.

dColLower and **dColUpper**

The lower and upper bounds of the variable.

colName

The name of the variable. Can be NULL.

COPT_AddPSDCol

Synopsis

```
int COPT_AddPSDCol(copt_prob *prob, int colDim, const char *name)
```

Description

Add a PSD variable to the problem.

Arguments

prob

The COPT problem.

colDim

Dimension of new PSD variable.

name

Name of new PSD variable. Can be NULL.

COPT_AddRow

Synopsis

```
int COPT_AddRow(  
    copt_prob *prob,  
    int nRowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    char cRowSense,  
    double dRowBound,  
    double dRowUpper,  
    const char *rowName)
```

Description

Adds one constraint (row) to the problem.

Arguments

prob

The COPT problem.

nRowMatCnt

Number of non-zero elements in the row.

rowMatIdx

Column index of non-zero elements in the row.

rowMatElem

Values of non-zero elements in the row.

cRowSense

The sense of the row.

Please refer to the list of all senses constants for all the supported types.

If `cRowSense` is 0, then `dRowBound` and `dRowUpper` will be treated as lower and upper bounds for the constraint. This is the recommended method for defining constraints.

If `cRowSense` is provided, then `dRowBound` and `dRowUpper` will be treated as RHS and **range** for the constraint. In this case, `dRowUpper` is only required when `cRowSense` = `COPT_RANGE`, where

lower bound is `dRowBound` - `dRowUpper`

upper bound is `dRowBound`

`dRowBound`

Lower bound or RHS of the constraint.

`dRowUpper`

Upper bound or **range** of the constraint.

`rowName`

The name of the constraint. Can be NULL.

COPT_AddCols

Synopsis

```
int COPT_AddCols(  
    copt_prob *prob,  
    int nAddCol,  
    const double *colObj,  
    const int *colMatBeg,  
    const int *colMatCnt,  
    const int *colMatIdx,  
    const double *colMatElem,  
    const char *colType,  
    const double *colLower,  
    const double *colUpper,  
    char const *const *colNames)
```

Description

Adds `nAddCol` variables (columns) to the problem.

Arguments

`prob`

The COPT problem.

`nAddCol`

Number of new variables.

`colObj`

Objective coefficients of new variables.

`colMatBeg`, `colMatCnt`, `colMatIdx` and `colMatElem`

Defines the coefficient matrix in compressed column storage (CCS) format.
Please see **other information** of `COPT_LoadProb` for an example of the CCS format.

`colType`

Types of new variables.

`colLower` and `colUpper`

Lower and upper bounds of new variables.

If `colLower` is NULL, lower bounds will be 0.

If `colUpper` is NULL, upper bounds will be `COPT_INFINITY`.

`colNames`

Names of new variables. Can be NULL.

COPT_AddPSDCols

Synopsis

```
int COPT_AddPSDCols(copt_prob *prob, int nAddCol, const int*
colDims, char const *const *names)
```

Description

Add `nAddCol` PSD variables to the problem.

Arguments

`prob`

The COPT problem.

`nAddCol`

Number of new PSD variables.

`colDims`

Dimensions of new PSD variables.

`names`

Names of new PSD variables. Can be NULL.

COPT_AddRows

Synopsis

```
int COPT_AddRows(
    copt_prob *prob,
    int nAddRow,
    const int *rowMatBeg,
    const int *rowMatCnt,
    const int *rowMatIdx,
    const double *rowMatElem,
    const char *rowSense,
    const double *rowBound,
```

```
const double *rowUpper,  
char const *const *rowNames)
```

Description

Adds `nAddRow` constraints (rows) to the problem.

Arguments

`prob`

The COPT problem.

`nAddRow`

Number of new constraints.

`rowMatBeg`, `rowMatCnt`, `rowMatIdx` and `rowMatElem`

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of `COPT_LoadProb`.

`rowSense`

Senses of new constraints.

Please refer to the list of all senses constants for all the supported types.

If `rowSense` is NULL, then `rowBound` and `rowUpper` will be treated as lower and upper bounds for constraints. This is the recommended method for defining constraints.

If `rowSense` is provided, then `rowBound` and `rowUpper` will be treated as RHS and **range** for constraints. In this case, `rowUpper` is only required when there are `COPT_RANGE` constraints, where the

lower bound is `rowBound[i] - fabs(rowUpper[i])`

upper bound is `rowBound[i]`

`rowBound`

Lower bounds or RHS of new constraints.

`rowUpper`

Upper bounds or **range** of new constraints.

`rowNames`

Names of new constraints. Can be NULL.

COPT_AddSOSs

Synopsis

```
int COPT_AddSOSs(  
    copt_prob *prob,  
    int nAddSOS,  
    const int *sosType,  
    const int *sosMatBeg,  
    const int *sosMatCnt,  
    const int *sosMatIdx,  
    const double *sosMatWt)
```

Description

Add `nAddSOS` SOS constraints to the problem. If `sosMatWt` is NULL, then COPT will generate it internally.

Note: if a problem contains SOS constraints, the problem is a MIP.

Arguments

`prob`

The COPT problem.

`nAddSOS`

Number of new SOS constraints.

`sosType`

Types of SOS constraints.

`sosMatBeg`, `sosMatCnt`, `sosMatIdx` and `sosMatWt`

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of `COPT_LoadProb`.

`sosMatWt`

Weights of variables in SOS constraints. Can be NULL.

COPT_AddCones**Synopsis**

```
int COPT_AddCones(
    copt_prob *prob,
    int nAddCone,
    const int *coneType,
    const int *coneBeg,
    const int *coneCnt,
    const int *coneIdx)
```

Description

Add `nAddCone` Second-Order-Cone (SOC) constraints.

Arguments

`prob`

The COPT problem.

`nAddCone`

Number of new SOC constraints.

`coneType`

Types of SOC constraints.

`coneBeg`, `coneCnt`, `coneIdx`

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of `COPT_LoadProb`.

COPT_AddExpCones

Synopsis

```
int COPT_AddExpCones(  
    copt_prob *prob,  
    int nAddCone,  
    const int *coneType,  
    const int *coneIdx)
```

Description

Add nAddCone exponential cone constraints.

Arguments

prob

The COPT problem.

nAddCone

Number of new exponential cone constraints.

coneType

Types of exponential cone constraints.

coneIdx

Array of subscripts for the variables that constitute the exponential cone constraints.

COPT_AddAffineCone

Synopsis

```
int COPT_AddAffineCone(  
    copt_prob *prob,  
    int coneType,  
    int nConeDim,  
    int nAlphaDim,  
    const double *alphaElem,  
    const int *psdBeg,  
    const int *psdCnt,  
    const int *psdColIdx,  
    const int *psdMatIdx,  
    const int *rowMatBeg,  
    const int *rowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    const double *rowConst,  
    const char *name)
```

Description

Add the affine cone constraints.

Arguments

`prob`

The COPT model.

`coneType`

The type of the affine cone. Please refer to *SOC constraint types* and *Exponential Cone type* for possible values.

`nConeDim`

The dimension of the affine cone.

`nAlphaDim`

Reserved parameter, currently not in use.

`alphaElem`

Reserved parameter, currently not in use.

`psdBeg, psdCnt, psdColIdx, psdMatIdx`

Represents the PSD terms in the affine cone.

`psdBeg` indicates the starting position of the PSD terms in each affine cone term, `psdCnt` specifies the number of PSD terms, `psdColIdx` indicates the index of the PSD variable, and `psdMatIdx` refers to the index of the symmetric matrix.

`rowMatBeg, rowMatCnt, rowMatIdx, rowMatElem`

Represents the linear terms in the affine cone.

The coefficient matrix is provided in CRS-format. For detailed examples, please refer to **Additional Information** in `COPT_LoadProb`.

`rowConst`

The constant terms in the affine cone.

`name`

The name of the affine cone.

COPT_AddQConstr

Synopsis

```
int COPT_AddQConstr(
    copt_prob *prob,
    int nRowMatCnt,
    const int *rowMatIdx,
    const int *rowMatElem,
    int nQMatCnt,
    const int *qMatRow,
    const int *qMatCol,
    const double *qMatElem,
    char cRowSense,
```

```
double dRowBound, const char *name)
```

Description

Add a general quadratic constraint.

Note Only convex quadratic constraint is currently supported.

Arguments

`prob`

The COPT problem.

`nRowMatCnt`

Number of non-zero linear terms of the quadratic constraint (row).

`rowMatIdx`

Column index of non-zero linear terms of the quadratic constraint (row).

`rowMatElem`

Values of non-zero linear terms of the quadratic constraint (row).

`nQMatCnt`

Number of non-zero quadratic terms of the quadratic constraint (row).

`qMatRow`

Row index of non-zero quadratic terms of the quadratic constraint (row).

`qMatCol`

Column index of non-zero quadratic terms of the quadratic constraint (row).

`qMatElem`

Values of non-zero quadratic terms of the quadratic constraint (row).

`cRowSense`

The sense of the quadratic constraint (row).

`dRowBound`

Right hand side of the quadratic constraint (row).

`name`

Name of the quadratic constraint (row).

COPT_AddPSDConstr

Synopsis

```
int COPT_AddPSDConstr(  
    copt_prob *prob,  
    int nRowMatCnt,  
    const int *rowMatIdx,  
    const int *rowMatElem,  
    int nColCnt,  
    const int *psdColIdx,  
    const int *symMatIdx,
```

```

char cRowSense,
double dRowBound,
double dRowUpper,
const char *name)

```

Description

Add a PSD constraint.

Arguments

prob

The COPT problem.

nRowMatCnt

Number of non-zero linear terms of the PSD constraint.

rowMatIdx

Column index of non-zero linear terms of the PSD constraint.

rowMatElem

Values of non-zero linear terms of the PSD constraint.

nColCnt

Number of PSD terms of the PSD constraint.

psdColIdx

PSD variable index of PSD terms of the PSD constraint.

symMatIdx

Symmetric matrix index of PSD terms of the PSD constraint.

cRowSense

Senses of new PSD constraint.

Please refer to the list of all senses constants for all the supported types.

If **cRowSense** is 0, then **dRowBound** and **dRowUpper** will be treated as lower and upper bounds for the constraint. This is the recommended method for defining constraints.

If **cRowSense** is provided, then **dRowBound** and **dRowUpper** will be treated as RHS and **range** for the constraint. In this case, **dRowUpper** is only required when **cRowSense** = COPT_RANGE, where

lower bound is **dRowBound** - **dRowUpper**

upper bound is **dRowBound**

dRowBound

Lower bound or RHS of the PSD constraint.

dRowUpper

Upper bound or **range** of the PSD constraint.

name

Name of the PSD constraint. Can be NULL.

COPT_AddLMIconstr

Synopsis

```
int COPT_AddLMIconstr(  
    copt_prob *prob,  
    int nDim,  
    int nLMIMatCnt,  
    const int *colIdx,  
    const int *symMatIdx,  
    int constMatIdx,  
    const char *name)
```

Description

Add a LMI constraint to the problem.

Arguments

prob

The COPT problem.

nDim

Dimension of symmetric matrix in the LMI constraint.

nLMIMatCnt

Number of coefficient matrix entries in the LMI constraint.

colIdx

Index of scalar variable in the LMI constraint.

symMatIdx

Index of symmetric coefficient matrix in the LMI constraint.

constMatIdx

Index of constant-term symmetric matrix in the LMI constraint.

name

Name of LMI constraint. Can be NULL.

COPT_AddIndicator

Synopsis

```
int COPT_AddIndicator(  
    copt_prob *prob,  
    int binColIdx,  
    int binColVal,  
    int nRowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    char cRowSense, double dRowBound)
```


Description

Add an indicator constraint to the problem.

Arguments

`prob`

The COPT problem.

`binColIdx`

Index of indicator variable (column).

`binColVal`

Value of indicator variable (column).

`nRowMatCnt`

Number of non-zero elements in the linear constraint (row).

`rowMatIdx`

Column index of non-zero elements in the linear constraint (row).

`rowMatElem`

Values of non-zero elements in the linear constraint (row).

`cRowSense`

The sense of the linear constraint (row). Options are: `COPT_EQUAL` , `COPT_LESS_EQUAL` and `COPT_GREATER_EQUAL` .

`dRowBound`

Right hand side of the linear constraint (row).

COPT_AddIndicators**Synopsis**

```
int COPT_AddIndicators(
    copt_prob *prob,
    int nInd,
    int *indType,
    int *binColIdx,
    int *binColVal,
    const int *rowMatBeg,
    const int *RowMatCnt,
    const int *rowMatIdx,
    const double *rowMatElem,
    char cRowSense,
    double *dRowBound,
    char const *const indNames);
```

Description

Add `nInd` indicator constraints to the problem.

Arguments

`prob`

The COPT problem.

`nInd`

Number of indicator constraints.

`indType`

Type for indicator constraints. Please refer to *Indicator constraint types* for possible values.

`binColIdx`

Index of indicator variable (column).

`binColVal`

Value of indicator variable (column).

`rowMatBeg`, `rowMatCnt`, `rowMatIdx` and `rowMatElem`

Defines the coefficient matrix in compressed row storage (CRS) format for linear constraint in the indicator constraints.

Please see **other information** of `COPT_LoadProb` for an example of the CRS format.

`cRowSense`

The sense of the linear constraint (row). Options are: `COPT_EQUAL` , `COPT_LESS_EQUAL` and `COPT_GREATER_EQUAL` .

`dRowBound`

Right hand side of the linear constraint (row).

`indNames`

Names for indicator constraints.

COPT_AddSymMat

Synopsis

```
int COPT_AddSymMat(copt_prob *prob, int ndim, int nelem, int *rows,
int *cols, double *elems)
```

Description

Add a symmetric matrix to the problem. (Expect lower triangle part)

Arguments

`prob`

The COPT problem.

`ndim`

Dimension of symmetric matrix.

`nelem`

Number of non-zeros of symmetric matrix.

`rows`

Row index of symmetric matrix.

`cols`

Column index of symmetric matrix.

elems

Nonzero elements of symmetric matrix.

COPT_AddNLConstr

Synopsis

```
int COPT_AddNLConstr(  
    copt_prob *prob,  
    int nToken,  
    int nTokenElem,  
    const int *token,  
    const double *tokenElem,  
    int nRowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    char cRowSense,  
    double dRowBound,  
    double dRowUpper,  
    const char *name)
```

Description

Add a nonlinear expression constraint. Currently, only prefix notation is supported.

Arguments

prob

The COPT problem.

nToken

Number of tokens in the expression.

nTokenElem

Number of constants in the expression.

token

Array of expression tokens.

tokenElem

Array of constants in the expression.

nRowMatCnt

Number of linear terms in the constraint.

rowMatIdx

Indices of linear terms in the constraint.

rowMatElem

Coefficients of linear terms in the constraint.

cRowSense

Constraint type.

Refer to the constants section for the supported constraint types in COPT.

If `cRowSense` is 0, then `dRowBound` and `dRowUpper` are treated as the lower and upper bounds of the constraint. This is the recommended way to define constraints.

If `cRowSense` is a meaningful value, then `dRowBound` and `dRowUpper` are treated as the RHS and **range**. In this case, `dRowUpper` is used only when the constraint type is `COPT_RANGE`. The constraint bounds in this scenario are:

Lower bound: `dRowBound - dRowUpper`

Upper bound: `dRowBound`

`dRowBound`

Lower bound or RHS of the constraint.

`dRowUpper`

Upper bound or **range** of the constraint.

`name`

Name of the constraint. Can be set to NULL.

COPT_AddNLConstrs

Synopsis

```
int COPT_AddNLConstrs(  
    copt_prob *prob,  
    int nConstrs,  
    const int *tokenBeg,  
    const int *tokenCnt,  
    const int *tokenElemBeg,  
    const int *tokenElemCnt,  
    const int *token,  
    const double *tokenElem,  
    const int *rowMatBeg,  
    const int *rowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    const char *rowSense,  
    const double *rowBound,  
    const double *rowUpper,  
    char const *const *rowNames)
```

Description

Add a set of nonlinear expression constraints. Currently, only prefix notation is supported.

Arguments

prob

The COPT problem.

nConstrs

Number of constraints.

tokenBeg

Array of starting positions of tokens in expressions.

tokenCnt

Array of counts of tokens in expressions.

tokenElemBeg

Array of starting positions of constants in expressions.

tokenElemCnt

Array of counts of constants in expressions.

token

Array of tokens in expressions.

tokenElem

Array of constants in expressions.

rowMatBeg, rowMatCnt, rowMatIdx and rowMatElem

Provide the coefficient matrix in a row-compressed storage format. For specific examples of sparse matrix compression storage format, refer to the **Additional Information** section in `COPT_LoadProb`.

rowSense

Constraint types.

Refer to the constants section for supported constraint types in COPT.

If **rowSense** is not provided, **rowBound** and **rowUpper** are treated as the lower and upper bounds of constraints. This is the recommended way to define constraints.

If **rowSense** is provided, **rowBound** and **rowUpper** are treated as the RHS and **range**. In this case, the **rowUpper** array is only used when there is a `COPT_RANGE` constraint type. The constraint bounds in this scenario are:

Lower bound: `rowBound[i] - fabs(rowUpper[i])`

Upper bound: `rowBound[i]`

rowBound

Lower bound or RHS of the new constraints.

rowUpper

Upper bound or **range** of the new constraints.

rowNames

Names of the new constraints. Can be set to NULL.

COPT_DelCols

Synopsis

```
int COPT_DelCols(copt_prob *prob, int num, const int *list)
```

Description

Deletes **num** variables (columns) from the problem.

Arguments

prob

The COPT problem.

num

Number of variables to be deleted.

list

A list of index of variables to be deleted.

COPT_DelPSDCols

Synopsis

```
int COPT_DelPSDCols(copt_prob *prob, int num, const int *list)
```

Description

Deletes **num** PSD variables from the problem.

Arguments

prob

The COPT problem.

num

Number of PSD variables to be deleted.

list

A list of index of PSD variables to be deleted.

COPT_DelRows

Synopsis

```
int COPT_DelRows(copt_prob *prob, int num, const int *list)
```

Description

Deletes **num** constraints (rows) from the problem.

Arguments

prob

The COPT problem.

num

The number of constraints to be deleted.

list

The list of index of constraints to be deleted.

COPT_DelSOSs

Synopsis

```
int COPT_DelSOSs(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` SOS constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of SOS constraints to be deleted.

`list`

The list of index of SOS constraints to be deleted.

COPT_DelCones

Synopsis

```
int COPT_DelCones(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` Second-Order-Cone (SOC) constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of SOC constraints to be deleted.

`list`

The list of index of SOC constraints to be deleted.

COPT_DelExpCones

Synopsis

```
int COPT_DelExpCones(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` exponential cone constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of exponential cone constraints to be deleted.

`list`

The list of index of exponential cone constraints to be deleted.

COPT_DelAffineCones

Synopsis

```
int COPT_DelAffineCones(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` affine cone constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of affine cone constraints to be deleted.

`list`

The list of index of affine cone constraints to be deleted.

COPT_DelQConstrs

Synopsis

```
int COPT_DelQConstrs(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` quadratic constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of quadratic constraints to be deleted.

`list`

The list of index of quadratic constraints to be deleted.

COPT_DelPSDConstrs

Synopsis

```
int COPT_DelPSDConstrs(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` PSD constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of PSD constraints to be deleted.

`list`

The list of index of PSD constraints to be deleted.

COPT_DelLMIconstrs

Synopsis

```
int COPT_DelLMIconstrs(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` LMI constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of LMI constraints to be deleted.

`list`

The list of index of LMI constraints to be deleted.

COPT_DelIndicators

Synopsis

```
int COPT_DelIndicators(copt_prob *prob, int num, const int *list)
```

Description

Deletes `num` indicator constraints from the problem.

Arguments

`prob`

The COPT problem.

`num`

The number of indicator constraints to be deleted.

`list`

The list of index of indicator constraints to be deleted.

COPT_DelNLConstrs

Synopsis

```
int COPT_DelNLConstrs(copt_prob *prob, int num, const int *list)
```

Description

Delete `num` nonlinear expression constraints.

Arguments

`prob`

The COPT problem.

`num`

Number of nonlinear expression constraints to delete.

`list`

List of indices of nonlinear expression constraints to delete.

COPT_DelQuadObj

Synopsis

```
int COPT_DelQuadObj(copt_prob *prob)
```

Description

Deletes the quadratic terms from the quadratic objective function.

Arguments

prob

The COPT problem.

COPT_DelNLObj

Synopsis

```
int COPT_DelNLObj(copt_prob *prob)
```

Description

Delete the nonlinear expression terms in the objective function.

Arguments

prob

The COPT problem.

COPT_DelPSDObj

Synopsis

```
int COPT_DelPSDObj(copt_prob *prob)
```

Description

Deletes the PSD terms from objective function.

Arguments

prob

The COPT problem.

COPT_SetElem

Synopsis

```
int COPT_SetElem(copt_prob *prob, int iCol, int iRow, double  
newElem)
```

Description

Set coefficient of specified row and column.

Note: If `newElem` is smaller than or equal to parameter `MatrixTol`, the coefficient will be set as zero.

Arguments

prob

The COPT problem.

iCol

Column index.

iRow

Row index.

newElem

New coefficient.

COPT_SetElems

Synopsis

```
int COPT_SetElems(copt_prob *prob, int nelem, const int *cols, const
int *rows, const double *elems)
```

Description

Set the coefficients of the specified columns and rows in batches.

Note The index pairs of columns and rows cannot appear repeatedly.

Arguments

prob

The COPT problem.

nelem

The number of new coefficients to be set.

cols

Column indexes.

rows

Row indexes.

elems

The values of the new coefficients to be set.

COPT_SetPSDElem

Synopsis

```
int COPT_SetPSDElem(copt_prob *prob, int iCol, int iRow, int newIdx)
```

Description

Set symmetric matrix index for given PSD term of PSD constraint.

Arguments

prob

The COPT problem.

iCol

PSD variable index.

iRow

PSD constraint index.

newIdx

New symmetric matrix index.

COPT_SetLMIElem

Synopsis

```
int COPT_SetLMIElem(copt_prob *prob, int iCol, int iRow, int newIdx)
```

Description

Set symmetric matrix index for given term of LMI constraint.

Arguments

prob

The COPT problem.

iCol

Scalar variable index.

iRow

LMI constraint index.

newIdx

New coefficient symmetric matrix index.

COPT_SetObjSense

Synopsis

```
int COPT_SetObjSense(copt_prob *prob, int iObjSense)
```

Description

Change the objective function sense.

Arguments

prob

The COPT problem.

iObjSense

The optimization sense, either COPT_MAXIMIZE or COPT_MINIMIZE.

COPT_SetObjConst

Synopsis

```
int COPT_SetObjConst(copt_prob *prob, double dObjConst)
```

Description

Set the constant term of objective function.

Arguments

prob

The COPT problem.

dObjConst

The constant term of objective function.

COPT_SetColObj/Type/Lower/Upper/Names

Synopsis

```
int COPT_SetColObj(copt_prob *prob, int num, const int *list, const
double *obj)

int COPT_SetColType(copt_prob *prob, int num, const int *list, const
char *type)

int COPT_SetColLower(copt_prob *prob, int num, const int *list,
const double *lower)

int COPT_SetColUpper(copt_prob *prob, int num, const int *list,
const double *upper)

int COPT_SetColNames(copt_prob *prob, int num, const int *list, char
const *const *names)
```

Description

These five API functions each modifies

- objective coefficients
- variable types
- lower bounds
- upper bounds
- names

of `num` variables (columns) in the problem.

Arguments

`prob`

The COPT problem.

`num`

Number of variables to modify.

`list`

A list of index of variables to modify.

`obj`

New objective coefficients for each variable in the `list`.

`types`

New types for each variable in the `list`.

`lower`

New lower bounds for each variable in the `list`.

`upper`

New upper bounds for each variable in the `list`.

`names`

New names for each variable in the `list`.

COPT_SetPSDColNames

Synopsis

```
int COPT_SetPSDColNames(copt_prob *prob, int num, const int *list,
char const *const *names)
```

Description

Modify names of `num` PSD variables.

Arguments

`prob`

The COPT problem.

`num`

Number of PSD variables to modify.

`list`

A list of index of PSD variables to modify.

`names`

New names for each PSD variable in the `list`.

COPT_SetRowLower/Upper/Names

Synopsis

```
int COPT_SetRowLower(copt_prob *prob, int num, const int *list,
const double *lower)
```

```
int COPT_SetRowUpper(copt_prob *prob, int num, const int *list,
const double *upper)
```

```
int COPT_SetRowNames(copt_prob *prob, int num, const int *list, char
const *const *names)
```

Description

These three API functions each modifies

lower bounds

upper bounds

names

of `num` constraints (rows) in the problem.

Arguments

`prob`

The COPT problem.

`num`

Number of constraints to modify.

`list`

A list of index of constraints to modify.

`lower`

New lower bounds for each constraint in the `list`.

`upper`

New upper bounds for each constraint in the `list`.

`names`

New names for each constraint in the `list`.

COPT_SetQConstrSense/Rhs/Names

Synopsis

```
int COPT_SetQConstrSense(copt_prob *prob, int num, const int *list,
const char *sense)

int COPT_SetQConstrRhs(copt_prob *prob, int num, const int *list,
const double *rhs)

int COPT_SetQConstrNames(copt_prob *prob, int num, const int *list,
char const *const *names)
```

Description

These three API functions each modifies

`senses`

`RHS`

`names`

of `num` quadratic constraints (rows) in the problem.

Arguments

`prob`

The COPT problem.

`num`

Number of quadratic constraints to modify.

`list`

A list of index of quadratic constraints to modify.

`sense`

New senses for each quadratic constraint in the `list`.

`rhs`

New RHS for each quadratic constraint in the `list`.

`names`

New names for each quadratic constraint in the `list`.

COPT_SetPSDConstrLower/Upper/Names

Synopsis

```
int COPT_SetPSDConstrLower(copt_prob *prob, int num, const int
*list, const double *lower)

int COPT_SetPSDConstrUpper(copt_prob *prob, int num, const int
*list, const double *upper)

int COPT_SetPSDConstrNames(copt_prob *prob, int num, const int
*list, char const *const *names)
```

Description

These three API functions each modifies

lower bounds

upper bounds

names

of `num` PSD constraints in the problem.

Arguments

`prob`

The COPT problem.

`num`

Number of PSD constraints to modify.

`list`

A list of index of PSD constraints to modify.

`lower`

New lower bounds for each PSD constraint in the `list`.

`upper`

New upper bounds for each PSD constraint in the `list`.

`names`

New names for each PSD constraint in the `list`.

COPT_SetLMIconstrRhs

Synopsis

```
int COPT_SetLMIconstrRhs(copt_prob *prob, int num, const int *list,  
const int *newIdx)
```

Description

Modify the constant-term symmetric matrix of `num` LMI constraints.

Arguments

`prob`

The COPT problem.

`num`

Number of LMI constraints to modify.

`list`

A list of index of LMI constraints to modify.

`newIdx`

The new index of the constant-term symmetric matrix to be set.

COPT_SetLMIconstrNames

Synopsis

```
int COPT_SetLMIconstrNames(copt_prob *prob, int num, const int
*list, char const *const *names)
```

Description

Modify the names of `num` LMI constraints.

Arguments

`prob`

The COPT problem.

`num`

Number of LMI constraints to modify.

`list`

A list of index of LMI constraints to modify.

`names`

New names for each LMI constraint in the `list`.

COPT_SetIndicatorNames

Synopsis

```
int COPT_SetIndicatorNames(copt_prob *prob, int num, const int
*list, char const *const *names)
```

Description

Modifies names of `num` indicator constraints in the problem.

Arguments

`prob`

The COPT problem.

`num`

Number of indicator constraints to modify.

`list`

A list of indexes of indicator constraints to modify.

`names`

New names for each indicator constraint in the `list`.

COPT_SetAffineConeNames

Synopsis

```
int COPT_SetAffineConeNames(copt_prob *prob, int num, const int
*list, char const *const *names)
```

Description

Modifies names of `num` affine cones in the problem.

Arguments

prob

The COPT problem.

num

Number of affine cones to modify.

list

A list of indexes of affine cones to modify.

names

New names for each affine cone in the **list**.

COPT_SetNLConstrLower/Upper/Names

Synopsis

```
int COPT_SetNLConstrLower(copt_prob *prob, int num, const int *list,  
const double *lower)
```

```
int COPT_SetNLConstrUpper(copt_prob *prob, int num, const int *list,  
const double *upper)
```

```
int COPT_SetNLConstrNames(copt_prob *prob, int num, const int *list,  
char const *const *names)
```

Description

These three functions respectively modify the following properties of **num** nonlinear expression constraints:

Lower bound

Upper bound

Name

Arguments

prob

The COPT problem.

num

Number of nonlinear expression constraints to modify.

list

List of nonlinear expression constraints to modify.

lower

New lower bounds for the listed nonlinear expression constraints.

upper

New upper bounds for the listed nonlinear expression constraints.

names

New names for the listed nonlinear expression constraints.

COPT_ReplaceColObj

Synopsis

```
int COPT_ReplaceColObj(copt_prob *prob, int num, const int *list,  
const double *obj)
```

Description

Replace objective function with new objective function represented by specified objective costs.

Arguments

`prob`

The COPT problem.

`num`

Number of variables to be modified.

`list`

Index of variables to be modified.

`obj`

Objective costs of modified variables.

COPT_ReplacePSDObj

Synopsis

```
int COPT_ReplacePSDObj(copt_prob *prob, int num, const int *list,  
const int *idx)
```

Description

Replace PSD terms in objective function with specified PSD terms.

Arguments

`prob`

The COPT problem.

`num`

Number of PSD variables to be modified.

`list`

Index of PSD variables to be modified.

`idx`

Symmetric matrix index of modified PSD variables.

COPT_SetQuadObj

Synopsis

```
int COPT_SetQuadObj(copt_prob *prob, int num, int *qRow, int *qCol,  
double *qElem)
```

Description

Set the quadratic terms of the quadratic objective function.

Arguments

prob

The COPT problem.

num

Number of non-zero quadratic terms of the quadratic objective function.

qRow

Row index of non-zero quadratic terms of the quadratic objective function.

qCol

Column index of non-zero quadratic terms of the quadratic objective function.

qElem

Values of non-zero quadratic terms of the quadratic objective function.

COPT_SetNLObj

Synopsis

```
int COPT_SetNLObj(copt_prob *prob, int nToken, int nTokenElem, const  
int *token, const double *tokenElem)
```

Description

Set the nonlinear expression terms in the nonlinear objective function.

Arguments

prob

The COPT problem.

nToken

Number of tokens in the expression.

nTokenElem

Number of constants in the expression.

token

Array of tokens in the expression.

tokenElem

Array of constants in the expression.

COPT_SetPSDObj

Synopsis

```
int COPT_SetPSDObj(copt_prob *prob, int iCol, int newIdx)
```

Description

Set PSD terms of objective function.

Arguments

`prob`

The COPT problem.

`iCol`

PSD variable index.

`newIdx`

Symmetric matrix index.

21.6.3 Reading and writing the problem

COPT_ReadMps

Synopsis

```
int COPT_ReadMps(copt_prob *prob, const char *mpsfilename)
```

Description

Reads a problem from a MPS file.

Arguments

`prob`

The COPT problem.

`mpsfilename`

The path to the MPS file.

COPT_ReadLp

Synopsis

```
int COPT_ReadLp(copt_prob *prob, const char *lpfilename)
```

Description

Read a problem from a LP file.

Arguments

`prob`

The COPT problem.

`lpfilename`

The path to the LP file.

COPT_ReadSDPA

Synopsis

```
int COPT_ReadSDPA(copt_prob *prob, const char *sdpafilename)
```

Description

Reads a problem from SDPA format file.

Arguments

`prob`

The COPT problem.

`sdpafilename`

The path to the SDPA format file.

COPT_ReadCbf

Synopsis

```
int COPT_ReadCbf(copt_prob *prob, const char *cbffilename)
```

Description

Reads a problem from CBF format file.

Arguments

`prob`

The COPT problem.

`cbffilename`

The path to the CBF format file.

COPT_ReadBin

Synopsis

```
int COPT_ReadBin(copt_prob *prob, const char *binfilename)
```

Description

Reads a problem from a COPT binary format file.

Arguments

`prob`

The COPT problem.

`binfilename`

The path to the COPT binary format file.

COPT_ReadBlob

Synopsis

```
int COPT_ReadBlob(copt_prob *prob, void *blob, COPT_INT64 len)
```

Description

Reads a problem from COPT serialized data.

Arguments

`prob`

The COPT problem.

`blob`

Serialized data.

`len`

Length of serialized data.

COPT_WriteMps

Synopsis

```
int COPT_WriteMps(copt_prob *prob, const char *mpsfilename)
```

Description

Writes the problem to a MPS file.

Arguments

`prob`

The COPT problem.

`mpsfilename`

The path to the MPS file.

COPT_WriteMpsStr

Synopsis

```
int COPT_WriteMpsStr(copt_prob *prob, char *str, int nStrSize, int *pReqSize)
```

Description

Writes the problem to a string buffer as MPS format.

Arguments

`prob`

The COPT problem.

`str`

String buffer of MPS-format problem.

`nStrSize`

The size of string buffer.

`pReqSize`

Minimum space requirement of string buffer for problem.

COPT_WriteLp

Synopsis

```
int COPT_WriteLp(copt_prob *prob, const char *lpfilename)
```

Description

Writes the problem to a LP file.

Arguments

prob

The COPT problem.

lpfilename

The path to the LP file.

COPT_WriteCbf

Synopsis

```
int COPT_WriteCbf(copt_prob *prob, const char *cbffilename)
```

Description

Writes the problem to a CBF format file.

Arguments

prob

The COPT problem.

cbffilename

The path to the CBF format file.

COPT_WriteBin

Synopsis

```
int COPT_WriteBin(copt_prob *prob, const char *binfilename)
```

Description

Writes the problem to a COPT binary format file.

Arguments

prob

The COPT problem.

binfilename

The path to the COPT binary format file.

COPT_WriteNL

Synopsis

```
int COPT_WriteNL(copt_prob *prob, const char *nlfilename)
```

Description

Export the internal COPT model to an NL format file.

Arguments

`prob`

The COPT problem.

`nlfilename`

Path to the NL format file.

COPT_WriteBlob

Synopsis

```
int COPT_WriteBlob(copt_prob *prob, int tryCompress, void **p_blob,  
COPT_INT64 *pLen)
```

Description

Writes the problem to COPT serialized data.

Arguments

`prob`

The COPT problem.

`tryCompress`

Whether to compress data.

`p_blob`

Output pointer of serialized data.

`pLen`

Pointer to length of serialized data.

21.6.4 Solving the problem and accessing solutions

COPT_SolveLp

Synopsis

```
int COPT_SolveLp(copt_prob *prob)
```

Description

Solves the LP, QP, QCP, SOCP and SDP problem.

If problem is a MIP, then integer restrictions on variables will be ignored, and SOS constraints, indicator constraints will be discarded, and the problem will be solved as a LP.

Arguments

`prob`

The COPT problem.

COPT_Solve

Synopsis

```
int COPT_Solve(copt_prob *prob)
```

Description

Solves the problem.

Arguments

prob

The COPT problem.

COPT_GetSolution

Synopsis

```
int COPT_GetSolution(copt_prob *prob, double *colVal)
```

Description

Obtains MIP solution.

Arguments

prob

The COPT problem.

colVal

Solution values of variables.

COPT_GetPoolObjVal

Synopsis

```
int COPT_GetPoolObjVal(copt_prob *prob, int iSol, double *p_objVal)
```

Description

Obtains the iSol -th objective value in solution pool.

Arguments

prob

The COPT problem.

iSol

Index of solution.

p_objVal

Pointer to objective value.

COPT_GetPoolSolution

Synopsis

```
int COPT_GetPoolSolution(copt_prob *prob, int iSol, int num, const
int *list, double *colVal)
```

Description

Obtains the iSol -th solution.

Arguments

prob

The COPT problem.

iSol

Index of solution.

num

Number of columns.

list

Index of columns. Can be NULL.

colVal

Array of solution.

COPT_GetLpSolution

Synopsis

```
int COPT_GetLpSolution(copt_prob *prob, double *value, double
*slack, double *rowDual, double *redCost)
```

Description

Obtains LP, QP, QCP, SOCP and SDP solutions.

Note: For SDP, please use COPT_GetPSDColInfo to obtain primal/dual solution of PSD variable.

Arguments

prob

The COPT problem.

value

Solution values of variables. Can be NULL.

slack

Solution values of slack variables. They are also known as activities of constraints. Can be NULL.

rowDual

Dual values of constraints. Can be NULL.

redCost

Reduced cost of variables. Can be NULL.

COPT_SetLpSolution

Synopsis

```
int COPT_SetLpSolution(copt_prob *prob, double *value, double
*slack, double *rowDual, double *redCost)
```

Description

Set LP solution.

Arguments

prob

The COPT problem.

value

Solution values of variables.

slack

Solution values of slack variables.

rowDual

Dual values of constraints.

redCost

Reduced cost of variables.

COPT_GetBasis

Synopsis

```
int COPT_GetBasis(copt_prob *prob, int *colBasis, int *rowBasis)
```

Description

Obtains LP basis.

Arguments

prob

The COPT problem.

colBasis and **rowBasis**

The basis status of variables and constraints. Please refer to basis constants for possible values and their meanings.

COPT_SetBasis

Synopsis

```
int COPT_SetBasis(copt_prob *prob, const int *colBasis, const int
*rowBasis)
```

Description

Sets LP basis. It can be used to warm-start an LP optimization.

Arguments

prob

The COPT problem.

colBasis and rowBasis

The basis status of variables and constraints. Please refer to basis constants for possible values and their meanings.

COPT_SetSlackBasis

Synopsis

```
int COPT_SetSlackBasis(copt_prob *prob)
```

Description

Sets a slack basis for LP. The slack basis is the default starting basis for an LP problem. This API function can be used to restore an LP problem to its starting basis.

Arguments

prob

The COPT problem.

COPT_Reset

Synopsis

```
int COPT_Reset(copt_prob *prob, int iClearAll)
```

Description

Reset basis and LP/MIP solution in problem, which forces next solve start from scratch. If iClearAll is 1, then clear additional information such as MIP start as well.

Arguments

prob

The COPT problem.

iClearAll

Whether to clear additional information.

COPT_ReadSol

Synopsis

```
int COPT_ReadSol(copt_prob *prob, const char *solfilename)
```

Description

Reads a MIP solution from file as MIP start information.

Note: The default solution value is 0, i.e. a partial solution will be automatically filled in with zeros.

Arguments

prob

The COPT problem.

solfilename

The path to the solution file.

COPT_WriteSol

Synopsis

```
int COPT_WriteSol(copt_prob *prob, const char *solfilename)
```

Description

Writes a LP/MIP solution to a file.

Arguments

`prob`

The COPT problem.

`solfilename`

The path to the solution file.

COPT_WritePoolSol

Synopsis

```
int COPT_WritePoolSol(copt_prob *prob, int iSol, const char  
*solfilename)
```

Description

Writes selected pool solution to a file.

Arguments

`prob`

The COPT problem.

`iSol`

Index of pool solution.

`solfilename`

The path to the solution file.

COPT_WriteBasis

Synopsis

```
int COPT_WriteBasis(copt_prob *prob, const char *basfilename)
```

Description

Writes the internal LP basis to a file.

Arguments

`prob`

The COPT problem.

`basfilename`

The path to the basis file.

COPT_ReadBasis

Synopsis

```
int COPT_ReadBasis(copt_prob *prob, const char *basfilename)
```

Description

Reads the LP basis from a file. It can be used to warm-start an LP optimization.

Arguments

prob

The COPT problem.

basfilename

The path to the basis file.

21.6.5 Accessing information of problem

COPT_GetCols

Synopsis

```
int COPT_GetCols(  
    copt_prob *prob,  
    int nCol,  
    const int *list,  
    int *colMatBeg,  
    int *colMatCnt,  
    int *colMatIdx,  
    double *colMatElem,  
    int nElemSize,  
    int *pReqSize)
```

Description

Extract coefficient matrix by columns.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `colMatBeg`, `colMatCnt`, `colMatIdx` and `colMatElem`, we get number of non-zeros elements by `pReqSize` specified by `nCol` and `list`. Secondly, allocate sufficient memory for CCS-format matrix and call this function again to extract coefficient matrix. If the memory of coefficient matrix passed to function is not sufficient, then return the first `nElemSize` non-zero elements, and the minimal required length of non-zero elements by `pReqSize`. If `list` is NULL, then the first `nCol` columns will be returned.

Arguments

prob

The COPT problem.

nCol

Number of columns.

list

Index of columns. Can be NULL.

colMatBeg, colMatCnt, colMatIdx and colMatElem

Defines the coefficient matrix in compressed column storage (CCS) format.
Please see **other information** of COPT_LoadProb for an example of the CCS format.

nElemSize

Length of array for non-zero coefficients.

pReqSize

Pointer to minimal length of array for non-zero coefficients. Can be NULL.

COPT_GetPSDCols

Synopsis

```
int COPT_GetPSDCols(copt_prob *prob, int nCol, int *list, int*  
colDims, int *colLens)
```

Description

Get dimension and flattened length of nCol PSD variables.

Arguments

prob

The COPT problem.

nCol

Number of PSD variables.

list

Index of PSD variables. Can be NULL.

colDims

Dimension of PSD variables.

colLens

Flattened length of PSD variables.

COPT_GetRows

Synopsis

```
int COPT_GetRows(  
    copt_prob *prob,  
    int nRow,  
    const int *list,  
    int *rowMatBeg,  
    int *rowMatCnt,  
    int *rowMatIdx,  
    double *rowMatElem,  
    int nElemSize,  
    int *pReqSize)
```


Description

Extract coefficient matrix by rows.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `rowMatBeg`, `rowMatCnt`, `rowMatIdx` and `rowMatElem`, we get number of non-zeros elements by `pReqSize` specified by `nRow` and `list`. Secondly, allocate sufficient memory for CRS-format matrix and call this function again to extract coefficient matrix. If the memory of coefficient matrix passed to function is not sufficient, then return the first `nElemSize` non-zero elements, and the minimal required length of non-zero elements by `pReqSize`. If `list` is NULL, then the first `nRow` rows will be returned.

Arguments

`prob`

The COPT problem.

`nRow`

Number of rows.

`list`

Index of rows. Can be NULL.

`rowMatBeg`, `rowMatCnt`, `rowMatIdx` and `rowMatElem`

Defines the coefficient matrix in compressed row storage (CRS) format. Please see **other information** of `COPT_LoadProb` for an example of the CRS format.

`nElemSize`

Length of array for non-zero coefficients.

`pReqSize`

Pointer to minimal length of array for non-zero coefficients. Can be NULL.

COPT_GetElem

Synopsis

```
int COPT_GetElem(copt_prob *prob, int iCol, int iRow, double
*p_elem)
```

Description

Get coefficient of specified row and column.

Arguments

`prob`

The COPT problem.

`iCol`

Column index.

`iRow`

Row index.

`p_elem`

Pointer to requested coefficient.

COPT_GetPSDElem

Synopsis

```
int COPT_GetPSDElem(copt_prob *prob, int iCol, int iRow, int *p_idx)
```

Description

Get symmetric matrix index of specified PSD constraint and PSD variable.

Arguments

prob

The COPT problem.

iCol

PSD variable index.

iRow

PSD constraint index.

p_idx

Pointer to requested symmetric matrix index.

COPT_GetLMIElem

Synopsis

```
int COPT_GetLMIElem(copt_prob *prob, int iCol, int iRow, int *p_idx)
```

Description

Get symmetric matrix index of specified LMI constraint and scalar variable.

Arguments

prob

The COPT problem.

iCol

Scalar variable index.

iRow

LMI constraint index.

p_idx

Pointer to requested coefficient matrix index.

COPT_GetSymMat

Synopsis

```
int COPT_GetSymMat(  
    copt_prob *prob,  
    int iMat,  
    int *p_nDim,  
    int *p_nElem,  
    int *rows,
```

```
int *cols,
double *elems)
```

Description

Get specified symmetric matrix.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `rows`, `cols` and `elems`, we get dimension and number of non-zeros of symmetric matrix by `p_nDim` and `p_nElem`, then allocate enough memory for `rows`, `cols` and `elems` and call this function to get the data of symmetric matrix.

Arguments

`prob`

The COPT problem.

`iMat`

Symmetric matrix index.

`p_nDim`

Pointer to dimension of symmetric matrix.

`p_nElem`

Pointer to number of nonzeros of symmetric matrix.

`rows`

Row index of symmetric matrix.

`cols`

Column index of symmetric matrix.

`elems`

Nonzero elements of symmetric matrix.

COPT_GetQuadObj

Synopsis

```
int COPT_GetQuadObj(copt_prob* prob, int* p_nQElem, int* qRow, int*
qCol, double* qElem)
```

Description

Get the quadratic terms of the quadratic objective function.

Arguments

`prob`

The COPT problem.

`p_nQElem`

Pointer to number of non-zero quadratic terms . Can be NULL.

`qRow`

Row index of non-zero quadratic terms of the quadratic objective function.

`qCol`

Column index of non-zero quadratic terms of the quadratic objective function.

qElem

Values of non-zero quadratic terms of the quadratic objective function.

COPT_GetPSDObj

Synopsis

```
int COPT_GetPSDObj(copt_prob *prob, int iCol, int *p_idx)
```

Description

Get the specified PSD term of objective function.

Arguments

prob

The COPT problem.

iCol

PSD variable index.

p_idx

Pointer to symmetric matrix index.

COPT_GetNLObj

Synopsis

```
int COPT_GetNLObj(  
    copt_prob *prob,  
    int *p_nToken,  
    int *p_nTokenElem,  
    int *token,  
    double *tokenElem)
```

Description

Retrieve the nonlinear expression terms in the objective function.

Arguments

prob

The COPT problem.

p_nToken

Pointer to the number of tokens in the expression.

p_nTokenElem

Pointer to the number of constants in the expression.

token

Array of tokens in the expression.

tokenElem

Array of constants in the expression.

COPT_GetSOSs

Synopsis

```
int COPT_GetSOSs(
    copt_prob *prob,
    int nSos,
    const int *list,
    int *sosMatBeg,
    int *sosMatCnt,
    int *sosMatIdx,
    double *sosMatWt,
    int nElemSize,
    int *pReqSize)
```

Description

Get the weight matrix of SOS constraints.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `sosMatBeg`, `sosMatCnt`, `sosMatIdx` and `sosMatWt`, we get number of non-zeros elements by `pReqSize` specified by `nSos` and `list`. Secondly, allocate sufficient memory for CRS-format matrix and call this function again to extract weight matrix. If the memory of weight matrix passed to function is not sufficient, then return the first `nElemSize` non-zero elements, and the minimal required length of non-zero elements by `pReqSize`. If `list` is NULL, then the first `nSos` rows will be returned.

Arguments

`prob`

The COPT problem.

`nSos`

Number of SOS constraints.

`list`

Index of SOS constraints. Can be NULL.

`sosMatBeg`, `sosMatCnt`, `sosMatIdx` and `sosMatWt`

Defines the weight matrix of SOS constraints in compressed row storage (CRS) format. Please see **other information** of `COPT_LoadProb` for an example of the CRS format.

`nElemSize`

Length of array for non-zero weights.

`pReqSize`

Pointer to minimal length of array for non-zero weights. Can be NULL.

COPT_GetCones

Synopsis

```
int COPT_GetCones(  
    copt_prob *prob,  
    int nCone,  
    const int *list,  
    int *coneBeg,  
    int *coneCnt,  
    int *coneIdx,  
    int nElemSize,  
    int *pReqSize)
```

Description

Get the matrix of Second-Order-Cone (SOC) constraints.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `coneBeg`, `coneCnt` and `coneIdx`, we get number of subscripts of variables by `pReqSize` specified by `nCone` and `list`. Secondly, allocate sufficient memory for CRS-format matrix and call this function again to extract weight matrix. If the memory of weight matrix passed to function is not sufficient, then return the first `nElemSize` subscripts of variables, and the minimal required length of non-zero elements by `pReqSize`. If `list` is NULL, then the first `nCone` rows will be returned.

Arguments

`prob`

The COPT problem.

`nCone`

Number of SOC constraints.

`list`

Index of SOC constraints. Can be NULL.

`coneBeg`, `coneCnt`, `coneIdx`

Defines the matrix of SOC constraints in compressed row storage (CRS) format. Please see **other information** of `COPT_LoadProb` for an example of the CRS format.

`nElemSize`

Length of array for non-zero weights.

`pReqSize`

Pointer to minimal length of array for non-zero weights. Can be NULL.

COPT_GetExpCones

Synopsis

```
int COPT_GetExpCones(
    copt_prob *prob,
    int nCone,
    const int *list,
    int *coneType,
    int *coneIdx,
    int nElemSize,
    int *pReqSize)
```

Description

Get the array of exponential cone constraints.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `coneIdx`, we get number of subscripts of variables by `nElemSize` specified by `nCone` and `list`. Secondly, allocate sufficient memory for array and call this function again to extract weight array. If the memory of weight array passed to function is not sufficient, then return the first `nElemSize` subscripts, and the minimal required length of subscripts by `pReqSize`. If `list` is NULL, then the first `nCone` rows will be returned.

Arguments

`prob`

The COPT problem.

`nCone`

Number of exponential cone constraints.

`list`

Index of exponential cone constraints. Can be NULL.

`coneType`

Type of exponential cone constraints. Please refer to *Exponential Cone type* for possible values.

`coneIdx`

Array of subscripts of variables constituting the exponential cone constraints.

`nElemSize`

Length of array for subscripts of variables.

`pReqSize`

Pointer to minimal length of array for subscripts of variables. Can be NULL.

COPT_GetAffineCone

Synopsis

```
int COPT_GetAffineCone(  
    copt_prob *prob,  
    int affConeIdx,  
    int *coneType,  
    int *nConeDim,  
    int *nAlphaDim,  
    double *alphaElem,  
    int *psdBeg,  
    int *psdCnt,  
    int *psdColIdx,  
    int *psdMatIdx,  
    int nPsdElemSize,  
    int *pPsdReqSize,  
    int *rowMatBeg,  
    int *rowMatCnt,  
    int *rowMatIdx,  
    double *rowMatElem,  
    double *rowConst,  
    int nElemSize,  
    int *pReqSize)
```

Description

Retrieve the array of affine cone constraints from the model.

Generally, the user needs to call this function twice to complete the extraction of the affine cone constraint.

First, pass NULL to **affConeIdx** to obtain the number of indices for the affine cone constraint array specified by **nConeDim** and **list** through **pReqSize**. Then, allocate appropriate space for the array parameters, and call the function again to retrieve the specified affine cone constraint array.

If the length of the affine cone constraint array passed in is insufficient, the function will return the first **nElemSize** variable index arrays and return the minimum required array length through **pReqSize**. If **list** is NULL, the function returns the affine cone constraint array corresponding to the first **nConeDim** rows.

Arguments

prob

The COPT problem.

affConeIdx

The index of the affine cone.

coneType

The type of the affine cone. Please refer to *SOC constraint types* and *Exponential Cone type* for possible values.

`nConeDim`

The dimension of the affine cone.

`nAlphaDim`

Reserved parameter, currently not in use.

`alphaElem`

Reserved parameter, currently not in use.

`psdBeg, psdCnt, psdColIdx, psdMatIdx`

Represents the PSD terms in the affine cone.

`psdBeg` indicates the starting position of the PSD terms in each affine cone term, `psdCnt` specifies the number of PSD terms, `psdColIdx` indicates the index of the PSD variable, and `psdMatIdx` refers to the index of the symmetric matrix.

First, the number of PSD terms is returned via `pPsdReqSize`, and `nPsdElemSize` represents the number of PSD terms to be retrieved.

`rowMatBeg, rowMatCnt, rowMatIdx, rowMatElem`

Represents the linear terms in the affine cone.

The coefficient matrix is provided in CRS-format. For detailed examples, please refer to **Additional Information** in `COPT_LoadProb`.

`rowConst`

The constant term in the affine cone.

`nElemSize`

Length of array for subscripts of variables.

`pReqSize`

Pointer to minimal length of array for subscripts of variables of the affine cone. Can be NULL.

COPT_GetQConstr

Synopsis

```
int COPT_GetQConstr(
    copt_prob *prob,
    int qConstrIdx,
    int *qMatRow,
    int *qMatCol,
    double *qMatElem,
    int nQElemSize,
    int *pQReqSize,
    int *rowMatIdx,
    double *rowMatElem,
    char *cRowSense,
```

```
double *dRowBound,  
int nElemSize,  
int *pReqSize)
```

Description

Get quadratic constraint.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `qMatRow`, `qMatCol`, `qMatElem`, `rowMatIdx` and `rowMatElem`, we get number of non-zero quadratic terms by `pQReqSize` and number of non-zero linear terms by `pReqSize` specified by `qConstrIdx`. Secondly, allocate sufficient memory for the quadratic terms and the linear terms, and call this function again to extract the quadratic constraint. If the memory of the array of the quadratic terms passed to function is not sufficient, then return the first `nQElemSize` quadratic terms, and the minimal required length of quadratic terms by `pQReqSize`. If the memory of the array of the linear terms passed to function is not sufficient, then return the first `nElemSize` linear terms, and the minimal required length of linear terms by `pReqSize`.

Arguments

`prob`

The COPT problem.

`qConstrIdx`

Index of the quadratic constraint.

`qMatRow`

Row index of non-zero quadratic terms of the quadratic constraint (row).

`qMatCol`

Column index of non-zero quadratic terms of the quadratic constraint (row).

`qMatElem`

Values of non-zero quadratic terms of the quadratic constraint (row).

`nQElemSize`

Length of array for non-zero quadratic terms of the quadratic constraint (row).

`pQReqSize`

Pointer to minimal length of array for non-zero quadratic terms of the quadratic constraint (row). Can be NULL.

`rowMatIdx`

Column index of non-zero linear terms of the quadratic constraint (row).

`rowMatElem`

Values of non-zero linear terms of the quadratic constraint (row).

`cRowSense`

The sense of the quadratic constraint (row).

`dRowBound`

Right hand side of the quadratic constraint (row).

`nElemSize`

Length of array for non-zero linear terms of the quadratic constraint (row).

`pReqSize`

Pointer to minimal length of array for non-zero linear terms of the quadratic constraint (row). Can be NULL.

COPT_GetPSDConstr

Synopsis

```
int COPT_GetPSDConstr(
    copt_prob *prob,
    int psdConstrIdx,
    int *psdColIdx,
    int *symMatIdx,
    int nColSize,
    int *pColReqSize,
    int *rowMatIdx,
    double *rowMatElem,
    double *dRowLower,
    double *dRowUpper,
    int nElemSize,
    int *pReqSize)
```

Description

Get PSD constraint.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `psdColIdx` and `symMatIdx`, we get number of PSD terms by `pColReqSize` specified by `psdConstrIdx`, by passing NULL to arguments `rowMatIdx` and `rowMatElem`, we get number of linear terms by `pReqSize` specified by `qConstrIdx`. Secondly, allocate sufficient memory for the PSD terms and the linear terms, and call this function again to extract the PSD constraint. If the memory of the array of the PSD terms passed to function is not sufficient, then return the first `nColSize` PSD terms, and the minimal required length of PSD terms by `pColReqSize`. If the memory of the array of the linear terms passed to function is not sufficient, then return the first `nElemSize` linear terms, and the minimal required length of linear terms by `pReqSize`.

Arguments

`prob`

The COPT problem.

`psdConstrIdx`

PSD constraint index.

`psdColIdx`

PSD variable index.

`symMatIdx`

Symmetric matrix index.

nColSize

Length of array for PSD terms of the PSD constraint.

pColReqSize

Pointer to minimal length of array for PSD terms of the PSD constraint.
Can be NULL.

rowMatIdx

Column index of non-zero linear terms of the PSD constraint.

rowMatElem

Values of non-zero linear terms of the PSD constraint.

dRowLower

Pointer to lower bound of the PSD constraint.

dRowUpper

Pointer to upper bound of the PSD constraint.

nElemSize

Length of array for non-zero linear terms of the PSD constraint.

pReqSize

Pointer to minimal length of array for non-zero linear terms of the PSD
constraint (row). Can be NULL.

COPT_GetLMIconstr

Synopsis

```
int COPT_GetLMIconstr(  
    copt_prob *prob,  
    int lmiConstrIdx,  
    int *nDim,  
    int *nLMILen,  
    int *colIdx,  
    int *symMatIdx,  
    int *constMatIdx,  
    int nElemSize,  
    int *pReqSize)
```

Description

Gets the LMI constraint with the specified index in the model.

Arguments

prob

The COPT problem.

lmiConstrIdx

LMI constraint index.

nDim

Pointer to the dimension of symmetric matrix in the LMI constraint.

nLMILen

Pointer to the flattened length of the LMI constraint.

colIdx

Index of scalar variable in the LMI constraint.

symMatIdx

Index of symmetric coefficient matrix in the LMI constraint.

constMatIdx

Pointer to the index of symmetric constant-term matrix in the LMI constraint.

nElemSize

Length of array for non-zero linear terms of the LMI constraint.

pReqSize

Pointer to minimal length of array for non-zero linear terms of the LMI constraint (row). Can be NULL.

COPT_GetIndicator

Synopsis

```
int COPT_GetIndicator(
    copt_prob *prob,
    int rowIdx,
    int *binColIdx,
    int *binColVal,
    int *nRowMatCnt,
    int *rowMatIdx,
    double *rowMatElem,
    char *cRowSense,
    double *dRowBound,
    int nElemSize,
    int *pReqSize)
```

Description

Get the data of an indicator constraint.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments **nRowMatCnt**, **rowMatIdx** and **rowMatElem**, we get number of non-zeros elements by **pReqSize** specified by **rowIdx**. Secondly, allocate sufficient memory for sparse row vector and call this function again to extract data.

If the memory of sparse row vector passed to function is not sufficient, then return the first **nElemSize** non-zero elements, and the minimal required length of non-zero elements by **pReqSize**.

Arguments

prob

The COPT problem.

`rowIdx`

Index of the indicator constraint.

`binColIdx`

Index of the indicator variable (column).

`binColVal`

Value of the indicator variable (column).

`nRowMatCnt`

Number of non-zeros elements in the linear constraint (row).

`rowMatIdx`

Column index of non-zeros elements in the linear constraint (row).

`rowMatElem`

Values of non-zero elements in the linear constraint (row).

`cRowSense`

The sense of the linear constraint (row).

`dRowBound`

Right hand side of the linear constraint (row).

`nElemSize`

Length of array for non-zero coefficients.

`pReqSize`

Pointer to minimal length of array for non-zero coefficients. Can be NULL.

COPT_GetIndicators

Synopsis

```
int COPT_GetIndicators(  
    copt_prob *prob,  
    int nInd,  
    int *list,  
    int *indType,  
    int *binColIdx,  
    int *binColVal,  
    int *rowMatBeg,  
    int *rowMatCnt,  
    int *rowMatIdx,  
    double *rowMatElem,  
    char *cRowSense,  
    double *dRowBound,  
    int nElemSize,  
    int *pReqSize)
```

Description

Get the data of a set of indicator constraints.

In general, users need to call this function twice to accomplish the task. Firstly, by passing NULL to arguments `rowMatBeg`, `rowMatCnt`, `rowMatIdx`, we get number of non-zeros elements by `pReqSize` specified by `nInd` and `list`. Secondly, allocate sufficient memory for CRS-format matrix and call this function again to extract coefficient matrix.

If the memory of coefficient matrix passed to function is not sufficient, then return the first `nElemSize` non-zero elements, and the minimal required length of non-zero elements by `pReqSize`. If `list` is NULL, then the first `nInd` rows will be returned.

Arguments

`prob`

The COPT problem.

`nInd`

Number of indicator constraints (rows).

`list`

Index of indicator constraints. Can be NULL.

`indType`

Type of indicator constraints. Please refer to *Indicator constraint types* for possible values.

`binColIdx`

Index of the indicator variable (column).

`binColVal`

Value of the indicator variable (column).

`rowMatBeg`, `rowMatCnt`, `rowMatIdx` and `rowMatElem`

Defines the coefficient matrix of indicator constraints in compressed row storage (CRS) format. Please see **other information** of `COPT_LoadProb` for an example of the CRS format.

`cRowSense`

The sense of the linear constraint (row).

`dRowBound`

Right hand side of the linear constraint (row).

`nElemSize`

Length of array for non-zero coefficients.

`pReqSize`

Pointer to minimal length of array for non-zero coefficients. Can be NULL.

COPT_GetNLConstr

Synopsis

```
int COPT_GetNLConstr(  
    copt_prob *prob,  
    int nlConstrIdx,  
    int *token,  
    double *tokenElem,  
    int nToken,  
    int nTokenElem,  
    int *pReqToken,  
    int *pReqTokenElem,  
    int *rowMatIdx,  
    double *rowMatElem,  
    double *dRowLower,  
    double *dRowUpper,  
    int nElemSize,  
    int *pReqElemSize)
```

Description

Retrieve the nonlinear expression constraint at the specified index.

Arguments

prob

The COPT problem.

nlConstrIdx

Index of the constraint.

token

Array of tokens in the expression.

tokenElem

Array of constants in the expression.

nToken

Number of tokens in the expression.

nTokenElem

Number of constants in the expression.

pReqToken

Pointer to the number of tokens in the expression.

pReqTokenElem

Pointer to the number of constants in the expression.

rowMatIdx

Indices of linear terms in the constraint.

rowMatElem

Coefficients of linear terms in the constraint.

dRowLower

Pointer to the lower bound of the constraint.

dRowUpper

Pointer to the upper bound of the constraint.

nElemSize

Number of linear terms in the constraint.

pReqElemSize

Pointer to the number of linear terms.

COPT_GetColIdx

Synopsis

```
int COPT_GetColIdx(copt_prob *prob, const char *colName, int
*p_iCol)
```

Description

Get index of column by name.

Arguments

prob

The COPT problem.

colName

Name of column.

p_iCol

Pointer to index of column.

COPT_GetPSDColIdx

Synopsis

```
int COPT_GetPSDColIdx(copt_prob *prob, const char *psdColName, int
*p_iPSDCol)
```

Description

Get index of PSD variable by name.

Arguments

prob

The COPT problem.

psdColName

Name of PSD variable.

p_iPSDCol

Pointer to index of PSD variable.

COPT_GetRowIdx

Synopsis

```
int COPT_GetRowIdx(copt_prob *prob, const char *rowName, int
*p_iRow)
```

Description

Get index of row by name.

Arguments

prob

The COPT problem.

rowName

Name of row.

p_iRow

Pointer to index of row.

COPT_GetQConstrIdx

Synopsis

```
int COPT_GetQConstrIdx(copt_prob *prob, const char *qConstrName, int
*p_iQConstr)
```

Description

Get index of quadratic constraint by name.

Arguments

prob

The COPT problem.

qConstrName

Name of quadratic constraint.

p_iQConstr

Pointer to index of quadratic constraint.

COPT_GetPSDConstrIdx

Synopsis

```
int COPT_GetPSDConstrIdx(copt_prob *prob, const char *psdConstrName,
int *p_iPSDConstr)
```

Description

Get index of PSD constraint by name.

Arguments

prob

The COPT problem.

psdConstrName

Name of PSD constraint.

`p_iPSDConstr`

Pointer to index of PSD constraint.

COPT_GetLMIconstrIdx

Synopsis

```
int COPT_GetLMIconstrIdx(copt_prob *prob, const char *lmiConstrName,  
int *p_iLMIconstr)
```

Description

Get index of LMI constraint by name.

Arguments

`prob`

The COPT problem.

`lmiConstrName`

Name of LMI constraint.

`p_iLMIconstr`

Pointer to index of LMI constraint.

COPT_GetIndicatorIdx

Synopsis

```
int COPT_GetIndicatorIdx(copt_prob *prob, const char *indicatorName,  
int *p_iIndicator)
```

Description

Get index of indicator constraint by name.

Arguments

`prob`

The COPT problem.

`indicatorName`

Name of indicator constraint.

`p_iIndicator`

Pointer to index of indicator constraint.

COPT_GetAffineConIdx

Synopsis

```
int COPT_GetAffineConIdx(copt_prob *prob, const char *affConeName,  
int *p_iAffCone)
```

Description

Get index of affine cone by name.

Arguments

`prob`

The COPT problem.

`affConeName`

Name of affine cone.

`p_iAffCone`

Pointer to index of affine cone.

COPT_GetNLConstrIdx

Synopsis

```
int COPT_GetNLConstrIdx(copt_prob *prob, const char *nlConstrName,
int *p_iNLConstr)
```

Description

Retrieve the index of a nonlinear expression constraint by name.

Arguments

`prob`

The COPT problem.

`nlConstrName`

Name of the nonlinear expression constraint.

`p_iNLConstr`

Pointer to the internal index of the nonlinear expression constraint in COPT.

COPT_GetColInfo

Synopsis

```
int COPT_GetColInfo(copt_prob *prob, const char *infoName, int num,
const int *list, double *info)
```

Description

Get information of column. If `list` is NULL, then information of the first `num` columns will be returned.

Arguments

`prob`

The COPT problem.

`infoName`

Name of information. Please refer to *Information* for supported information.

`num`

Number of columns.

`list`

Index of columns. Can be NULL.

`info`

Array of information.

COPT_GetPSDCollInfo

Synopsis

```
int COPT_GetPSDCollInfo(copt_prob *prob, const char *infoName, int
iCol, double *info)
```

Description

Get information of PSD variable.

Arguments

prob

The COPT problem.

infoName

Name of information. Please refer to *Information* for supported information.

iCol

Index of PSD variable.

info

Array of information.

COPT_GetRowInfo

Synopsis

```
int COPT_GetRowInfo(copt_prob *prob, const char *infoName, int num,
const int *list, double *info)
```

Description

Get information of row. If **list** is NULL, then information of the first **num** rows will be returned.

Arguments

prob

The COPT problem.

infoName

Name of information. Please refer to *Information* for supported information.

num

Number of rows.

list

Index of rows. Can be NULL.

info

Array of information.

COPT_GetQConstrInfo

Synopsis

```
int COPT_GetQConstrInfo(copt_prob *prob, const char *infoName, int
num, const int *list, double *info)
```

Description

Get information of quadratic constraints. If `list` is NULL, then information of the first `num` quadratic constraints will be returned.

Arguments

`prob`

The COPT problem.

`infoName`

Name of information. Please refer to *Information* for supported information.

`num`

Number of quadratic constraints.

`list`

Index of quadratic constraints. Can be NULL.

`info`

Array of information.

COPT_GetPSDConstrInfo

Synopsis

```
int COPT_GetPSDConstrInfo(copt_prob *prob, const char *infoName, int
num, const int* list, double *info)
```

Description

Get information of PSD constraints. If `list` is NULL, then information of the first `num` PSD constraints will be returned.

Arguments

`prob`

The COPT problem.

`infoName`

Name of information. Please refer to *Information* for supported information.

`num`

Number of PSD constraints.

`list`

Index of PSD constraints. Can be NULL.

`info`

Array of information.

COPT_GetLMInfo

Synopsis

```
int COPT_GetLMInfo(copt_prob *prob, const char *infoName, int
iLMI, double *info)
```

Description

Get a set of information about LMI constraints.

Arguments

prob

The COPT problem.

infoName

Name of information. Possible values are: COPT_DBLINFO_SLACK and COPT_DBLINFO_DUAL.

iLMI

The index of the LMI constraint whose information is to be retrieved.

info

Array of information.

COPT_GetNLInfo

Synopsis

```
int COPT_GetNLInfo(copt_prob *prob, const char *infoName, int
num, const int *list, double *info)
```

Description

Retrieve information about nonlinear expression constraints. If **list** is NULL, the function returns information for the first **num** nonlinear expression constraints.

Arguments

prob

The COPT problem.

infoName

Name of the information to retrieve. Currently supported nonlinear expression constraint information is: "LB" , "UB" and "Slack" .

num

Number of nonlinear expression constraints to retrieve information for.

list

Index list of nonlinear expression constraints to retrieve information for. Can be NULL.

info

Array to store the retrieved information.

COPT_GetColType

Synopsis

```
int COPT_GetColType(copt_prob *prob, int num, const int *list, char
*type)
```

Description

Get types of columns. If `list` is NULL, then types of the first `num` columns will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of columns.

`list`

Index of columns. Can be NULL.

`type`

Types of columns.

COPT_GetColBasis

Synopsis

```
int COPT_GetColBasis(copt_prob *prob, int num, const int *list, int
*colBasis)
```

Description

Get basis status of columns. If `list` is NULL, then basis status of the first `num` columns will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of columns.

`list`

Index of columns. Can be NULL.

`colBasis`

Basis status of columns.

COPT_GetRowBasis

Synopsis

```
int COPT_GetRowBasis(copt_prob *prob, int num, const int *list, int
*rowBasis)
```

Description

Get basis status of rows. If `list` is NULL, then basis status of the first `num` rows will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of rows.

`list`

Index of rows. Can be NULL.

`rowBasis`

Basis status of rows.

COPT_GetQConstrSense

Synopsis

```
int COPT_GetQConstrSense(copt_prob *prob, int num, const int *list,
char *sense)
```

Description

Get senses of quadratic constraints. If `list` is NULL, then types of the first `num` quadratic constraints will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of quadratic constraints.

`list`

Index of quadratic constraints. Can be NULL.

`sense`

Array of senses.

COPT_GetQConstrRhs

Synopsis

```
int COPT_GetQConstrRhs(copt_prob *prob, int num, const int *list,  
double *rhs)
```

Description

Get RHS of quadratic constraints. If `list` is NULL, then types of the first `num` quadratic constraints will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of quadratic constraints.

`list`

Index of quadratic constraints. Can be NULL.

`rhs`

Array of RHS.

COPT_GetColName

Synopsis

```
int COPT_GetColName(copt_prob *prob, int iCol, char *buff, int  
buffSize, int *pReqSize)
```

Description

Get name of column by index. If memory of `buff` is not sufficient, then return the first `buffSize` length of sub-string, and the length of name requested by `pReqSize`. If `buff` is NULL, then we can get the length of name requested by `pReqSize`.

Arguments

`prob`

The COPT problem.

`iCol`

Index of column.

`buff`

Buffer for storing name.

`buffSize`

Length of the buffer.

`pReqSize`

Length of the requested name. Can be NULL.

COPT_GetPSDColName

Synopsis

```
int COPT_GetPSDColName(copt_prob *prob, int iPSDCol, char *buff, int
buffSize, int *pReqSize)
```

Description

Get name of PSD variable by index. If memory of `buff` is not sufficient, then return the first `buffSize` length of sub-string, and the length of name requested by `pReqSize`. If `buff` is NULL, then we can get the length of name requested by `pReqSize`.

Arguments

`prob`

The COPT problem.

`iPSDCol`

Index of PSD variable.

`buff`

Buffer for storing name.

`buffSize`

Length of the buffer.

`pReqSize`

Length of the requested name. Can be NULL.

COPT_GetRowName

Synopsis

```
int COPT_GetRowName(copt_prob *prob, int iRow, char *buff, int
buffSize, int *pReqSize)
```

Description

Get name of row by index. If memory of `buff` is not sufficient, then return the first `buffSize` length of sub-string, and the length of name requested by `pReqSize`. If `buff` is NULL, then we can get the length of name requested by `pReqSize`.

Arguments

`prob`

The COPT problem.

`iRow`

Index of row.

`buff`

Buffer for storing name.

`buffSize`

Length of the buffer.

`pReqSize`

Length of the requested name. Can be NULL.

COPT_GetQConstrName

Synopsis

```
int COPT_GetQConstrName(copt_prob *prob, int iQConstr, char *buff,  
int buffSize, int *pReqSize)
```

Description

Get name of quadratic constraint by index. If memory of **buff** is not sufficient, then return the first **buffSize** length of sub-string, and the length of name requested by **pReqSize**. If **buff** is NULL, then we can get the length of name requested by **pReqSize**.

Arguments

prob

The COPT problem.

iQConstr`

Index of quadratic constraint.

buff

Buffer for storing name.

buffSize

Length of the buffer.

pReqSize

Length of the requested name. Can be NULL.

COPT_GetPSDConstrName

Synopsis

```
int COPT_GetPSDConstrName(copt_prob *prob, int iPSDConstr, char  
*buff, int buffSize, int *pReqSize)
```

Description

Get name of PSD constraint by index. If memory of **buff** is not sufficient, then return the first **buffSize** length of sub-string, and the length of name requested by **pReqSize**. If **buff** is NULL, then we can get the length of name requested by **pReqSize**.

Arguments

prob

The COPT problem.

iPSDConstr`

Index of PSD constraint.

buff

Buffer for storing name.

buffSize

Length of the buffer.

pReqSize

Length of the requested name. Can be NULL.

COPT_GetLMIconstrName

Synopsis

```
int COPT_CALL COPT_GetLMIconstrName(copt_prob *prob, int iLMIconstr,
char *buff, int buffSize, int *pReqSize)
```

Description

Get name of LMI constraint by index. If memory of **buff** is not sufficient, then return the first **buffSize** length of sub-string, and the length of name requested by **pReqSize**. If **buff** is NULL, then we can get the length of name requested by **pReqSize**.

Arguments

prob

The COPT problem.

iLMIconstr

Index of LMI constraint.

buff

Buffer for storing name.

buffSize

Length of the buffer.

pReqSize

Length of the requested name. Can be NULL.

COPT_GetIndicatorName

Synopsis

```
int COPT_GetIndicatorName(copt_prob *prob, int iIndicator, char
*buff, int buffSize, int *pReqSize)
```

Description

Get name of indicator constraints by index. If memory of **buff** is not sufficient, then return the first **buffSize** length of sub-string, and the length of name requested by **pReqSize**. If **buff** is NULL, then we can get the length of name requested by **pReqSize**.

Arguments

prob

The COPT problem.

iIndicator

Index of indicator constraint.

buff

Buffer for storing name.

buffSize

Length of the buffer.

pReqSize

Length of the requested name. Can be NULL.

COPT_GetAffineConeName

Synopsis

```
int COPT_GetAffineConeName(copt_prob *prob, int iAffCone, char
*buff, int buffSize, int *pReqSize)
```

Description

Get name of affine cone by index. If memory of **buff** is not sufficient, then return the first **buffSize** length of sub-string, and the length of name requested by **pReqSize**. If **buff** is NULL, then we can get the length of name requested by **pReqSize**.

Arguments

prob

The COPT problem.

iAffCone

Index of affine cone.

buff

Buffer for storing name.

buffSize

Length of the buffer.

pReqSize

Length of the requested name. Can be NULL.

COPT_GetNLConstrName

Synopsis

```
int COPT_GetNLConstrName(copt_prob *prob, int iNLConstr, char *buff,
int buffSize, int *pReqSize)
```

Description

Retrieve the name of nonlinear constraint by index. If the provided **buff** length is insufficient, the function returns a substring of length **buffSize**, and the full required string length is returned via **pReqSize**.

If **buff** is NULL, the function returns the required string length via **pReqSize**.

Arguments

prob

The COPT problem.

iNLConstr

Index of the nonlinear expression constraint.

buff

Array to store the retrieved name string.

buffSize

Size of the provided array.

pReqSize

Pointer to store the minimum required string length for the full name. Can be NULL.

COPT_GetLMIconstrRhs

Synopsis

```
int COPT_GetLMIconstrRhs(copt_prob *prob, int num, const int *list,
int *constMatIdx)
```

Description

Get the constant-term symmetric matrix of `num` LMI constraints.

Arguments

`prob`

The COPT problem.

`num`

Number of LMI constraints.

`list`

Index of LMI constraints.

`constMatIdx`

Index of constant-term symmetric in the LMI constraints.

21.6.6 Accessing and setting parameters

COPT_SetIntParam

Synopsis

```
int COPT_SetIntParam(copt_prob *prob, const char *paramName, int
intParam)
```

Description

Sets an integer parameter.

Arguments

`prob`

The COPT problem.

`paramName`

The name of the integer parameter.

`intParam`

The value of the integer parameter.

COPT_GetIntParam, COPT_GetIntParamDef/Min/Max

Synopsis

```
int COPT_GetIntParam(copt_prob *prob, const char *paramName, int
*p_intParam)

int COPT_GetIntParamDef(copt_prob *prob, const char *paramName, int
*p_intParam)

int COPT_GetIntParamMin(copt_prob *prob, const char *paramName, int
*p_intParam)

int COPT_GetIntParamMax(copt_prob *prob, const char *paramName, int
*p_intParam)
```

Description

Gets the
current
default
minimal
maximal
value of an integer parameter.

Arguments

prob
The COPT problem.

paramName
The name of the integer parameter.

p_intParam
Pointer to the value of the integer parameter.

COPT_SetDblParam

Synopsis

```
int COPT_SetDblParam(copt_prob *prob, const char *paramName, double
dblParam)
```

Description

Sets a double parameter.

Arguments

prob
The COPT problem.

paramName
The name of the double parameter.

dblParam
The value of the double parameter.

COPT_GetDblParam, COPT_GetDblParamDef/Min/Max**Synopsis**

```
int COPT_GetDblParam(copt_prob *prob, const char *paramName, double
*p_dblParam)

int COPT_GetDblParamDef(copt_prob *prob, const char *paramName,
double *p_dblParam)

int COPT_GetDblParamMin(copt_prob *prob, const char *paramName,
double *p_dblParam)

int COPT_GetDblParamMax(copt_prob *prob, const char *paramName,
double *p_dblParam)
```

Description

Gets the
current
default
minimal
maximal
value of a double parameter.

Arguments

prob
The COPT problem.

paramName
The name of the double parameter.

p_dblParam
Pointer to the value of the double parameter.

COPT_ResetParam**Synopsis**

```
int COPT_ResetParam(copt_prob *prob)
```

Description

Reset parameters to default settings.

Arguments

prob
The COPT problem.

COPT_WriteParam**Synopsis**

```
int COPT_WriteParam(copt_prob *prob, const char *parfilename)
```

Description

Writes user defined parameters to a file. This API function will write out all the parameters that are different from their default values.

Arguments

prob

The COPT problem.

parfilename

The path to the parameter file.

COPT_WriteParamStr**Synopsis**

```
int COPT_WriteParamStr(copt_prob *prob, char *str, int nStrSize, int *pReqSize)
```

Description

Writes the modified parameters to a string buffer.

Arguments

prob

The COPT problem.

str

String buffer of modified parameters.

nStrSize

The size of string buffer.

pReqSize

Minimum space requirement of string buffer for modified parameters.

COPT_ReadParam**Synopsis**

```
int COPT_ReadParam(copt_prob *prob, const char *parfilename)
```

Description

Reads and applies parameters settings as defined in the parameter file.

Arguments

prob

The COPT problem.

parfilename

The path to the parameter file.

COPT_ReadParamStr

Synopsis

```
int COPT_ReadParamStr(copt_prob *prob, const char *strParam)
```

Description

Read parameter settings from string buffer, and set parameters in COPT.

Arguments

prob

The COPT problem.

strParam

String buffer of parameter settings.

21.6.7 Accessing attributes

COPT_GetIntAttr

Synopsis

```
int COPT_GetIntAttr(copt_prob *prob, const char *attrName, int  
*p_intAttr)
```

Description

Gets the value of an integer attribute.

Arguments

prob

The COPT problem.

attrName

The name of the integer attribute.

p_intAttr

Pointer to the value of the integer attribute.

COPT_GetDblAttr

Synopsis

```
int COPT_GetDblAttr(copt_prob *prob, const char *attrName, int  
*p_dblAttr)
```

Description

Gets the value of an double attribute.

Arguments

prob

The COPT problem.

attrName

The name of the double attribute.

p_dblAttr

Pointer to the value of the double attribute.

21.6.8 Logging utilities

COPT_SetLogFile

Synopsis

```
int COPT_SetLogFile(copt_prob *prob, char *logfilename)
```

Description

Set log file for the problem.

Arguments

`prob`

The COPT problem.

`logfilename`

The path to the log file.

COPT_SetLogCallback

Synopsis

```
int COPT_SetLogCallback(copt_prob *prob, void (*logcb)(char *msg,  
void *userdata), void *userdata)
```

Description

Set message callback for the problem.

Arguments

`prob`

The COPT problem.

`logcb`

Callback function for message.

`userdata`

User defined data. The data will be passed to the solver without modification.

21.6.9 MIP start utilities

COPT_AddMipStart

Synopsis

```
int COPT_AddMipStart(copt_prob *prob, int num, const int *list,  
double *colVal)
```

Description

Add MIP start information for the problem. If `list` is NULL, then information of the first `num` columns will be added.

One MIP start information will be added for each call to this function.

Arguments

prob
The COPT problem.

num
Number of variables (columns).

list
Index of variables (columns). Can be NULL.

colVal
MIP start information.

COPT_ReadMst

Synopsis

```
int COPT_ReadMst(copt_prob *prob, const char *mstfilename)
```

Description

Read MIP start information from file, and used as initial solution for the problem.

Arguments

prob
The COPT problem.

mstfilename
The path to the MIP start file.

COPT_WriteMst

Synopsis

```
int COPT_WriteMst(copt_prob *prob, const char *mstfilename)
```

Description

Write solution or existed MIP start information in problem to file.

Arguments

prob
The COPT problem.

mstfilename
The path to the MIP start file.

21.6.10 Nonlinear start point utilities

COPT_SetNLPrimalStart

Synopsis

```
int COPT_SetNLPrimalStart(copt_prob *prob, int num, const int *list,  
double *colVal)
```

Description

Set nonlinear primal start information for the problem. If **list** is NULL, then information of the first **num** columns will be set.

Arguments

- prob**
The COPT problem.
- num**
Number of variables (columns).
- list**
Index of variables (columns). Can be NULL.
- colVal**
Nonlinear primal start information.

21.6.11 IIS utilities**COPT_ComputeIIS****Synopsis**

```
int COPT_ComputeIIS(copt_prob *prob)
```

Description

Compute IIS (Irreducible Inconsistent Subsystem) for infeasible problem.

Arguments

- prob**
The COPT problem.

COPT_GetColLowerIIS**Synopsis**

```
int COPT_GetColLowerIIS(copt_prob *prob, int num, const int *list,  
int *colLowerIIS)
```

Description

Get IIS status of lower bounds of columns. If **list** is NULL, then IIS status of the first **num** columns will be returned.

Arguments

- prob**
The COPT problem.
- num**
Number of columns.
- list**
Index of columns. Can be NULL.
- colLowerIIS**
IIS status of lower bounds of columns.

COPT_GetColUpperIIS

Synopsis

```
int COPT_GetColUpperIIS(copt_prob *prob, int num, const int *list,  
int *colUpperIIS)
```

Description

Get IIS status of upper bounds of columns. If `list` is `NULL`, then IIS status of the first `num` columns will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of columns.

`list`

Index of columns. Can be `NULL`.

`colUpperIIS`

IIS status of upper bounds of columns.

COPT_GetRowLowerIIS

Synopsis

```
int COPT_GetRowLowerIIS(copt_prob *prob, int num, const int *list,  
int *rowLowerIIS)
```

Description

Get IIS status of lower bounds of rows. If `list` is `NULL`, then IIS status of the first `num` rows will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of rows.

`list`

Index of rows. Can be `NULL`.

`rowLowerIIS`

IIS status of lower bounds of rows.

COPT_GetRowUpperIIS

Synopsis

```
int COPT_GetRowUpperIIS(copt_prob *prob, int num, const int *list,
int *rowUpperIIS)
```

Description

Get IIS status of upper bounds of rows. If `list` is `NULL`, then IIS status of the first `num` rows will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of rows.

`list`

Index of rows. Can be `NULL`.

`rowUpperIIS`

IIS status of upper bounds of rows.

COPT_GetSOSIIS

Synopsis

```
int COPT_GetSOSIIS(copt_prob *prob, int num, const int *list, int
*sosIIS)
```

Description

Get IIS status of SOS constraints. If `list` is `NULL`, then IIS status of the first `num` SOS constraints will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of SOS constraints.

`list`

Index of SOS constraints. Can be `NULL`.

`sosIIS`

IIS status of SOS constraints.

COPT_GetIndicatorIIS

Synopsis

```
int COPT_GetIndicatorIIS(copt_prob *prob, int num, const int *list,
int *indicatorIIS)
```

Description

Get IIS status of indicator constraints. If `list` is NULL, then IIS status of the first `num` indicator constraints will be returned.

Arguments

`prob`

The COPT problem.

`num`

Number of indicator constraints.

`list`

Index of indicator constraints. Can be NULL.

`indicatorIIS`

IIS status of indicator constraints.

21.6.12 Feasibility relaxation utilities

COPT_FeasRelax

Synopsis

```
int COPT_FeasRelax(copt_prob *prob, double *colLowPen, double
*colUppPen, double *rowBndPen, double *rowUppPen)
```

Description

Compute feasibility relaxation to infeasible problem.

Arguments

`prob`

The COPT problem.

`colLowPen`

Penalty for lower bounds of columns. If NULL, then no relaxation for lower bounds of columns are allowed; If penalty in `colLowPen` is COPT_INFINITY, then no relaxation is allowed for corresponding bound.

`colUppPen`

Penalty for upper bounds of columns. If NULL, then no relaxation for upper bounds of columns are allowed; If penalty in `colUppen` is COPT_INFINITY, then no relaxation is allowed for corresponding bound.

`rowBndPen`

Penalty for bounds of rows. If NULL, then no relaxation for bounds of rows are allowed; If penalty in `rowBndPen` is COPT_INFINITY, then no relaxation is allowed for corresponding bound.

`rowUppPen`

Penalty for upper bounds of rows. If problem has two-sided rows, and `rowUppPen` is not NULL, then `rowUppPen` is penalty for upper bounds of rows; If penalty in `rowUppPen` is `COPT_INFINITY`, then no relaxation is allowed for corresponding bound.

Note: Normally, just set `rowUppPen` to NULL.

COPT_WriteRelax

Synopsis

```
int COPT_WriteRelax(copt_prob *prob, const char *relaxfilename)
```

Description

Write feasrelax problem to file.

Arguments

`prob`

The COPT problem.

`relaxfilename`

Name of feasrelax problem file.

21.6.13 Parameter tuning utilities

COPT_Tune

Synopsis

```
int COPT_Tune(copt_prob *prob)
```

Description

Parameter tuning of the model.

Arguments

`prob`

COPT model.

COPT_LoadTuneParam

Synopsis

```
int COPT_LoadTuneParam(copt_prob *prob, int idx)
```

Description

Load the parameter tuning results of the specified number into the model.

Arguments

`prob`

COPT model.

`idx`

The number of the parameter tuning result.

COPT_ReadTune

Synopsis

```
int COPT_ReadTune(copt_prob *prob, const char *tunefilename)
```

Description

Read the parameter combination to be tuned from the tuning file to the model.

Arguments

`prob`

COPT model.

`tunefilename`

Tuning file names.

COPT_WriteTuneParam

Synopsis

```
int COPT_WriteTuneParam(copt_prob *prob, int idx, const char
*parfilename)
```

Description

Output the parameter tuning result of the specified number to the parameter file.

Arguments

`prob`

COPT model.

`idx`

The number of the parameter tuning result.

`parfilename`

parameter file name.

21.6.14 Callback utilities

Certain callback utilities methods can only be called in certain contexts, which are listed below:

Table 21.1: Callback utilities

Context	Methods
COPT_CBCONTEXT_INCUMBENT	<i>COPT_AddCallbackSolution, COPT_GetCallbackInfo</i>
COPT_CBCONTEXT_MIPSOL	<i>COPT_AddCallbackLazyConstr,</i> <i>COPT_AddCallbackLazyConstrs,</i> <i>COPT_AddCallbackSolution, COPT_GetCallbackInfo</i>
COPT_CBCONTEXT_MIPRELAX	<i>COPT_AddCallbackUserCut, COPT_AddCallbackUserCuts,</i> <i>COPT_AddCallbackSolution, COPT_GetCallbackInfo</i>
COPT_CBCONTEXT_MIPNODE	<i>COPT_AddCallbackSolution, COPT_GetCallbackInfo</i>

COPT_AddLazyConstr

Synopsis

```
int COPT_AddLazyConstr(  
    copt_prob *prob,  
    int nRowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    char cRowSense,  
    double dRowBound,  
    double dRowUpper,  
    const char *rowName)
```

Description

Add a lazy constraint to the MIP model.

Arguments

prob

The COPT problem.

nRowMatCnt

Number of non-zero elements in the lazy constraint.

rowMatIdx

Column index of non-zero elements in the lazy constraint.

rowMatElem

Values of non-zero elements in the lazy constraint.

cRowSense

The sense of the new lazy constraint.

Please refer to *Constraint senses* for all the supported types.

If **cRowSense** is 0, then **dRowBound** and **dRowUpper** will be treated as lower and upper bounds for the constraint. This is the recommended method for defining constraints.

If **cRowSense** is provided, then **dRowBound** and **dRowUpper** will be treated as RHS and **range** for the constraint. In this case, **dRowUpper** is only required when **cRowSense** = COPT_RANGE, where

lower bound is **dRowBound** - **dRowUpper**

upper bound is **dRowBound**

dRowBound

Lower bound or RHS of the lazy constraint.

dRowUpper

Upper bound or **range** of the lazy constraint.

rowName

The name of the lazy constraint. Can be NULL.

COPT_AddLazyConstrs

Synopsis

```
int COPT_AddLazyConstrs(
    copt_prob *prob,
    int nAddRow,
    const int *rowMatBeg,
    const int *rowMatCnt,
    const int *rowMatIdx,
    const double *rowMatElem,
    const char *rowSense,
    const double *rowBound,
    const double *rowUpper,
    char const *const *rowNames)
```

Description

Add a set of lazy constraints to the MIP model.

Arguments

prob

The COPT problem.

nAddRow

Number of new lazy constraints.

rowMatBeg, rowMatCnt, rowMatIdx and rowMatElem

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of COPT_LoadProb.

rowSense

Senses of new lazy constraints.

Please refer to *Constraint senses* for all the supported types.

If **rowSense** is NULL, then **rowBound** and **rowUpper** will be treated as lower and upper bounds for constraints. This is the recommended method for defining constraints.

If **rowSense** is provided, then **rowBound** and **rowUpper** will be treated as RHS and **range** for constraints. In this case, **rowUpper** is only required when there are COPT_RANGE constraints, where the

lower bound is `rowBound[i] - fabs(rowUpper[i])`

upper bound is `rowBound[i]`

rowBound

Lower bounds or RHS of new lazy constraints.

rowUpper

Upper bounds or **range** of new lazy constraints.

rowNames

Names of new lazy constraints. Can be NULL.

COPT_AddUserCut

Synopsis

```
int COPT_AddUserCut(  
    copt_prob* prob,  
    int nRowMatCnt,  
    const int* rowMatIdx,  
    const double* rowMmatElem,  
    char cRowSense,  
    double dRowBound,  
    double dRowUpper,  
    const char* rowName)
```

Description

Add a user cut to the MIP model.

Arguments

prob

The COPT problem.

nRowMatCnt

Number of non-zero elements in the user cut.

rowMatIdx

Column index of non-zero elements in the user cut.

rowMatElem

Values of non-zero elements in the user cut.

cRowSense

The sense of the user cut.

Please refer to *Constraint senses* for all the supported types.

If **cRowSense** is 0, then **dRowBound** and **dRowUpper** will be treated as lower and upper bounds for the constraint. This is the recommended method for defining constraints.

If **cRowSense** is provided, then **dRowBound** and **dRowUpper** will be treated as RHS and **range** for the constraint. In this case, **dRowUpper** is only required when **cRowSense** = COPT_RANGE, where

lower bound is **dRowBound** - **dRowUpper**

upper bound is **dRowBound**

dRowBound

Lower bound or RHS of the user cut.

dRowUpper

Upper bound or **range** of the user cut.

rowName

The name of the user cut. Can be NULL.

COPT_AddUserCuts

Synopsis

```
int COPT_CALL COPT_AddUserCuts(
    copt_prob *prob,
    int nAddRow,
    const int *rowMatBeg,
    const int *rowMatCnt,
    const int *rowMatIdx,
    const double *rowMatElem,
    const char *rowSense,
    const double *rowBound,
    const double *rowUpper,
    char const *const *rowNames)
```

Description

Add a set of user cuts to the MIP model.

Arguments

prob

The COPT problem.

nAddRow

Number of new user cuts.

rowMatBeg, rowMatCnt, rowMatIdx and rowMatElem

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of COPT_LoadProb.

rowSense

Senses of new user cuts.

Please refer to *Constraint senses* for all the supported types.

If **rowSense** is NULL, then **rowBound** and **rowUpper** will be treated as lower and upper bounds for constraints. This is the recommended method for defining constraints.

If **rowSense** is provided, then **rowBound** and **rowUpper** will be treated as RHS and **range** for constraints. In this case, **rowUpper** is only required when there are COPT_RANGE constraints, where the

lower bound is `rowBound[i] - fabs(rowUpper[i])`

upper bound is `rowBound[i]`

rowBound

Lower bounds or RHS of new user cuts.

rowUpper

Upper bounds or **range** of new user cuts.

rowNames

Names of new user cuts. Can be NULL.

COPT_SetCallback

Synopsis

```
int COPT_SetCallback(  
    copt_prob *prob,  
    int (COPT_CALL *cb)(copt_prob *prob, void *cbdata, int cbctx,  
        void *userdata),  
    int cbctx,  
    void *userdata)
```

Description

Set the callback function of the model.

Arguments

prob

The COPT problem.

cb

Callback function.

cbctx

Callback context. Please refer to *Callback context* .

userdata

User defined data. The data will be passed to the solver without modification.

COPT_GetCallbackInfo

Synopsis

```
int COPT_GetCallbackInfo(void *cbdata, const char* cbinfo, void  
    *p_val)
```

Description

Retrieve the value of the specified callback information.

Arguments

cbdata

The cbdata argument that was passed into the user callback by COPT. This argument must be passed unmodified from the user callback to COPT_GetCallbackInfo().

cbinfo

The name of the callback information. Please refer to *Callback information* for possible values.

p_val

Pointer to the value of the callback information.

COPT_AddCallbackSolution

Synopsis

```
int COPT_AddCallbackSolution(void *cbdata, const double *sol,
double* p_objval)
```

Description

Set feasible solutions for the specified variables.

Arguments

cbdata

The cbdata argument that was passed into the user callback by COPT. This argument must be passed unmodified from the user callback to COPT_AddCallbackSolution().

sol

The solution vector.

p_objval

Pointer to the objective value for solution.

COPT_AddCallbackUserCut

Synopsis

```
int COPT_AddCallbackUserCut(
    void *cbdata,
    int nRowMatCnt,
    const int *rowMatIdx,
    const double *rowMatElem,
    char cRowSense,
    double dRowRhs)
```

Description

Add a user cut to the MIP model from within the callback function.

Arguments

cbdata

The cbdata argument that was passed into the user callback by COPT. This argument must be passed unmodified from the user callback to COPT_AddCallbackUserCut().

nRowMatCnt

Number of non-zero elements in the user cut.

rowMatIdx

Column index of non-zero elements in the user cut.

rowMatElem

Values of non-zero elements in the user cut.

cRowSense

The sense of the new user cut. It supports for LESS_EQUAL, GREATER_EQUAL, EQUAL and FREE .

The user cut added from within callback can only have a single bound.

dRowRhs

RHS of the user cut.

COPT_AddCallbackUserCuts

Synopsis

```
int COPT_AddCallbackUserCuts(  
    void *cbdata,  
    int nAddRow,  
    const int *rowMatBeg,  
    const int *rowMatCnt,  
    const int *rowMatIdx,  
    const double *rowMatElem,  
    const char *rowSense,  
    const double *rowRhs)
```

Description

Add a set of user cuts to the MIP model from within the callback function.

Arguments

cbdata

The cbdata argument that was passed into the user callback by COPT. This argument must be passed unmodified from the user callback to COPT_AddCallbackUserCuts().

nAddRow

Number of new user cuts.

rowMatBeg, rowMatCnt, rowMatIdx and rowMatElem

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of COPT_LoadProb.

rowSense

Senses of new user cuts. It supports for LESS_EQUAL, GREATER_EQUAL, EQUAL and FREE .

The user cuts added from within callback can only have single bounds.

rowRhs

RHS of new user cuts.

COPT_AddCallbackLazyConstr

Synopsis

```
int COPT_AddCallbackLazyConstr(
    void *cbdata,
    int nRowMatCnt,
    const int *rowMatIdx,
    const double *rowMatElem,
    char cRowSense,
    double dRowRhs)
```

Description

Add a lazy constraint to the MIP model from within the callback function.

Arguments

cbdata

The cbdata argument that was passed into the user callback by COPT. This argument must be passed unmodified from the user callback to COPT_AddCallbackLazyConstr().

nRowMatCnt

Number of non-zero elements in the lazy constraint.

When **nRowMatCnt** ≤ 0, the MIP candidate solution will be directly rejected without adding a lazy constraint. And **rowMatIdx**, **rowMatElem**, **cRowSense** and **dRowRhs** will be ignored.

rowMatIdx

Column index of non-zero elements in the lazy constraint.

rowMatElem

Values of non-zero elements in the lazy constraint.

cRowSense

The sense of new lazy constraint. It supports for LESS_EQUAL, GREATER_EQUAL, EQUAL and FREE .

The lazy constraint added from within callback can only have a single bound.

dRowRhs

RHS of the lazy constraint.

COPT_AddCallbackLazyConstrs

Synopsis

```
int COPT_AddCallbackLazyConstrs(
    void *cbdata,
    int nAddRow,
    const int *rowMatBeg,
    const int *rowMatCnt,
```

```
const int *rowMatIdx,  
const double *rowMatElem,  
const char *rowSense,  
const double *rowRhs)
```

Description

Add a set of lazy constraints to the MIP model from within the callback function.

Arguments

cbdata

The **cbdata** argument that was passed into the user callback by COPT. This argument must be passed unmodified from the user callback to COPT_AddCallbackLazyConstrs().

nAddRow

Number of new lazy constraints.

When **nAddRow**≤0, the MIP candidate solution will be directly rejected without adding lazy constraints.

And other parameters(apart from **cbdata**) will be ignored.

rowMatBeg, **rowMatCnt**, **rowMatIdx** and **rowMatElem**

Defines the coefficient matrix in compressed row storage (CRS) format. The CRS format is similar to the CCS format described in the **other information** of COPT_LoadProb.

rowSense

Senses of new lazy constraints. It supports for LESS_EQUAL, GREATER_EQUAL, EQUAL and FREE .

The lazy constraints added from within callback can only have single bounds.

rowRhs

RHS of new lazy constraints.

Note: If the user gives a solution to COPT in a callback, the user should ensure that this fulfills the lazy constraint callback since that won't be called for user-provided solutions.

21.6.15 Other API functions

COPT_GetBanner

Synopsis

```
int COPT_GetBanner(char *buff, int buffSize)
```

Description

Obtains a C-style string as banner, which describes the COPT version information.

Arguments

buff

A buffer for holding the resulting string.

buffSize

The size of the above buffer.

COPT_GetRetcodeMsg

Synopsis

```
int COPT_GetRetcodeMsg(int code, char *buff, int buffSize)
```

Description

Obtains a C-style string which explains a return code value in plain text.

Arguments

`code`

The return code from a COPT API function.

`buff`

A buffer for holding the resulting string.

`buffSize`

The size of the above buffer.

COPT_Interrupt

Synopsis

```
int COPT_Interrupt(copt_prob *prob)
```

Description

Interrupt solving process of current problem.

Arguments

`prob`

The COPT problem.

Chapter 22

Python API Reference

The **Cardinal Optimizer** provides a Python API library. This chapter documents all COPT Python constants and API functions for python applications.

22.1 Constants

Python Constants are necessary to solve a problem using the Python interface. There are four types of constants defined in COPT Python API library. They are general constants, information constants, parameters and attributes.

22.1.1 General Constants

For the contents of Python general constants, see [General Constants](#).

General constants are those commonly used in modeling, such as optimization directions, variable types, and solving status, etc. Users may refer to general constants with a 'COPT' prefix. For instance, COPT.VERSION_MAJOR is the major version number of the **Cardinal Optimizer**.

22.1.2 Attributes

For the contents of Python attribute constants, see [Attributes](#).

In the Python API, users may refer to attributes using a 'COPT.Attr' prefix. For instance, COPT.Attr.Cols is the number of variables or columns in the model.

In the Python API, user can get the attribute value by specifying the attribute name. Attributes are mostly used in Model.getAttr() method to query properties of the model, please refer to [Python API: Model Class](#) for details. Here is an example:

- `Model.getAttr()`: `Model.getAttr("Cols")` obtain the number of variables or columns in the model.

22.1.3 Information

For the contents of Python API information class constants, see [Information](#).

In the Python API, user can access the information through the `COPT.Info` prefix. For instance, `COPT.Info.Obj` is the objective function coefficients for variables (columns).

In the Python API, user can get or set the information value of the object by specifying the information name:

- Get the value of variable or constraint information: `Model.getInfo()` / `Var.getInfo()` / `Constraint.getInfo()`
- Set the value of variable or constraint information: `Model.setInfo()` / `Var.setInfo()` / `Constraint.setInfo()`

22.1.4 Callback Information

For the content of Python API callback information class constants, see [Callback Information](#).

In the Python API, callback-related information constants are defined in the `CbInfo` class. User can access the callback information via `COPT.CbInfo.` prefix.

For instance, `COPT.CbInfo.BestObj` is the current best objective.

In the Python API, user can get the value of callback information by specifying the information name.

For instance, `CallbackBase.getInfo(COPT.CbInfo.BestObj)` : get the value of the current best objective.

22.1.5 Parameters

For the contents of Python API Parameters class constants, see [Parameters](#).

Parameters control the operation of the **Cardinal Optimizer**. They can be modified before the optimization begins.

In the Python API, user can access parameters through the `COPT.Param` prefix. For instance, `COPT.Param.TimeLimit` is time limit in seconds of the optimization.

In the Python API, user can get and set the parameter value by specifying the parameter name. The provided functions are as follows, please refer to [Python API: Model Class](#) for details.

- Get detailed information of the specified parameter (current value/max/min): `Model.getParamInfo()`
- Get the current value of the specified parameter: `Model.getParam()`
- Set the specified parameter value: `Model.setParam()`

22.2 Python Modeling Classes

Python modeling classes are essential for the Python interface of Cardinal Optimizer. It provides plentiful easy-to-use methods to quickly build optimization models in complex practical scenarios. This section will explain these functions and their usage.

22.2.1 EnvrConfig Class

EnvrConfig object contains operations related to client configuration, and provides the following methods:

EnvrConfig()

Synopsis

```
EnvrConfig()
```

Description

Constructor of EnvrConfig class. This method creates and returns an *EnvrConfig* *Class* object.

Example

```
# Create client configuration
envconfig = EnvrConfig()
```

EnvrConfig.set()

Synopsis

```
set(name, value)
```

Description

Set client configuration.

Arguments

name

Name of configuration parameter. Please refer to *Client configuration* for possible values.

value

Value of configuration parameter.

Example

```
# Set client configuration
envconfig.set(COPT.CLIENT_WAITTIME, 600)
envconfig.set(COPT.CLIENT_CLUSTER, "127.0.0.1")
# Turn off the banner output when creating COPT environment (such as version, etc.)
envconfig.set("nobanner", "1")
```

22.2.2 Envr Class

Envr object contains operations related to COPT optimization environment, and provides the following methods:

Envr()

Synopsis

```
Envr(arg=None)
```

Description

Function for constructing Envr object. This method creates and returns an *Envr Class* object.

Arguments

arg

Path of license file or client configuration. Optional argument, defaults to None.

Example

```
# Create solving environment
env = Envr()
```

Envr.createModel()

Synopsis

```
createModel(name="")
```

Description

Create optimization model and return a *Model Class* object.

Arguments

name

The name of the Model object to be created. Optional, "" by default.

Example

```
# Create optimization model
model = env.createModel("coptprob")
```

Envr.close()

Synopsis

```
close()
```

Description

Close connection to remote server.

Example

```
# Close connection to remote server
env.close()
```

22.2.3 Model Class

For easy access to model's attributes and optimization parameters, Model object provides methods such as `Model.Rows`. The full list of attributes can be found in [Attributes](#) section. For convenience, attributes can be accessed by their names in capital or lower case.

Note that for LP or MIP, both the objective value and the solution status can be accessed through `Model.objval` and `Model.status`.

For optimization parameters, they can be set in the form `"Model.Param.TimeLimit = 10"`. For details of the parameter names supported, please refer to [Parameters](#) section.

Class Model contains COPT model-related operations and provides the following methods:

Model.addVar()

Synopsis

```
addVar(lb=0.0, ub=COPT.INFINITY, obj=0.0, vtype=COPT.CONTINUOUS,
name="", column=None)
```

Description

Add a decision variable to model and return the added *Var Class* object.

Arguments

`lb`

Lower bound for new variable. Optional, 0.0 by default.

`ub`

Upper bound for new variable. Optional, `COPT.INFINITY` by default.

`obj`

Objective parameter for new variable. Optional, 0.0 by default.

`vtype`

Variable type. Optional, `COPT.CONTINUOUS` by default. Please refer to [Variable types](#) for possible types.

`name`

Name for new variable. Optional, "" by default, which is automatically generated by solver.

`column`

Column corresponds to the variable. Optional, `None` by default.

Example

```
# Add a continuous variable
x = m.addVar()
# Add a binary variable
y = m.addVar(vtype=COPT.BINARY)
# Add an integer variable with lowerbound -1.0, upperbound 1.0, objective coefficient 1.0
# and variable name "z"
z = m.addVar(-1.0, 1.0, 1.0, COPT.INTEGER, "z")
```

Model.addVars()

Synopsis

```
addVars(*indices, lb=0.0, ub=COPT.INFINITY, obj=0.0, vtype=COPT.
CONTINUOUS, nameprefix="C")
```

Description

Add multiple new variables to a model. Return a *tupledict Class*, whose key is indice of the variable and value is the *Var Class* object.

Arguments

***indices**

Indices for accessing the new variables.

lb

Lower bounds for new variables. Optional, 0.0 by default.

ub

Upper bounds for new variables. Optional, COPT.INFINITY by default.

obj

Objective costs for new variables. Optional, 0.0 by default.

vtype

Variable types. Optional, COPT.CONTINUOUS by default. Please refer to *Variable types* for possible types.

nameprefix

Name prefix for new variables. Optional, "C" by default. The actual name and the index of the variables are automatically generated by COPT.

Example

```
# Add three-dimensional integer variable, 6 variables in total
x = m.addVars(1, 2, 3, vtype=COPT.INTEGER)
# Add two continuous variable y, whose indice is designated by elements in tuplelist
↳ and prefix is "tl"
tl = tuplelist([(0, 1), (1, 2)])
y = m.addVars(tl, nameprefix="tl")
```

Model.addMVar()

Synopsis

```
addMVar(shape, lb=0.0, ub=COPT.INFINITY, obj=0.0, vtype=COPT.
CONTINUOUS, nameprefix="")
```

Description

Add *MVar Class* object to the model. It is used in matrix modeling and can be operated like a multidimensional array in NumPy, its shape and dimensions are similarly defined.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of a *MVar Class* object.

lb

The lower bound of the variable. Optional parameter, defaults to 0.0.

ub

The upper bound of the variable. Optional parameter, defaults to COPT.INFINITY.

obj

The objective function coefficients for the variables. Optional parameter, defaults to 0.0.

vtype

The type of the variable. Optional parameter, the default is COPT.CONTINUOUS, see the possible values in *Variable types*.

nameprefix

Variable name prefix. Optional parameter, the default is "", its actual name is automatically generated by combining the subscript of the variable.

Return value

Returns a *MVar Class* object

Example

```
model.addMVar((2, 3), lb=0.0, nameprefix="mx")
```

Model.addConstr()**Synopsis**

```
addConstr(lhs, sense=None, rhs=None, name="")
```

Description

Add a linear constraint to the model, return *Constraint Class* object or *MConstr Class* object;

Add a semidefinite constraint to the model, return *PsdConstraint Class* object or *MPsdConstr Class* object;

Add an indicator constraint to the model and return the *GenConstr Class* object;

Adds a LMI constraint to the model, returning a *LmiConstraint Class* object.

If a linear constraint added, then the parameter **lhs** can take the value of *Var Class* object, *LinExpr Class* object, *ConstrBuilder Class* object or *MConstrBuilder Class*.

If a positive semi-definite constraint added, then the parameter **lhs** can take the value of *PsdExpr Class* object, *PsdConstrBuilder Class* object or *MPsdConstrBuilder Class*.

If an indicator constraint added, then the parameter **lhs** is *GenConstrBuilder Class* object, ignoring other parameters.

If a LMI constraint added, then the parameter **lhs** can take the value of *LmiExpr Class* object.

Arguments**lhs**

Left-hand side expression for new linear constraint or constraint builder.

sense

Sense for the new constraint. Optional, None by default. Please refer to *Constraint type* for possible values.

rhs

Right-hand side expression for the new constraint. Optional, None by default. It can be a constant, or *Var Class* object, or *LinExpr Class* object.

name

Name for new constraint. Optional, "" by default, generated by solver automatically.

Example

```
# Add a linear constraint: x + y == 2
m.addConstr(x + y, COPT.EQUAL, 2)
# Add a linear constraint: x + 2*y >= 3
m.addConstr(x + 2*y >= 3.0)
# Add an indicator constraint
m.addConstr((x == 1) >> (2*y + 3*z <= 4))
```

Model.addBoundConstr()**Synopsis**

```
addBoundConstr(expr, lb=-COPT.INFINITY, ub=COPT.INFINITY, name="")
```

Description

Add a constraint with a lower bound and an upper bound to a model and return the added *Constraint Class* object.

Arguments**expr**

Expression for the new constraint, which can be *Var Class* object or *LinExpr Class* object.

lb

Lower bound for the new constraint. Optional, -COPT.INFINITY by default.

ub

Upper bound for the new constraint. Optional, COPT.INFINITY by default.

name

Name for new constraint. Optional, "" by default, automatically generated by solver.

Example

```
# Add linear bilateral constraint: -1 <= x + y <= 1
m.addBoundConstr(x + y, -1.0, 1.0)
```

Model.addConstrs()

Synopsis

```
addConstrs(generator, nameprefix="R")
```

Description

Add a set of linear constraints, semidefinite constraints, or indicator constraints to the model.

If parameter **generator** is integer, the return a *ConstrArray Class* object consisting of **generator** number of empty *Constraint Class* objects, and users need to specify these constraints.

If parameter **generator** is expression generator, then return a *tupledict Class* object whose key is the indice of linear constraint and value is the corresponding *Constraint Class* object. Every iteration generates a *Constraint Class* object.

If the parameter **generator** is a matrix expression generator, return a *MConstr Class* object or a *MPsdConstr Class* object.

If the parameter **generator** is an indicator expression generator, return a *GenConstrArray Class* object.

Arguments

generator

A generator expression, where each iteration produces a *Constraint Class* object, or a matrix expression builder, or an indicator expression generator.

nameprefix

Name prefix for new constraints. Optional, "R" by default. The actual name and the index of the constraints are automatically generated by COPT.

Example

```
# Add 10 linear constraints, each constraint shaped like: x[0] + y[0] >= 2.0
m.addConstrs(x[i] + y[i] >= 2.0 for i in range(10))
```

Model.addMConstr()

Synopsis

```
addMConstr(A, x, sense, b, nameprefix="")
```

Description

By means of matrix modeling, a set of linear constraints are added to the model. If the value of **sense** here is `COPT.LESS_EQUAL`, the added constraint is $Ax \leq b$.

It is more convenient to generate *MLinExpr Class* objects by matrix multiplication, and then use overloaded comparison operators to generate *MConstrBuilder Class* object, which can be used as input of `Model.addConstrs()` to generate a set of linear constraints.

Arguments

A

Parameter A is a two-dimensional NumPy matrix, SciPy compressed sparse column matrix (`csc_matrix`) or compressed sparse row matrix (`csr_matrix`).

x

The variable corresponding to the linear term can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object. If it is empty, but the parameter *c* is not empty, all variables in the model are taken.

sense

The type of constraint. Possible values refer to *Constraint type*.

b

The value on the right side of the constraint, usually a floating point number, can also be a set of numbers, or a one-dimensional array of NumPy.

nameprefix

Constraint name prefix.

Return value

Returns a *MConstr Class* object

Example

```
A = np.full((2, 3), 1)
mx = model.addMVar(3, nameprefix="mx")
mc = model.addMConstr(A, mx, 'L', 1.0, nameprefix="mc")
```

Model.addSOS()

Synopsis

```
addSOS(sostype, vars, weights=None)
```

Description

Add a SOS constraint to model and return the added *SOS Class* object.

If param **sostype** is *SOSBuilder Class* object, then the values of param **vars** and param **weights** will be ignored;

If param **sostype** is SOS constraint type, it can be valued as *SOS-constraint types*, then param **vars** represents variables of SOS constraint, taking the value of *VarArray Class* object, list, dict or *tupledict Class* object;

If param **weights** is *None*, then variable weights of SOS constraints will be automatically generated by solver. Otherwise take the input from user as weights, possible values can be list, dictionary or *tupledict Class* object.

Arguments

sostype

SOS constraint type or SOS constraint builder.

vars

Variables of SOS constraints.

weights

Weights of variables in SOS constraints, optional, *None* by default.

Example

```
# Add an SOS1 constraint, including variable x and y, weights of 1 and 2.
m.addSOS(COPT.SOS_TYPE1, [x, y], [1, 2])
```


Model.addGenConstrIndicator()**Synopsis**

```
addGenConstrIndicator(binvar, binval, lhs, sense=None, rhs=None,
type=COPT.INDICATOR_IF, name="")
```

Description

Add an indicator constraint with the specified type to a model and return the added *GenConstr Class* object.

If the parameter `lhs` is *ConstrBuilder Class* object, then the values of parameter `sense` and parameter `rhs` will be ignored.

If parameter `lhs` represents Left-hand side expression, it can take value of *Var Class* object or *LinExpr Class* object.

Arguments

`binvar`

Indicator variable.

`binval`

Value of indicator variable, can be `True` or `False`.

`lhs`

Left-hand side expression for the linear constraint triggered by the indicator or linear constraint builder.

`sense`

Sense for the linear constraint. Optional, `None` by default. Please refer to *Constraint type* for possible values.

`rhs`

Right-hand-side value for the linear constraint triggered by the indicator. Optional, `None` by default, value type is constant.

`type`

Type of the indicator constraint. Optional, `COPT.INDICATOR_IF` by default. Please refer to *Indicator Constraint type* for possible values.

`name`

Name for new indicator constraint. Optional, "" by default, generated by solver automatically.

Example

```
# Add an indicator constraint, if x is True, then the linear constraint y + 2*z >= 3
↳ should hold
m.addGenConstrIndicator(x, True, y + 2*z >= 3)
# Add an indicator constraint, if the linear constraint y + 2*z >= 3 hold, then x
↳ should be True
m.addGenConstrIndicator(x, True, y + 2*z >= 3, type=COPT.INDICATOR_ONLYIF)
```

Model.addGenConstrIndicators()

Synopsis

```
addGenConstrIndicators(builders, nameprefix="")
```

Description

Add a set of indicator constraints with the specified type to a model and return the added *GenConstrArray Class* object.

Arguments

builders

A set of indicator constraint builders. The possible values could be *GenConstrBuilderArray Class* object, a list or dictionary of *GenConstrBuilder Class* object.

nameprefix

Nameprefix of indicator variable. Optional, "" by default, generated by solver automatically.

Model.addGenConstrMin()

Synopsis

```
addGenConstrMin(resvar, vars, constant=None, name="")
```

Description

Add a constraint of the form $y = \min\{x_1, x_2, \dots, x_n, c\}$ to the model.

Arguments

resvar

The term y on the left side of the equation and can be an object of class **Var** or **MVar** .

vars

The variable of the $\min\{\}$ function on the right side of the equation,
Possible values are **list** class objects.

constant

The constant term in the $\min\{\}$ function on the right side of the equation,
Optional parameter, the possible value is a floating number,
The default value is **None**.

name

Constraint name, optional parameter, default value is "" .

Return value

It returns a **GenConstrX Class** object.

Model.addGenConstrMax()**Synopsis**

```
addGenConstrMax(resvar, vars, constant=None, name="")
```

Description

Add a constraint of the form $y = \max\{x_1, x_2, \dots, x_n, c\}$ to the model.

Arguments

resvar

The term y on the left side of the equation and can be an object of class **Var** or **MVar** .

vars

The variable of the $\max\{\}$ function on the right side of the equation.

Possible values are **list** class objects.

constant

The constant term in the $\max\{\}$ function on the right side of the equation.

Optional parameter, the possible value is a floating number.

The default value is **None** .

name

Constraint name, optional parameter, default value is "" .

Return value

It returns a **GenConstrX** Class object.

Model.addGenConstrAbs()**Synopsis**

```
addGenConstrAbs(resvar, argvar, name="")
```

Description

Add a constraint of the form $cy + d = |ax + b|$ to the model.

Arguments

resvar

$cy + d$, possible values are objects of class **Var** / **MVar** or class **LinExpr** / **MLinExpr** .

argvar

$ax + b$, the possible value is object of class **Var** / **MVar** or class **LinExpr** / **MLinExpr** .

name

Constraint name, optional parameter, default value is "" .

Return value

It returns a **GenConstrX** Class object.

Model.addGenConstrAnd()**Synopsis**

```
addGenConstrAnd(resvar, vars, name="")
```

Description

Add a logical **and** constraint of the form $y = x_1 \text{ and } x_2 \cdots \text{ and } x_n$ to the model.

Arguments

resvar

The term **y** on the left side of the equation and can be an object of class **Var** or **MVar** .

vars

Elements connected by logical operator **and** x_i , for $i \in \{1, 2, \dots, n\}$

Possible values are **List** class (where the elements are binary **Var** class or **MVar** class objects).

name

Constraint name, optional parameter, default value is "" .

Return value

It returns a **GenConstrX** Class object.

Model.addGenConstrOr()**Synopsis**

```
addGenConstrOr(resvar, vars, name="")
```

Description

Add a logical **or** constraint of the form $y = x_1 \text{ or } x_2 \cdots \text{ or } x_n$ to the model.

Arguments

resvar

The term **y** on the left side of the equation and can be an object of class **Var** or **MVar** .

vars

Elements connected by logical operator **or** x_i , for $i \in \{1, 2, \dots, n\}$

Possible values are **List** class (where the elements are binary **Var** class or **MVar** objects).

name

Constraint name, optional parameter, default value is "" .

Return value

It returns a **GenConstrX** Class object.

Model.addGenConstrPWL()**Synopsis**

```
addGenConstrPWL(xvar, yvar, xpts, ypts, name="")
```

Description

Add a constraint of the form $y = f(x)$, where a piecewise linear function is defined as:

$$f(v) = \begin{cases} \tilde{y}_1 + \frac{\tilde{y}_2 - \tilde{y}_1}{\tilde{x}_2 - \tilde{x}_1}(v - \tilde{x}_1), & \text{if } v \leq \tilde{x}_1 \\ \tilde{y}_i + \frac{\tilde{y}_{i+1} - \tilde{y}_i}{\tilde{x}_{i+1} - \tilde{x}_i}(v - \tilde{x}_i), & \text{if } \tilde{x}_i \leq v \leq \tilde{x}_{i+1} \\ \tilde{y}_n + \frac{\tilde{y}_n - \tilde{y}_{n-1}}{\tilde{x}_n - \tilde{x}_{n-1}}(v - \tilde{x}_n), & \text{if } v \geq \tilde{x}_n \end{cases}$$

Arguments

xvar

x, which can be an object of class **Var** or class **MVar** .

yvar

The term y on the left side of the equation,

Possible values are objects of class **Var** / **MVar** or class **LinExpr** / **MLinExpr** .

xpts

\tilde{x} , the abscissa of the segmentation point.

It should be arranged in ascending order of values, possible values are **List** class.

ypts

\tilde{y} , the vertical coordinate of the segmentation point,

Possible values are **List** class.

name

Constraint name, optional parameter, default value is "" .

Return value

It returns a **GenConstrX** Class object.

Model.addConeByDim()**Synopsis**

```
addConeByDim(dim, ctype, vtype, nameprefix="ConeV")
```

Description

Add a Second-Order-Cone (SOC) constraint with given dimension, and return the added *Cone Class* object.

Arguments

dim

Dimension of SOC constraint.

ctype

Type of SOC constraint.

`vtype`

Variable types of SOC constraint.

`nameprefix`

Name prefix of variables in SOC constraint. Optional, default to "ConeV".

Example

```
# Add a 5 dimension rotated SOC constraint
m.addConeByDim(5, COPT.CONE_RQUAD, None)
```

Model.addExpConeByDim()

Synopsis

```
addExpConeByDim(ctype, vtype, nameprefix="ExpConeV")
```

Description

Add an exponential cone constraint and return the added *ExpCone Class* object.

Arguments

`ctype`

Type of exponential cone constraint.

`vtype`

Variable types of exponential cone constraint.

`nameprefix`

Name prefix of variables in exponential cone constraint. Optional, default to "ExpConeV" .

Example

```
# Add a primal exponential cone
m.addExpConeByDim(COPT.EXPCONE_PRIMAL, None)
```

Model.addCone()

Synopsis

```
addCone(vars, ctype)
```

Description

Add a Second-Order-Cone (SOC) constraint with given variables.

If argument `vars` is a *ConeBuilder Class* object, then the value of argument `ctype` will be ignored; If argument `vars` are variables, the optional values are *VarArray Class* objects, Python list, Python dictionary or *tupledict Class* objects, argument `ctype` is the type of SOC constraint.

Arguments

`vars`

Variables of SOC constraint.

`ctype`

Type of SOC constraint. Please refer *SOC constraint types* for possible values.

Example

```
# Add a SOC constraint with [z, x, y] as variables
m.addCone([z, x, y], COPT.CONE_QUAD)
```

Model.addCones()**Synopsis**

```
addCones(vars, ctype)
```

Description

Add a set of Second-Order-Cone (SOC) constraint with given variables.

If argument **vars** is a *ConeBuilder Class* object or *ConeBuilderArray Class* object, then the value of argument **ctype** will be ignored; If argument **vars** are *MVar Class*, the argument **ctype** is the type of SOC constraint, and it must be specified.

Arguments

vars

Variables of SOC constraint.

ctype

Type of SOC constraint. Please refer *SOC constraint types* for possible values.

Model.addExpCone()**Synopsis**

```
addExpCone(vars, ctype)
```

Description

Add an exponential cone to the model.

For example, the primal exponential cone defined by the $\mathbf{x} \in \mathbb{R}^3$:

$$K_{exp} = \text{cl} \left\{ \mathbf{x} \in \mathbb{R}^3 \mid x_0 \geq x_1 \exp \left(\frac{x_2}{x_1} \right), x_1 > 0 \right\}$$

Please refer to *Exponential Cone type* for more details.

If argument **vars** is a *ExpConeBuilder Class* object, then the value of argument **ctype** will be ignored.

If argument **vars** are variables, the optional values are *VarArray Class* objects, a one-dimensional *MVar Class* object, *tupledict Class* object, dictionary or list, the argument **ctype** specifies the type of the exponential cone and must be explicitly provided.

Arguments

vars

The variables forming the exponential cone.

Possible values are *ExpConeBuilder Class* object, *VarArray Class* object, one-dimensional *MVar Class* object, *tupledict Class* object, dictionary or list.

ctype

Type of the exponential cone. Please refer to *Exponential Cone type* for possible values.

Example

```
# Add a primal exponential cone formed by mx
mx = m.addMVar(3)
model.addExpCone(mx, ctype=COPT.EXPCONE_PRIMAL)
```

Model.addExpCones()

Synopsis

```
addExpCones(vars, ctype)
```

Description

Add a batch of exponential cones to the model. Return a *ExpConeArray Class* object.

If argument `vars` is a *ExpConeBuilder Class* object, then the value of argument `ctype` will be ignored.

If argument `vars` is a *MVar Class* object, the `ctype` argument specifies the type of the exponential cones and must be explicitly provided.

Arguments

`vars`

Variables forming the exponential cones. Possible values are *ExpConeBuilderArray Class* object, 2-dimensional *MVar Class* object.

`ctype`

Type of the exponential cone. Please refer to *Exponential Cone type* for possible values.

Example

```
# Add two primal exponential cones formed by my
model.matrixmodelmode = 'experimental'
my = model.addMVar(shape=(2, 3))
model.addExpCones(my, COPT.EXPCONE_PRIMAL)
```

Model.addAffineCone()

Synopsis

```
addAffineCone(exprs, ctype=None, name="")
```

Description

Adds an affine cone to the model.

If the argument `exprs` is a *AffineConeBuilder Class* object, the value of the argument `ctype` will be ignored.

If the argument `exprs` is an *MLinearExpr Class* object or an *MPsdExpr Class* object, the argument `ctype` specifies the type of the affine cone and must be explicitly provided.

Arguments

`exprs`

An affine cone generator or a multi-dimensional array expression that forms the affine cone.

ctype

The type of the affine cone. Possible values are detailed in *SOC constraint types* or *Exponential Cone type*.

Example

```
# Add a standard second-order affine cone formed by  $Ax+b$  and  $c^Tx+d$ 
A = np.array([[1, 2, 3],
              [4, 5, 6],
              [7, 8, 9]])
b = 10
c = np.array([1, -1, 2])
d = 5
x = model.addMVar(3)
model.addAffineCone(cp.vstack(c @ x + d, A @ x + b), ctype=COPT.CONE_QUAD)
```

Model.addAffineCones()

Synopsis

```
addAffineCones(exprs, ctype=None, nameprefix="AffineConV")
```

Description

Adds a set of affine cones to the model.

If the argument **exprs** is a *AffineConeBuilder Class* object or a *AffineConeBuilder-Array Class* object, the value of the argument **ctype** is ignored.

If the argument **exprs** is an *MLinExpr Class* object or an *MPsdExpr Class* object, the argument **ctype** specifies the type of the affine cones and must be explicitly provided.

Arguments

exprs

Affine cone generators or multi-dimensional array expressions that form the affine cones.

ctype

The type of the affine cone. Possible values are detailed in *SOC constraint types* or *Exponential Cone type*.

Model.addQConstr()

Synopsis

```
addQConstr(lhs, sense=None, rhs=None, name="")
```

Description

Add a linear or quadratic constraint, and return the added *Constraint Class* object or *QConstraint Class* object.

If the constraint is linear, then value of parameter **lhs** can be taken *Var Class* object, *LinExpr Class* object or *ConstrBuilder Class* object; If the constraint is quadratic, then value of parameter **lhs** can be taken *QConstrBuilder Class* object, or *MQConstrBuilder Class* object and other parameters will be ignored.

Arguments

lhs

Left-hand side expression for new constraint or constraint builder.

sense

Sense for the new constraint. Optional, None by default. Please refer to *Constraint type* for possible values.

rhs

Right-hand side expression for the new constraint. Optional, None by default. It can be a constant, *Var Class* object, *LinExpr Class* object or *QuadExpr Class* object.

name

Name for new constraint. Optional, "" by default, generated by solver automatically.

Example

```
# add a linear equality: x + y == 2
m.addQConstr(x + y, COPT.EQUAL, 2)
# add a quadratic inequality: x*x + y*y <= 3
m.addQConstr(x*x + y*y <= 3.0)
```

Model.addMQConstr()

Synopsis

```
addMQConstr(Q, c, sense, rhs, xQ_L=None, xQ_R=None, xc=None,
name="")
```

Description

By means of matrix modeling, a quadratic constraint is added to the model. If the value of **sense** here is `COPT.LESS_EQUAL`, the added constraint is $x_{Q_L} Q x_{Q_R} + c x_c \leq rhs$.

It is more convenient to generate *MQuadExpr Class* objects by matrix multiplication, and then use overloaded comparison operators to generate *MQConstrBuilder Class* object, which can be used as input of `Model.addQConstr()` to generate quadratic constraints.

Arguments

Q

If the quadratic term is not empty, the parameter Q needs to be provided, which is a two-dimensional NumPy matrix, SciPy compressed sparse column matrix (`csc_matrix`) or compressed sparse row matrix (`csr_matrix`).

c

If the item is non-empty, you need to provide the parameter c, which is a one-dimensional NumPy array, or a Python list.

sense

The type of constraint. Possible values refer to *Constraint type*.

rhs

The value on the right side of the constraint, usually a floating point number.

`xQ_L`

The variable on the left side of the quadratic term, can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

If empty, all variables in the model are taken.

`xQ_R`

The variable on the right side of the quadratic term, can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

If empty, all variables in the model are taken.

`xc`

The variable corresponding to the linear term can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

If it is empty, but the parameter `c` is not empty, all variables in the model are taken.

`name`

constraint name.

Return value

Returns a *QConstraint Class* object

Example

```
Q = np.full((3, 3), 1)
mx = model.addMVar(3, nameprefix="mx")
mqc = model.addMQConstr(Q, None, 'L', 1.0, mx, mx, None, name="mqc")
```

Model.addPsdVar()

Synopsis

```
addPsdVar(dim, name="")
```

Description

Add a positive semi-definite variable.

Arguments

`dim`

Dimension for the positive semi-definite variable.

`name`

Name for the positive semi-definite variable.

Example

```
# Add a three-dimensional positive semi-definite variable, "X"
m.addPsdVar(3, "X")
```

Model.addPsdVars()

Synopsis

```
addPsdVars(dims, nameprefix="PSDV")
```

Description

Add multiple new positive semi-definite variables to a model.

Arguments

`dim`

Dimensions for new positive semi-definite variables.

`nameprefix`

Name prefix for new positive semi-definite variables.

Example

```
# Add two three-dimensional positive semi-definite variables
m.addPsdVars([3, 3])
```

Model.addUserCut()

Synopsis

```
addUserCut(lhs, sense = None, rhs = None, name="")
```

Description

Add a user cut to the MIP model.

Arguments

`lhs`

Left-hand side expression for the new user cut. It can take the value of *Var Class* object, *LinExpr Class* object or *ConstrBuilder Class* object.

`sense`

The sense of the new user cut. Please refer to *Constraint type* for possible values.

Optional. None by default.

`rhs`

Right-hand side expression for the new user cut.

Optional. None by default.

It can be a constant, or *Var Class* object, or *LinExpr Class* object.

`name`

Name for the new user cut. Optional, "" by default, automatically generated by solver.

Example

```
model.addUserCut(x+y <= 1)

model.addUserCut(x+y == [0, 1])
```

Model.addUserCuts()**Synopsis**

```
addUserCuts(generator, nameprefix="U")
```

Description

Add a set of user cuts to the MIP model.

Arguments

generator

A generator expression, where each iteration produces a *Constraint Class* object, or *MConstrBuilder Class* object.

nameprefix

Name prefix for new user cuts. Optional, "U" by default. The actual name and the index of the constraints are automatically generated by COPT.

Example

```
model.addUserCuts(x[i]+y[i] <= 1 for i in range(10))
```

Model.addLazyConstr()**Synopsis**

```
addLazyConstr(lhs, sense = None, rhs = None, name="")
```

Description

Add a lazy constraint to the MIP model.

Arguments

lhs

Left-hand side expression for the new lazy constraint. It can take the value of *Var Class* object, *LinExpr Class* object or *ConstrBuilder Class* object.

sense

The sense of the lazy constraint. Please refer to *Constraint type* for possible values.

Optional. None by default.

rhs

Right-hand side expression for the new lazy constraint.

Optional. None by default.

It can be a constant, or *Var Class* object, or *LinExpr Class* object.

name

Name for the new lazy constraint. Optional, "" by default, automatically generated by solver.

Example

```
model.addLazyConstr(x+y <= 1)
model.addLazyConstr(x+y == [0, 1])
```

Model.addLazyConstrs()

Synopsis

```
addLazyConstrs(generator, nameprefix="L")
```

Description

Add a set of lazy constraints to the MIP model.

Arguments

generator

A generator expression, where each iteration produces a *Constraint Class* object, or *MConstrBuilder Class* object.

nameprefix

Name prefix for new lazy constraints. Optional, "L" by default. The actual name and the index of the constraints are automatically generated by COPT.

Example

```
model.addLazyConstrs(x[i]+y[i] <= 1 for i in range(10))
```

Model.addSparseMat()

Synopsis

```
addSparseMat(dim, rows, cols=None, vals=None)
```

Description

Add a sparse symmetric matrix in triplet format

Arguments

dim

Dimension for the matrix.

rows

Row indices for accessing rows of non-zero elements.

cols

Column indices for accessing columns of non-zero elements.

vals

Coefficient values for non-zero elements

Example

```
# Add a three-dimensional symmetric matrix
m.addSparseMat(3, [0, 1, 2], [0, 1, 2], [2.0, 5.0, 8.0])
# Add a two-dimensional symmetric matrix
m.addSparseMat(2, [(0, 0, 3.0), (1, 0, 1.0)])
```

Model.addDenseMat()**Synopsis**

```
addDenseMat(dim, vals)
```

Description

Add a dense symmetric matrix

Arguments

`dim`

Dimension for the matrix.

`vals`

Coefficient values, which can be a constant or a list.

Example

```
# Add a tree-dimensional matrix (filled with ones)
m.addDenseMat(3, 1.0)
```

Model.addDiagMat()**Synopsis**

```
addDiagMat(dim, vals, offset=None)
```

Description

Add a diagonal symmetric matrix

Arguments

`dim`

Dimension for the matrix.

`vals`

Coefficient values, which can be a constant or a list.

`offset`

Offset of diagonal elements. Positive: above the diagonal; Negative: below the diagonal

Example

```
# Add a tree-dimensional identity matrix
m.addDiagMat(3, 1.0)
```

Model.addOnesMat()**Synopsis**

```
addOnesMat(dim)
```

Description

Add a matrix filled with ones.

Arguments

`dim`

Dimension for the matrix.

Example

```
# Add a tree-dimensional matrix (filled with ones)
m.addOnesMat(3)
```

Model.addEyeMat()

Synopsis

```
addEyeMat(dim)
```

Description

Add an identity matrix

Arguments

dim

Dimension for the matrix.

Example

```
# Add a tree-dimensional identity matrix
m.addEyeMat(3)
```

Model.setObjective()

Synopsis

```
setObjective(expr, sense=None)
```

Description

Set the model objective.

Arguments

expr

Objective expression. Argument can be a constant, *Var Class* object, *LinExpr Class* object, *QuadExpr Class* object, *MLinExpr Class* object, or *MQuadExpr Class* object.

Note: If **expr** is a *LinExpr Class* object, the linear term in the objective will be updated; If it is a *QuadExpr Class* object, both the quadratic and linear terms in the objective will be updated.

sense

Optimization sense. Optional, **None** by default, which means no change to objective sense. Users can get access to current objective sense by attribute **ObjSense** . Please refer to *Optimization directions* for possible values.

Example

```
# Set objective function = x+y, optimization sense is maximization.
m.setObjective(x + y, COPT.MAXIMIZE)
```


Model.setMObjective()

Synopsis

```
setMObjective(Q, c, constant, xQ_L=None, xQ_R=None, xc=None,
sense=None)
```

Description

Set the secondary objective of the model by matrix modeling. Objective functions of the form $x_{Q_L} Q x_{Q_R} + c x_c + \text{constant}$ can be added.

Even more convenient is to generate a *MQuadExpr Class* object via matrix multiplication, available as the input to `setObjective()` to set the objective function.

Arguments

Q

If the quadratic term is not empty, the parameter Q needs to be provided, which is a two-dimensional NumPy matrix, SciPy compressed sparse column matrix (`csc_matrix`) or compressed sparse row matrix (`csr_matrix`).

c

If the item is non-empty, you need to provide the parameter c, which is a one-dimensional NumPy array, or a Python list.

constant

Constant term, usually a floating point number.

xQ_L

The variable on the left side of the quadratic term, can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

If empty, all variables in the model are taken.

xQ_R

The variable on the right side of the quadratic term, can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

If empty, all variables in the model are taken.

xc

The variable corresponding to the linear term can be a *MVar Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

If it is empty, but the parameter c is not empty, all variables in the model are taken.

sense

The optimization direction of the objective function. Optional parameter, the default is `None`, which means that the optimization direction of the model will not be changed. The current optimization direction of the model is viewed through the property `ObjSense`. See *Optimization Direction* for possible values.

Example

```
Q = np.full((3, 3), 1)
mx = model.addMVar(3, nameprefix="mx")
my = model.addVars(3, nameprefix="my")
mqc = model.setMObjective(Q, None, 0.0, mx, my, None, sense=COPT.MINIMIZE)
```

Model.setObjSense()**Synopsis**

```
setObjSense(sense)
```

Description

Set optimization sense.

Arguments

sense

Optimization sense. Please refer to *Optimization directions* for possible values.

Example

```
# Set optimization sense as maximization
m.setObjSense(COPT.MAXIMIZE)
```

Model.setObjConst()**Synopsis**

```
setObjConst(const)
```

Description

Set constant objective offset.

Arguments

const

Constant objective offset.

Example

```
# Set constant objective offset 1.0
m.setObjConst(1.0)
```

Model.getObjective()**Synopsis**

```
getObjective()
```

Description

Retrieve current model objective. Return a *LinExpr Class* object.

Example

```
# Retrieve the optimization objective.
obj = m.getObjective()
```

Model.delQuadObj()**Synopsis**

```
delQuadObj()
```

Description

Deletes the quadratic terms from the quadratic objective function.

Example

```
# Deletes the quadratic terms from the quadratic objective function
m.delQuadObj()
```

Model.delPsdObj()**Synopsis**

```
delPsdObj()
```

Description

Delete the positive semi-definite terms from the objective function

Example

```
# Delete the positive semi-definite terms from the objective function
m.delPsdObj()
```

Model.getCol()**Synopsis**

```
getCol(var)
```

Description

Retrieve the list of constraints in which a variable participates, Return value is a *Column Class* object that captures the set of constraints in which the variable participates.

Example

```
# Get column that captures the set of constraints in which x participates.
col = m.getCol(x)
```

Model.getRow()**Synopsis**

```
getRow(constr)
```

Description

Retrieve the list of variables that participate in a specific constraint and return a *LinExpr Class* object.

Example

```
# Return variables that participate in conx.
linexpr = m.getRow(conx)
```

Model.getQuadRow()**Synopsis**

```
getQuadRow(qconstr)
```

Description

Retrieve the list of variables that participate in a specific quadratic constraint and return a *QuadExpr Class* object.

Example

```
# Return variables that participate in qconx
quadexpr = m.getQuadRow(qconx)
```

Model.getPsdRow()**Synopsis**

```
getPsdRow(constr)
```

Description

Retrieve the list of variables that participate in a specific positive semi-definite constraint and return a *PsdExpr Class* object.

Example

```
# Retrieve the row corresponding to a specific positive semi-definite constraint
psdexpr = m.getPsdRow(psdcon)
```

Model.getVar()**Synopsis**

```
getVar(idx)
```

Description

Retrieve a variable according to its index in the coefficient matrix. Return a *Var Class* object.

Arguments

`idx`

Index of the desired variable in the coefficient matrix, starting with 0.

Example

```
# Retrieve variable with indice of 1.
x = m.getVar(1)
```

Model.getVarByName()

Synopsis

```
getVarByName(name)
```

Description

Retrieves a variable by name. Return a *Var Class* object.

Arguments

name

Name of the desired variable.

Example

```
# Retrieve variable with name "x".
x = m.getVarByName("x")
```

Model.getVars()

Synopsis

```
getVars()
```

Description

Retrieve all variables in the model. Return a *VarArray Class* object.

Example

```
# Retrieve all variables in the model
vars = m.getVars()
```

Model.getConstr()

Synopsis

```
getConstr(idx)
```

Description

Retrieve a constraint by its indice in the coefficient matrix. Return a *Constraint Class* object.

Arguments

idx

Index of the desired constraint in the coefficient matrix, starting with 0.

Example

```
# Retrieve linear constraint with indice of 1.
r = m.getConstr(1)
```

Model.getConstrByName()

Synopsis

```
getConstrByName(name)
```

Description

Retrieves a linear constraint by name. Return a *Constraint Class* object.

Arguments

name

The name of the constraint.

Example

```
# Retrieve linear constraint with name "r".
r = m.getConstrByName("r")
```

Model.getConstrs()

Synopsis

```
getConstrs()
```

Description

Retrieve all constraints in the model. Return a *ConstrArray Class* object.

Example

```
# Retrieve all constraints in the model
cons = m.getConstrs()
```

Model.getConstrBuilders()

Synopsis

```
getConstrBuilders(constrs=None)
```

Description

Retrieve linear constraint builders in current model.

If parameter **constrs** is **None**, then return a *ConstrBuilderArray Class* object composed of all linear constraint builders.

If parameter **constrs** is *Constraint Class* object, then return the *ConstrBuilder Class* object corresponding to the specific constraint.

If parameter **constrs** is a list or a *ConstrArray Class* object, then return a *ConstrBuilderArray Class* object composed of specified constraints' builders.

If parameter **constrs** is dictionary or *tupledict Class* object, then the indice of the specified constraint is returned as key, the value is a *tupledict Class* object composed of the specified constraints' builders.

Arguments

constrs

The specified linear constraint. Optional, **None** by default.

Example

```
# Retrieve all of linear constraint builders.
conbuilders = m.getConstrBuilders()
# Retrieve the builder corresponding to linear constraint x.
conbuilders = m.getConstrBuilders(x)
# Retrieve builders corresponding to linear constraint x and y.
conbuilders = m.getConstrBuilders([x, y])
# Retrieve builders corresponding to linear constraint in tupledict object xx.
conbuilders = m.getConstrBuilders(xx)
```

Model.getSOS(sos)**Synopsis**

```
getSOS(sos)
```

Description

Retrieve the SOS constraint builder corresponding to specific SOS constraint. Return a *SOSBuilder Class* object

Arguments

sos

The specified SOS constraint.

Example

```
# Retrieve the builder corresponding to SOS constraint sosx.
sosbuilder = m.getSOS(sosx)
```

Model.getSOSs()**Synopsis**

```
getSOSs()
```

Description

Retrieve all SOS constraints in model and return a *SOSArray Class* object.

Example

```
# Retrieve all SOS constraints in model.
soss = m.getSOSs()
```

Model.getSOSBuilders()**Synopsis**

```
getSOSBuilders(soss=None)
```

Description

Retrieve the SOS constraint builder corresponding to the specified SOS constraint.

If parameter **soss** is **None**, then return a *SOSBuilderArray Class* object consisting of builders corresponding to all SOS constraints.

If parameter **soss** is *SOS Class* object, then return a *SOSBuilder Class* corresponding to the specified SOS constraint.

If parameter `so` is list or *SOSArray Class* object, then return a *SOSBuilderArray Class* object consisting of builders corresponding to the specific SOS constraints.

Arguments

`so`

The specific SOS constraint. Optional, None by default.

Example

```
# Retrieve builders corresponding to all SOS constraints in the model.
so = m.getSOSBuilders()
```

Model.getGenConstrIndicator()

Synopsis

```
getGenConstrIndicator(genconstr)
```

Description

Retrieve the builder corresponding to specific indicator constraint. Return a *GenConstrBuilder Class* object.

Arguments

`genconstr`

The specified indicator constraint.

Example

```
# Retrieve the builder corresponding to indicator constraint genx.
indic = m.getGenConstrIndicator(genx)
```

Model.getGenConstr()

Synopsis

```
getGenConstr(idx)
```

Description

Retrieve an indicator constraint by its indice in the model. Return a *GenConstr Class* object.

Arguments

`idx`

Index of the desired constraint in the model, starting with 0.

Example

```
# Retrieve indicator constraint with indice of 0
genx = m.getGenConstr(0)
```


Model.getGenConstrs()**Synopsis**

```
getGenConstrs()
```

Description

Retrieve all indicator constraints in the model. Return a *GenConstrArray Class* object.

Example

```
# Retrieve all indicator constraints in the model
cons = m.getGenConstrs()
```

Model.getGenConstrByName()**Synopsis**

```
getGenConstrByName(name)
```

Description

Retrieves an indicator constraint by the specified name. Return a *GenConstr Class* object.

Arguments

name

The name of the indicator constraint.

Example

```
# Retrieve indicator constraint with name "r"
r = m.getGenConstrByName("r")
```

Model.getGenConstrIndicators()**Synopsis**

```
getGenConstrIndicators(genconstrs=None)
```

Description

Retrieve the specified indicator constraints' builders in the model. All indicator constraints will be retrieved in default. Return a *GenConstrBuilder Class* or *GenConstrBuilderArray Class* object.

Example

```
# Retrieve all indicator constraints' builders in the model
cons = m.getGenConstrIndicators()
```

Model.getCone()**Synopsis**

```
getCone(idx)
```

Description

Retrieves the second-order cone at the specified index in the model. Returns a *Cone Class* object.

Arguments

`idx`

The specified index. Indexing starts at 0.

Example

```
# Retrieve the second-order cone at index 1 in the model
cones = m.getCone(1)
```

Model.getExpCone()**Synopsis**

```
getExpCone(idx)
```

Description

Retrieves the exponential cone at the specified index in the model. Returns an *ExpCone Class* object.

Arguments

`idx`

The specified index. Indexing starts at 0.

Example

```
# Retrieve the exponential cone at index 1 in the model
cones = m.getExpCone(1)
```

Model.getAffineCone()**Synopsis**

```
getAffineCone(idx)
```

Description

Retrieves the affine cone at the specified index in the model. Returns an *AffineCone Class* object.

Arguments

`idx`

The specified index. Indexing starts at 0.

Example

```
# Retrieve the affine cone at index 1 in the model
cones = m.getAffineCone(1)
```

Model.getAffineConeByName()**Synopsis**

```
getAffineConeByName(name)
```

Description

Retrieves the affine cone with the specified name in the model. Returns a *AffineCone Class* object.

Arguments

name

The specified name.

Example

```
# Retrieve the affine cone with the name "afcone" in the model
cones = m.getAffineConeByName("afcone")
```

Model.getCones()**Synopsis**

```
getCones()
```

Description

Retrieve all Second-Order-Cone (SOC) constraints in model, and return a *ConeArray Class* object.

Example

```
# Retrieve all SOC constraints
cones = m.getCones()
```

Model.getExpCones()**Synopsis**

```
getExpCones()
```

Description

Retrieve all exponential cone constraints in model, and return a *ExpConeArray Class* object.

Example

```
# Retrieve all exponential cone constraints
cones = m.getExpCones()
```

Model.getAffineCones()

Synopsis

```
getAffineCones()
```

Description

Retrieves all affine cones in the model. Returns a *AffineConeArray Class* object.

Example

```
# Retrieve all affine cones in the model
cones = m.getAffineCones()
```

Model.getConeBuilders()

Synopsis

```
getConeBuilders(cones=None)
```

Description

Retrieve Second-Order-Cone (SOC) constraint builders for given SOC constraints.

If argument **cones** is **None**, then return a *ConeBuilderArray Class* object consists of all SOC constraints' builders; If argument **cones** is *Cone Class* object, then return a *ConeBuilder Class* object of given SOC constraint; If **cones** is Python list or *ConeArray Class* object, then return a *ConeBuilderArray Class* object consists of builders of given SOC constraints.

Arguments

cones

Given SOC constraints. Optional, default to **None**.

Example

```
# Retrieve all SOC constraints' builders
cones = m.getConeBuilders()
```

Model.getExpConeBuilders()

Synopsis

```
getExpConeBuilders(cones=None)
```

Description

Retrieve the exponential cone constraint builders corresponding to the specified exponential cone constraint.

If argument **cones** is **None**, then return a *ExpConeBuilderArray Class* object consists of all exponential cone constraints' builders; If argument **cones** is *ExpCone Class* object, then return a *ExpConeBuilder Class* object of given exponential cone constraints; If **cones** is Python list or *ExpConeArray Class* object, then return a *ExpConeBuilderArray Class* object consists of builders of given exponential cone constraints.

Arguments

cones

Given exponential cone constraints. Optional, default to **None**.

Example

```
# Retrieve all exponential cone constraints' builders
cones = m.getExpConeBuilders()
```

Model.getAffineConeBuilders()**Synopsis**

```
getAffineConeBuilders(cones=None)
```

Description

Retrieves the affine cone builders corresponding to the specified affine cones.

If the argument `cones` is `None`, returns a *AffineConeBuilderArray Class* object containing the builders for all affine cones in the model.

If the argument `cones` is a *AffineCone Class* object, returns the corresponding *AffineConeBuilder Class* object.

If the argument `cones` is a list or a *AffineConeArray Class* object, returns a *AffineConeBuilderArray Class* object containing the builders for the specified affine cones.

Arguments

`cones`

The specified affine cones. Optional, defaulting to `None`.

Example

```
# Retrieve the builders for all affine cones in the model
cones = m.getAffineConeBuilders()
```

Model.getQConstr()**Synopsis**

```
getQConstr(idx)
```

Description

Retrieve a quadratic constraint by its indice, and return a *QConstraint Class* object.

Arguments

`idx`

Index of the desired quadratic constraint, starting with 0.

Example

```
# Retrieve a quadratic constraint with indice of 1
qr = m.getQConstr(1)
```

Model.getQConstrByName()**Synopsis**

```
getQConstrByName(name)
```

Description

Retrieve a quadratic constraint by its name, and return a *QConstraint Class* object.

Arguments

`name`

Name of the desired quadratic constraint.

Example

```
# Retrieve a quadratic constraint with name "qr"
qr = m.getQConstrByName("qr")
```

Model.getQConstrs()**Synopsis**

```
getQConstrs()
```

Description

Retrieve all quadratic constraints in the model. Return a *QConstrArray Class* object.

Example

```
# Retrieve all quadratic constraints in the model
qcons = m.getQConstrs()
```

Model.getQConstrBuilders()**Synopsis**

```
getQConstrBuilders(qconstrs=None)
```

Description

Retrieve quadratic constraint builders in current model.

If parameter `qconstrs` is `None`, then return a *QConstrBuilderArray Class* object composed of all quadratic constraint builders.

If parameter `qconstrs` is *QConstraint Class* object, then return the *QConstrBuilder Class* object corresponding to the specific quadratic constraint.

If parameter `qconstrs` is a list or a *QConstrArray Class* object, then return a *QConstrBuilderArray Class* object composed of specified quadratic constraints' builders.

If parameter `qconstrs` is dictionary or *tupledict Class* object, then the indice of the specified quadratic constraint is returned as key, the value is a *tupledict Class* object composed of the specified quadratic constraints' builders.

Arguments

`qconstrs`

The specified quadratic constraint. Optional, `None` by default.

Example

```
# Retrieve all of quadratic constraint builders.
qconbuilders = m.getQConstrBuilders()
# Retrive the builder corresponding to quadratic contstraint qx.
qconbuilders = m.getQConstrBuilders(qx)
# Retrieve builders corresponding to quadratic constraint qx and qy.
qconbuilders = m.getQConstrBuilders([qx, qy])
# Retrieve builders corresponding to quadratic constraint in tupledict object qxx.
qconbuilders = m.getQConstrBuilders(qxx)
```

Model.getPsdVar()

Synopsis

```
getPsdVar(idx)
```

Description

Retrieve a positive semi-definite variable according to its index in the model. Return a *PsdVar Class* object.

Arguments

`idx`

Index of the desired positive semi-definite variable in the model, starting with 0.

Example

```
# Retrieve a positive semi-definite variable with index of 1
x = m.getPsdVar(1)
```

Model.getPsdVarByName()

Synopsis

```
getPsdVarByName(name)
```

Description

Retrieve a positive semi-definite variable by name. Return a *PsdVar Class* object.

Arguments

`name`

The name of the positive semi-definite variable.

Example

```
# Retrieve a positive semi-definite variable with name "x".
x = m.getPsdVarByName("x")
```

Model.getPsdVars()**Synopsis**

```
getPsdVars()
```

Description

Retrieve all positive semi-definite variables in the model, and return a *PsdVarArray Class* object.

Example

```
# Retrieve all positive semi-definite variables in the model.
vars = m.getPsdVars()
```

Model.getPsdConstr()**Synopsis**

```
getPsdConstr(idx)
```

Description

Retrieve the positive semi-definite constraint according to its index in the model. Return a *PsdConstraint Class* object.

Arguments

```
idx
```

Index for the positive semi-definite constraint, starting with 0.

Example

```
# Retrieve the positive semi-definite constraint with index of 1
r = m.getPsdConstr(1)
```

Model.getPsdConstrByName()**Synopsis**

```
getPsdConstrByName(name)
```

Description

Retrieve a positive semi-definite constraint by name. Return a *PsdConstraint Class* object.

Arguments

```
name
```

The name of the positive semi-definite constraint.

Example

```
# Retrieve the positive semi-definite constraint with name "r".
r = m.getPsdConstrByName("r")
```


Model.getPsdConstrs()**Synopsis**

```
getPsdConstrs()
```

Description

Retrieve all positive semi-definite constraints in the model. Return a *PsdConstrArray Class* object.

Example

```
# Retrieve all positive semi-definite constraints in the model
cons = m.getPsdConstrs()
```

Model.getPsdConstrBuilders()**Synopsis**

```
getPsdConstrBuilders(constrs=None)
```

Description

Retrieve positive semi-definite constraint builders in current model.

If parameter **constrs** is **None**, then return a *PsdConstrBuilderArray Class* object composed of all positive semi-definite constraint builders.

If parameter **constrs** is *PsdConstraint Class* object, then return the *PsdConstrBuilder Class* object corresponding to the specific positive semi-definite constraint.

If parameter **constrs** is a list or a *PsdConstrArray Class* object, then return a *PsdConstrBuilderArray Class* object composed of specified positive semi-definite constraints' builders.

If parameter **constrs** is dictionary or *tupledict Class* object, then the indice of the specified positive semi-definite constraint is returned as key, the value is a *tupledict Class* object composed of the specified positive semi-definite constraints' builders.

Arguments

constrs

The specified positive semi-definite constraint. Optional, **None** by default.

Example

```
# Retrieve all of positive semi-definite constraint builders.
conbuilders = m.getPsdConstrBuilders()
# Retrive the builder corresponding to positive semi-definite constraint x.
conbuilders = m.getPsdConstrBuilders(x)
# Retrieve builders corresponding to positive semi-definite constraint x and y.
conbuilders = m.getPsdConstrBuilders([x, y])
# Retrieve builders corresponding to positive semi-definite constraint in tupledict
↪ object xx.
conbuilders = m.getPsdConstrBuilders(xx)
```

Model.getLmiRow()**Synopsis**

```
getLmiRow(constr)
```

Description

Get the LMI expression involved in the specified LMI constraint, including variables and corresponding coefficient matrices.

Arguments

`constr`

The specified LMI constraint.

Example

```
# Get the expression in LMI constraint c
expr = m.getLmiRow(c)
```

Model.getLmiConstr()**Synopsis**

```
getLmiConstr(idx)
```

Description

Get the LMI constraint corresponding to the specified index in the model.

Arguments

`idx`

The index of the LMI constraint in the model. Starts with 0.

Example

```
# Get the 1st LMI constraint in the model
coeff = m.getLmiConstr(1)
```

Model.getLmiConstrByName()**Synopsis**

```
getLmiConstrByName(name)
```

Description

Get the LMI constraint of the specified name in the model.

Arguments

`name`

The specified name of the LMI constraint.

Example

```
# Get the LMI constraint named r1 in the model
name = m.getLmiConstrByName("r1")
```

Model.getLmiConstrs()**Synopsis**

```
getLmiConstrs()
```

Description

Get all LMI constraints in the model. Returns a *LmiConstrArray Class* object composed of LMI constraints.

Model.getLmiRhs()**Synopsis**

```
getLmiRhs(constr)
```

Description

Get the constant term of the specified LMI constraint. Returns a *SymMatrix Class* object.

Arguments

`constr`

The specified LMI constraint.

Model.setLmiRhs()**Synopsis**

```
setLmiRhs(constr, mat)
```

Description

Set the constant term of the specified LMI constraint.

Arguments

`constr`

The specified LMI constraint.

`mat`

The new constant-term symmetric to set.

Example

```
# Set the constant-term symmetric of the LMI constraint con to D
m.setLmiRhs(con, D)
```

Model.getLmiSolution()**Synopsis**

```
getLmiSolution()
```

Description

Get the value and dual value of the LMI constraint.

Model.getLmiSlacks()**Synopsis**

```
getLmiSlacks()
```

Description

Get the values of all slack variables of LMI constraints. Returns a list object.

Model.getLmiDuals()**Synopsis**

```
getLmiDuals()
```

Description

Get the values of all dual variables of the LMI constraint. Returns a list object.

Model.getCoeff()**Synopsis**

```
getCoeff(constr, var)
```

Description

Get the coefficient of variable in linear constraint, PSD constraint or LMI constraint.

Arguments

`constr`

The requested linear constraint, PSD constraint or LMI constraint.

`var`

The requested variable or PSD variable.

Example

```
# Get the coefficient of variable x in linear constraint c1
coeff1 = m.getCoeff(c1, x)
# Get the coefficient of PSD variable X in PSD constraint c2
coeff2 = m.getCoeff(c2, X)
```

Model.setCoeff()**Synopsis**

```
setCoeff(constr, var, newval)
```

Description

Set the coefficient of variable in linear constraint, PSD constraint or LMI constraint.

Arguments

`constr`

The requested linear constraint, PSD constraint or LMI constraint.

`var`

The requested variable or PSD variable.

`newval`

New coefficient or symmetric matrix coefficient.

Example

```
# Set the coefficient of variable x in linear constraint c to 1.0
m.setCoeff(c, x, 1.0)
```

Model.setCoeffs()

Synopsis

```
setCoeffs(constrs, vars, vals)
```

Description

Set the coefficients of variables in the linear constraints in batches.

Note The constraint and variable pair cannot repeat with the same or different coefficient to be set.

Arguments

`constrs`

Specifies the constraints related to the coefficients to be set, which could be a dictionary, *tupledict Class* , *ConstrArray Class* or a list of *Constraint Class* objects.

`vars`

Specifies the variables related to the coefficients to be set, which could be a dictionary, *tupledict Class* , *VarArray Class* or a list of *Var Class* objects.

`vals`

The new coefficient values to be set, which could be a constant, or the list/dictionary corresponding to the `constrs` .

Model.getA()

Synopsis

```
getA()
```

Description

Get the coefficient matrix of model, returns a `scipy.sparse.csc_matrix` object. This method requires the `scipy` package.

Example

```
# Get the coefficient matrix
A = model.getA()
```

Model.loadMatrix()

Synopsis

```
loadMatrix(c, A, lhs, rhs, lb, ub, vtype=None)
```

Description

Load matrix and vector data to build model. This method requires the `scipy` package.

Arguments

`c`

Objective costs. If `None`, the objective costs are all zeros.

`A`

Coefficient matrix. Must be of type `scipy.sparse.csc_matrix`.

`lhs`

Lower bounds of constraints.

`rhs`

Upper bounds of constraints.

`lb`

Lower bounds of variables. If `None`, the lower bounds are all zeros.

`ub`

Upper bounds of variables. If `None`, the upper bounds are all COPT.INFINITY.

`vtype`

Variable types. Default to `None`, which means all variables are continuous.

Example

```
# Build model by problem matrix
m.loadMatrix(c, A, lhs, rhs, lb, ub)
```

Model.loadCone()

Synopsis

```
loadCone(ncone, types, dims, indices)
```

Description

Load Second-Order-Cones (SOC) to the model.

Arguments

`ncone`

Number of SOC.

`types`

Type of SOC, please refer to *SOC constraint types* for possible values.

`dims`

Dimension of SOC.

`indices`

Array of subscripts for the variables that constitute the SOC.

Model.loadExpCone()

Synopsis

```
loadExpCone(ncone, types, indices)
```

Description

Load exponential cones to the model.

Arguments

`ncone`

Number of exponential cones.

`types`

Type of exponential cones, please refer to *Exponential Cone type* for possible values.

`indices`

Array of subscripts for the variables that constitute the exponential cones.

Model.getLpSolution()

Synopsis

```
getLpSolution()
```

Description

Retrieve the values of variables, slack variables, dual variables and reduced cost of variables. Return a quad tuple object, in which each element is a list.

Example

```
# Retrieve solutions of linear model.
values, slacks, duals, redcosts = m.getLpSolution()
```

Model.setLpSolution()

Synopsis

```
setLpSolution(values, slack, duals, redcost)
```

Description

Set LP solution.

Arguments

`values`

Solution of variables.

`slack`

Solution of slack variables.

`duals`

Solution of dual variables.

`redcost`

Reduced costs of variables.

Example

```
# Set LP solution
m.setLpSolution(values, slack, duals, redcost)
```

Model.getValues()**Synopsis**

```
getValues()
```

Description

Retrieve solution values of all variables in a LP or MIP. Return a Python list.

Example

```
values = m.getValues()
```

Model.getRedcosts()**Synopsis**

```
getRedcosts()
```

Description

Retrieve reduced costs of all variables in a LP. Return a list.

Example

```
# Retrieve reduced cost of all variables in model.
redcosts = m.getRedcosts()
```

Model.getSlacks()**Synopsis**

```
getSlacks()
```

Description

Retrieve values of all slack variables in a LP. Return a Python list.

Example

```
# Retrieve value of all slack variables in model.
slacks = m.getSlacks()
```


Model.getDUALS()**Synopsis**

```
getDuals()
```

Description

Obtain values of all dual variables in a LP. Return a Python list.

Example

```
# Retrieve value of all dual variables in model.
duals = m.getDUALS()
```

Model.getVarBasis()**Synopsis**

```
getVarBasis(vars=None)
```

Description

Obtain basis status of specified variables.

If parameter **vars** is **None**, then return a list object consistinf of all variables' basis status. If parameter **vars** is *Var Class* object, then return basis status of the specified variable. If parameter **vars** is list or *VarArray Class* object, then return a list object consisting of the specified variables' basis status. If parameter **vars** is dictionary or *tupledict Class* object, then return indice of the specified variable as key and *tupledict Class* object consisting of the specified variables' basis status as value.

Arguments

vars

The specified variables. Optional, **None** by default,

Example

```
# Retrieve all variables' basis status in model.
varbasis = m.getVarBasis()
# Retrieve basis status of variable x and y.
varbasis = m.getVarBasis([x, y])
# Retrieve basis status of tupledict object xx.
varbasis = m.getVarBasis(xx)
```

Model.getConstrBasis()**Synopsis**

```
getConstrBasis(constrs=None)
```

Description

Obtain the basis status of linear constraints in LP.

If parameter **constrs** is **None**, then return a list object consisting of all linear constraints' basis status. If parameter **constrs** is *Constraint Class* object, then return basis status of the specified linear constraint. If parameter **constrs** is list or *ConstrArray Class* object, then return a list object consisting of the specified linear constraints' basis status. If parameter **constrs** is dictionary or *tupledict Class* object, then return the indice of the specified linear constraint as key and

return *tupledict Class* object consisting of the specified linear constraints' basis status as value.

Arguments

`constrs`

The specified linear constraint. Optional, `None` by default.

Example

```
# Retrieve all linear constraints' basis status in model.
conbasis = m.getConstrBasis()
# Retrieve basis status corresponding to linear constraint r0 and r1 in model.
conbasis = m.getConstrBasis([r0, r1])
# Retrieve basis status of linear constraints in tupledict rr.
conbasis = m.getConstrBasis(rr)
```

Model.getPoolObjVal()

Synopsis

```
getPoolObjVal(isol)
```

Description

Obtain the `isol` -th objective value in solution pool, return a constant.

Arguments

`isol`

Index of solution.

Example

```
# Obtain the second objective value
objval = m.getPoolObjVal(2)
```

Model.getPoolSolution()

Synopsis

```
getPoolSolution(isol, vars)
```

Description

Obtain variable values in the `isol` -th solution of solution pool.

If parameter `vars` is *Var Class* object, then return values of the specified variable. If parameter `vars` is list or *VarArray Class* object, then return a list consisting of the specified variables' values. If parameter `vars` is dictionary or *tupledict Class* object, then return indice of the specified variable as key and *tupledict Class* object consisting of the specified variables' values as value.

Arguments

`isol`

Index of solution

`vars`

The specified variables.

Example

```
# Get value of x in the second solution
xval = m.getPoolSolution(2, x)
```

Model.getVarLowerIIS()

Synopsis

```
getVarLowerIIS(vars)
```

Description

Obtain IIS status of lower bounds of variables.

If parameter **vars** is *Var Class* object, then return IIS status of lower bound of variable. If parameter **vars** is list or *VarArray Class* object, then return a list object consisting of the IIS status of lower bounds of variables. If parameter **vars** is dictionary or *tupledict Class* object, then return indice of the specified variable as key and *tupledict Class* object consisting of the IIS status of lower bounds of variables as value.

Arguments

vars

The specified variables.

Example

```
# Retrieve IIS status of lower bounds of variable x and y.
lowerIIS = m.getVarLowerIIS([x, y])
# Retrieve IIS status of lower bounds of variables in tupledict object xx.
lowerIIS = m.getVarLowerIIS(xx)
```

Model.getVarUpperIIS()

Synopsis

```
getVarUpperIIS(vars)
```

Description

Obtain IIS status of upper bounds of variables.

If parameter **vars** is *Var Class* object, then return IIS status of upper bound of variable. If parameter **vars** is list or *VarArray Class* object, then return a list object consisting of the IIS status of upper bounds of variables. If parameter **vars** is dictionary or *tupledict Class* object, then return indice of the specified variable as key and *tupledict Class* object consisting of the IIS status of upper bounds of variables as value.

Arguments

vars

The specified variables.

Example

```
# Retrieve IIS status of upper bounds of variable x and y.
upperIIS = m.getVarUpperIIS([x, y])
# Retrieve IIS status of upper bounds of variables in tupledict object xx.
upperIIS = m.getVarUpperIIS(xx)
```

Model.getConstrLowerIIS()

Synopsis

```
getConstrLowerIIS(constrs)
```

Description

Obtain the IIS status of lower bounds of constraints.

If parameter **constrs** is *Constraint Class* object, then return IIS status of lower bound of constraint. If parameter **constrs** is list or *ConstrArray Class* object, then return a list object consisting of the IIS status of lower bounds of constraints. If parameter **constrs** is dictionary or *tupledict Class* object, then return the indice of the specified linear constraint as key and return *tupledict Class* object consisting of the IIS status of lower bounds of constraints.

Arguments

constrs

The specified linear constraint.

Example

```
# Retrieve IIS status corresponding to lower bounds of linear constraint r0 and r1 in
↳model.
lowerIIS = m.getConstrLowerIIS([r0, r1])
# Retrieve IIS status of lower bounds of linear constraints in tupledict rr.
lowerIIS = m.getConstrLowerIIS(rr)
```

Model.getConstrUpperIIS()

Synopsis

```
getConstrUpperIIS(constrs)
```

Description

Obtain the IIS status of upper bounds of constraints.

If parameter **constrs** is *Constraint Class* object, then return IIS status of upper bound of constraint. If parameter **constrs** is list or *ConstrArray Class* object, then return a list object consisting of the IIS status of upper bounds of constraints. If parameter **constrs** is dictionary or *tupledict Class* object, then return the indice of the specified linear constraint as key and return *tupledict Class* object consisting of the IIS status of upper bounds of constraints.

Arguments

constrs

The specified linear constraint.

Example

```
# Retrieve IIS status corresponding to upper bounds of linear constraint r0 and r1 in
↳model.
upperIIS = m.getConstrUpperIIS([r0, r1])
# Retrieve IIS status of upper bounds of linear constraints in tupledict rr.
upperIIS = m.getConstrUpperIIS(rr)
```

Model.getSOSIIS()**Synopsis**

```
getSOSIIS(soss)
```

Description

Obtain the IIS status of SOS constraints.

If parameter `soss` is *SOS Class* object, then return IIS status of SOS constraint. If parameter `soss` is list or *SOSArray Class* object, then return a list object consisting of the IIS status of SOS constraints. If parameter `soss` is dictionary or *tupledict Class* object, then return the indice of the specified SOS constraint as key and return *tupledict Class* object consisting of the IIS status of SOS constraints.

Arguments

`soss`

The specified SOS constraint.

Example

```
# Retrieve IIS status corresponding to SOS constraint r0 and r1 in model.
sosIIS = m.getSOSIIS([r0, r1])
# Retrieve IIS status of SOS constraints in tupledict rr.
sosIIS = m.getSOSIIS(rr)
```

Model.getIndicatorIIS()**Synopsis**

```
getIndicatorIIS(genconstrs)
```

Description

Obtain the IIS status of indicator constraints.

If parameter `genconstrs` is *GenConstr Class* object, then return IIS status of indicator constraint. If parameter `genconstrs` is list or *GenConstrArray Class* object, then return a list object consisting of the IIS status of indicator constraints. If parameter `genconstrs` is dictionary or *tupledict Class* object, then return the indice of the specified indicator constraint as key and return *tupledict Class* object consisting of the IIS status of indicator constraints.

Arguments

`genconstrs`

The specified indicator constraint.

Example

```
# Retrieve IIS status corresponding to indicator constraint r0 and r1 in model.
indicatorIIS = m.getIndicatorIIS([r0, r1])
# Retrieve IIS status of indicator constraints in tupledict rr.
indicatorIIS = m.getIndicatorIIS(rr)
```

Model.getAttr()

Synopsis

```
getAttr(attrname)
```

Description

Get the value of an attribute of model. Return a constant.

Arguments

attrname

The specified attribute name. The full list of available attributes can be found in *Attributes* section.

Example

```
# Retrieve the constant terms of objective.
objconst = m.getAttr(COPT.Attr.ObjConst)
```

Model.getInfo()

Synopsis

```
getInfo(infename, args)
```

Description

Retrieve specified information.

If parameter **args** is *Var Class* object or *Constraint Class* object, then return info of the specified variable or constraint.

If parameter **args** is list or *VarArray Class* object or *ConstrArray Class* object, then return a list consisting of the specified variables or constraints.

If parameter **args** is dictionary or *tupledict Class* object, then return the indice of the specified variables or constraints as key and return *tupledict Class* object consisting of info corresponding to the specified variables or constraints as value.

If parameter **args** is *MVar Class* object, *MConstr Class* object, *MQConstr Class* object or *MPsdConstr Class* object, then return a `numpy.ndarray` consisting of the specified variables or constraints.

Arguments

infename

The specified information name. The full list of available attributes can be found in *Information* section.

args

Variables and constraints to get information.

Example

```
# Retrieve lower bound information of all linear constraints in model.
lb = m.getInfo(COPT.Info.LB, m.getConstrs())
# Retrieve value information of variables x and y.
sol = m.getInfo(COPT.Info.Value, [x, y])
# Retrieve the dual variable value corresponding to linear constraint in tupledict_
↪ object shipconstr.
dual = m.getInfo(COPT.Info.Dual, shipconstr)
```

Model.getParam()**Synopsis**

```
getParam(paramname)
```

Description

Retrieve the current value of the specified parameter. Return a constant.

Arguments

`paramname`

The name of the parameter to get access to. The full list of available attributes can be found in *Parameters* section.

Example

```
# Retrieve current value of time limit.
timelimit = m.getParam(COPT.Param.TimeLimit)
```

Model.getParamInfo()**Synopsis**

```
getParamInfo(paramname)
```

Description

Retrieve information of the specified optimization parameter. Return a tuple object, consisting of param name, current value, default value, minimum value, maximum value.

Arguments

`paramname`

Name of the specified parameter. The full list of available values can be found in *Parameters* section.

Example

```
# Retrieve information of time limit.
pname, pcur, pdef, pmin, pmax = m.getParamInfo(COPT.Param.TimeLimit)
```

Model.setBasis()**Synopsis**

```
setBasis(varbasis, constrbasis)
```

Description

Set basis status for all variables and linear constraints in LP. The parameters `varbasis` and `constrbasis` are list objects whose number of elements is the total number of variables or linear constraints.

Arguments

`varbasis`

The basis status of variables.

`constrbasis`

The basis status of constraints.

Example

```
# Set basis status for all variables and linear constraints in the model.
m.setBasis(varbasis, constrbasis)
```

Model.setSlackBasis()

Synopsis

```
setSlackBasis()
```

Description

Set LP basis to be slack.

Example

```
# Set LP basis to be slack.
m.setSlackBasis()
```

Model.setVarType()

Synopsis

```
setVarType(vars, vartypes)
```

Description

Set the type of specific variable.

If parameter **vars** is *Var Class* object, then parameter **vartypes** is *Variable types* constant;

If parameter **vars** is dictionary or *tupledict Class* object, then parameter **vartypes** can be *Variable types* constant, dictionary or *tupledict Class* object;

If parameter **vars** is list or *VarArray Class* object, then parameter **vartypes** can be *Variable types* constant or list object.

Arguments

vars

The specified variable.

vartypes

Type of the specified variable.

Example

```
# Set variable x as integer variable.
m.setVarType(x, COPT.INTEGER)
# Set variables x and y as binary variables.
m.setVarType([x, y], COPT.BINARY)
# Set the variables in tupledict object xdict as continuous variables.
m.setVarType(xdict, COPT.CONTINUOUS)
```


Model.setNames()**Synopsis**

```
setNames(args, names)
```

Description

Sets the name(s) of the specified variable(s) or constraint(s).

Arguments

args

The specified variable(s) or constraint(s), which could be: *Var Class* , *Constraint Class* , *QConstraint Class* , *PsdVar Class* , *PsdConstraint Class* , *LmiConstraint Class* , *GenConstr Class* object, *AffineCone Class* or the dictionary/list they constitute.

names

The name(s) of the specified variable(s) or constraint(s), which could be a single string or the list/dictionary corresponding to the **args** .

Example

```
# Set the name of x to "var"
m.setNames(x, "var")
#Set the name of constr1 to "c1" and the name of constr2 to "c2"
m.setNames([constr1, constr2], ["c1", "c2"])
```

Model.setMipStart()**Synopsis**

```
setMipStart(vars, startvals)
```

Description

Set initial value for specified variables, valid only for integer programming.

If parameter **vars** is *Var Class* object, then parameter **startvals** is constant; If parameter **vars** is dictionary or *tupledict Class* object, then parameter **startvals** can be constant, dictionary or *tupledict Class* object; If parameter **vars** is list or *VarArray Class* object, then parameter **startvals** can be constant or list object.

Notice: You may want to call this method several times to input the MIP start. Please call `loadMipStart()` once when the input is done.

Arguments

vars

The specified variable.

startvals

Initial value of the specified variable

Example

```
# Set initial value of x as 1.
m.setMipStart(x, 1)
# Set initial value of x, y as 2, 3.
m.setMipStart([x, y], [2, 3])
# Set initial value of all variables in tupledict xdict as 1.
```

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```
m.setMipStart(xdict, 1)

# Load initial solution to model
m.loadMipStart()
```

Model.loadMipStart()

Synopsis

```
loadMipStart()
```

Description

Load the currently specified initial values into model.

Notice: After calling this method, the previously initial values will be cleared, and users can continue to set initial values for specified variables.

Model.setInfo()

Synopsis

```
setInfo(infoname, args, newvals)
```

Description

Set new information value for specific variables or constraints.

If parameter `args` is *Var Class* object or *Constraint Class* object, then parameter `newvals` is constant; If parameter `args` is dictionary or *tupledict Class* object, then parameter `newvals` can be constant, dictionary or *tupledict Class* object; If parameter `args` is list, *VarArray Class* object or *ConstrArray Class* object, then parameter `newvals` can be constant or list; If parameter `args` is *MVar Class* object, *MConstr Class* object, *MQConstr Class* object or *MPsdConstr Class* object. then parameter `newvals` can be constant or `numpy.ndarray`.

Arguments

`infoname`

The specified information name. The full list of available names can be found in *Information* section.

`args`

The specified variables of constraints.

`newvals`

Value of the specified information.

Example

```
m.setInfo(COPT.Info.LB, [x, y], [1.0, 2.0])

# Set the upperbound of variable x as 1.0
m.setInfo(COPT.Info.UB, x, 1.0)
# Set the lowerbound of variables x and y as 1.0, 2.0, respectively.
m.setInfo(COPT.Info.LB, [x, y], [1.0, 2.0])
# Set the objective of all variables in tupledict xdict as 0.
m.setInfo(COPT.Info.OBJ, xdict, 0.0)
```

Model.setParam()**Synopsis**

```
setParam(paramname, newval)
```

Description

Set the value of a parameter to a specific value.

Arguments

paramname

The name of parameter to be set. The list of available names can be found in *Parameters* section.

newval

New value of parameter.

Example

```
# Set time limit of solving to 1 hour.
m.setParam(COPT.Param.TimeLimit, 3600)
```

Model.resetParam()**Synopsis**

```
resetParam()
```

Description

Reset all parameters to their default values.

Example

```
# Reset all parameters to their default values.
m.resetParam()
```

Model.read()**Synopsis**

```
read(filename)
```

Description

Determine the type of data by the file suffix and read it into a model.

Currently, it supports MPS files (suffix `'.mps'` or `'.mps.gz'`), LP files (suffix `'.lp'` or `'.lp.gz'`), SDPA files (suffix `'.dat-s'` or `'.dat-s.gz'`), CBF files (suffix `'.cbf'` or `'.cbf.gz'`), COPT binary format files (suffix `'.bin'`), basis files (suffix `'.bas'`), result files (suffix `'.sol'`), start files (suffix `'.mst'`), and parameter files (suffix `'.par'`).

Arguments

filename

Name of the file to be read.

Example

```
# Read MPS format model file
m.read('test.mps.gz')
# Read LP format model file
m.read('test.lp.gz')
# Read COPT binary format model file
m.read('test.bin')
# Read basis file
m.read('testlp.bas')
# Read solution file
m.read('testmip.sol')
# Read start file
m.read('testmip.mst')
# Read paramter file
m.read('test.par')
```

Model.readMps()

Synopsis

```
readMps(filename)
```

Description

Read MPS file to model.

Arguments

filename

The name of the MPS file to be read.

Example

```
# Read file "test.mps.gz" according to mps file format
m.readMps('test.mps.gz')
# Read file "test.lp.gz" according to mps file format
m.readMps('test.lp.gz')
```

Model.readLp()

Synopsis

```
readLp(filename)
```

Description

Read a file to model according to LP file format.

Arguments

filename

Name of the LP file to be read.

Example

```
# Read file "test.mps.gz" according to LP file format
m.readLp('test.mps.gz')
# Read file "test.lp.gz" according to LP file format
m.readLp('test.lp.gz')
```

Model.readSdpa()**Synopsis**

```
readSdpa(filename)
```

Description

Read a file to model according to SDPA file format.

Arguments

filename

Name of the SDPA file to be read.

Example

```
# Read file "test.dat-s" according to SDPA file format
m.readSdpa('test.dat-s')
```

Model.readCbf()**Synopsis**

```
readCbf(filename)
```

Description

Read a file to model according to CBF file format.

Arguments

filename

Name of the CBF file to be read.

Example

```
# Read file "test.cbf" according to CBF file format
m.readCbf('test.cbf')
```

Model.readBin()**Synopsis**

```
readBin(filename)
```

Description

Read COPT binary format file to model.

Arguments

filename

The name of the COPT binary format file to be read.

Example

```
# Read file "test.bin" according COPT binary file format
m.readBin('test.bin')
```

Model.readSol()

Synopsis

```
readSol(filename)
```

Description

Read a file to model according to solution file format.

Notice: The default solution value is 0, i.e. a partial solution will be automatically filled in with zeros. If read successfully, then the values read can be act as initial solution for integer programming.

Arguments

filename

Name of file to be read.

Example

```
# Read file "testmip.sol" according to solution file format.
m.readSol('testmip.sol')
# Read file testmip.txt" according to solution file format.
m.readSol('testmip.txt')
```

Model.readBasis()

Synopsis

```
readBasis(filename)
```

Description

Read basis status of variables and linear constraints to model accoring to basis solution format, valid only for linear programming.

Arguments

filename

The name of the basis file to be read.

Example

```
# Read file "testmip.bas" to basis solution format
m.readBasis('testmip.bas')
# Read file "testmip.txt" to basis solution format
m.readBasis('testmip.txt')
```

Model.readMst()

Synopsis

```
readMst(filename)
```

Description

Read initial solution data to model according to initial solution file format.

Notice: If read successfully, the read value will be act as initial solution for integer programming model. Variable values may not be specified completely, if the value of variable is specified for multiple times, the last specified value is used.

Arguments

filename

Name of the file to be read.

Example

```
# Read file "testmip.mst" according to initial solution file format.
m.readMst('testmip.mst')
# Read file "testmip.txt" according to initial solution file format.
m.readMst('testmip.txt')
```

Model.readParam()

Synopsis

readParam(filename)

Description

Read optimization parameters to model according to parameter file format.

Notice: If any optimization parameter is specified multiple times, the last specified value is used.

Arguments

filename

The name of the parameter file to be read.

Example

```
# Read file "testmip.par" according to parameter file format.
m.readParam('testmip.par')
# Read file "testmip.txt" according to parameter file format.
m.readParam('testmip.txt')
```

Model.readTune()

Synopsis

readTune(filename)

Description

Read the tuning parameters and combine them into the model according to the tuning file format.

Arguments

filename

The name of the file to be read.

Example

Model.write()**Synopsis**

```
write(filename)
```

Description

Currently, COPT supports writing of MPS files (suffix `'.mps'`), LP files (suffix `'.lp'`), CBF files (suffix `'.cbf'`), COPT binary format files (suffix `'.bin'`), basis files (suffix `'.bas'`), LP solution files (suffix `'.sol'`), initial solution files (suffix `'.mst'`), and parameter files (suffix `'.par'`).

Arguments

`filename`

The file name to be written.

Example

```
# Write MPS file
m.write('test.mps')
# Write LP file
m.write('test.lp')
# Write COPT binary format file
m.write('test.bin')
# Write basis file
m.write('testlp.bas')
# Write solution file
m.write('testmip.sol')
# Write initial solution file
m.write('testmip.mst')
# Write parameter file
m.write('test.par')
```

Model.writeMps()**Synopsis**

```
writeMps(filename)
```

Description

Write current model into an MPS file.

Arguments

`filename`

The name of the MPS file to be written.

Example

```
# Write MPS model file "test.mps"
m.writeMps('test.mps')
```


Model.writeMpsStr()**Synopsis**

```
writeMpsStr()
```

Description

Write current model into a buffer as MPS format.

Example

```
# Write model to buffer 'buff' and print model
buff = m.writeMpsStr()
print(buff.getData())
```

Model.writeLp()**Synopsis**

```
writeLp(filename)
```

Description

Write current optimization model to a LP file.

Arguments

filename

The name of the LP file to be written.

Example

```
# Write LP model file "test.lp"
m.writeLp('test.lp')
```

Model.writeCbf()**Synopsis**

```
writeCbf(filename)
```

Description

Write current optimization model to a CBF file.

Arguments

filename

The name of the CBF file to be written.

Example

```
# Write CBF model file "test.cbf"
m.writeCbf('test.cbf')
```

Model.writeBin()

Synopsis

```
writeBin(filename)
```

Description

Write current model into an COPT binary format file.

Arguments

filename

The name of the COPT binary format file to be written.

Example

```
# Write COPT binary format model file "test.bin"
m.writeBin('test.bin')
```

Model.writeIIS()

Synopsis

```
writeIIS(filename)
```

Description

Write current irreducible inconsistent subsystem into an IIS file.

Arguments

filename

The name of the IIS file to be written.

Example

```
# Write IIS file "test.iis"
m.writeIIS('test.iis')
```

Model.writeRelax()

Synopsis

```
writeRelax(filename)
```

Description

Write the feasibility relaxation model into a Relax file.

Arguments

filename

The name of the Relax file to be written.

Example

```
# Write Relax file "test.relax"
m.writeRelax('test.relax')
```

Model.writeSol()**Synopsis**

```
writeSol(filename)
```

Description

Output the model solution to a solution file.

Arguments

filename

The name of the solution file to be written.

Example

```
# Write solution file "test.sol"
m.writeSol('test.sol')
```

Model.writePoolSol()**Synopsis**

```
writePoolSol(isol, filename)
```

Description

Output selected pool solution to a solution file.

Arguments

isol

Index of pool solution.

filename

The name of the solution file to be written.

Example

```
# Write 1-th pool solution to solution file "poolsol_1.sol"
m.writePoolSol('poolsol_1.sol')
```

Model.writeBasis()**Synopsis**

```
writeBasis(filename)
```

Description

Write the LP basic solution to a basis file.

Arguments

filename

The name of the basis file to be written.

Example

```
# Write the basis file "testlp.bas"
m.writeBasis('testlp.bas')
```

Model.writeMst()**Synopsis**

```
writeMst(filename)
```

Description

For integer programming models, write the best integer solution currently to the initial solution file. If there are no integer solutions, then the first set of initial solution stored in model is output.

Arguments

filename

Name of the file to be written.

Example

```
# Output initial solution file "testmip.mst"
m.writeMst('testmip.mst')
```

Model.writeParam()**Synopsis**

```
writeParam(filename)
```

Description

Output modified parameters to a parameter file.

Arguments

filename

The name of the parameter file to be written.

Example

```
# Output parameter file "testmip.par"
m.writeParam('testmip.par')
```

Model.writeTuneParam()**Synopsis**

```
writeTuneParam(idx, filename)
```

Description

Output the parameter tuning result of the specified number to the parameter file.

Arguments

idx

Parameter tuning result number.

filename

The name of the parameter file to be output.

Example

Model.setLogFile()**Synopsis**

```
setLogFile(logfile)
```

Description

Set the optimizer log file.

Arguments

logfile

The log file.

Example

```
# Set the log file as "copt.log"
m.setLogFile('copt.log')
```

Model.setLogCallback()**Synopsis**

```
setLogCallback(logcb)
```

Description

Set the call back function of log.

Arguments

logcb

Call back function of log.

Example

```
# Set the call back function of log as a python function 'logcbfun'.
m.setLogCallback(logcbfun)
```

Model.solve()**Synopsis**

```
solve()
```

Description

Solve an optimization problem.

Example

```
# Solve the model.
m.solve()
```

Model.solveLP()**Synopsis**

```
solveLP()
```

Description

Solve LP model. If the model is integer programming, then the model will be solved as LP.

Example

```
# Solve a model calling LP solver.
m.solveLP()
```

Model.computeIIS()**Synopsis**

```
computeIIS()
```

Description

Compute IIS for infeasible model.

Example

```
# Compute IIS for infeasible model.
m.computeIIS()
```

Model.feasRelax()**Synopsis**

```
feasRelax(vars, lbpen, ubpen, constrs, rhspen, uppen=None)
```

Description

Compute the feasibility relaxation of an infeasible model.

Arguments

vars

The variables to relax.

Possible values are *Var Class* objects, *VarArray Class* objects, arrays, lists, dictionaries, or *tupledict Class* objects.

If **vars** is a *Var Class* object, then **lbpen** / **ubpen** can be constant.

If **vars** is a *VarArray Class* object, an array or a list. then **lbpen** / **ubpen** can correspondingly be array, list or constant.

If **vars** is a *tupledict Class* object or a dictionary, then **lbpen** / **ubpen** can be dictionary or constant.

lbpen

The penalty factor for the lower bound of the variables.

If **lbpen** is **None**, no relaxation of the variables' lower bound is allowed.

If **lbpen** is **COPT.INFINITY**, the lower bound of the corresponding variable in **vars** is not relaxed.

ubpen

The penalty factor for the upper bound of the variables.

If `ubpen` is `None`, no relaxation of the variables' lower bound is allowed.

If `ubpen` is `COPT.INFINITY`, the upper bound of the corresponding variable in `vars` is not relaxed.

`constrs`

The constraints to relax.

Possible values are *Constraint Class* objects, *ConstrArray Class* objects, arrays, lists, or dictionaries.

If `constrs` is a *Constraint Class* object, then `rhspen` / `uppen` can be constant.

If `constrs` is a *ConstrArray Class* object, an array, or a list, then `rhspen` / `uppen` can correspondingly be array, list, or constant.

If `constrs` is a dictionary, then `rhspen` / `uppen` can be dictionary or constant.

`rhspen`

The penalty factor for the right-hand side of the constraints.

If `rhspen` is `None`, no relaxation of the constraint boundaries is applied.

If `rhspen` is `COPT.INFINITY`, the constraint's right-hand side is not relaxed.

`uppen`

The penalty factor for the upper bound of bilateral constraints.

If `uppen` is `None`, the penalty factor is specified by `rhspen`.

If `uppen` is `COPT.INFINITY`, the upper bound of the constraint is not relaxed.

Example

```
# Compute the feasibility relaxation for an infeasible model
x = model.addVars(3, ub=1)
y = model.addVars(3, ub=2)
c = model.addConstrs(x[i] + y[i] <= 1 for i in range(3))
model.feasRelax([x[0], x[1]], [0.5, 1], [COPT.INFINITY, 2], c, 1)
```

Model.feasRelaxS()

Synopsis

```
feasRelaxS(vrelax, crelax)
```

Description

Compute the feasibility relaxation of an infeasible model in a simplified mode.

Arguments

`vrelax`

Whether to relax variables.

`crelax`

Whether to relax constraints.

Example

```
# Compute the feasibility relaxation of model m
m.feasRelaxS(True, True)
```

Model.feasRelaxN()

Synopsis

feasRelaxN(vars, lbpen, ubpen, constrs, rhspen, uppen=None)

Description

Computes the feasibility relaxation of an infeasible model formulated by matrix modeling.

Either **vars** or **constrs** must be a matrix modeling object; that is, at least one of the following conditions must hold:

- **vars** is a *MVar Class* object.
- **constrs** is a *MConstr Class* object.

Arguments

vars

The variables to relax.

Possible values are *MVar Class* objects, *Var Class* objects, *VarArray Class* objects, arrays, lists, dictionaries, or *tupledict Class* objects.

If **vars** is a *MVar Class* object, then **lbpen** / **ubpen** can be a *NdArray Class* object, array, list, dictionary, or constant.

If **vars** is a *Var Class* object, then **lbpen** / **ubpen** can be constant.

If **vars** is a *VarArray Class* object, an array, or a list, then **lbpen** / **ubpen** can be array, list, or constant.

If **vars** is a *tupledict Class* object or dictionary, then **lbpen** / **ubpen** can be dictionary or constant.

lbpen

The penalty factor for the lower bound of the variables.

If **lbpen** is **None**, no relaxation of the variables' lower bound is allowed.

If **lbpen** is **COPT.INFINITY**, the lower bound of the corresponding variable in **vars** is not relaxed.

ubpen

The penalty factor for the upper bound of the variables.

If **ubpen** is **None**, no relaxation of the variables' lower bound is allowed.

If **ubpen** is **COPT.INFINITY**, the upper bound of the corresponding variable in **vars** is not relaxed.

constrs

The constraints to relax.

Possible values are *MConstr Class* objects, *Constraint Class* objects, *ConstrArray Class* objects, arrays, lists, or dictionaries.

If **constrs** is a *MConstr Class* object, then **rhspen** / **uppen** can be a *NdArray Class* object, array, list, dictionary, or constant.

If `constrs` is a *Constraint Class* object, then `rhspen` / `uppen` can be constant.

If `constrs` is a *ConstrArray Class* object, an array, or a list, then `rhspen` / `uppen` can correspondingly be array, list, or constant.

If `constrs` is a dictionary, then `rhspen` / `uppen` can be dictionary or constant.

`rhspen`

The penalty factor for the right-hand side of the constraints.

If `rhspen` is `None`, no relaxation of the constraint boundaries is applied.

If `rhspen` is `COPT.INFINITY`, the constraint's right-hand side is not relaxed.

`uppen`

The penalty factor for the upper bound of bilateral constraints.

If `uppen` is `None`, the penalty factor is specified by `rhspen`.

If `uppen` is `COPT.INFINITY`, the upper bound of the constraint is not relaxed.

Example

```
# Compute the feasibility relaxation for an infeasible model formulated using matrix
↪ modeling
mx = model.addMVar(shape=3, nameprefix="x")
# Define constraints
A = np.array([[1, 2, 3], [4, 5, 6]])
b = np.array([10, 20])
mc = model.addConstr(A @ x <= b, name="constrs")
# Define relaxation penalty factors
# The lower bound of the 2nd element of mx is not relaxed
lbpen = [1.0, COPT.INFINITY, 0.5]
# The upper bound of the 3rd element of mx is not relaxed
ubpen = NdArray([0.8, 1.5, COPT.INFINITY])
# Relaxation penalty factor for mc
rhspen = 2.0
# Compute feasibility relaxation for mx and mc in matrix modeling
model.feasRelaxN(mx, lbpen, ubpen, mc, rhspen)
```

`Model.tune()`

Synopsis

```
tune()
```

Description

Parameter tuning of the model.

Example

Model.loadTuneParam()**Synopsis**

```
loadTuneParam(idx)
```

Description

Load the parameter tuning results of the specified number into the model.

Example**Model.interrupt()****Synopsis**

```
interrupt()
```

Description

Interrupt solving process of current problem.

Example

```
# Interrupt the solving process.  
m.interrupt()
```

Model.remove()**Synopsis**

```
remove(args)
```

Description

Remove variables or constraints from a model.

To remove variable, then parameter **args** can be *Var Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

To remove linear constraint, then parameter **args** can be *Constraint Class* object, *ConstrArray Class* object, list, dictionary or *tupledict Class* object.

To remove SOS constraint, then parameter **args** can be *SOS Class* object, *SOSArray Class* object, list, dictionary or *tupledict Class* object.

To remove Second-Order-Cone constraints, then parameter **args** can be *Cone Class* object, *ConeArray Class* object, list, dictionary or *tupledict Class* object.

To remove exponential cone constraints, then parameter **args** can be *ExpCone Class* object, *ExpConeArray Class* object, list, dictionary or *tupledict Class* object.

To remove affine cone constraints, then parameter **args** can be *AffineCone Class* object, *AffineConeArray Class* object, list, dictionary or *tupledict Class* object.

To remove quadratic constraints, then parameter **args** can be *QConstraint Class* object, *QConstrArray Class* object, list, dictionary or *tupledict Class* object.

To remove positive semi-definite constraints, then parameter **args** can be *Psd-Constraint Class* object, *PsdConstrArray Class* object, list, dictionary or *tupledict Class* object.

To remove indicator constraint, then parameter **args** can be *GenConstr Class* object, *GenConstrArray Class* object, list, dictionary or *tupledict Class* object.

To remove LMI constraint, then parameter **args** can be *LmiConstraint Class* object, *LmiConstrArray Class* object, list, dictionary or *tupledict Class* object.

To remove matrix variables or matrix constraints, then parameter **args** can be *MVar Class* object, *MConstr Class* object, *MQConstr Class* object or *MPsdConstr Class* object.

Arguments

args

Variables or constraints to be removed.

Example

```
# Remove linear constraint conx
m.remove(conx)
# Remove variables x and y
m.remove([x, y])
```

Model.reset()

Synopsis

reset()

Description

Reset the result information of the model.

Example

```
# Reset the result information in model.
m.reset()
```

Model.resetAll()

Synopsis

resetAll()

Description

Reset the result and other additional information of the model, such as MIP start, IIS, etc. By executing this function, the information that needs to be calculated of the model will be all cleared, only the original model itself will be kept.

Example

```
# Reset the result and other additional information of the model
m.reset()
```

Model.clear()

Synopsis

clear()

Description

Clear all content of the whole model. By executing this function, all content of the whole model will be cleared, including the added variables, objective, and constraints.

Example

```
# Clear all content of the model.
m.clear()
```

Model.clone()

Synopsis

```
clone()
```

Description

Create a deep copy of an existing model. Return a *Model Class* object.

Example

```
# Create a deep copy of model
mcopy = m.clone()
```

Model.setCallback()

Synopsis

```
setCallback(cb, cbctx)
```

Description

Set the callback function of the model.

Arguments

cb

Callback Class object.

cbctx

Callback context. Please refer to *Callback context* .

Example

```
cb = CoptCallback()
model.setCallback(cb, COPT.CBCONTEXT_MIPSOL)
```

22.2.4 Var Class

For easy access to information of variables, Var object provides methods such as `Var.LB`. The full list of information can be found in the *Information* section. For convenience, information can be accessed by names in original case or lowercase.

In addition, you can also access the value of the variable through `Var.x`, the variable type through `Var.vtype`, the name of the variable through `Var.name`, the Reduced cost value of the variable in LP through `Var.rc`, the basis status through `Var.basis`, and the index of the variable in the coefficient matrix through `Var.index` the Reduced cost value of the variable in LP through `Var.rc`, the basis status through `Var.basis`, and the index of the variable in the coefficient matrix through `Var.index`.

For the model-related information of the variables, as well as the variable type and name, the user can set the corresponding information value in the form of "`Var.LB = 0.0`".

Var object contains related operations of COPT variables and provides the following methods:

Var.getType()**Synopsis**`getType()`**Description**

Retrieve the type of variable.

Example

```
# Retrieve the type of variable v
vtype = v.getType()
```

Var.getName()**Synopsis**`getName()`**Description**

Retrieve the name of variable.

Example

```
# Retrieve the name of variable v
varname = v.getName()
```

Var.getBasis()**Synopsis**`getBasis()`**Description**

Retrieve the basis status of variable.

Example

```
# Retrieve the basis status of variable v
varbasis = v.getBasis()
```

Var.getLowerIIS()**Synopsis**`getLowerIIS()`**Description**

Retrieve the IIS status of lower bound of variable.

Example

```
# Retrieve the IIS status of lower bound of variable v
lowerIIS = v.getLowerIIS()
```

Var.getUpperIIS()**Synopsis**

```
getUpperIIS()
```

Description

Retrieve the IIS status of upper bound of variable.

Example

```
# Retrieve the IIS status of upper bound of variable v
upperIIS = v.getUpperIIS()
```

Var.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the subscript of the variable in the coefficient matrix.

Example

```
# Retrieve the subscript of variable v
vindex = v.getIdx()
```

Var.setType()**Synopsis**

```
setType(newtype)
```

Description

Set the type of variable.

Arguments

`newtype`

The type of variable to be set. Please refer to *Variable types* section for possible values.

Example

```
# Set the type of variable v
v.setType(COPT.BINARY)
```

Var.setName()**Synopsis**

```
setName(newname)
```

Description

Set the name of variable.

Arguments

`newname`

The name of variable to be set.

Example

```
# Set the name of variable v
v.setName(COPT.BINARY)
```

Var.getInfo()

Synopsis

```
getInfo(infoname)
```

Description

Retrieve specified information. Return a constant.

Arguments

`infoname`

The name of the information. Please refer to *Information* for possible values.

Example

```
# Get lowerbound of variable x
x.getInfo(COPT.Info.LB)
```

Var.setInfo()

Synopsis

```
setInfo(infoname, newval)
```

Description

Set new information value for a variable.

Arguments

`infoname`

The name of the information to be set. Please refer to *Information* section for possible values.

`newval`

New information value to set.

Example

```
# Set the lower bound of variable x
x.setInfo(COPT.Info.LB, 1.0)
```

Var.remove()**Synopsis**

```
remove()
```

Description

Delete the variable from model.

Example

```
# Delete variable 'x'
x.remove()
```

22.2.5 VarArray Class

To facilitate users to operate on multiple *Var Class* objects, the Python interface of COPT provides VarArray object with the following methods:

VarArray()**Synopsis**

```
VarArray(vars=None)
```

Description

Create a *VarArray Class* object.

If parameter **vars** is **None**, then create an empty *VarArray Class* object, otherwise initialize the new created *VarArray Class* object based on **vars**.

Arguments

vars

Variables to be added. Optional, **None** by default. **vars** can be *Var Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty VarArray object
vararr = VarArray()
# Create an empty VarArray object and initialize variables x, y.
vararr = VarArray([x, y])
```

VarArray.pushBack()**Synopsis**

```
pushBack(vars)
```

Description

Add single or multiple *Var Class* objects.

Arguments

vars

Variables to be applied. **vars** can be *Var Class* object, *VarArray Class* object, list, dictionary or *tupledict Class* object.

Example


```
# Add variable x to vararr
vararr.pushBack(x)
# Add variables x and y to vararr
vararr.pushBack([x, y])
```

VarArray.getVar()

Synopsis

```
getVar(idx)
```

Description

Retrieve a variable from an index in a *VarArray Class* object. Return a *Var Class* object.

Arguments

idx

Subscript of the specified variable in *VarArray Class* object, starting with 0.

Example

```
# Get the variable with subscript of 1 in vararr
vararr.getVar(1)
```

VarArray.getAll()

Synopsis

```
getAll()
```

Description

Retrieve all variables in *VarArray Class* object. Returns a list object.

Example

```
# Get all variables in 'vararr'
varall = vararr.getAll()
```

VarArray.getSize()

Synopsis

```
getSize()
```

Description

Retrieve the number of variables in *VarArray Class* object.

Example

```
# Retrieve the number of variables in vararr.
arrsize = vararr.getSize()
```

22.2.6 PsdVar Class

PsdVar object contains related operations of COPT positive semi-definite variables and provides the following methods:

PsdVar.getName()

Synopsis

getName()

Description

Retrieve the name of positive semi-definite variable.

Example

```
# Retrieve the name of variable v
varname = v.getName()
```

PsdVar.getIdx()

Synopsis

getIdx()

Description

Retrieve the subscript of the variable in the model.

Example

```
# Retrieve the subscript of variable v
vindex = v.getIdx()
```

PsdVar.getDim()

Synopsis

getDim()

Description

Retrieve the dimension of positive semi-definite variable.

Example

```
# Retrieve the dimension of variable "v"
vdim = v.getDim()
```

PsdVar.getLen()

Synopsis

getLen()

Description

Retrieve the length of the expanded positive semi-definite variable.

Example

```
# Retrieve the length of the expanded positive semi-definite variable "v"
vlen = v.getLen()
```

PsdVar.setName()

Synopsis

```
setName(newname)
```

Description

Set the name of positive semi-definite variable.

Arguments

`newname`

The name of positive semi-definite variable to be set.

Example

```
# Set the name of variable v
v.setName('v')
```

PsdVar.getInfo()

Synopsis

```
getInfo(infename)
```

Description

Retrieve specified information of positive semi-definite variable. Return a list.

Arguments

`infename`

The name of the information. Please refer to *Information* for possible values.

Example

```
# Get solution values of positive semi-definite variable x
sol = x.getInfo(COPT.Info.Value)
```

PsdVar.remove()

Synopsis

```
remove()
```

Description

Delete the positive semi-definite variable from model.

Example

```
# Delete variable 'x'
x.remove()
```

PsdVar.diag()**Synopsis**

```
diag(offset=0)
```

Description

Retrieves the diagonal elements of the PSD variable.

Arguments

offset

The diagonal offset, default is 0.

If `offset > 0`, it represents a downward diagonal offset. If `offset < 0`, it represents an upward diagonal offset.

Return Value

A *PsdExpr* object.

Example

```
# Retrieve the main diagonal elements of the PSD variable
v.diag(offset=0)
```

PsdVar.pick()**Synopsis**

```
pick(indexes)
```

Description

Retrieves a PSD expression composed of the elements at the specified indices of the PSD variable.

Arguments

indexes

The array of specified indices.

Return Value

A *PsdExpr* object.

Example

```
# Retrieve a PSD expression composed of the element at index 0
barX = model.addPsdVars(3, "BAR_X")
barX.pick([0])
```

PsdVar.sum()**Synopsis**

```
sum()
```

Description

Retrieves a PSD expression composed of the sum of all elements in the PSD variable.

Return Value

A *PsdExpr* object.

PsdVar.toexpr()**Synopsis**

`toexpr()`

Description

Retrieves the PSD expression equivalent to the PSD variable.

Return Value

A *PsdExpr* object.

PsdVar.shape**Synopsis**

`shape`

Description

Shape of the *PsdVar* object.

Return value

Integer tuple.

PsdVar.size**Synopsis**

`size`

Description

Size of the *PsdVar* object.

Return value

Integer tuple.

PsdVar.dim**Synopsis**

`dim`

Description

Dimension of the *PsdVar* object.

Return value

Integer.

PsdVar.len**Synopsis**

len

Description

Flattened length of the *PsdVar* object.

Return value

Integer.

22.2.7 PsdVarArray Class

To facilitate users to operate on multiple *PsdVar Class* objects, the Python interface of COPT provides *PsdVarArray* object with the following methods:

PsdVarArray()**Synopsis**

PsdVarArray(vars=None)

Description

Create a *PsdVarArray Class* object.

If parameter **vars** is **None**, then create an empty *PsdVarArray Class* object, otherwise initialize the new created *PsdVarArray Class* object based on **vars**.

Arguments

vars

Positive semi-definite variables to be added. Optional, **None** by default. **vars** can be *PsdVar Class* object, *PsdVarArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty PsdVarArray object
vararr = PsdVarArray()
# Create a PsdVarArray object containing positive semi-definite variables x, y.
vararr = PsdVarArray([x, y])
```

PsdVarArray.pushBack()**Synopsis**

pushBack(var)

Description

Add single or multiple *PsdVar Class* objects.

Arguments

var

Postive semi-definite variables to be applied. **vars** can be *PsdVar Class* object, *PsdVarArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add variable x to vararr
vararr.pushBack(x)
# Add variables x and y to vararr
vararr.pushBack([x, y])
```

PsdVarArray.getPsdVar()

Synopsis

```
getPsdVar(idx)
```

Description

Retrieve a positive semi-definite variable from an index in a *PsdVarArray Class* object. Return a *PsdVar Class* object.

Arguments

idx

Subscript of the specified positive semi-definite variable in *PsdVarArray Class* object, starting with 0.

Example

```
# Get the positive semi-definite variable with subscript of 1 in vararr
var = vararr.getPsdVar(1)
```

PsdVarArray.getSize()

Synopsis

```
getSize()
```

Description

Retrieve the number of positive semi-definite variables in *PsdVarArray Class* object.

Example

```
# Retrieve the number of variables in vararr.
arrsize = vararr.getSize()
```

22.2.8 SymMatrix Class

SymMatrix object contains related operations of COPT symmetric matrices and provides the following methods:

SymMatrix.getIdx()

Synopsis

```
getIdx()
```

Description

Retrieve the subscript of the symmetric matrix in the model.

Example

```
# Retrieve the subscript of symmetric matrix mat
matidx = mat.getIdx()
```

SymMatrix.getDim()

Synopsis

```
getDim()
```

Description

Retrieve the dimension of symmetric matrix.

Example

```
# Retrieve the dimension of symmetric matrix "mat".
matdim = mat.getDim()
```

22.2.9 SymMatrixArray Class

To facilitate users to operate on multiple *SymMatrix Class* objects, the Python interface of COPT provides SymMatrixArray object with the following methods:

SymMatrixArray()

Synopsis

```
SymMatrixArray(mats=None)
```

Description

Create a *SymMatrixArray Class* object.

If parameter `mats` is `None`, then create an empty *SymMatrixArray Class* object, otherwise initialize the new created *SymMatrixArray Class* object based on `mats`.

Arguments

`mats`

`mats` can be *SymMatrix Class* object, *SymMatrixArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty SymMatrixArray object
matarr = SymMatrixArray()
# Create a SymMatrixArray object containing matx, maty.
matarr = SymMatrixArray([matx, maty])
```


SymMatrixArray.pushBack()**Synopsis**

```
pushBack(mat)
```

Description

Add single or multiple *SymMatrix Class* objects.

Arguments

mat

Symmetric matrices to be applied. mat can be *SymMatrix Class* object, *SymMatrixArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add symmetric matrix matx to matarr
matarr.pushBack(matx)
# Add symmetric matrices matx and maty to matarr
matarr.pushBack([matx, maty])
```

SymMatrixArray.getMatrix()**Synopsis**

```
getMatrix(idx)
```

Description

Retrieve a symmetric matrix from an index in a *SymMatrixArray Class* object.
Return a *SymMatrix Class* object.

Arguments

idx

Subscript of the specified symmetric matrix in *SymMatrixArray Class* object, starting with 0.

Example

```
# Get the symmetric matrix with subscript of 1 in matarr
mat = matarr.getMatrix(1)
```

SymMatrixArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of symmetric matrices in *SymMatrixArray Class* object.

Example

```
# Retrieve the number of symmetric matrices in matarr.
arrsize = matarr.getSize()
```

22.2.10 Constraint Class

For easy access to information of constraints, Constraint class provides methods such as `Constraint.LB`. The supported information can be found in *Information* section. For convenience, information can be queried by names in original case or lowercase.

In addition, you can access the name of the constraint through `Constraint.name`, the dual value of the constraint in LP through `Constraint.pi`, the basis status of the constraint through `Constraint.basis`, and the index in the coefficient matrix through `Constraint.index`.

For the model-related information and constraint name, the user can also set the corresponding information in the form of "`Constraint.lb = -100`".

Constraint object contains related operations of COPT constraints and provides the following methods:

Constraint.getName()

Synopsis

```
getName()
```

Description

Retrieve the name of linear constraint.

Example

```
# Retrieve the name of linear constraint 'con'.
conname = con.getName()
```

Constraint.getBasis()

Synopsis

```
getBasis()
```

Description

Retrieve the basis status of linear constraint.

Example

```
# Retrieve the basis status of linear constraint 'con'.
conbasis = con.getBasis()
```

Constraint.getLowerIIS()

Synopsis

```
getLowerIIS()
```

Description

Retrieve the IIS status of lower bound of linear constraint.

Example

```
# Retrieve the IIS status of lower bound of linear constraint 'con'.
lowerIIS = con.getLowerIIS()
```

Constraint.getUpperIIS()**Synopsis**

```
getUpperIIS()
```

Description

Retrieve the IIS status of upper bound of linear constraint.

Example

```
# Retrieve the IIS status of upper bound of linear constraint 'con'.  
upperIIS = con.getUpperIIS()
```

Constraint.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the subscript of linear constraint in coefficient matrix.

Example

```
# Retrieve the subscript of linear constraint con.  
conidx = con.getIdx()
```

Constraint.setName()**Synopsis**

```
setName(newname)
```

Description

Set the name of linear constraint.

Arguments

`newname`

The name of constraint to be set.

Example

```
# Set the name of linear constraint 'con'.  
con.setName('con')
```

Constraint.getInfo()**Synopsis**

```
getInfo(infename)
```

Description

Retrieve specified information. Return a constant.

Arguments

`infename`

Name of the information to be obtained. Please refer to *Information* section for possible values.

Example

```
# Get the lower bound of linear constraint con
conlb = con.getInfo(COPT.Info.LB)
```

Constraint.setInfo()**Synopsis**

```
setInfo(infename, newval)
```

Description

Set new information value to the specified constraint.

Arguments

infename

The name of the information to be set. Please refer to *Information* section for possible values.

newval

New information value to be set.

Example

```
# Set the lower bound of linear constraint con
con.setInfo(COPT.Info.LB, 1.0)
```

Constraint.remove()**Synopsis**

```
remove()
```

Description

Delete the linear constraint from model.

Example

```
# Delete the linear constraint 'conx'
conx.remove()
```

22.2.11 ConstrArray Class

To facilitate users to operate on multiple *Constraint Class* objects, the Python interface of COPT provides ConstrArray class with the following methods:

ConstrArray()

Synopsis

`ConstrArray(constrs=None)`

Description

Create a *ConstrArray Class* object.

If parameter `constrs` is `None`, the create an empty *ConstrArray Class* object, otherwise initialize the newly created *ConstrArray Class* object with parameter `constrs`

Arguments

`constrs`

Linear constraints to be added. `None` by default.

`constrs` can be *Constraint Class* object, *ConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty ConstrArray object
conarr = ConstrArray()
# Create an ConstrArray object initialized with linear constraint conx and cony
conarr = ConstrArray([conx, cony])
```

ConstrArray.pushBack()

Synopsis

`pushBack(constrs)`

Description

Add single or multiple *Constraint Class* objects.

Arguments

`constrs`

Linear constraints to be applied. `constrs` can be *Constraint Class* object, *ConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add linear constraint r to conarr
conarr.pushBack(r)
# Add linear constraint r0 and r1 to conarr
conarr.pushBack([r0, r1])
```

ConstrArray.getConstr()**Synopsis**

```
getConstr(idx)
```

Description

Retrieve the linear constraint according to its subscript in *ConstrArray Class* object. Return a *Constraint Class* object.

Arguments

idx

Subscript of the desired constraint in *ConstrArray Class* object, starting with 0.

Example

```
# Retrieve the linear constraint with subscript 1 in conarr
conarr.getConstr(1)
```

ConstrArray.getAll()**Synopsis**

```
getAll()
```

Description

Retrieve all linear constraints in *ConstrArray Class* object. Returns a list object.

Example

```
# Get all linear constraints in 'conarr'
cons = conarr.getAll()
```

ConstrArray.getSize()**Synopsis**

```
getSize()
```

Description

Get the number of elements in *ConstrArray Class* object.

Example

```
# Get the number of linear constraints in conarr
arrsize = conarr.getSize()
```

22.2.12 ConstrBuilder Class

ConstrBuilder object contains operations related to temporary constraints when building constraints, and provides the following methods:

ConstrBuilder()

Synopsis

```
ConstrBuilder()
```

Description

Create an empty *ConstrBuilder Class* object

Example

```
# Create an empty linear constraint builder
constrbuilder = ConstrBuilder()
```

ConstrBuilder.setBuilder()

Synopsis

```
setBuilder(expr, sense, rhs)
```

Description

Set expression and constraint type for linear constraint builder.

Arguments

expr

The expression to be set, which can be *Var Class* expression or *LinExpr Class* expression.

sense

Sense of constraint. The full list of available types can be found in *Constraint type* section.

rhs

Right hand side of constraint.

Example

```
# Set the expression of linear constraint builder as: x+y==1
constrbuilder.setBuilder(x + y, COPT.EQUAL, 1)
```

ConstrBuilder.getExpr()

Synopsis

```
getExpr()
```

Description

Retrieve the expression of a linear constraint builder object.

Example

```
# Retrieve the expression of a linear constraint builder
linexpr = constrbuilder.getExpr()
```

ConstrBuilder.getSense()

Synopsis

```
getSense()
```

Description

Retrieve the constraint sense of linear constraint builder object.

Example

```
# Retrieve the constraint sense of linear constraint builder object.
consense = constrbuilder.getSense()
```

22.2.13 ConstrBuilderArray Class

To facilitate users to operate on multiple *ConstrBuilder Class* objects, the Python interface of COPT provides ConstrArray object with the following methods:

ConstrBuilderArray()

Synopsis

```
ConstrBuilderArray(constrbuilders=None)
```

Description

Create a *ConstrBuilderArray Class* object.

If parameter `constrbuilders` is `None`, then create an empty *ConstrBuilderArray Class* object, otherwise initialize the newly created *ConstrBuilderArray Class* object by parameter `constrbuilders`.

Arguments

`constrbuilders`

Linear constraint builder to be added. Optional, `None` by default. It can be *ConstrBuilder Class* object, *ConstrBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty ConstrBuilderArray object.
conbuilderarr = ConstrBuilderArray()
# Create a ConstrBuilderArray object and initialize it with builders: conbuilderx and
↪ conbuildery
conbuilderarr = ConstrBuilderArray([conbuilderx, conbuildery])
```

ConstrBuilderArray.pushBack()

Synopsis

```
pushBack(constrbuilder)
```

Description

Add single or multiple *ConstrBuilder Class* objects.

Arguments

`constrbuilder`

Builder of linear constraint to be added, which can be *ConstrBuilder Class* object, *ConstrBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add linear constraint builder conbuilderx to conbuilderarr
conbuilderarr.pushBack(conbuilderx)
# Add linear constraint builders conbuilderx and conbuildery to conbuilderarr
conbuilderarr.pushBack([conbuilderx, conbuildery])
```

ConstrBuilderArray.getBuilder()

Synopsis

```
getBuilder(idx)
```

Description

Retrieve a temporary constraint from its index in *ConstrBuilderArray Class* object.
Return a *ConstrBuilder Class* object.

Retrieve the corresponding builder object according to the subscript of linear constraint builder in *ConstrBuilderArray Class* object.

Arguments

`idx`

Subscript of the linear constraint builder in the *ConstrBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the builder with subscript 1 in conbuilderarr
conbuilder = conbuilderarr.getBuilder(1)
```

ConstrBuilderArray.getSize()

Synopsis

```
getSize()
```

Description

Get the number of elements in *ConstrBuilderArray Class* object.

Example

```
# Get the number of builders in conbuilderarr
arrsize = conbuilderarr.getSize()
```

22.2.14 QConstraint Class

For easy access to information of quadratic constraints, QConstraint class provides methods such as `QConstraint.index`. The supported information can be found in [Information](#) section. For convenience, information can be queried by names in original case or lowercase.

In addition, you can access the name of the quadratic constraint through `QConstraint.name`, and the index in the model through `QConstraint.index`.

For the model-related information and constraint name, the user can also set the corresponding information in the form of "`QConstraint.rhs = -100`".

QConstraint object contains related operations of COPT quadratic constraints and provides the following methods:

QConstraint.getName()

Synopsis

```
getName()
```

Description

Retrieve the name of quadratic constraint.

Example

```
# Retrieve the name of quadratic constraint 'qcon'
qconname = qcon.getName()
```

QConstraint.getRhs()

Synopsis

```
getRhs()
```

Description

Retrieve the right hand side of quadratic constraint.

Example

```
# Retrieve the RHS of quadratic constraint 'qcon'
qconrhs = qcon.getRhs()
```

QConstraint.getSense()

Synopsis

```
getSense()
```

Description

Retrieve the type of quadratic constraint.

Example

```
# Retrieve the type of quadratic constraint 'qcon'
qconsense = qcon.getSense()
```

QConstraint.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the subscript of quadratic constraint.

Example

```
# Retrieve the subscript of quadratic constraint 'qcon'  
qconidx = qcon.getIdx()
```

QConstraint.setName()**Synopsis**

```
setName(newname)
```

Description

Set the name of quadratic constraint.

Arguments

newname

The name of quadratic constraint to be set.

Example

```
# Set the name of quadratic constraint 'qcon'.  
qcon.setName('qcon')
```

QConstraint.setRhs()**Synopsis**

```
setRhs(rhs)
```

Description

Set the right hand side of quadratic constraint.

Arguments

rhs

The right hand side of quadratic constraint to be set.

Example

```
# Set the RHS of quadratic constraint 'qcon' to 0.0  
qcon.setRhs(0.0)
```

QConstraint.setSense()

Synopsis

```
setSense(sense)
```

Description

Set the sense of quadratic constraint.

Arguments

sense

The sense of quadratic constraint to be set.

Example

```
# Set the sense of quadratic constraint 'qcon' to <=
qcon.setSense(COPT.LESS_EQUAL)
```

QConstraint.getInfo()

Synopsis

```
getInfo(infename)
```

Description

Retrieve specified information. Return a constant.

Arguments

infename

Name of the information to be obtained. Please refer to *Information* section for possible values.

Example

```
# Get the row activity of quadratic constraint 'qcon'
qconlb = qcon.getInfo(COPT.Info.Slack)
```

QConstraint.setInfo()

Synopsis

```
setInfo(infename, newval)
```

Description

Set new information value to the specified quadratic constraint.

Arguments

infename

The name of the information to be set. Please refer to *Information* section for possible values.

newval

New information value to be set.

Example

```
# Set the lower bound of quadratic constraint 'qcon'
qcon.setInfo(COPT.Info.LB, 1.0)
```

Constraint.remove()

Synopsis

```
remove()
```

Description

Delete the quadratic constraint from model.

Example

```
# Delete the quadratic constraint 'qconx'
qconx.remove()
```

22.2.15 QConstrArray Class

To facilitate users to operate on multiple *QConstraint Class* objects, the Python interface of COPT provides *QConstrArray* class with the following methods:

QConstrArray()

Synopsis

```
QConstrArray(qconstrs=None)
```

Description

Create a *QConstrArray Class* object.

If parameter *qconstrs* is *None*, the create an empty *QConstrArray Class* object, otherwise initialize the newly created *QConstrArray Class* object with parameter *qconstrs*

Arguments

qconstrs

Quadratic constraints to be added. *None* by default.

qconstrs can be *QConstraint Class* object, *QConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty QConstrArray object
qconarr = QConstrArray()
# Create an QConstrArray object initialized with quadratic constraint qconx and qcony
qconarr = QConstrArray([qconx, qcony])
```

QConstrArray.pushBack()**Synopsis**

```
pushBack(constr)
```

Description

Add single or multiple *QConstraint Class* object.

Arguments

`constr`

Quadratic constraints to be added. `None` by default.

`qconstrs` can be *QConstraint Class* object, *QConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add quadratic constraint qr to conarr
qconarr.pushBack(qr)
# Add quadratic constraint qr0 and qr1 to qconarr
qconarr.pushBack([qr0, qr1])
```

QConstrArray.getQConstr()**Synopsis**

```
getQConstr(idx)
```

Description

Retrieve the quadratic constraint according to its subscript in *QConstrArray Class* object. Return a *QConstraint Class* object.

Arguments

`idx`

Subscript of the desired quadratic constraint in *QConstrArray Class* object, starting with 0.

Example

```
# Retrieve the quadratic constraint with subscript 1 in qconarr
qcon = qconarr.getQConstr(1)
```

QConstrArray.getSize()**Synopsis**

```
getSize()
```

Description

Get the number of elements in *QConstrArray Class* object.

Example

```
# Get the number of quadratic constraints in qconarr
qarrsize = qconarr.getSize()
```

22.2.16 QConstrBuilder Class

QConstrBuilder object contains operations related to temporary constraints when building quadratic constraints, and provides the following methods:

QConstrBuilder()

Synopsis

```
QConstrBuilder()
```

Description

Create an empty *QConstrBuilder Class* object.

Example

```
# Create an empty quadratic constraint builder
qconstrbuilder = QConstrBuilder()
```

QConstrBuilder.setBuilder()

Synopsis

```
setBuilder(expr, sense, rhs)
```

Description

Set expression, constraint type and RHS for quadratic constraint builder.

Arguments

expr

The expression to be set, which can be *Var Class* object, *LinExpr Class* object or *QuadExpr Class* object.

sense

Sense of quadratic constraint. The full list of available types can be found in *Constraint type* section.

rhs

Right hand side of quadratic constraint.

Example

```
# Set the expression of quadratic constraint builder as: x+y, sense of constraint as
↳equal and RHS as 1
qconstrbuilder.setBuilder(x + y, COPT.LESS_EQUAL, 1.0)
```

QConstrBuilder.getQuadExpr()

Synopsis

```
getQuadExpr()
```

Description

Retrieve the expression of a quadratic constraint builder object.

Example

```
# Retrieve the expression of a quadratic constraint builder
quadexpr = constrbuilder.getQuadExpr()
```

QConstrBuilder.getSense()

Synopsis

```
getSense()
```

Description

Retrieve the constraint sense of quadratic constraint builder object.

Example

```
# Retrieve the constraint sense of quadratic constraint builder object.
qconsense = qconstrbuilder.getSense()
```

22.2.17 QConstrBuilderArray Class

To facilitate users to operate on multiple *QConstrBuilder Class* objects, the Python interface of COPT provides QConstrArray object with the following methods:

QConstrBuilderArray()

Synopsis

```
QConstrBuilderArray(qconstrbuilders=None)
```

Description

Create a *QConstrBuilderArray Class* object.

If parameter `qconstrbuilders` is `None`, then create an empty *QConstrBuilderArray Class* object, otherwise initialize the newly created *QConstrBuilderArray Class* object by parameter `qconstrbuilders`.

Arguments

`qconstrbuilders`

Quadratic constraint builder to be added. Optional, `None` by default. It can be *QConstrBuilder Class* object, *QConstrBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty QConstrBuilderArray object.
qconbuilderarr = QConstrBuilderArray()
# Create a QConstrBuilderArray object and initialize it with builders: qconbuilderx
↪ and qconbuildery
qconbuilderarr = QConstrBuilderArray([qconbuilderx, qconbuildery])
```


QConstrBuilderArray.pushBack()**Synopsis**

```
pushBack(qconstrbuilder)
```

Description

Add single or multiple *QConstrBuilder Class* objects.

Arguments

qconstrbuilder

Builder of quadratic constraint to be added, which can be *QConstrBuilder Class* object, *QConstrBuilderArray Class* object, list, dictionary or *tuple-dict Class* object.

Example

```
# Add quadratic constraint builder qconbuilderx to qconbuilderarr
qconbuilderarr.pushBack(qconbuilderx)
# Add quadratic constraint builders qconbuilderx and qconbuildery to qconbuilderarr
qconbuilderarr.pushBack([qconbuilderx, qconbuildery])
```

QConstrBuilderArray.getBuilder()**Synopsis**

```
getBuilder(idx)
```

Description

Retrieve the corresponding builder object according to the subscript of quadratic constraint builder in *QConstrBuilderArray Class* object.

Arguments

idx

Subscript of the quadratic constraint builder in the *QConstrBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the builder with subscript 1 in qconbuilderarr
qconbuilder = qconbuilderarr.getBuilder(1)
```

QConstrBuilderArray.getSize()**Synopsis**

```
getSize()
```

Description

Get the number of elements in *QConstrBuilderArray Class* object.

Example

```
# Get the number of builders in qconbuilderarr
qarrsize = qconbuilderarr.getSize()
```

22.2.18 PsdConstraint Class

PsdConstraint object contains related operations of COPT positive semi-definite constraints and provides the following methods:

PsdConstraint.getName()

Synopsis

getName()

Description

Retrieve the name of positive semi-definite constraint.

Example

```
# Retrieve the name of positive semi-definite constraint 'con'.
conname = con.getName()
```

PsdConstraint.getIdx()

Synopsis

getIdx()

Description

Retrieve the subscript of positive semi-definite constraint in the model.

Example

```
# Retrieve the subscript of positive semi-definite constraint con.
conidx = con.getIdx()
```

PsdConstraint.setName()

Synopsis

setName(newname)

Description

Set the name of positive semi-definite constraint.

Arguments

newname

The name of positive semi-definite constraint to be set.

Example

```
# Set the name of positive semi-definite constraint 'con'.
con.setName('con')
```

PsdConstraint.getInfo()**Synopsis**

```
getInfo(infoname)
```

Description

Retrieve specified information. Return a constant.

Arguments

`infoname`

Name of the information to be obtained. Please refer to *Information* section for possible values.

Example

```
# Get the lower bound of positive semi-definite constraint con
conlb = con.getInfo(COPT.Info.LB)
```

PsdConstraint.setInfo()**Synopsis**

```
setInfo(infoname, newval)
```

Description

Set new information value to the specified positive semi-definite constraint.

Arguments

`infoname`

The name of the information to be set. Please refer to *Information* section for possible values.

`newval`

New information value to be set.

Example

```
# Set the lower bound of positive semi-definite constraint con
con.setInfo(COPT.Info.LB, 1.0)
```

PsdConstraint.remove()**Synopsis**

```
remove()
```

Description

Delete the positive semi-definite constraint from model.

Example

```
# Delete the positive semi-definite constraint 'conx'
conx.remove()
```

22.2.19 PsdConstrArray Class

To facilitate users to operate on multiple *PsdConstraint Class* objects, the Python interface of COPT provides PsdConstrArray class with the following methods:

PsdConstrArray()

Synopsis

```
PsdConstrArray(constrs=None)
```

Description

Create a *PsdConstrArray Class* object.

If parameter `constrs` is `None`, the create an empty *PsdConstrArray Class* object, otherwise initialize the newly created *PsdConstrArray Class* object with parameter `constrs` .

Arguments

`constrs`

Positive semi-definite constraints to be added. `None` by default.

`constrs` can be *PsdConstraint Class* object, *PsdConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty PsdConstrArray object
conarr = PsdConstrArray()
# Create an PsdConstrArray object containing positive semi-definite constraint conx
↳ and cony
conarr = PsdConstrArray([conx, cony])
```

PsdConstrArray.pushBack()

Synopsis

```
pushBack(constr)
```

Description

Add single or multiple *PsdConstraint Class* objects.

Arguments

`constr`

Positive semi-definite constraints to be applied. `constrs` can be *Psd-Constraint Class* object, *PsdConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add positive semi-definite constraint r to conarr
conarr.pushBack(r)
# Add positive semi-definite constraint r0 and r1 to conarr
conarr.pushBack([r0, r1])
```

PsdConstrArray.getPsdConstr()**Synopsis**

```
getPsdConstr(idx)
```

Description

Retrieve the positive semi-definite constraint according to its subscript in *PsdConstrArray Class* object. Return a *PsdConstraint Class* object.

Arguments

`idx`

Subscript of the desired positive semi-definite constraint in *PsdConstrArray Class* object, starting with 0.

Example

```
# Retrieve the positive semi-definite constraint with subscript 1 in conarr
con = conarr.getPsdConstr(1)
```

PsdConstrArray.getSize()**Synopsis**

```
getSize()
```

Description

Get the number of elements in *PsdConstrArray Class* object.

Example

```
# Get the number of positive semi-definite constraints in conarr
arrsize = conarr.getSize()
```

22.2.20 PsdConstrBuilder Class

PsdConstrBuilder object contains operations related to temporary constraints when building positive semi-definite constraints, and provides the following methods:

PsdConstrBuilder()**Synopsis**

```
PsdConstrBuilder()
```

Description

Create an empty *PsdConstrBuilder Class* object

Example

```
# Create an empty positive semi-definite constraint builder
constrbuilder = PsdConstrBuilder()
```

PsdConstrBuilder.setBuilder()

Synopsis

```
setBuilder(expr, sense, rhs)
```

Description

Set expression, constraint type and right hand side for positive semi-definite constraint builder.

Arguments

expr

The expression to be set, which can be *PsdVar Class* expression or *PsdExpr Class* expression.

sense

Sense of constraint. The full list of available types can be found in *Constraint type* section.

rhs

The right hand side of constraint.

Example

```
# Set the expression of positive semi-definite constraint builder as: x + y == 1, and ↵  
↵sense of constraint as equal  
constrbuilder.setBuilder(x + y, COPT.EQUAL, 1)
```

PsdConstrBuilder.setRange()

Synopsis

```
setRange(expr, range)
```

Description

Set a range positive semi-definite constraint builder where **expr** is less than or equals to 0 and greater than or equals to - **range**.

Arguments

expr

The expression to be set, which can be *PsdVar Class* expression or *PsdExpr Class* expression.

range

Range of constraint, nonnegative constant.

Example

```
# Set a range positive semi-definite constraint builder: -1 <= x + y - 1 <= 0  
constrbuilder.setRange(x + y - 1, 1)
```

PsdConstrBuilder.getPsdExpr()**Synopsis**

```
getPsdExpr()
```

Description

Retrieve the expression of a positive semi-definite constraint builder object.

Example

```
# Retrieve the expression of a positive semi-definite constraint builder
psdexpr = constrbuilder.getPsdExpr()
```

PsdConstrBuilder.getSense()**Synopsis**

```
getSense()
```

Description

Retrieve the constraint sense of positive semi-definite constraint builder object.

Example

```
# Retrieve the constraint sense of positive semi-definite constraint builder object.
consense = constrbuilder.getSense()
```

PsdConstrBuilder.getRange()**Synopsis**

```
getRange()
```

Description

Retrieve the range of positive semi-definite constraint builder object, i.e. length from lower bound to upper bound of the constraint

Example

```
# Retrieve the range of positive semi-definite constraint builder object
rngval = constrbuilder.getRange()
```

22.2.21 PsdConstrBuilderArray Class

To facilitate users to operate on multiple *PsdConstrBuilder Class* objects, the Python interface of COPT provides PsdConstrBuilderArray object with the following methods:

PsdConstrBuilderArray()

Synopsis

`PsdConstrBuilderArray(builders=None)`

Description

Create a *PsdConstrBuilderArray Class* object.

If parameter `builders` is `None`, then create an empty *PsdConstrBuilderArray Class* object, otherwise initialize the newly created *PsdConstrBuilderArray Class* object by parameter `builders`.

Arguments

`builders`

Positive semi-definite constraint builder to be added. Optional, `None` by default. It can be *PsdConstrBuilder Class* object, *PsdConstrBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty PsdConstrBuilderArray object.
conbuilderarr = PsdConstrBuilderArray()
# Create a PsdConstrBuilderArray object containing builders: conbuilderx and
↳ conbuildery
conbuilderarr = PsdConstrBuilderArray([conbuilderx, conbuildery])
```

PsdConstrBuilderArray.pushBack()

Synopsis

`pushBack(builder)`

Description

Add single or multiple *PsdConstrBuilder Class* objects.

Arguments

`builder`

Builder of positive semi-definite constraint to be added, which can be *PsdConstrBuilder Class* object, *PsdConstrBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add positive semi-definite constraint builder conbuilderx to conbuilderarr
conbuilderarr.pushBack(conbuilderx)
# Add positive semi-definite constraint builders conbuilderx and conbuildery to
↳ conbuilderarr
conbuilderarr.pushBack([conbuilderx, conbuildery])
```


PsdConstrBuilderArray.getBuilder()**Synopsis**

```
getBuilder(idx)
```

Description

Retrieve the corresponding builder object according to the subscript of positive semi-definite constraint builder in *PsdConstrBuilderArray Class* object.

Arguments

`idx`

Subscript of the positive semi-definite constraint builder in the *PsdConstrBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the builder with subscript 1 in conbuilderarr
conbuilder = conbuilderarr.getBuilder(1)
```

PsdConstrBuilderArray.getSize()**Synopsis**

```
getSize()
```

Description

Get the number of elements in *PsdConstrBuilderArray Class* object.

Example

```
# Get the number of builders in conbuilderarr
arrsize = conbuilderarr.getSize()
```

22.2.22 LmiConstraint Class

LmiConstraint object contains related operations of COPT LMI (Linear Matrix Inequality) constraints and provides the following methods:

LmiConstraint.getName()**Synopsis**

```
getName()
```

Description

Retrieve the name of the *LmiConstraint Class* object.

Example

```
# Get name of the LmiConstraint con
conname = con.getName()
```

LmiConstraint.getIdx()

Synopsis

getIdx()

Description

Retrieve the subscript of the LMI constraint in the model.

Example

```
# Retrieve the subscript of the LMI constraint
conidx = con.getIdx()
```

LmiConstraint.getDim()

Synopsis

getDim()

Description

Retrieve the dimension of the LMI constraint.

Example

```
# Retrieve the dimension of the LMI constraint
conidx = con.getDim()
```

LmiConstraint.getLen()

Synopsis

getLen()

Description

Retrieve the flattened length of the LMI constraint.

Example

```
# Retrieve the flattened length of the LMI constraint
conidx = con.getDim()
```

LmiConstraint.setName()

Synopsis

setName(newname)

Description

Set the name of the LMI constraint to **newname** .

Arguments

newname

The name of the LMI constraint to be set.

Example

```
# Set the name of the LMI constraint
con.setName('con')
```

LmiConstraint.setRhs()**Synopsis**

```
setRhs(mat)
```

Description

Set the constant-term symmetric matrix of the LMI constraint.

Arguments

mat

The constant-term symmetric matrix of the LMI constraint to be set. It should be *SymMatrix Class* .

Example

```
# Set the constant-term symmetric of the LMI constraint
D = m.addSparseMat(2, [0, 1], [0, 1], [1.0, 1.0])
con.setRhs(D)
```

LmiConstraint.getInfo()**Synopsis**

```
getInfo(infename)
```

Description

Retrieve the specified information with the name `infename` .

Arguments

infename

Name of the information to be obtained. Please refer to *Information* section for possible values.

Example

```
# Get slack of the LMI constraint con
conlb = con.getInfo(COPT.Info.Slack)
```

LmiConstraint.remove()**Synopsis**

```
remove()
```

Description

Remove the current LMI constraint from the model.

Example

```
# Remove the LMI constraint conx
conx.remove()
```

LmiConstraint.shape

Synopsis

shape

Description

Shape of the `LmiConstraint` object.

Return value

Integer tuple.

LmiConstraint.size

Synopsis

size

Description

Size of the `LmiConstraint` object.

Return value

Integer tuple.

LmiConstraint.dim

Synopsis

dim

Description

Dimension of the `LmiConstraint` object.

Return value

Integer.

LmiConstraint.len

Synopsis

len

Description

Flattened length of the `LmiConstraint` object.

Return value

Integer.

22.2.23 LmiConstrArray Class

To facilitate users to operate on multiple *LmiConstraint Class* objects, the Python interface of COPT provides LmiConstrArray class with the following methods:

LmiConstrArray()

Synopsis

```
LmiConstrArray(constrs=None)
```

Description

Create a *LmiConstrArray Class* object.

If parameter `constrs` is `None`, then create an empty *LmiConstrArray Class* object, otherwise initialize the newly created *LmiConstrArray Class* object with parameter `constrs`.

Arguments

`constrs`

Can be *LmiConstraint Class* object, *LmiConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty LmiConstrArray class object
conarr = LmiConstrArray()
# Create a LmiConstrArray class object and initialize it with the LMI constraints
↳ conx and cony
conarr = LmiConstrArray([conx, cony])
```

LmiConstrArray.pushBack()

Synopsis

```
pushBack(constr)
```

Description

Add single or multiple *LmiConstraint Class* objects.

Arguments

`constr`

`constrs` can be *LmiConstraint Class* object, *LmiConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add LMI constraint r to conarr
conarr.pushBack(r)
# Add LMI constraint r0 and r1 to conarr
conarr.pushBack([r0, r1])
```

LmiConstrArray.getLmiConstr()**Synopsis**

```
getLmiConstr(idx)
```

Description

Retrieve the LMI constraint according to its subscript in *LmiConstrArray Class* object. Return a *LmiConstraint Class* object.

Arguments

idx

Subscript of the desired LMI constraint in *LmiConstrArray Class* object, starting with 0.

Example

```
# Get the LMI constraint with subscript 1 in conarr
con = conarr.getLmiConstr(1)
```

LmiConstrArray.getSize()**Synopsis**

```
getSize()
```

Description

Get the number of elements in *LmiConstrArray Class* object.

Example

```
# Get the number of LMI constraints in conarr
arrsize = conarr.getSize()
```

LmiConstrArray.reserve()**Synopsis**

```
reserve(n)
```

Description

Reserve space for *LmiConstrArray Class* objects of size n.

Arguments

n

The number of elements in the object *LmiConstrArray Class* .

22.2.24 SOS Class

SOS object contains related operations of COPT SOS constraints. The following methods are provided:

SOS.getIdx()

Synopsis

```
getIdx()
```

Description

Retrieve the subscript of SOS constraint in model.

Example

```
# Retrieve the subscript of SOS constraint sosx.
sosidx = sosx.getIdx()
```

SOS.remove()

Synopsis

```
remove()
```

Description

Delete the SOS constraint from model.

Example

```
# Delete the SOS constraint 'sosx'
sosx.remove()
```

22.2.25 SOSArray Class

To facilitate users to operate on a set of *SOS Class* objects, COPT designed SOSArray class in Python interface. The following methods are provided:

SOSArray()

Synopsis

```
SOSArray(soss=None)
```

Description

Create a *SOSArray Class* object.

If parameter **soss** is **None**, then build an empty *SOSArray Class* object, otherwise initialize the newly created *SOSArray Class* object with **soss**.

Arguments

soss

SOS constraint to be added. Optional, **None** by default. It can be *SOS Class* object, *SOSArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create a new SOSArray object
sosarr = SOSArray()
# Create a SOSArray object, and initialize it with SOS constraints sosx and soty.
sosarr = SOSArray([sosx, soty])
```

SOSArray.pushBack()

Synopsis

```
pushBack(sos)
```

Description

Add one or multiple *SOS Class* objects.

Arguments

sos

SOS constraints to be added, which can be *SOS Class* object, *SOSArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add SOS constraint sosx to sosarr
sosarr.pushBack(sosx)
# Add SOS constraints sosx and soty to sosarr
sosarr.pushBack([sosx, soty])
```

SOSArray.getSOS()

Synopsis

```
getSOS(idx)
```

Description

Retrieve the corresponding SOS constraint according to its subscript in *SOSArray Class* object and return a *SOS Class* object.

Arguments

idx

Indice of the SOS constraint in *SOSArray Class* object, starting with 0.

Example

```
# Retrieve the SOS constraint with indice of 1 in sosarr
sos = sosarr.getSOS(1)
```


SOSArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *SOSArray Class* object.

Example

```
# Retrieve the number of SOS constraints in sosarr.
arrsize = sosarr.getSize()
```

22.2.26 SOSBuilder Class

For easy access builders of SOS constraints, SOSBuilder class provides the following methods:

SOSBuilder()**Synopsis**

```
SOSBuilder()
```

Description

Create an empty *SOSBuilder Class* object.

Example

```
# Create an empty SOSBuilder object.
sosbuilder = SOSBuilder()
```

SOSBuilder.setBuilder()**Synopsis**

```
setBuilder(sostype, vars, weights=None)
```

Description

Set type, variable, weight of variable on *SOSBuilder Class* object.

Arguments

sostype

SOS constraint type. Full list of available types can be found in *SOS-constraint types*.

vars

Variables of SOS constarint, which can be *VarArray Class* object, list, dictionary or *tupledict Class* object.

weights

Weights of variables in SOS constraint. Optional, *None* by default. Could be list, dictionary or *tupledict Class* object.

Example

```
# Set the type of SOS constraint builder as SOS1, variables x and y, weights of 1
↳ variables as 1 and 2 respectively.
sosbuilder.setBuilder(COPT.SOS_TYPE1, [x, y], [1, 2])
```

SOSBuilder.getType()

Synopsis

```
getType()
```

Description

Retrieve the SOS constraint type of *SOSBuilder Class* object.

Example

```
# Retrieve the type of SOS constraint builder sosx.
sostype = sosbuilder.getType(sosx)
```

SOSBuilder.getVar()

Synopsis

```
getVar(idx)
```

Description

Retrieve the corresponding variables according to its indice in *SOSBuilder Class* object, and return a *Var Class* object.

Arguments

idx

Indice of the variable in *SOSBuilder Class* object, starting with 0.

Example

```
# Retrieve the variable in SOS constraint builder sosx with indice of 1
sosvar = sosx.getVar(1)
```

SOSBuilder.getVars()

Synopsis

```
getVars()
```

Description

Retrieve all variables in *SOSBuilder Class* objects, and return a *VarArray Class* object.

Example

```
# Retrieve all variables in SOS constraint builder sosx.
sosvars = sosx.getVars()
```

SOSBuilder.getWeight()**Synopsis**

```
getWeight(idx)
```

Description

Retrieve the corresponding weight of variable according to its indice in *SOSBuilder Class* object.

Arguments

```
idx
```

Indice of the variable in *SOSBuilder Class* object, starting with 0.

Example

```
# Retrieve the corresponding weight of variable according to its indice in the SOS
↳constraint builder sosx.
sosweight = sosx.getWeight(1)
```

SOSBuilder.getWeights()**Synopsis**

```
getWeights()
```

Description

Retrieve weights of all the variables in *SOSBuilder Class* object.

Example

```
# Retrieve weights of all the variables in SOS constraint builder sosx.
sosweights = sosx.getWeights()
```

SOSBuilder.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *SOSBuilder Class* object.

Example

```
# Retrieve the number of elements in SOS constraint builder sosx.
sossizes = sosx.getSize()
```

22.2.27 SOSBuilderArray Class

In order to facilitate users to operate on a set of *SOSBuilder Class* objects, COPT provides SOSBuilderArray class in Python interface, providing the following methods:

SOSBuilderArray()

Synopsis

```
SOSBuilderArray(sosbuilders=None)
```

Description

Create a *SOSBuilderArray Class* object.

If parameter `sosbuilders` is `None`, then create an empty *SOSBuilderArray Class* object, otherwise initialize the newly created *SOSBuilderArray Class* object with parameter `sosbuilders`.

Arguments

`sosbuilders`

SOS constraint builder to be added. Optional, `None` by default. Could be *SOSBuilder Class* object, *SOSBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty SOSBuilderArray object.
sosbuilderarr = SOSBuilderArray()
# Create a SOSBuilderArray object and initialize it with SOS constraint builder sosx
↪ and sosy
sosbuilderarr = SOSBuilderArray([sosx, sosy])
```

SOSBuilderArray.pushBack()

Synopsis

```
pushBack(sosbuilder)
```

Description

Add one or multiple *SOSBuilder Class* objects.

Arguments

`sosbuilder`

SOS constraint builderto be added. Could be *SOSBuilder Class* object, *SOSBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add SOS constraint builder sosx to sosbuilderarr
sosbuilderarr.pushBack(sosx)
```

SOSBuilderArray.getBuilder()**Synopsis**

```
getBuilder(idx)
```

Description

Retrieve the corresponding builder according to the indice of SOS constraint builder in *SOSBuilderArray Class* object.

Arguments

idx

Indice of the SOS constraint builder in *SOSBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the SOS constraint builder with indice of 1 in sosbuilderarr
sosbuilder = sosbuilderarr.getBuilder(1)
```

SOSBuilderArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *SOSBuilderArray Class* object.

Example

```
# Retrieve the number of elements in sosbuilderarr
sosbuildersize = sosbuilderarr.getSize()
```

22.2.28 Cone Class

Cone object contains related operations of COPT Second-Order-Cone (SOC) constraints. The following methods are provided:

Cone.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the subscript of SOC constraint in model.

Example

```
# Retrieve the subscript of SOC constraint cone.
coneidx = cone.getIdx()
```

Cone.remove()**Synopsis**

```
remove()
```

Description

Delete the SOC constraint from model.

Example

```
# Delete the SOC constraint 'cone'
cone.remove()
```

22.2.29 ConeArray Class

To facilitate users to operate on a set of *Cone Class* objects, COPT designed ConeArray class in Python interface. The following methods are provided:

ConeArray()**Synopsis**

```
ConeArray(cones=None)
```

Description

Create a *ConeArray Class* object.

If parameter `cones` is `None`, then build an empty *ConeArray Class* object, otherwise initialize the newly created *ConeArray Class* object with `cones`.

Arguments

`cones`

Second-Order-Cone constraint to be added. Optional, `None` by default. It can be *Cone Class* object, *ConeArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create a new ConeArray object
conearr = ConeArray()
# Create a ConeArray object, and initialize it with SOC constraints conex and coney.
conearr = ConeArray([conex, coney])
```

ConeArray.pushBack()**Synopsis**

```
pushBack(cone)
```

Description

Add one or multiple *Cone Class* objects.

Arguments

`cone`

Second-Order-Cone constraints to be added, which can be *Cone Class* object, *ConeArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add SOC constraint conex to conearr
conearr.pushBack(conex)
# Add SOC constraints conex and coney to conearr
conearr.pushBack([conex, coney])
```

ConeArray.getCone()**Synopsis**

```
getCone(idx)
```

Description

Retrieve the corresponding Second-Order-Cone (SOC) constraint according to its subscript in *ConeArray Class* object and return a *Cone Class* object.

Arguments

```
idx
```

Indice of the SOC constraint in *ConeArray Class* object, starting with 0.

Example

```
# Retrieve the SOC constraint with indice of 1 in conearr
cone = conearr.getCone(1)
```

ConeArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *ConeArray Class* object.

Example

```
# Retrieve the number of SOC constraints in conearr.
arrsize = conearr.getSize()
```

22.2.30 ConeBuilder Class

For easy access builders of Second-Order-Cone (SOC) constraints, ConeBuilder class provides the following methods:

ConeBuilder()**Synopsis**

```
ConeBuilder()
```

Description

Create an empty *ConeBuilder Class* object.

Example

```
# Create an empty ConeBuilder object.
conebuilder = ConeBuilder()
```

ConeBuilder.setBuilder()

Synopsis

```
setBuilder(conetype, vars)
```

Description

Set type, variables of *ConeBuilder Class* object.

Arguments

conetype

Type of Second-Order-Cone (SOC) constraint. Full list of available types can be found in *SOC-constraint types*.

vars

Variables of SOC constarint, which can be *VarArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Set type as regular, variables as [z, x, y] for SOC constraint builder
conebuilder.setBuilder(COPT.CONE_QUAD, [z, x, y])
```

ConeBuilder.getType()

Synopsis

```
getType()
```

Description

Retrieve the Second-Order-Cone (SOC) constraint type of *ConeBuilder Class* object.

Example

```
# Retrieve the type of SOC constraint builder conex.
conetype = conebuilder.getType(conex)
```

ConeBuilder.getVar()

Synopsis

```
getVar(idx)
```

Description

Retrieve the corresponding variables according to its indice in *ConeBuilder Class* object, and return a *Var Class* object.

Arguments

idx

Indice of the variable in *ConeBuilder Class* object, starting with 0.

Example


```
# Retrieve the variable in SOC constraint builder conex with indice of 1
conevar = conex.getVar(1)
```

ConeBuilder.getVars()

Synopsis

```
getVars()
```

Description

Retrieve all variables in *ConeBuilder Class* objects, and return a *VarArray Class* object.

Example

```
# Retrieve all variables in SOC constraint builder conex.
conevars = conex.getVars()
```

ConeBuilder.getSize()

Synopsis

```
getSize()
```

Description

Retrieve the number of elements in *ConeBuilder Class* object.

Example

```
# Retrieve the number of elements in SOC constraint builder conex.
conesize = conex.getSize()
```

22.2.31 ConeBuilderArray Class

In order to facilitate users to operate on a set of *ConeBuilder Class* objects, COPT provides ConeBuilderArray class in Python interface, providing the following methods:

ConeBuilderArray()

Synopsis

```
ConeBuilderArray(conebuilders=None)
```

Description

Create a *ConeBuilderArray Class* object.

If parameter **conebuilders** is **None**, then create an empty *ConeBuilderArray Class* object, otherwise initialize the newly created *ConeBuilderArray Class* object with parameter **conebuilders**.

Arguments

conebuilders

SOC constraint builder to be added. Optional, **None** by default. Could be *ConeBuilder Class* object, *ConeBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty ConeBuilderArray object.
conebuilderarr = ConeBuilderArray()
# Create a ConeBuilderArray object and initialize it with SOC constraint builder
↳ coneX and coneY
conebuilderarr = ConeBuilderArray([coneX, coneY])
```

ConeBuilderArray.pushBack()

Synopsis

```
pushBack(conebuilder)
```

Description

Add one or multiple *ConeBuilder Class* objects.

Arguments

conebuilder

SOC constraint builder to be added. Could be *ConeBuilder Class* object, *ConeBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add SOC constraint builder coneX to conebuilderarr
conebuilderarr.pushBack(coneX)
```

ConeBuilderArray.getBuilder()

Synopsis

```
getBuilder(idx)
```

Description

Retrieve the corresponding builder according to the indice of SOC constraint builder in *ConeBuilderArray Class* object.

Arguments

idx

Indice of the SOC constraint builder in *ConeBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the SOC constraint builder with indice of 1 in conebuilderarr
ConeBuilder = conebuilderarr.getBuilder(1)
```

ConeBuilderArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *ConeBuilderArray Class* object.

Example

```
# Retrieve the number of elements in conebuilderarr
conebuildersize = conebuilderarr.getSize()
```

22.2.32 ExpCone Class

ExpCone object contains related operations of COPT exponential cone constraints. The following methods are provided:

ExpCone.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the subscript of exponential cone constraint in model.

Example

```
# Retrieve the subscript of exponential cone constraint cone.
coneidx = cone.getIdx()
```

ExpCone.remove()**Synopsis**

```
remove()
```

Description

Delete the exponential cone constraint from model.

Example

```
# Delete the exponential cone constraint 'cone'
cone.remove()
```

22.2.33 ExpConeArray Class

To facilitate users to operate on a set of *ExpCone Class* objects, COPT designed ExpConeArray class in Python interface. The following methods are provided:

ExpConeArray()

Synopsis

```
ExpConeArray(cones=None)
```

Description

Create a *ExpConeArray Class* object.

If parameter `cones` is `None`, then build an empty *ExpConeArray Class* object, otherwise initialize the newly created *ExpConeArray Class* object with `cones`.

Arguments

`cones`

Exponential cone constraint to be added. Optional, `None` by default. It can be *ExpCone Class* object, *ExpConeArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create a new ExpConeArray object
conearr = ExpConeArray()
# Create a ExpConeArray object, and initialize it with exponential cone constraints
↳ conex and coney.
conearr = ExpConeArray([conex, coney])
```

ExpConeArray.pushBack()

Synopsis

```
pushBack(cone)
```

Description

Add one or multiple *ExpCone Class* objects.

Arguments

`cone`

Exponential cone constraints to be added, which can be *ExpCone Class* object, *ExpConeArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add exponential cone constraint conex to conearr
conearr.pushBack(conex)
# Add exponential cone constraints conex and coney to conearr
conearr.pushBack([conex, coney])
```

ExpConeArray.getCone()**Synopsis**

```
getCone(idx)
```

Description

Retrieve the corresponding exponential cone constraint according to its subscript in *ExpConeArray Class* object and return a *ExpCone Class* object.

Arguments

`idx`

Indice of the exponential cone constraint in *ExpConeArray Class* object, starting with 0.

Example

```
# Retrieve the exponential cone constraint with indice of 1 in conearr
cone = conearr.getCone(1)
```

ExpConeArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *ExpConeArray Class* object.

Example

```
# Retrieve the number of exponential cone constraints in conearr.
arrsize = conearr.getSize()
```

22.2.34 ExpConeBuilder Class

For easy access builders of exponential cone constraints, ExpConeBuilder class provides the following methods:

ExpConeBuilder()**Synopsis**

```
ExpConeBuilder()
```

Description

Create an empty *ExpConeBuilder Class* object.

Example

```
# Create an empty ExpConeBuilder object.
ExpConeBuilder = ExpConeBuilder()
```

ExpConeBuilder.setBuilder()

Synopsis

```
setBuilder(conetype, vars)
```

Description

Set type of variables of *ExpConeBuilder Class* object.

Arguments

conetype

Type of exponential cone constraint. Full list of available types can be found in *exponential cone types*.

vars

Variables of exponential cone constraint, which can be *VarArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Set type as regular, variables as [z, x, y] for exponential cone constraint builder
ExpConeBuilder.setBuilder(COPT.EXPCONE_PRIMAL, [z, x, y])
```

ExpConeBuilder.getType()

Synopsis

```
getType()
```

Description

Retrieve the exponential cone constraint type of *ExpConeBuilder Class* object.

Example

```
# Retrieve the type of exponential cone constraint builder conex.
conetype = ExpConeBuilder.getType(conex)
```

ExpConeBuilder.getVar()

Synopsis

```
getVar(idx)
```

Description

Retrieve the corresponding variables according to its indice in *ExpConeBuilder Class* object, and return a *Var Class* object.

Arguments

idx

Indice of the variable in *ExpConeBuilder Class* object, starting with 0.

Example

```
# Retrieve the variable in exponential cone constraint builder conex with indice of 1
conevar = conex.getVar(1)
```

ExpConeBuilder.getVars()**Synopsis**

```
getVars()
```

Description

Retrieve all variables in *ExpConeBuilder Class* objects, and return a *VarArray Class* object.

Example

```
# Retrieve all variables in exponential cone constraint builder conex.
conevars = conex.getVars()
```

ExpConeBuilder.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *ExpConeBuilder Class* object.

Example

```
# Retrieve the number of elements in exponential cone constraint builder conex.
conesize = conex.getSize()
```

22.2.35 ExpConeBuilderArray Class

In order to facilitate users to operate on a set of *ExpConeBuilder Class* objects, COPT provides *ExpConeBuilderArray* class in Python interface, providing the following methods:

ExpConeBuilderArray()**Synopsis**

```
ExpConeBuilderArray(ExpConeBuilders=None)
```

Description

Create a *ExpConeBuilderArray Class* object.

If parameter *ExpConeBuilders* is *None*, then create an empty *ExpConeBuilderArray Class* object, otherwise initialize the newly created *ExpConeBuilderArray Class* object with parameter *ExpConeBuilders*.

Arguments

ExpConeBuilders

Exponential cone constraint builder to be added. Optional, *None* by default. Could be *ExpConeBuilder Class* object, *ExpConeBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create an empty ExpConeBuilderArray object.
ExpConeBuilderarr = ExpConeBuilderArray()
# Create a ExpConeBuilderArray object and initialize it with exponential cone
↳ constraint builder conex and coney
ExpConeBuilderarr = ExpConeBuilderArray([conex, coney])
```

ExpConeBuilderArray.pushBack()

Synopsis

```
pushBack(conebuilder)
```

Description

Add one or multiple *ExpConeBuilder Class* objects.

Arguments

conebuilder

Exponential cone constraint builder to be added. Could be *ExpConeBuilder Class* object, *ExpConeBuilderArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Add exponential cone constraint builder conex to ExpConeBuilderarr
ExpConeBuilderarr.pushBack(conex)
```

ExpConeBuilderArray.getBuilder()

Synopsis

```
getBuilder(idx)
```

Description

Retrieve the corresponding builder according to the indice of exponential cone constraint builder in *ExpConeBuilderArray Class* object.

Arguments

idx

Indice of the exponential cone constraint builder in *ExpConeBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the exponential cone constraint builder with indice of 1 in
↳ ExpConeBuilderarr
ExpExpConeBuilder = ExpConeBuilderarr.getBuilder(1)
```


ExpConeBuilderArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *ExpConeBuilderArray Class* object.

Example

```
# Retrieve the number of elements in ExpConeBuilderarr
ExpConeBuildersize = ExpConeBuilderarr.getSize()
```

22.2.36 AffineCone Class

The AffineCone class encapsulates operations related to affine cone in COPT. The following methods are provided:

AffineCone.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the index of the affine cone in the model.

Example

```
# Retrieve the index of the afcone
afconeidx = afcone.getIdx()
```

AffineCone.getName()**Synopsis**

```
getName()
```

Description

Retrieve the name of the affine cone.

Example

```
# Retrieve the name of the afcone
afconename = afcone.getName()
```

AffineCone.setName()**Synopsis**

```
setName(newname)
```

Description

Set the name of the affine cone.

Arguments

`newname`

The name to set for the affine cone.

Example

```
# Set the name of the afcone
afcone.setName("afcone")
```

AffineCone.remove()**Synopsis**

```
remove()
```

Description

Remove the current affine cone from the model.

Example

```
# Remove the current afcone from the model
afcone.remove()
```

22.2.37 AffineConeArray Class

To facilitate user operations on a group of *AffineCone Class* objects, COPT introduces the *AffineConeArray* class. The following methods are provided:

AffineConeArray()**Synopsis**

```
AffineConeArray(cones=None)
```

Description

Creates an *AffineConeArray Class* object.

If the argument `cones` is `None`, an empty *AffineConeArray Class* object is created. Otherwise, the new *AffineConeArray Class* object is initialized with the argument `cones`.

Arguments

`cones`

Affine cone constraints to be added. This is an optional parameter, the default value is `None`.

Acceptable values include *AffineCone Class* objects, *AffineConeArray Class* objects, lists, dictionaries, or *tupledict Class* objects.

Example

```
# Create an empty AffineConeArray object
afconearr = AffineConeArray()
# Create an AffineConeArray object initialized with afconex and afconey
afconearr = AffineConeArray([afconex, afconey])
```

AffineConeArray.pushBack()

Synopsis

```
pushBack(cone)
```

Description

Adds one or more *AffineCone Class* objects.

Arguments

cone

Affine cone constraints to be added. Possible values include *AffineCone Class* objects, *AffineConeArray Class* objects, lists, dictionaries, or *tuple-dict Class* objects.

Example

```
# Add afconex to afconearr
afconearr.pushBack(afconex)
# Add afconex and afconey to afconearr
afconearr.pushBack([afconex, afconey])

dict_cone = {'AC': afcone1, 'CA': afcone2}
afconearr2 = AffineConeArray({'AC': afcone1, 'CA': afcone2})
```

AffineConeArray.getCone()

Synopsis

```
getCone(idx)
```

Description

Retrieves the affine cone at the specified index in the *AffineConeArray Class* object.
Returns an *AffineCone Class* object.

Arguments

idx

Index of the affine cone constraint in the *AffineConeArray Class* object.
Indexing starts at 0.

Example

```
# Retrieve the affine cone at index 1 in afconearr
afcone = afconearr.getCone(1)
```

AffineConeArray.getSize()

Synopsis

```
getSize()
```

Description

Retrieves the number of elements in the *AffineConeArray Class* object.

Example

```
# Get the number of affine cone in afconearr
arrsize = afconearr.getSize()
```

22.2.38 AffineConeBuilder Class

The *AffineConeBuilder* class is an encapsulation of the builder for constructing affine cone in COPT. The following methods are provided:

AffineConeBuilder()

Synopsis

```
AffineConeBuilder()
```

Description

Creates an empty *AffineConeBuilder Class* object.

Example

```
# Create an empty AffineConeBuilder object
afconebuilder = AffineConeBuilder()
```

AffineConeBuilder.setBuilder()

Synopsis

```
setBuilder(conetype, exprs)
```

Description

Sets up the affine cone builder according to `conetype` and `exprs` .

Arguments

`conetype`

The type of affine cone. For possible values, refer to *Second-Order Cone Constraint Types* and *Exponential Cone Constraint Types*.

`exprs`

Mathematical expressions forming the affine cone. Possible values include linear expressions or semidefinite expressions.

Example

```
# Set the affine cone builder's type to standard second-order cone,
# composed of z, x+y, y
afconebuilder = AffineConeBuilder()
afconebuilder.setBuilder(COPT.CONE_QUAD, [z, x+y, y])
```

AffineConeBuilder.hasPsdTerm()**Synopsis**

```
hasPsdTerm()
```

Description

Checks if the affine cone builder contains any semidefinite terms.

Return Value

Bool. If `False`, the affine cone contains no semidefinite terms, and linear expressions can be directly retrieved.

AffineConeBuilder.getType()**Synopsis**

```
getType()
```

Description

Retrieves the affine cone type of the *AffineConeBuilder Class* object.

Example

```
# Retrieve the type of afconex
afconetype = afconebuilder.getType(afconex)
```

AffineConeBuilder.getExpr()**Synopsis**

```
getExpr(idx)
```

Description

Retrieves the expression at the specified index in the affine cone builder.

Arguments

```
idx
```

The index of the expression in the affine cone builder, starting with 0 .

Return Value

If semidefinite terms exist, returns a *PsdExpr* object; otherwise, returns a *LinExpr* object.

Example

```
# Retrieve the expression at index 0 in the affine cone builder
expr = afconstrbuilder.getExpr(0)
```

AffineConeBuilder.getPsdExpr()**Synopsis**

```
getPsdExpr(idx)
```

Description

Retrieves the semidefinite expression at the specified index in the affine cone builder.

Arguments

`idx`

The index of the semidefinite expression in the affine cone builder, , starting with 0 .

Return Value

Returns a *PsdExpr* object.

Example

```
# Retrieve the semidefinite expression at index 0 in the afconstrbuilder
psdexpr = afconstrbuilder.getPsdExpr(0)
```

AffineConeBuilder.getExprs()**Synopsis**

```
getExprs(idx=None)
```

Description

Retrieves a group of expressions from the affine cone builder at the specified indices.

Arguments

`idx`

The indices of the expressions in the affine cone builder.

If `idx` is `None`, all expressions in the affine cone are returned. If `idx` is a Python list, the expressions at the specified indices are returned.

Return Value

If semidefinite terms exist, returns *PsdExpr* objects; otherwise, returns *LinExpr* objects.

Example

```
# Retrieve all expressions in the affine cone builder
allexprs = afconstrbuilder.getExprs()
```

AffineConeBuilder.getPsdExprs()**Synopsis**

```
getPsdExprs(idx=None)
```

Description

Retrieves a group of semidefinite expressions from the affine cone builder at the specified indices.

Arguments

`idx`

The indices of the semidefinite expressions in the affine cone builder.

If `idx` is `None`, all semidefinite expressions in the affine cone are returned.

If `idx` is a Python list, the semidefinite expressions at the specified indices are returned.

Return Value

Returns *PsdExpr* objects.

Example

```
# Retrieve all semidefinite expressions in the afconstrbuilder
allpsdexprs = afconstrbuilder.getPsdExprs()
```

AffineConeBuilder.getSize()**Synopsis**

```
getSize()
```

Description

Retrieves the number of expressions in the affine cone builder.

Example

```
# Retrieve the number of expressions in the afconebuilder
afconesize = afconebuilder.getSize()
```

22.2.39 AffineConeBuilderArray Class

To facilitate user operations on a group of *AffineConeBuilder Class* objects, COPT introduces the *AffineConeBuilderArray* class, providing the following methods:

AffineConeBuilderArray()**Synopsis**

```
AffineConeBuilderArray(conebuilders=None)
```

Description

Creates an *AffineConeBuilderArray Class* object.

If the argument `conebuilders` is `None`, an empty *AffineConeBuilderArray Class* object is created. Otherwise, the new *AffineConeBuilderArray Class* object is initialized with the argument `conebuilders`.

Arguments

conebuilders

Affine cone constraint builders to add. This is an optional argument, defaulting to `None`. Acceptable values include *AffineConeBuilder Class* objects, *AffineConeBuilderArray Class* objects, lists, dictionaries, or *tupledict Class* objects.

Example

```
# Create an empty AffineConeBuilderArray object
conebuilderarr = AffineConeBuilderArray()
# Create an AffineConeBuilderArray object initialized with conex and coney
conebuilderarr = AffineConeBuilderArray([conex, coney])
```

AffineConeBuilderArray.pushBack()**Synopsis**

```
pushBack(AffineConeBuilder)
```

Description

Adds one or more *AffineConeBuilder Class* objects.

Arguments

AffineConeBuilder

Affine cone builders to add. Acceptable values include *AffineConeBuilder Class* objects, *AffineConeBuilderArray Class* objects, lists, dictionaries, or *tupledict Class* objects.

Example

```
# Add affine cone builder afconex to afconebuilderarr
afconebuilderarr.pushBack(afconex)
```

AffineConeBuilderArray.getBuilder()**Synopsis**

```
getBuilder(idx)
```

Description

Retrieves the affine cone builder at the specified index in the *AffineConeBuilderArray Class* object.

Arguments

idx

The index of the affine cone builder in the *AffineConeBuilderArray Class* object. Indexing starts at 0.

Example

```
# Retrieve the second-order affine cone builder at index 1 in afconebuilderarr
affineConeBuilder = afconebuilderarr.getBuilder(1)
```


AffineConeBuilderArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieves the number of elements in the *AffineConeBuilderArray Class* object.

Example

```
# Get the number of elements in afconebuilderarr
afconebuildersize = afconebuilderarr.getSize()
```

22.2.40 GenConstr Class

For easy access to indicator constraints, COPT provides GenConstr class which containing the following methods:

GenConstr.getName()**Synopsis**

```
getName()
```

Description

Retrieve the name of the indicator constraint in model.

Example

```
# Retrieve the name of indicator constraint indicx
indiname = indicx.getName()
```

GenConstr.setName()**Synopsis**

```
setName(newname)
```

Description

Set the name of the indicator constraint in model with **newname** .

Example

```
# Set the name of the indicator constraint indicx with "if"
indicx.setName("if")
```

GenConstr.getIdx()**Synopsis**

```
getIdx()
```

Description

Retrieve the subscript of indicator constraint in model.

Example

```
# Retrieve the indice of indicator constraint indicx
indidx = indicx.getIdx()
```

GenConstr.remove()**Synopsis**

```
remove()
```

Description

Delete the indicator constraint from model.

Example

```
# Delete indicator constraint 'indx'
indx.remove()
```

22.2.41 GenConstrArray Class

In order to facilitate users to operate on a set of *GenConstr Class* objects, COPT provides *GenConstrArray* class in Python interface, providing the following methods:

GenConstrArray()**Synopsis**

```
GenConstrArray(genconstrs=None)
```

Description

Create a *GenConstrArray Class* object.

If parameter `genconstrs` is `None`, then create an empty *GenConstrArray Class* object, otherwise initialize the newly created *GenConstrArray Class* object with parameter `genconstrs`.

Arguments

`genconstrs`

Indicator constraint to be added. Optional, `None` by default. Could be *GenConstr Class* object, *GenConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Create a new GenConstrArray object
genconstrarr = GenConstrArray()
# Create a GenConstrArray object and user indicator constraints genx and geny to
↳ initialize it.
genconstrarr = GenConstrArray([genx, geny])
```

GenConstrArray.pushBack()

Synopsis

```
pushBack(genconstr)
```

Description

Add one or multiple *GenConstr Class* objects.

Arguments

constrs

The indicator constraint to be added. Could be *GenConstr Class* object, *GenConstrArray Class* object, list, dictionary or *tupledict Class* object.

Example

```
# Aff indicator constraint genx to genconarr
genconarr.pushBack(genx)
# Add indicator constraint genx and geny to genconarr
genconarr.pushBack([genx, geny])
```

GenConstrArray.getGenConstr()

Synopsis

```
getGenConstr(idx)
```

Description

Retrieve the corresponding indicator constraint according to the indice of indicator constraint in *GenConstrArray Class* object, and return a *GenConstr Class* object.

Arguments

idx

Indice of the indicator constraint in *GenConstrArray Class*, starting with 0.

Example

```
# Retrieve the indicator constraint with indice of 1 in genconarr
genconstr = genconarr.getGenConstr(1)
```

GenConstrArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in *GenConstrArray Class* object.

Example

```
# Retrieve the number of elements in genconarr
genconsize = genconarr.getSize()
```

22.2.42 GenConstrBuilder Class

GenConstrBuilder object contains operations for building indicator constraints, and provides the following methods:

GenConstrBuilder()**Synopsis**

```
GenConstrBuilder()
```

Description

Create an empty *GenConstrBuilder Class* object.

Example

```
# Create an empty GenConstrBuilder object
genconbuilder = GenConstrBuilder()
```

GenConstrBuilder.setBuilder()**Synopsis**

```
setBuilder(var, val, expr, sense, type=COPT.INDICATOR_IF)
```

Description

Set indicator variable, the value of indicator variable, the expression/sense of constraint, and the type of indicator constraint of the *GenConstrBuilder Class* object.

Arguments

var

Indicator variable.

val

Value of an indicator variable.

expr

Expression of linear constraint, which can be *Var Class* object or *LinExpr Class* object.

sense

Sense for the linear constraint. Please refer to *Constraint type* for possible values.

type

Type of the indicator constraint. The default value is COPT.INDICATOR_IF (If-Then). Please refer to *Indicator constraint type* for possible values.

Example

```
# Set indicator variable of indicator constraint builder to x. When x is true, the
↪ linear constraint  $x + y == 1$  holds
genconbuilder.setBuilder(x, True, x + y - 1, COPT.EQUAL)
```

GenConstrBuilder.getBinVar()

Synopsis

getBinVar()

Description

Retrieve the indicator variable of a *GenConstrBuilder Class* object.

Example

```
# Retrieve the indicator variable of indicator constraint builder genbuilderx
indvar = genbuilderx.getBinVar()
```

GenConstrBuilder.getBinVal()

Synopsis

getBinVal()

Description

Retrieve the value of indicator variable of a *GenConstrBuilder Class* object.

Example

```
# Retrieve the value when the indicator variable of indicator constraint builder
↪ genbuilderx is valid
indval = genbuilderx.getBinVal()
```

GenConstrBuilder.getExpr()

Synopsis

getExpr()

Description

Retrieve the linear expression of a *GenConstrBuilder Class* object.

Example

```
# Retrieve the linear expression of indicator constraint builder genbuilderx
linexpr = genbuilderx.getExpr()
```

GenConstrBuilder.getSense()

Synopsis

```
getSense()
```

Description

Retrieve the sense for the linear constraint of a *GenConstrBuilder Class* object.

Example

```
# Retrieve the sense for the linear constraint of indicator constraint builder
↳ genbuilderx
linsense = genbuilderx.getSense()
```

GenConstrBuilder.getIndType()

Synopsis

```
getIndType()
```

Description

Retrieve the type for the indicator constraint of a *GenConstrBuilder Class* object.

Example

```
# Retrieve the type for the indicator constraint of indicator constraint builder
↳ genbuilderx
linsense = genbuilderx.getIndType()
```

22.2.43 GenConstrBuilderArray Class

To facilitate users to operate on multiple *GenConstrBuilder Class* objects, the Python interface of COPT provides *GenConstrBuilderArray* object with the following methods:

GenConstrBuilderArray()

Synopsis

```
GenConstrBuilderArray(genconstrbuilders=None)
```

Description

Create a *GenConstrBuilderArray Class* object.

If argument `genconstrbuilders` is `None`, then create an empty *GenConstrBuilderArray Class* object; otherwise use the argument `genconstrbuilders` to initialize the newly created *GenConstrBuilderArray Class* object.

Arguments

`genconstrbuilders`

Indicator constraint builder to add. Optional, `None` by default. It can be *GenConstrBuilder Class* object, *GenConstrBuilderArray Class* object, list, dict, or *tupledict Class* object.

Example

```
# Create an empty GenConstrBuilderArray object
genbuilderarr = GenConstrBuilderArray()
# Create a GenConstrBuilderArray object and use indicator constraint builder
↳ genbuilderx and genbuildery to initialize it.
genbuilderarr = GenConstrBuilderArray([genbuilderx, genbuildery])
```

GenConstrBuilderArray.pushBack()

Synopsis

```
pushBack(genconstrbuilder)
```

Description

Add single or multiple *GenConstrBuilder Class* objects.

Arguments

genconstrbuilder

Indicator constraint builders to add, which can be *GenConstrBuilder Class* object, *GenConstrBuilderArray Class* object, list, dict, or *tupledict Class* object.

Example

```
# Add an indicator constraint builder to genbuilderarr
genbuilderarr.pushBack(genbuilderx)
# Add indicator constraint builders genbuilderx and genbuildery to genbuilderarr
genbuilderarr.pushBack([genbuilderx, genbuildery])
```

GenConstrBuilderArray.getBuilder()

Synopsis

```
getBuilder(idx)
```

Description

Retrieve the indicator constraint builder according to its index in the *GenConstrBuilderArray Class* object, and return a *GenConstrBuilder Class* object.

Arguments

idx

Index of the indicator constraint builder in the *GenConstrBuilderArray Class* object, starting with 0.

Example

```
# Retrieve the indicator constraint builder whose index in genbuilderarr is 1
genbuilder = genbuilderarr.getBuilder(1)
```

GenConstrBuilderArray.getSize()

Synopsis

getSize()

Description

Retrieve the number of elements in the *GenConstrBuilderArray Class* object.

Example

```
# Retrieve the number of elements in genbuilderarr
genbuildersize = genbuilderarr.getSize()
```

22.2.44 Column Class

To facilitate users to model by column, the Python interface of COPT provides Column object with the following methods:

Column()

Synopsis

Column(constrs=0.0, coeffs=None)

Description

Create an *Column Class* object.

If argument **constrs** is **None** and argument **coeffs** is **None**, then create an empty *Column Class* object; otherwise use the argument **constrs** and **coeffs** to initialize the newly created *Column Class* object. If argument **constrs** is a *Constraint Class* or *Column Class* object, then argument **coeffs** is a constant. If argument **coeffs** is **None**, then it is considered to be constant 1.0; If argument **constrs** is a list and argument **coeffs** is **None**, then the elements of argument **constrs** are constraint-coefficient pairs; For other forms of arguments, call method **addTerms** to initialize the newly created *Column Class* object.

Arguments

constrs

Linear constraint.

coeffs

Coefficient for variables in the linear constraint.

Example

```
# Create an empty Column object
col = Column()
# Create a Column object and add two terms: coefficient is 2 in constraint conx and 3
  ↳ in constraint cony
col = Column([(conx, 2), (cony, 3)])
# Create a Column object and add two terms: coefficient is 1 in constraint conxx and
  ↳ 2 in constraint conyy
col = Column([conxx, conyy], [1, 2])
```


Column.getCoeff()

Synopsis

```
getCoeff(idx)
```

Description

Retrieve the coefficient according to its index in the *Column Class* object.

Arguments

idx

Index for the element, starting with 0.

Example

```
# Retrieve the coefficient whose index is 0 in col
coeff = col.getCoeff(0)
```

Column.getConstr()

Synopsis

```
getConstr(idx)
```

Description

Retrieve the linear constraint according to its index in the *Column Class* object.

Arguments

idx

Index for the element, starting with 0.

Example

```
# Retrieve the linear constraint whose index is 1 in col
constr = col.getConstr(1)
```

Column.getSize()

Synopsis

```
getSize()
```

Description

Retrieve the number of elements in the *Column Class* object.

Example

```
# Retrieve the number of elements in col
colsize = col.getSize()
```

Column.addTerm()

Synopsis

```
addTerm(constr, coeff=1.0)
```

Description

Add a new term.

Arguments

`constr`

The linear constraint for the term to add.

`coeff`

The coefficient for the term to add. Optional, 1.0 by default.

Example

```
# Add an term to col, whose constraint is cony and coefficient is 2.0
col.addTerm(cony, 2.0)
# Add an term to col, whose constraint is conx and coefficient is 1.0
col.addTerm(conx)
```

Column.addTerms()

Synopsis

```
addTerms(constrs, coeffs)
```

Description

Add single or multiple terms.

If argument `constrs` is *Constraint Class* object, then argument `coeffs` is constant;
If argument `constrs` is *ConstrArray Class* object or list, then argument `coeffs` is constant or list;
If argument `constrs` is dictionary or *tupledict Class* object, then argument `coeffs` is constant, dict, or *tupledict Class* object.

Arguments

`constrs`

The linear constraints for terms to add.

`coeffs`

The coefficients for terms to add.

Example

```
# Add two terms: constraint conx with coefficient 2.0, constraint cony with
↪coefficient 3.0
col.addTerms([conx, cony], [2.0, 3.0])
```

Column.addColumn()**Synopsis**

```
addColumn(col, mult=1.0)
```

Description

Add a new column to current column.

Arguments

`col`

Column to add.

`mult`

Magnification coefficient for added column. Optional, 1.0 by default.

Example

```
# Add column coly to column colx. The magnification coefficient for coly is 2.0
colx.addColumn(coly, 2.0)
```

Column.clone()**Synopsis**

```
clone()
```

Description

Create a deep copy of a column.

Example

```
# Create a deep copy of column col
colcopy = col.clone()
```

Column.remove()**Synopsis**

```
remove(item)
```

Description

Remove a term from a column.

If argument `item` is a constant, then remove the term by its index; otherwise argument `item` is a *Constraint Class* object.

Arguments

`item`

Constant index or the linear constraint for the term to be removed.

Example

```
# Remove the term whose index is 2 from column col
col.remove(2)
# Remove the term of the linear constraint conx from col
col.remove(conx)
```

Column.clear()**Synopsis**

```
clear()
```

Description

Remove all terms from a column.

Example

```
# Remove all terms from column col
col.clear()
```

22.2.45 ColumnArray Class

To facilitate users to operate on multiple *Column Class* objects, the Python interface of COPT provides *ColumnArray* object with the following methods:

ColumnArray()**Synopsis**

```
ColumnArray(columns=None)
```

Description

Create a *ColumnArray Class* object.

If argument `columns` is `None`, then create an empty *ColumnArray Class* object; otherwise use argument `columns` to initialize the newly created *ColumnArray Class* object.

Arguments

`columns`

Columns to add. Optional, `None` by default. It can be *Column Class* object, *ColumnArray Class* object, list, dict, or *tupledict Class* object.

Example

```
# Create an empty ColumnArray object
colarr = ColumnArray()
# Create a ColumnArray object and use columns colx and coly to initialize it
colarr = ColumnArray([colx, coly])
```

ColumnArray.pushBack()**Synopsis**

```
pushBack(column)
```

Description

Add single or multiple *Column Class* objects.

Arguments

`column`

Columns to add, which can be *Column Class* object, *ColumnArray Class* object, list, dict, or *tupledict Class* object.

Example

```
# Add column colx to colarr
colarr.pushBack(colx)
# Add columns colx and coly to colarr
colarr.pushBack([colx, coly])
```

ColumnArray.getColumn()**Synopsis**

```
getColumn(idx)
```

Description

Retrieve the column according to its index in a *ColumnArray Class* object. Return a *Column Class* object.

Arguments

```
idx
```

Index of the column in the *ColumnArray Class* object, starting with 0.

Example

```
# Retrieve the column whose index is 1 in colarr
col = colarr.getColumn(1)
```

ColumnArray.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of elements in a *ColumnArray Class* object.

Example

```
# Retrieve the number of element in colarr
colsize = colarr.getSize()
```

ColumnArray.clear()**Synopsis**

```
clear()
```

Description

Remove all terms from a *ColumnArray Class* object.

Example

```
# Remove all terms from colarr
colarr.clear()
```

22.2.46 MVar Class

The MVar class is used in COPT to build multi-dimensional variables and supports NumPy's multi-dimensional array operations. We recommend to generate it through the method `addVars` or `addMVar` of the model class, although it can also be converted and generated through the two built-in class methods `fromlist` and `fromvar`. The following member methods are provided:

MVar.fromlist()

Synopsis

```
fromlist(vars)
```

Description

Generate a *MVar Class* object from a set of *Var Class* objects. This is the class generation method and can be called directly without MVar object.

Arguments

`vars`

A set of Var objects, which can be a multi-dimensional list or ndarray.

Return value

new MVar object whose dimensions depend on the dimensions of the arguments `vars`.

Example

```
vars = model.addVars(4)
mx_1d = MVar.fromlist(vars)
mx_2d = MVar.fromlist([vars[0], vars[1]], [vars[2], vars[3]])
```

MVar.fromvar()

Synopsis

```
fromvar(var)
```

Description

Generate a 0-dimensional *MVar Class* object from a *Var Class* object. This is the class generation method and can be called directly without MVar object.

Arguments

`var`

A Var object.

Return value

The new 0-dimensional MVar object.

Example

```
x = model.addVar()
mx_0d = MVar.fromvar(x)
```

MVar.clone()

Synopsis

clone()

Description

Deep-copy a *MVar Class* object.

Return value

new MVar object

Example

```
# Create a 2-D variable and make a copy. Note that the actual variable is
→not incremented.
mx = model.addMVar((3, 2), nameprefix="mx")
mx_copy = mx.clone()
```

MVar.diagonal()

Synopsis

diagonal(offset=0, axis1=0, axis2=1)

Description

Generate a *MVar Class* object whose elements are the elements on the diagonal of the original MVar object.

Arguments

offset

Optional parameter, indicating the offset of the diagonal, the default value is 0. If the value is greater than 0, it means the diagonal upward offset; if the value is less than 0, it means the diagonal downward offset.

axis1

Optional parameter, the axis to use as the first axis of the 2D sub MVar, from where the diagonal should start. The default first axis is 0.

axis2

Optional parameter, the axis to use as the second axis of the 2D sub MVar, from where the diagonal should start. The default second axis is 1.

Return value

new MVar object

Example

```
mx = model.addMVar((5, 5), nameprefix="mx")
diag_m0 = mx.diagonal()
diag_a1 = mx.diagonal(1)
diag_b1 = mx.diagonal(-1)
```

MVar.getInfo()

Synopsis

```
getInfo(infoname)
```

Description

Get the information value of each variable inside MVar.

Arguments

infoname

The name of the information being queried. Please refer to [Information Section](#) for possible values.

Return value

Returns a NumPy ndarray with the same dimension as the MVar object, whose elements are the information values of the corresponding variable.

Example

```
mx = model.addMVar(3)
print(mx.getInfo("LB"))
```

MVar.item()

Synopsis

```
item()
```

Description

Get the Var variable inside the 0-dimensional MVar. Raises a ValueError exception if the MVar object is not 0-dimensional.

Return value

Returns the Var object.

Example

```
mx = model.addMVar(3)
var = mx[0].item()
```

MVar.reshape()

Synopsis

```
reshape(shape, order='C')
```

Description

Returns a new MVar object whose elements remain unchanged but whose shape is transformed by the parameter shape.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of the new MVar object.

order

Optional parameter, the default is the character 'C', which means it is compatible with the C language, that is, it is stored in rows; it can also be set to the character 'F', that is, it is stored in columns, and it is compatible with the Fortune language.

Return value

Returns a new MVar object with the same elements as the original MVar object but with a different shape.

Example

```
mx = model.addMVar(6)
mx_2x3 = mx.reshape((2, 3))
```

MVar.setInfo()

Synopsis

```
setInfo(infoname, newval)
```

Description

Sets the information value of each variable inside the MVar.

Arguments

infoname

The name of the information being queried. Please refer to *Information Section* for possible values.

newval

The information value to be set.

Example

```
mx = model.addMVar(3)
mx.setInfo("ub", 9.0)
mx.setInfo(COPT.Info.LB, 0.0)
```

MVar.sum()

Synopsis

```
sum(axis=None)
```

Description

Sum the variables in the MVar, returning a new *MLinExpr Class* object.

Arguments

axis

Optional integer parameter, the default value is None, that is, to sum up variables one by one. Otherwise, sum over the given axis.

Return value

Returns an MLinExpr object representing the sum of the corresponding variables.

Example

```
mx = model.addMVar((3, 5))
sum_all = mx.sum() #Return 0-dimensional MLinExpr object
sum_row = mx.sum(axis = 0) #Return a 1-dimensional MLinExpr object with a
↳ shape of (5, )
```

MVar.tolist()

Synopsis

```
tolist()
```

Description

Convert an MVar object to a one-dimensional list of Var objects.

Return value

Returns a one-dimensional list containing Var objects.

Example

```
mx = model.addMVar((3, 5))
print(mx.tolist())
```

MVar.transpose()

Synopsis

```
transpose()
```

Description

Generates a new MVar object that is the transpose of the original MVar object.

Return value

Return the new MVar object.

Example

```
mx = model.addMVar((3, 5))
print(mx.transpose().shape) #its shape is (5, 3)
```

MVar.ndim

Synopsis

```
ndim
```

Description

Dimensions of the MVar object.

Return value

Integer value.

Example

```
mx = model.addMVar((3, 5))
print(mx.ndim) #ndim = 2
```

MVar.shape

Synopsis

shape

Description

The shape of the MVar object.

Return value

Integer tuple.

Example

```
mx = model.addMVar((3,))
print(mx.shape) # shape = (3, )
```

MVar.size

Synopsis

size

Description

The number of Var variables in the MVar object.

Return value

Integer value.

Example

```
mx = model.addMVar((3, 4))
print(mx.size) # size = 12
```

MVar.T

Synopsis

T

Description

Transpose of the MVar object. Similar to the class method transpose().

Return value

Returns the transposed MVar object.

Example

```
mx = model.addMVar((3, 4))
print(mx.T.shape) # shape = (4, 3)
```

22.2.47 MConstr Class

The MConstr class holds multi-dimensional linear constraints in COPT and supports NumPy's multi-dimensional array operations. It is generated by the method `addConstrs` or `addMConstr` of the model class. The following member methods are provided:

MConstr.getInfo()

Synopsis

```
getInfo(infoname)
```

Description

Get the information value of each constraint within MConstr.

Arguments

`infoname`

The name of the information being queried. Please refer to [Information Section](#) for possible values.

Return value

Returns a NumPy ndarray with the same dimension as the MConstr object, whose elements are the attribute values of the corresponding constraint.

Example

```
a = np.random.rand(4)
mx = m.addMVar((4, 3), nameprefix="mx")
b = np.random.rand(3)
mc = m.addConstrs(a @ mx <= b)
print(mc.getInfo("pi"))
```

MConstr.item()

Synopsis

```
item()
```

Description

Get the constraint object in 0-dimensional MConstr. If the MConstr object is not 0-dimensional, a `ValueError` exception is raised.

Return value

Returns the linear constraint object.

Example

```
mc = m.addConstrs(a @ mx <= b)
print(mc[0].item())
```

MConstr.reshape()**Synopsis**

```
reshape(shape, order='C')
```

Description

Returns a new MConstr object whose elements remain unchanged but whose shape is transformed by the argument shape.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of the new MConstr object.

order

Optional parameter, the default is the character 'C', which means it is compatible with the C language, that is, it is stored in rows; it can also be set to the character 'F', that is, it is stored in columns, and it is compatible with the Fortune language.

Return value

Returns a new MConstr object with the same elements as the original MConstr object but with a different shape.

Example

```
mc = m.addConstrs(a @ mx <= b)
mc_2x2 = mc.reshape((2, 2))
```

MConstr.setInfo()**Synopsis**

```
setInfo(infename, newval)
```

Description

Set information values for each constraint within MConstr.

Arguments

infename

The name of the information to be set. Please refer to *Information Section* for possible values.

newval

The new value to be set.

Example

```
mc = model.addConstrs(a @ mx <= b)
mc.setInfo("obj", 9.0)
```

MConstr.tolist()**Synopsis**

```
tolist()
```

Description

Convert the MConstr object to a one-dimensional list of constraints.

Return value

Returns a one-dimensional list containing Constraint objects.

Example

```
mc = m.addConstrs(a @ mx <= b)
print(mc.tolist())
```

MConstr.transpose()**Synopsis**

```
transpose()
```

Description

Generates a new MConstr object that is the transpose of the original MConstr object.

Return value

Returns the transposed MConstr object.

Example

```
mc = m.addConstrs(a @ mx <= b)
print(mc.transpose())
```

MConstr.ndim**Synopsis**

```
ndim
```

Description

Dimensions of the MConstr object.

Return value

Integer value.

Example

```
mc = m.addConstrs(a @ mx <= b)
print(mc.ndim)
```

MConstr.shape**Synopsis**

shape

Description

The shape of the MConstr object.

Return value

Integer tuple.

Example

```
mc = m.addConstrs(a @ mx <= b)
print(mc.shape)
```

MConstr.size**Synopsis**

size

Description

The number of constraints of the MConstr object.

Return value

Integer value.

Example

```
mc = m.addConstrs(a @ mx <= b)
print(mc.size)
```

MConstr.T**Synopsis**

T

Description

Transpose of the MConstr object. Similar to the class method transpose().

Return value

Returns the transposed MConstr object.

Example

```
A = np.ones([2, 4])
mx = m.addMVar((4, 3), nameprefix="mx")
mc = m.addConstrs(A @ X == 0.0)
print(mc.T.shape) # shape = (3, 2)
```

22.2.48 MConstrBuilder Class

The MConstrBuilder class is used to build multi-dimensional linear constraints in COPT and supports NumPy's multi-dimensional array operations. Users might create a MConstrBuilder object by its constructor with a list of *ConstrBuilder Class* objects, or simply by overloaded comparison operator of *MLinearExpr Class*. The following member methods are provided:

MConstrBuilder()

Synopsis

```
MConstrBuilder(args, shape=None)
```

Description

constructor of MConstrBuilder.

Arguments

args

one or a set of *ConstrBuilder Class* objects, in form of Python list or NumPy ndarray.

shape

an integer, or tuple of integers, which is the shape of new MConstrBuilder object.

Example

```
vars = m.addVars(4)
builders = [x <= 1.0 for x in vars]
mcb = MConstrBuilder(builders, (2, 2))

# or by overloaded comparison operator of MVar
mx = m.addMVar((3, 2))
mcb = mx >= 1.0

# or immediately passed to addConstrs()
model.addConstrs(mx >= 1.0)
```

22.2.49 MQConstr Class

The MQConstr class holds multi-dimensional quadratic constraints in COPT and supports NumPy's multi-dimensional array operations. In experimental version of matrix modeling, it is generated by the method addQConstr or addMQConstr of the model class. The following member methods are provided:

MQConstr.getInfo()

Synopsis

```
getInfo(infoname)
```

Description

Get the information value of each quadratic constraint within MQConstr.

Arguments

infoname

The name of the information being queried. Please refer to [Information Section](#) for possible values.

Return value

Returns a built-in ndarray with the same shape as the MQConstr object, whose elements are the information values of the corresponding constraints.

Example

```
mx = m.addMVar((1, 3), nameprefix="mx")
mc = m.addQConstr(mx @ mx.T <= 1.0)
print(mc.getInfo("x"))
```

MQConstr.item()

Synopsis

```
item()
```

Description

Get the quadratic constraint object in MQConstr object. If the MQConstr object has more than one item, an exception of ValueError is raised.

Return value

Returns the quadratic constraint object.

Example

```
mc = m.addQConstr(mx @ mx.T <= 1.0)
print(mc.item())
```

MQConstr.reshape()

Synopsis

```
reshape(shape, order='C')
```

Description

Returns a new MQConstr object whose elements remain unchanged but whose shape is transformed by the argument shape.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of the new MQConstr object.

order

Optional parameter, the default is the character 'C', which means it is compatible with the C language. The other option 'F' is not implemented yet.

Return value

Returns a new MQConstr object with the same elements as the original MQConstr object but with a different shape.

Example

```
mc = m.addQConstr(mx.T @ mx <= 1.0)
mc_1x9 = mc.reshape((1, 9))
```

MQConstr.setInfo()

Synopsis

```
setInfo(infoname, newval)
```

Description

Set information values for each quadratic constraint within MQConstr.

Arguments

infoname

The name of the information to be set. Please refer to *Information Section* for possible values.

newval

The new value to be set.

Example

```
mc = model.addQConstr(mx @ mx.T <= 1.0)
mc.setInfo("LB", 9.0)
```

MQConstr.tolist()

Synopsis

```
tolist()
```

Description

Convert the MQConstr object to a one-dimensional list of quadratic constraints.

Return value

Returns a one-dimensional list containing *QConstraint Class* objects.

Example

```
mc = m.addQConstr(mx.T @ mx <= 1.0)
print(mc.tolist())
```

MQConstr.transpose()

Synopsis

```
transpose()
```

Description

Generates a new MQConstr object that is the transpose of the original MQConstr object.

Return value

Returns the transposed MQConstr object.

Example

```
mc = m.addQConstr(mx.T @ mx <= 1.0)
print(mc.transpose())
```

MQConstr.ndim

Synopsis

ndim

Description

Dimensions of the MQConstr object.

Return value

Integer value.

Example

```
mc = m.addQConstr(mx.T @ mx <= 1.0)
print(mc.ndim)
```

MQConstr.shape

Synopsis

shape

Description

The shape of the MQConstr object.

Return value

Integer tuple.

Example

```
mc = m.addQConstr(mx.T @ mx <= 1.0)
print(mc.shape)
```

MQConstr.size

Synopsis

size

Description

The number of constraints of the MQConstr object.

Return value

Integer value.

Example

```
mc = m.addQConstr(mx.T @ mx <= 1.0)
print(mc.size)
```

MQConstr.T

Synopsis

T

Description

Transpose of the MQConstr object. Similar to the class method `transpose()` .

Return value

Returns the transposed MQConstr object.

Example

```
A = np.ones([4, 3])
mx = model.addMVar((3, 4), nameprefix="mx")
mc = model.addQConstr(mx @ A @ mx == 0.0)
print(mc.shape) # shape = (3, 4)
print(mc.T.shape) # shape = (4, 3)
```

22.2.50 MQConstrBuilder Class

The MQConstrBuilder class is used to build multi-dimensional quadratic constraints in COPT and supports NumPy's multi-dimensional array operations. Users might create a MQConstrBuilder object by its constructor with a list of *QConstrBuilder Class* objects, or simply by overloaded comparison operator of *MQuadExpr Class*. The following member methods are provided:

MQConstrBuilder()

Synopsis

MQConstrBuilder(args, shape=None)

Description

constructor of MQConstrBuilder.

Arguments

args

one or a set of *QConstrBuilder Class* objects, in form of Python list or NumPy ndarray.

shape

an integer, or tuple of integers, which is the shape of new MQConstrBuilder object.

Example

```
x = model.addVar()
mqcb = MQConstrBuilder(x * x <= 9.0)

# or by overloaded comparison operator of MQuadExpr
mx = model.addMVar(3, 3)
mqcb = mx @ mx >= 1.0

# or immediately passed to addConstrs()
ma = model.addMVar(2)
A = np.full((2,3), 1)
```

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```
mb = model.addMVar(3)
model.addQConstr(ma @ A @ mb <= 1.0)
```

22.2.51 MPsdConstr Class

The *MPsdConstr* class in the COPT is used to construct multi-dimensional semidefinite constraints. It is created via the *addConstr* or *addConstrs* methods of the model class. The following member methods are provided:

MPsdConstr.getInfo()

Synopsis

```
getInfo(infename)
```

Description

Retrieves the information value for each semidefinite constraint in the *MPsdConstr*.

Arguments

infename

The name of the information to retrieve. Possible values are detailed in *Information Section*.

Return Value

Returns the information value as a multi-dimensional array.

Example

```
mpsdcon = model.addConstr(barX[:-1, :-1].sum() == 1)
print(mpsdcon.UB)
print(mpsdcon.getInfo("UB"))
```

MPsdConstr.setInfo()

Synopsis

```
setInfo(infename, newval)
```

Description

Sets the information value for each semidefinite constraint in the *MPsdConstr*.

Arguments

infename

The name of the information to set. Possible values are detailed in *Information Section*.

newval

The new value to set for the information.

Example

```
barX = model.addPsdVars(3, "BAR_X")
mY = model.addMVar(2, nameprefix="M_X")
mpsdCon = model.addConstrs(barX[:-1, :-1].diagonal() == mY)
mpsdCon.UB = 10
mpsdCon.setInfo("UB", 10)
```

MPsdConstr.item()

Synopsis

```
item()
```

Description

Retrieves the semidefinite constraint object in a 0-dimensional *MPsdConstr*. If the *MPsdConstr* object is not 0-dimensional, raises a *ValueError*.

Return Value

Returns a *PsdConstraint* object.

Example

```
barX = model.addPsdVars(3, "BAR_X")
mY = model.addMVar(2, nameprefix="M_X")
mpsdCon = model.addConstrs(barX[:-1, :-1].diagonal() == mY)
psdCon = mpsdCon[1].item()
```

MPsdConstr.clone()

Synopsis

```
clone()
```

Description

Creates a deep copy of an *MPsdConstr Class* object.

Return Value

Returns a new *MPsdConstr* object.

Example

```
barX = model.addPsdVars(3, "BAR_X")
mY = model.addMVar(2, nameprefix="M_X")
mpsdCon = model.addConstrs(barX[:-1, :-1].diagonal() == mY)
mpsdCon_copy = mpsdCon.clone()
```

22.2.52 MPsdConstrBuilder Class

The *MPsdConstrBuilder* class in COPT is used as a generator for multi-dimensional semidefinite constraints. It can be generated from a group of *PsdConstrBuilder Class* objects or by overloading the comparison operators of *MVar Class* and *MPsdExpr Class* objects. The following methods are provided:

MPsdConstrBuilder()

Synopsis

```
MPsdConstrBuilder()
```

Description

Creates an empty *MPsdConstrBuilder Class* object.

Example

```
# Create an empty semidefinite constraint builder
constrbuilder = MPsdConstrBuilder()
```

MPsdConstrBuilder.setBuilder()

Synopsis

```
setBuilder(expr, sense, rhs)
```

Description

Sets the expression and constraint type for the multi-dimensional semidefinite constraint builder.

Arguments

expr

The expression to set. Possible values include constants, *MVar Class* objects, *MLinExpr Class* objects, or *MPsdExpr Class* objects.

sense

The constraint type. Possible values are detailed in *Constraint Types*.

rhs

The right-hand side of the constraint. Possible values include constants, *MVar Class* objects, *MLinExpr Class* objects, or *MPsdExpr Class* objects.

Example

```
# Set the expression for the multi-dimensional PSD constraint builder: x + y == 1
constrbuilder.setBuilder(x + y, COPT.EQUAL, 1)
```

MPsdConstrBuilder.setRange()

Synopsis

```
setRange(expr, range)
```

Description

Sets the expression and the range for the multi-dimensional PSD constraint builder. The format is *expr* less than or equal to 0, and greater than or equal to *-range*.

Arguments

expr

The expression to set. Possible values include *MPsdExpr Class* objects.

range

The right-hand side of the range constraint. Must be non-negative.

Example

```
# Set the expression for the multi-dimensional PSD constraint builder:  $x + y - 1$ ,  
↪with range 1  
constrbuilder.setRange(x + y - 1, 1)
```

MPsdConstrBuilder.getPsdExpr()**Synopsis**

```
getPsdExpr()
```

Description

Retrieves the expression of the multi-dimensional PSD constraint builder.

Example

```
# Retrieve the expression of the multi-dimensional PSD constraint builder  
psdexpr = constrbuilder.getPsdExpr()
```

MPsdConstrBuilder.getSense()**Synopsis**

```
getSense()
```

Description

Retrieves the constraint type of the multi-dimensional PSD constraint builder.

Example

```
# Retrieve the constraint type of the multi-dimensional PSD constraint builder  
consense = constrbuilder.getSense()
```

MPsdConstrBuilder.getRange()**Synopsis**

```
getRange()
```

Description

Retrieves the range right-hand side of the multi-dimensional PSD constraint builder, representing the range between the upper and lower bounds.

Example

```
# Retrieve the range right-hand side of the multi-dimensional PSD constraint builder  
rngval = constrbuilder.getRange()
```


22.2.53 MLinExpr Class

The MLinExpr class is used in COPT to build multi-dimensional linear expressions and supports NumPy's multi-dimensional array operations. The MLinExpr object with an initial value of 0.0 can be generated by the class generation method `zeros()`, or by *MVar Class* object to generate a linear combination. The following member methods are provided:

MLinExpr.zeros()

Synopsis

```
zeros(shape)
```

Description

This is the class generation method and can be called directly without the MLinExpr object.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of the new MLinExpr object.

Return value

new MLinExpr object.

Example

```
mexpr = MLinExpr.zeros((2,3))
x = model.addVar()
mexpr += x
```

MLinExpr.clear()

Synopsis

```
clear()
```

Description

Resets each element of the *MLinExpr Class* object to 0.0.

Example

```
mexpr = 2.0 * model.addMVar(3)
mexpr.clear()
```

MLinExpr.clone()

Synopsis

```
clone()
```

Description

Deep-copy a *MLinExpr Class* object.

Return value

new MLinExpr object

Example

```
mexpr = 2.0 * model.addMVar(3)
mexpr_copy = mexpr.clone()
```

MLinExpr.getValue()

Synopsis

```
getValue()
```

Description

Get the evaluation of each linear expression within the *MLinExpr Class* object.

Return value

Returns a NumPy ndarray of the same dimensions as the MLinExpr object whose elements are the evaluations of the corresponding expression.

Example

```
a = np.random.rand(4)
mx = m.addMVar((4, 3), nameprefix="mx")
mexpr = a @ mx
mc = m.addConstrs(mexpr <= 1.0)
model.solve()
print(mc.getValue())
```

MLinExpr.item()

Synopsis

```
item()
```

Description

Get the constraint object in 0-dimensional MLinExpr. Raises a ValueError exception if the MLinExpr object is not 0-dimensional.

Return value

Returns the linear constraint object.

Example

```
mexpr = 2.0 * model.addMVar(3)
print(mexpr[0].item())
```

MLinExpr.reshape()

Synopsis

```
reshape(shape, order='C')
```

Description

Returns a new MLinExpr object whose elements remain unchanged but whose shape is transformed by the argument shape.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of the new MLinExpr object.

order

Optional parameter, the default is the character 'C', which means it is compatible with the C language, that is, it is stored in rows; it can also be set to the character 'F', that is, it is stored in columns, and it is compatible with the Fortran language.

Return value

Returns a new MLinExpr object with the same elements as the original MLinExpr object but with a different shape.

Example

```
mc = m.addConstrs(a @ mx <= b)
mc_2x2 = mc.reshape((2, 2))
```

MLinExpr.sum()

Synopsis

```
sum(axis=None)
```

Description

Sum the variables in the MLinExpr object, returning a new *MLinExpr Class* object.

Arguments

axis

Optional integer parameter, the default value is None, that is, to sum up variables one by one. Otherwise, sum over the given axis.

Return value

Returns an MLinExpr object representing the sum of the corresponding linear expressions.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
sum_all = mexpr.sum() #return 0-dimensional MLinExpr object
sum_row = mexpr.sum(axis = 0) #Return a 1-dimensional MLinExpr object with
↳ a shape of (5, )
```

MLinExpr.tolist()

Synopsis

```
tolist()
```

Description

Converts an MLinExpr object to a one-dimensional list whose elements are linear expressions.

Return value

Return a 1D list containing *LinExpr Class*.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
print(mexpr.tolist())
```

MLinExpr.transpose()

Synopsis

transpose()

Description

Generates a new MLinExpr object that is the transpose of the original MLinExpr object.

Return value

Returns the transposed MLinExpr object.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
print(mexpr.transpose())
```

MLinExpr.ndim

Synopsis

ndim

Description

MLinExpr Class Dimensions of the object.

Return value

Integer value.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
print(mexpr.ndim)
```

MLinExpr.shape

Synopsis

shape

Description

MLinExpr Class The shape of the object.

Return value

Integer tuple.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
print(mexpr.shape)
```

MLinExpr.size**Synopsis**

size

Description

The number of elements of *MLinExpr Class* object.

Return value

Integer value.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
print(mexpr.size)
```

MLinExpr.T**Synopsis**

T

Description

Transpose of *MLinExpr Class* object. Similar to the class method `transpose()`.

Return value

Returns the transposed *MLinExpr* object.

Example

```
mexpr = 2.0 * model.addMVar((3, 5))
print(mexpr.T.shape) # The transposed shape is (5, 3)
```

MLinExpr.__eq__()**Synopsis**

__eq__()

Description

Overload the `==` operator to build a *MConstrBuilder Class* object, which can be passed as the first argument to *Model.addConstrs*.

Return value

a *MConstrBuilder Class* object.

Example

```
model.addConstrs(A @ x == 1.0)
```

MLinExpr.__ge__()**Synopsis**

```
__ge__()
```

Description

Overload the \geq operator to build a *MConstrBuilder Class* object, which can be passed as the first argument to *Model.addConstrs*.

Return value

a *MConstrBuilder Class* object.

Example

```
model.addConstrs(A @ x >= 1.0)
```

MLinExpr.__le__()**Synopsis**

```
__le__()
```

Description

Overload the \leq operator to build a *MConstrBuilder Class* object, which can be passed as the first argument to *Model.addConstrs*.

Return value

a *MConstrBuilder Class* object.

Example

```
model.addConstrs(A @ x <= 1.0)
```

22.2.54 MQuadExpr Class

The MQuadExpr class is used in COPT to construct multi-dimensional quadratic expressions and supports NumPy's multi-dimensional array operations. The MQuadExpr object with an initial value of 0.0 can be generated by the class generation method `zeros()`, or by pairing two *MVar Class* objects are generated by (matrix) multiplication. The following member methods are provided:

MQuadExpr.zeros()**Synopsis**

```
zeros(shape)
```

Description

This is the class generation method and can be called directly without an MQuadExpr object.

Arguments

`shape`

The value is an integer, or a tuple of integers. which represents the shape of the new MQuadExpr object.

Return value

new MQuadExpr object.

Example

```
mqx = MQuadExpr.zeros((2,3)) # shape = (2, 3)
x = model.addVar()
mqx += 2.0 * x * x           # broadcast scalar
mqx += model.addMVar(3)      # broadcast MVar of shape (3,)
```

MQuadExpr.clear()

Synopsis

```
clear()
```

Description

Resets each element of the *MQuadExpr Class* object to 0.0.

Example

```
ma = model.addMVar(3, nameprefix='a')
mb = model.addMVar(3, nameprefix='b')
mqx = ma * mb      # elementwise multiply, shape = (3,)
mqx.clear()
print(mqx)         # result is [0.0, 0.0, 0.0]
```

MQuadExpr.clone()

Synopsis

```
clone()
```

Description

Deep-copy a *MQuadExpr Class* object.

Return value

new MQuadExpr object

Example

```
mx = model.addMVar((3, 3), nameprefix='mx')
mqx = 2.0 * mx @ mx      # matrix multiply, shape = (3, 3)
mqx_copy = mqx.clone()
mqx_copy.clear()
print(mqx)               # mqx is untouched
```

MQuadExpr.getValue()

Synopsis

```
getValue()
```

Description

Get the evaluation of each linear expression within the *MQuadExpr Class* object.

Return value

Returns a NumPy ndarray of the same dimensions as the MQuadExpr object whose elements are the evaluations of the corresponding expression.

Example

```
A = np.eye(3)
mx = m.addMVar(3, nameprefix="mx")
mqx = mx @ A @ mx          # 0-D MQuadExpr, shape = ()
m.addQConstr(mqx <= 9.0)
m.solve()
print(mqx.getValue())
```

MQuadExpr.item()**Synopsis**

```
item()
```

Description

Get the constraint object in the 0-dimensional MQuadExpr. Raises a ValueError exception if the MQuadExpr object is not 0-dimensional.

Return value

Returns the linear constraint object.

Example

```
x = m.addVar()
mqx = MQuadExpr.zeros(3) + x * x
print(mqx[1].item()) # Return QuadExpr(x * x)
```

MQuadExpr.reshape()**Synopsis**

```
reshape(shape, order='C')
```

Description

Returns a new MQuadExpr object whose elements are unchanged but whose shape is transformed by the argument shape.

Arguments

shape

The value is an integer, or a tuple of integers. which represents the shape of the new MQuadExpr object.

order

Optional parameter, the default is the character 'C', which means it is compatible with the C language, that is, it is stored in rows; it can also be set to the character 'F', that is, it is stored in columns, and it is compatible with the Fortran language.

Return value

Returns a new MQuadExpr object with the same elements as the original MQuadExpr object but with a different shape.

Example

```
mqx = MQuadExpr.zeros(6)
mqx_2x3 = mqx.reshape((2, 3))
```


MQuadExpr.sum()

Synopsis

```
sum(axis=None)
```

Description

Sums the variables in the MQuadExpr object, returning a new *MQuadExpr Class* object.

Arguments

axis

Optional integer parameter, the default value is None, that is, to sum up variables one by one. Otherwise, sum over the given axis.

Return value

Returns an MQuadExpr object representing the sum of the corresponding linear expressions.

Example

```

ma = model.addMVar((2, 3), nameprefix='ma')
mb = model.addMVar((3, 2), nameprefix='mb')
mqx = ma @ mb
sum_all = mqx.sum() # Return 0-dimensional MQuadExpr object
sum_row = mqx.sum(axis = 0) # Return a 1-dimensional MQuadExpr object with
→ a shape of (2, )

```

MQuadExpr.tolist()

Synopsis

```
tolist()
```

Description

Converts an MQuadExpr object to a one-dimensional list whose elements are linear expressions.

Return value

Return a 1D list containing *LinExpr Class*.

Example

```
print(MQuadExpr.zeros((2,3)).tolist()) # a list of length 6
```

MQuadExpr.transpose()

Synopsis

```
transpose()
```

Description

Generates a new MQuadExpr object that is the transpose of the original MQuadExpr object.

Return value

Returns the transposed MQuadExpr object.

Example

```
mqx = MQuadExpr.zeros((2,3))
print(mqx.transpose().shape) # shape = (3, 2)
```

MQuadExpr.ndim

Synopsis

ndim

Description

MQuadExpr Class Dimensions of the object.

Return value

Integer value.

Example

```
mqx = MQuadExpr.zeros((2,3))
print(mqx.ndim) # ndim = 2
```

MQuadExpr.shape

Synopsis

shape

Description

MQuadExpr Class The shape of the object.

Return value

Integer tuple.

Example

```
print(MQuadExpr.zeros((2,3)).shape) # shape = (2, 3)
```

MQuadExpr.size

Synopsis

size

Description

The number of elements of *MQuadExpr Class* object.

Return value

Integer value.

Example

```
mqx = MQuadExpr.zeros((2,3))
print(mqx.size) # size= 6
```

MQuadExpr.T**Synopsis**

T

Description

Transpose of *MQuadExpr Class* object. Similar to the class method `transpose()`.

Return value

Returns the transposed MQuadExpr object.

Example

```
mqx = MQuadExpr.zeros((2,3))
print(mqx.T.shape) # shape = (3, 2)
```

MQuadExpr.__eq__()**Synopsis**

__eq__()

Description

Overload the == operator to build a *MQConstrBuilder Class* object, which can be passed as the first argument to *Model.addQConstr*.

Return value

a *MQConstrBuilder Class* object.

Example

```
model.addQConstr(x @ Q @ y == 1.0)
```

MQuadExpr.__ge__()**Synopsis**

__ge__()

Description

Overload the >= operator to build a *MQConstrBuilder Class* object, which can be passed as the first argument to *Model.addQConstr*.

Return value

a *MQConstrBuilder Class* object.

Example

```
model.addQConstr(x @ Q @ y >= 1.0)
```

MQuadExpr.__le__()**Synopsis**

```
__le__()
```

Description

Overload the `<=` operator to build a *MQConstrBuilder Class* object, which can be passed as the first argument to *Model.addQConstr*.

Return value

a *MQConstrBuilder Class* object.

Example

```
model.addQConstr(x @ Q @ y <= 1.0)
```

22.2.55 NdArray Class

The *NdArray* class is a built-in multi-dimensional array class in COPT. It represents a table of elements of the same type, indexed by a tuple of integers. The following methods are provided:

NdArray()**Synopsis**

```
NdArray(args=None, dtype=None, shape=None)
```

Description

Create a *NdArray Class* object.

Return value

Returns a *NdArray* object.

Example

```
# Create a NdArray object with a shape of 3x3 and initialize its elements ↵  
↵ to 0  
ndmat = NdArray(shape=(3, 3))
```

NdArray.item()**Synopsis**

```
item()
```

Description

Gets the single element within a 0-dimensional *NdArray* object. If the *NdArray* object is not 0-dimensional, a *ValueError* exception will be triggered.

Return value

Returns the type of the elements in the 0-dimensional *NdArray* object. (For example: "float" or "int", etc.)

Example

```
ndmat = NdArray(args=1.1, shape=(1,))
# Type of value is "float"
value = ndmat.item()
```

NdArray.reshape()

Synopsis

```
reshape(shape, order='C')
```

Description

Returns a new NdArray object whose elements remain unchanged where shape is transformed according to the shape in the arguments.

Arguments

shape

The value could be an integer or a tuple of integers, representing the shape of the new NdArray object.

order

Optional. The default is the character 'C', which means it is compatible with C language (stored in rows). The current version does not yet support the character 'F' (stored in columns).

Return value

Returns a new NdArray object with the same elements as the original one but a different shape.

Example

```
ndmat = NdArray(shape=(6,))
ndmat_2x3 = ndmat.reshape((2, 3))
```

NdArray.sum()

Synopsis

```
sum(axis=None)
```

Description

Sum the elements in NdArray according to given axis.

Arguments

axis

Optional integer argument. The default value is None, which means summing all elements. Otherwise, it will sum according to the given axis.

Return value

If **axis** is empty, returns a new 0-dimensional NdArray object, in which element is the sum of the corresponding elements.

If **axis** is non-empty, returns a new N-1-dimensional NdArray object, in which elements are the sum of the elements on the given axis.

Example

```
ndmat = NdArray(args=1.1, shape=(2, 2))
# Sum all elements in ndmat and return a 0-dimensional NdArray object
sum_all = ndmat.sum()
# Sum the elements in ndmat row by row and return a 1-dimensional NdArray
→ object with a shape of (2, )
sum_row = ndmat.sum(axis=0)
```

NdArray.tolist()

Synopsis

```
tolist()
```

Description

Convert a NdArray object into a list.

Return value

Returns a list object.

Example

```
# Type of object mat_tolist is "list"
mat_tolist = ndmat.tolist()
```

NdArray.tonumpy()

Synopsis

```
tonumpy()
```

Description

Convert a NdArray object to a NumPy ndarray object.

Return value

Returns a numpy ndarray object.

Example

```
# Type of object mat_tolist is "numpy.ndarray"
mat_tonumpy = ndmat.tonumpy()
```

NdArray.fill()

Synopsis

```
fill(value)
```

Description

Fills each element in the NdArray object with the specified value.

Arguments

value

The new value of each element in the NdArray object.

Return value

Returns a NdArray object.

Example

```
mat_fillvalue = ndmat.fill(100.0)
```

NdArray.expand()**Synopsis**

```
expand(axis=0)
```

Description

Expand the NdArray object into an N+1 dimensional shape on the axis.

Arguments

`axis`

The specified dimension, which defaults to 0 (the first dimension).

Return value

Returns a N+1 dimensional NdArray object.

Example

```
mat_1 = ndmat.expand()
```

NdArray.squeeze()**Synopsis**

```
squeeze(axis=0)
```

Description

Reduce the NdArray object to an N-1 dimensional shape on the axis.

Arguments

`axis`

The specified dimension, default to 0 (the first dimension).

Return value

Returns a N-1 dimensional NdArray object.

Example

```
mat_1 = ndmat.squeeze()
```

NdArray.flatten()**Synopsis**

```
flatten()
```

Description

Expand a NdArray object into a one-dimensional shape.

Return value

Returns a new one-dimensional NdArray object.

Example

```
ndmat = NdArray(shape=(2, 2))
# The shape of mat_1 is (4,)
mat_1 = ndmat.flatten()
```

NdArray.setItem()

Synopsis

```
setItem(idx, value)
```

Description

Sets the value of the element according to the given index in the NdArray object.

Arguments

idx

The specified one-dimensional index is the corresponding one after flattening NdArray into one dimension.

value

The new value of the specified element.

Return value

Returns a NdArray object in which the element value of **idx** is set to **value**.

Example

```
# Set the value of the element at index 0 to 100
mat_1 = ndmat.setItem(0, 100)
```

NdArray.transpose()

Synopsis

```
transpose()
```

Description

Generates a new NdArray object, which is the transpose of the original one.

Return value

Returns a new NdArray object.

Example

```
ndmat = NdArray(shape=(3, 5))
print(ndmat.transpose().shape) #shape=(5, 3)
```


NdArray.diagonal()**Synopsis**

```
diagonal(offset=0, axis1=0, axis2=1)
```

Description

Generate a *NdArray Class* object, in which elements are the ones on the diagonal of the original NdArray object.

Arguments

offset

Optional argument, indicating the offset of the diagonal, the default value is 0. If the value is greater than 0, it represents the upward offset of the diagonal. If the value is less than 0, it represents the downward offset of the diagonal.

axis1

Optional argument. Axis to be used as the first axis of the 2-D sub-NdArrays from which the diagonals should be taken. Defaults to first axis (0).

axis2

Optional argument. Axis to be used as the second axis of the 2-D sub-NdArrays from which the diagonals should be taken. Defaults to second axis (1).

Return value

A new NdArray object.

Example

```
ndmat = NdArray(shape=(3, 3), args=[[1,1,1],[2,2,2],[3,3,3]])

diag_m0 = ndmat.diagonal(0)
diag_a1 = ndmat.diagonal(1)
diag_b1 = ndmat.diagonal(-1)
```

NdArray.ndim**Synopsis**

```
ndim
```

Description

The dimensions of the NdArray object.

Return value

An integer Value

Example

```
ndmat = NdArray((3, 5))
print(ndmat.ndim) # ndim = 2
```

NdArray.shape

Synopsis

shape

Description

The shape of the NdArray object.

Return value

An integer tuple.

Example

```
ndmat = NdArray((3, 5))
print(ndmat.shape) # shape = (3, 5)
```

NdArray.pick()

Synopsis

pick(indexes)

Description

Retrieves a new multi-dimensional array from the *NdArray* object according to the specified indices.

Arguments

indexes

The specified indices.

Return Value

Returns a new *NdArray* object.

NdArray.hstack()

Synopsis

hstack(other)

Description

Stacks another *NdArray* object along the horizontal dimension (last dimension) to form a new *NdArray* object.

Arguments

other

Another *NdArray* object.

Return Value

Returns a new *NdArray* object.

NdArray.vstack()**Synopsis**

```
vstack(other)
```

Description

Stacks another *NdArray* object along the vertical dimension to form a new *NdArray* object.

Arguments

other

Another *NdArray* object.

Return Value

Returns a new *NdArray* object.

NdArray.stack()**Synopsis**

```
stack(other, axis)
```

Description

Stacks another *NdArray* object along the specified axis to form a new *NdArray* object.

Arguments

other

Another *NdArray* object.

axis

The specified axis index.

Return Value

Returns a new *NdArray* object.

NdArray.size**Synopsis**

```
size
```

Description

The number of elements in the *NdArray* object.

Return value

An integer value.

Example

```
ndmat = NdArray((3, 5))
print(ndmat.size) # size = 15
```

NdArray.T

Synopsis

T

Description

Transpose of NdArray objects, similar to the method `NdArray.transpose()` .

Return value

Returns the transposed NdArray object.

Example

```
ndmat = NdArray(shape=(3, 5))
print(ndmat.T.shape) # shape = (5, 3)
```

22.2.56 ExprBuilder Class

ExprBuilder object contains operations related to building linear expressions, and provides the following methods:

ExprBuilder()

Synopsis

`ExprBuilder(arg1=0.0, arg2=None)`

Description

Create a *ExprBuilder Class* object.

If argument `arg1` is constant, argument `arg2` is `None`, then create a *ExprBuilder Class* object and initialize it using argument `arg1`. If argument `arg1` is *Var Class* or *ExprBuilder Class* object, and argument `arg2` is constant or considered to be constant 1.0 when argument `arg2` is `None`, then initialize the newly created *ExprBuilder Class* object using arguments `arg1` and `arg2`. If argument `arg1` and `arg2` are list objects, then they are variables and coefficients used to initialize the newly created *ExprBuilder Class* object.

Arguments

`arg1`

Optional, 0.0 by default.

`arg2`

Optional, `None` by default.

Example

```
# Create a new ExprBuilder object and initialize it to 0.0
expr0 = ExprBuilder()
# Create a ExprBuilder object and initialize it to x + 2*y
expr2 = ExprBuilder([x, y], [1, 2])
```

ExprBuilder.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of terms in an expression builder.

Example

```
# Retrieve the number of terms in expression builder 'expr'
exprsize = expr.getSize()
```

ExprBuilder.getCoeff()**Synopsis**

```
getCoeff(idx)
```

Description

Retrieve the coefficient of a variable by its index from an expression builder.

Arguments

```
idx
```

Index of the variable in the expression builder, starting with 0.

Example

```
# Retrieve the coefficient for the term at index 1 from expression builder 'expr'
coeff = expr.getCoeff(1)
```

ExprBuilder.getVar()**Synopsis**

```
getVar(idx)
```

Description

Retrieve the variable by its index from an expression builder. Return a *Var Class* object.

Arguments

```
idx
```

Index of the variable in the expression builder, starting with 0.

Example

```
# Retrieve the variable for the term at index 1 from expression builder 'expr'
x = expr.getVar(1)
```

ExprBuilder.getConstant()**Synopsis**

```
getConstant()
```

Description

Retrieve the constant term from an expression builder.

Example

```
# Retrieve the constant term from linear expression builder 'expr'
constant = expr.getConstant()
```

ExprBuilder.addTerm()**Synopsis**

```
addTerm(var, coeff=1.0)
```

Description

Add a new term to current expression builder.

Arguments

var

Variable to add.

coeff

Magnification coefficient for added term. Optional, 1.0 by default.

Example

```
# Add term 2*x to linear expression builder 'expr'
expr.addTerm(x, 2.0)
```

ExprBuilder.addExpr()**Synopsis**

```
addExpr(expr, coeff=1.0)
```

Description

Add new expression builder to the current one.

Arguments

expr

Expression builder to add.

coeff

Magnification coefficients for the added expression builder. Optional, 1.0 by default.

Example

```
# Add linear expression builder 2*x + 2*y to 'expr'
expr.addExpr(x + y, 2.0)
```

ExprBuilder.clone()**Synopsis**

```
clone()
```

Description

Create a deep copy of the expression builder.

Example

```
# Create a deep copy of expression builder 'expr'
exprcopy = expr.clone()
```

ExprBuilder.getExpr()**Synopsis**

```
getExpr()
```

Description

Create a linear expression related to the expression builder. Returns a *LinExpr Class* object.

Example

```
# Get the linear expression object related to expression builder 'exprbuilder'
expr = exprbuilder.getExpr()
```

22.2.57 LinExpr Class

LinExpr object contains operations related to variables for building linear constraints, and provides the following methods:

LinExpr()**Synopsis**

```
LinExpr(arg1=0.0, arg2=None)
```

Description

Create a *LinExpr Class* object.

If argument **arg1** is constant, argument **arg2** is **None**, then create a *LinExpr Class* object and initialize it using argument **arg1**. If argument **arg1** is *Var Class* or *LinExpr Class* object, and argument **arg2** is constant or considered to be constant 1.0 when argument **arg2** is **None**, then initialize the newly created *LinExpr Class* object using arguments **arg1** and **arg2**. If argument **arg1** is list object and argument **arg2** is **None**, then argument **arg1** contains a list of variable-coefficient pairs and initialize the newly created *LinExpr Class* object using arguments **arg1** and **arg2**. For other forms of arguments, call method **addTerms** to initialize the newly created *LinExpr Class* object.

Arguments

arg1

Optional, 0.0 by default.

arg2

Optional, None by default.

Example

```
# Create a new LinExpr object and initialize it to 0.0
expr0 = LinExpr()
# Create a LinExpr object and initialize it to 2*x + 3*y
expr1 = LinExpr([(x, 2), (y, 3)])
# Create a LinExpr object and initialize it to x + 2*y
expr2 = LinExpr([x, y], [1, 2])
```

LinExpr.setCoeff()

Synopsis

```
setCoeff(idx, newval)
```

Description

Set new coefficient value of a variable based on its index in an expression.

Arguments

idx

Index of the variable in the expression, starting with 0.

newval

New coefficient value of the variable.

Example

```
# Set the coefficient for the term at index 0 in expression expr to 1.0
expr.setCoeff(0, 1.0)
```

LinExpr.getCoeff()

Synopsis

```
getCoeff(idx)
```

Description

Retrieve the coefficient of a variable by its index from an expression.

Arguments

idx

Index of the variable in the expression, starting with 0.

Example

```
# Retrieve the coefficient for the term at index 1 from expression expr
coeff = expr.getCoeff(1)
```


LinExpr.getVar()**Synopsis**

```
getVar(idx)
```

Description

Retrieve the variable by its index from an expression. Return a *Var Class* object.

Arguments

```
idx
```

Index of the variable in the expression, starting with 0.

Example

```
# Retrieve the variable for the term at index 1 from expression expr
x = expr.getVar(1)
```

LinExpr.getConstant()**Synopsis**

```
getConstant()
```

Description

Retrieve the constant term from an expression.

Example

```
# Retrieve the constant term from linear expression expr
constant = expr.getConstant()
```

LinExpr.getValue()**Synopsis**

```
getValue()
```

Description

Retrieve the value of an expression computed using the current solution.

Example

```
# Retrieve the value of expression expr for the current solution.
val = expr.getValue()
```

LinExpr.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of terms in an expression.

Example

```
# Retrieve the number of terms in expression expr
exprsize = expr.getSize()
```

LinExpr.setConstant()**Synopsis**

```
setConstant(newval)
```

Description

Set the constant term of linear expression.

Arguments

`newval`

Constant term to be set.

Example

```
# Set constant term of linear expression 'expr' to 2.0
expr.setConstant(2.0)
```

LinExpr.addConstant()**Synopsis**

```
addConstant(newval)
```

Description

Add a constant to an expression.

Arguments

`newval`

Constant to add.

Example

```
# Add constant 2.0 to linear expression 'expr'
expr.addConstant(2.0)
```

LinExpr.addTerm()**Synopsis**

```
addTerm(var, coeff=1.0)
```

Description

Add a new term to current expression.

Arguments

`var`

Variable to add.

`coeff`

Magnification coefficient for added term. Optional, 1.0 by default.

Example

```
# Add term x to linear expression 'expr'
expr.addTerm(x)
```

LinExpr.addTerms()**Synopsis**

```
addTerms(vars, coeffs)
```

Description

Add a single term or multiple terms into an expression.

If argument **vars** is *Var Class* object, then argument **coeffs** is constant; If argument **vars** is *VarArray Class* object or list, then argument **coeffs** is constant or list; If argument **vars** is dictionary or *tupledict Class* object, then argument **coeffs** is constant, dict, or *tupledict Class* object.

Arguments

vars

Variables to add.

coeffs

Coefficients for variables.

Example

```
# Add term 2*x + 2*y to linear expression 'expr'
expr.addTerms([x, y], [2.0, 3.0])
```

LinExpr.addExpr()**Synopsis**

```
addExpr(expr, coeff=1.0)
```

Description

Add new expression to the current one.

Arguments

expr

Expression or expression builder to add.

coeff

Magnification coefficients for the added expression. Optional, 1.0 by default.

Example

```
# Add linear expression 2*x + 2*y to 'expr'
expr.addExpr(x + y, 2.0)
```

LinExpr.clone()**Synopsis**

```
clone()
```

Description

Create a deep copy of the expression.

Example

```
# Create a deep copy of expression expr
exprcopy = expr.clone()
```

LinExpr.reserve()**Synopsis**

```
reserve(n)
```

Description

Pre-allocate space for linear expression object.

Arguments

`n`

Number of terms to be allocated.

Example

```
# Allocate 100 terms for linear expression 'expr'
expr.reserve(100)
```

LinExpr.remove()**Synopsis**

```
remove(item)
```

Description

Remove a term from a linear expression.

If argument `item` is constant, then remove the term stored at index `i` of the expression; otherwise argument `item` is *Var Class* object.

Arguments

`item`

Constant index or variable of the term to be removed.

Example

```
# Remove the term whose index is 2 from linear expression expr
expr.remove(2)
# Remove the term whose variable is x from linear expression expr
expr.remove(x)
```

22.2.58 QuadExpr Class

QuadExpr object contains operations related to variables for building quadratic constraints, and provides the following methods:

QuadExpr()

Synopsis

```
QuadExpr(expr=0.0)
```

Description

Create a *QuadExpr Class* object.

Argument `expr` is constant, *Var Class*, *LinExpr Class* object or *QuadExpr Class* object.

Arguments

`expr`

Optional, 0.0 by default.

Example

```
# Create a new QuadExpr object and initialize it to 0.0
quadexpr0 = QuadExpr()
# Create a QuadExpr object and initialize it to 2*x + 3*y
quadexpr1 = QuadExpr([(x, 2), (y, 3)])
# Create a QuadExpr object and initialize it to x*x + 2*x*y
quadexpr2 = QuadExpr(x*x + 2*x*y)
```

QuadExpr.setCoeff()

Synopsis

```
setCoeff(idx, newval)
```

Description

Set new coefficient value of a term based on its index in a quadratic expression.

Arguments

`idx`

Index of the term in the quadratic expression, starting with 0.

`newval`

New coefficient value of the term.

Example

```
# Set the coefficient for the term at index 0 in quadratic expression quadexpr to 1.0
quadexpr.setCoeff(0, 1.0)
```

QuadExpr.getCoeff()**Synopsis**

```
getCoeff(idx)
```

Description

Retrieve the coefficient of a term by its index from a quadratic expression.

Arguments

idx

Index of the term in the quadratic expression, starting with 0.

Example

```
# Retrieve the coefficient for the term at index 1 from quadratic expression quadexpr
coeff = quadexpr.getCoeff(1)
```

QuadExpr.getVar1()**Synopsis**

```
getVar1(idx)
```

Description

Retrieve the first variable of a quadratic term by its index from an expression.
Return a *Var Class* object.

Arguments

idx

Index of the quadratic term in the expression, starting with 0.

Example

```
# Retrieve the first variable of a quadratic term at index 1 from quadratic_
↪expression quadexpr
x = quadexpr.getVar1(1)
```

QuadExpr.getVar2()**Synopsis**

```
getVar2(idx)
```

Description

Retrieve the second variable of a quadratic term by its index from an expression.
Return a *Var Class* object.

Arguments

idx

Index of the quadratic term in the expression, starting with 0.

Example

```
# Retrieve the first variable of a quadratic term at index 1 from quadratic_
↪expression quadexpr
y = quadexpr.getVar2(1)
```

QuadExpr.getLinExpr()**Synopsis**

```
getLinExpr()
```

Description

Retrieve the linear terms (if exist) from quadratic expression. Return a *LinExpr* *Class* object.

Example

```
# Retrieve the linear terms from a quadratic expression quadexpr
linexpr = quadexpr.getLinExpr()
```

QuadExpr.getConstant()**Synopsis**

```
getConstant()
```

Description

Retrieve the constant term from a quadratic expression.

Example

```
# Retrieve the constant term from quadratic expression quadexpr
constant = quadexpr.getConstant()
```

QuadExpr.getValue()**Synopsis**

```
getValue()
```

Description

Retrieve the value of a quadratic expression computed using the current solution.

Example

```
# Retrieve the value of quadratic expression quadexpr for the current solution.
val = quadexpr.getValue()
```

QuadExpr.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of terms in a quadratic expression.

Example

```
# Retrieve the number of terms in quadratic expression quadexpr
exprsize = quadexpr.getSize()
```

QuadExpr.setConstant()**Synopsis**

```
setConstant(newval)
```

Description

Set the constant term of quadratic expression.

Arguments

`newval`

Constant to set.

Example

```
# Set constant term of quadratic expression 'quadexpr' to 2.0
quadexpr.setConstant(2.0)
```

QuadExpr.addConstant()**Synopsis**

```
addConstant(newval)
```

Description

Add a constant to a quadratic expression.

Arguments

`newval`

Constant to add.

Example

```
# Add constant 2.0 to quadratic expression 'quadexpr'
quadexpr.addConstant(2.0)
```

QuadExpr.addTerm()**Synopsis**

```
addTerm(coeff, var1, var2=None)
```

Description

Add a new term to current quadratic expression.

Arguments

`coeff`

Magnification coefficient for added term. Optional, 1.0 by default.

`var1`

The first variable for added term.

`var2`

The second variable for added term, defaults to `None`, i.e. add a linear term.

Example


```
# Add term x to quadratic expression 'quadexpr'
quadexpr.addTerm(1.0, x)
```

QuadExpr.addTerms()

Synopsis

```
addTerms(coeffs, vars1, vars2=None)
```

Description

Add a single term or multiple terms into a quadratic expression.

If argument **vars** is *Var Class* object, then argument **vars2** is *Var Class* object or *None*, argument **coeffs** is constant; If argument **vars** is *VarArray Class* object or list, then argument **vars2** is *VarArray Class* object, list or *None*, argument **coeffs** is constant or list; If argument **vars** is dictionary or *tupledict Class* object, then argument **vars2** is dictionary, *tupledict Class* object or *None*, argument **coeffs** is constant, dictionary, or *tupledict Class* object.

Arguments

coeffs

Coefficients for terms.

vars1

The first variable of each term.

vars2

The second variable of each term, defaults to *None*, i.e. add a linear term.

Example

```
# Add term 2*x + 3y + 2*x*x + 3*x*y to quadratic expression 'quadexpr'
# Note: Mixed format is supported by addTerms yet.
quadexpr.addTerms([2.0, 3.0], [x, y])
quadexpr.addTerms([2.0, 3.0], [x, x], [x, y])
```

QuadExpr.addLinExpr()

Synopsis

```
addLinExpr(expr, mult=1.0)
```

Description

Add new linear expression to the current quadratic expression.

Arguments

expr

Linear expression or linear expression builder to add.

mult

Magnification coefficient for the added expression. Optional, 1.0 by default.

Example

```
# Add linear expression 2*x + 2*y to 'quadexpr'
quadexpr.addLinExpr(x + y, 2.0)
```

QuadExpr.addQuadExpr()**Synopsis**

```
addQuadExpr(expr, mult=1.0)
```

Description

Add new quadratic expression to the current one.

Arguments

`expr`

Expression or expression builder to add.

`mult`

Magnification coefficients for the added expression. Optional, 1.0 by default.

Example

```
# Add quadratic expression  $x*x + 2*y$  to 'quadexpr'  
quadexpr.addQuadExpr(x*x + 2*y, 2.0)
```

QuadExpr.clone()**Synopsis**

```
clone()
```

Description

Create a deep copy of the expression.

Example

```
# Create a deep copy of quadratic expression quadexpr  
exprcopy = quadexpr.clone()
```

QuadExpr.reserve()**Synopsis**

```
reserve(n)
```

Description

Pre-allocate space for quadratic expression object.

Arguments

`n`

Number of terms to be allocated.

Example

```
# Allocate 100 terms for quadratic expression 'expr'  
expr.reserve(100)
```

QuadExpr.remove()**Synopsis**

```
remove(item)
```

Description

Remove a term from a quadratic expression.

If argument `item` is constant, then remove the term stored at index `i` of the expression; otherwise argument `item` is *Var Class* object.

Arguments

`item`

Constant index or variable of the term to be removed.

Example

```
# Remove the term whose index is 2 from quadratic expression quadexpr
quadexpr.remove(2)
# Remove the terms one of which variable is x from quadratic expression quadexpr
quadexpr.remove(x)
```

22.2.59 PsdExpr Class

PsdExpr object contains operations related to variables for building positive semi-definite constraints, and provides the following methods:

PsdExpr()**Synopsis**

```
PsdExpr(expr=0.0)
```

Description

Create a *PsdExpr Class* object.

Arguments

`expr`

Optional, 0.0 by default, which can be a constant, *Var Class*, *LinExpr Class* object or *PsdExpr Class* object.

Example

```
# Create a new PsdExpr object and initialize it to 0.0
expr0 = PsdExpr()
# Create a PsdExpr object and initialize it to 2*x + 3*y
expr1 = PsdExpr(2*x + 3*y)
```

PsdExpr.setCoeff()**Synopsis**

```
setCoeff(idx, mat)
```

Description

Set the coefficient symmetric matrix corresponding to the specified index value `idx` in the LMI expression.

Arguments

`idx`

Index of the positive semi-definite variable in the expression, starting with 0.

`mat`

New symmetric matrix coefficient of the positive semi-definite variable.

Example

```
# Set symmetric matrix for the positive semi-definite variable at index 0 in ↵  
↪ expression "expr" to mat  
expr.setCoeff(0, mat)
```

PsdExpr.getCoeff()**Synopsis**

```
getCoeff(idx)
```

Description

Retrieve the symmetric matrix coefficient of a positive semi-definite variable by its index from the expression.

Arguments

`idx`

Index of the positive semi-definite variable in the expression, starting with 0.

Example

```
# Retrieve the symmetric matrix coefficient for the positive semi-definite variable ↵  
↪ at index 1 from expression expr  
mat = expr.getCoeff(1)
```

PsdExpr.getPsdVar()**Synopsis**

```
getPsdVar(idx)
```

Description

Retrieve a positive semi-definite variable by its index from the expression. Return a *PsdVar Class* object.

Arguments

`idx`

Index of the positive semi-definite variable in the expression, starting with 0.

Example

```
# Retrieve the positive semi-definite variable at index 1 from expression expr
x = expr.getPsdVar(1)
```

PsdExpr.getLinExpr()

Synopsis

```
getLinExpr()
```

Description

Retrieve the linear terms (if exist) from positive semi-definite expression. Return a *LinExpr Class* object.

Example

```
# Retrieve the linear terms from a positive semi-definite expression expr
linexpr = expr.getLinExpr()
```

PsdExpr.getConstant()

Synopsis

```
getConstant()
```

Description

Retrieve the constant term from a positive semi-definite expression.

Example

```
# Retrieve the constant term from expression expr
constant = expr.getConstant()
```

PsdExpr.getValue()

Synopsis

```
getValue()
```

Description

Retrieve the value of a positive semi-definite expression computed using the current solution.

Example

```
# Retrieve the value of positive semi-definite expression expr for the current
↪ solution.
val = expr.getValue()
```

PsdExpr.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of terms in a positive semi-definite expression.

Example

```
# Retrieve the number of terms in expression expr
exprsize = expr.getSize()
```

PsdExpr.setConstant()**Synopsis**

```
setConstant(newval)
```

Description

Set the constant term of positive semi-definite expression.

Arguments

`newval`

Constant to set.

Example

```
# Set constant term of expression 'expr' to 2.0
expr.setConstant(2.0)
```

PsdExpr.addConstant()**Synopsis**

```
addConstant(newval)
```

Description

Add a constant to a positive semi-definite expression.

Arguments

`newval`

Constant to add.

Example

```
# Add constant 2.0 to expression 'expr'
expr.addConstant(2.0)
```

PsdExpr.addTerm()**Synopsis**

```
addTerm(var, mat)
```

Description

Add a new term to current positive semi-definite expression.

Arguments

var

The positive semi-definite variable to add.

mat

The symmetric matrix coefficient for the positive semi-definite variable.

Example

```
# Add positive semi-definite term C1 * X to expression 'expr'
expr.addTerm(X, C1)
```

PsdExpr.addTerms()**Synopsis**

```
addTerms(vars, mats)
```

Description

Add a single term or multiple positive semi-definite terms into a positive semi-definite expression.

If argument **vars** is *PsdVar Class* object, then argument **mats** is *SymMatrix Class* object; If argument **vars** is *PsdVarArray Class* object or list, then argument **mats** is *SymMatrixArray Class* or list;

Arguments

vars

The positive semi-definite variables to add.

mats

The symmetric matrices of the positive semi-definite terms.

Example

```
# Add terms C1 * X1 + C2 * X2 to expression 'expr'
expr.addTerms([X1, X2], [C1, C2])
```

PsdExpr.addLinExpr()**Synopsis**

```
addLinExpr(expr, mult=1.0)
```

Description

Add new linear expression to the current positive semi-definite expression.

Arguments

expr

Linear expression or linear expression builder to add.

`mult`

Magnification coefficient for the added expression. Optional, 1.0 by default.

Example

```
# Add linear expression 2*x + 2*y to 'expr'
expr.addLinExpr(x + y, 2.0)
```

PsdExpr.addPsdExpr()

Synopsis

```
addPsdExpr(expr, mult=1.0)
```

Description

Add new positive semi-definite expression to the current one.

Arguments

`expr`

Positive semi-definite expression or positive semi-definite expression builder to add.

`mult`

Magnification coefficient for the added positive semi-definite expression. Optional, 1.0 by default.

Example

```
# Add positive semi-definite expression C * X to 'expr'
expr.addPsdExpr(C*X)
```

PsdExpr.addMExpr()

Synopsis

```
addMExpr(expr, mult=1.0)
```

Description

Add a new multi-dimensional expression to the current PSD expression.

Arguments

`expr`

The multi-dimensional array expression or expression builder object to add.

`mult`

The scaling factor for the multi-dimensional array expression. Optional, defaulting to 1.0.

Example

```
# Add a multi-dimensional linear expression: 2.0 * A @ x to the PSD expression expr
expr.addMExpr(A @ x, 2.0)
```


PsdExpr.clone()**Synopsis**

```
clone()
```

Description

Create a deep copy of the expression.

Example

```
# Create a deep copy of expression expr
exprcopy = expr.clone()
```

PsdExpr.reserve()**Synopsis**

```
reserve(n)
```

Description

Pre-allocate space for positive semi-definite expression object.

Arguments

`n`

Number of terms to be allocated.

Example

```
# Allocate 100 terms for positive semi-definite expression 'expr'
expr.reserve(100)
```

PsdExpr.remove()**Synopsis**

```
remove(item)
```

Description

Remove a term from a positive semi-definite expression.

If argument `item` is constant, then remove the term stored at index `i` of the expression; otherwise argument `item` is *PsdVar Class* object.

Arguments

`item`

Constant index or *PsdVar Class* variable of the term to be removed.

Example

```
# Remove the term whose index is 2 from positive semi-definite expression expr
expr.remove(2)
# Remove the terms one of which variable is x from positive semi-definite expression
↪ expr
expr.remove(x)
```

22.2.60 MPsdExpr Class

The *MPsdExpr* class in COPT is used for operations that combine PSD variables into multi-dimensional PSD expressions. The following methods are provided:

MPsdExpr.addTerm()

Synopsis

```
addTerm(var, mat)
```

Description

Adds a new PSD term to the current multi-dimensional PSD expression.

Arguments

var

The semidefinite variable in the term to be added.

mat

The symmetric matrix in the term to be added.

Example

```
# Add the PSD term C1 * X to mexpr
mexpr.addTerm(X, C1)
```

MPsdExpr.addTerms()

Synopsis

```
addTerms(vars, coeffs)
```

Description

Adds new terms to the multi-dimensional PSD expression object.

Arguments

vars

Multi-dimensional array variable objects. Possible value could be *MVar*.

coeffs

Coefficient matrices for the terms. Possible values could be a floating number or *NdArray*.

Example

```
# Add terms: mA @ mX to mpsdexpr
mX = model.addMVar((3,3), nameprefix="M_X")
mA = cp.NdArray(np.ones(shape=(3,3)))
mpsdexpr.addTerms(mX, mA)
```

MPsdExpr.addLinExpr()**Synopsis**

```
addLinExpr(expr, mult=1.0)
```

Description

Adds a new linear expression to the current multi-dimensional PSD expression.

Arguments

expr

The linear expression or expression builder object to add. Possible values could be *LinExpr* or *ExprBuilder*.

mult

The scaling factor for the linear expression. Optional, defaulting to 1.0.

Example

```
# Add a linear expression: 2*x + 2*y to mexpr
mexpr.addLinExpr(x + y, 2.0)
```

MPsdExpr.addPsdExpr()**Synopsis**

```
addPsdExpr(expr, mult=1.0)
```

Description

Adds a new semidefinite expression to the current multi-dimensional PSD expression.

Arguments

expr

The semidefinite expression to add.

mult

The scaling factor for the PSD expression. Optional, defaulting to 1.0.

Example

```
# Add a PSD expression: C * X to mexpr
mexpr.addPsdExpr(C * X)
```

MPsdExpr.addMExpr()**Synopsis**

```
addMExpr(expr, mult=1.0)
```

Description

Add a new multi-dimensional expression to the current multi-dimensional PSD expression.

Arguments

expr

The multi-dimensional expression or expression builder object to add.

`mult`

The scaling factor for the multi-dimensional expression. Optional, defaulting to 1.0.

Example

```
# Add a multi-dimensional linear expression: 2.0 * A @ x to mexpr
mexpr.addMExpr(A @ x, 2.0)
```

MPsdExpr.addMLinExpr()

Synopsis

```
addMLinExpr(exprs, mult=1.0)
```

Description

Add corresponding linear expressions to each PSD expression in the `MPsdExpr` object.

Arguments

`exprs`

The multi-dimensional linear expressions or expression builder objects to add.

`mult`

The same scaling factor for all linear expressions to add. Optional, defaulting to 1.0.

Example

```
# Add a linear expression A @ x to each PSD expression in mexpr
mexpr.addMLinExpr(A @ x)
```

MPsdExpr.addMPsdExpr()

Synopsis

```
addMPsdExpr(exprs, mult=1.0)
```

Description

Adds corresponding new PSD expressions to each PSD expression in the `MPsdExpr` object.

Arguments

`exprs`

The new semidefinite expressions to add.

`mult`

The same scaling factor for all PSD expressions to add. Optional, defaulting to 1.0.

Example

```
# Add a PSD expression: C * X to each PSD expression in mexpr
mexpr.addMPsdExpr(C * X)
```

MPsdExpr.item()**Synopsis**

```
item()
```

Description

Retrieves the *PsdExpr* in a 0-dimensional semidefinite expression. If the *MPsdExpr* object is not 0-dimensional, raises a *ValueError*.

Return Value

Returns a *PsdExpr* object.

Example

```
barX = model.addPsdVars(3, "BAR_X")
mpsdexpr = barX[:-1, :-1]
psdexpr1 = mpsdexpr[0,0].item()
psdexpr2 = mpsdexpr.sum().item()
```

MPsdExpr.sum()**Synopsis**

```
sum(axis=None)
```

Description

Computes the sum of the semidefinite terms along the specified axis in the *MPsdExpr* object.

Arguments

axis

Optional. Defaults to *None*, which sums over all variables. Otherwise, sums along the specified axis.

Return Value

Returns an *MPsdExpr Class* object representing the sum of the corresponding multi-dimensional PSD expressions.

MPsdExpr.clear()**Synopsis**

```
clear()
```

Description

Resets every element of the *MPsdExpr Class* object to 0.0.

Example

```
barX = model.addPsdVars(3, "BAR_X")
mpsdexpr = barX[:-1, :-1]
mpsdexpr.clear()
```

MPsdExpr.clone()**Synopsis**

```
clone()
```

Description

Creates a deep copy of an *MPsdExpr Class* object.

Return Value

Returns a new *MPsdExpr* object.

Example

```
barX = model.addPsdVars(3, "BAR_X")
mpsdexpr = barX[:-1, :-1]
newmpsdexpr = mpsdexpr.clone()
```

22.2.61 LmiExpr Class

LmiExpr object contains operations related to variables for building LMI constraints, and provides the following methods:

LmiExpr()**Synopsis**

```
LmiExpr(arg1=None, arg2=None)
```

Description

Create a *LmiExpr Class* object.

Arguments

The default value of **arg1** is *None*, and the possible values are: *Var Class* object, or *SymMatrix Class* object.

If the argument **arg1** is a *Var Class* object, then the argument **arg2** is a *SymMatrix Class* object.

LmiExpr.setCoeff()**Synopsis**

```
setCoeff(idx, mat)
```

Description

Set the coefficient matrix for the entry corresponding to the specified index **idx** in the LMI expression.

Arguments

idx

The specified the index value. Starts with 0.

mat

The new coefficient symmetric matrix of the variable to be set, which must be a *SymMatrix Class* class object.

Example

```
# Set the coefficient of the 0-th term of the LMI expression expr to the symmetric
↪matrix mat
expr.setCoeff(0, mat)
```

LmiExpr.getCoeff()

Synopsis

```
getCoeff(idx)
```

Description

Get the coefficient matrix for the entry corresponding to the specified index *idx* in the LMI expression.

Arguments

idx

The specified the index value. Starts with 0.

Example

```
# Get the symmetric matrix coefficient of the 1st term of the LMI expression expr
mat = expr.getCoeff(1)
```

LmiExpr.getVar()

Synopsis

```
getVar(idx)
```

Description

Get the variable in the entry corresponding to the specified index *idx* in the LMI expression.

Arguments

idx

The specified the index value. Starts with 0.

Example

```
# Get the variable of the 1st item of the LMI expression expr
mat = expr.getVar(1)
```

LmiExpr.getConstant()

Synopsis

```
getConstant()
```

Description

Get the constant-term symmetric matrix in the LMI expression.

Example

```
# Get the constant term of the LMI expression expr
constant = expr.getConstant()
```

LmiExpr.getSize()**Synopsis**

```
getSize()
```

Description

Retrieve the number of terms in the LMI expression.

Example

```
# Retrieve the number of terms in the LMI expression expr.
val = expr.getSize()
```

LmiExpr.setConstant()**Synopsis**

```
setConstant(mat)
```

Description

Set the constant-term symmetric matrix of the LMI expression.

Arguments

`mat`

The symmetric matrix corresponding to the constant item, must be a *SymMatrix Class* object.

Example

```
# Sets the constant term of the LMI expression expr to the symmetric matrix D1
expr.setConstant(D1)
```

LmiExpr.addConstant()**Synopsis**

```
addConstant(mat)
```

Description

Add the symmetric matrix to constant term of the LMI expression.

Arguments

`mat`

Matrix expression object added to constant term.

Example

```
# Add to the constant term of the LMI expression expr with symmetric matrix D2
expr.addConstant(D2)
```


LmiExpr.addTerm()**Synopsis**

```
addTerm(var, mat)
```

Description

Add a new term to current LMI expression.

Arguments

var

The variable in the new item.

mat

The symmetric matrix as variable coefficients in the new term.

Example

```
# Add the term C1 * X to expression 'expr'
expr.addTerm(x, C1)
```

PsdExpr.addTerms()**Synopsis**

```
addTerms(vars, mats)
```

Description

Adds multiple new terms to the LMI expression.

If argument **vars** is *PsdVar Class* object, then argument **mats** is *SymMatrix Class* object; If argument **vars** is *PsdVarArray Class* object or list, then argument **mats** is *SymMatrixArray Class* or list;

Arguments

vars

Array of variables to add new items to.

mats

The symmetric array of matrices to add new items to.

Example

```
# Add terms x1 * C1 + x2 * C2 to expression 'expr'
expr.addTerms([x1, x2], [C1, C2])
```

LmiExpr.addLmiExpr()**Synopsis**

```
addLmiExpr(expr, mult=1.0)
```

Description

Add a new LMI expression to the current LMI expression.

Arguments

expr

LMI expression to add.

mult

Magnification coefficient for the added LMI expression. Optional, 1.0 by default.

Example

```
# Add linear expression 2 * x * C to 'expr'
expr.addLinExpr(x * C, 2.0)
```

LmiExpr.clone()

Synopsis

clone()

Description

Create a deep copy of the expression.

Example

```
# Create a deep copy of expression expr
exprcopy = expr.clone()
```

LmiExpr.reserve()

Synopsis

reserve(n)

Description

Pre-allocate space for LMI expression object.

Arguments

n

Number of terms to be allocated.

Example

```
# Allocate 100 terms for LMI expression 'expr'
expr.reserve(100)
```

LmiExpr.remove()

Synopsis

remove(item)

Description

Remove a term from the LMI expression.

If argument `item` is constant, then remove the term stored at index `i` of the expression; otherwise argument `item` is *Var Class* object.

Arguments

item

Constant index or *Var Class* variable of the term to be removed.

Example

```
# Remove the term whose index is 2 from positive semi-definite expression expr
expr.remove(2)
# Remove the terms one of which variable is x from LMI expression expr
expr.remove(x)
```

22.2.62 CallbackBase Class

COPT CallbackBase class. This is an abstract class, the user needs to implement the function *CallbackBase.callback()* to create an instance. The instance is passed in as the first argument of the method *Model.setCallback()*

CallbackBase.where()

Synopsis

```
where()
```

Description

Get context in callback.

Return value

Returns an integer value.

CallbackBase.callback()

Synopsis

```
callback()
```

Description

The callback function is a pure virtual function which needs to be implemented by the user. The user can describe the information that needs to be obtained or the operation that needs to be performed during the solution process.

Example

```
class CoptCallback(CallbackBase):
    def __init__(self):
        super().__init__()
    def callback(self):
        # Get the objective value when finding a feasible MIP solution
        if self.where() == COPT.CBCONTEXT_MIPSOL:
            db = self.getInfo(COPT.CBInfo.MipCandObj)
```

CallbackBase.interrupt()

Synopsis

```
interrupt()
```

Description

Interrupt the callback process.

CallbackBase.addUserCut()**Synopsis**

```
addUserCut(lhs, sense = None, rhs = None)
```

Description

Add a user cut to the MIP model from within the callback function.

Arguments

lhs

Left-hand side expression for the new user cut. It can take the value of *Var Class* object, *LinExpr Class* object, or *ConstrBuilder Class*.

sense

The sense of the new user cut. It supports for LESS_EQUAL, GREATER_EQUAL, EQUAL and FREE.

Optional. None by default.

The user cut added from within callback can only have a single comparison operator.

rhs

Right-hand side expression for the new user cut.

Optional. None by default.

It can be a constant, or *Var Class* object, or *LinExpr Class* object.

Example

```
self.addUserCut(x+y <= 1)
```

CallbackBase.addUserCuts()**Synopsis**

```
addUserCuts(generator)
```

Description

Add a set of user cuts to the MIP model from within the callback function.

Arguments

generator

Array of builders for user cuts. It can be *ConstrBuilderArray Class* object or *MConstrBuilder Class* object.

Example

```
self.addUserCuts(x[i]+y[i] <= 1 for i in range(10))
```

CallbackBase.addLazyConstr()**Synopsis**

```
addLazyConstr(lhs, sense = None, rhs = None)
```

Description

Add a lazy constraint to the MIP model from within the callback function.

Arguments

lhs

Left-hand side expression for the new lazy constraint. It can take the value of *Var Class* object, *LinExpr Class* object or *ConstrBuilder Class* object.

sense

The sense of the lazy constraint. It supports for LESS_EQUAL, GREATER_EQUAL, EQUAL and FREE .

Optional. None by default.

The lazy constraint added from within callback can only have a single comparison operator.

rhs

Right-hand side expression for the new lazy constraint.

Optional. None by default.

It can be a constant, or *Var Class* object, or *LinExpr Class* object.

Example

```
self.addLazyConstr(x+y <= 1)
```

CallbackBase.addLazyConstrs()**Synopsis**

```
addLazyConstrs(generator)
```

Description

Add a set of lazy constraints to the MIP model from within the callback function.

Arguments

generator

Array of builders for lazy constraints. It can be *ConstrBuilderArray Class* object or *MConstrBuilder Class* object.

Example

```
self.addLazyConstrs(x[i] + y[i] <= 1 for i in range(10))
```

CallbackBase.getInfo()

Synopsis

```
getInfo(cbinfo)
```

Description

Retrieve the value of the specified callback information.

Arguments

`cbinfo`

The name of the callback information. Please refer to *Callback Information* for possible values.

Return value

Returns a constant(int-valued or double-valued).

Example

```
db = self.getInfo(COPT.CBInfo.BestBnd)
```

CallbackBase.getRelaxSol()

Synopsis

```
getRelaxSol(vars)
```

Description

Retrieve the LP-relaxation solution of the specified variables at the current node.

Note that this method can only be invoked if `CallbackBase.where() == COPT.CBCONTEXT_MIPRELAX`.

Arguments

`vars`

The variables to retrieve the LP-relaxation solution values.

Return value

When parameter `vars` is *Var Class* object, it returns a constant, which is the LP-relaxation solution value of the specified variable.

When parameter `vars` is list or *VarArray Class* object, it returns a list of constants, consisting of the solution of the specified variables.

When parameter `args` is dictionary or *tupledict Class* object, it returns *tupledict Class* object(the indices of specified variables as key, the solutions of the specified variables as value).

When parameter `args` is `None` , it returns the LP-relaxation solution values of all variables.

Example

```
vals = self.getRelaxSol(vars)
```

CallbackBase.getIncumbent()**Synopsis**

```
getIncumbent(vars)
```

Description

Retrieve values from the best feasible solution of the specified variables.

Arguments

vars

The variables whose solution values to retrieve.

Return value

When parameter **vars** is *Var Class* object, it returns a constant, which is the solution value of the specified variable.

When parameter **vars** is list or *VarArray Class* object, it returns a list of constants, consisting of the solution of the specified variables.

When parameter **args** is dictionary or *tupledict Class* object, it returns *tupledict Class* object(the indices of specified variables as key, the solutions of the specified variables as value).

When parameter **args** is `None` , it returns the incumbent values of all variables.

Example

```
vals = self.getIncumbent(vars)
```

CallbackBase.getSolution()**Synopsis**

```
getSolution(vars)
```

Description

Retrieve values from the current solution of the specified variables.

Note that this method can only be invoked if `CallbackBase.where() == COPT.CBCONTEXT_MIPSOL`.

Arguments

vars

The variables whose solution values to retrieve.

Return value

When parameter **vars** is *Var Class* object, it returns a constant, which is the solution value of the specified variable.

When parameter **vars** is list or *VarArray Class* object, it returns a list of constants, consisting of the solution of the specified variables.

When parameter **args** is dictionary or *tupledict Class* object, it returns *tupledict Class* object(the indices of specified variables as key, the solutions of the specified variables as value).

When parameter **args** is `None` , it returns the solution values of all variables.

Example

```
vals = self.getSolution(vars)
```

CallbackBase.setSolution()

Synopsis

```
setSolution(vars, vals)
```

Description

Set feasible solution values for the specified variables.

When parameter **vars** is *Var Class* object, parameter **vals** is constant;

When parameter **vars** is dictionary or *tupledict Class* object, parameter **vals** can be constant, dictionary or *tupledict Class* object;

When parameter **vars** is list, *VarArray Class* object, parameter **vals** can be constant or list.

Arguments

vars

The variables to be set value.

vals

The values of the variables in the solution.

Example

```
self.setSolution(x, 1)
```

CallbackBase.loadSolution()

Synopsis

```
loadSolution()
```

Description

Load the currently feasible solution into model.

Note that a complete solution is required here.

Example

```
self.loadSolution()
```

22.2.63 GenConstrX Class

In the *Model* class, the constraints added by `addGenConstrXXX` (such as: `addGenConstrMax`) will return a *GenConstrX* object.

GenConstrX.getAttr()

Synopsis

```
getAttr(attrname)
```

Description

Get the attribute value of the **GenConstrX** class object, support to get the type and name of the **GenConstrX** class object.

Example

```
# Get the name of con_max
con_max.getAttr("name")
# Get the type of con_max
con_max.getAttr("type")
```

GenConstrX.setAttr()

Synopsis

```
setAttr(attrname)
```

Arguments

Set the attribute value of the **GenConstrX** class object, and support setting the name of the **GenConstrX** class object.

Example

```
# Set the name of con_max
con_max.setAttr("name")
```

22.2.64 CoptError Class

CoptError Class provides operations on error. An exception of the CoptError is thrown when error occurs in a method call corresponding to the underlying interface of solver. The following attributes are provided to retrieve error information:

- CoptError.retcode
Error code.
- CoptError.message
Error message.

22.3 Helper Functions and Utilities

Helper functions and utilities are encapsulated based on Python's basic data types, providing easy-to-use data types to facilitate the rapid construction of complex optimization models. This section will explain its functions and usages.

22.3.1 Helper Functions

multidict()

Synopsis

```
multidict(data)
```

Description

Split a single dictionary into keys and multiple dictionaries. Return keys and dictionaries.

Arguments

`data`

A Python dictionary to be applied. Each key should map to a list of n values.

Example

```
keys, dict1, dict2 = multidict({
    "hello": [0, 1],
    "world": [2, 3]})
```

quicksum()

Synopsis

```
quicksum(data)
```

Description

Build expressions efficiently. Return a *LinExpr Class* object.

Arguments

`data`

Terms to add.

Example

```
expr = quicksum(m.getVars())
```

22.3.2 tuplelist Class

The tuplelist object is an encapsulation based on Python lists, and provides the following methods:

tuplelist()

Synopsis

```
tuplelist(list)
```

Description

Create and return a *tuplelist Class* object.

Arguments

`list`

A Python list.

Example

```
t1 = tuplelist([(0, 1), (1, 2)])
t1 = tuplelist([('a', 'b'), ('b', 'c')])
```

tuplelist.add()**Synopsis**

```
add(item)
```

Description

Add an item to a *tuplelist Class* object

Arguments

```
item
```

Item to add, which can be a Python tuple.

Example

```
t1 = tuplelist([(0, 1), (1, 2)])
t1.add((2, 3))
```

tuplelist.select()**Synopsis**

```
select(pattern)
```

Description

Get all terms that match the specified pattern. Return a *tuplelist Class* object.

Arguments

```
pattern
```

Specified pattern.

Example

```
t1 = tuplelist([(0, 1), (0, 2), (1, 2)])
t1.select(0, '*')
```

repeat()**Synopsis**

```
repeat(obj, repeats)
```

Description

Repeats the specified object a given number of times.

Arguments

```
obj
```

A Python object.

```
repeats
```

The number of repetitions.

hstack()

Synopsis

```
hstack(left, right)
```

Description

Horizontally stacks the input objects.

Arguments

`left`

A Python object.

`right`

A Python object.

vstack()

Synopsis

```
vstack(left, right)
```

Description

Vertically stacks the input objects.

Arguments

`left`

A Python object.

`right`

A Python object.

stack()

Synopsis

```
stack(left, right, axis)
```

Description

Stacks the input objects along the specified axis.

Arguments

`left`

A Python object.

`right`

A Python object.

`axis`

The specified axis index.

22.3.3 tupledict Class

The tupledict class is an encapsulation based on Python dictionaries, and provides the following methods:

tupledict()

Synopsis

```
tupledict(args, kwargs)
```

Description

Create and return a *tupledict Class* object.

Arguments

args

Positional arguments.

kwargs

Named arguments.

Example

```
d = tupledict([(0, "hello"), (1, "world")])
```

tupledict.select()

Synopsis

```
select(pattern)
```

Description

Get all terms that match the specified pattern. Return a *tupledict Class* object.

Arguments

pattern

Specified pattern.

Example

```
d = tupledict([(0, "hello"), (1, "world")])
d.select()
```

tupledict.sum()

Synopsis

```
sum(pattern)
```

Description

Sum all terms that match the specified pattern. Return a *LinExpr Class* object.

Arguments

pattern

Specified pattern.

Example

```
expr = x.sum()
```

tupledict.prod()

Synopsis

```
prod(coeff, pattern)
```

Description

Filter terms that match the specified pattern and multiply by coefficients. Return a *LinExpr Class* object.

Arguments

coeff

Coefficients, which can be a dict or a *tupledict Class* object.

pattern

Specified pattern.

Example

```
coeff = dict([(1, 0.1), (2, 0.2)])  
expr = x.prod(coeff)
```

22.3.4 ProbBuffer Class

The ProbBuffer is an encapsulation of buffer of string stream, and provides the following methods:

ProbBuffer()

Synopsis

```
ProbBuffer(buff)
```

Description

Create and return a *ProbBuffer Class* object.

Arguments

buff

Size of buffer, defaults to **None**, i.e. the buffer size is 0.

Example

```
# Create a buffer of size 100  
buff = ProbBuffer(100)
```

ProbBuffer.getData()**Synopsis**`getData()`**Description**

Get the contents of buffer.

Example

```
# Print the contents in buffer
print(buff.getData())
```

ProbBuffer.getSize()**Synopsis**`getSize()`**Description**

Get the size of the buffer.

Example

```
# Get the size of the buffer
print(buff.getSize())
```

ProbBuffer.resize()**Synopsis**`resize(sz)`**Description**

Resize the size of the buffer.

Arguments`sz`

New size of buffer.

Example

```
# Resize the size of buffer to 100
buff.resize(100)
```


Chapter 23

C++ API Reference

The **Cardinal Optimizer** provides C++ API library. This chapter documents all COPT constants, including parameters and attributes, and API functions for C++ applications.

23.1 Constants

All C++ constants are the same as C constants. Please refer to *C API Reference: Constants* for more details.

23.2 Attributes

All C++ attributes are the same as C attributes. Please refer to *C API Reference: Attributes* for more details.

In the C++ API, user can get the attribute value by specifying the attribute name. The provided functions are as follows, please refer to *C++ API: Model Class* for details.

- `Model::GetIntAttr()` : Get value of a COPT integer attribute.
- `Model::GetDblAttr()` : Get value of a COPT double attribute.

23.3 Information

All C++ information is the same as C information. Please refer to *C API Reference: Information* .

In the C++ API, user can get or set the information value by specifying the information name. The functions provided are as follows, please refer to *C++ Model class* for details. Information of variables or constraints can also be obtained/set through the `Get()/Set()` function of themselves.

- `Model::Get()` : Get the value of information related to the variables or constraints.
- `Model::Set()` : Set the value of information related to the variables or constraints.

23.4 Parameters

All C++ parameters are the same as C parameters. Please refer to *C API Reference: Parameters* for more details.

In the C++ API, user can get and set the parameter value by specifying the parameter name. The provided functions are as follows, please refer to *C++ Model class* for details.

- Get detailed information of the specified parameter (current value/max/min): `Model::GetParamInfo()`
- Get the current value of the specified integer/double parameter: `Model::GetIntParam()` / `Model::GetDblParam()`
- Set the specified integer/double parameter value: `Model::SetIntParam()` / `Model::SetDblParam()`

23.5 C++ Modeling Classes

This chapter documents COPT C++ interface. Users may refer to C++ classes described below for details of how to construct and solve C++ models.

23.5.1 Envr

Essentially, any C++ application using Cardinal Optimizer should start with a COPT environment. COPT models are always associated with a COPT environment. User must create an environment object before populating models. User generally only need a single environment object in program.

Envr::Envr()

Constructor of COPT Envr object.

Synopsis

```
Envr()
```

Envr::Envr()

Constructor of COPT Envr object, given a license folder.

Synopsis

```
Envr(const char *szLicDir)
```

Arguments

`szLicDir`: directory having local license or client config file.

Envr::Envr()

Constructor of COPT Envr object, given an Envr config object.

Synopsis

```
Envr(const EnvrConfig &config)
```

Arguments

config: Envr config object holding settings for remote connection.

Envr::Close()

close remote connection and token becomes invalid for all problems in current envr.

Synopsis

```
void Close()
```

Envr::CreateModel()

Create a COPT model object.

Synopsis

```
Model CreateModel(const char *szName)
```

Arguments

szName: customized model name.

Return

a COPT model object.

23.5.2 EnvrConfig

If user connects to COPT remote services, such as floating token server or compute cluster, it is necessary to add config settings with EnvrConfig object.

EnvrConfig::EnvrConfig()

Constructor of COPT environment config object.

Synopsis

```
EnvrConfig()
```

EnvrConfig::Set()

Set config settings in terms of name-value pair.

Synopsis

```
void Set(const char *szName, const char *szValue)
```

Arguments

szName: keyword of a config setting

szValue: value of a config setting

23.5.3 Model

In general, a COPT model consists of a set of variables, a (linear) objective function on these variables, a set of constraints on these variables, etc. COPT model class encapsulates all required methods for constructing a COPT model.

Model::AddAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone AddAffineCone(const AffineConeBuilder &builder, const
char *szName)
```

Arguments

builder: builder for new affine cone constraint.

szName: optional, name of new affine cone constraint.

Return

new affine cone constraint object.

Model::AddAffineCone()

Add an affine cone constraint to a model.

Synopsis

```
AffineCone AddAffineCone(
    const MLinExpr<1> &exprs,
    int type,
    const char *szName)
```

Arguments

exprs: 1-dimensional array of linear expressions.

type: type of an affine cone.

szName: name of new affine cone constraint.

Return

new affine cone constraint object.

Model::AddAffineCone()

Add an affine cone constraint to a model.

Synopsis

```
AffineCone AddAffineCone(
    const MPsdExpr<1> &exprs,
    int type,
    const char *szName)
```

Arguments

exprs: 1-dimensional array of PSD expressions.

type: type of an affine cone.

szName: name of new affine cone constraint.

Return

new affine cone constraint object.

Model::AddAffineCones()

Add a list of affine cone constraints to a model.

Synopsis

```
AffineConeArray AddAffineCones(  
    const MLinExpr<2> &exprs,  
    int type,  
    const char *szPrefix)
```

Arguments

exprs: 2-dimensional array of linear expressions.

type: type of an affine cone.

szPrefix: name prefix for new affine cone constraints.

Return

array of new affine cone constraint objects.

Model::AddAffineCones()

Add a list of affine cone constraints to a model.

Synopsis

```
AffineConeArray AddAffineCones(  
    const MPsdExpr<2> &exprs,  
    int type,  
    const char *szPrefix)
```

Arguments

exprs: 2-dimensional array of PSD expressions.

type: type of an affine cone.

szPrefix: name prefix for new affine cone constraints.

Return

array of new affine cone constraint objects.

Model::AddCone()

Add a cone constraint to a model, given its dimension.

Synopsis

```
Cone AddCone(  
    int dim,  
    int type,  
    char *pvtype,  
    const char *szPrefix)
```

Arguments

dim: dimension of the cone constraint.
type: type of the cone constraint.
pvtype: types of variables in the cone.
szPrefix: name prefix of variables in the cone.

Return

object of new cone constraint.

Model::AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(const ConeBuilder &builder)
```

Arguments

builder: builder for new cone constraint.

Return

new cone constraint object.

Model::AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(const VarArray &vars, int type)
```

Arguments

vars: variables that participate in the cone constraint.
type: type of the cone constraint.

Return

object of new cone constraint.

Model::AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(const MVar<1> &vars, int type)
```

Arguments

vars: one-dimensional variables in the cone constraint.

type: type of the cone constraint.

Return

object of new cone constraint.

Model::AddCones()

Add a list of cone constraints to a model.

Synopsis

```
ConeArray AddCones(const MVar<2> &vars, int type)
```

Arguments

vars: 2-dimensional array of variables.

type: type of a cone.

Return

array of new cone constraint objects.

Model::AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    const Expr &expr,  
    char sense,  
    double rhs,  
    const char *szName)
```

Arguments

expr: expression for the new constraint.

sense: sense for new linear constraint, other than range sense.

rhs: right hand side value for the new constraint.

szName: optional, name of new constraint.

Return

new constraint object.

Model::AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    const Expr &lhs,  
    char sense,  
    const Expr &rhs,  
    const char *szName)
```

Arguments

lhs: left hand side expression for the new constraint.

sense: sense for new linear constraint, other than range sense.

rhs: right hand side expression for the new constraint.

szName: optional, name of new constraint.

Return

new constraint object.

Model::AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    const Expr &expr,  
    double lb,  
    double ub,  
    const char *szName)
```

Arguments

expr: expression for the new constraint.

lb: lower bound for the new constraint.

ub: upper bound for the new constraint

szName: optional, name of new constraint.

Return

new constraint object.

Model::AddConstr()

Add a linear constraint to a model.

Synopsis

```
Constraint AddConstr(const ConstrBuilder &builder, const char
*szName)
```

Arguments

builder: builder for the new constraint.

szName: optional, name of new constraint.

Return

new constraint object.

Model::AddConstrs()

Add linear constraints to model.

Synopsis

```
ConstrArray AddConstrs(
    int count,
    char *pSense,
    double *pRhs,
    const char *szPrefix)
```

Arguments

count: number of constraints added to model.

pSense: sense array for new linear constraints, other than range sense.

pRhs: right hand side values for new variables.

szPrefix: name prefix for new constraints.

Return

array of new constraint objects.

Model::AddConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray AddConstrs(
    int count,
    double *pLower,
    double *pUpper,
    const char *szPrefix)
```

Arguments

count: number of constraints added to the model.
pLower: lower bounds of new constraints.
pUpper: upper bounds of new constraints.
szPrefix: name prefix for new constraints.

Return

array of new constraint objects.

Model::AddConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray AddConstrs(  
    int count,  
    double *pLower,  
    double *pUpper,  
    const char *szNames,  
    size_t len)
```

Arguments

count: number of constraints added to the model.
pLower: lower bounds of new constraints.
pUpper: upper bounds of new constraints.
szNames: name buffer of new constraints.
len: length of the name buffer.

Return

array of new constraint objects.

Model::AddConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray AddConstrs(const ConstrBuilderArray &builders, const  
    char *szPrefix)
```

Arguments

builders: builders for new constraints.
szPrefix: name prefix for new constraints.

Return

array of new constraint objects.

Model::AddConstrs()

Add linear constraints to model.

Synopsis

```
ConstrArray AddConstrs(  
    const ConstrBuilderArray &builders,  
    const char *szNames,  
    size_t len)
```

Arguments

builders: builders for new constraints.
szNames: name buffer of new constraints.
len: length of the name buffer.

Return

array of new constraint objects.

Model::AddDenseMat()

Add a dense symmetric matrix to a model.

Synopsis

```
SymMatrix AddDenseMat(  
    int dim,  
    double *pVals,  
    int len)
```

Arguments

dim: dimension of the dense symmetric matrix.
pVals: array of non-zero elements, filled in column-wise up to len or max length of symmetric matrix.
len: length of value array.

Return

new symmetric matrix object.

Model::AddDenseMat()

Add a dense symmetric matrix to a model.

Synopsis

```
SymMatrix AddDenseMat(int dim, double val)
```

Arguments

dim: dimension of dense symmetric matrix.
val: value to fill dense symmetric matrix.

Return

new symmetric matrix object.

Model::AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(int dim, double val)
```

Arguments

dim: dimension of diagonal matrix.

val: value to fill diagonal elements.

Return

new diagonal matrix object.

Model::AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(  
    int dim,  
    double *pVals,  
    int len)
```

Arguments

dim: dimension of diagonal matrix.

pVals: array of values of diagonal elements.

len: length of value array.

Return

new diagonal matrix object.

Model::AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(  
    int dim,  
    double val,  
    int offset)
```

Arguments

dim: dimension of diagonal matrix.

val: value to fill diagonal elements.

offset: shift distance against diagonal line.

Return

new diagonal matrix object.

Model::AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(  
    int dim,  
    double *pVals,  
    int len,  
    int offset)
```

Arguments

dim: dimension of diagonal matrix.
pVals: array of values of diagonal elements.
len: length of value array.
offset: shift distance against diagonal line.

Return

new diagonal matrix object.

Model::AddExpCone()

Add an exponential cone constraint to a model.

Synopsis

```
ExpCone AddExpCone(  
    int type,  
    char *pvtype,  
    const char *szPrefix)
```

Arguments

type: type of the exponential cone constraint.
pvtype: types of variables in the exponential cone.
szPrefix: name prefix of variables in the exponential cone.

Return

object of new exponential cone constraint.

Model::AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(const ExpConeBuilder &builder)
```

Arguments

builder: builder for new exponential cone constraint.

Return

new exponential cone constraint object.

Model::AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(const VarArray &vars, int type)
```

Arguments

vars: variables that participate in the exponential cone constraint.

type: type of the exponential cone constraint.

Return

object of new exponential cone constraint.

Model::AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(const MVar<1> &vars, int type)
```

Arguments

vars: 1-dimensional variables in the exponential cone constraint.

type: type of the exponential cone constraint.

Return

object of new exponential cone constraint.

Model::AddExpCones()

Add a list of exponential cone constraints to a model.

Synopsis

```
ExpConeArray AddExpCones(const MVar<2> &vars, int type)
```

Arguments

vars: 2-dimensional array of variables.

type: type of an exponential cone.

Return

array of new exponential cone constraint objects.

Model::AddEyeMat()

Add an identity matrix to a model.

Synopsis

```
SymMatrix AddEyeMat(int dim)
```

Arguments

dim: dimension of identity matrix.

Return

new identity matrix object.

Model::AddGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr AddGenConstrIndicator(const GenConstrBuilder &builder,  
                                const char *szName)
```

Arguments

builder: builder for the general constraint.
szName: optional, name of new general constraint.

Return

new general constraint object of type indicator.

Model::AddGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr AddGenConstrIndicator(  
    Var binVar,  
    int binVal,  
    const ConstrBuilder &builder,  
    int type,  
    const char *szName)
```

Arguments

binVar: binary indicator variable.
binVal: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).
builder: builder for linear constraint.
type: type of general constraint with default value of COPT_INDICATOR_IF.
szName: optional, name of new general constraint.

Return

new general constraint object of type indicator.

Model::AddGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr AddGenConstrIndicator(  
    Var binVar,  
    int binVal,  
    const Expr &expr,  
    char sense,  
    double rhs,
```

```
int type,  
const char *szName)
```

Arguments

binVar: binary indicator variable.

binVal: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).

expr: expression for new linear constraint.

sense: sense for new linear constraint.

rhs: right hand side value for new linear constraint.

type: type of general constraint with default value of COPT_INDICATOR_IF.

szName: optional, name of new general constraint.

Return

new general constraint object of type indicator.

Model::AddGenConstrIndicators()

Add general constraints of type indicator to model.

Synopsis

```
GenConstrArray AddGenConstrIndicators(  
    Var binVar,  
    int binVal,  
    const MConstrBuilder<N> &builders,  
    int type,  
    const char *szPrefix)
```

Arguments

binVar: binary indicator variable.

binVal: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).

builders: builder for linear constraints in matrix format.

type: type of general constraint with default value of COPT_INDICATOR_IF.

szPrefix: optional, name prefix of new general constraints.

Return

new general constraint objects of type indicator.

Model::AddGenConstrIndicators()

Add a list of general constraints to model.

Synopsis

```
GenConstrArray AddGenConstrIndicators(const GenConstrBuilderArray
&builders, const char *szPrefix)
```

Arguments

builders: builders for new general constraints.
szPrefix: name prefix for new general constraints.

Return

array of new general constraint objects.

Model::AddGenConstrIndicators()

Add a list of general constraints to model.

Synopsis

```
GenConstrArray AddGenConstrIndicators(
    const GenConstrBuilderArray &builders,
    const char *szNames,
    size_t len)
```

Arguments

builders: builders for new general constraints.
szNames: name buffer of new general constraints.
len: length of the name buffer.

Return

array of new general constraint objects.

Model::AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(
    const Expr &lhs,
    char sense,
    double rhs,
    const char *szName)
```

Arguments

lhs: expression for lazy constraint.
sense: sense for lazy constraint.
rhs: right hand side value for lazy constraint.
szName: optional, name of lazy constraint.

Model::AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(  
    const Expr &lhs,  
    char sense,  
    const Expr &rhs,  
    const char *szName)
```

Arguments

lhs: left hand side expression for lazy constraint.
sense: sense for lazy constraint.
rhs: right hand side expression for lazy constraint.
szName: optional, name of lazy constraint.

Model::AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(const ConstrBuilder &builder, const char *szName)
```

Arguments

builder: builder for lazy constraint.
szName: optional, name of lazy constraint.

Model::AddLazyConstrs()

Add lazy constraints to model.

Synopsis

```
void AddLazyConstrs(const ConstrBuilderArray &builders, const char  
*szPrefix)
```

Arguments

builders: array of builders for lazy constraints.
szPrefix: name prefix of new lazy constraints.

Model::AddLmiConstr()

Add an LMI constraint to model.

Synopsis

```
LmiConstraint AddLmiConstr(const LmiExpr &expr, const char *szName)
```

Arguments

expr: LMI expression for new LMI constraint.
szName: optional, name of new LMI constraint.

Return

new LMI constraint object.

Model::AddMConstr()

Add a MConstr object in N-dimensions to model.

Synopsis

```
template <int N> MConstr<N> AddMConstr(const MConstrBuilder<N>
&builder, const char *szPrefix)
```

Arguments

builder: builder for MConstr object.

szPrefix: name prefix for constraints in MConstr object.

Return

new MConstr object.

Model::AddMConstr()

Add a N-dimensional MConstr object to model.

Synopsis

```
template <int N> MConstr<N> AddMConstr(
    const MLinExpr<N> &exprs,
    char sense,
    double rhs,
    const char *szPrefix)
```

Arguments

exprs: N-dimensional MLinExpr object.

sense: sense for new linear constraints.

rhs: double value at right side of the new linear constraints.

szPrefix: name prefix for constraints in MConstr object.

Return

new MConstr object.

Model::AddMPsdConstr()

Add a N-dimensional MPsdConstr object to model.

Synopsis

```
template <int N> MPsdConstr<N> AddMPsdConstr(const
MPsdConstrBuilder<N> &builder, const char *szPrefix)
```

Arguments

builder: builder for MPsdConstr object.

szPrefix: name prefix of PSD constraints in MPsdConstr object.

Return

new MPsdConstr object.

Model::AddMPsdConstr()

Add a N-dimensional MPsdConstr object to model.

Synopsis

```
template <int N> MPsdConstr<N> AddMPsdConstr(  
    const MPsdExpr<N> &exprs,  
    char sense,  
    double rhs,  
    const char *szPrefix)
```

Arguments

exprs: N-dimensional MPsdExpr object.
sense: sense for new PSD constraints.
rhs: double value at right side of the new PSD constraints.
szPrefix: name prefix of PSD constraints in MPsdConstr object.

Return

new MPsdConstr object.

Model::AddMQConstr()

Add a N-dimensional MQConstr object to model.

Synopsis

```
template <int N> MQConstr<N> AddMQConstr(const MQConstrBuilder<N>  
&builder, const char *szPrefix)
```

Arguments

builder: builder for MQConstr object.
szPrefix: name prefix of quadratic constraints in MQConstr object.

Return

new MQConstr object.

Model::AddMQConstr()

Add a N-dimensional MQConstr object to model.

Synopsis

```
template <int N> MQConstr<N> AddMQConstr(  
    const MQuadExpr<N> &exprs,  
    char sense,  
    double rhs,  
    const char *szPrefix)
```

Arguments

exprs: N-dimensional MQuadExpr object.

sense: sense for new quadratic constraints.

rhs: double value at right side of the new quadratic constraints.

szPrefix: name prefix of quadratic constraints in MQConstr object.

Return

new MQConstr object.

Model::AddMVar()

Add a MVar object in N-dimensions to model.

Synopsis

```
template <int N> MVar<N> AddMVar(  
    const Shape<N> &shp,  
    char vtype,  
    const char *szPrefix)
```

Arguments

shp: shape of MVar object.

vtype: type of variables in MVar object.

szPrefix: name prefix of variables in MVar object.

Return

new MVar object.

Model::AddMVar()

Add a MVar object in N-dimensions to model.

Synopsis

```
MVar<N> AddMVar(  
    const Shape<N> &shp,  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    const char *szPrefix)
```

Arguments

shp: shape of MVar object.

lb: lower bound for variables in MVar object.

ub: upper bound for variables in MVar object.

obj: objective coefficient for variables in MVar object.

vtype: type of variables in MVar object.

szPrefix: name prefix of variables in MVar object.

Return

new MVar object.

Model::AddMVar()

Add a MVar object in N-dimensions to model.

Synopsis

```
MVar<N> AddMVar(  
    const Shape<N> &shp,  
    double *plb,  
    double *pub,  
    double *pobj,  
    char *pvtype,  
    const char *szPrefix)
```

Arguments

shp: shape of MVar object.

plb: lower bounds for variables in MVar object. If NULL, lower bounds are 0.0.

pub: upper bounds for variables in Mar object. If NULL, upper bounds are infinity or 1 for binary variables.

pobj: objective coefficient for variables in MVar object. If NULL, objective coefficients are 0.0.

pvtype: type of variables in MVar object. If NULL, variable types are continuous.

szPrefix: name prefix of variables in MVar object.

Return

new MVar object.

Model::AddOnesMat()

Add a dense symmetric matrix of value one to a model.

Synopsis

```
SymMatrix AddOnesMat(int dim)
```

Arguments

dim: dimension of dense symmetric matrix.

Return

new symmetric matrix object.

Model::AddPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint AddPsdConstr(  
    const PsdExpr &expr,  
    char sense,  
    double rhs,  
    const char *szName)
```

Arguments

expr: PSD expression for new PSD constraint.

sense: sense for new PSD constraint.

rhs: double value at right side of the new PSD constraint.

szName: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model::AddPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint AddPsdConstr(  
    const PsdExpr &expr,  
    double lb,  
    double ub,  
    const char *szName)
```

Arguments

expr: expression for new PSD constraint.

lb: lower bound for new PSD constraint.

ub: upper bound for new PSD constraint.

szName: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model::AddPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint AddPsdConstr(  
    const PsdExpr &lhs,  
    char sense,  
    const PsdExpr &rhs,  
    const char *szName)
```

Arguments

lhs: PSD expression at left side of new PSD constraint.

sense: sense for new PSD constraint.

rhs: PSD expression at right side of new PSD constraint.

szName: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model::AddPsdConstr()

Add a PSD constraint to a model.

Synopsis

```
PsdConstraint AddPsdConstr(const PsdConstrBuilder &builder, const  
    char *szName)
```

Arguments

builder: builder for new PSD constraint.

szName: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model::AddPsdVar()

Add a new PSD variable to model.

Synopsis

```
PsdVar AddPsdVar(int dim, const char *szName)
```

Arguments

dim: dimension of new PSD variable.

szName: name of new PSD variable.

Return

PSD variable object.

Model::AddPsdVars()

Add new PSD variables to model.

Synopsis

```
PsdVarArray AddPsdVars(  
    int count,  
    int *pDim,  
    const char *szPrefix)
```

Arguments

count: number of new PSD variables.
pDim: array of dimensions of new PSD variables.
szPrefix: name prefix of new PSD variables.

Return

array of PSD variable objects.

Model::AddPsdVars()

Add new PSD variables to model.

Synopsis

```
PsdVarArray AddPsdVars(  
    int count,  
    int *pDim,  
    const char *szNames,  
    size_t len)
```

Arguments

count: number of new PSD variables.
pDim: array of dimensions of new PSD variables.
szNames: name buffer of new PSD variables.
len: length of the name buffer.

Return

array of PSD variable objects.

Model::AddQConstr()

Add a quadratic constraint to model.

Synopsis

```
QConstraint AddQConstr(  
    const QuadExpr &expr,  
    char sense,  
    double rhs,  
    const char *szName)
```

Arguments

expr: quadratic expression for the new constraint.
sense: sense for new quadratic constraint.
rhs: double value at right side of the new quadratic constraint.
szName: optional, name of new quadratic constraint.

Return

new quadratic constraint object.

Model::AddQConstr()

Add a quadratic constraint to model.

Synopsis

```
QConstraint AddQConstr(  
    const QuadExpr &lhs,  
    char sense,  
    const QuadExpr &rhs,  
    const char *szName)
```

Arguments

lhs: quadratic expression at left side of the new quadratic constraint.
sense: sense for new quadratic constraint.
rhs: quadratic expression at right side of the new quadratic constraint.
szName: optional, name of new quadratic constraint.

Return

new quadratic constraint object.

Model::AddQConstr()

Add a quadratic constraint to a model.

Synopsis

```
QConstraint AddQConstr(const QConstrBuilder &builder, const char  
    *szName)
```

Arguments

builder: builder for the new quadratic constraint.
szName: optional, name of new quadratic constraint.

Return

new quadratic constraint object.

Model::AddSos()

Add a SOS constraint to model.

Synopsis

```
Sos AddSos(const SosBuilder &builder)
```

Arguments

builder: builder for new SOS constraint.

Return

new SOS constraint object.

Model::AddSos()

Add a SOS constraint to model.

Synopsis

```
Sos AddSos(  
    const VarArray &vars,  
    const double *pWeights,  
    int type)
```

Arguments

vars: variables that participate in the SOS constraint.

pWeights: optional, weights for variables in the SOS constraint.

type: type of SOS constraint.

Return

new SOS constraint object.

Model::AddSparseMat()

Add a sparse symmetric matrix to a model.

Synopsis

```
SymMatrix AddSparseMat(  
    int dim,  
    int nElems,  
    int *pRows,  
    int *pCols,  
    double *pVals)
```

Arguments

dim: dimension of the sparse symmetric matrix.

nElems: number of non-zero elements in the sparse symmetric matrix.

pRows: array of row indexes of non-zero elements.

pCols: array of col indexes of non-zero elements.

pVals: array of values of non-zero elements.

Return

new symmetric matrix object.

Model::AddSymMat()

Given a symmetric matrix expression, add results matrix to model.

Synopsis

```
SymMatrix AddSymMat(const SymMatExpr &expr)
```

Arguments

expr: symmetric matrix expression object.

Return

results symmetric matrix object.

Model::AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    const Expr &lhs,  
    char sense,  
    double rhs,  
    const char *szName)
```

Arguments

lhs: expression for user cut.

sense: sense for user cut.

rhs: right hand side value for user cut.

szName: optional, name of user cut.

Model::AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    const Expr &lhs,  
    char sense,  
    const Expr &rhs,  
    const char *szName)
```

Arguments

lhs: left hand side expression for user cut.

sense: sense for user cut.

rhs: right hand side expression for user cut.

szName: optional, name of user cut.

Model::AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(const ConstrBuilder &builder, const char *szName)
```

Arguments

builder: builder for user cut.

szName: optional, name of user cut.

Model::AddUserCuts()

Add user cuts to model.

Synopsis

```
void AddUserCuts(const ConstrBuilderArray &builders, const char  
*szPrefix)
```

Arguments

builders: array of builders for user cuts.

szPrefix: name prefix of new user cuts.

Model::AddVar()

Add a variable to model.

Synopsis

```
Var AddVar(  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    const char *szName)
```

Arguments

lb: lower bound for new variable.

ub: upper bound for new variable.

obj: objective coefficient for new variable.

vtype: variable type for new variable.

szName: optional, name for new variable.

Return

new variable object.

Model::AddVar()

Add a variable and the associated non-zero coefficients as column.

Synopsis

```
Var AddVar(  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    const Column &col,  
    const char *szName)
```

Arguments

lb: lower bound for new variable.

ub: upper bound for new variable.

obj: objective coefficient for new variable.

vtype: variable type for new variable.

col: column object for specifying a set of constraints to which the variable belongs.

szName: optional, name for new variable.

Return

new variable object.

Model::AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    char vtype,  
    const char *szPrefix)
```

Arguments

count: the number of variables to add.

vtype: variable types for new variables.

szPrefix: prefix part for names of new variables.

Return

array of new variable objects.

Model::AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    char vtype,  
    const char *szNames,  
    size_t len)
```

Arguments

count: the number of variables to add.
vtype: variable types for new variables.
szNames: name buffer for new variables.
len: length of name buffer.

Return

array of new variable objects.

Model::AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    const char *szPrefix)
```

Arguments

count: the number of variables to add.
lb: lower bound for new variable.
ub: upper bound for new variable.
obj: objective coefficient for new variable.
vtype: variable types for new variables.
szPrefix: prefix part for names of new variables.

Return

array of new variable objects.

Model::AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    const char *szNames,  
    size_t len)
```

Arguments

count: the number of variables to add.
lb: lower bound for new variable.
ub: upper bound for new variable.
obj: objective coefficient for new variable.
vtype: variable types for new variables.
szNames: name buffer for new variables.
len: length of name buffer.

Return

array of new variable objects.

Model::AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double *plb,  
    double *pub,  
    double *pobj,  
    char *pvtype,  
    const char *szPrefix)
```

Arguments

count: the number of variables to add.
plb: lower bounds for new variables. if NULL, lower bounds are 0.0.
pub: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.
pobj: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

pvtype: variable types for new variables. if NULL, variable types are continuous.

szPrefix: prefix part for names of new variables.

Return

array of new variable objects.

Model::AddVars()

Add new decision variables to a model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double *plb,  
    double *pub,  
    double *pobj,  
    char *pvtype,  
    const char *szNames,  
    size_t len)
```

Arguments

count: the number of variables to add.

plb: lower bounds for new variables. if NULL, lower bounds are 0.0.

pub: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

pobj: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

pvtype: variable types for new variables. if NULL, variable types are continuous.

szNames: name buffer for new variables.

len: length of name buffer.

Return

array of new variable objects.

Model::AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double *plb,  
    double *pub,  
    double *pobj,  
    char *pvtype,  
    const ColumnArray &cols,
```

```
const char *szPrefix)
```

Arguments

count: the number of variables to add.

plb: lower bounds for new variables. if NULL, lower bounds are 0.0.

pub: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

pobj: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

pvtype: variable types for new variables. if NULL, variable types are continuous.

cols: column objects for specifying a set of constraints to which each new variable belongs.

szPrefix: prefix part for names of new variables.

Return

array of new variable objects.

Model::Clear()

Clear all settings including problem itself.

Synopsis

```
void Clear()
```

Model::Clone()

Deep copy COPT model.

Synopsis

```
Model Clone()
```

Return

cloned model object.

Model::ComputeIIS()

Compute IIS for infeasible model.

Synopsis

```
void ComputeIIS()
```

Model::DelPsdObj()

delete PSD part of objective in model.

Synopsis

```
void DelPsdObj()
```

Model::DelQuadObj()

delete quadratic part of objective in model.

Synopsis

```
void DelQuadObj()
```

Model::FeasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void FeasRelax(  
    const VarArray &vars,  
    double *pColLowPen,  
    double *pColUppPen,  
    const ConstrArray &cons,  
    double *pRowBndPen,  
    double *pRowUppPen)
```

Arguments

vars: an array of variables.
pColLowPen: penalties for lower bounds of variables.
pColUppPen: penalties for upper bounds of variables.
cons: an array of constraints.
pRowBndPen: penalties for right hand sides of constraints.
pRowUppPen: penalties for upper bounds of range constraints.

Model::FeasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void FeasRelax(  
    const MVar<1> &vars,  
    double *pColLowPen,  
    double *pColUppPen,  
    const MConstr<1> &cons,  
    double *pRowBndPen,  
    double *pRowUppPen)
```

Arguments

vars: one-dimensional variables.
pColLowPen: penalties for lower bounds of variables.
pColUppPen: penalties for upper bounds of variables.
cons: one-dimensional constraints.

pRowBndPen: penalties for right hand sides of constraints.

pRowUppPen: penalties for upper bounds of range constraints.

Model::FeasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void FeasRelax(  
    const MVar<N> &vars,  
    const NdArray<double, N> &colLowPen,  
    const NdArray<double, N> &colUppPen,  
    const MConstr<M> &cons,  
    const NdArray<double, M> &rowBndPen,  
    const NdArray<double, M> &rowUppPen)
```

Arguments

vars: N-dimensional variables.

colLowPen: penalties for lower bounds of variables.

colUppPen: penalties for upper bounds of variables.

cons: M-dimensional constraints.

rowBndPen: penalties for right hand sides of constraints.

rowUppPen: penalties for upper bounds of range constraints.

Model::FeasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void FeasRelax(int ifRelaxVars, int ifRelaxCons)
```

Arguments

ifRelaxVars: whether to relax variables.

ifRelaxCons: whether to relax constraints.

Model::Get()

Query values of information associated with variables.

Synopsis

```
int Get(  
    const char *szName,  
    const VarArray &vars,  
    double *pOut)
```

Arguments

szName: name of information.

vars: a list of desired variables.

pOut: output array of information values.

Return

the number of valid variables. If failed, return -1.

Model::Get()

Query values of information associated with constraints.

Synopsis

```
int Get(  
    const char *szName,  
    const ConstrArray &constrs,  
    double *pOut)
```

Arguments

szName: name of information.

constrs: a list of desired constraints.

pOut: output array of information values.

Return

the number of valid constraints. If failed, return -1.

Model::Get()

Query values of information associated with quadratic constraints.

Synopsis

```
int Get(  
    const char *szName,  
    const QConstrArray &constrs,  
    double *pOut)
```

Arguments

szName: name of information.

constrs: a list of desired quadratic constraints.

pOut: output array of information values.

Return

the number of valid quadratic constraints. If failed, return -1.

Model::Get()

Query values of information associated with PSD constraints.

Synopsis

```
int Get(  
    const char *szName,  
    const PsdConstrArray &constrs,  
    double *pOut)
```

Arguments

szName: name of information.

constrs: a list of desired PSD constraints.

pOut: output array of information values.

Return

the number of valid PSD constraints. If failed, return -1.

Model::GetAffineCone()

Get an affine cone constraint of given index in model.

Synopsis

```
AffineCone GetAffineCone(int idx)
```

Arguments

idx: index of the desired affine cone constraint.

Return

the desired affine cone constraint object.

Model::GetAffineConeBuilder()

Get builder of given affine cone constraint in model.

Synopsis

```
AffineConeBuilder GetAffineConeBuilder(const AffineCone &cone)
```

Arguments

cone: an affine cone constraint.

Return

desired affine cone constraint builder.

Model::GetAffineConeBuilders()

Get builders of desired affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray GetAffineConeBuilders(const AffineConeArray
&cones)
```

Arguments

cones: array of affine cone constraints.

Return

array object of desired affine cone constraint builders.

Model::GetAffineConeBuilders()

Get builders of all affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray GetAffineConeBuilders()
```

Return

array object of all affine cone constraint builders.

Model::GetAffineConeByName()

Get an affine cone constraint of given name in model.

Synopsis

```
AffineCone GetAffineConeByName(const char *szName)
```

Arguments

szName: name of the affine cone constraint.

Return

the desired affine cone constraint object.

Model::GetAffineCones()

Get all affine cone constraints in model.

Synopsis

```
AffineConeArray GetAffineCones()
```

Return

array object of affine cone constraints.

Model::GetCoeff()

Get the coefficient of variable in a linear constraint.

Synopsis

```
double GetCoeff(const Constraint &constr, const Var &var)
```

Arguments

constr: The requested constraint.

var: The requested variable.

Return

The requested coefficient.

Model::GetCol()

Get a column object that have a list of constraints in which the variable participates.

Synopsis

```
Column GetCol(const Var &var)
```

Arguments

var: a variable object.

Return

a column object associated with a variable.

Model::GetColBasis()

Get status of column basis.

Synopsis

```
int GetColBasis(int *pBasis)
```

Arguments

pBasis: integer pointer to basis status.

Return

number of columns.

Model::GetCone()

Get a cone constraint of given index in model.

Synopsis

```
Cone GetCone(int idx)
```

Arguments

idx: index of the desired cone constraint.

Return

the desired cone constraint object.

Model::GetConeBuilders()

Get builders of all cone constraints in model.

Synopsis

```
ConeBuilderArray GetConeBuilders()
```

Return

array object of all cone constraint builders.

Model::GetConeBuilders()

Get builders of given cone constraints in model.

Synopsis

```
ConeBuilderArray GetConeBuilders(const ConeArray &cones)
```

Arguments

cones: array of cone constraints.

Return

array object of desired cone constraint builders.

Model::GetCones()

Get all cone constraints in model.

Synopsis

```
ConeArray GetCones()
```

Return

array object of cone constraints.

Model::GetConstr()

Get a constraint of given index in model.

Synopsis

```
Constraint GetConstr(int idx)
```

Arguments

idx: index of the desired constraint.

Return

the desired constraint object.

Model::GetConstrBuilder()

Get builder of a constraint in model, including variables and associated coefficients, sense and RHS.

Synopsis

```
ConstrBuilder GetConstrBuilder(Constraint constr)
```

Arguments

`constr`: a constraint object.

Return

constraint builder object.

Model::GetConstrBuilders()

Get builders of all constraints in model.

Synopsis

```
ConstrBuilderArray GetConstrBuilders()
```

Return

array object of constraint builders.

Model::GetConstrByName()

Get a constraint of given name in model.

Synopsis

```
Constraint GetConstrByName(const char *szName)
```

Arguments

`szName`: name of the desired constraint.

Return

the desired constraint object.

Model::GetConstrLowerIIS()

Get IIS status of lower bounds of constraints.

Synopsis

```
int GetConstrLowerIIS(const ConstrArray &constrs, int *pLowerIIS)
```

Arguments

`constrs`: Array of constraints.

`pLowerIIS`: IIS status of lower bounds of constraints.

Return

Number of constraints.

Model::GetConstrs()

Get all constraints in model.

Synopsis

```
ConstrArray GetConstrs()
```

Return

array object of constraints.

Model::GetConstrUpperIIS()

Get IIS status of upper bounds of constraints.

Synopsis

```
int GetConstrUpperIIS(const ConstrArray &constrs, int *pUpperIIS)
```

Arguments

constrs: Array of constraints.

pUpperIIS: IIS status of upper bounds of constraints.

Return

Number of constraints.

Model::GetDblAttr()

Get value of a COPT double attribute.

Synopsis

```
double GetDblAttr(const char *szAttr)
```

Arguments

szAttr: name of double attribute.

Return

value of double attribute.

Model::GetDblParam()

Get value of a COPT double parameter.

Synopsis

```
double GetDblParam(const char *szParam)
```

Arguments

szParam: name of integer parameter.

Return

value of double parameter.

Model::GetExpCone()

Get an exponential cone constraint of given index in model.

Synopsis

```
ExpCone GetExpCone(int idx)
```

Arguments

idx: index of the desired exponential cone constraint.

Return

the desired exponential cone constraint object.

Model::GetExpConeBuilders()

Get builders of all exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray GetExpConeBuilders()
```

Return

array object of all exponential cone constraint builders.

Model::GetExpConeBuilders()

Get builders of given exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray GetExpConeBuilders(const ExpConeArray &cones)
```

Arguments

cones: array of exponential cone constraints.

Return

array object of desired exponential cone constraint builders.

Model::GetExpCones()

Get all exponential cone constraints in model.

Synopsis

```
ExpConeArray GetExpCones()
```

Return

array object of exponential cone constraints.

Model::GetGenConstr()

Get a general constraint of given index in model.

Synopsis

```
GenConstr GetGenConstr(int idx)
```

Arguments

idx: index of the desired general constraint.

Return

the desired general constraint object.

Model::GetGenConstrByName()

Get a general constraint of given name in model.

Synopsis

```
GenConstr GetGenConstrByName(const char *szName)
```

Arguments

szName: name of the desired general constraint.

Return

the desired general constraint object.

Model::GetGenConstrIndicator()

Get builder of given general constraint of type indicator.

Synopsis

```
GenConstrBuilder GetGenConstrIndicator(const GenConstr &indicator)
```

Arguments

indicator: a general constraint of type indicator.

Return

builder object of general constraint of type indicator.

Model::GetGenConstrIndicators()

Get builders of all general constraints in model.

Synopsis

```
GenConstrBuilderArray GetGenConstrIndicators()
```

Return

array object of general constraint builders.

Model::GetGenConstrs()

Get all general constraints in model.

Synopsis

```
GenConstrArray GetGenConstrs()
```

Return

array object of general constraints.

Model::GetIndicatorIIS()

Get IIS status of indicator constraints.

Synopsis

```
int GetIndicatorIIS(const GenConstrArray &genconstrs, int *pIIS)
```

Arguments

genconstrs: Array of indicator constraints.

pIIS: IIS status of indicator constraints.

Return

Number of indicator constraints.

Model::GetIntAttr()

Get value of a COPT integer attribute.

Synopsis

```
int GetIntAttr(const char *szAttr)
```

Arguments

szAttr: name of integer attribute.

Return

value of integer attribute.

Model::GetIntParam()

Get value of a COPT integer parameter.

Synopsis

```
int GetIntParam(const char *szParam)
```

Arguments

szParam: name of integer parameter.

Return

value of integer parameter.

Model::GetLmiCoeff()

Get the symmetric matrix of variable in LMI constraint.

Synopsis

```
SymMatrix GetLmiCoeff(const LmiConstraint &constr, const Var &var)
```

Arguments

constr: The desired LMI constraint.

var: The desired variable.

Return

The associated coefficient matrix.

Model::GetLmiConstr()

Get LMI constraint of given index in model.

Synopsis

```
LmiConstraint GetLmiConstr(int idx)
```

Arguments

idx: index of desired LMI constraint.

Return

LMI constraint object.

Model::GetLmiConstrByName()

Get LMI constraint of given name in model.

Synopsis

```
LmiConstraint GetLmiConstrByName(const char *szName)
```

Arguments

szName: name of desired LMI constraint.

Return

LMI constraint object.

Model::GetLmiConstrs()

Get all LMI constraints in model.

Synopsis

```
LmiConstrArray GetLmiConstrs()
```

Return

array object of LMI constraints.

Model::GetLmiRhs()

Get the symmetric matrix of constant of LMI constraint.

Synopsis

```
SymMatrix GetLmiRhs(const LmiConstraint &constr)
```

Arguments

constr: The desired LMI constraint.

Return

matrix of constant term.

Model::GetLmiRow()

Get variables and associated symmetric matrices that participate in a LMI constraint.

Synopsis

```
LmiExpr GetLmiRow(const LmiConstraint &constr)
```

Arguments

constr: given LMI constraint object.

Return

pointer to LMI expression object of LMI constraint.

Model::GetLpSolution()

Get LP solution.

Synopsis

```
void GetLpSolution(  
    double *pValue,  
    double *pSlack,  
    double *pRowDual,  
    double *pRedCost)
```

Arguments

pValue: optional, double pointer to solution values.

pSlack: optional, double pointer to slack values.

pRowDual: optional, double pointer to dual values.

pRedCost: optional, double pointer to reduced costs.

Model::GetObjective()

Get linear expression of objective for model.

Synopsis

```
Expr GetObjective()
```

Return

a linear expression object.

Model::GetParamAttrType()

Get type of a COPT parameter or attribute.

Synopsis

```
int GetParamAttrType(const char *szName)
```

Arguments

szName: name of parameter or attribute.

Return

type of parameter or attribute.

Model::GetParamInfo()

Get current, default, minimum, maximum of COPT integer parameter.

Synopsis

```
void GetParamInfo(  
    const char *szParam,  
    int *pnCur,  
    int *pnDef,  
    int *pnMin,  
    int *pnMax)
```

Arguments

szParam: name of integer parameter.

pnCur: out, current value of integer parameter.

pnDef: out, default value of integer parameter.

pnMin: out, minimum value of integer parameter.

pnMax: out, maximum value of integer parameter.

Model::GetParamInfo()

Get current, default, minimum, maximum of COPT double parameter.

Synopsis

```
void GetParamInfo(  
    const char *szParam,  
    double *pdCur,  
    double *pdDef,  
    double *pdMin,  
    double *pdMax)
```

Arguments

szParam: name of double parameter.
pdCur: out, current value of double parameter.
pdDef: out, default value of double parameter.
pdMin: out, minimum value of double parameter.
pdMax: out, maximum value of double parameter.

Model::GetPoolObjVal()

Get the iSol-th objective value in solution pool.

Synopsis

```
double GetPoolObjVal(int iSol)
```

Arguments

iSol: Index of solution.

Return

The requested objective value.

Model::GetPoolSolution()

Get the iSol-th solution in solution pool.

Synopsis

```
int GetPoolSolution(  
    int iSol,  
    const VarArray &vars,  
    double *pColVals)
```

Arguments

iSol: Index of solution.
vars: The requested variables.
pColVals: Pointer to the requested solutions.

Return

The length of requested solution array.

Model::GetPsdCoeff()

Get the symmetric matrix of PSD variable in a PSD constraint.

Synopsis

```
SymMatrix GetPsdCoeff(const PsdConstraint &constr, const PsdVar  
&var)
```

Arguments

constr: The desired PSD constraint.

var: The desired PSD variable.

Return

The associated coefficient matrix.

Model::GetPsdConstr()

Get PSD constraint of given index in model.

Synopsis

```
PsdConstraint GetPsdConstr(int idx)
```

Arguments

idx: index of desired PSD constraint.

Return

PSD constraint object.

Model::GetPsdConstrBuilder()

Get builder of a PSD constraint in model, including PSD variables, sense and associated symmetric matrix.

Synopsis

```
PsdConstrBuilder GetPsdConstrBuilder(const PsdConstraint &constr)
```

Arguments

constr: PSD constraint object.

Return

pointer to PSD constraint builder object.

Model::GetPsdConstrBuilders()

Get builders of all PSD constraints in model.

Synopsis

```
PsdConstrBuilderArray GetPsdConstrBuilders()
```

Return

pointer to array object of PSD constraint builders.

Model::GetPsdConstrByName()

Get PSD constraint of given name in model.

Synopsis

```
PsdConstraint GetPsdConstrByName(const char *szName)
```

Arguments

szName: name of desired PSD constraint.

Return

PSD constraint object.

Model::GetPsdConstrs()

Get all PSD constraints in model.

Synopsis

```
PsdConstrArray GetPsdConstrs()
```

Return

pointer to array object of PSD constraints.

Model::GetPsdObjective()

Get PSD objective of model.

Synopsis

```
PsdExpr GetPsdObjective()
```

Return

a PSD expression object.

Model::GetPsdRow()

Get PSD variables and associated symmetric matrices that participate in a PSD constraint.

Synopsis

```
PsdExpr GetPsdRow(const PsdConstraint &constr)
```

Arguments

constr: PSD constraint object.

Return

pointer to PSD expression object of the PSD constraint.

Model::GetPsdRow()

Get PSD variables, associated symmetric matrix, LB/UB that participate in a PSD constraint.

Synopsis

```
PsdExpr GetPsdRow(  
    const PsdConstraint &constr,  
    double *pLower,  
    double *pUpper)
```

Arguments

constr: a PSD constraint object.
pLower: pointer to double value of lower bound.
pUpper: pointer to double value of upper bound.

Return

pointer to PSD expression object of the PSD constraint.

Model::GetPsdVar()

Get a PSD variable of given index in model.

Synopsis

```
PsdVar GetPsdVar(int idx)
```

Arguments

idx: index of the desired PSD variable.

Return

the desired PSD variable object.

Model::GetPsdVarByName()

Get a PSD variable of given name in model.

Synopsis

```
PsdVar GetPsdVarByName(const char *szName)
```

Arguments

szName: name of the desired PSD variable.

Return

the desired PSD variable object.

Model::GetPsdVars()

Get all PSD variables in model.

Synopsis

```
PsdVarArray GetPsdVars()
```

Return

array object of PSD variables.

Model::GetQConstr()

Get a quadratic constraint of given index in model.

Synopsis

```
QConstraint GetQConstr(int idx)
```

Arguments

idx: index of the desired quadratic constraint.

Return

the desired quadratic constraint object.

Model::GetQConstrBuilder()

Get builder of a constraint in model, including variables and associated coefficients, sense and RHS.

Synopsis

```
QConstrBuilder GetQConstrBuilder(const QConstraint &constr)
```

Arguments

constr: a constraint object.

Return

constraint builder object.

Model::GetQConstrBuilders()

Get builders of all constraints in model.

Synopsis

```
QConstrBuilderArray GetQConstrBuilders()
```

Return

array object of constraint builders.

Model::GetQConstrByName()

Get a quadratic constraint of given name in model.

Synopsis

```
QConstraint GetQConstrByName(const char *szName)
```

Arguments

szName: name of the desired constraint.

Return

the desired quadratic constraint object.

Model::GetQConstrs()

Get all quadratic constraints in model.

Synopsis

```
QConstrArray GetQConstrs()
```

Return

array object of quadratic constraints.

Model::GetQuadObjective()

Get quadratic objective of model.

Synopsis

```
QuadExpr GetQuadObjective()
```

Return

a quadratic expression object.

Model::GetQuadRow()

Get two variables and associated coefficients that participate in a quadratic constraint.

Synopsis

```
QuadExpr GetQuadRow(const QConstraint &constr)
```

Arguments

constr: a quadratic constraint object.

Return

quadratic expression object of the constraint.

Model::GetQuadRow()

Get two variables and associated coefficients that participate in a quadratic constraint.

Synopsis

```
QuadExpr GetQuadRow(  
    const QConstraint &constr,  
    char *pSense,  
    double *pBound)
```

Arguments

constr: a quadratic constraint object.
pSense: sense of quadratic constraint.
pBound: right hand side of quadratic constraint.

Return

quadratic expression object of the constraint.

Model::GetRow()

Get variables that participate in a constraint, and the associated coefficients.

Synopsis

```
Expr GetRow(const Constraint &constr)
```

Arguments

constr: a constraint object.

Return

expression object of the constraint.

Model::GetRowBasis()

Get status of row basis.

Synopsis

```
int GetRowBasis(int *pBasis)
```

Arguments

pBasis: integer pointer to basis status.

Return

number of rows.

Model::GetSolution()

Get MIP solution.

Synopsis

```
void GetSolution(double *pValue)
```

Arguments

pValue: double pointer to solution values.

Model::GetSos()

Get a SOS constraint of given index in model.

Synopsis

```
Sos GetSos(int idx)
```

Arguments

idx: index of the desired SOS constraint.

Return

the desired SOS constraint object.

Model::GetSosBuilders()

Get builders of all SOS constraints in model.

Synopsis

```
SosBuilderArray GetSosBuilders()
```

Return

array object of SOS constraint builders.

Model::GetSosBuilders()

Get builders of given SOS constraints in model.

Synopsis

```
SosBuilderArray GetSosBuilders(const SosArray &ssoss)
```

Arguments

ssoss: array of SOS constraints.

Return

array object of desired SOS constraint builders.

Model::GetSOSIIS()

Get IIS status of SOS constraints.

Synopsis

```
int GetSOSIIS(const SosArray &ssoss, int *piIS)
```

Arguments

ssoss: Array of SOS constraints.

piIS: IIS status of SOS constraints.

Return

Number of SOS constraints.

Model::GetSoss()

Get all SOS constraints in model.

Synopsis

```
SosArray GetSoss()
```

Return

array object of SOS constraints.

Model::GetSymMat()

Get a symmetric matrix of given index in model.

Synopsis

```
SymMatrix GetSymMat(int idx)
```

Arguments

idx: index of the desired symmetric matrix.

Return

the desired symmetric matrix object.

Model::GetVar()

Get a variable of given index in model.

Synopsis

```
Var GetVar(int idx)
```

Arguments

idx: index of the desired variable.

Return

the desired variable object.

Model::GetVarByName()

Get a variable of given name in model.

Synopsis

```
Var GetVarByName(const char *szName)
```

Arguments

szName: name of the desired variable.

Return

the desired variable object.

Model::GetVarLowerIIS()

Get IIS status of lower bounds of variables.

Synopsis

```
int GetVarLowerIIS(const VarArray &vars, int *pLowerIIS)
```

Arguments

vars: Array of variables

pLowerIIS: IIS status of lower bounds of variables.

Return

Number of variables.

Model::GetVars()

Get all variables in model.

Synopsis

```
VarArray GetVars()
```

Return

variable array object.

Model::GetVarUpperIIS()

Get IIS status of upper bounds of variables.

Synopsis

```
int GetVarUpperIIS(const VarArray &vars, int *pUpperIIS)
```

Arguments

vars: Array of variables

pUpperIIS: IIS status of upper bounds of variables.

Return

Number of variables.

Model::Interrupt()

Interrupt optimization of current problem.

Synopsis

```
void Interrupt()
```

Model::LoadMipStart()

Load final initial values of variables to the problem.

Synopsis

```
void LoadMipStart()
```

Model::LoadTuneParam()

Load specified tuned parameters into model.

Synopsis

```
void LoadTuneParam(int idx)
```

Arguments

idx: Index of tuned parameters.

Model::Read()

Read problem, solution, basis, MIP start or COPT parameters from file.

Synopsis

```
void Read(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadBasis()

Read basis from file.

Synopsis

```
void ReadBasis(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadBin()

Read problem in COPT binary format from file.

Synopsis

```
void ReadBin(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadCbf()

Read problem in CBF format from file.

Synopsis

```
void ReadCbf(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadLp()

Read problem in LP format from file.

Synopsis

```
void ReadLp(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadMps()

Read problem in MPS format from file.

Synopsis

```
void ReadMps(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadMst()

Read MIP start information from file.

Synopsis

```
void ReadMst(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadParam()

Read COPT parameters from file.

Synopsis

```
void ReadParam(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadSdpa()

Read problem in SDPA format from file.

Synopsis

```
void ReadSdpa(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadSol()

Read solution from file.

Synopsis

```
void ReadSol(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::ReadTune()

Read tuning parameters from file.

Synopsis

```
void ReadTune(const char *szFileName)
```

Arguments

szFileName: an input file name.

Model::Remove()

Remove a list of variables from model.

Synopsis

```
void Remove(VarArray &vars)
```

Arguments

vars: an array of variables.

Model::Remove()

Remove a list of constraints from model.

Synopsis

```
void Remove(ConstrArray &constrs)
```

Arguments

constrs: an array of constraints.

Model::Remove()

Remove a list of SOS constraints from model.

Synopsis

```
void Remove(SosArray &ssoss)
```

Arguments

ssoss: an array of SOS constraints.

Model::Remove()

Remove a list of gernal constraints from model.

Synopsis

```
void Remove(GenConstrArray &genConstrs)
```

Arguments

genConstrs: an array of general constraints.

Model::Remove()

Remove a list of cone constraints from model.

Synopsis

```
void Remove(ConeArray &cones)
```

Arguments

cones: an array of cone constraints.

Model::Remove()

Remove a list of exponential cone constraints from model.

Synopsis

```
void Remove(ExpConeArray &cones)
```

Arguments

cones: an array of exponential cone constraints.

Model::Remove()

Remove a list of affine cone constraints from model.

Synopsis

```
void Remove(AffineConeArray &cones)
```

Arguments

cones: an array of affine cone constraints.

Model::Remove()

Remove a list of quadratic constraints from model.

Synopsis

```
void Remove(QConstrArray &qconstrs)
```

Arguments

qconstrs: an array of quadratic constraints.

Model::Remove()

Remove a list of PSD variables from model.

Synopsis

```
void Remove(PsdVarArray &vars)
```

Arguments

vars: an array of PSD variables.

Model::Remove()

Remove a list of PSD constraints from model.

Synopsis

```
void Remove(PsdConstrArray &constrs)
```

Arguments

constrs: an array of PSD constraints.

Model::Remove()

Remove a list of LMI constraints from model.

Synopsis

```
void Remove(LmiConstrArray &constrs)
```

Arguments

constrs: an array of LMI constraints.

Model::Reset()

Reset solution of problem only.

Synopsis

```
void Reset()
```


Model::ResetAll()

Reset solution of problem, and additional information such as MIP start, etc.

Synopsis

```
void ResetAll()
```

Model::ResetParam()

Reset parameters to default settings.

Synopsis

```
void ResetParam()
```

Model::Set()

Set values of information associated with variables.

Synopsis

```
void Set(  
    const char *szName,  
    const VarArray &vars,  
    double *pVals,  
    int len)
```

Arguments

szName: name of double information.

vars: a list of desired variables.

pVals: array of information values.

len: length of value array.

Model::Set()

Set values of information associated with constraints.

Synopsis

```
void Set(  
    const char *szName,  
    const ConstrArray &constrs,  
    double *pVals,  
    int len)
```

Arguments

szName: name of double information.

constrs: a list of desired constraints.

pVals: array of information values.

len: length of value array.

Model::Set()

Set values of information associated with PSD constraints.

Synopsis

```
void Set(  
    const char *szName,  
    const PsdConstrArray &constrs,  
    double *pVals,  
    int len)
```

Arguments

szName: name of double information.
constrs: a list of desired PSD constraints.
pVals: array of values of information.
len: length of value array.

Model::SetBasis()

Set column and row basis status to model.

Synopsis

```
void SetBasis(int *pColBasis, int *pRowBasis)
```

Arguments

pColBasis: pointer to status of column basis.
pRowBasis: pointer to status of row basis.

Model::SetCallback()

Set user callback to COPT model.

Synopsis

```
void SetCallback(ICallback *pcb, int cbctx)
```

Arguments

pcb: pointer to user callback object.
cbctx: COPT callback context, see definition in `copt.h`

Model::SetCoeff()

Set the coefficient of a variable in a linear constraint.

Synopsis

```
void SetCoeff(  
    const Constraint &constr,  
    const Var &var,  
    double newVal)
```

Arguments

constr: The requested constraint.

var: The requested variable.

newVal: New coefficient.

Model::SetCoeffs()

Set a list of coefficients in the model.

Synopsis

```
void SetCoeffs(  
    const ConstrArray &constrs,  
    const VarArray &vars,  
    double *vals,  
    int len)
```

Arguments

constrs: A list of constraints for coefficients to be set.

vars: A list of vars for coefficients to be set.

vals: New values for coefficients.

len: Length of values.

Model::SetDblParam()

Set value of a COPT double parameter.

Synopsis

```
void SetDblParam(const char *szParam, double dVal)
```

Arguments

szParam: name of integer parameter.

dVal: double value.

Model::SetIntParam()

Set value of a COPT integer parameter.

Synopsis

```
void SetIntParam(const char *szParam, int nVal)
```

Arguments

szParam: name of integer parameter.

nVal: integer value.

Model::SetLmiCoeff()

Set the coefficient matrix of a variable in LMI constraint.

Synopsis

```
void SetLmiCoeff(  
    const LmiConstraint &constr,  
    const Var &var,  
    const SymMatrix &mat)
```

Arguments

constr: The desired LMI constraint.

var: The desired variable.

mat: new coefficient matrix.

Model::SetLmiRhs()

Set constant matrix of LMI constraint.

Synopsis

```
void SetLmiRhs(const LmiConstraint &constr, const SymMatrix &mat)
```

Arguments

constr: The desired LMI constraint.

mat: new constant matrix.

Model::SetLpSolution()

Set LP solution.

Synopsis

```
void SetLpSolution(  
    double *pValue,  
    double *pSlack,  
    double *pRowDual,  
    double *pRedCost)
```

Arguments

pValue: double pointer to solution values.

pSlack: double pointer to slack values.

pRowDual: double pointer to dual values.

pRedCost: double pointer to reduced costs.

Model::SetMipStart()

Set initial values for variables of given number, starting from the first one.

Synopsis

```
void SetMipStart(int count, double *pVals)
```

Arguments

count: the number of variables to set.

pVals: pointer to initial values of variables.

Model::SetMipStart()

Set initial value for the specified variable.

Synopsis

```
void SetMipStart(const Var &var, double val)
```

Arguments

var: an interested variable.

val: initial value of the variable.

Model::SetMipStart()

Set initial values for an array of variables.

Synopsis

```
void SetMipStart(const VarArray &vars, double *pVals)
```

Arguments

vars: a list of interested variables.

pVals: pointer to initial values of variables.

Model::SetNames()

Set names for given variables in model.

Synopsis

```
void SetNames(  
    const VarArray &vars,  
    const char *szNames,  
    size_t len)
```

Arguments

vars: array object of variables.

szNames: name buffer for variables.

len: length of name buffer.

Model::SetNames()

Set names for given constraints in model.

Synopsis

```
void SetNames(  
    const ConstrArray &cons,  
    const char *szNames,  
    size_t len)
```

Arguments

cons: array object of constraints.
szNames: name buffer for constraints.
len: length of name buffer.

Model::SetNames()

Set names for given gernal constraints in model.

Synopsis

```
void SetNames(  
    const GenConstrArray &genConstrs,  
    const char *szNames,  
    size_t len)
```

Arguments

genConstrs: array object of general constrains.
szNames: name buffer for general constraints.
len: length of name buffer.

Model::SetNames()

Set names for given affine cone constraints in model.

Synopsis

```
void SetNames(  
    const AffineConeArray &cons,  
    const char *szNames,  
    size_t len)
```

Arguments

cons: array object of affine cone constraints.
szNames: name buffer for affine cone constraints.
len: length of name buffer.

Model::SetNames()

Set names for given quadratic constraints in model.

Synopsis

```
void SetNames(  
    const QConstrArray &cons,  
    const char *szNames,  
    size_t len)
```

Arguments

cons: array object of quadratic constraints.
szNames: name buffer for quadratic constraints.
len: length of name buffer.

Model::SetNames()

Set names for given PSD variables in model.

Synopsis

```
void SetNames(  
    const PsdVarArray &vars,  
    const char *szNames,  
    size_t len)
```

Arguments

vars: array object of PSD variables.
szNames: name buffer for PSD variables.
len: length of name buffer.

Model::SetNames()

Set names for given PSD constraints in model.

Synopsis

```
void SetNames(  
    const PsdConstrArray &cons,  
    const char *szNames,  
    size_t len)
```

Arguments

cons: array object of PSD constraints.
szNames: name buffer for PSD constraints.
len: length of name buffer.

Model::SetNames()

Set names for given LMI constraints in model.

Synopsis

```
void SetNames(  
    const LmiConstrArray &cons,  
    const char *szNames,  
    size_t len)
```

Arguments

cons: array object of LMI constraints.

szNames: name buffer for LMI constraints.

len: length of name buffer.

Model::SetObjConst()

Set objective constant.

Synopsis

```
void SetObjConst(double constant)
```

Arguments

constant: constant value to set.

Model::SetObjective()

Set objective for model.

Synopsis

```
void SetObjective(const Expr &expr, int sense)
```

Arguments

expr: expression of the objective.

sense: optimization sense. optional, default value 0 does not change COPT sense.

Model::SetObjSense()

Set objective sense for model.

Synopsis

```
void SetObjSense(int sense)
```

Arguments

sense: the objective sense.

Model::SetPsdCoeff()

Set the coefficient matrix of a PSD variable in a PSD constraint.

Synopsis

```
void SetPsdCoeff(  
    const PsdConstraint &constr,  
    const PsdVar &var,  
    const SymMatrix &mat)
```

Arguments

constr: The desired PSD constraint.

var: The desired PSD variable.

mat: new coefficient matrix.

Model::SetPsdObjective()

Set PSD objective for model.

Synopsis

```
void SetPsdObjective(const PsdExpr &expr, int sense)
```

Arguments

expr: PSD expression of the objective.

sense: optimization sense. optional, default value 0 does not change COPT sense.

Model::SetQuadObjective()

Set quadratic objective for model.

Synopsis

```
void SetQuadObjective(const QuadExpr &expr, int sense)
```

Arguments

expr: quadratic expression of the objective.

sense: optimization sense. optional, default value 0 does not change COPT sense.

Model::SetSlackBasis()

Set slack basis to model.

Synopsis

```
void SetSlackBasis()
```

Model::SetSolverLogCallback()

Set log callback for COPT.

Synopsis

```
void SetSolverLogCallback(ILogCallback *pcb)
```

Arguments

pcb: pointer to ILogCallback object.

Model::SetSolverLogFile()

Set log file for COPT.

Synopsis

```
void SetSolverLogFile(const char *szLogFile)
```

Arguments

szLogFile: log file name.

Model::Solve()

Solve the model as MIP.

Synopsis

```
void Solve()
```

Model::SolveLp()

Solve the model as LP.

Synopsis

```
void SolveLp()
```

Model::Tune()

Tune model.

Synopsis

```
void Tune()
```

Model::Write()

Output problem, solution, basis, MIP start or modified COPT parameters to file.

Synopsis

```
void Write(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteBasis()

Output optimal basis to a file of type '.bas'.

Synopsis

```
void WriteBasis(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteBin()

Output problem to a file as COPT binary format.

Synopsis

```
void WriteBin(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteIIS()

Output IIS to file.

Synopsis

```
void WriteIIS(const char *szFileName)
```

Arguments

szFileName: Output file name.

Model::WriteLp()

Output problem to a file as LP format.

Synopsis

```
void WriteLp(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteMps()

Output problem to a file as MPS format.

Synopsis

```
void WriteMps(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteMpsStr()

Output problem to a buffer as MPS format.

Synopsis

```
ProbBuffer WriteMpsStr()
```

Return

output problem buffer.

Model::WriteMst()

Output MIP start information to a file of type '.mst'.

Synopsis

```
void WriteMst(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteParam()

Output modified COPT parameters to a file of type '.par'.

Synopsis

```
void WriteParam(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WritePoolSol()

Output selected pool solution to a file of type '.sol'.

Synopsis

```
void WritePoolSol(int iSol, const char *szFileName)
```

Arguments

iSol: index of pool solution.

szFileName: an output file name.

Model::WriteRelax()

Output feasibility relaxation problem to file.

Synopsis

```
void WriteRelax(const char *szFileName)
```

Arguments

szFileName: Output file name.

Model::WriteSol()

Output solution to a file of type ‘.sol’.

Synopsis

```
void WriteSol(const char *szFileName)
```

Arguments

szFileName: an output file name.

Model::WriteTuneParam()

Output specified tuned parameters to a file of type ‘.par’.

Synopsis

```
void WriteTuneParam(int idx, const char *szFileName)
```

Arguments

idx: Index of tuned parameters.

szFileName: Output file name.

23.5.4 Var

COPT variable object. Variables are always associated with a particular model. User creates a variable object by adding a variable to a model, rather than by using constructor of Var class.

Var::Get()

Get information of the variable. Support informations of “Value”, “RedCost”, “LB”, “UB”, and “Obj”.

Synopsis

```
double Get(const char *szInfo)
```

Arguments

szInfo: name of information.

Return

value of information

Var::GetIdx()

Get index of the variable.

Synopsis

```
inline int GetIdx()
```

Return

variable index.

Var::GetLowerIIS()

Get IIS status for lower bound of the variable.

Synopsis

```
int GetLowerIIS()
```

Return

IIS status.

Var::GetName()

Get name of the variable.

Synopsis

```
const char *GetName()
```

Return

variable name.

Var::GetType()

Get type of the variable.

Synopsis

```
char GetType()
```

Return

variable type.

Var::GetUpperIIS()

Get IIS status for upper bound of the variable.

Synopsis

```
int GetUpperIIS()
```

Return

IIS status.

Var::Remove()

Remove variable from model.

Synopsis

```
void Remove()
```

Var::Set()

Set information value of the variable. Support informations of “LB”, “UB” and “Obj”.

Synopsis

```
void Set(const char *szInfo, double value)
```

Arguments

szInfo: name of information.

value: new information value.

Var::SetName()

Set name of the variable.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: variable name.

Var::SetType()

Set type of the variable.

Synopsis

```
void SetType(char type)
```

Arguments

type: variable type.

23.5.5 VarArray

COPT variable array object. To store and access a set of C++ *Var* objects, Cardinal Optimizer provides C++ VarArray class, which defines the following methods.

VarArray::GetVar()

Get i-th variable object.

Synopsis

```
Var &GetVar(int i)
```

Arguments

i: index of the variable.

Return

variable object with index i.

VarArray::PushBack()

Add a variable object to variable array.

Synopsis

```
void PushBack(const Var &var)
```

Arguments

var: a variable object.

VarArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for variable object.

VarArray::Size()

Get the number of variable objects.

Synopsis

```
int Size()
```

Return

number of variable objects.

23.5.6 Expr

COPT linear expression object. A linear expression consists of a constant term, a list of terms of variables and associated coefficients. Linear expressions are used to build constraints.

Expr::Expr()

Constructor of a constant linear expression.

Synopsis

```
Expr(double constant)
```

Arguments

constant: constant value in expression object.

Expr::Expr()

Constructor of a linear expression with one term.

Synopsis

```
Expr(const Var &var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

Expr::AddConstant()

Add constant for the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

Expr::AddExpr()

Add an expression to self.

Synopsis

```
void AddExpr(const Expr &expr, double mult)
```

Arguments

expr: expression to be added.

mult: optional, constant multiplier, default value is 1.0.

Expr::AddTerm()

Add a term to expression object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: a variable for new term.

coeff: coefficient for new term.

Expr::AddTerms()

Add terms to expression object.

Synopsis

```
int AddTerms(  
    const VarArray &vars,  
    double *pCoeff,  
    int len)
```

Arguments

vars: variables for added terms.

pCoeff: coefficient array for added terms.

len: length of coefficient array.

Return

number of added terms.

Expr::Clone()

Deep copy linear expression object.

Synopsis

```
Expr Clone()
```

Return

cloned expression object.

Expr::Evaluate()

evaluate linear expression after solving

Synopsis

```
double Evaluate()
```

Return

value of linear expression

Expr::GetCoeff()

Get coefficient from the i-th term in expression.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in expression object.

Expr::GetConstant()

Get constant in expression.

Synopsis

```
double GetConstant()
```

Return

constant in expression.

Expr::GetVar()

Get variable from the i-th term in expression.

Synopsis

```
Var &GetVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in expression object.

Expr::operator*=()

Multiply a constant to self.

Synopsis

```
void operator*=(double c)
```

Arguments

c: constant multiplier.

Expr::operator*()

Multiply constant and return new expression.

Synopsis

```
Expr operator*(double c)
```

Arguments

c: constant multiplier.

Return

result expression.

Expr::operator*()

Multiply a variable and return new quadratic expression object.

Synopsis

```
QuadExpr operator*(const Var &var)
```

Arguments

var: variable object.

Return

result quadratic expression.

Expr::operator*()

Multiply a linear expression and return new quadratic expression object.

Synopsis

```
QuadExpr operator*(const Expr &other)
```

Arguments

other: linear expression object.

Return

result quadratic expression.

Expr::operator+=()

Add an expression to self.

Synopsis

```
void operator+=(const Expr &expr)
```

Arguments

expr: expression to be added.

Expr::operator+()

Add expression and return new expression.

Synopsis

```
Expr operator+(const Expr &other)
```

Arguments

other: other expression to add.

Return

result expression.

Expr::operator-=()

Subtract an expression from self.

Synopsis

```
void operator-=(const Expr &expr)
```

Arguments

expr: expression to be subtracted.

Expr::operator-()

Subtract expression and return new expression.

Synopsis

```
Expr operator-(const Expr &other)
```

Arguments

other: other expression to subtract.

Return

result expression.

Expr::Remove()

Remove i-th term from expression object.

Synopsis

```
void Remove(int i)
```

Arguments

i: index of the term to be removed.

Expr::Remove()

Remove the term associated with variable from expression.

Synopsis

```
void Remove(const Var &var)
```

Arguments

var: a variable whose term should be removed.

Expr::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(size_t n)
```

Arguments

n: minimum capacity for linear expression object.

Expr::SetCoeff()

Set coefficient for the i-th term in expression.

Synopsis

```
void SetCoeff(int i, double val)
```

Arguments

i: index of the term.

val: coefficient of the term.

Expr::SetConstant()

Set constant for the expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

Expr::Size()

Get number of terms in expression.

Synopsis

```
size_t Size()
```

Return

number of terms.

23.5.7 Constraint

COPT constraint object. Constraints are always associated with a particular model. User creates a constraint object by adding a constraint to a model, rather than by using constructor of Constraint class.

Constraint::Get()

Get information value of the constraint. Support informations of “Dual”, “Slack”, “LB”, “UB”.

Synopsis

```
double Get(const char *szInfo)
```

Arguments

szInfo: name of the information being queried.

Return

value of information.

Constraint::GetBasis()

Get basis status of this constraint.

Synopsis

```
int GetBasis()
```

Return

basis status.

Constraint::GetIdx()

Get index of the constraint.

Synopsis

```
int GetIdx()
```

Return

the index of the constraint.

Constraint::GetLowerIIS()

Get IIS status for lower bound of the constraint.

Synopsis

```
int GetLowerIIS()
```

Return

IIS status.

Constraint::GetName()

Get name of the constraint.

Synopsis

```
const char *GetName()
```

Return

the name of the constraint.

Constraint::GetUpperIIS()

Get IIS status for upper bound of the constraint.

Synopsis

```
int GetUpperIIS()
```

Return

IIS status.

Constraint::Remove()

Remove this constraint from model.

Synopsis

```
void Remove()
```

Constraint::Set()

Set information value of the constraint. Support informations of “LB” and “UB”.

Synopsis

```
void Set(const char *szInfo, double value)
```

Arguments

szInfo: name of the information.

value: new information value.

Constraint::SetName()

Set name for the constraint.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: the name to set.

23.5.8 ConstrArray

COPT constraint array object. To store and access a set of C++ *Constraint* objects, Cardinal Optimizer provides C++ ConstrArray class, which defines the following methods.

ConstrArray::GetConstr()

Get i-th constraint object.

Synopsis

```
Constraint &GetConstr(int i)
```

Arguments

i: index of the constraint.

Return

constraint object with index i.

ConstrArray::PushBack()

Add a constraint object to constraint array.

Synopsis

```
void PushBack(const Constraint &constr)
```

Arguments

constr: a constraint object.

ConstrArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for Constraint object.

ConstrArray::Size()

Get the number of constraint objects.

Synopsis

```
int Size()
```

Return

number of constraint objects.

23.5.9 ConstrBuilder

COPT constraint builder object. To help building a constraint, given a linear expression, constraint sense and right-hand side value, Cardinal Optimizer provides C++ ConstrBuilder class, which defines the following methods.

ConstrBuilder::GetExpr()

Get expression associated with constraint.

Synopsis

```
const Expr &GetExpr()
```

Return

expression object.

ConstrBuilder::GetRange()

Get range from lower bound to upper bound of range constraint.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of the constraint.

ConstrBuilder::GetSense()

Get sense associated with constraint.

Synopsis

```
char GetSense()
```

Return

constraint sense.

ConstrBuilder::Set()

Set detail of a constraint to its builder object.

Synopsis

```
void Set(  
    const Expr &expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the constraint

sense: constraint sense other than COPT_RANGE.

rhs: constant of right side of the constraint.

ConstrBuilder::SetRange()

Set a range constraint to its builder.

Synopsis

```
void SetRange(const Expr &expr, double range)
```

Arguments

expr: expression object, whose constant is negative upper bound.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

23.5.10 ConstrBuilderArray

COPT constraint builder array object. To store and access a set of C++ *ConstrBuilder* objects, Cardinal Optimizer provides C++ *ConstrBuilderArray* class, which defines the following methods.

ConstrBuilderArray::GetBuilder()

Get i-th constraint builder object.

Synopsis

```
ConstrBuilder &GetBuilder(int i)
```

Arguments

i: index of the constraint builder.

Return

constraint builder object with index i.

ConstrBuilderArray::PushBack()

Add a constraint builder object to constraint builder array.

Synopsis

```
void PushBack(const ConstrBuilder &builder)
```

Arguments

builder: a constraint builder object.

ConstrBuilderArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for constraint builder object.

ConstrBuilderArray::Size()

Get the number of constraint builder objects.

Synopsis

```
int Size()
```

Return

number of constraint builder objects.

23.5.11 Column

COPT column object. A column consists of a list of constraints and associated coefficients. Columns are used to represent the set of constraints in which a variable participates, and the associated coefficients.

Column::Column()

Constructor of column.

Synopsis

```
Column()
```

Column::AddColumn()

Add a column to self.

Synopsis

```
void AddColumn(const Column &col, double mult)
```

Arguments

col: column object to be added.

mult: multiply constant.

Column::AddTerm()

Add a term to column object.

Synopsis

```
void AddTerm(const Constraint &constr, double coeff)
```

Arguments

constr: a constraint for new term.

coeff: coefficient for new term.

Column::AddTerms()

Add terms to column object.

Synopsis

```
int AddTerms(  
    const ConstrArray &constrs,  
    double *pCoeff,  
    int len)
```

Arguments

constrs: constraints for added terms.

pCoeff: coefficients for added terms.

len: number of terms to be added.

Return

number of added terms.

Column::Clear()

Clear all terms.

Synopsis

```
void Clear()
```

Column::Clone()

Deep copy column object.

Synopsis

```
Column Clone()
```

Return

cloned column object.

Column::GetCoeff()

Get coefficient from the i-th term in column object.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in column object.

Column::GetConstr()

Get constraint from the i-th term in column object.

Synopsis

```
Constraint GetConstr(int i)
```

Arguments

i: index of the term.

Return

constraint of the i-th term in column object.

Column::Remove()

Remove i-th term from column object.

Synopsis

```
void Remove(int i)
```

Arguments

i: index of the term to be removed.

Column::Remove()

Remove the term associated with constraint from column object.

Synopsis

```
bool Remove(const Constraint &constr)
```

Arguments

constr: a constraint whose term should be removed.

Return

true if constraint exists in column object.

Column::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for Column object.

Column::Size()

Get number of terms in column object.

Synopsis

```
int Size()
```

Return

number of terms.

23.5.12 ColumnArray

COPT column array object. To store and access a set of C++ *Column* objects, Cardinal Optimizer provides C++ ColumnArray class, which defines the following methods.

ColumnArray::Clear()

Clear all column objects.

Synopsis

```
void Clear()
```

ColumnArray::GetColumn()

Get i-th column object.

Synopsis

```
Column &GetColumn(int i)
```

Arguments

i: index of the column.

Return

column object with index i.

ColumnArray::PushBack()

Add a column object to column array.

Synopsis

```
void PushBack(const Column &col)
```

Arguments

col: a column object.

ColumnArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for linear expression object.

ColumnArray::Size()

Get the number of column objects.

Synopsis

```
int Size()
```

Return

number of column objects.

23.5.13 Sos

COPT SOS constraint object. SOS constraints are always associated with a particular model. User creates an SOS constraint object by adding an SOS constraint to a model, rather than by using constructor of Sos class.

An SOS constraint can be type 1 or 2 (COPT_SOS_TYPE1 or COPT_SOS_TYPE2).

Sos::GetIdx()

Get the index of SOS constraint.

Synopsis

```
int GetIdx()
```

Return

index of SOS constraint.

Sos::GetIIS()

Get IIS status of the SOS constraint.

Synopsis

```
int GetIIS()
```

Return

IIS status.

Sos::Remove()

Remove the SOS constraint from model.

Synopsis

```
void Remove()
```

23.5.14 SosArray

COPT SOS constraint array object. To store and access a set of C++ *Sos* objects, Cardinal Optimizer provides C++ *SosArray* class, which defines the following methods.

SosArray::GetSos()

Get i-th SOS constraint object.

Synopsis

```
Sos &GetSos(int i)
```

Arguments

i: index of the SOS constraint.

Return

SOS constraint object with index i.

SosArray::PushBack()

Add a SOS constraint object to SOS constraint array.

Synopsis

```
void PushBack(const Sos &sos)
```

Arguments

sos: a SOS constraint object.

SosArray::Size()

Get the number of SOS constraint objects.

Synopsis

```
int Size()
```

Return

number of SOS constraint objects.

23.5.15 SosBuilder

COPT SOS constraint builder object. To help building an SOS constraint, given the SOS type, a set of variables and associated weights, Cardinal Optimizer provides C++ SosBuilder class, which defines the following methods.

SosBuilder::GetSize()

Get number of terms in SOS constraint.

Synopsis

```
int GetSize()
```

Return

number of terms.

SosBuilder::GetType()

Get type of SOS constraint.

Synopsis

```
int GetType()
```

Return

type of SOS constraint.

SosBuilder::GetVar()

Get variable from the i-th term in SOS constraint.

Synopsis

```
Var GetVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in SOS constraint.

SosBuilder::GetVars()

Get variables of all terms in SOS constraint.

Synopsis

```
VarArray GetVars()
```

Return

variable array object.

SosBuilder::GetWeight()

Get weight from the i-th term in SOS constraint.

Synopsis

```
double GetWeight(int i)
```

Arguments

i: index of the term.

Return

weight of the i-th term in SOS constraint.

SosBuilder::GetWeights()

Get weights of all terms in SOS constraint.

Synopsis

```
double GetWeights()
```

Return

pointer to array of weights.

SosBuilder::Set()

Set variables and weights of SOS constraint.

Synopsis

```
void Set(  
    const VarArray &vars,  
    const double *pWeights,  
    int type)
```

Arguments

vars: variable array object.

pWeights: pointer to array of weights.

type: type of SOS constraint.

23.5.16 SosBuilderArray

COPT SOS constraint builder array object. To store and access a set of C++ *SosBuilder* objects, Cardinal Optimizer provides C++ *SosBuilderArray* class, which defines the following methods.

SosBuilderArray::GetBuilder()

Get i-th SOS constraint builder object.

Synopsis

```
SosBuilder &GetBuilder(int i)
```

Arguments

i: index of the SOS constraint builder.

Return

SOS constraint builder object with index i.

SosBuilderArray::PushBack()

Add a SOS constraint builder object to SOS constraint builder array.

Synopsis

```
void PushBack(const SosBuilder &builder)
```

Arguments

builder: a SOS constraint builder object.

SosBuilderArray::Size()

Get the number of SOS constraint builder objects.

Synopsis

```
int Size()
```

Return

number of SOS constraint builder objects.

23.5.17 GenConstr

COPT general constraint object. General constraints are always associated with a particular model. User creates a general constraint object by adding a general constraint to a model, rather than by using constructor of GenConstr class.

GenConstr::GetIdx()

Get the index of the general constraint.

Synopsis

```
int GetIdx()
```

Return

index of the general constraint.

GenConstr::GetIIS()

Get IIS status of the general constraint.

Synopsis

```
int GetIIS()
```

Return

IIS status.

GenConstr::GetName()

Get name of general constraint.

Synopsis

```
const char *GetName()
```

Return

the name of general constraint.

GenConstr::Remove()

Remove the general constraint from model.

Synopsis

```
void Remove()
```

GenConstr::SetName()

Set name of general constraint.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: new name to set.

23.5.18 GenConstrArray

COPT general constraint array object. To store and access a set of C++ *GenConstr* objects, Cardinal Optimizer provides C++ GenConstrArray class, which defines the following methods.

GenConstrArray::GetGenConstr()

Get i-th general constraint object.

Synopsis

```
GenConstr &GetGenConstr(int i)
```

Arguments

i: index of the general constraint.

Return

general constraint object with index i.

GenConstrArray::PushBack()

Add a general constraint object to general constraint array.

Synopsis

```
void PushBack(const GenConstr &constr)
```

Arguments

constr: a general constraint object.

GenConstrArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for general constraint objects.

GenConstrArray::Size()

Get the number of general constraint objects.

Synopsis

```
int Size()
```

Return

number of general constraint objects.

23.5.19 GenConstrBuilder

COPT general constraint builder object. To help building a general constraint, given a binary variable and associated value, a linear expression and constraint sense, Cardinal Optimizer provides C++ GenConstrBuilder class, which defines the following methods.

GenConstrBuilder::GetBinVal()

Get binary value associated with general constraint.

Synopsis

```
int GetBinVal()
```

Return

binary value.

GenConstrBuilder::GetBinVar()

Get binary variable associated with general constraint.

Synopsis

```
Var GetBinVar()
```

Return

binary variable object.

GenConstrBuilder::GetExpr()

Get expression associated with general constraint.

Synopsis

```
const Expr &GetExpr()
```

Return

expression object.

GenConstrBuilder::GetIndType()

Get type of general constraint.

Synopsis

```
int GetIndType()
```

Return

type of GenConstr, COPT_INDICATOR_IF, COPT_INDICATOR_ONLYIF and COPT_INDICATOR_IFANDONLYIF.

GenConstrBuilder::GetSense()

Get sense associated with general constraint.

Synopsis

```
char GetSense()
```

Return

constraint sense.

GenConstrBuilder::Set()

Set binary variable, binary value, expression, sense and type of general constraint.

Synopsis

```
void Set(  
    Var bvar,  
    int bval,  
    const Expr &expr,  
    char sense,  
    int type)
```

Arguments

bvar: binary variable.

bval: binary value.

expr: expression object.

sense: general constraint sense.

type: type of general constraint with default value of COPT_INDICATOR_IF.

23.5.20 GenConstrBuilderArray

COPT general constraint builder array object. To store and access a set of C++ *GenConstrBuilder* objects, Cardinal Optimizer provides C++ *GenConstrBuilderArray* class, which defines the following methods.

GenConstrBuilderArray::GetBuilder()

Get i-th general constraint builder object.

Synopsis

```
GenConstrBuilder &GetBuilder(int i)
```

Arguments

i: index of the general constraint builder.

Return

general constraint builder object with index i.

GenConstrBuilderArray::PushBack()

Add a general constraint builder object to general constraint builder array.

Synopsis

```
void PushBack(const GenConstrBuilder &builder)
```

Arguments

builder: a general constraint builder object.

GenConstrBuilderArray::Size()

Get the number of general constraint builder objects.

Synopsis

```
int Size()
```

Return

number of general constraint builder objects.

23.5.21 Cone

COPT cone constraint object. Cone constraints are always associated with a particular model. User creates a cone constraint object by adding a cone constraint to a model, rather than by using constructor of Cone class.

A cone constraint can be regular or rotated (COPT_CONE_QUAD or COPT_CONE_RQUAD).

Cone::GetIdx()

Get the index of a cone constraint.

Synopsis

```
int GetIdx()
```

Return

index of a cone constraint.

Cone::Remove()

Remove the cone constraint from model.

Synopsis

```
void Remove()
```

23.5.22 ConeArray

COPT cone constraint array object. To store and access a set of C++ *Cone* objects, Cardinal Optimizer provides C++ *ConeArray* class, which defines the following methods.

ConeArray::GetCone()

Get i-th cone constraint object.

Synopsis

```
Cone &GetCone(int i)
```

Arguments

i: index of the cone constraint.

Return

cone constraint object with index i.

ConeArray::PushBack()

Add a cone constraint object to cone constraint array.

Synopsis

```
void PushBack(const Cone &cone)
```

Arguments

cone: a cone constraint object.

ConeArray::Size()

Get the number of cone constraint objects.

Synopsis

```
int Size()
```

Return

number of cone constraint objects.

23.5.23 ConeBuilder

COPT cone constraint builder object. To help building a cone constraint, given the cone type and a set of variables, Cardinal Optimizer provides C++ ConeBuilder class, which defines the following methods.

ConeBuilder::GetSize()

Get number of vars in a cone constraint.

Synopsis

```
int GetSize()
```

Return

number of vars.

ConeBuilder::GetType()

Get type of a cone constraint.

Synopsis

```
int GetType()
```

Return

type of a cone constraint.

ConeBuilder::GetVar()

Get the i-th variable in a cone constraint.

Synopsis

```
Var GetVar(int i)
```

Arguments

i: index of vars in a cone constraint.

Return

the i-th variable in a cone constraint.

ConeBuilder::GetVars()

Get all variables in a cone constraint.

Synopsis

```
VarArray GetVars()
```

Return

variable array object.

ConeBuilder::Set()

Set variables of a cone constraint.

Synopsis

```
void Set(const VarArray &vars, int type)
```

Arguments

vars: variable array object.

type: type of cone constraint.

23.5.24 ConeBuilderArray

COPT cone constraint builder array object. To store and access a set of C++ *ConeBuilder* objects, Cardinal Optimizer provides C++ *ConeBuilderArray* class, which defines the following methods.

ConeBuilderArray::GetBuilder()

Get i-th cone constraint builder object.

Synopsis

```
ConeBuilder &GetBuilder(int i)
```

Arguments

i: index of the cone constraint builder.

Return

cone constraint builder object with index i.

ConeBuilderArray::PushBack()

Add a cone constraint builder object to cone constraint builder array.

Synopsis

```
void PushBack(const ConeBuilder &builder)
```

Arguments

builder: a cone constraint builder object.

ConeBuilderArray::Size()

Get the number of cone constraint builder objects.

Synopsis

```
int Size()
```

Return

number of cone constraint builder objects.

23.5.25 ExpCone

COPT exponential cone constraint object. ExpCone constraints are always associated with a particular model. User creates an exponential cone constraint object by adding an expcone constraint to a model, rather than by using constructor of ExpCone class.

ExpCone::GetIdx()

Get the index of an exponential cone constraint.

Synopsis

```
int GetIdx()
```

Return

index of an exponential cone constraint.

ExpCone::Remove()

Remove the exponential cone constraint from model.

Synopsis

```
void Remove()
```

23.5.26 ExpConeArray

COPT exponential cone constraint array object. To store and access a set of C++ *ExpCone* objects, Cardinal Optimizer provides C++ ExpConeArray class, which defines the following methods.

ExpConeArray::GetCone()

Get i-th exponential cone constraint object.

Synopsis

```
ExpCone &GetCone(int i)
```

Arguments

i: index of the exponential cone constraint.

Return

exponential cone constraint object with index i.

ExpConeArray::PushBack()

Add an exponential cone constraint object to exponential cone constraint array.

Synopsis

```
void PushBack(const ExpCone &cone)
```

Arguments

cone: an exponential constraint object.

ExpConeArray::Size()

Get the number of exponential cone constraint objects.

Synopsis

```
int Size()
```

Return

number of exponential cone constraint objects.

23.5.27 ExpConeBuilder

COPT exponential cone constraint builder object. To help building a exponential cone constraint, given the expcone type and a set of variables, Cardinal Optimizer provides C++ ExpConeBuilder class, which defines the following methods.

ExpConeBuilder::GetSize()

Get number of vars in an exponential cone constraint.

Synopsis

```
int GetSize()
```

Return

number of vars.

ExpConeBuilder::GetType()

Get type of an exponential cone constraint.

Synopsis

```
int GetType()
```

Return

type of an exponential cone constraint.

ExpConeBuilder::GetVar()

Get the i-th variable in an exponential cone constraint.

Synopsis

```
Var GetVar(int i)
```

Arguments

i: index of vars in an exponential cone constraint.

Return

the i-th variable in an exponential cone constraint.

ExpConeBuilder::GetVars()

Get all variables in an exponential cone constraint.

Synopsis

```
VarArray GetVars()
```

Return

variable array object.

ExpConeBuilder::Set()

Set variables of an exponential cone constraint.

Synopsis

```
void Set(const VarArray &vars, int type)
```

Arguments

vars: variable array object.

type: type of exponential cone constraint.

23.5.28 ExpConeBuilderArray

COPT exponential cone constraint builder array object. To store and access a set of C++ *ExpConeBuilder* objects, Cardinal Optimizer provides C++ *ExpConeBuilderArray* class, which defines the following methods.

ExpConeBuilderArray::GetBuilder()

Get i-th exponential cone constraint builder object.

Synopsis

```
ExpConeBuilder &GetBuilder(int i)
```

Arguments

i: index of the exponential cone constraint builder.

Return

exponential cone constraint builder object with index i.

ExpConeBuilderArray::PushBack()

Add an exponential cone constraint builder object to exponential cone constraint builder array.

Synopsis

```
void PushBack(const ExpConeBuilder &builder)
```

Arguments

builder: an exponential cone constraint builder object.

ExpConeBuilderArray::Size()

Get the number of exponential cone constraint builder objects.

Synopsis

```
int Size()
```

Return

number of exponential cone constraint builder objects.

23.5.29 AffineCone

The *AffineCone* class in COPT encapsulates operations related to affine cone constraints. The following methods are provided:

AffineCone::GetIdx()

Get the index of an affine cone constraint.

Synopsis

```
int GetIdx()
```

Return

index of an affine cone constraint.

AffineCone::GetName()

Get name of affine cone constraint.

Synopsis

```
const char *GetName()
```

Return

name of affine cone constraint.

AffineCone::Remove()

Remove the affine cone constraint from model.

Synopsis

```
void Remove()
```

AffineCone::SetName()

Set name of affine cone constraint.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: name of affine cone constraint.

23.5.30 AffineConeArray

To facilitate user operations on a group of C++ *AffineCone* objects, the C++ interface of COPT introduces the *AffineConeArray* class. The following methods are provided:

AffineConeArray::GetCone()

Get i-th affine cone constraint object.

Synopsis

```
AffineCone &GetCone(int i)
```

Arguments

i: index of the affine cone constraint.

Return

affine cone constraint object with index i.

AffineConeArray::PushBack()

Add an affine cone constraint object to affine cone constraint array.

Synopsis

```
void PushBack(const AffineCone &cone)
```

Arguments

cone: an affine constraint object.

AffineConeArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for affine cone constraint objects.

AffineConeArray::Size()

Get the number of affine cone constraint objects.

Synopsis

```
int Size()
```

Return

number of affine cone constraint objects.

23.5.31 AffineConeBuilder

The *AffineConeBuilder* class in COPT encapsulates the builder for constructing affine cone constraints. The following methods are provided:

AffineConeBuilder::GetExpr()

Get the i-th linear expression in an affine cone constraint.

Synopsis

```
const Expr &GetExpr(int i)
```

Arguments

i: index of linear expression in an affine cone constraint.

Return

the i-th linear expression in an affine cone constraint.

AffineConeBuilder::GetExprs()

Get all linear expressions in an affine cone constraint.

Synopsis

```
MLinExpr<1> GetExprs()
```

Return

MLinExpr object.

AffineConeBuilder::GetPsdExpr()

Get the i-th PSD expression in an affine cone constraint.

Synopsis

```
const PsdExpr &GetPsdExpr(int i)
```

Arguments

i: index of PSD expression in an affine cone constraint.

Return

the i-th PSD expression in an affine cone constraint.

AffineConeBuilder::GetPsdExprs()

Get all PSD expressions in an affine cone constraint.

Synopsis

```
const MPsdExpr<1> &GetPsdExprs()
```

Return

MPsdExpr object.

AffineConeBuilder::GetSize()

Get number of expressions in an affine cone constraint.

Synopsis

```
int GetSize()
```

Return

number of expressions.

AffineConeBuilder::GetType()

Get type of an affine cone constraint.

Synopsis

```
int GetType()
```

Return

type of an affine cone constraint.

AffineConeBuilder::HasPsdTerm()

Check whether affine cone has PSD terms.

Synopsis

```
bool HasPsdTerm()
```

Return

flag to indicate whether affine cone has PSD terms.

AffineConeBuilder::Set()

Set linear expressions of an affine cone constraint.

Synopsis

```
void Set(const MLinExpr<1> &exprs, int type)
```

Arguments

exprs: 1-dimensional MLinExpr object.

type: type of affine cone constraint.

AffineConeBuilder::Set()

Set PSD expressions of an affine cone constraint.

Synopsis

```
void Set(const MPsdExpr<1> &exprs, int type)
```

Arguments

exprs: 1-dimensional MPsdExpr object.

type: type of affine cone constraint.

23.5.32 AffineConeBuilderArray

To facilitate user operations on a group of C++ *AffineConeBuilder* objects, the C++ interface of COPT introduces the *AffineConeBuilderArray* class. The following methods are provided:

AffineConeBuilderArray::GetBuilder()

Get i-th affine cone constraint builder object.

Synopsis

```
AffineConeBuilder &GetBuilder(int i)
```

Arguments

i: index of the affine cone constraint builder.

Return

affine cone constraint builder object with index i.

AffineConeBuilderArray::PushBack()

Add an affine cone constraint builder object to affine cone constraint builder array.

Synopsis

```
void PushBack(const AffineConeBuilder &builder)
```

Arguments

builder: an affine cone constraint builder object.

AffineConeBuilderArray::Size()

Get the number of affine cone constraint builder objects.

Synopsis

```
int Size()
```

Return

number of affine cone constraint builder objects.

23.5.33 QuadExpr

COPT quadratic expression object. A quadratic expression consists of a linear expression, a list of variable pairs and associated coefficients of quadratic terms. Quadratic expressions are used to build quadratic constraints and objectives.

QuadExpr::QuadExpr()

Constructor of a quadratic expression with a constant.

Synopsis

```
QuadExpr(double constant)
```

Arguments

constant: constant value in quadratic expression object.

QuadExpr::QuadExpr()

Constructor of a quadratic expression with one term.

Synopsis

```
QuadExpr(const Var &var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

QuadExpr::QuadExpr()

Constructor of a quadratic expression with a linear expression.

Synopsis

```
QuadExpr(const Expr &expr)
```

Arguments

expr: input linear expression.

QuadExpr::QuadExpr()

Constructor of a quadratic expression with two linear expression.

Synopsis

```
QuadExpr(const Expr &expr, const Var &var)
```

Arguments

expr: one linear expression.

var: another variable.

QuadExpr::QuadExpr()

Constructor of a quadratic expression with two linear expression.

Synopsis

```
QuadExpr(const Expr &left, const Expr &right)
```

Arguments

left: one linear expression.

right: another linear expression.

QuadExpr::AddConstant()

Add constant for the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

QuadExpr::AddLinExpr()

Add a linear expression to self.

Synopsis

```
void AddLinExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: optional, constant multiplier, default value is 1.0.

QuadExpr::AddQuadExpr()

Add a quadratic expression to self.

Synopsis

```
void AddQuadExpr(const QuadExpr &expr, double mult)
```

Arguments

expr: quadratic expression to be added.

mult: optional, constant multiplier, default value is 1.0.

QuadExpr::AddTerm()

Add a linear term to expression object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new linear term.

coeff: coefficient of new linear term.

QuadExpr::AddTerm()

Add a quadratic term to expression object.

Synopsis

```
void AddTerm(  
    const Var &var1,  
    const Var &var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.

var2: second variable of new quadratic term.

coeff: coefficient of new quadratic term.

QuadExpr::AddTerms()

Add linear terms to expression object.

Synopsis

```
int AddTerms(  
    const VarArray &vars,  
    double *pCoeff,  
    int len)
```

Arguments

vars: variables for added linear terms.

pCoeff: coefficient array for added linear terms.

len: length of coefficient array.

Return

number of added linear terms.

QuadExpr::AddTerms()

Add quadratic terms to expression object.

Synopsis

```
int AddTerms(  
    const VarArray &vars1,  
    const VarArray &vars2,  
    double *pCoeff,  
    int len)
```

Arguments

vars1: first set of variables for added quadratic terms.

vars2: second set of variables for added quadratic terms.

pCoeff: coefficient array for added quadratic terms.

len: length of coefficient array.

Return

number of added quadratic terms.

QuadExpr::Clone()

Deep copy quadratic expression object.

Synopsis

```
QuadExpr Clone()
```

Return

cloned quadratic expression object.

QuadExpr::Evaluate()

evaluate quadratic expression after solving

Synopsis

```
double Evaluate()
```

Return

value of quadratic expression

QuadExpr::GetCoeff()

Get coefficient from the i-th term in quadratic expression.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the quadratic term.

Return

coefficient of the i-th quadratic term in quadratic expression object.

QuadExpr::GetConstant()

Get constant in quadratic expression.

Synopsis

```
double GetConstant()
```

Return

constant in quadratic expression.

QuadExpr::GetLinExpr()

Get linear expression in quadratic expression.

Synopsis

```
Expr &GetLinExpr()
```

Return

linear expression object.

QuadExpr::GetVar1()

Get the first variable from the i-th term in quadratic expression.

Synopsis

```
Var &GetVar1(int i)
```

Arguments

i: index of the term.

Return

the first variable of the i-th term in quadratic expression object.

QuadExpr::GetVar2()

Get the second variable from the i-th term in quadratic expression.

Synopsis

```
Var &GetVar2(int i)
```

Arguments

i: index of the term.

Return

the second variable of the i-th term in quadratic expression object.

QuadExpr::operator*=()

Multiply a constant to self.

Synopsis

```
void operator*=(double c)
```

Arguments

c: constant multiplier.

QuadExpr::operator*()

Multiply constant and return new expression.

Synopsis

```
QuadExpr operator*(double c)
```

Arguments

c: constant multiplier.

Return

result expression.

QuadExpr::operator+=()

Add an expression to self.

Synopsis

```
void operator+=(const QuadExpr &expr)
```

Arguments

expr: expression to be added.

QuadExpr::operator+()

Add expression and return new expression.

Synopsis

```
QuadExpr operator+(const QuadExpr &other)
```

Arguments

other: other expression to add.

Return

result expression.

QuadExpr::operator-=()

Subtract an expression from self.

Synopsis

```
void operator-=(const QuadExpr &expr)
```

Arguments

expr: expression to be subtracted.

QuadExpr::operator-()

Subtract expression and return new expression.

Synopsis

```
QuadExpr operator-(const QuadExpr &other)
```

Arguments

other: other expression to subtract.

Return

result expression.

QuadExpr::Remove()

Remove i-th term from expression object.

Synopsis

```
void Remove(int i)
```

Arguments

i: index of the term to be removed.

QuadExpr::Remove()

Remove the term associated with variable from expression.

Synopsis

```
void Remove(const Var &var)
```

Arguments

var: a variable whose term should be removed.

QuadExpr::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(size_t n)
```

Arguments

n: minimum capacity for quadratic expression object.

QuadExpr::SetCoeff()

Set coefficient of the i-th term in quadratic expression.

Synopsis

```
void SetCoeff(int i, double val)
```

Arguments

i: index of the quadratic term.

val: coefficient of the term.

QuadExpr::SetConstant()

Set constant for the expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

QuadExpr::Size()

Get number of terms in expression.

Synopsis

```
size_t Size()
```

Return

number of terms.

23.5.34 QConstraint

COPT quadratic constraint object. Quadratic constraints are always associated with a particular model. User creates a quadratic constraint object by adding a quadratic constraint to a model, rather than by using constructor of QConstraint class.

QConstraint::Get()

Get information value of the quadratic constraint. Support related quadratic informations.

Synopsis

```
double Get(const char *szInfo)
```

Arguments

szInfo: name of the information being queried.

Return

value of information.

QConstraint::GetIdx()

Get index of the quadratic constraint.

Synopsis

```
int GetIdx()
```

Return

the index of the quadratic constraint.

QConstraint::GetName()

Get name of the quadratic constraint.

Synopsis

```
const char *GetName()
```

Return

the name of the quadratic constraint.

QConstraint::GetRhs()

Get rhs of quadratic constraint.

Synopsis

```
double GetRhs()
```

Return

rhs of quadratic constraint.

QConstraint::GetSense()

Get sense of quadratic constraint.

Synopsis

```
char GetSense()
```

Return

sense of quadratic constraint.

QConstraint::Remove()

Remove this quadratic constraint from model.

Synopsis

```
void Remove()
```

QConstraint::Set()

Set information value of the quadratic constraint. Support related quadratic informations.

Synopsis

```
void Set(const char *szInfo, double value)
```

Arguments

szInfo: name of the information.

value: new information value.

QConstraint::SetName()

Set name of a quadratic constraint.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: the name to set.

QConstraint::SetRhs()

Set rhs of quadratic constraint.

Synopsis

```
void SetRhs(double rhs)
```

Arguments

rhs: rhs of quadratic constraint.

QConstraint::SetSense()

Set sense of quadratic constraint.

Synopsis

```
void SetSense(char sense)
```

Arguments

sense: sense of quadratic constraint.

23.5.35 QConstrArray

COPT quadratic constraint array object. To store and access a set of C++ *QConstraint* objects, Cardinal Optimizer provides C++ *QConstrArray* class, which defines the following methods.

QConstrArray::GetQConstr()

Get i-th quadratic constraint object.

Synopsis

```
QConstraint &GetQConstr(int idx)
```

Arguments

idx: index of the quadratic constraint.

Return

quadratic constraint object with index i.

QConstrArray::PushBack()

Add a quadratic constraint object to constraint array.

Synopsis

```
void PushBack(const QConstraint &constr)
```

Arguments

constr: a quadratic constraint object.

QConstrArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for quadratic constraint objects.

QConstrArray::Size()

Get the number of quadratic constraint objects.

Synopsis

```
int Size()
```

Return

number of quadratic constraint objects.

23.5.36 QConstrBuilder

COPT quadratic constraint builder object. To help building a quadratic constraint, given a quadratic expression, constraint sense and right-hand side value, Cardinal Optimizer provides C++ QConstrBuilder class, which defines the following methods.

QConstrBuilder::GetQuadExpr()

Get expression associated with quadratic constraint.

Synopsis

```
const QuadExpr &GetQuadExpr()
```

Return

quadratic expression object.

QConstrBuilder::GetSense()

Get sense associated with quadratic constraint.

Synopsis

```
char GetSense()
```

Return

quadratic constraint sense.

QConstrBuilder::Set()

Set detail of a quadratic constraint to its builder object.

Synopsis

```
void Set(  
    const QuadExpr &expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the quadratic constraint.

sense: quadratic constraint sense.

rhs: constant of right side of quadratic constraint.

23.5.37 QConstrBuilderArray

COPT quadratic constraint builder array object. To store and access a set of C++ *QConstrBuilder* objects, Cardinal Optimizer provides C++ *QConstrBuilderArray* class, which defines the following methods.

QConstrBuilderArray::GetBuilder()

Get i-th quadratic constraint builder object.

Synopsis

```
QConstrBuilder &GetBuilder(int idx)
```

Arguments

idx: index of the quadratic constraint builder.

Return

quadratic constraint builder object with index i.

QConstrBuilderArray::PushBack()

Add a quadratic constraint builder object to quadratic constraint builder array.

Synopsis

```
void PushBack(const QConstrBuilder &builder)
```

Arguments

builder: a quadratic constraint builder object.

QConstrBuilderArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for quadratic constraint builder object.

QConstrBuilderArray::Size()

Get the number of quadratic constraint builder objects.

Synopsis

```
int Size()
```

Return

number of quadratic constraint builder objects.

23.5.38 PsdVar

COPT PSD variable object. PSD variables are always associated with a particular model. User creates a PSD variable object by adding a PSD variable to model, rather than by constructor of PsdVar class.

PsdVar::Get()

Get information values of PSD variable.

Synopsis

```
double Get(const char *szInfo, int sz)
```

Arguments

szInfo: name of information.

sz: length of the output array.

Return

output array of information values.

PsdVar::Get()

Get information values of PSD variable.

Synopsis

```
NdArray<double, 2> Get(const char *szInfo)
```

Arguments

szInfo: name of information.

Return

2-dimensional NdArray with related information values.

PsdVar::GetDim()

Get dimension of PSD variable.

Synopsis

```
int GetDim()
```

Return

dimension of PSD variable.

PsdVar::GetIdx()

Get index of PSD variable.

Synopsis

```
int GetIdx()
```

Return

index of PSD variable.

PsdVar::GetLen()

Get length of PSD variable.

Synopsis

```
int GetLen()
```

Return

length of PSD variable.

PsdVar::GetName()

Get name of PSD variable.

Synopsis

```
const char *GetName()
```

Return

name of PSD variable.

PsdVar::GetSize()

Get size or length of PSD variable.

Synopsis

```
int GetSize()
```

Return

Size of PSD variable.

PsdVar::Remove()

Remove PSD variable from model.

Synopsis

```
void Remove()
```

PsdVar::SetName()

Set name of PSD variable.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: name of PSD variable.

23.5.39 PsdVarArray

COPT PSD variable array object. To store and access a set of *PsdVar* objects, Cardinal Optimizer provides PsdVarArray class, which defines the following methods.

PsdVarArray::GetPsdVar()

Get idx-th PSD variable object.

Synopsis

```
PsdVar &GetPsdVar(int idx)
```

Arguments

idx: index of the PSD variable.

Return

PSD variable object with index idx.

PsdVarArray::PushBack()

Add a PSD variable object to PSD variable array.

Synopsis

```
void PushBack(const PsdVar &var)
```

Arguments

var: a PSD variable object.

PsdVarArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for PSD variable object.

PsdVarArray::Size()

Get the number of PSD variable objects.

Synopsis

```
int Size()
```

Return

number of PSD variable objects.

23.5.40 PsdExpr

COPT PSD expression object. A PSD expression consists of a linear expression, a list of PSD variables and associated coefficient matrices of PSD terms. PSD expressions are used to build PSD constraints and objectives.

PsdExpr::PsdExpr()

Constructor of a PSD expression with a constant.

Synopsis

```
PsdExpr(double constant)
```

Arguments

constant: constant value in PSD expression object.

PsdExpr::PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(const Var &var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

PsdExpr::PsdExpr()

Constructor of a PSD expression with a linear expression.

Synopsis

```
PsdExpr(const Expr &expr)
```

Arguments

expr: input linear expression.

PsdExpr::PsdExpr()

Constructor of a PSD expression with a MExpression object.

Synopsis

```
PsdExpr(const MExpression &expr)
```

Arguments

expr: input MExpression object.

PsdExpr::PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(const PsdVar &var, const SymMatrix &mat)
```

Arguments

var: PSD variable for the added term.

mat: coefficient matrix for the added term.

PsdExpr::PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(const PsdVar &var, const SymMatExpr &expr)
```

Arguments

var: PSD variable for the added term.

expr: coefficient expression of symmetric matrices for the added term.

PsdExpr::AddConstant()

Add constant to the PSD expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: value to be added.

PsdExpr::AddLinExpr()

Add a linear expression to self.

Synopsis

```
void AddLinExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: optional, constant multiplier, default value is 1.0.

PsdExpr::AddMExpr()

Add MExpression to PsdExpr object.

Synopsis

```
void AddMExpr(const MExpression &expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

PsdExpr::AddPsdExpr()

Add a PSD expression to self.

Synopsis

```
void AddPsdExpr(const PsdExpr &expr, double mult)
```

Arguments

expr: PSD expression to be added.

mult: optional, constant multiplier, default value is 1.0.

PsdExpr::AddTerm()

Add a linear term to PSD expression object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new linear term.

coeff: coefficient of new linear term.

PsdExpr::AddTerm()

Add a PSD term to PSD expression object.

Synopsis

```
void AddTerm(const PsdVar &var, const SymMatrix &mat)
```

Arguments

var: PSD variable of new PSD term.

mat: coefficient matrix of new PSD term.

PsdExpr::AddTerm()

Add a PSD term to PSD expression object.

Synopsis

```
void AddTerm(const PsdVar &var, const SymMatExpr &expr)
```

Arguments

var: PSD variable of new PSD term.

expr: coefficient expression of symmetric matrices of new PSD term.

PsdExpr::AddTerms()

Add linear terms to PSD expression object.

Synopsis

```
int AddTerms(  
    const VarArray &vars,  
    double *pCoeff,  
    int len)
```

Arguments

vars: variables for added linear terms.

pCoeff: coefficient array for added linear terms.

len: length of coefficient array.

Return

number of added linear terms.

PsdExpr::AddTerms()

Add PSD terms to PSD expression object.

Synopsis

```
int AddTerms(const PsdVarArray &vars, const SymMatrixArray &mats)
```

Arguments

vars: PSD variables for added PSD terms.

mats: coefficient matrixes for added PSD terms.

Return

number of added PSD terms.

PsdExpr::Clone()

Deep copy PSD expression object.

Synopsis

```
PsdExpr Clone()
```

Return

cloned PSD expression object.

PsdExpr::Evaluate()

evaluate PSD expression after solving

Synopsis

```
double Evaluate()
```

Return

value of PSD expression

PsdExpr::GetCoeff()

Get coefficient from the i-th term in PSD expression.

Synopsis

```
SymMatExpr &GetCoeff(int i)
```

Arguments

i: index of the PSD term.

Return

coefficient of the i-th PSD term in PSD expression object.

PsdExpr::GetConstant()

Get constant in PSD expression.

Synopsis

```
double GetConstant()
```

Return

constant in PSD expression.

PsdExpr::GetLinExpr()

Get linear expression in PSD expression.

Synopsis

```
Expr &GetLinExpr()
```

Return

linear expression object.

PsdExpr::GetPsdVar()

Get the PSD variable from the i-th term in PSD expression.

Synopsis

```
PsdVar &GetPsdVar(int i)
```

Arguments

i: index of the term.

Return

the first variable of the i-th term in PSD expression object.

PsdExpr::operator*=()

Multiply a constant to self.

Synopsis

```
void operator*=(double c)
```

Arguments

c: constant multiplier.

PsdExpr::operator*()

Multiply constant and return new expression.

Synopsis

```
PsdExpr operator*(double c)
```

Arguments

c: constant multiplier.

Return

result expression.

PsdExpr::operator+=()

Add an expression to self.

Synopsis

```
void operator+=(const PsdExpr &expr)
```

Arguments

expr: expression to be added.

PsdExpr::operator+()

Add expression and return new expression.

Synopsis

```
PsdExpr operator+(const PsdExpr &other)
```

Arguments

other: other expression to add.

Return

result expression.

PsdExpr::operator-=()

Subtract an expression from self.

Synopsis

```
void operator-=(const PsdExpr &expr)
```

Arguments

expr: expression to be subtracted.

PsdExpr::operator-()

Subtract expression and return new expression.

Synopsis

```
PsdExpr operator-(const PsdExpr &other)
```

Arguments

other: other expression to subtract.

Return

result expression.

PsdExpr::Remove()

Remove i-th term from PSD expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

PsdExpr::Remove()

Remove the term associated with variable from PSD expression.

Synopsis

```
void Remove(const Var &var)
```

Arguments

var: a variable whose term should be removed.

PsdExpr::Remove()

Remove the term associated with PSD variable from PSD expression.

Synopsis

```
void Remove(const PsdVar &var)
```

Arguments

var: a PSD variable whose term should be removed.

PsdExpr::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(size_t n)
```

Arguments

n: minimum capacity for PSD expression object.

PsdExpr::SetCoeff()

Set coefficient matrix of the i-th term in PSD expression.

Synopsis

```
void SetCoeff(int i, const SymMatrix &mat)
```

Arguments

i: index of the PSD term.

mat: coefficient matrix of the term.

PsdExpr::SetConstant()

Set constant for the PSD expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

PsdExpr::Size()

Get number of PSD terms in expression.

Synopsis

```
size_t Size()
```

Return

number of PSD terms.

23.5.41 PsdConstraint

COPT PSD constraint object. PSD constraints are always associated with a particular model. User creates a PSD constraint object by adding a PSD constraint to model, rather than by constructor of PsdConstraint class.

PsdConstraint::Get()

Get information value of the PSD constraint. Support related PSD informations.

Synopsis

```
double Get(const char *szInfo)
```

Arguments

szInfo: name of queried information.

Return

value of information.

PsdConstraint::GetIdx()

Get index of the PSD constraint.

Synopsis

```
int GetIdx()
```

Return

the index of the PSD constraint.

PsdConstraint::GetName()

Get name of the PSD constraint.

Synopsis

```
const char *GetName()
```

Return

the name of the PSD constraint.

PsdConstraint::Remove()

Remove this PSD constraint from model.

Synopsis

```
void Remove()
```

PsdConstraint::Set()

Set information value of the PSD constraint. Support related PSD informations.

Synopsis

```
void Set(const char *szInfo, double value)
```

Arguments

szInfo: name of queried information.

value: new information value.

PsdConstraint::SetName()

Set name of a PSD constraint.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: the name to set.

23.5.42 PsdConstrArray

COPT PSD constraint array object. To store and access a set of *PsdConstraint* objects, Cardinal Optimizer provides PsdConstrArray class, which defines the following methods.

PsdConstrArray::GetPsdConstr()

Get idx-th PSD constraint object.

Synopsis

```
PsdConstraint &GetPsdConstr(int idx)
```

Arguments

idx: index of the PSD constraint.

Return

PSD constraint object with index idx.

PsdConstrArray::PushBack()

Add a PSD constraint object to PSD constraint array.

Synopsis

```
void PushBack(const PsdConstraint &constr)
```

Arguments

constr: a PSD constraint object.

PsdConstrArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for PSD constraint objects.

PsdConstrArray::Size()

Get the number of PSD constraint objects.

Synopsis

```
int Size()
```

Return

number of PSD constraint objects.

23.5.43 PsdConstrBuilder

COPT PSD constraint builder object. To help building a PSD constraint, given a PSD expression, constraint sense and right-hand side value, Cardinal Optimizer provides PsdConstrBuilder class, which defines the following methods.

PsdConstrBuilder::GetPsdExpr()

Get expression associated with PSD constraint.

Synopsis

```
const PsdExpr &GetPsdExpr()
```

Return

PSD expression object.

PsdConstrBuilder::GetRange()

Get range from lower bound to upper bound of range constraint.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of the constraint.

PsdConstrBuilder::GetSense()

Get sense associated with PSD constraint.

Synopsis

```
char GetSense()
```

Return

PSD constraint sense.

PsdConstrBuilder::Set()

Set detail of a PSD constraint to its builder object.

Synopsis

```
void Set(  
    const PsdExpr &expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the PSD constraint.

sense: PSD constraint sense, other than COPT_RANGE.

rhs: constant at right side of the PSD constraint.

PsdConstrBuilder::SetRange()

Set a range constraint to its builder.

Synopsis

```
void SetRange(const PsdExpr &expr, double range)
```

Arguments

expr: PSD expression object, whose constant is negative upper bound.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

23.5.44 PsdConstrBuilderArray

COPT PSD constraint builder array object. To store and access a set of *PsdConstrBuilder* objects, Cardinal Optimizer provides PsdConstrBuilderArray class, which defines the following methods.

PsdConstrBuilderArray::GetBuilder()

Get idx-th PSD constraint builder object.

Synopsis

```
PsdConstrBuilder &GetBuilder(int idx)
```

Arguments

idx: index of the PSD constraint builder.

Return

PSD constraint builder object with index idx.

PsdConstrBuilderArray::PushBack()

Add a PSD constraint builder object to PSD constraint builder array.

Synopsis

```
void PushBack(const PsdConstrBuilder &builder)
```

Arguments

builder: a PSD constraint builder object.

PsdConstrBuilderArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for PSD constraint builder object.

PsdConstrBuilderArray::Size()

Get the number of PSD constraint builder objects.

Synopsis

```
int Size()
```

Return

number of PSD constraint builder objects.

23.5.45 LmiConstraint

COPT LMI constraint object. LMI constraints are always associated with a particular model. User creates a LMI constraint object by adding a LMI constraint to model, rather than by constructor of LmiConstraint class.

LmiConstraint::Get()

Get information values of LMI expression.

Synopsis

```
double Get(const char *szInfo, int len)
```

Arguments

szInfo: name of queried information.

len: length of output array.

Return

output list of information values.

LmiConstraint::GetDim()

Get dimension of LMI constraint.

Synopsis

```
int GetDim()
```

Return

dimension of LMI constraint.

LmiConstraint::GetIdx()

Get index of LMI constraint.

Synopsis

```
int GetIdx()
```

Return

index of LMI constraint.

LmiConstraint::GetLen()

Get length of LMI constraint.

Synopsis

```
int GetLen()
```

Return

length of LMI constraint.

LmiConstraint::GetName()

Get name of LMI constraint.

Synopsis

```
const char *GetName()
```

Return

the name of LMI constraint.

LmiConstraint::Remove()

Remove this LMI constraint from model.

Synopsis

```
void Remove()
```

LmiConstraint::SetName()

Set name of LMI constraint.

Synopsis

```
void SetName(const char *szName)
```

Arguments

szName: new name to set.

LmiConstraint::SetRhs()

Set constant term of LMI constraint.

Synopsis

```
void SetRhs(const SymMatrix &mat)
```

Arguments

mat: new symmetric matrix for constant term.

23.5.46 LmiConstrArray

COPT LMI constraint array object. To store and access a set of *LmiConstraint* objects, Cardinal Optimizer provides LmiConstrArray class, which defines the following methods.

LmiConstrArray::GetLmiConstr()

Get idx-th LMI constraint object.

Synopsis

```
LmiConstraint &GetLmiConstr(int idx)
```

Arguments

idx: index of the LMI constraint.

Return

LMI constraint object with index idx.

LmiConstrArray::PushBack()

Add a LMI constraint to LMI constraint array.

Synopsis

```
void PushBack(const LmiConstraint &constr)
```

Arguments

constr: LMI constraint object.

LmiConstrArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: capacity number of LMI constraint objects.

LmiConstrArray::Size()

Get the number of LMI constraint objects.

Synopsis

```
int Size()
```

Return

number of LMI constraint objects.

23.5.47 LmiExpr

COPT LMI expression object. A LMI expression consists of a list of variables, associated coefficient matrices of LMI term, and constant matrices. LMI expressions are used to build LMI constraints.

LmiExpr::LmiExpr()

Default constructor of a LMI expression.

Synopsis

```
LmiExpr()
```

LmiExpr::LmiExpr()

Constructor of LMI expression with given symmetric matrix.

Synopsis

```
LmiExpr(const SymMatrix &mat)
```

Arguments

mat: symmetric matrix as constant term of LMI expression.

LmiExpr::LmiExpr()

Constructor of LMI expression with given matrix expression.

Synopsis

```
LmiExpr(const SymMatExpr &expr)
```

Arguments

expr: matrix expression as constant term of LMI expression.

LmiExpr::LmiExpr()

Constructor of LMI expression with one term.

Synopsis

```
LmiExpr(const Var &var, const SymMatrix &mat)
```

Arguments

var: variable of the added term.

mat: coefficient matrix of the added term.

LmiExpr::LmiExpr()

Constructor of LMI expression with one term.

Synopsis

```
LmiExpr(const Var &var, const SymMatExpr &expr)
```

Arguments

var: variable of the added term.

expr: coefficient expression of symmetric matrices for the added term.

LmiExpr::AddConstant()

Add to constant term of LMI expression.

Synopsis

```
void AddConstant(const SymMatExpr &expr)
```

Arguments

expr: matrix expression object added to constant term.

LmiExpr::AddLmiExpr()

Add a LMI expression to self.

Synopsis

```
void AddLmiExpr(const LmiExpr &expr, double mult)
```

Arguments

expr: LMI expression to be added.

mult: optional, constant multiplier, default value is 1.0.

LmiExpr::AddTerm()

Add a term to LMI expression.

Synopsis

```
void AddTerm(const Var &var, const SymMatrix &mat)
```

Arguments

var: variable of new LMI term.

mat: coefficient matrix object of new LMI term.

LmiExpr::AddTerm()

Add a term to LMI expression.

Synopsis

```
void AddTerm(const Var &var, const SymMatExpr &expr)
```

Arguments

var: variable of new LMI term.

expr: coefficient expression object of symmetric matrices of new LMI term.

LmiExpr::AddTerms()

Add LMI terms to LMI expression.

Synopsis

```
int AddTerms(const VarArray &vars, const SymMatrixArray &mats)
```

Arguments

vars: variables of added LMI terms.

mats: coefficient matrix objects for added LMI terms.

Return

number of added LMI terms.

LmiExpr::Clone()

Deep copy LMI expression.

Synopsis

```
LmiExpr Clone()
```

Return

cloned LMI expression object.

LmiExpr::GetCoeff()

Get coefficient from the i-th term in LMI expression.

Synopsis

```
SymMatExpr &GetCoeff(int i)
```

Arguments

i: index of the LMI term.

Return

coefficient matrix expression object of the i-th LMI term in LMI expression.

LmiExpr::GetConstant()

Get constant term in LMI expression.

Synopsis

```
SymMatExpr &GetConstant()
```

Return

matrix expression object in LMI expression.

LmiExpr::GetVar()

Get variable from the i-th term in LMI expression.

Synopsis

```
Var &GetVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in LMI expression object.

LmiExpr::operator*=()

Multiply a double constant to self.

Synopsis

```
void operator*=(double c)
```

Arguments

c: constant multiplier.

LmiExpr::operator*()

Multiply double constant and return new expression.

Synopsis

```
LmiExpr operator*(double c)
```

Arguments

c: constant multiplier.

Return

result expression.

LmiExpr::operator+=()

Add a symmetric matrix or LMI expression to self.

Synopsis

```
void operator+=(const LmiExpr &expr)
```

Arguments

expr: symmetric matrix or LMI expression to be added.

LmiExpr::operator+()

Add a symmetric matrix or LMI expression and return new LMI expression.

Synopsis

```
LmiExpr operator+(const LmiExpr &other)
```

Arguments

other: other symmetric matrix or LMI expression to add.

Return

result expression.

LmiExpr::operator-=()

Subtract a symmetric matrix or LMI expression from self.

Synopsis

```
void operator-=(const LmiExpr &expr)
```

Arguments

expr: symmetric matrix or LMI expression to be subtracted.

LmiExpr::operator-()

Subtract a symmetric matrix or LMI expression and return new expression.

Synopsis

```
LmiExpr operator-(const LmiExpr &other)
```

Arguments

other: other symmetric matrix or LMI expression to subtract.

Return

result expression.

LmiExpr::Remove()

Remove i-th term from LMI expression.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

LmiExpr::Remove()

Remove the term associated with given variable from LMI expression.

Synopsis

```
void Remove(const Var &var)
```

Arguments

var: a variable whose term should be removed.

LmiExpr::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(size_t n)
```

Arguments

n: capacity number of LMI expression.

LmiExpr::SetCoeff()

Set coefficient matrix of the i-th term in LMI expression.

Synopsis

```
void SetCoeff(int i, const SymMatrix &mat)
```

Arguments

i: index of the LMI term.

mat: new coefficient matrix object.

LmiExpr::SetConstant()

Set constant term of the LMI expression.

Synopsis

```
void SetConstant(const SymMatrix &mat)
```

Arguments

mat: new matrix object.

LmiExpr::Size()

Get number of terms in LMI expression.

Synopsis

```
size_t Size()
```

Return

number of LMI terms.

23.5.48 SymMatrix

COPT symmetric matrix object. Symmetric matrices are always associated with a particular model. User creates a symmetric matrix object by adding a symmetric matrix to model, rather than by constructor of SymMatrix class.

Symmetric matrices are used as coefficient matrices of PSD terms in PSD expressions, PSD constraints or PSD objectives.

SymMatrix::GetDim()

Get the dimension of a symmetric matrix.

Synopsis

```
int GetDim()
```

Return

dimension of a symmetric matrix.

SymMatrix::GetIdx()

Get the index of a symmetric matrix.

Synopsis

```
int GetIdx()
```

Return

index of a symmetric matrix.

23.5.49 SymMatrixArray

COPT symmetric matrix object. To store and access a set of *SymMatrix* objects, Cardinal Optimizer provides SymMatrixArray class, which defines the following methods.

SymMatrixArray::GetMatrix()

Get i-th SymMatrix object.

Synopsis

```
SymMatrix &GetMatrix(int idx)
```

Arguments

idx: index of the SymMatrix object.

Return

SymMatrix object with index idx.

SymMatrixArray::PushBack()

Add a SymMatrix object to SymMatrix array.

Synopsis

```
void PushBack(const SymMatrix &mat)
```

Arguments

mat: a SymMatrix object.

SymMatrixArray::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for symmetric matrix object.

SymMatrixArray::Size()

Get the number of SymMatrix objects.

Synopsis

```
int Size()
```

Return

number of SymMatrix objects.

23.5.50 SymMatExpr

COPT symmetric matrix expression object. A symmetric matrix expression is a linear combination of symmetric matrices, which is still a symmetric matrix. However, by doing so, we are able to delay computing the final matrix until setting PSD constraints or PSD objective.

SymMatExpr::SymMatExpr()

Constructor of a symmetric matrix expression.

Synopsis

```
SymMatExpr()
```

SymMatExpr::SymMatExpr()

Constructor of a symmetric matrix expression with one term.

Synopsis

```
SymMatExpr(const SymMatrix &mat, double coeff)
```

Arguments

mat: symmetric matrix of the added term.

coeff: optional, coefficient for the added term. Its default value is 1.0.

SymMatExpr::AddSymMatExpr()

Add a symmetric matrix expression to self.

Synopsis

```
void AddSymMatExpr(const SymMatExpr &expr, double mult)
```

Arguments

expr: symmetric matrix expression to be added.

mult: optional, constant multiplier, default value is 1.0.

SymMatExpr::AddTerm()

Add a term to symmetric matrix expression object.

Synopsis

```
bool AddTerm(const SymMatrix &mat, double coeff)
```

Arguments

mat: symmetric matrix of the new term.

coeff: coefficient of the new term.

Return

True if the term is added successfully.

SymMatExpr::AddTerms()

Add multiple terms to expression object.

Synopsis

```
int AddTerms(  
    const SymMatrixArray &mats,  
    double *pCoeff,  
    int len)
```

Arguments

mats: symmetric matrix array object for added terms.

pCoeff: coefficient array for added terms.

len: length of coefficient array.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr::Clone()

Deep copy symmetric matrix expression object.

Synopsis

```
SymMatExpr Clone()
```

Return

cloned expression object.

SymMatExpr::GetCoeff()

Get coefficient of the i-th term in expression object.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term.

SymMatExpr::GetDim()

Get dimension of symmetric matrix in expression.

Synopsis

```
int GetDim()
```

Return

dimension of symmetric matrix.

SymMatExpr::GetSymMat()

Get symmetric matrix of the i-th term in expression object.

Synopsis

```
SymMatrix &GetSymMat(int i)
```

Arguments

i: index of the term.

Return

the symmetric matrix of the i-th term.

SymMatExpr::operator*=(())

Multiply a constant to self.

Synopsis

```
void operator*=(double c)
```

Arguments

c: constant multiplier.

SymMatExpr::operator*()

Multiply constant and return new expression.

Synopsis

```
SymMatExpr operator*(double c)
```

Arguments

c: constant multiplier.

Return

result expression.

SymMatExpr::operator+=(())

Add a symmetric matrix expression to self.

Synopsis

```
void operator+=(const SymMatExpr &expr)
```

Arguments

expr: symmetric matrix expression to be added.

SymMatExpr::operator+()

Add expression and return new expression.

Synopsis

```
SymMatExpr operator+(const SymMatExpr &other)
```

Arguments

other: other expression to add.

Return

result expression.

SymMatExpr::operator-=(())

Subtract a symmetric matrix expression from self.

Synopsis

```
void operator-=(const SymMatExpr &expr)
```

Arguments

expr: symmetric matrix to be subtracted.

SymMatExpr::operator-()

Subtract expression and return new expression.

Synopsis

```
SymMatExpr operator-(const SymMatExpr &other)
```

Arguments

other: other expression to subtract.

Return

result expression.

SymMatExpr::Remove()

Remove i-th term from expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

SymMatExpr::Remove()

Remove the term associated with the symmetric matrix.

Synopsis

```
void Remove(const SymMatrix &mat)
```

Arguments

mat: a symmetric matrix whose term should be removed.

SymMatExpr::Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(size_t n)
```

Arguments

n: minimum capacity for expression object.

SymMatExpr::SetCoeff()

Set coefficient for the i-th term in expression object.

Synopsis

```
void SetCoeff(int i, double val)
```

Arguments

i: index of the term.

val: coefficient of the term.

SymMatExpr::Size()

Get number of terms in expression.

Synopsis

```
size_t Size()
```

Return

number of terms.

23.5.51 MVar

COPT multi-dimensional variable object. It is used to construct multi-dimensional variables and support operations with the built-in multi-dimensional array *NdArray* in COPT. It can be created by calling the method `addMVar` of *Model*. The following methods are provided:

MVar::MVar()

Construct a MVar object with the given shape, filling with the given variable.

Synopsis

```
MVar(const Shape<N> &shp, const Var &var)
```

Arguments

shp: shape of MVar.

var: Variable object.

MVar::MVar()

Construct a MVar object with the given shape, filling with an array of variables.

Synopsis

```
MVar(const Shape<N> &shp, const VarArray &vars)
```

Arguments

shp: shape of MVar.

vars: an array of variables.

MVar::Clone()

Clone MVar object.

Synopsis

```
MVar Clone()
```

Return

new MVar object.

MVar::Diagonal()

Get diagonals of MVar object.

Synopsis

```
MVar<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MVar.

axis2: 2nd axis of MVar.

Return

(N-1)-dimensional diagonals.

MVar::Expand()

Expand shape of MVar object.

Synopsis

```
MVar<N + 1> Expand(int axis)
```

Arguments

axis: axis of MVar.

Return

MVar object of (N+1)-dimensional shape.

MVar::Flatten()

Flatten a MVar object to a 1-dimensional shape.

Synopsis

```
MVar<1> Flatten()
```

Return

a MVar object collapsed into one dimension.

MVar::Get()

Get values of information associated with variables in MVar object.

Synopsis

```
NdArray<double, N> Get(const char *szInfo)
```

Arguments

szInfo: name of information.

Return

multi-dimensional array of information of variables.

MVar::GetBasis()

Get basis of variables in MVar object.

Synopsis

```
NdArray<int, N> GetBasis()
```

Return

multi-dimensional array of basis of variables.

MVar::GetDim()

Get i-th dimension of MVar object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MVar::GetIdx()

Get indexes of variables in MVar object.

Synopsis

```
NdArray<int, N> GetIdx()
```

Return

multi-dimensional array of indexes of variables.

MVar::GetLowerIIS()

Get IIS status of lower bound of variables in MVar object.

Synopsis

```
NdArray<int, N> GetLowerIIS()
```

Return

multi-dimensional array of IIS status of lower bounds of variables.

MVar::GetND()

Get number of dimensions of MVar object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MVar::GetShape()

Get shape of MVar object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MVar::GetSize()

Get size of MVar object.

Synopsis

```
size_t GetSize()
```

Return

number of vars.

MVar::GetType()

Get types of variables in MVar object.

Synopsis

```
NdArray<char, N> GetType()
```

Return

multi-dimensional array of types of variables.

MVar::GetUpperIIS()

Get IIS status of upper bound of variables in MVar object.

Synopsis

```
NdArray<int, N> GetUpperIIS()
```

Return

multi-dimensional array of IIS status of upper bounds of variables.

MVar::Item()

Get variable of given index from MVar object.

Synopsis

```
Var &Item(size_t idx)
```

Arguments

idx: index of var.

Return

Var object.

MVar::operator[]()

Get variable of given index from MVar object.

Synopsis

```
Var &operator[] (size_t idx)
```

Arguments

idx: index of var.

Return

Var object.

MVar::operator[]()

Get sub-arrays of MVar object, given view object.

Synopsis

```
MVar operator[] (const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MVar object.

MVar::Pick()

Given a list of indexes, get variables from MVar object.

Synopsis

```
MVar<1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired variables.

MVar::Pick()

Given a list of indexes, get variables from MVar object.

Synopsis

```
MVar<1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired variables.

MVar::Repeat()

Repeat each element of MVar along given axis.

Synopsis

```
MVar<N> Repeat(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MVar.

Return

new MVar object.

MVar::RepeatBlock()

Repeat an MVar a number of times along given axis.

Synopsis

```
MVar<N> RepeatBlock(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MVar.

Return

new MVar object.

MVar::Represent()

String representation of MVar object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MVar::Reshape()

Reshape MVar object to new shape.

Synopsis

```
template <int M> MVar<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MVar object.

MVar::Set()

Set values of information associated with variables in MVar object.

Synopsis

```
void Set(const char *szInfo, double val)
```

Arguments

szInfo: name of information.

val: value of information.

MVar::Set()

Set values of information associated with variables in MVar object.

Synopsis

```
void Set(const char *szInfo, const NdArray<double, N> &vals)
```

Arguments

szInfo: name of information.

vals: multi-dimensional array of values of information.

MVar::SetItem()

Set variable of given index to MVar object.

Synopsis

```
void SetItem(size_t idx, const Var &var)
```

Arguments

idx: index of element.

var: Var object.

MVar::Squeeze()

Remove axis of length 1 from shape of MVar object.

Synopsis

```
MVar<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MVar, where the length is 1.

Return

MVar object of (N-1)-dimensional shape.

MVar::Stack()

Stack with other MVar object along given axis.

Synopsis

```
MVar<N> Stack(const MVar<N> &other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MVar.

Return

the result MVar object.

MVar::Sum()

Sum of all variables in MVar object.

Synopsis

```
MLinExpr<0> Sum()
```

Return

sum in zero dimension.

MVar::Sum()

Sum of variables at given axis of MVar object.

Synopsis

```
MLinExpr<N - 1> Sum(int axis)
```

Arguments

axis: axis of MVar.

Return

MLinExpr object in (N-1)-dimension.

MVar::Transpose()

Perform matrix transpose of MVar object.

Synopsis

```
MVar<N> Transpose()
```

Return

transposed MVar object.

23.5.52 MConstr

COPT multi-dimensional linear constraint object. It can be created by calling the method `addMConstr` of *Model*. The following methods are provided:

MConstr::MConstr()

Construct a MConstr object with the given shape, filling with the given constraint.

Synopsis

```
MConstr(const Shape<N> &shp, const Constraint &con)
```

Arguments

shp: shape of MConstr.

con: Constraint object.

MConstr::MConstr()

Construct a MConstr object with the given shape, filling with an array of constraints.

Synopsis

```
MConstr(const Shape<N> &shp, const ConstrArray &cons)
```

Arguments

shp: shape of MConstr.

cons: an array of constraints.

MConstr::Clone()

Clone MConstr object.

Synopsis

```
MConstr Clone()
```

Return

new MConstr object.

MConstr::Diagonal()

Get diagonals of MConstr object.

Synopsis

```
MConstr<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MConstr.

axis2: 2nd axis of MConstr.

Return

(N-1)-dimensional diagonals.

MConstr::Expand()

Expand shape of MConstr object.

Synopsis

```
MConstr<N + 1> Expand(int axis)
```

Arguments

axis: axis of MConstr.

Return

MConstr object of (N+1)-dimensional shape.

MConstr::Flatten()

Flatten a MConstr object to a 1-dimensional shape.

Synopsis

```
MConstr<1> Flatten()
```

Return

a MConstr object collapsed into one dimension.

MConstr::Get()

Get values of information associated with constraints in MConstr object.

Synopsis

```
NdArray<double, N> Get(const char *szInfo)
```

Arguments

szInfo: name of information.

Return

multi-dimensional array of information of constraints.

MConstr::GetBasis()

Get basis of constraints in MConstr object.

Synopsis

```
NdArray<int, N> GetBasis()
```

Return

multi-dimensional array of basis of constraints.

MConstr::GetDim()

Get i-th dimension of MConstr object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MConstr::GetIdx()

Get index of constraints in MConstr object.

Synopsis

```
NdArray<int, N> GetIdx()
```

Return

multi-dimensional array of indexes of constraints.

MConstr::GetLowerIIS()

Get IIS status of lower bound of constraints in MConstr object.

Synopsis

```
NdArray<int, N> GetLowerIIS()
```

Return

multi-dimensional array of IIS status of lower bounds of constraints.

MConstr::GetND()

Get number of dimensions of MConstr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MConstr::GetShape()

Get shape of MConstr object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MConstr::GetSize()

Get size of MConstr object.

Synopsis

```
size_t GetSize()
```

Return

number of constraints.

MConstr::GetUpperIIS()

Get IIS status of upper bound of constraints in MConstr object.

Synopsis

```
NdArray<int, N> GetUpperIIS()
```

Return

multi-dimensional array of IIS status of upper bounds of constraints.

MConstr::Item()

Get constraint of given index from MConstr object.

Synopsis

```
Constraint &Item(size_t idx)
```

Arguments

idx: index of constraint.

Return

Constraint object.

MConstr::operator[]()

Get constraint of given index from MConstr object.

Synopsis

```
Constraint &operator[] (size_t idx)
```

Arguments

idx: index of constraint.

Return

Constraint object.

MConstr::operator[]()

Get constraints of given view from MConstr object.

Synopsis

```
MConstr operator[] (const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new MConstr object.

MConstr::Pick()

Given a list of indexes, get constraints from MConstr object.

Synopsis

```
MConstr<1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired constraints.

MConstr::Pick()

Given a list of indexes, get constraints from MConstr object.

Synopsis

```
MConstr<1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired constraints.

MConstr::Represent()

String representation of MConstr object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MConstr::Reshape()

Reshape MConstr object to new shape.

Synopsis

```
template <int M> MConstr<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MConstr object.

MConstr::Set()

Set values of information associated with constraints in MConstr object.

Synopsis

```
void Set(const char *szInfo, double val)
```

Arguments

szInfo: name of information.

val: value of information.

MConstr::Set()

Set values of information associated with constraints in MConstr object.

Synopsis

```
void Set(const char *szInfo, const NdArray<double, N> &vals)
```

Arguments

szInfo: name of information.

vals: multi-dimensional array of values of information.

MConstr::SetItem()

Set constraint of given index to MConstr object.

Synopsis

```
void SetItem(size_t idx, const Constraint &con)
```

Arguments

idx: index of element.

con: constraint object.

MConstr::Squeeze()

Remove axis of length 1 from shape of MConstr object.

Synopsis

```
MConstr<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MConstr, where the length is 1.

Return

MConstr object of (N-1)-dimensional shape.

MConstr::Stack()

Stack with other MConstr object along given axis.

Synopsis

```
MConstr<N> Stack(const MConstr<N> &other, int axis)
```

Arguments

other: a MConstr object.

axis: an axis of MConstr.

Return

the result MConstr object.

MConstr::Transpose()

Perform matrix transpose of MConstr object.

Synopsis

```
MConstr<N> Transpose()
```

Return

transposed MConstr object.

23.5.53 MConstrBuilder

COPT builder object of multi-dimensional linear constraints. It is used to generate multi-dimensional linear constraints and support operations with the built-in multi-dimensional array *NdArray* in COPT. It is recommended to create MConstrBuilder object by comparing two objects, one of which should be *MVar* object or *MLinExpr* object, by comparison operators. The following methods are provided:

MConstrBuilder::MConstrBuilder()

Construct a MConstrBuilder object with the given shape.

Synopsis

```
MConstrBuilder(const Shape<N> &shp)
```

Arguments

shp: shape of MConstrBuilder.

MConstrBuilder::Flatten()

Flatten a MConstrBuilder object to a 1-dimensional shape.

Synopsis

```
MConstrBuilder<1> Flatten()
```

Return

a MConstrBuilder object collapsed into one dimension.

MConstrBuilder::GetExpr()

Get N-dimensional linear expressions associated with N-dimensional constraints.

Synopsis

```
const MLinExpr<N> &GetExpr()
```

Return

MLinExpr object.

MConstrBuilder::GetND()

Get number of dimensions of MConstrBuilder object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MConstrBuilder::GetRange()

Get range from lower bound to upper bound of N-dimensional range constraints.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of range constraints.

MConstrBuilder::GetSense()

Get sense associated with N-dimensional constraints.

Synopsis

```
char GetSense()
```

Return

constraint sense.

MConstrBuilder::Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
void Set(  
    const MLinExpr<N> &expr,  
    char sense,  
    double rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: constant of right side of constraints.

MConstrBuilder::Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
template <class T> void Set(  
    const MLinExpr<N> &expr,  
    char sense,  
    const NdArray<T, N> &rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: N-dimensional constants at right side of constraints.

MConstrBuilder::Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
template <int M> void Set(  
    const MLinExpr<N> &expr,  
    char sense,  
    const MVar<M> &rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MVar object at right side of constraints.

MConstrBuilder::Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
template <int M> void Set(  
    const MLinExpr<N> &expr,  
    char sense,  
    const MLinExpr<M> &rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MLinExpr object at right side of constraints.

MConstrBuilder::SetRange()

Set N-dimensional range constraints to its builder object.

Synopsis

```
void SetRange(const MLinExpr<N> &expr, double range)
```

Arguments

expr: MLinExpr object.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

23.5.54 MExpression

The MExpression class is a generalized version of *Expr*. It represents a linear expression and supports most of methods in Expr class. In addition, it supports linear combination of multi-dimensional objects, such as *MVar* object and *NdArray* object. The following methods are provided:

MExpression::MExpression()

Construct a MExpression object with the given constant.

Synopsis

```
MExpression(double constant)
```

Arguments

constant: constant number.

MExpression::MExpression()

Construct a MExpression object with the given linear expression.

Synopsis

```
MExpression(const Expr &expr)
```

Arguments

expr: a linear expression.

MExpression::MExpression()

Construct a MExpression object with the given variable.

Synopsis

```
MExpression(const Var &var)
```

Arguments

var: variable object.

MExpression::AddConstant()

Add constant for the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MExpression::AddExpr()

Add a linear expression to MExpression object.

Synopsis

```
void AddExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MExpression::AddMExpr()

Add MExpression to MExpression object.

Synopsis

```
void AddMExpr(const MExpression &expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MExpression::AddTerm()

Add a linear term to MExpression object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MExpression::Clone()

Clone MExpression object.

Synopsis

```
MExpression Clone()
```

Return

new MExpression object.

MExpression::GetConstant()

Get constant in expression.

Synopsis

```
double GetConstant()
```

Return

constant in expression.

MExpression::Represent()

String representation of MExpression object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MExpression::SetConstant()

Set constant for the expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

23.5.55 MLinExpr

COPT multi-dimensional linear expression object. It is used to construct multi-dimensional linear expressions and perform operations with the built-in multi-dimensional array *NdArray* in COPT. Its elements are *MExpression* objects. It can be created by linear combination of *MVar* objects. The following methods are provided:

MLinExpr::MLinExpr()

Construct a MLinExpr object with the given shape and a constant.

Synopsis

```
MLinExpr(const Shape<N> &shp, double constant)
```

Arguments

shp: shape of MLinExpr.

constant: constant number.

MLinExpr::MLinExpr()

Construct a MLinExpr object with the given shape and a linear expression.

Synopsis

```
MLinExpr(const Shape<N> &shp, const Expr &expr)
```

Arguments

shp: shape of MLinExpr.

expr: a linear expression.

MLinExpr::MLinExpr()

Construct a MLinExpr object with the given shape and a MExpression object.

Synopsis

```
MLinExpr(const Shape<N> &shp, const MExpression &expr)
```

Arguments

shp: shape of MLinExpr.

expr: a MExpression object.

MLinExpr::AddConstant()

Add constant to each expression in MLinExpr object.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MLinExpr::AddConstant()

Add constants to each expression in MLinExpr object.

Synopsis

```
template <class T> void AddConstant(const NdArray<T, N> &constants)
```

Arguments

constants: N-dimension NdArray object.

MLinExpr::AddExpr()

Add a linear expression to each expression in MLinExpr object.

Synopsis

```
void AddExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MLinExpr::AddMExpr()

Add MExpression to each expression in MLinExpr object.

Synopsis

```
void AddMExpr(const MExpression &expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MLinExpr::AddMLinExpr()

Add linear expressions to MLinExpr object.

Synopsis

```
void AddMLinExpr(const MLinExpr<N> &exprs, double mult)
```

Arguments

exprs: N-dimension MLinExpr object.

mult: the same multiplier for added linear expressions, default value is 1.0.

MLinExpr::AddTerm()

Add a linear term to MLinExpr object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MLinExpr::AddTerms()

Add terms to expressions in MLinExpr object.

Synopsis

```
void AddTerms(const MVar<N> &vars, double mult)
```

Arguments

vars: N-dimension MVar object for added terms.

mult: the same coefficient for added terms, default value 1.0.

MLinExpr::AddTerms()

Add terms to expressions in MLinExpr object.

Synopsis

```
void AddTerms(const MVar<N> &vars, const NdArray<double, N> &coeffs)
```

Arguments

vars: N-dimension MVar object for added terms.

coeffs: N-dimension NdArray object of coefficients for added terms.

MLinExpr::Clear()

Clear MLinExpr object.

Synopsis

```
void Clear()
```

MLinExpr::Clone()

Clone MLinExpr object.

Synopsis

```
MLinExpr Clone()
```

Return

new MLinExpr object.

MLinExpr::Diagonal()

Get diagonals of MLinExpr object.

Synopsis

```
MLinExpr<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MLinExpr.

axis2: 2nd axis of MLinExpr.

Return

(N-1)-dimensional diagonals.

MLinExpr::Expand()

Expand shape of MLinExpr object.

Synopsis

```
MLinExpr<N + 1> Expand(int axis)
```

Arguments

axis: axis of MLinExpr.

Return

MLinExpr object of (N+1)-dimensional shape.

MLinExpr::Flatten()

Flatten a MLinExpr object to a 1-dimensional shape.

Synopsis

```
MLinExpr<1> Flatten()
```

Return

a MLinExpr object collapsed into one dimension.

MLinExpr::GetDim()

Get i-th dimension of MLinExpr object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MLinExpr::GetND()

Get number of dimensions of MLinExpr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MLinExpr::GetShape()

Get shape of MLinExpr object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MLinExpr::GetSize()

Get size of MLinExpr object.

Synopsis

```
size_t GetSize()
```

Return

number of MExpressions.

MLinExpr::Item()

Get expression of given index from MLinExpr object.

Synopsis

```
MExpression &Item(size_t idx)
```

Arguments

idx: index of expression.

Return

expression object.

MLinExpr::Item()

Get sub-arrays of MLinExpr object, given view object.

Synopsis

```
MLinExpr Item(const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MLinExpr object.

MLinExpr::operator[]()

Get expression of given index from MLinExpr object.

Synopsis

```
MExpression &operator[] (size_t i)
```

Arguments

i: index of expression.

Return

expression object.

MLinExpr::operator[]()

Get constraints of given view from MLinExpr object.

Synopsis

```
MLinExpr operator[] (const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new MLinExpr object.

MLinExpr::Pick()

Given a list of indexes, get linear expressions from MLinExpr object.

Synopsis

```
MLinExpr<1> Pick(const NArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired linear expressions.

MLinExpr::Pick()

Given a list of indexes, get linear expressions from MLinExpr object.

Synopsis

```
MLinExpr<1> Pick(const NArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired linear expressions.

MLinExpr::Repeat()

Repeat each element of MLinExpr along given axis.

Synopsis

```
MLinExpr<N> Repeat(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MLinExpr.

Return

new MLinExpr object.

MLinExpr::RepeatBlock()

Repeat an MLinExpr a number of times along given axis.

Synopsis

```
MLinExpr<N> RepeatBlock(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MLinExpr.

Return

new MLinExpr object.

MLinExpr::Represent()

String representation of MLinExpr object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MLinExpr::Reshape()

Reshape MLinExpr object to new shape.

Synopsis

```
template <int M> MLinExpr<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MLinExpr object.

MLinExpr::SetItem()

Set expression of given index to MLinExpr object.

Synopsis

```
void SetItem(size_t idx, const MExpression &expr)
```

Arguments

idx: index of element.

expr: MExpression object.

MLinExpr::Squeeze()

Remove axis of length 1 from shape of MLinExpr object.

Synopsis

```
MLinExpr<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MLinExpr, where the length is 1.

Return

MLinExpr object of (N-1)-dimensional shape.

MLinExpr::Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MLinExpr<N> Stack(const MLinExpr<N> &other, int axis)
```

Arguments

other: a MLinExpr object.

axis: an axis of MLinExpr.

Return

the result MLinExpr object.

MLinExpr::Stack()

Stack with other MVar object along given axis.

Synopsis

```
MLinExpr<N> Stack(const MVar<N> &other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MLinExpr.

Return

the result MLinExpr object.

MLinExpr::Stack()

Stack with other NdArray object along given axis.

Synopsis

```
template <class T> MLinExpr<N> Stack(const NdArray<T, N> &other, int
axis)
```

Arguments

other: a NdArray object.

axis: an axis of MLinExpr.

Return

the result MLinExpr object.

MLinExpr::SubConstant()

Subtract constants from each expression in MLinExpr object.

Synopsis

```
template <class T> void SubConstant(const NdArray<T, N> &constants)
```

Arguments

constants: N-dimension NdArray object.

MLinExpr::Sum()

Sum of all expressions in MLinExpr object.

Synopsis

```
MLinExpr<0> Sum()
```

Return

sum in zero dimension.

MLinExpr::Sum()

Sum of expressions at given axis of MLinExpr object.

Synopsis

```
MLinExpr<N - 1> Sum(int axis)
```

Arguments

axis: axis of MLinExpr

Return

MLinExpr object in (N-1)-dimension.

MLinExpr::Transpose()

Perform matrix transpose of MLinExpr object.

Synopsis

```
MLinExpr<N> Transpose()
```

Return

transposed MLinExpr object.

23.5.56 MPsdConstr Class

The *MPsdConstr* class in COPT represents multi-dimensional semidefinite constraints. It is generated through the methods `addConstrs` or `addConstr` of *Model*. The following member methods are provided:

MPsdConstr::MPsdConstr()

Construct a MPsdConstr object with the given shape, filling with the given PSD constraint.

Synopsis

```
MPsdConstr(const Shape<N> &shp, const PsdConstraint &con)
```

Arguments

`shp`: shape of MPsdConstr.

`con`: PSD constraint object.

MPsdConstr::MPsdConstr()

Construct a MPsdConstr object with the given shape, filling with an array of PSD constraints.

Synopsis

```
MPsdConstr(const Shape<N> &shp, const PsdConstrArray &cons)
```

Arguments

`shp`: shape of MPsdConstr.

`cons`: an array of PSD constraints.

MPsdConstr::Clone()

Clone MPsdConstr object.

Synopsis

```
MPsdConstr Clone()
```

Return

new MPsdConstr object.

MPsdConstr::Diagonal()

Get diagonals of MPsdConstr object.

Synopsis

```
MPsdConstr<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MPsdConstr.

axis2: 2nd axis of MPsdConstr.

Return

(N-1)-dimensional diagonals.

MPsdConstr::Expand()

Expand shape of MPsdConstr object.

Synopsis

```
MPsdConstr<N + 1> Expand(int axis)
```

Arguments

axis: axis of MPsdConstr.

Return

MPsdConstr object of (N+1)-dimensional shape.

MPsdConstr::Flatten()

Flatten a MPsdConstr object to a 1-dimensional shape.

Synopsis

```
MPsdConstr<1> Flatten()
```

Return

a MPsdConstr object collapsed into one dimension.

MPsdConstr::Get()

Get values of information associated with PSD constraints in MPsdConstr object.

Synopsis

```
NdArray<double, N> Get(const char *szInfo)
```

Arguments

szInfo: name of information.

Return

multi-dimensional array of information of PSD constraints.

MPsdConstr::GetDim()

Get i-th dimension of MPsdConstr object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MPsdConstr::GetIdx()

Get index of PSD constraints in MPsdConstr object.

Synopsis

```
NdArray<int, N> GetIdx()
```

Return

multi-dimensional array of indexes of PSD constraints.

MPsdConstr::GetND()

Get number of dimensions of MPsdConstr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MPsdConstr::GetShape()

Get shape of MPsdConstr object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MPsdConstr::GetSize()

Get size of MPsdConstr object.

Synopsis

```
size_t GetSize()
```

Return

number of QConstraints

MPsdConstr::Item()

Get PSD constraint of given index from MPsdConstr object.

Synopsis

```
PsdConstraint &Item(size_t idx)
```

Arguments

idx: index of PSD constraint.

Return

PsdConstraint object.

MPsdConstr::operator[]()

Get PSD constraint of given index from MPsdConstr object.

Synopsis

```
PsdConstraint &operator[] (size_t idx)
```

Arguments

idx: index of PSD constraint.

Return

PsdConstraint object.

MPsdConstr::operator[]()

Get constraints of given view from MPsdConstr object.

Synopsis

```
MPsdConstr operator[] (const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new MPsdConstr object.

MPsdConstr::Pick()

Given a list of indexes, get PSD constraints from MPsdConstr object.

Synopsis

```
MPsdConstr<1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired PSD constraints.

MPsdConstr::Pick()

Given a list of indexes, get PSD constraints from MPsdConstr object.

Synopsis

```
MPsdConstr<1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired PSD constraints.

MPsdConstr::Represent()

String representation of MPsdConstr object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MPsdConstr::Reshape()

Reshape MPsdConstr object to new shape.

Synopsis

```
template <int M> MPsdConstr<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MPsdConstr object.

MPsdConstr::Set()

Set values of information associated with PSD constraints in MPsdConstr object.

Synopsis

```
void Set(const char *szInfo, const NdArray<double, N> &vals)
```

Arguments

szInfo: name of information.

vals: multi-dimensional array of values of information.

MPsdConstr::Set()

Set values of information associated with PSD constraints in MPsdConstr object.

Synopsis

```
void Set(const char *szInfo, double val)
```

Arguments

szInfo: name of information.

val: value of information.

MPsdConstr::SetItem()

Set PSD constraint of given index to MPsdConstr object.

Synopsis

```
void SetItem(size_t idx, const PsdConstraint &con)
```

Arguments

idx: index of element.

con: PSD constraint object.

MPsdConstr::Squeeze()

Remove axis of length 1 from shape of MPsdConstr object.

Synopsis

```
MPsdConstr<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MPsdConstr, where the length is 1.

Return

MPsdConstr object of (N-1)-dimensional shape.

MPsdConstr::Stack()

Stack with other MPsdConstr object along given axis.

Synopsis

```
MPsdConstr<N> Stack(const MPsdConstr<N> &other, int axis)
```

Arguments

other: a MPsdConstr object.

axis: an axis of MPsdConstr.

Return

the result MPsdConstr object.

MPsdConstr::Transpose()

Perform matrix transpose of MPsdConstr object.

Synopsis

```
MPsdConstr<N> Transpose()
```

Return

transposed MPsdConstr object.

23.5.57 MPsdConstrBuilder

The *MPsdConstrBuilder* class in COPT serves as a builder for multi-dimensional semidefinite constraints. It is used to generate multi-dimensional semidefinite constraints and supports operations with the built-in multi-dimensional array *NdArray*. An *MPsdConstrBuilder* object can be created through comparison operations between two objects, one of which can be an *MPsdExpr Class* object. The following member methods are provided:

MPsdConstrBuilder::MPsdConstrBuilder()

Construct a MPsdConstrBuilder object with the given shape.

Synopsis

```
MPsdConstrBuilder(const Shape<N> &shp)
```

Arguments

shp: shape of MPsdConstrBuilder.

MPsdConstrBuilder::Flatten()

Flatten a MPsdConstrBuilder object to a 1-dimensional shape.

Synopsis

```
MPsdConstrBuilder<1> Flatten()
```

Return

a MPsdConstrBuilder object collapsed into one dimension.

MPsdConstrBuilder::GetND()

Get number of dimensions of MPsdConstrBuilder object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MPsdConstrBuilder::GetPsdExpr()

Get N-dimensional PSD expressions associated with N-dimensional PSD constraints.

Synopsis

```
const MPsdExpr<N> &GetPsdExpr()
```

Return

MPsdExpr object.

MPsdConstrBuilder::GetRange()

Get range from lower bound to upper bound of N-dimensional range PSD constraints.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of range PSD constraints.

MPsdConstrBuilder::GetSense()

Get sense associated with N-dimensional PSD constraints.

Synopsis

```
char GetSense()
```

Return

PSD constraint sense.

MPsdConstrBuilder::Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
template <int M> void Set(  
    const MPsdExpr<N> &exprs,  
    char sense,  
    const MPsdExpr<M> &rhs)
```

Arguments

exprs: MPsdExpr object

sense: PSD constraint sense other than COPT_RANGE.

rhs: MPsdExpr object at right side of PSD constraints.

MPsdConstrBuilder::Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
void Set(  
    const MPsdExpr<N> &exprs,  
    char sense,  
    double rhs)
```

Arguments

exprs: MPsdExpr object

sense: PSD constraint sense other than COPT_RANGE.

rhs: constant of right side of PSD constraints.

MPsdConstrBuilder::Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
template <class T> void Set(  
    const MPsdExpr<N> &exprs,  
    char sense,  
    const NdArray<T, N> &rhs)
```

Arguments

exprs: MPsdExpr object

sense: PSD constraint sense other than COPT_RANGE.

rhs: N-dimensional constants at right side of PSD constraints.

MPsdConstrBuilder::Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
template <int M> void Set(  
    const MPsdExpr<N> &exprs,  
    char sense,  
    const MVar<M> &rhs)
```

Arguments

exprs: MPsdExpr object

sense: PSD constraint sense other than COPT_RANGE.

rhs: MVar object at right side of PSD constraints.

MPsdConstrBuilder::Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
template <int M> void Set(
    const MPsdExpr<N> &exprs,
    char sense,
    const MLinExpr<M> &rhs)
```

Arguments

exprs: MPsdExpr object

sense: PSD constraint sense other than COPT_RANGE.

rhs: MLinExpr object at right side of PSD constraints.

MPsdConstrBuilder::SetRange()

Set N-dimensional range PSD constraints to its builder object.

Synopsis

```
void SetRange(const MPsdExpr<N> &exprs, double range)
```

Arguments

exprs: MPsdExpr object.

range: length from lower bound to upper bound of PSD constraint. Must greater than 0.

23.5.58 MPsdExpr Class

The *MPsdExpr* class in COPT represents multi-dimensional semidefinite expressions. It is used to construct multi-dimensional semidefinite expressions and perform operations with the built-in multi-dimensional array *NdArray* in COPT.

The elements of *MPsdExpr* are either *PsdExpr* objects or their multi-dimensional linear combinations.

The following member methods are provided:

MPsdExpr::MPsdExpr()

Construct a MPsdExpr object with the given shape and a constant.

Synopsis

```
MPsdExpr(const Shape<N> &shp, double constant)
```

Arguments

shp: shape of MPsdExpr.

constant: constant number, default vlaue is 0.0.

MPsdExpr::MPsdExpr()

Construct a MPsdExpr object with the given shape and a PSD expression.

Synopsis

```
MPsdExpr(const Shape<N> &shp, const PsdExpr &expr)
```

Arguments

shp: shape of MPsdExpr.

expr: a PSD expression.

MPsdExpr::AddConstant()

Add constant to each quadratic expression in MPsdExpr object.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MPsdExpr::AddConstant()

Add constants to each PSD expression in MPsdExpr object.

Synopsis

```
template <class T> void AddConstant(const NdArray<T, N> &constants)
```

Arguments

constants: N-dimension NdArray object.

MPsdExpr::AddLinExpr()

Add a linear expression to each PsdExpr in MPsdExpr object.

Synopsis

```
void AddLinExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MPsdExpr::AddMExpr()

Add MExpression to each PSD expression in MPsdExpr object.

Synopsis

```
void AddMExpr(const MExpression &expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MPsdExpr::AddMLinExpr()

Add linear expressions to MPsdExpr object.

Synopsis

```
void AddMLinExpr(const MLinExpr<N> &exprs, double mult)
```

Arguments

exprs: N-dimension MLinExpr object.

mult: the same multiplier for added linear expressions, default value is 1.0.

MPsdExpr::AddMPsdExpr()

Add PSD expressions to MPsdExpr object.

Synopsis

```
void AddMPsdExpr(const MPsdExpr<N> &exprs, double mult)
```

Arguments

exprs: N-dimension MPsdExpr object.

mult: the same multiplier for added PSD expressions, default value is 1.0.

MPsdExpr::AddPsdExpr()

Add a PSD expression to each PSD expression in MPsdExpr object.

Synopsis

```
void AddPsdExpr(const PsdExpr &expr, double mult)
```

Arguments

expr: PSD expression object.

mult: the multiplier of PSD expression, default value is 1.0.

MPsdExpr::AddTerm()

Add a linear term to MPsdExpr object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MPsdExpr::AddTerm()

Add a PSD term to MPsdExpr object.

Synopsis

```
void AddTerm(const PsdVar &var, const SymMatrix &mat)
```

Arguments

var: PSD variable of new PSD term.

mat: coefficient matrix of new PSD term.

MPsdExpr::AddTerm()

Add a PSD term to MPsdExpr object.

Synopsis

```
void AddTerm(const PsdVar &var, const SymMatExpr &expr)
```

Arguments

var: PSD variable of new PSD term.

expr: coefficient expression of symmetric matrices of new PSD term.

MPsdExpr::AddTerms()

Add terms to PSD expressions in MPsdExpr object.

Synopsis

```
void AddTerms(const MVar<N> &vars, double mult)
```

Arguments

vars: N-dimension MVar object for added terms.

mult: the same coefficient for added terms, default value 1.0.

MPsdExpr::AddTerms()

Add terms to PSD expressions in MPsdExpr object.

Synopsis

```
void AddTerms(const MVar<N> &vars, const NdArray<double, N> &coeffs)
```

Arguments

vars: N-dimension MVar object for added terms.

coeffs: N-dimension NdArray object of coefficients for added terms.

MPsdExpr::Clear()

Clear MPsdExpr object.

Synopsis

```
void Clear()
```

MPsdExpr::Clone()

Clone MPsdExpr object.

Synopsis

```
MPsdExpr Clone()
```

Return

new MPsdExpr object.

MPsdExpr::Diagonal()

Get diagonals of MPsdExpr object.

Synopsis

```
MPsdExpr<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MPsdExpr.

axis2: 2nd axis of MPsdExpr.

Return

(N-1)-dimensional diagonals.

MPsdExpr::Expand()

Expand shape of MPsdExpr object.

Synopsis

```
MPsdExpr<N + 1> Expand(int axis)
```

Arguments

axis: axis of MPsdExpr.

Return

MPsdExpr object of (N+1)-dimensional shape.

MPsdExpr::Flatten()

Flatten a MPsdExpr object to a 1-dimensional shape.

Synopsis

```
MPsdExpr<1> Flatten()
```

Return

a MPsdExpr object collapsed into one dimension.

MPsdExpr::GetDim()

Get i-th dimension of MPsdExpr object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MPsdExpr::GetND()

Get number of dimensions of MPsdExpr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MPsdExpr::GetShape()

Get shape of MPsdExpr object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MPsdExpr::GetSize()

Get size of MPsdExpr object.

Synopsis

```
size_t GetSize()
```

Return

number of PSD expressions.

MPsdExpr::Item()

Get PSD expression of given index from MPsdExpr object.

Synopsis

```
PsdExpr &Item(size_t idx)
```

Arguments

idx: index of PSD expression.

Return

PSD expression object.

MPsdExpr::Item()

Get sub-arrays of MPsdExpr object, given view object.

Synopsis

```
MPsdExpr Item(const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MPsdExpr object.

MPsdExpr::operator[]()

Get PSD expression of given index from MPsdExpr object.

Synopsis

```
PsdExpr &operator[] (size_t i)
```

Arguments

i: index of PSD expression.

Return

PSD expression object.

MPsdExpr::operator[]()

Get PSD expressions of given view from MPsdExpr object.

Synopsis

```
MPsdExpr operator[] (const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new MPsdExpr object.

MPsdExpr::Pick()

Given a list of indexes, get PSD expressions from MPsdExpr object.

Synopsis

```
MPsdExpr<1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired PSD expressions.

MPsdExpr::Pick()

Given a list of indexes, get PSD expressions from MPsdExpr object.

Synopsis

```
MPsdExpr<1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired PSD expressions.

MPsdExpr::Repeat()

Repeat each element of MPsdExpr along given axis.

Synopsis

```
MPsdExpr<N> Repeat(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MPsdExpr.

Return

new MPsdExpr object.

MPsdExpr::RepeatBlock()

Repeat an MPsdExpr a number of times along given axis.

Synopsis

```
MPsdExpr<N> RepeatBlock(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MPsdExpr.

Return

new MPsdExpr object.

MPsdExpr::Represent()

String representation of MPsdExpr object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MPsdExpr::Reshape()

Reshape MPsdExpr object to new shape.

Synopsis

```
template <int M> MPsdExpr<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MPsdExpr object.

MPsdExpr::SetItem()

Set PSD expression of given index to MPsdExpr object.

Synopsis

```
void SetItem(size_t idx, const PsdExpr &expr)
```

Arguments

idx: index of element.

expr: PSD expression object.

MPsdExpr::Squeeze()

Remove axis of length 1 from shape of MPsdExpr object.

Synopsis

```
MPsdExpr<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MPsdExpr, where the length is 1.

Return

MPsdExpr object of (N-1)-dimensional shape.

MPsdExpr::Stack()

Stack with other MPsdExpr object along given axis.

Synopsis

```
MPsdExpr<N> Stack(const MPsdExpr<N> &other, int axis)
```

Arguments

other: a MPsdExpr object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr::Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MPsdExpr<N> Stack(const MLinExpr<N> &other, int axis)
```

Arguments

other: a MLinExpr object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr::Stack()

Stack with other MVar object along given axis.

Synopsis

```
MPsdExpr<N> Stack(const MVar<N> &other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr::Stack()

Stack with other NdArray object along given axis.

Synopsis

```
template <class T> MPsdExpr<N> Stack(const NdArray<T, N> &other, int  
axis)
```

Arguments

other: a NdArray object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr::SubConstant()

Subtract constants from each PSD expression in MPsdExpr object.

Synopsis

```
template <class T> void SubConstant(const NdArray<T, N> &constants)
```

Arguments

constants: N-dimension NdArray object.

MPsdExpr::Sum()

Sum of all quadratic expressions in MPsdExpr object.

Synopsis

```
MPsdExpr<0> Sum()
```

Return

sum in zero dimension.

MPsdExpr::Sum()

Sum of quadratic expressions at given axis of MPsdExpr object.

Synopsis

```
MPsdExpr<N - 1> Sum(int axis)
```

Arguments

axis: axis of MPsdExpr.

Return

MPsdExpr object in (N-1)-dimension.

MPsdExpr::Transpose()

Perform matrix transpose of MPsdExpr object.

Synopsis

```
MPsdExpr<N> Transpose()
```

Return

transposed MPsdExpr object.

23.5.59 MQConstr

The MQConstr class is a COPT multi-dimensional quadratic constraint object. It can be created by calling the method `addMQConstr` of *Model*. The following methods are provided:

MQConstr::MQConstr()

Construct a MQConstr object with the given shape, filling with the given quadratic constraint.

Synopsis

```
MQConstr(const Shape<N> &shp, const QConstraint &con)
```

Arguments

`shp`: shape of MQConstr.

`con`: Quadratic constraint object.

MQConstr::MQConstr()

Construct a MQConstr object with the given shape, filling with an array of quadratic constraints.

Synopsis

```
MQConstr(const Shape<N> &shp, const QConstrArray &cons)
```

Arguments

`shp`: shape of MQConstr.

`cons`: an array of quadratic constraints.

MQConstr::Clone()

Clone MQConstr object.

Synopsis

```
MQConstr Clone()
```

Return

new MQConstr object.

MQConstr::Diagonal()

Get diagonals of MQConstr object.

Synopsis

```
MQConstr<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

`offset`: offset of the diagonal from the main diagonal. Can be positive or negative.

`axis1`: 1st axis of MQConstr.

`axis2`: 2nd axis of MQConstr.

Return

(N-1)-dimensional diagonals.

MQConstr::Expand()

Expand shape of MQConstr object.

Synopsis

```
MQConstr<N + 1> Expand(int axis)
```

Arguments

axis: axis of MQConstr.

Return

MQConstr object of (N+1)-dimensional shape.

MQConstr::Flatten()

Flatten a MQConstr object to a 1-dimensional shape.

Synopsis

```
MQConstr<1> Flatten()
```

Return

a MQConstr object collapsed into one dimension.

MQConstr::Get()

Get values of information associated with quadratic constraints in MQConstr object.

Synopsis

```
NdArray<double, N> Get(const char *szInfo)
```

Arguments

szInfo: name of information.

Return

multi-dimensional array of information of quadratic constraints.

MQConstr::GetDim()

Get i-th dimension of MQConstr object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MQConstr::GetIdx()

Get index of quadratic constraints in MQConstr object.

Synopsis

```
NdArray<int, N> GetIdx()
```

Return

multi-dimensional array of indexes of quadratic constraints.

MQConstr::GetND()

Get number of dimensions of MQConstr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MQConstr::GetRhs()

Get RHS of quadratic constraints in MQConstr object.

Synopsis

```
NdArray<double, N> GetRhs()
```

Return

multi-dimensional array of RHS of quadratic constraints.

MQConstr::GetSense()

Get senses of quadratic constraints in MQConstr object.

Synopsis

```
NdArray<char, N> GetSense()
```

Return

multi-dimensional array of senses of quadratic constraints.

MQConstr::GetShape()

Get shape of MQConstr object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MQConstr::GetSize()

Get size of MQConstr object.

Synopsis

```
size_t GetSize()
```

Return

number of QConstraints

MQConstr::Item()

Get quadratic constraint of given index from MQConstr object.

Synopsis

```
QConstraint &Item(size_t idx)
```

Arguments

idx: index of quadratic constraint.

Return

QConstraint object.

MQConstr::operator[]()

Get quadratic constraint of given index from MQConstr object.

Synopsis

```
QConstraint &operator[] (size_t idx)
```

Arguments

idx: index of quadratic constraint.

Return

QConstraint object.

MQConstr::operator[]()

Get constraints of given view from MQConstr object.

Synopsis

```
MQConstr operator[] (const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new MQConstr object.

MQConstr::Pick()

Given a list of indexes, get quadratic constraints from MQConstr object.

Synopsis

```
MQConstr<1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired quadratic constraints.

MQConstr::Pick()

Given a list of indexes, get quadratic constraints from MQConstr object.

Synopsis

```
MQConstr<1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired quadratic constraints.

MQConstr::Represent()

String representation of MQConstr object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MQConstr::Reshape()

Reshape MQConstr object to new shape.

Synopsis

```
template <int M> MQConstr<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MQConstr object.

MQConstr::Set()

Set values of information associated with quadratic constraints in MQConstr object.

Synopsis

```
void Set(const char *szInfo, double val)
```

Arguments

szInfo: name of information.

val: value of information.

MQConstr::Set()

Set values of information associated with quadratic constraints in MQConstr object.

Synopsis

```
void Set(const char *szInfo, const NdArray<double, N> &vals)
```

Arguments

szInfo: name of information.

vals: multi-dimensional array of values of information.

MQConstr::SetItem()

Set quadratic constraint of given index to MQConstr object.

Synopsis

```
void SetItem(size_t idx, const QConstraint &con)
```

Arguments

idx: index of element.

con: quadratic constraint object.

MQConstr::Squeeze()

Remove axis of length 1 from shape of MQConstr object.

Synopsis

```
MQConstr<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MQConstr, where the length is 1.

Return

MQConstr object of (N-1)-dimensional shape.

MQConstr::Stack()

Stack with other MQConstr object along given axis.

Synopsis

```
MQConstr<N> Stack(const MQConstr<N> &other, int axis)
```

Arguments

other: a MQConstr object.

axis: an axis of MQConstr.

Return

the result MQConstr object.

MQConstr::Transpose()

Perform matrix transpose of MQConstr object.

Synopsis

```
MQConstr<N> Transpose()
```

Return

transposed MQConstr object.

23.5.60 MQConstrBuilder

The MQConstrBuilder class is a COPT builder object of multi-dimensional quadratic constraints. It is used to generate multi-dimensional quadratic constraints and supports operations with the built-in multi-dimensional array *NdArray* in COPT. It can be created by comparing two objects, one of which should be *MQuadExpr* object, by comparison operators. The following methods are provided:

MQConstrBuilder::MQConstrBuilder()

Construct a MQConstrBuilder object with the given shape.

Synopsis

```
MQConstrBuilder(const Shape<N> &shp)
```

Arguments

shp: shape of MQConstrBuilder.

MQConstrBuilder::Flatten()

Flatten a MQConstrBuilder object to a 1-dimensional shape.

Synopsis

```
MQConstrBuilder<1> Flatten()
```

Return

a MQConstrBuilder object collapsed into one dimension.

MQConstrBuilder::GetND()

Get number of dimensions of MQConstrBuilder object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MQConstrBuilder::GetQuadExpr()

Get N-dimensional quadratic expressions associated with N-dimensional quadratic constraints.

Synopsis

```
const MQuadExpr<N> &GetQuadExpr()
```

Return

MQuadExpr object.

MQConstrBuilder::GetSense()

Get sense associated with N-dimensional quadratic constraints.

Synopsis

```
char GetSense()
```

Return

quadratic constraint sense.

MQConstrBuilder::Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
void Set(  
    const MQuadExpr<N> &expr,  
    char sense,  
    double rhs)
```

Arguments

expr: MQuadExpr object

sense: constraint sense other than COPT_RANGE.

rhs: constant of right side of quadratic constraints.

MQConstrBuilder::Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
template <class T> void Set(  
    const MQuadExpr<N> &expr,  
    char sense,  
    const NdArray<T, N> &rhs)
```

Arguments

expr: MQuadExpr object

sense: constraint sense other than COPT_RANGE.

rhs: N-dimensional constants at right side of quadratic constraints.

MQConstrBuilder::Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
template <int M> void Set(  
    const MQuadExpr<N> &expr,  
    char sense,  
    const MVar<M> &rhs)
```

Arguments

expr: MQuadExpr object

sense: constraint sense other than COPT_RANGE.

rhs: MVar object at right side of quadratic constraints.

MQConstrBuilder::Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
template <int M> void Set(  
    const MQuadExpr<N> &expr,  
    char sense,  
    const MLinExpr<M> &rhs)
```

Arguments

expr: MQuadExpr object

sense: constraint sense other than COPT_RANGE.

rhs: MLinExpr object at right side of quadratic constraints.

MQConstrBuilder::Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
template <int M> void Set(
    const MQuadExpr<N> &expr,
    char sense,
    const MQuadExpr<M> &rhs)
```

Arguments

expr: MQuadExpr object

sense: constraint sense other than COPT_RANGE.

rhs: MQuadExpr object at right side of quadratic constraints.

23.5.61 MQExpression

The MQExpression class is a generalized version of *QuadExpr*. It represents a quadratic expression and supports most of methods in QuadExpr class. In addition, it supports quadratic combination of multi-dimensional objects, such as *MVar* object and *MLinExpr* object. The following methods are provided:

MQExpression::MQExpression()

Construct a MQExpression object with the given constant.

Synopsis

```
MQExpression(double constant)
```

Arguments

constant: constant number.

MQExpression::MQExpression()

Construct a MQExpression object with the given quadratic expression.

Synopsis

```
MQExpression(const QuadExpr &expr)
```

Arguments

expr: a quadratic expression.

MQExpression::AddConstant()

Add constant for the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MQExpression::AddExpr()

Add a linear expression to MQExpression object.

Synopsis

```
void AddExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MQExpression::AddMExpr()

Add MExpression to MQExpression object.

Synopsis

```
void AddMExpr(const MExpression &expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MQExpression::AddMQExpr()

Add MQExpression to MQExpression object.

Synopsis

```
void AddMQExpr(const MQExpression &expr, double mult)
```

Arguments

expr: MQExpression object.

mult: the multiplier of MQExpression, default value is 1.0.

MQExpression::AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(const MExpression &left, const MExpression &right)
```

Arguments

left: left MExpression object.

right: right MExpression object.

MQExpression::AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(const QuadExpr &expr, double mult)
```

Arguments

expr: quadratic expression object.

mult: the multiplier of quadratic expression, default value is 1.0.

MQExpression::AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(const MExpression &expr, const Var &var)
```

Arguments

expr: MExpression object.

var: Var object.

MQExpression::AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(const MExpression &left, const Expr &right)
```

Arguments

left: MExpression object.

right: Expr object.

MQExpression::AddTerm()

Add a linear term to MQExpression object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MQExpression::AddTerm()

Add a quadratic term to MQExpression object.

Synopsis

```
void AddTerm(  
    const Var &var1,  
    const Var &var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.
var2: second variable of new quadratic term.
coeff: coefficient of new quadratic term.

MQExpression::Clone()

Clone MQExpression object.

Synopsis

```
MQExpression Clone()
```

Return

new MQExpression object.

MQExpression::GetConstant()

Get constant in expression.

Synopsis

```
double GetConstant()
```

Return

constant in expression.

MQExpression::Represent()

String representation of MQExpression object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

23.5.62 MQuadExpr

COPT multi-dimensional quadratic expression object. It is used to construct multi-dimensional quadratic expressions and perform operations with the multi-dimensional array built in COPT *NdArray*. Its elements are *MQExpression* objects. It can be created by quadratic combination of *MVar* objects. The following methods are provided:

MQuadExpr::MQuadExpr()

Construct a MQuadExpr object with the given shape and a constant.

Synopsis

```
MQuadExpr(const Shape<N> &shp, double constant)
```

Arguments

shp: shape of MQuadExpr.

constant: constant number.

MQuadExpr::MQuadExpr()

Construct a MQuadExpr object with the given shape and a quadratic expression.

Synopsis

```
MQuadExpr(const Shape<N> &shp, const QuadExpr &expr)
```

Arguments

shp: shape of MQuadExpr.

expr: a quadratic expression.

MQuadExpr::MQuadExpr()

Construct a MQuadExpr object with the given shape and a MQExpression object.

Synopsis

```
MQuadExpr(const Shape<N> &shp, const MQExpression &expr)
```

Arguments

shp: shape of MQuadExpr.

expr: a MQExpression object.

MQuadExpr::AddConstant()

Add constant to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MQuadExpr::AddConstant()

Add constants to each quadratic expression in MQuadExpr object.

Synopsis

```
template <class T> void AddConstant(const NdArray<T, N> &constants)
```

Arguments

constants: N-dimension NdArray object.

MQuadExpr::AddExpr()

Add a linear expression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddExpr(const Expr &expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MQuadExpr::AddMExpr()

Add MExpression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddMExpr(const MExpression &expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MQuadExpr::AddMLinExpr()

Add linear expressions to MQuadExpr object.

Synopsis

```
void AddMLinExpr(const MLinExpr<N> &exprs, double mult)
```

Arguments

exprs: N-dimension MLinExpr object.

mult: the same multiplier for added linear expressions, default value is 1.0.

MQuadExpr::AddMQExpr()

Add MQExpression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddMQExpr(const MQExpression &expr, double mult)
```

Arguments

expr: MQExpression object.

mult: the multiplier of MQExpression, default value is 1.0.

MQuadExpr::AddMQuadExpr()

Add quadratic expressions to MQuadExpr object.

Synopsis

```
void AddMQuadExpr(const MQuadExpr<N> &exprs, double mult)
```

Arguments

exprs: N-dimension MQuadExpr object.

mult: the same multiplier for added quadratic expressions, default value is 1.0.

MQuadExpr::AddQuadExpr()

Add a quadratic expression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddQuadExpr(const QuadExpr &expr, double mult)
```

Arguments

expr: quadratic expression object.

mult: the multiplier of quadratic expression, default value is 1.0.

MQuadExpr::AddTerm()

Add a linear term to MQuadExpr object.

Synopsis

```
void AddTerm(const Var &var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MQuadExpr::AddTerm()

Add a quadratic term to MQuadExpr object.

Synopsis

```
void AddTerm(  
    const Var &var1,  
    const Var &var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.

var2: second variable of new quadratic term.

coeff: coefficient of new quadratic term.

MQuadExpr::AddTerms()

Add terms to quadratic expressions in MQuadExpr object.

Synopsis

```
void AddTerms(const MVar<N> &vars, double mult)
```

Arguments

vars: N-dimension MVar object for added terms.

mult: the same coefficient for added terms, default value 1.0.

MQuadExpr::AddTerms()

Add terms to quadratic expressions in MQuadExpr object.

Synopsis

```
void AddTerms(const MVar<N> &vars, const NdArray<double, N> &coeffs)
```

Arguments

vars: N-dimension MVar object for added terms.

coeffs: N-dimension NdArray object of coefficients for added terms.

MQuadExpr::Clear()

Clear MQuadExpr object.

Synopsis

```
void Clear()
```

MQuadExpr::Clone()

Clone MQuadExpr object.

Synopsis

```
MQuadExpr Clone()
```

Return

new MQuadExpr object.

MQuadExpr::Diagonal()

Get diagonals of MQuadExpr object.

Synopsis

```
MQuadExpr<N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MQuadExpr.

axis2: 2nd axis of MQuadExpr.

Return

(N-1)-dimensional diagonals.

MQuadExpr::Expand()

Expand shape of MQuadExpr object.

Synopsis

```
MQuadExpr<N + 1> Expand(int axis)
```

Arguments

axis: axis of MQuadExpr.

Return

MQuadExpr object of (N+1)-dimensional shape.

MQuadExpr::Flatten()

Flatten a MQuadExpr object to a 1-dimensional shape.

Synopsis

```
MQuadExpr<1> Flatten()
```

Return

a MQuadExpr object collapsed into one dimension.

MQuadExpr::GetDim()

Get i-th dimension of MQuadExpr object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MQuadExpr::GetND()

Get number of dimensions of MQuadExpr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MQuadExpr::GetShape()

Get shape of MQuadExpr object.

Synopsis

```
Shape<N> GetShape()
```

Return

shape object.

MQuadExpr::GetSize()

Get size of MQuadExpr object.

Synopsis

```
size_t GetSize()
```

Return

number of MQExpressions.

MQuadExpr::Item()

Get quadratic expression of given index from MQuadExpr object.

Synopsis

```
MQExpression &Item(size_t idx)
```

Arguments

idx: index of quadratic expression.

Return

quadratic expression object.

MQuadExpr::Item()

Get sub-arrays of MQuadExpr object, given view object.

Synopsis

```
MQuadExpr Item(const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MQuadExpr object.

MQuadExpr::operator[]()

Get quadratic expression of given index from MQuadExpr object.

Synopsis

```
MQExpression &operator[](size_t i)
```

Arguments

i: index of quadratic expression.

Return

quadratic expression object.

MQuadExpr::operator[]()

Get constraints of given view from MQuadExpr object.

Synopsis

```
MQuadExpr operator[](const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new MQuadExpr object.

MQuadExpr::Pick()

Given a list of indexes, get quadratic expressions from MQuadExpr object.

Synopsis

```
MQuadExpr<1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired quadratic expressions.

MQuadExpr::Pick()

Given a list of indexes, get quadratic expressions from MQuadExpr object.

Synopsis

```
MQuadExpr<1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired quadratic expressions.

MQuadExpr::Repeat()

Repeat each element of MQuadExpr along given axis.

Synopsis

```
MQuadExpr<N> Repeat(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MQuadExpr.

Return

new MQuadExpr object.

MQuadExpr::RepeatBlock()

Repeat an MQuadExpr a number of times along given axis.

Synopsis

```
MQuadExpr<N> RepeatBlock(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MQuadExpr.

Return

new MQuadExpr object.

MQuadExpr::Represent()

String representation of MQuadExpr object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation.

Return

string object.

MQuadExpr::Reshape()

Reshape MQuadExpr object to new shape.

Synopsis

```
template <int M> MQuadExpr<M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional MQuadExpr object.

MQuadExpr::SetItem()

Set quadratic expression of given index to MQuadExpr object.

Synopsis

```
void SetItem(size_t idx, const MQExpression &expr)
```

Arguments

idx: index of element.

expr: MQExpression object.

MQuadExpr::Squeeze()

Remove axis of length 1 from shape of MQuadExpr object.

Synopsis

```
MQuadExpr<N - 1> Squeeze(int axis)
```

Arguments

axis: axis of MQuadExpr, where the length is 1.

Return

MQuadExpr object of (N-1)-dimensional shape.

MQuadExpr::Stack()

Stack with other MQuadExpr object along given axis.

Synopsis

```
MQuadExpr<N> Stack(const MQuadExpr<N> &other, int axis)
```

Arguments

other: a MQuadExpr object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr::Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MQuadExpr<N> Stack(const MLinExpr<N> &other, int axis)
```

Arguments

other: a MLinExpr object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr::Stack()

Stack with other MVar object along given axis.

Synopsis

```
MQuadExpr<N> Stack(const MVar<N> &other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr::Stack()

Stack with other NdArray object along given axis.

Synopsis

```
template <class T> MQuadExpr<N> Stack(const NdArray<T, N> &other,  
int axis)
```

Arguments

other: a NdArray object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr::SubConstant()

Subtract constants from each quadratic expression in MQuadExpr object.

Synopsis

```
template <class T> void SubConstant(const NdArray<T, N> &constants)
```

Arguments

constants: N-dimension NdArray object.

MQuadExpr::Sum()

Sum of all quadratic expressions in MQuadExpr object.

Synopsis

```
MQuadExpr<0> Sum()
```

Return

sum in zero dimension.

MQuadExpr::Sum()

Sum of quadratic expressions at given axis of MQuadExpr object.

Synopsis

```
MQuadExpr<N - 1> Sum(int axis)
```

Arguments

axis: axis of MQuadExpr.

Return

MQuadExpr object in (N-1)-dimension.

MQuadExpr::Transpose()

Perform matrix transpose of MQuadExpr object.

Synopsis

```
MQuadExpr<N> Transpose()
```

Return

transposed MQuadExpr object.

23.5.63 NdArray

The NdArray class is a built-in multi-dimensional array in COPT. It represents a table of elements of the same type, indexed by a tuple of integers. The following methods are provided:

NdArray::NdArray()

Construct an NdArray object with the given shape, filling with the given element.

Synopsis

```
NdArray(const Shape<N> &shape, const T &val)
```

Arguments

shape: shape of NdArray.

val: value of element.

NdArray::NdArray()

Construct an NdArray object with the given shape, filling with an array of type T.

Synopsis

```
NdArray(
    const Shape<N> &shape,
    const T *data,
    size_t sz)
```

Arguments

shape: shape of NdArray.
data: an array of elements.
sz: size of elements.

NdArray::NdArray()

Construct an NdArray object with the given shape and the filling function.

Synopsis

```
NdArray(const Shape<N> &shape)
```

Arguments

shape: shape of NdArray.

NdArray::Clone()

Clone NdArray object.

Synopsis

```
NdArray<T, N> Clone()
```

Return

new NdArray object.

NdArray::Diagonal()

Get diagonals of NdArray object.

Synopsis

```
NdArray<T, N - 1> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of NdArray.

axis2: 2nd axis of NdArray.

Return

(N-1)-dimensional diagonals.

NdArray::Expand()

Expand shape of NdArray object.

Synopsis

```
NdArray<T, N + 1> Expand(int axis)
```

Arguments

axis: axis of NdArray.

Return

NdArray object in (N+1)-dimensions.

NdArray::Fill()

Fill NdArray object with given value.

Synopsis

```
void Fill(const T &val)
```

Arguments

val: new value.

NdArray::Flatten()

Flatten an NdArray object to a 1-dimensional shape.

Synopsis

```
NdArray<T, 1> Flatten()
```

Return

An NdArray object collapsed into one dimension.

NdArray::GetDim()

Get i-th dimension of NdArray object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

NdArray::GetND()

Get number of dimensions of NdArray object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

NdArray::GetShape()

Get shape of NdArray object.

Synopsis

```
const Shape<N> &GetShape()
```

Return

shape object.

NdArray::GetSize()

Get size of NdArray object.

Synopsis

```
size_t GetSize()
```

Return

number of elements.

NdArray::Item()

Get element of given index from NdArray object.

Synopsis

```
T &Item(size_t idx)
```

Arguments

idx: index of element.

Return

value of element.

NdArray::Item()

Get sub-array of NdArray object, given View object.

Synopsis

```
NdArray<T, N> Item(const View &view)
```

Arguments

view: View object.

Return

sub NdArray without copying underlying data.

NdArray::operator[]()

Get element of given index from NdArray object.

Synopsis

```
T &operator[](size_t idx)
```

Arguments

idx: index of element.

Return

value of element.

NdArray::operator[]()

Get constraints of given view from NdArray object.

Synopsis

```
NdArray<T, N> operator[](const View &view)
```

Arguments

view: view of multi-dimensional array.

Return

new NdArray object.

NdArray::Pick()

Given a list of indexes, get elements from NdArray object.

Synopsis

```
NdArray<T, 1> Pick(const NdArray<int, 1> &indexes)
```

Arguments

indexes: indexes of elements.

Return

one-dimensional array of desired elements.

NdArray::Pick()

Given a list of indexes, get elements from NdArray object.

Synopsis

```
NdArray<T, 1> Pick(const NdArray<int, 2> &idxrows)
```

Arguments

idxrows: indexes in format of 2-dimensional array, where each row is position of element.

Return

one-dimensional array of desired elements.

NdArray::Repeat()

Repeat each element of an array along given axis.

Synopsis

```
NdArray<T, N> Repeat(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of NdArray.

Return

new NdArray object.

NdArray::RepeatBlock()

Repeat an array a number of times along given axis.

Synopsis

```
NdArray<T, N> RepeatBlock(size_t repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of NdArray.

Return

new NdArray object.

NdArray::Represent()

String representation of NdArray object.

Synopsis

```
std::string Represent(size_t maxlen)
```

Arguments

maxlen: max length of representation string.

Return

representation string object.

NdArray::Reshape()

Reshape NdArray object to new shape.

Synopsis

```
template <int M> NdArray<T, M> Reshape(const Shape<M> &shape)
```

Arguments

shape: new shape of M-dimensions.

Return

M-dimensional NdArray object.

NdArray::SetItem()

Set element of given index to NdArray object.

Synopsis

```
void SetItem(size_t idx, const T &val)
```

Arguments

idx: index of element.

val: value of element.

NdArray::Squeeze()

Remove axis of length 1 from shape of NdArray object.

Synopsis

```
NdArray<T, N - 1> Squeeze(int axis)
```

Arguments

axis: axis of NdArray, where the length is 1.

Return

(N-1)-dimensional NdArray object.

NdArray::Sum()

Sum of all elements in NdArray object.

Synopsis

```
template <class Ta> NdArray<Ta, 0> Sum()
```

Return

sum in zero dimension.

NdArray::Sum()

Sum of elements at given axis of NdArray object.

Synopsis

```
template <class Ta> NdArray<Ta, N - 1> Sum(int axis)
```

Arguments

axis: axis of NdArray.

Return

(N-1)-dimensional NdArray object.

NdArray::Transpose()

Perform matrix transpose of NdArray object.

Synopsis

```
NdArray<T, N> Transpose()
```

Return

transposed NdArray object.

23.5.64 Shape

The Shape class encapsulates a tuple of integers, indicating the size of array along each dimension. It refers to dimensions of built-in *NdArray* in COPT. The following methods are provided:

Shape::Expand()

Expand shape of Shape object.

Synopsis

```
Shape<N + 1> Expand(int axis)
```

Arguments

axis: given axis.

Return

Shape object in (N+1)-dimensions.

Shape::GetDim()

Get i-th dimension in Shape object.

Synopsis

```
size_t GetDim(int i)
```

Arguments

i: index of dimensions.

Return

the i-th dimension.

Shape::GetND()

Get number of dimensions in Shape object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

Shape::GetSize()

Get size of Shape object.

Synopsis

```
size_t GetSize()
```

Return

size of shape.

Shape::GetStart()

Get the i-th start position in Shape object.

Synopsis

```
int64_t GetStart(int i)
```

Arguments

i: index of dimensions.

Return

start position in i-th dimension.

Shape::GetStride()

Get i-th stride in Shape object.

Synopsis

```
int64_t GetStride(int i)
```

Arguments

i: index of dimensions.

Return

stride in i-th dimension.

Shape::operator!=(())

Use operator '!=' to compare with other Shape object.

Synopsis

```
bool operator!=(const Shape<N> &other)
```

Arguments

other: other Shape object.

Return

True if shape is not the same.

Shape::operator==()

Use operator '==' to compare with other Shape object.

Synopsis

```
bool operator==(const Shape<N> &other)
```

Arguments

other: other Shape object.

Return

True if shape is the same.

Shape::Rebuild()

Rebuild Shape object, that is, keep dimensions while reset strides and starts.

Synopsis

```
Shape<N> Rebuild()
```

Return

new Shape object.

Shape::Represent()

String representation of Shape object.

Synopsis

```
std::string Represent(int type)
```

Arguments

type: 0: dimensions; 1: strides; 2: starts.

Return

string object.

Shape::Squeeze()

Remove axis of length 1 from Shape object.

Synopsis

```
Shape<N - 1> Squeeze(int axis)
```

Arguments

axis: given axis, where the length is 1.

Return

Shape object in (N-1)-dimensions.

23.5.65 View

The View class is used to perform slicing operations on multi-dimensional arrays. The following methods are provided:

View::View()

Create an empty View object. Call `make_view()` for your convenience.

Synopsis

```
View()
```

View::AddFull()

Create full view object at current dimension.

Synopsis

```
View &AddFull()
```

Return

View object.

View::AddScalar()

Create view object of given index at current dimension.

Synopsis

```
View &AddScalar(int64_t n)
```

Arguments

`n`: given index.

Return

View object.

View::AddSlice()

Create view object of slice at current dimension.

Synopsis

```
View &AddSlice(int64_t start)
```

Arguments

`start`: start index, inclusive.

Return

View object.

View::AddSlice()

Create view object of slice at current dimension.

Synopsis

```
View &AddSlice(int64_t start, int64_t stop)
```

Arguments

start: start index, inclusive.

stop: stop index, exclusive.

Return

View object.

View::AddSlice()

Create view object of slice at current dimension.

Synopsis

```
View &AddSlice(  
    int64_t start,  
    int64_t stop,  
    int64_t step)
```

Arguments

start: start index, inclusive.

stop: stop index, exclusive.

step: step size between start and stop index. It can be negative.

Return

View object.

View::operator>()()

Create full view object at current dimension.

Synopsis

```
View &operator()()
```

Return

View object.

View::operator()(int64_t start, int64_t stop)

Create view object of slice at current dimension.

Synopsis

```
View &operator()(int64_t start, int64_t stop)
```

Arguments

start: start index, inclusive.

stop: stop index, exclusive.

Return

View object.

View::operator()()

Create view object of slice at current dimension.

Synopsis

```
View &operator()(
    int64_t start,
    int64_t stop,
    int64_t step)
```

Arguments

start: start index, inclusive.

stop: stop index, exclusive.

step: step size between start and stop index. It can be negative.

Return

View object.

View::operator()(n)

Create view object of given index at current dimension.

Synopsis

```
View &operator()(int64_t n)
```

Arguments

n: given index.

Return

View object.

23.5.66 CallbackBase

COPT Callback abstract base object. Users must implment its virtual method `virtual void CallbackBase::callback()` to instantiate an instance, which pass to `Model::SetCallback(ICallback* pcb, int cbctx)` as the first parameter. Subclass of `CallbackBase` inherits the following methods:

CallbackBase::AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(
    const Expr &lhs,
    char sense,
    double rhs)
```

Arguments

lhs: expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side value for lazy constraint.

CallbackBase::AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(  
    const Expr &lhs,  
    char sense,  
    const Expr &rhs)
```

Arguments

lhs: left hand side expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side expression for lazy constraint.

CallbackBase::AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(const ConstrBuilder &builder)
```

Arguments

builder: builder for lazy constraint.

CallbackBase::AddLazyConstrs()

Add lazy constraints to model.

Synopsis

```
void AddLazyConstrs(const ConstrBuilderArray &builders)
```

Arguments

builders: array of builders for lazy constraints.

CallbackBase::AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    const Expr &lhs,  
    char sense,  
    double rhs)
```

Arguments

lhs: expression for user cut.
sense: sense for user cut.
rhs: right hand side value for user cut.

CallbackBase::AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    const Expr &lhs,  
    char sense,  
    const Expr &rhs)
```

Arguments

lhs: left hand side expression for user cut.
sense: sense for user cut.
rhs: right hand side expression for user cut.

CallbackBase::AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(const ConstrBuilder &builder)
```

Arguments

builder: builder for user cut.

CallbackBase::AddUserCuts()

Add user cuts to model.

Synopsis

```
void AddUserCuts(const ConstrBuilderArray &builders)
```

Arguments

builders: array of builders for user cuts.

CallbackBase::GetDblInfo()

Get double value of given information name in callback.

Synopsis

```
double GetDblInfo(const char *cbinfo)
```

Arguments

cbinfo: name of callback info.

Return

value of desired information.

CallbackBase::GetIncumbent()

Get best feasible solution of given variable in callback.

Synopsis

```
double GetIncumbent(Var &var)
```

Arguments

var: given variable.

Return

best feasible solution of given variable.

CallbackBase::GetIncumbent()

Get best feasible solution of variables in callback.

Synopsis

```
int GetIncumbent(VarArray &vars, double *pOut)
```

Arguments

vars: an array of variables.

pOut: best feasible solution of desired variables.

Return

the number of valid variables. If failed, return -1.

CallbackBase::GetIncumbent()

Get best feasible solution of all variables in callback.

Synopsis

```
int GetIncumbent(double *pOut, int len)
```

Arguments

pOut: optional, output best feasible solution of all variables.

len: the length of output array. The solution is written up to number of len.

Return

number of all variables. Return -1 if error occurs.

CallbackBase::GetIntInfo()

Get integer value of given information name in callback.

Synopsis

```
int GetIntInfo(const char *cbinfo)
```

Arguments

cbinfo: name of callback info.

Return

value of desired information.

CallbackBase::GetRelaxSol()

Get LP-relaxation solution of given variable in callback.

Synopsis

```
double GetRelaxSol(Var &var)
```

Arguments

var: given variable.

Return

LP-relaxation solution of given variable.

CallbackBase::GetRelaxSol()

Get LP-relaxation solution of variables in callback.

Synopsis

```
int GetRelaxSol(VarArray &vars, double *pOut)
```

Arguments

vars: an array of variables.

pOut: LP-relaxation solution of desired variables.

Return

the number of valid variables. If failed, return -1.

CallbackBase::GetRelaxSol()

Get LP-relaxation solution of all variables in callback.

Synopsis

```
int GetRelaxSol(double *pOut, int len)
```

Arguments

pOut: optional, output LP-relaxation solution of all variables.

len: the length of output array. The solution is written up to number of len.

Return

number of all variables. Return -1 if error occurs.

CallbackBase::GetSolution()

Get solution of given variable in callback.

Synopsis

```
double GetSolution(Var &var)
```

Arguments

var: given variable.

Return

solution of desired variable.

CallbackBase::GetSolution()

Get solution of variables in callback.

Synopsis

```
int GetSolution(VarArray &vars, double *pOut)
```

Arguments

vars: an array of variables.

pOut: solution of desired variables.

Return

the number of valid variables. If failed, return -1.

CallbackBase::GetSolution()

Get solution of all variables in callback.

Synopsis

```
int GetSolution(double *pOut, int len)
```

Arguments

pOut: optional, output solution of all variables.

len: the length of output array. The solution is written up to number of len.

Return

number of all variables. Return -1 if error occurs.

CallbackBase::Interrupt()

Interrupt solving problems in callback

Synopsis

```
void Interrupt()
```

CallbackBase::LoadSolution()

Load customized solution to model.

Synopsis

```
double LoadSolution()
```

Return

objective value of given solution.

CallbackBase::SetSolution()

Set solution of a given variable in callback.

Synopsis

```
void SetSolution(Var &var, double val)
```

Arguments

var: a variable object.

val: double value.

CallbackBase::SetSolution()

Set solution of variables in callback.

Synopsis

```
void SetSolution(  
    VarArray &vars,  
    const double *vals,  
    int len)
```

Arguments

vars: an array of variable objects.

vals: an array of double values.

len: length of array of double values.

CallbackBase::Where()

Get context in callback.

Synopsis

```
int Where()
```

Return

integer value of context.

23.5.67 ProbBuffer

Buffer object for COPT problem. ProbBuffer object holds the (MPS) problem in string format.

ProbBuffer::ProbBuffer()

Constructor of ProbBuffer object.

Synopsis

```
ProbBuffer(int sz)
```

Arguments

sz: initial size of the problem buffer.

ProbBuffer::GetData()

Get string of problem in problem buffer.

Synopsis

```
char *GetData()
```

Return

string of problem in problem buffer.

ProbBuffer::Resize()

Resize buffer to given size, and zero-ended

Synopsis

```
void Resize(int sz)
```

Arguments

sz: new buffer size.

ProbBuffer::Size()

Get the size of problem buffer.

Synopsis

```
int Size()
```

Return

size of problem buffer.

Chapter 24

C# API Reference

The **Cardinal Optimizer** provides C# API library. This chapter documents all COPT C# constants and API functions for C# applications.

24.1 Constants

There are four types of constants defined in **Cardinal Optimizer**. They are general constants, information constants, attributes and parameters.

24.1.1 General Constants

For the contents of C# general constants, see *General Constants*.

General constants are defined in `Consts` class. User may refer general constants with namespace, that is, `Copt.Consts.XXXX`.

24.1.2 Attributes

For the contents of C# attribute constants, see *Attributes*.

All COPT C# attributes are defined in `DblAttr` and `IntAttr` classes. User may refer double attributes by `Copt.DblAttr.XXXX`, and integer attributes by `Copt.IntAttr.XXXX`.

In the C# API, user can get the attribute value by specifying the attribute name. The two functions of obtaining attribute values are as follows, please refer to *C# API: Model Class* for details.

- `Model.GetIntAttr()`: Get value of a COPT integer attribute.
- `Model.GetDblAttr()`: Get value of a COPT double attribute.

24.1.3 Information

For the content of C# information constants, see *Information*.

In the C# API, information constants are defined in the `DblInfo` class. Users can access information constants through the prefix `Copt` in the namespace (usually can be omitted) `Copt.DblInfo`.

For instance, `Copt.DblInfo.Obj` is the coefficients of variables in the objective function.

24.1.4 Callback Information

For the content of C# API callback information class constants, see *Callback Information*.

In the C# API, callback-related information constants are defined in the `CbInfo` class. Users can access information constants through the prefix `Copt` in the namespace (usually can be omitted) `Copt.CbInfo`.

For instance, `Copt.CbInfo.BestObj` is the current best objective.

24.1.5 Parameters

For the contents of C# parameters constants, see *Parameters*.

All COPT C# parameters are defined in `DblParam` and `IntParam` classes. User may refer double parameters by `Copt.DblParam.XXXX`, and integer parameters by `Copt.IntParam.XXXX`.

In the C# API, user can get and set the parameter value by specifying the parameter name. The provided functions are as follows, please refer to *C# API: Model Class* for details.

- Get detailed information of the specified parameter (current value/max/min): `Model.GetParamInfo()`
- Get the current value of the specified integer/double parameter: `Model.GetIntParam()` / `Model.GetDblParam()`
- Set the specified integer/double parameter value: `Model.SetIntParam()` / `Model.SetDblParam()`

24.2 C# Modeling Classes

This chapter documents COPT C# interface. Users may refer to C# classes described below for details of how to construct and solve C# models.

24.2.1 Envr

Essentially, any C# application using Cardinal Optimizer should start with a COPT environment. COPT models are always associated with a COPT environment. User must create an environment object before populating models. User generally only need a single environment object in program.

Envr.Envr()

Constructor of COPT Envr object.

Synopsis

```
Envr()
```

Envr.Envr()

Constructor of COPT Envr object, given a license folder.

Synopsis

```
Envr(string licDir)
```

Arguments

`licDir`: directory having local license or client config file.

Envr.Envr()

Constructor of COPT Envr object, given an Envr config object.

Synopsis

```
Envr(EnvrConfig config)
```

Arguments

config: Envr config object holding settings for remote connection.

Envr.Close()

close remote connection and token becomes invalid for all problems in current envr.

Synopsis

```
void Close()
```

Envr.CreateModel()

Create a model object.

Synopsis

```
Model CreateModel(string name)
```

Arguments

name: customized model name.

Return

a model object.

24.2.2 EnvrConfig

If user connects to COPT remote services, such as floating token server or compute cluster, it is necessary to add config settings with EnvrConfig object.

EnvrConfig.EnvrConfig()

Constructor of envr config object.

Synopsis

```
EnvrConfig()
```

EnvrConfig.Set()

Set config settings in terms of name-value pair.

Synopsis

```
void Set(string name, string value)
```

Arguments

name: keyword of a config setting.

value: value of a config setting.

24.2.3 Model

In general, a COPT model consists of a set of variables, a (linear) objective function on these variables, a set of constraints on these variables, etc. COPT model class encapsulates all required methods for constructing a COPT model.

Model.Model()

Constructor of model.

Synopsis

```
Model(Envr env, string name)
```

Arguments

env: associated environment object.

name: string of model name.

Model.AddAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone AddAffineCone(AffineConeBuilder builder, string name)
```

Arguments

builder: builder for new affine cone constraint.

name: optional, name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCone()

Add an affine cone constraint to a model.

Synopsis

```
AffineCone AddAffineCone(  
    MLinExpr expr,  
    int type,  
    string name)
```

Arguments

expr: 1-dimensional array of linear expressions.

type: type of an affine cone.

name: name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCone()

Add an affine cone constraint to a model.

Synopsis

```
AffineCone AddAffineCone(  
    MVar vars,  
    int type,  
    string name)
```

Arguments

vars: 1-dimensional array of variables.

type: type of an affine cone.

name: name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone AddAffineCone(  
    Expr[] exprs,  
    int type,  
    string name)
```

Arguments

exprs: linear expressions that participate in the affine cone constraint.

type: type of an affine cone constraint.

name: name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCone()

Add an affine cone constraint to a model.

Synopsis

```
AffineCone AddAffineCone(  
    Var[] vars,  
    int type,  
    string name)
```

Arguments

vars: variables that participate in the affine cone constraint.

type: type of an affine cone.

name: name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCone()

Add an affine cone constraint to a model.

Synopsis

```
AffineCone AddAffineCone(  
    MPsdExpr expr,  
    int type,  
    string name)
```

Arguments

expr: 1-dimensional array of PSD expressions.

type: type of an affine cone.

name: name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone AddAffineCone(  
    PsdExpr[] exprs,  
    int type,  
    string name)
```

Arguments

exprs: PSD expressions that participate in the affine cone constraint.

type: type of an affine cone constraint.

name: name of new affine cone constraint.

Return

new affine cone constraint object.

Model.AddAffineCones()

Add a list of affine cone constraints to a model.

Synopsis

```
AffineConeArray AddAffineCones(  
    MLinExpr exprs,  
    int type,  
    string prefix)
```

Arguments

exprs: 2-dimensional array of linear expressions.

type: type of an affine cone.

prefix: name prefix for new affine cone constraints.

Return

array of new affine cone constraint objects.

Model.AddAffineCones()

Add a list of affine cone constraints to a model.

Synopsis

```
AffineConeArray AddAffineCones(  
    MVar vars,  
    int type,  
    string prefix)
```

Arguments

vars: 2-dimensional array of variables

type: type of affine cones.

prefix: name prefix for new affine cone constraints.

Return

array of new affine cone constraint objects.

Model.AddAffineCones()

Add a list of affine cone constraints to a model.

Synopsis

```
AffineConeArray AddAffineCones(  
    MPsdExpr exprs,  
    int type,  
    string prefix)
```

Arguments

exprs: 2-dimensional array of PSD expressions.
type: type of an affine cone.
prefix: name prefix for new affine cone constraints.

Return

array of new affine cone constraint objects.

Model.AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(  
    int dim,  
    int type,  
    char[] pvttype,  
    string prefix)
```

Arguments

dim: dimension of the cone constraint.
type: type of the cone constraint.
pvttype: type of variables in the cone.
prefix: optional, name prefix of variables in the cone, default value is "ConeV".

Return

new cone constraint object.

Model.AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(ConeBuilder builder)
```

Arguments

builder: builder for new cone constraint.

Return

new cone constraint object.

Model.AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(Var[] vars, int type)
```

Arguments

vars: variables that participate in the cone constraint.
type: type of the cone constraint.

Return

new cone constraint object.

Model.AddCone()

Add a cone constraint to model.

Synopsis

```
Cone AddCone(VarArray vars, int type)
```

Arguments

vars: variables that participate in the cone constraint.

type: type of a cone constraint.

Return

new cone constraint object.

Model.AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    Expr expr,  
    char sense,  
    double rhs,  
    string name)
```

Arguments

expr: expression for the new constraint.

sense: sense for new linear constraint, other than range sense.

rhs: right hand side value for the new constraint.

name: optional, name of new constraint.

Return

new constraint object.

Model.AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    Expr expr,  
    char sense,  
    Var var,  
    string name)
```

Arguments

expr: expression for the new constraint.
sense: sense for new linear constraint, other than range sense.
var: variable as right hand side for the new constraint.
name: optional, name of new constraint.

Return

new constraint object.

Model.AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    Expr lhs,  
    char sense,  
    Expr rhs,  
    string name)
```

Arguments

lhs: left hand side expression for the new constraint.
sense: sense for new linear constraint, other than range sense.
rhs: right hand side expression for the new constraint.
name: optional, name of new constraint.

Return

new constraint object.

Model.AddConstr()

Add a linear constraint to model.

Synopsis

```
Constraint AddConstr(  
    Expr expr,  
    double lb,  
    double ub,  
    string name)
```

Arguments

expr: expression for the new constraint.
lb: lower bound for the new constraint.
ub: upper bound for the new constraint
name: optional, name of new constraint.

Return

new constraint object.

Model.AddConstr()

Add a linear constraint to a model.

Synopsis

```
Constraint AddConstr(ConstrBuilder builder, string name)
```

Arguments

builder: builder for the new constraint.

name: optional, name of new constraint.

Return

new constraint object.

Model.AddConstrs()

Add linear constraints to model.

Synopsis

```
ConstrArray AddConstrs(  
    int count,  
    char[] senses,  
    double[] rhss,  
    string prefix)
```

Arguments

count: number of constraints added to model.

senses: sense array for new linear constraints, other than range sense.

rhss: right hand side values for new variables.

prefix: optional, name prefix for new constraints, default value is 'R'.

Return

array of new constraint objects.

Model.AddConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray AddConstrs(  
    int count,  
    double[] lbs,  
    double[] ubs,  
    string prefix)
```

Arguments

count: number of constraints added to the model.

lbs: lower bounds of new constraints.

ubs: upper bounds of new constraints.

prefix: optional, name prefix for new constraints, default value is 'R'.

Return

array of new constraint objects.

Model.AddConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray AddConstrs(ConstrBuilderArray builders, string prefix)
```

Arguments

builders: builders for new constraints.

prefix: optional, name prefix for new constraints, default value is 'R'.

Return

array of new constraint objects.

Model.AddDenseMat()

Add a dense symmetric matrix to a model.

Synopsis

```
SymMatrix AddDenseMat(int dim, double[] vals)
```

Arguments

dim: dimension of the dense symmetric matrix.

vals: array of non-zero elements, filled in column-wise up to len or max length of symmetric matrix.

Return

new symmetric matrix object.

Model.AddDenseMat()

Add a dense symmetric matrix to a model.

Synopsis

```
SymMatrix AddDenseMat(int dim, double val)
```

Arguments

dim: dimension of dense symmetric matrix.

val: value to fill dense symmetric matrix.

Return

new symmetric matrix object.

Model.AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(int dim, double val)
```

Arguments

dim: dimension of diagonal matrix.

val: value to fill diagonal elements.

Return

new diagonal matrix object.

Model.AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(int dim, double[] vals)
```

Arguments

dim: dimension of diagonal matrix.

vals: array of values of diagonal elements.

Return

new diagonal matrix object.

Model.AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(  
    int dim,  
    double val,  
    int offset)
```

Arguments

dim: dimension of diagonal matrix.

val: value to fill diagonal elements.

offset: shift distance against diagonal line.

Return

new diagonal matrix object.

Model.AddDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix AddDiagMat(  
    int dim,  
    double[] vals,  
    int offset)
```

Arguments

dim: dimension of diagonal matrix.

vals: array of values of diagonal elements.

offset: shift distance against diagonal line.

Return

new diagonal matrix object.

Model.AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(  
    int type,  
    char[] pvtype,  
    string prefix)
```

Arguments

type: type of the exponential cone constraint.

pvtype: type of variables in the exponential cone.

prefix: optional, name prefix of variables in the exponential cone, default value is "ExpConeV".

Return

new exponential cone constraint object.

Model.AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(ExpConeBuilder builder)
```

Arguments

builder: builder for new exponential cone constraint.

Return

new exponential cone constraint object.

Model.AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(Var[] vars, int type)
```

Arguments

vars: variables that participate in the exponential cone constraint.

type: type of the exponential cone constraint.

Return

new exponential cone constraint object.

Model.AddExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone AddExpCone(VarArray vars, int type)
```

Arguments

vars: variables that participate in the exponential cone constraint.

type: type of an exponential cone constraint.

Return

new exponential cone constraint object.

Model.AddEyeMat()

Add an identity matrix to a model.

Synopsis

```
SymMatrix AddEyeMat(int dim)
```

Arguments

dim: dimension of identity matrix.

Return

new identity matrix object.

Model.AddGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr AddGenConstrIndicator(GenConstrBuilder builder, string  
name)
```

Arguments

builder: builder for the general constraint.

name: optional, name of new general constraint.

Return

new general constraint object of type indicator.

Model.AddGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr AddGenConstrIndicator(  
    Var binvar,  
    int binval,  
    ConstrBuilder builder,  
    int type,  
    string name)
```

Arguments

binvar: binary indicator variable.

binval: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).

builder: builder for linear constraint.

type: type of general constraint.

name: optional, name of new general constraint.

Return

new general constraint object of type indicator.

Model.AddGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr AddGenConstrIndicator(  
    Var binvar,  
    int binval,  
    Expr expr,  
    char sense,  
    double rhs,  
    int type,  
    string name)
```

Arguments

binvar: binary indicator variable.

binval: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).

expr: expression for new linear constraint.

sense: sense for new linear constraint.

rhs: right hand side value for new linear constraint.

type: type of general constraint.

name: optional, name of new general constraint.

Return

new general constraint object of type indicator.

Model.AddGenConstrIndicators()

Add general constraints to a model.

Synopsis

```
GenConstrArray AddGenConstrIndicators(GenConstrBuilderArray  
builders, string prefix)
```

Arguments

builders: builders for new general constraints.

prefix: optional, name prefix for new general constraints.

Return

array of new general constraint objects.

Model.AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(  
    Expr lhs,  
    char sense,  
    double rhs,  
    string name)
```

Arguments

lhs: expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side value for lazy constraint.

name: optional, name of lazy constraint.

Model.AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(  
    Expr lhs,  
    char sense,  
    Expr rhs,  
    string name)
```

Arguments

lhs: left hand side expression for lazy constraint.
sense: sense for lazy constraint.
rhs: right hand side expression for lazy constraint.
name: optional, name of lazy constraint.

Model.AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(ConstrBuilder builder, string name)
```

Arguments

builder: builder for lazy constraint.
name: optional, name of lazy constraint.

Model.AddLazyConstrs()

Add lazy constraints to model.

Synopsis

```
void AddLazyConstrs(ConstrBuilderArray builders, string prefix)
```

Arguments

builders: array of builders for lazy constraints.
prefix: name prefix of new lazy constraints.

Model.AddLmiConstr()

Add an LMI constraint to model.

Synopsis

```
LmiConstraint AddLmiConstr(LmiExpr expr, string name)
```

Arguments

expr: LMI expression for new LMI constraint.
name: optional, name of new LMI constraint.

Return

new LMI constraint object.

Model.AddMConstr()

Add a MConstr object in N-dimensions to model.

Synopsis

```
MConstr AddMConstr(MConstrBuilder builder, string prefix)
```

Arguments

builder: builder for MConstr object.
prefix: name prefix for constraints in MConstr object.

Return

new MConstr object.

Model.AddMConstr()

Add a N-dimensional MConstr object to model.

Synopsis

```
MConstr AddMConstr(  
    MLinExpr exprs,  
    char sense,  
    double rhs,  
    string prefix)
```

Arguments

exprs: N-dimensional MLinExpr object.
sense: sense for new linear constraints.
rhs: double value at right side of the new linear constraints.
prefix: name prefix for constraints in MConstr object.

Return

new MConstr object.

Model.AddMPsdConstr()

Add a N-dimensional MPsdConstr object to model.

Synopsis

```
MPsdConstr AddMPsdConstr(MPsdConstrBuilder builder, string prefix)
```

Arguments

builder: builder for MPsdConstr object.
prefix: name prefix of PSD constraints in MPsdConstr object.

Return

new MPsdConstr object.

Model.AddMPsdConstr()

Add a N-dimensional MPsdConstr object to model.

Synopsis

```
MPsdConstr AddMPsdConstr(  
    MPsdExpr exprs,  
    char sense,  
    double rhs,  
    string prefix)
```

Arguments

exprs: N-dimensional MPsdExpr object.
sense: sense for new PSD constraints.
rhs: double value at right side of the new PSD constraints.
prefix: name prefix of PSD constraints in MPsdConstr object.

Return

new MPsdConstr object.

Model.AddMQConstr()

Add a N-dimensional MQConstr object to model.

Synopsis

```
MQConstr AddMQConstr(MQConstrBuilder builder, string prefix)
```

Arguments

builder: builder for MQConstr object.
prefix: name prefix of quadratic constraints in MQConstr object.

Return

new MQConstr object.

Model.AddMQConstr()

Add a N-dimensional MQConstr object to model.

Synopsis

```
MQConstr AddMQConstr(  
    MQuadExpr exprs,  
    char sense,  
    double rhs,  
    string prefix)
```

Arguments

exprs: N-dimensional MQuadExpr object.
sense: sense for new quadratic constraints.
rhs: double value at right side of the new quadratic constraints.
prefix: name prefix of quadratic constraints in MQConstr object.

Return

new MQConstr object.

Model.AddMVar()

Add a MVar object in N-dimensions to model.

Synopsis

```
MVar AddMVar(  
    Shape shp,  
    char vtype,  
    string prefix)
```

Arguments

shp: shape of MVar object.
vtype: type of variables in MVar object.
prefix: name prefix of variables in MVar object.

Return

new MVar object.

Model.AddMVar()

Add a MVar object in N-dimensions to model.

Synopsis

```
MVar AddMVar(  
    Shape shp,  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    string prefix)
```

Arguments

shp: shape of MVar object.
lb: lower bound for variables in MVar object.
ub: upper bound for variables in MVar object.
obj: objective coefficient for variables in MVar object.
vtype: type of variables in MVar object.
prefix: name prefix of variables in MVar object.

Return

new MVar object.

Model.AddMVar()

Add a MVar object in N-dimensions to model.

Synopsis

```
MVar AddMVar(  
    Shape shp,  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    string prefix)
```

Arguments

shp: shape of MVar object.

lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.

ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

types: variable types for new variables. if NULL, variable types are continuous.

prefix: name prefix of variables in MVar object.

Return

new MVar object.

Model.AddOnesMat()

Add a dense symmetric matrix of value one to a model.

Synopsis

```
SymMatrix AddOnesMat(int dim)
```

Arguments

dim: dimension of dense symmetric matrix.

Return

new symmetric matrix object.

Model.AddPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint AddPsdConstr(  
    PsdExpr expr,  
    char sense,  
    double rhs,  
    string name)
```


Arguments

expr: PSD expression for new PSD constraint.
sense: sense for new PSD constraint.
rhs: double value at right side of the new PSD constraint.
name: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model.AddPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint AddPsdConstr(  
    PsdExpr expr,  
    double lb,  
    double ub,  
    string name)
```

Arguments

expr: expression for new PSD constraint.
lb: lower bound for new PSD constraint.
ub: upper bound for new PSD constraint.
name: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model.AddPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint AddPsdConstr(  
    PsdExpr lhs,  
    char sense,  
    PsdExpr rhs,  
    string name)
```

Arguments

lhs: PSD expression at left side of new PSD constraint.
sense: sense for new PSD constraint.
rhs: PSD expression at right side of new PSD constraint.
name: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model.AddPsdConstr()

Add a PSD constraint to a model.

Synopsis

```
PsdConstraint AddPsdConstr(PsdConstrBuilder builder, string name)
```

Arguments

builder: builder for new PSD constraint.

name: optional, name of new PSD constraint.

Return

new PSD constraint object.

Model.AddPsdVar()

Add a new PSD variable to model.

Synopsis

```
PsdVar AddPsdVar(int dim, string name)
```

Arguments

dim: dimension of new PSD variable.

name: name of new PSD variable.

Return

PSD variable object.

Model.AddPsdVars()

Add new PSD variables to model.

Synopsis

```
PsdVarArray AddPsdVars(  
    int count,  
    int[] dims,  
    string prefix)
```

Arguments

count: number of new PSD variables.

dims: array of dimensions of new PSD variables.

prefix: name prefix of new PSD variables, default prefix is PSD_V.

Return

array of PSD variable objects.

Model.AddQConstr()

Add a quadratic constraint to model.

Synopsis

```
QConstraint AddQConstr(  
    QuadExpr expr,  
    char sense,  
    double rhs,  
    string name)
```

Arguments

expr: quadratic expression for the new constraint.

sense: sense for new quadratic constraint.

rhs: double value at right side of the new quadratic constraint.

name: optional, name of new quadratic constraint.

Return

new quadratic constraint object.

Model.AddQConstr()

Add a quadratic constraint to model.

Synopsis

```
QConstraint AddQConstr(  
    QuadExpr lhs,  
    char sense,  
    QuadExpr rhs,  
    string name)
```

Arguments

lhs: quadratic expression at left side of the new quadratic constraint.

sense: sense for new quadratic constraint.

rhs: quadratic expression at right side of the new quadratic constraint.

name: optional, name of new quadratic constraint.

Return

new quadratic constraint object.

Model.AddQConstr()

Add a quadratic constraint to a model.

Synopsis

```
QConstraint AddQConstr(QConstrBuilder builder, string name)
```

Arguments

builder: builder for the new quadratic constraint.

name: optional, name of new quadratic constraint.

Return

new quadratic constraint object.

Model.AddSos()

Add a SOS constraint to model.

Synopsis

```
Sos AddSos(SosBuilder builder)
```

Arguments

builder: builder for new SOS constraint.

Return

new SOS constraint object.

Model.AddSos()

Add a SOS constraint to model.

Synopsis

```
Sos AddSos(  
    Var[] vars,  
    double[] weights,  
    int type)
```

Arguments

vars: variables that participate in the SOS constraint.

weights: weights for variables in the SOS constraint.

type: type of SOS constraint.

Return

new SOS constraint object.

Model.AddSos()

Add a SOS constraint to model.

Synopsis

```
Sos AddSos(  
    VarArray vars,  
    double[] weights,  
    int type)
```

Arguments

vars: variables that participate in the SOS constraint.

weights: weights for variables in the SOS constraint.

type: type of SOS constraint.

Return

new SOS constraint object.

Model.AddSparseMat()

Add a sparse symmetric matrix to a model.

Synopsis

```
SymMatrix AddSparseMat(  
    int dim,  
    int nElems,  
    int[] rows,  
    int[] cols,  
    double[] vals)
```

Arguments

dim: dimension of the sparse symmetric matrix.

nElems: number of non-zero elements in the sparse symmetric matrix.

rows: array of row indexes of non-zero elements.

cols: array of col indexes of non-zero elements.

vals: array of values of non-zero elements.

Return

new symmetric matrix object.

Model.AddSymMat()

Given a symmetric matrix expression, add results matrix to model.

Synopsis

```
SymMatrix AddSymMat(SymMatExpr expr)
```

Arguments

expr: symmetric matrix expression object.

Return

results symmetric matrix object.

Model.AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    Expr lhs,  
    char sense,  
    double rhs,  
    string name)
```

Arguments

lhs: expression for user cut.

sense: sense for user cut.

rhs: right hand side value for user cut.

name: optional, name of user cut.

Model.AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    Expr lhs,  
    char sense,  
    Expr rhs,  
    string name)
```

Arguments

lhs: left hand side expression for user cut.

sense: sense for user cut.

rhs: right hand side expression for user cut.

name: optional, name of user cut.

Model.AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(ConstrBuilder builder, string name)
```

Arguments

builder: builder for user cut.

name: optional, name of user cut.

Model.AddUserCuts()

Add user cuts to model.

Synopsis

```
void AddUserCuts(ConstrBuilderArray builders, string prefix)
```

Arguments

builders: array of builders for user cuts.

prefix: name prefix of new user cuts.

Model.AddVar()

Add a variable and the associated non-zero coefficients as column.

Synopsis

```
Var AddVar(  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    string name)
```

Arguments

lb: lower bound for new variable.

ub: upper bound for new variable.

obj: objective coefficient for new variable.

vtype: variable type for new variable.

name: optional, name for new variable.

Return

new variable object.

Model.AddVar()

Add a variable and the associated non-zero coefficients as column.

Synopsis

```
Var AddVar(  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    Column col,  
    string name)
```

Arguments

lb: lower bound for new variable.

ub: upper bound for new variable.

obj: objective coefficient for new variable.

vtype: variable type for new variable.

col: column object for specifying a set of constraints to which the variable belongs.

name: optional, name for new variable.

Return

new variable object.

Model.AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    char vtype,  
    string prefix)
```

Arguments

count: the number of variables to add.

vtype: variable types for new variables.

prefix: optional, prefix part for names of new variables, default value is 'C'.

Return

array of new variable objects.

Model.AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    string prefix)
```

Arguments

count: the number of variables to add.

lb: lower bound for new variables.

ub: upper bound for new variables.

obj: objective coefficient for new variables.

vtype: variable type for new variables.

prefix: optional, prefix part for names of new variables, default value is 'C'.

Return

array of new variable objects.

Model.AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    int count,  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    string prefix)
```

Arguments

count: the number of variables to add.

lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.

ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

types: variable types for new variables. if NULL, variable types are continuous.

prefix: optional, prefix part for names of new variables, default value is 'C'.

Return

array of new variable objects.

Model.AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    Column[] cols,  
    string prefix)
```

Arguments

lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.

ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

types: variable types for new variables. if NULL, variable types are continuous.

cols: column objects for specifying a set of constraints to which each new variable belongs.

prefix: optional, prefix part for names of new variables, default value is 'C'.

Return

array of new variable objects.

Model.AddVars()

Add new variables to model.

Synopsis

```
VarArray AddVars(  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    ColumnArray cols,  
    string prefix)
```

Arguments

lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.

ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

types: variable types for new variables. if NULL, variable types are continuous.

cols: columnarray for specifying a set of constraints to which each new variable belongs.

prefix: optional, prefix part for names of new variables, default value is 'C'.

Return

array of new variable objects.

Model.Clear()

Clear all settings including problem itself.

Synopsis

```
void Clear()
```

Model.Clone()

Deep copy COPT model.

Synopsis

```
Model Clone()
```

Return

cloned model object.

Model.ComputeIIS()

Compute IIS for model

Synopsis

```
void ComputeIIS()
```

Model.DelPsdObj()

delete PSD part of objective in model.

Synopsis

```
void DelPsdObj()
```

Model.DelQuadObj()

delete quadratic part of objective in model.

Synopsis

```
void DelQuadObj()
```

Model.FeasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void FeasRelax(  
    VarArray vars,  
    double[] colLowPen,  
    double[] colUppPen,  
    ConstrArray cons,  
    double[] rowBndPen,  
    double[] rowUppPen)
```

Arguments

vars: an array of variables.
colLowPen: penalties for lower bounds of variables.
colUppPen: penalties for upper bounds of variables.
cons: an array of constraints.
rowBndPen: penalties for right hand sides of constraints.
rowUppPen: penalties for upper bounds of range constraints.

Model.FeasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void FeasRelax(int ifRelaxVars, int ifRelaxCons)
```

Arguments

ifRelaxVars: whether to relax variables.
ifRelaxCons: whether to relax constraints.

Model.Get()

Query values of information associated with variables.

Synopsis

```
double[] Get(string name, Var[] vars)
```

Arguments

name: name of information.
vars: a list of interested variables.

Return

values of information.

Model.Get()

Query values of information associated with variables.

Synopsis

```
double[] Get(string name, VarArray vars)
```

Arguments

name: name of information.

vars: array of interested variables.

Return

values of information.

Model.Get()

Query values of information associated with constraints.

Synopsis

```
double[] Get(string name, Constraint[] constrs)
```

Arguments

name: name of information.

constrs: a list of interested constraints.

Return

values of information.

Model.Get()

Query values of information associated with constraints.

Synopsis

```
double[] Get(string name, ConstrArray constrs)
```

Arguments

name: name of information.

constrs: array of interested constraints.

Return

values of information.

Model.Get()

Query values of information associated with quadratic constraints.

Synopsis

```
double[] Get(string name, QConstraint[] constrs)
```

Arguments

name: name of information.

constrs: a list of interested quadratic constraints.

Return

values of information.

Model.Get()

Query values of information associated with quadratic constraints.

Synopsis

```
double[] Get(string name, QConstrArray constrs)
```

Arguments

name: name of information.

constrs: array of interested quadratic constraints.

Return

values of information.

Model.Get()

Query values of information associated with PSD constraints.

Synopsis

```
double[] Get(string name, PsdConstraint[] constrs)
```

Arguments

name: name of information.

constrs: a list of desired PSD constraints.

Return

output array of information values.

Model.Get()

Query values of information associated with PSD constraints.

Synopsis

```
double[] Get(string name, PsdConstrArray constrs)
```

Arguments

name: name of information.

constrs: a list of desired PSD constraints.

Return

output array of information values.

Model.GetAffineCone()

Get an affine cone constraint of given index in model.

Synopsis

```
AffineCone GetAffineCone(int idx)
```

Arguments

idx: index of the desired affine cone constraint.

Return

the desired affine cone constraint object.

Model.GetAffineConeBuilder()

Get builder of given affine cone constraint in model.

Synopsis

```
AffineConeBuilder GetAffineConeBuilder(AffineCone cone)
```

Arguments

cone: affine cone constraint.

Return

desired affine cone constraint builder.

Model.GetAffineConeBuilders()

Get builders of all affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray GetAffineConeBuilders()
```

Return

array object of affine cone constraint builders.

Model.GetAffineConeBuilders()

Get builders of given affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray GetAffineConeBuilders(AffineCone[] cones)
```

Arguments

cones: array of affine cone constraints.

Return

array object of desired affine cone constraint builders.

Model.GetAffineConeBuilders()

Get builders of given affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray GetAffineConeBuilders(AffineConeArray cones)
```

Arguments

cones: array of affine cone constraints.

Return

array object of desired affine cone constraint builders.

Model.GetAffineConeByName()

Get an affine cone constraint of given name in model.

Synopsis

```
AffineCone GetAffineConeByName(string name)
```

Arguments

name: name of the desired affine cone constraint.

Return

the desired affine cone constraint object.

Model.GetAffineCones()

Get all affine cone constraints in model.

Synopsis

```
AffineConeArray GetAffineCones()
```

Return

array object of affine cone constraints.

Model.GetCoeff()

Get the coefficient of variable in linear constraint.

Synopsis

```
double GetCoeff(Constraint constr, Var var)
```

Arguments

constr: The requested constraint.

var: The requested variable.

Return

The requested coefficient.

Model.GetCol()

Get a column object that have a list of constraints in which the variable participates.

Synopsis

```
Column GetCol(Var var)
```

Arguments

var: a variable object.

Return

a column object associated with a variable.

Model.GetColBasis()

Get status of column basis.

Synopsis

```
int[] GetColBasis()
```

Return

basis status.

Model.GetCone()

Get a cone constraint of given index in model.

Synopsis

```
Cone GetCone(int idx)
```

Arguments

idx: index of the desired cone constraint.

Return

the desired cone constraint object.

Model.GetConeBuilders()

Get builders of all cone constraints in model.

Synopsis

```
ConeBuilderArray GetConeBuilders()
```

Return

array object of cone constraint builders.

Model.GetConeBuilders()

Get builders of given cone constraints in model.

Synopsis

```
ConeBuilderArray GetConeBuilders(Cone[] cones)
```

Arguments

cones: array of cone constraints.

Return

array object of desired cone constraint builders.

Model.GetConeBuilders()

Get builders of given cone constraints in model.

Synopsis

```
ConeBuilderArray GetConeBuilders(ConeArray cones)
```

Arguments

cones: array of cone constraints.

Return

array object of desired cone constraint builders.

Model.GetCones()

Get all cone constraints in model.

Synopsis

```
ConeArray GetCones()
```

Return

array object of cone constraints.

Model.GetConstr()

Get a constraint of given index in model.

Synopsis

```
Constraint GetConstr(int idx)
```

Arguments

idx: index of the desired constraint.

Return

the desired constraint object.

Model.GetConstrBuilder()

Get builder of a constraint in model, including variables and associated coefficients, sense and RHS.

Synopsis

```
ConstrBuilder GetConstrBuilder(Constraint constr)
```

Arguments

`constr`: a constraint object.

Return

constraint builder object.

Model.GetConstrBuilders()

Get builders of all constraints in model.

Synopsis

```
ConstrBuilderArray GetConstrBuilders()
```

Return

array object of constraint builders.

Model.GetConstrByName()

Get a constraint of given name in model.

Synopsis

```
Constraint GetConstrByName(string name)
```

Arguments

`name`: name of the desired constraint.

Return

the desired constraint object.

Model.GetConstrLowerIIS()

Get IIS status of lower bounds of constraints.

Synopsis

```
int[] GetConstrLowerIIS(ConstrArray constrs)
```

Arguments

`constrs`: Array of constraints.

Return

IIS status of lower bounds of constraints.

Model.GetConstrLowerIIS()

Get IIS status of lower bounds of constraints.

Synopsis

```
int[] GetConstrLowerIIS(Constraint[] constrs)
```

Arguments

constrs: Array of constraints.

Return

IIS status of lower bounds of constraints.

Model.GetConstrs()

Get all constraints in model.

Synopsis

```
ConstrArray GetConstrs()
```

Return

array object of constraints.

Model.GetConstrUpperIIS()

Get IIS status of upper bounds of constraints.

Synopsis

```
int[] GetConstrUpperIIS(ConstrArray constrs)
```

Arguments

constrs: Array of constraints.

Return

IIS status of upper bounds of constraints.

Model.GetConstrUpperIIS()

Get IIS status of upper bounds of constraints.

Synopsis

```
int[] GetConstrUpperIIS(Constraint[] constrs)
```

Arguments

constrs: Array of constraints.

Return

IIS status of upper bounds of constraints.

Model.GetDblAttr()

Get value of a COPT double attribute.

Synopsis

```
double GetDblAttr(string attr)
```

Arguments

attr: name of double attribute.

Return

value of double attribute.

Model.GetDblParam()

Get value of a COPT double parameter.

Synopsis

```
double GetDblParam(string param)
```

Arguments

param: name of integer parameter.

Return

value of double parameter.

Model.GetExpCone()

Get an exponential cone constraint of given index in model.

Synopsis

```
ExpCone GetExpCone(int idx)
```

Arguments

idx: index of the desired exponential cone constraint.

Return

the desired exponential cone constraint object.

Model.GetExpConeBuilders()

Get builders of all exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray GetExpConeBuilders()
```

Return

array object of exponential cone constraint builders.

Model.GetExpConeBuilders()

Get builders of given exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray GetExpConeBuilders(ExpCone[] cones)
```

Arguments

cones: array of exponential cone constraints.

Return

array object of desired exponential cone constraint builders.

Model.GetExpConeBuilders()

Get builders of given exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray GetExpConeBuilders(ExpConeArray cones)
```

Arguments

cones: array of exponential cone constraints.

Return

array object of desired exponential cone constraint builders.

Model.GetExpCones()

Get all exponential cone constraints in model.

Synopsis

```
ExpConeArray GetExpCones()
```

Return

array object of exponential cone constraints.

Model.GetGenConstr()

Get a general constraint of given index in model.

Synopsis

```
GenConstr GetGenConstr(int idx)
```

Arguments

idx: index of the desired general constraint.

Return

the desired general constraint object.

Model.GetGenConstrByName()

Get a general constraint of given name in model.

Synopsis

```
GenConstr GetGenConstrByName(string name)
```

Arguments

name: name of the desired general constraint.

Return

the desired general constraint object.

Model.GetGenConstrIndicator()

Get builder of given general constraint of type indicator.

Synopsis

```
GenConstrBuilder GetGenConstrIndicator(GenConstr indicator)
```

Arguments

indicator: a general constraint of type indicator.

Return

builder object of general constraint of type indicator.

Model.GetGenConstrIndicators()

Get builders of all general constraints in model.

Synopsis

```
GenConstrBuilderArray GetGenConstrIndicators()
```

Return

array object of general constraint builders.

Model.GetGenConstrs()

Get all general constraints in model.

Synopsis

```
GenConstrArray GetGenConstrs()
```

Return

array object of general constraints.

Model.GetIndicatorIIS()

Get IIS status of indicator constraints.

Synopsis

```
int[] GetIndicatorIIS(GenConstrArray genconstrs)
```

Arguments

genconstrs: Array of indicator constraints.

Return

IIS status of indicator constraints.

Model.GetIndicatorIIS()

Get IIS status of indicator constraints.

Synopsis

```
int[] GetIndicatorIIS(GenConstr[] genconstrs)
```

Arguments

genconstrs: Array of indicator constraints.

Return

IIS status of indicator constraints.

Model.GetIntAttr()

Get value of a COPT integer attribute.

Synopsis

```
int GetIntAttr(string attr)
```

Arguments

attr: name of integer attribute.

Return

value of integer attribute.

Model.GetIntParam()

Get value of a COPT integer parameter.

Synopsis

```
int GetIntParam(string param)
```

Arguments

param: name of integer parameter.

Return

value of integer parameter.

Model.GetLmiCoeff()

Get the symmetric matrix of variable in LMI constraint.

Synopsis

```
SymMatrix GetLmiCoeff(LmiConstraint constr, Var var)
```

Arguments

constr: The desired LMI constraint.

var: The desired variable.

Return

The associated coefficient matrix.

Model.GetLmiConstr()

Get LMI constraint of given index in model.

Synopsis

```
LmiConstraint GetLmiConstr(int idx)
```

Arguments

idx: index of desired LMI constraint.

Return

LMI constraint object.

Model.GetLmiConstrByName()

Get LMI constraint of given name in model.

Synopsis

```
LmiConstraint GetLmiConstrByName(string name)
```

Arguments

name: name of desired LMI constraint.

Return

LMI constraint object.

Model.GetLmiConstrs()

Get all LMI constraints in model.

Synopsis

```
LmiConstrArray GetLmiConstrs()
```

Return

array object of LMI constraints.

Model.GetLmiRhs()

Get the symmetric matrix of constant of LMI constraint.

Synopsis

```
SymMatrix GetLmiRhs(LmiConstraint constr)
```

Arguments

constr: The desired LMI constraint.

Return

matrix of constant term.

Model.GetLmiRow()

Get variables and associated symmetric matrices that participate in a LMI constraint.

Synopsis

```
LmiExpr GetLmiRow(LmiConstraint constr)
```

Arguments

constr: given LMI constraint object.

Return

LMI expression object of LMI constraint.

Model.GetLpSolution()

Get LP solution.

Synopsis

```
void GetLpSolution(  
    out double[] value,  
    out double[] slack,  
    out double[] rowDual,  
    out double[] redCost)
```

Arguments

value: out, solution values.

slack: out, slack values.

rowDual: out, dual values.

redCost: out, reduced costs.

Model.GetObjective()

Get linear expression of objective for model.

Synopsis

```
Expr GetObjective()
```

Return

an linear expression object.

Model.GetParamInfo()

Get current, default, minimum, maximum of COPT integer parameter.

Synopsis

```
void GetParamInfo(  
    string name,  
    out int cur,  
    out int def,  
    out int min,  
    out int max)
```

Arguments

name: name of integer parameter.

cur: out, current value of integer parameter.

def: out, default value of integer parameter.

min: out, minimum value of integer parameter.

max: out, maximum value of integer parameter.

Model.GetParamInfo()

Get current, default, minimum, maximum of COPT double parameter.

Synopsis

```
void GetParamInfo(  
    string name,  
    out double cur,  
    out double def,  
    out double min,  
    out double max)
```

Arguments

name: name of integer parameter.

cur: out, current value of double parameter.

def: out, default value of double parameter.

min: out, minimum value of double parameter.

max: out, maximum value of double parameter.

Model.GetPoolObjVal()

Get the idx-th objective value in solution pool.

Synopsis

```
double GetPoolObjVal(int idx)
```

Arguments

idx: Index of solution.

Return

The requested objective value.

Model.GetPoolSolution()

Get the idx-th solution in solution pool.

Synopsis

```
double[] GetPoolSolution(int idx, VarArray vars)
```

Arguments

idx: Index of solution.

vars: The requested variables.

Return

The requested solution.

Model.GetPoolSolution()

Get the idx-th solution in solution pool.

Synopsis

```
double[] GetPoolSolution(int idx, Var[] vars)
```

Arguments

idx: Index of solution.

vars: The requested variables.

Return

The requested solution.

Model.GetPsdCoeff()

Get the symmetric matrix of PSD variable in a PSD constraint.

Synopsis

```
SymMatrix GetPsdCoeff(PsdConstraint constr, PsdVar var)
```

Arguments

constr: The desired PSD constraint.

var: The desired PSD variable.

Return

The associated coefficient matrix.

Model.GetPsdConstr()

Get a PSD constraint of given index in model.

Synopsis

```
PsdConstraint GetPsdConstr(int idx)
```

Arguments

idx: index of desired PSD constraint.

Return

PSD constraint object.

Model.GetPsdConstrBuilder()

Get builder of a PSD constraint in model, including PSD variables, sense and associated symmetric matrices.

Synopsis

```
PsdConstrBuilder GetPsdConstrBuilder(PsdConstraint constr)
```

Arguments

constr: PSD constraint object.

Return

PSD constraint builder object.

Model.GetPsdConstrBuilders()

Get builders of all PSD constraints in model.

Synopsis

```
PsdConstrBuilderArray GetPsdConstrBuilders()
```

Return

array object of PSD constraint builders.

Model.GetPsdConstrByName()

Get a PSD constraint of given name in model.

Synopsis

```
PsdConstraint GetPsdConstrByName(string name)
```

Arguments

name: name of desired PSD constraint.

Return

PSD constraint object.

Model.GetPsdConstrs()

Get all PSD constraints in model.

Synopsis

```
PsdConstrArray GetPsdConstrs()
```

Return

array object of PSD constraints.

Model.GetPsdObjective()

Get PSD objective of model.

Synopsis

```
PsdExpr GetPsdObjective()
```

Return

a PSD expression object.

Model.GetPsdRow()

Get PSD variables and associated symmetric matrices that participate in a PSD constraint.

Synopsis

```
PsdExpr GetPsdRow(PsdConstraint constr)
```

Arguments

constr: PSD constraint object.

Return

PSD expression object of the PSD constraint.

Model.GetPsdSolution()

Get PSD solution.

Synopsis

```
void GetPsdSolution(  
    out double[] psdValue,  
    out double[] psdSlack,  
    out double[] psdRowDual,  
    out double[] psdRedCost)
```

Arguments

psdValue: out, solution of PSD variables.

psdSlack: out, slack of PSD constraints.

psdRowDual: out, dual of PSD constraints.

psdRedCost: out, reduced costs of PSD variables.

Model.GetPsdVar()

Get a PSD variable of given index in model.

Synopsis

```
PsdVar GetPsdVar(int idx)
```

Arguments

idx: index of the desired PSD variable.

Return

the desired PSD variable object.

Model.GetPsdVarByName()

Get a PSD variable of given name in model.

Synopsis

```
PsdVar GetPsdVarByName(string name)
```

Arguments

name: name of the desired PSD variable.

Return

the desired PSD variable object.

Model.GetPsdVars()

Get all PSD variables in model.

Synopsis

```
PsdVarArray GetPsdVars()
```

Return

array object of PSD variables.

Model.GetQConstr()

Get a quadratic constraint of given index in model.

Synopsis

```
QConstraint GetQConstr(int idx)
```

Arguments

idx: index of the desired quadratic constraint.

Return

the desired quadratic constraint object.

Model.GetQConstrBuilder()

Get builder of a constraint in model, including variables and associated coefficients, sense and RHS.

Synopsis

```
QConstrBuilder GetQConstrBuilder(QConstraint constr)
```

Arguments

constr: a constraint object.

Return

constraint builder object.

Model.GetQConstrBuilders()

Get builders of all constraints in model.

Synopsis

```
QConstrBuilderArray GetQConstrBuilders()
```

Return

array object of constraint builders.

Model.GetQConstrByName()

Get a quadratic constraint of given name in model.

Synopsis

```
QConstraint GetQConstrByName(string name)
```

Arguments

name: name of the desired constraint.

Return

the desired quadratic constraint object.

Model.GetQConstrs()

Get all quadratic constraints in model.

Synopsis

```
QConstrArray GetQConstrs()
```

Return

array object of quadratic constraints.

Model.GetQuadObjective()

Get quadratic objective of model.

Synopsis

```
QuadExpr GetQuadObjective()
```

Return

a quadratic expression object.

Model.GetQuadRow()

Get two variables and associated coefficients that participate in a quadratic constraint.

Synopsis

```
QuadExpr GetQuadRow(QConstraint constr)
```

Arguments

constr: a quadratic constraint object.

Return

quadratic expression object of the constraint.

Model.GetRow()

Get variables that participate in a constraint, and the associated coefficients.

Synopsis

```
Expr GetRow(Constraint constr)
```

Arguments

constr: a constraint object.

Return

expression object of the constraint.

Model.GetRowBasis()

Get status of row basis.

Synopsis

```
int[] GetRowBasis()
```

Return

basis status.

Model.GetSolution()

Get MIP solution.

Synopsis

```
double[] GetSolution()
```

Return

solution values.

Model.GetSos()

Get a SOS constraint of given index in model.

Synopsis

```
Sos GetSos(int idx)
```

Arguments

idx: index of the desired SOS constraint.

Return

the desired SOS constraint object.

Model.GetSosBuilders()

Get builders of all SOS constraints in model.

Synopsis

```
SosBuilderArray GetSosBuilders()
```

Return

array object of SOS constraint builders.

Model.GetSosBuilders()

Get builders of given SOS constraints in model.

Synopsis

```
SosBuilderArray GetSosBuilders(Sos[] soss)
```

Arguments

soss: array of SOS constraints.

Return

array object of desired SOS constraint builders.

Model.GetSosBuilders()

Get builders of given SOS constraints in model.

Synopsis

```
SosBuilderArray GetSosBuilders(SosArray soss)
```

Arguments

soss: array of SOS constraints.

Return

array object of desired SOS constraint builders.

Model.GetSOSIIS()

Get IIS status of SOS constraints.

Synopsis

```
int[] GetSOSIIS(SosArray soss)
```

Arguments

soss: Array of SOS constraints.

Return

IIS status of SOS constraints.

Model.GetSOSIIS()

Get IIS status of SOS constraints.

Synopsis

```
int[] GetSOSIIS(Sos[] soss)
```

Arguments

soss: Array of SOS constraints.

Return

IIS status of SOS constraints.

Model.GetSoss()

Get all SOS constraints in model.

Synopsis

```
SosArray GetSoss()
```

Return

array object of SOS constraints.

Model.GetSymMat()

Get a symmetric matrix of given index in model.

Synopsis

```
SymMatrix GetSymMat(int idx)
```

Arguments

idx: index of the desired symmetric matrix.

Return

the desired symmetric matrix object.

Model.GetVar()

Get a variable of given index in model.

Synopsis

```
Var GetVar(int idx)
```

Arguments

idx: index of the desired variable.

Return

the desired variable object.

Model.GetVarByName()

Get a variable of given name in model.

Synopsis

```
Var GetVarByName(string name)
```

Arguments

name: name of the desired variable.

Return

the desired variable object.

Model.GetVarLowerIIS()

Get IIS status of lower bounds of variables.

Synopsis

```
int[] GetVarLowerIIS(VarArray vars)
```

Arguments

vars: Array of variables.

Return

IIS status of lower bounds of variables.

Model.GetVarLowerIIS()

Get IIS status of lower bounds of variables.

Synopsis

```
int[] GetVarLowerIIS(Var[] vars)
```

Arguments

vars: Array of variables.

Return

IIS status of lower bounds of variables.

Model.GetVars()

Get all variables in model.

Synopsis

```
VarArray GetVars()
```

Return

variable array object.

Model.GetVarUpperIIS()

Get IIS status of upper bounds of variables.

Synopsis

```
int[] GetVarUpperIIS(VarArray vars)
```

Arguments

vars: Array of variables.

Return

IIS status of upper bounds of variables.

Model.GetVarUpperIIS()

Get IIS status of upper bounds of variables.

Synopsis

```
int[] GetVarUpperIIS(Var[] vars)
```

Arguments

vars: Array of variables.

Return

IIS status of upper bounds of variables.

Model.Interrupt()

Interrupt optimization of current problem.

Synopsis

```
void Interrupt()
```

Model.LoadMipStart()

Load final initial values of variables to the problem.

Synopsis

```
void LoadMipStart()
```

Model.LoadTuneParam()

Load specified tuned parameters into model.

Synopsis

```
void LoadTuneParam(int idx)
```

Arguments

idx: Index of tuned parameters.

Model.Read()

Read problem, solution, basis, MIP start or COPT parameters from file.

Synopsis

```
void Read(string filename)
```

Arguments

filename: an input file name.

Model.ReadBasis()

Read basis from file.

Synopsis

```
void ReadBasis(string filename)
```

Arguments

filename: an input file name

Model.ReadBin()

Read problem in COPT binary format from file.

Synopsis

```
void ReadBin(string filename)
```

Arguments

filename: an input file name.

Model.ReadCbf()

Read problem in CBF format from file.

Synopsis

```
void ReadCbf(string filename)
```

Arguments

filename: an input file name.

Model.ReadLp()

Read problem in LP format from file.

Synopsis

```
void ReadLp(string filename)
```

Arguments

filename: an input file name.

Model.ReadMps()

Read problem in MPS format from file.

Synopsis

```
void ReadMps(string filename)
```

Arguments

filename: an input file name.

Model.ReadMst()

Read MIP start information from file.

Synopsis

```
void ReadMst(string filename)
```

Arguments

filename: an input file name.

Model.ReadParam()

Read COPT parameters from file.

Synopsis

```
void ReadParam(string filename)
```

Arguments

filename: an input file name.

Model.ReadSdpa()

Read problem in SDPA format from file.

Synopsis

```
void ReadSdpa(string filename)
```

Arguments

filename: an input file name.

Model.ReadSol()

Read solution from file.

Synopsis

```
void ReadSol(string filename)
```

Arguments

filename: an input file name.

Model.ReadTune()

Read tuning parameters from file.

Synopsis

```
void ReadTune(string filename)
```

Arguments

filename: an input file name.

Model.Remove()

Remove an array of variables from model.

Synopsis

```
void Remove(Var[] vars)
```

Arguments

vars: a list of variables.

Model.Remove()

Remove an array of variables from model.

Synopsis

```
void Remove(VarArray vars)
```

Arguments

vars: array of variables.

Model.Remove()

Remove a list of constraints from model.

Synopsis

```
void Remove(Constraint[] constrs)
```

Arguments

constrs: a list of constraints.

Model.Remove()

Remove a list of constraints from model.

Synopsis

```
void Remove(ConstrArray constrs)
```

Arguments

constrs: an array of constraints.

Model.Remove()

Remove a list of SOS constraints from model.

Synopsis

```
void Remove(Sos[] soss)
```

Arguments

soss: a list of SOS constraints.

Model.Remove()

Remove a list of SOS constraints from model.

Synopsis

```
void Remove(SosArray soss)
```

Arguments

soss: an array of SOS constraints.

Model.Remove()

Remove a list of cone constraints from model.

Synopsis

```
void Remove(Cone[] cones)
```

Arguments

cones: a list of cone constraints.

Model.Remove()

Remove a list of cone constraints from model.

Synopsis

```
void Remove(ConeArray cones)
```

Arguments

cones: an array of cone constraints.

Model.Remove()

Remove a list of exponential cone constraints from model.

Synopsis

```
void Remove(ExpCone[] cones)
```

Arguments

cones: a list of exponential cone constraints.

Model.Remove()

Remove a list of exponential cone constraints from model.

Synopsis

```
void Remove(ExpConeArray cones)
```

Arguments

cones: an array of exponential cone constraints.

Model.Remove()

Remove a list of affine cone constraints from model.

Synopsis

```
void Remove(AffineCone[] cones)
```

Arguments

cones: a list of affine cone constraints.

Model.Remove()

Remove an array of affine cone constraints from model.

Synopsis

```
void Remove(AffineConeArray cones)
```

Arguments

cones: an array of affine cone constraints.

Model.Remove()

Remove a list of gernal constraints from model.

Synopsis

```
void Remove(GenConstr[] genConstrs)
```

Arguments

genConstrs: a list of general constraints.

Model.Remove()

Remove a list of gernal constraints from model.

Synopsis

```
void Remove(GenConstrArray genConstrs)
```

Arguments

genConstrs: an array of general constraints.

Model.Remove()

Remove a list of quadratic constraints from model.

Synopsis

```
void Remove(QConstraint[] qconstrs)
```

Arguments

qconstrs: an array of quadratic constraints.

Model.Remove()

Remove a list of quadratic constraints from model.

Synopsis

```
void Remove(QConstrArray qconstrs)
```

Arguments

qconstrs: an array of quadratic constraints.

Model.Remove()

Remove a list of PSD variables from model.

Synopsis

```
void Remove(PsdVar[] vars)
```

Arguments

vars: an array of PSD variables.

Model.Remove()

Remove a list of PSD variables from model.

Synopsis

```
void Remove(PsdVarArray vars)
```

Arguments

vars: an array of PSD variables.

Model.Remove()

Remove a list of PSD constraints from model.

Synopsis

```
void Remove(PsdConstraint[] constra)
```

Arguments

constra: an array of PSD constraints.

Model.Remove()

Remove a list of PSD constraints from model.

Synopsis

```
void Remove(PsdConstrArray constra)
```

Arguments

constra: an array of PSD constraints.

Model.Remove()

Remove a list of LMI constraints from model.

Synopsis

```
void Remove(LmiConstrArray constra)
```

Arguments

constra: an array of LMI constraints.

Model.Remove()

Remove a list of LMI constraints from model.

Synopsis

```
void Remove(LmiConstraint[] constra)
```

Arguments

constra: an array of LMI constraints.

Model.Reset()

Reset solution of problem only.

Synopsis

```
void Reset()
```

Model.ResetAll()

Reset solution in problem, and additional information such as MIP start, etc.

Synopsis

```
void ResetAll()
```

Model.ResetParam()

Reset parameters to default settings.

Synopsis

```
void ResetParam()
```

Model.Set()

Set values of information associated with variables.

Synopsis

```
void Set(  
    string name,  
    Var[] vars,  
    double[] vals)
```

Arguments

name: name of information.

vars: a list of interested variables.

vals: values of information.

Model.Set()

Set values of information associated with variables.

Synopsis

```
void Set(  
    string name,  
    VarArray vars,  
    double[] vals)
```

Arguments

name: name of information.

vars: array of interested variables.

vals: values of information.

Model.Set()

Set values of information associated with constraints.

Synopsis

```
void Set(  
    string name,  
    Constraint[] constrs,  
    double[] vals)
```

Arguments

name: name of information.
constrs: a list of interested constraints.
vals: values of information.

Model.Set()

Set values of information associated with constraints.

Synopsis

```
void Set(  
    string name,  
    ConstrArray constrs,  
    double[] vals)
```

Arguments

name: name of information.
constrs: array of interested constraints.
vals: values of information.

Model.Set()

Set values of information associated with PSD constraints.

Synopsis

```
void Set(  
    string name,  
    PsdConstraint[] constrs,  
    double[] vals)
```

Arguments

name: name of information.
constrs: a list of desired PSD constraints.
vals: array of values of information.

Model.Set()

Set values of information associated with PSD constraints.

Synopsis

```
void Set(  
    string name,  
    PsdConstrArray constrs,  
    double[] vals)
```

Arguments

name: name of information.
constrs: a list of desired PSD constraints.
vals: array of values of information.

Model.SetBasis()

Set column and row basis status to model.

Synopsis

```
void SetBasis(int[] colbasis, int[] rowbasis)
```

Arguments

colbasis: status of column basis.
rowbasis: status of row basis.

Model.SetCallback()

Set user callback to COPT model.

Synopsis

```
void SetCallback(CallbackBase cb, int cbctx)
```

Arguments

cb: user callback instance, inheriting from CallbackBase class.
cbctx: COPT callback context.

Model.SetCoeff()

Set the coefficient of a variable in a linear constraint.

Synopsis

```
void SetCoeff(  
    Constraint constr,  
    Var var,  
    double newVal)
```

Arguments

constr: The requested constraint.

var: The requested variable.

newVal: New coefficient.

Model.SetCoeffs()

Set a list of coefficients in the model.

Synopsis

```
void SetCoeffs(  
    Constraint[] constrs,  
    Var[] vars,  
    double[] vals)
```

Arguments

constrs: Array of constraints for coefficients to be set.

vars: Array of vars for coefficients to be set.

vals: New values for coefficients.

Model.SetCoeffs()

Set a list of coefficients in the model.

Synopsis

```
void SetCoeffs(  
    ConstrArray constrs,  
    VarArray vars,  
    double[] vals)
```

Arguments

constrs: A list of constraints for coefficients to be set.

vars: A list of vars for coefficients to be set.

vals: New values for coefficients.

Model.SetDbiParam()

Set value of a COPT double parameter.

Synopsis

```
void SetDbiParam(string param, double val)
```

Arguments

param: name of integer parameter.

val: double value.

Model.SetIntParam()

Set value of a COPT integer parameter.

Synopsis

```
void SetIntParam(string param, int val)
```

Arguments

param: name of integer parameter.

val: integer value.

Model.SetLmiCoeff()

Set the coefficient matrix of a variable in LMI constraint.

Synopsis

```
void SetLmiCoeff(  
    LmiConstraint constr,  
    Var var,  
    SymMatrix mat)
```

Arguments

constr: The desired LMI constraint.

var: The desired variable.

mat: new coefficient matrix.

Model.SetLmiRhs()

Set constant matrix of LMI constraint.

Synopsis

```
void SetLmiRhs(LmiConstraint constr, SymMatrix mat)
```

Arguments

constr: The desired LMI constraint.

mat: new constant matrix.

Model.SetLpSolution()

Set LP solution.

Synopsis

```
void SetLpSolution(  
    double[] value,  
    double[] slack,  
    double[] rowDual,  
    double[] redCost)
```

Arguments

`value`: solution values.
`slack`: slack values.
`rowDual`: dual values.
`redCost`: reduced costs.

Model.SetMipStart()

Set initial values for variables of given number, starting from the first one.

Synopsis

```
void SetMipStart(int count, double[] vals)
```

Arguments

`count`: the number of variables to set.
`vals`: values of variables.

Model.SetMipStart()

Set initial value for the specified variable.

Synopsis

```
void SetMipStart(Var var, double val)
```

Arguments

`var`: an interested variable.
`val`: initial value of the variable.

Model.SetMipStart()

Set initial value for the specified variable.

Synopsis

```
void SetMipStart(Var[] vars, double[] vals)
```

Arguments

`vars`: a list of interested variables.
`vals`: initial values of the variables.

Model.SetMipStart()

Set initial value for the specified variable.

Synopsis

```
void SetMipStart(VarArray vars, double[] vals)
```

Arguments

`vars`: a list of interested variables.
`vals`: initial values of the variables.

Model.SetNames()

Set names for given variables in model.

Synopsis

```
void SetNames(Var[] vars, string[] names)
```

Arguments

vars: array of variables.

names: string array of names for variables.

Model.SetNames()

Set names for given variables in model.

Synopsis

```
void SetNames(VarArray vars, string[] names)
```

Arguments

vars: a list of variables.

names: string array of names for variables.

Model.SetNames()

Set names for given constraints in model.

Synopsis

```
void SetNames(Constraint[] cons, string[] names)
```

Arguments

cons: array of constraints.

names: string array of names for constraints.

Model.SetNames()

Set names for given constraints in model.

Synopsis

```
void SetNames(ConstrArray cons, string[] names)
```

Arguments

cons: a list of constraints.

names: string array of names for constraints.

Model.SetNames()

Set names for given general constraints in model.

Synopsis

```
void SetNames(GenConstr[] genConstrs, string[] names)
```

Arguments

genConstrs: array of general constraints.

names: string array of names for general constraints.

Model.SetNames()

Set names for given general constraints in model.

Synopsis

```
void SetNames(GenConstrArray genConstrs, string[] names)
```

Arguments

genConstrs: a list of general constraints.

names: string array of names for general constraints.

Model.SetNames()

Set names for given quadratic constraints in model.

Synopsis

```
void SetNames(QConstraint[] cons, string[] names)
```

Arguments

cons: array of quadratic constraints.

names: string array of names for quadratic constraints.

Model.SetNames()

Set names for given quadratic constraints in model.

Synopsis

```
void SetNames(QConstrArray cons, string[] names)
```

Arguments

cons: a list of quadratic constraints.

names: string array of names for quadratic constraints.

Model.SetNames()

Set names for given PSD variables in model.

Synopsis

```
void SetNames(PsdVar[] vars, string[] names)
```

Arguments

vars: array of PSD variables.

names: string array of names for PSD variables.

Model.SetNames()

Set names for given PSD variables in model.

Synopsis

```
void SetNames(PsdVarArray vars, string[] names)
```

Arguments

vars: a list of PSD variables.

names: string array of names for PSD variables.

Model.SetNames()

Set names for given PSD constraints in model.

Synopsis

```
void SetNames(PsdConstraint[] cons, string[] names)
```

Arguments

cons: array of PSD constraints.

names: string array of names for PSD constraints.

Model.SetNames()

Set names for given PSD constraints in model.

Synopsis

```
void SetNames(PsdConstrArray cons, string[] names)
```

Arguments

cons: a list of PSD constraints.

names: string array of names for PSD constraints.

Model.SetNames()

Set names for given LMI constraints in model.

Synopsis

```
void SetNames(LmiConstraint[] cons, string[] names)
```

Arguments

cons: array of LMI constraints.

names: string array of names for LMI constraints.

Model.SetNames()

Set names for given LMI constraints in model.

Synopsis

```
void SetNames(LmiConstrArray cons, string[] names)
```

Arguments

cons: a list of LMI constraints.

names: string array of names for LMI constraints.

Model.SetNames()

Set names for given affine cone constraints in model.

Synopsis

```
void SetNames(AffineConeArray cones, string[] names)
```

Arguments

cones: an array of affine cone constraints.

names: string array of names for affine cone constraints.

Model.SetObjConst()

Set objective constant.

Synopsis

```
void SetObjConst(double constant)
```

Arguments

constant: constant value to set.

Model.SetObjective()

Set objective for model.

Synopsis

```
void SetObjective(MExpression expr, int sense)
```

Arguments

expr: expression of the objective.

sense: optimization sense. optional, default value 0 does not change COPT sense

Model.SetObjSense()

Set objective sense for model.

Synopsis

```
void SetObjSense(int sense)
```

Arguments

sense: the objective sense.

Model.SetPsdCoeff()

Set the coefficient matrix of a PSD variable in a PSD constraint.

Synopsis

```
void SetPsdCoeff(  
    PsdConstraint constr,  
    PsdVar var,  
    SymMatrix mat)
```

Arguments

constr: The desired PSD constraint.

var: The desired PSD variable.

mat: new coefficient matrix.

Model.SetPsdObjective()

Set PSD objective for model.

Synopsis

```
void SetPsdObjective(PsdExpr expr, int sense)
```

Arguments

expr: PSD expression of the objective.

sense: optimization sense. optional, default value 0 does not change COPT sense.

Model.SetQuadObjective()

Set quadratic objective for model.

Synopsis

```
void SetQuadObjective(QuadExpr expr, int sense)
```

Arguments

expr: quadratic expression of the objective.

sense: optimization sense. optional, default value 0 does not change COPT sense.

Model.SetSlackBasis()

Set slack basis to model.

Synopsis

```
void SetSlackBasis()
```

Model.SetSolverLogFile()

Set log file for COPT.

Synopsis

```
void SetSolverLogFile(string filename)
```

Arguments

filename: log file name.

Model.Solve()

Solve the model as MIP.

Synopsis

```
void Solve()
```

Model.SolveLp()

Solve the model as LP.

Synopsis

```
void SolveLp()
```

Model.Tune()

Tune model.

Synopsis

```
void Tune()
```

Model.Write()

Output problem, solution, basis, MIP start or modified COPT parameters to file.

Synopsis

```
void Write(string filename)
```

Arguments

filename: an output file name.

Model.WriteBasis()

Output optimal basis to a file of type '.bas'.

Synopsis

```
void WriteBasis(string filename)
```

Arguments

filename: an output file name.

Model.WriteBin()

Output problem to a file as COPT binary format.

Synopsis

```
void WriteBin(string filename)
```

Arguments

filename: an output file name.

Model.WriteIIS()

Output IIS to file.

Synopsis

```
void WriteIIS(string filename)
```

Arguments

filename: Output file name.

Model.WriteLp()

Output problem to a file as LP format.

Synopsis

```
void WriteLp(string filename)
```

Arguments

filename: an output file name.

Model.WriteMps()

Output problem to a file as MPS format.

Synopsis

```
void WriteMps(string filename)
```

Arguments

filename: an output file name.

Model.WriteMpsStr()

Output MPS problem to problem buffer.

Synopsis

```
ProbBuffer WriteMpsStr()
```

Return

problem buffer for string of MPS problem.

Model.WriteMst()

Output MIP start information to a file of type '.mst'.

Synopsis

```
void WriteMst(string filename)
```

Arguments

filename: an output file name.

Model.WriteParam()

Output modified COPT parameters to a file of type '.par'.

Synopsis

```
void WriteParam(string filename)
```

Arguments

filename: an output file name.

Model.WritePoolSol()

Output selected pool solution to a file of type '.sol'.

Synopsis

```
void WritePoolSol(int idx, string filename)
```

Arguments

idx: index of pool solution.

filename: an output file name.

Model.WriteRelax()

Output feasibility relaxation problem to file.

Synopsis

```
void WriteRelax(string filename)
```

Arguments

filename: Output file name.

Model.WriteSol()

Output solution to a file of type ‘.sol’.

Synopsis

```
void WriteSol(string filename)
```

Arguments

filename: an output file name.

Model.WriteTuneParam()

Output specified tuned parameters to a file of type ‘.par’.

Synopsis

```
void WriteTuneParam(int idx, string filename)
```

Arguments

idx: Index of tuned parameters.

filename: Output file name.

24.2.4 Var

COPT variable object. Variables are always associated with a particular model. User creates a variable object by adding a variable to a model, rather than by using constructor of Var class.

Var.Get()

Get information value of the variable. Support informations of “Value”, “RedCost”, “LB”, “UB”, and “Obj”.

Synopsis

```
double Get(string info)
```

Arguments

info: information name.

Return

information value.

Var.GetBasis()

Get basis status of the variable.

Synopsis

```
int GetBasis()
```

Return

Basis status.

Var.GetIdx()

Get index of the variable.

Synopsis

```
int GetIdx()
```

Return

variable index.

Var.GetLowerIIS()

Get IIS status for lower bound of the variable.

Synopsis

```
int GetLowerIIS()
```

Return

IIS status.

Var.GetName()

Get name of the variable.

Synopsis

```
string GetName()
```

Return

variable name.

Var.GetType()

Get type of the variable.

Synopsis

```
char GetType()
```

Return

variable type.

Var.GetUpperIIS()

Get IIS status for upper bound of the variable.

Synopsis

```
int GetUpperIIS()
```

Return

IIS status.

Var.Remove()

Remove variable from model.

Synopsis

```
void Remove()
```

Var.Set()

Set information value of the variable. Support informations of “LB”, “UB” and “Obj”.

Synopsis

```
void Set(string info, double val)
```

Arguments

info: information name.

val: new information value.

Var.SetName()

Set name of the variable.

Synopsis

```
void SetName(string name)
```

Arguments

name: variable name.

Var.SetType()

Set type of the variable.

Synopsis

```
void SetType(char vtype)
```

Arguments

vtype: variable type.

24.2.5 VarArray

COPT variable array object. To store and access a set of C# *Var* objects, Cardinal Optimizer provides C# VarArray class, which defines the following methods.

VarArray.VarArray()

Constructor of vararray.

Synopsis

```
VarArray()
```

VarArray.GetVar()

Get idx-th variable object.

Synopsis

```
Var GetVar(int idx)
```

Arguments

idx: index of the variable.

Return

variable object with index idx.

VarArray.PushBack()

Add a variable object to variable array.

Synopsis

```
void PushBack(Var var)
```

Arguments

var: a variable object.

VarArray.Size()

Get the number of variable objects.

Synopsis

```
int Size()
```

Return

number of variable objects.

24.2.6 Expr

COPT linear expression object. A linear expression consists of a constant term, a list of terms of variables and associated coefficients. Linear expressions are used to build constraints.

Expr.Expr()

Constructor of a constant linear expression with default constant value 0.

Synopsis

```
Expr(double constant)
```

Arguments

constant: optional, constant value in expression object.

Expr.Expr()

Constructor of a linear expression with one term.

Synopsis

```
Expr(Var var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term with default value 1.0.

Expr.AddConstant()

Add extra constant to the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: delta value to be added to expression constant.

Expr.AddExpr()

Add an expression to self.

Synopsis

```
void AddExpr(Expr expr, double mult)
```

Arguments

expr: expression to be added.

mult: multiply constant.

Expr.AddTerm()

Add a term to expression object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: a variable for new term.

coeff: coefficient for new term.

Expr.AddTerms()

Add terms to expression object.

Synopsis

```
void AddTerms(Var[] vars, double coeff)
```

Arguments

vars: variables for added terms.

coeff: coefficient array for added terms with default value 1.0.

Expr.AddTerms()

Add terms to expression object.

Synopsis

```
void AddTerms(Var[] vars, double[] coeffs)
```

Arguments

vars: variables for added terms.

coeffs: coefficients array for added terms.

Expr.AddTerms()

Add terms to expression object.

Synopsis

```
void AddTerms(VarArray vars, double coeff)
```

Arguments

vars: variables for added terms.

coeff: coefficient array for added terms with default value 1.0.

Expr.AddTerms()

Add terms to expression object.

Synopsis

```
void AddTerms(VarArray vars, double[] coeffs)
```

Arguments

vars: variables for added terms.

coeffs: coefficients array for added terms.

Expr.Clone()

Deep copy linear expression object.

Synopsis

```
Expr Clone()
```

Return

cloned linear expression object.

Expr.GetCoeff()

Get coefficient from the i-th term in expression.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in expression object.

Expr.GetConstant()

Get constant in expression.

Synopsis

```
double GetConstant()
```

Return

constant in expression.

Expr.GetVar()

Get variable from the i-th term in expression.

Synopsis

```
Var GetVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in expression object.

Expr.Remove()

Remove idx-th term from expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

Expr.Remove()

Remove the term associated with variable from expression.

Synopsis

```
void Remove(Var var)
```

Arguments

var: a variable whose term should be removed.

Expr.SetCoeff()

Set coefficient for the i-th term in expression.

Synopsis

```
void SetCoeff(int i, double val)
```

Arguments

i: index of the term.

val: coefficient of the term.

Expr.SetConstant()

Set constant for the expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

Expr.Size()

Get number of terms in expression.

Synopsis

```
long Size()
```

Return

number of terms.

24.2.7 Constraint

COPT constraint object. Constraints are always associated with a particular model. User creates a constraint object by adding a constraint to a model, rather than by using constructor of Constraint class.

Constraint.Get()

Get information value of the constraint. Support informations of “Dual”, “Slack”, “LB”, “UB”.

Synopsis

```
double Get(string info)
```

Arguments

info: name of information being queried.

Return

information value.

Constraint.GetBasis()

Get basis status of this constraint.

Synopsis

```
int GetBasis()
```

Return

basis status.

Constraint.GetIdx()

Get index of the constraint.

Synopsis

```
int GetIdx()
```

Return

the index of the constraint.

Constraint.GetLowerIIS()

Get IIS status for lower bound of the constraint.

Synopsis

```
int GetLowerIIS()
```

Return

IIS status.

Constraint.GetName()

Get name of the constraint.

Synopsis

```
string GetName()
```

Return

the name of the constraint.

Constraint.GetUpperIIS()

Get IIS status for upper bound of the constraint.

Synopsis

```
int GetUpperIIS()
```

Return

IIS status.

Constraint.Remove()

Remove this constraint from model.

Synopsis

```
void Remove()
```

Constraint.Set()

Set information value of the constraint. Support informations of “LB” and “UB”.

Synopsis

```
void Set(string info, double val)
```

Arguments

info: name of information.

val: new information value.

Constraint.SetName()

Set name for the constraint.

Synopsis

```
void SetName(string name)
```

Arguments

name: the name to set.

24.2.8 ConstrArray

COPT constraint array object. To store and access a set of C# *Constraint* objects, Cardinal Optimizer provides C# *ConstrArray* class, which defines the following methods.

ConstrArray.ConstrArray()

Constructor of constrarray object.

Synopsis

```
ConstrArray()
```

ConstrArray.GetConstr()

Get idx-th constraint object.

Synopsis

```
Constraint GetConstr(int idx)
```

Arguments

idx: index of the constraint.

Return

constraint object with index idx.

ConstrArray.PushBack()

Add a constraint object to constraint array.

Synopsis

```
void PushBack(Constraint constr)
```

Arguments

constr: a constraint object.

ConstrArray.Size()

Get the number of constraint objects.

Synopsis

```
int Size()
```

Return

number of constraint objects.

24.2.9 ConstrBuilder

COPT constraint builder object. To help building a constraint, given a linear expression, constraint sense and right-hand side value, Cardinal Optimizer provides C# ConstrBuilder class, which defines the following methods.

ConstrBuilder.ConstrBuilder()

Constructor of constrbuilder object.

Synopsis

```
ConstrBuilder()
```

ConstrBuilder.GetExpr()

Get expression associated with constraint.

Synopsis

```
Expr GetExpr()
```

Return

expression object.

ConstrBuilder.GetRange()

Get range from lower bound to upper bound of range constraint.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of the constraint.

ConstrBuilder.GetSense()

Get sense associated with constraint.

Synopsis

```
char GetSense()
```

Return

constraint sense.

ConstrBuilder.Set()

Set detail of a constraint to its builder object.

Synopsis

```
void Set(  
    Expr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the constraint

sense: constraint sense other than COPT_RANGE.

rhs: constant of right side of the constraint.

ConstrBuilder.SetRange()

Set a range constraint to its builder.

Synopsis

```
void SetRange(Expr expr, double range)
```

Arguments

expr: expression object, whose constant is negative upper bound.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

24.2.10 ConstrBuilderArray

COPT constraint builder array object. To store and access a set of C# *ConstrBuilder* objects, Cardinal Optimizer provides C# *ConstrBuilderArray* class, which defines the following methods.

ConstrBuilderArray.ConstrBuilderArray()

Constructor of constrbuilderarray object.

Synopsis

```
ConstrBuilderArray()
```

ConstrBuilderArray.GetBuilder()

Get idx-th constraint builder object.

Synopsis

```
ConstrBuilder GetBuilder(int idx)
```

Arguments

idx: index of the constraint builder.

Return

constraint builder object with index idx.

ConstrBuilderArray.PushBack()

Add a constraint builder object to constraint builder array.

Synopsis

```
void PushBack(ConstrBuilder builder)
```

Arguments

builder: a constraint builder object.

ConstrBuilderArray.Size()

Get the number of constraint builder objects.

Synopsis

```
int Size()
```

Return

number of constraint builder objects.

24.2.11 Column

COPT column object. A column consists of a list of constraints and associated coefficients. Columns are used to represent the set of constraints in which a variable participates, and the associated coefficients.

Column.Column()

Constructor of column.

Synopsis

`Column()`

Column.AddColumn()

Add a column to self.

Synopsis

`void AddColumn(Column col, double mult)`

Arguments

`col`: column object to be added.

`mult`: multiply constant.

Column.AddTerm()

Add a term to column object.

Synopsis

`void AddTerm(Constraint constr, double coeff)`

Arguments

`constr`: a constraint for new term.

`coeff`: coefficient for new term.

Column.AddTerms()

Add terms to column object.

Synopsis

`void AddTerms(Constraint[] constra, double coeff)`

Arguments

`constra`: constraints for added terms.

`coeff`: coefficient for added terms,default value is 1.

Column.AddTerms()

Add terms to column object.

Synopsis

`void AddTerms(Constraint[] constra, double[] coeffs)`

Arguments

`constra`: constraints for added terms.

`coeffs`: coefficients for added terms.

Column.AddTerms()

Add terms to column object.

Synopsis

```
void AddTerms(ConstrArray constrs, double coeff)
```

Arguments

constrs: constraints for added terms.

coeff: coefficient for added terms,default value is 1.

Column.AddTerms()

Add terms to column object.

Synopsis

```
void AddTerms(ConstrArray constrs, double[] coeffs)
```

Arguments

constrs: constraints for added terms.

coeffs: coefficients for added terms.

Column.Clear()

Clear all terms.

Synopsis

```
void Clear()
```

Column.Clone()

Deep copy column object.

Synopsis

```
Column Clone()
```

Return

cloned column object.

Column.GetCoeff()

Get coefficient from the i-th term in column object.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in column object.

Column.GetConstr()

Get constraint from the i-th term in column object.

Synopsis

```
Constraint GetConstr(int i)
```

Arguments

i: index of the term.

Return

constraint of the i-th term in column object.

Column.Remove()

Remove idx-th term from column object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

Column.Remove()

Remove the term associated with constraint from column object.

Synopsis

```
void Remove(Constraint constr)
```

Arguments

constr: a constraint whose term should be removed.

Column.Size()

Get number of terms in column object.

Synopsis

```
int Size()
```

Return

number of terms.

24.2.12 ColumnArray

COPT column array object. To store and access a set of C# *Column* objects, Cardinal Optimizer provides C# *ColumnArray* class, which defines the following methods.

ColumnArray.ColumnArray()

Constructor of columnarray object.

Synopsis

```
ColumnArray()
```

ColumnArray.Clear()

Clear all column objects.

Synopsis

```
void Clear()
```

ColumnArray.GetColumn()

Get idx-th column object.

Synopsis

```
Column GetColumn(int idx)
```

Arguments

idx: index of the column.

Return

column object with index idx.

ColumnArray.PushBack()

Add a column object to column array.

Synopsis

```
void PushBack(Column col)
```

Arguments

col: a column object.

ColumnArray.Size()

Get the number of column objects.

Synopsis

```
int Size()
```

Return

number of column objects.

24.2.13 Sos

COPT SOS constraint object. SOS constraints are always associated with a particular model. User creates an SOS constraint object by adding an SOS constraint to a model, rather than by using constructor of Sos class.

An SOS constraint can be type 1 or 2 (COPT_SOS_TYPE1 or COPT_SOS_TYPE2).

Sos.GetIdx()

Get the index of SOS constraint.

Synopsis

```
int GetIdx()
```

Return

index of SOS constraint.

Sos.GetIIS()

Get IIS status of the SOS constraint.

Synopsis

```
int GetIIS()
```

Return

IIS status.

Sos.Remove()

Remove the SOS constraint from model.

Synopsis

```
void Remove()
```

24.2.14 SosArray

COPT SOS constraint array object. To store and access a set of C# *Sos* objects, Cardinal Optimizer provides C# SosArray class, which defines the following methods.

SosArray.SosArray()

Constructor of sosarray object.

Synopsis

```
SosArray()
```

SosArray.GetSos()

Get idx-th SOS object.

Synopsis

```
Sos GetSos(int idx)
```

Arguments

idx: index of SOS.

Return

SOS object with index idx.

SosArray.PushBack()

Add a SOS constraint object to SOS constraint array.

Synopsis

```
void PushBack(Sos sos)
```

Arguments

sos: a SOS constraint object.

SosArray.Size()

Get the number of SOS constraint objects.

Synopsis

```
int Size()
```

Return

number of SOS constraint objects.

24.2.15 SosBuilder

COPT SOS constraint builder object. To help building an SOS constraint, given the SOS type, a set of variables and associated weights, Cardinal Optimizer provides C# SosBuilder class, which defines the following methods.

SosBuilder.SosBuilder()

Constructor of sosbuilder object.

Synopsis

```
SosBuilder()
```

SosBuilder.GetSize()

Get number of terms in SOS constraint.

Synopsis

```
int GetSize()
```

Return

number of terms.

SosBuilder.GetType()

Get type of SOS constraint.

Synopsis

```
int GetType()
```

Return

type of SOS constraint.

SosBuilder.GetVar()

Get variable from the idx-th term in SOS constraint.

Synopsis

```
Var GetVar(int idx)
```

Arguments

idx: index of the term.

Return

variable of the idx-th term in SOS constraint.

SosBuilder.GetVars()

Get all variables in a SOS constraint.

Synopsis

```
VarArray GetVars()
```

Return

variables in a SOS constraint.

SosBuilder.GetWeight()

Get weight from the idx-th term in SOS constraint.

Synopsis

```
double GetWeight(int idx)
```

Arguments

idx: index of the term.

Return

weight of the idx-th term in SOS constraint.

SosBuilder.GetWeights()

Get weights of all terms in SOS constraint.

Synopsis

```
double[] GetWeights()
```

Return

array of weights.

SosBuilder.Set()

Set variables and weights of SOS constraint.

Synopsis

```
void Set(  
    VarArray vars,  
    double[] weights,  
    int type)
```

Arguments

vars: variable array object.

weights: pointer to array of weights.

type: type of SOS constraint.

24.2.16 SosBuilderArray

COPT SOS constraint builder array object. To store and access a set of C# *SosBuilder* objects, Cardinal Optimizer provides C# *SosBuilderArray* class, which defines the following methods.

SosBuilderArray.SosBuilderArray()

Constructor of sosbuilderarray object.

Synopsis

```
SosBuilderArray()
```

SosBuilderArray.GetBuilder()

Get idx-th SOS constraint builder object.

Synopsis

```
SosBuilder GetBuilder(int idx)
```

Arguments

idx: index of the SOS constraint builder.

Return

SOS constraint builder object with index idx.

SosBuilderArray.PushBack()

Add a SOS constraint builder object to SOS constraint builder array.

Synopsis

```
void PushBack(SosBuilder builder)
```

Arguments

builder: a SOS constraint builder object.

SosBuilderArray.Size()

Get the number of SOS constraint builder objects.

Synopsis

```
int Size()
```

Return

number of SOS constraint builder objects.

24.2.17 GenConstr

COPT general constraint object. General constraints are always associated with a particular model. User creates a general constraint object by adding a general constraint to a model, rather than by using constructor of GenConstr class.

GenConstr.GetIdx()

Get the index of the general constraint.

Synopsis

```
int GetIdx()
```

Return

index of the general constraint.

GenConstr.GetIIS()

Get IIS status of the general constraint.

Synopsis

```
int GetIIS()
```

Return

IIS status.

GenConstr.GetName()

Get name of general constraint.

Synopsis

```
string GetName()
```

Return

the name of general constraint.

GenConstr.Remove()

Remove the general constraint from model.

Synopsis

```
void Remove()
```

GenConstr.SetName()

Set name for general constraint.

Synopsis

```
void SetName(string name)
```

Arguments

name: the name to set.

24.2.18 GenConstrArray

COPT general constraint array object. To store and access a set of C# *GenConstr* objects, Cardinal Optimizer provides C# *GenConstrArray* class, which defines the following methods.

GenConstrArray.GenConstrArray()

Constructor of genconstrarray.

Synopsis

```
GenConstrArray()
```

GenConstrArray.GetGenConstr()

Get idx-th general constraint object.

Synopsis

```
GenConstr GetGenConstr(int idx)
```

Arguments

idx: index of the general constraint.

Return

general constraint object with index idx.

GenConstrArray.PushBack()

Add a general constraint object to general constraint array.

Synopsis

```
void PushBack(GenConstr genconstr)
```

Arguments

genconstr: a general constraint object.

GenConstrArray.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: capacity number of general constraint object.

GenConstrArray.Size()

Get the number of general constraint objects.

Synopsis

```
int Size()
```

Return

number of general constraint objects.

24.2.19 GenConstrBuilder

COPT general constraint builder object. To help building a general constraint, given a binary variable and associated value, a linear expression and constraint sense, Cardinal Optimizer provides C# GenConstrBuilder class, which defines the following methods.

GenConstrBuilder.GenConstrBuilder()

Constructor of genconstrbuilder.

Synopsis

```
GenConstrBuilder()
```

GenConstrBuilder.GetBinVal()

Get binary value associated with general constraint.

Synopsis

```
int GetBinVal()
```

Return

binary value.

GenConstrBuilder.GetBinVar()

Get binary variable associated with general constraint.

Synopsis

```
Var GetBinVar()
```

Return

binary variable object.

GenConstrBuilder.GetExpr()

Get expression associated with general constraint.

Synopsis

```
Expr GetExpr()
```

Return

expression object.

GenConstrBuilder.GetIndType()

Get type of general constraint.

Synopsis

```
int GetIndType()
```

Return

type of general constraint.

GenConstrBuilder.GetSense()

Get sense associated with general constraint.

Synopsis

```
char GetSense()
```

Return

constraint sense.

GenConstrBuilder.Set()

Set binary variable, binary value, expression and sense of general constraint.

Synopsis

```
void Set(  
    Var binvar,  
    int binval,  
    Expr expr,  
    char sense,  
    int type)
```

Arguments

binvar: binary variable.
binval: binary value.
expr: expression object.
sense: general constraint sense.
type: type of general constraint.

24.2.20 GenConstrBuilderArray

COPT general constraint builder array object. To store and access a set of C# *GenConstrBuilder* objects, Cardinal Optimizer provides C# *GenConstrBuilderArray* class, which defines the following methods.

GenConstrBuilderArray.GenConstrBuilderArray()

Constructor of *genconstrbuilderarray*.

Synopsis

```
GenConstrBuilderArray()
```

GenConstrBuilderArray.GetBuilder()

Get idx-th general constraint builder object.

Synopsis

```
GenConstrBuilder GetBuilder(int idx)
```

Arguments

idx: index of the general constraint builder.

Return

general constraint builder object with index **idx**.

GenConstrBuilderArray.PushBack()

Add a general constraint builder object to general constraint builder array.

Synopsis

```
void PushBack(GenConstrBuilder builder)
```

Arguments

builder: a general constraint builder object.

GenConstrBuilderArray.Size()

Get the number of general constraint builder objects.

Synopsis

```
int Size()
```

Return

number of general constraint builder objects.

24.2.21 Cone

COPT cone constraint object. Cone constraints are always associated with a particular model. User creates a cone constraint object by adding a cone constraint to a model, rather than by using constructor of Cone class.

A cone constraint can be regular or rotated (COPT_CONE_QUAD or COPT_CONE_RQUAD).

Cone.GetIdx()

Get the index of a cone constraint.

Synopsis

```
int GetIdx()
```

Return

index of the cone constraint.

Cone.Remove()

Remove the cone constraint from model.

Synopsis

```
void Remove()
```

24.2.22 ConeArray

COPT cone constraint array object. To store and access a set of C# *Cone* objects, Cardinal Optimizer provides C# ConeArray class, which defines the following methods.

ConeArray.ConeArray()

Constructor of ConeArray object.

Synopsis

```
ConeArray()
```

ConeArray.GetCone()

Get idx-th cone object.

Synopsis

```
Cone GetCone(int idx)
```

Arguments

idx: index of cone.

Return

cone object with index idx.

ConeArray.PushBack()

Add a cone constraint object to cone constraint array.

Synopsis

```
void PushBack(Cone cone)
```

Arguments

cone: a cone constraint object.

ConeArray.Size()

Get the number of cone constraint objects.

Synopsis

```
int Size()
```

Return

number of cone constraint objects.

24.2.23 ConeBuilder

COPT cone constraint builder object. To help building a cone constraint, given the cone type and a set of variables, Cardinal Optimizer provides C# ConeBuilder class, which defines the following methods.

ConeBuilder.ConeBuilder()

Constructor of ConeBuilder object.

Synopsis

```
ConeBuilder()
```

ConeBuilder.GetSize()

Get number of variables in a cone constraint.

Synopsis

```
int GetSize()
```

Return

number of variables.

ConeBuilder.GetType()

Get type of a cone constraint.

Synopsis

```
int GetType()
```

Return

type of the cone constraint.

ConeBuilder.GetVar()

Get i-th variable in a cone constraint.

Synopsis

```
Var GetVar(int idx)
```

Arguments

idx: index of vars.

Return

the i-th variable in a cone constraint.

ConeBuilder.GetVars()

Get all variables in a cone constraint.

Synopsis

```
VarArray GetVars()
```

Return

variables in a cone constraint.

ConeBuilder.Set()

Set variables and type of a cone constraint.

Synopsis

```
void Set(VarArray vars, int type)
```

Arguments

vars: variable array object.

type: type of a cone constraint.

24.2.24 ConeBuilderArray

COPT cone constraint builder array object. To store and access a set of C# *ConeBuilder* objects, Cardinal Optimizer provides C# *ConeBuilderArray* class, which defines the following methods.

ConeBuilderArray.ConeBuilderArray()

Constructor of *ConeBuilderArray* object.

Synopsis

```
ConeBuilderArray()
```

ConeBuilderArray.GetBuilder()

Get idx-th cone constraint builder object.

Synopsis

```
ConeBuilder GetBuilder(int idx)
```

Arguments

idx: index of the cone constraint builder.

Return

cone constraint builder object with index idx.

ConeBuilderArray.PushBack()

Add a cone constraint builder object to cone constraint builder array.

Synopsis

```
void PushBack(ConeBuilder builder)
```

Arguments

builder: a cone constraint builder object.

ConeBuilderArray.Size()

Get the number of cone constraint builder objects.

Synopsis

```
int Size()
```

Return

number of cone constraint builder objects.

24.2.25 ExpCone

COPT exponential cone constraint object. Exponential Cone constraints are always associated with a particular model. User creates an exponential cone constraint object by adding an exponential cone constraint to a model, rather than by using constructor of ExpCone class.

ExpCone.GetIdx()

Get the index of an exponential cone constraint.

Synopsis

```
int GetIdx()
```

Return

index of the exponential cone constraint.

ExpCone.Remove()

Remove the exponential cone constraint from model.

Synopsis

```
void Remove()
```

24.2.26 ExpConeArray

COPT exponential cone constraint array object. To store and access a set of C# *ExpCone* objects, Cardinal Optimizer provides C# *ExpConeArray* class, which defines the following methods.

ExpConeArray.ExpConeArray()

Constructor of *ExpConeArray* object.

Synopsis

```
ExpConeArray()
```

ExpConeArray.GetCone()

Get idx-th exponential cone object.

Synopsis

```
ExpCone GetCone(int idx)
```

Arguments

idx: index of exponential cone.

Return

exponential cone object with index idx.

ExpConeArray.PushBack()

Add an exponential cone constraint object to exponential cone constraint array.

Synopsis

```
void PushBack(ExpCone cone)
```

Arguments

cone: an exponential cone constraint object.

ExpConeArray.Size()

Get the number of exponential cone constraint objects.

Synopsis

```
int Size()
```

Return

number of exponential cone constraint objects.

24.2.27 ExpConeBuilder

COPT exponential cone constraint builder object. To help building an exponential cone constraint, given the exponential cone type and a set of variables, Cardinal Optimizer provides C# ExpConeBuilder class, which defines the following methods.

ExpConeBuilder.ExpConeBuilder()

Constructor of ExpConeBuilder object.

Synopsis

```
ExpConeBuilder()
```

ExpConeBuilder.GetSize()

Get number of variables in an exponential cone constraint.

Synopsis

```
int GetSize()
```

Return

number of variables.

ExpConeBuilder.GetType()

Get type of an exponential cone constraint.

Synopsis

```
int GetType()
```

Return

type of the exponential cone constraint.

ExpConeBuilder.GetVar()

Get i-th variable in an exponential cone constraint.

Synopsis

```
Var GetVar(int idx)
```

Arguments

idx: index of vars.

Return

the i-th variable in an exponential cone constraint.

ExpConeBuilder.GetVars()

Get all variables in an exponential cone constraint.

Synopsis

```
VarArray GetVars()
```

Return

variables in an exponential cone constraint.

ExpConeBuilder.Set()

Set variables and type of an exponential cone constraint.

Synopsis

```
void Set(VarArray vars, int type)
```

Arguments

vars: variable array object.

type: type of an exponential cone constraint.

24.2.28 ExpConeBuilderArray

COPT exponential cone constraint builder array object. To store and access a set of C# *ExpConeBuilder* objects, Cardinal Optimizer provides C# *ExpConeBuilderArray* class, which defines the following methods.

ExpConeBuilderArray.ExpConeBuilderArray()

Constructor of *ExpConeBuilderArray* object.

Synopsis

```
ExpConeBuilderArray()
```

ExpConeBuilderArray.GetBuilder()

Get idx-th exponential cone constraint builder object.

Synopsis

```
ExpConeBuilder GetBuilder(int idx)
```

Arguments

idx: index of the exponential cone constraint builder.

Return

exponential cone constraint builder object with index idx.

ExpConeBuilderArray.PushBack()

Add an exponential cone constraint builder object to exponential cone constraint builder array.

Synopsis

```
void PushBack(ExpConeBuilder builder)
```

Arguments

builder: an exponential cone constraint builder object.

ExpConeBuilderArray.Size()

Get the number of exponential cone constraint builder objects.

Synopsis

```
int Size()
```

Return

number of exponential cone constraint builder objects.

24.2.29 AffineCone

The *AffineCone* class in COPT encapsulates operations related to affine cones. The following methods are provided:

AffineCone.GetIdx()

Get the index of an affine cone constraint.

Synopsis

```
int GetIdx()
```

Return

index of the affine cone constraint.

AffineCone.GetName()

Get name of the affine cone.

Synopsis

```
string GetName()
```

Return

affine cone name.

AffineCone.Remove()

Remove the affine cone constraint from model.

Synopsis

```
void Remove()
```

AffineCone.SetName()

Set name of the affine cone.

Synopsis

```
void SetName(string name)
```

Arguments

name: affinecone name.

24.2.30 AffineConeArray

To facilitate operations on a group of C# *AffineCone* objects, the C# interface of COPT introduces the *AffineConeArray* class. The following methods are provided:

AffineConeArray.AffineConeArray()

Constructor of AffineConeArray object.

Synopsis

```
AffineConeArray()
```

AffineConeArray.GetCone()

Get idx-th affine cone object.

Synopsis

```
AffineCone GetCone(int idx)
```

Arguments

idx: index of affine cone.

Return

affine cone object with index idx.

AffineConeArray.PushBack()

Add an affine cone constraint object to affine cone constraint array.

Synopsis

```
void PushBack(AffineCone cone)
```

Arguments

cone: an affine cone constraint object.

AffineConeArray.Size()

Get the number of affine cone constraint objects.

Synopsis

```
int Size()
```

Return

number of affine cone constraint objects.

24.2.31 AffineConeBuilder

The *AffineConeBuilder* class in COPT encapsulates the builder for constructing affine cones. The following methods are provided:

AffineConeBuilder.AffineConeBuilder()

Constructor of AffineConeBuilder object.

Synopsis

```
AffineConeBuilder()
```

AffineConeBuilder.GetExpr()

Get i-th linear expression in an affine cone constraint.

Synopsis

```
Expr GetExpr(int idx)
```

Arguments

idx: index of linear expression.

Return

the i-th linear expression in an affine cone constraint.

AffineConeBuilder.GetExprs()

Get all linear expressions in an affine cone constraint.

Synopsis

```
Expr[] GetExprs()
```

Return

array of linear expressions.

AffineConeBuilder.GetPsdExpr()

Get idx-th PSD expression in an affine cone constraint.

Synopsis

```
PsdExpr GetPsdExpr(int idx)
```

Arguments

idx: index of PSD expression.

Return

the idx-th PSD expression in an affine cone constraint.

AffineConeBuilder.GetPsdExprs()

Get all PSD expressions in an affine cone constraint.

Synopsis

```
PsdExpr[] GetPsdExprs()
```

Return

array of PSD expressions.

AffineConeBuilder.GetSize()

Get number of variables in an affine cone constraint.

Synopsis

```
int GetSize()
```

Return

number of variables.

AffineConeBuilder.GetType()

Get type of an affine cone constraint.

Synopsis

```
int GetType()
```

Return

type of the affine cone constraint.

AffineConeBuilder.HasPsdTerm()

Check whether affine cone has PSD terms.

Synopsis

```
bool HasPsdTerm()
```

Return

flag to indicate whether affine cone has PSD terms.

AffineConeBuilder.Set()

Set linear expressions and type of an affine cone constraint.

Synopsis

```
void Set(Expr[] exprs, int type)
```

Arguments

exprs: array of linear expressions.

type: type of an affine cone constraint.

AffineConeBuilder.Set()

Set PSD expressions and type of an affine cone constraint.

Synopsis

```
void Set(PsdExpr[] exprs, int type)
```

Arguments

exprs: array of PSD expressions.

type: type of an affine cone constraint.

24.2.32 AffineConeBuilderArray

To facilitate operations on a group of C# *AffineConeBuilder* objects, the C# interface of COPT introduces the *AffineConeBuilderArray* class. The following methods are provided:

AffineConeBuilderArray.AffineConeBuilderArray()

Constructor of AffineConeBuilderArray object.

Synopsis

```
AffineConeBuilderArray()
```

AffineConeBuilderArray.GetBuilder()

Get idx-th affine cone constraint builder object.

Synopsis

```
AffineConeBuilder GetBuilder(int idx)
```

Arguments

idx: index of the affine cone constraint builder.

Return

affine cone constraint builder object with index idx.

AffineConeBuilderArray.PushBack()

Add an affine cone constraint builder object to affine cone constraint builder array.

Synopsis

```
void PushBack(AffineConeBuilder builder)
```

Arguments

builder: an affine cone constraint builder object.

AffineConeBuilderArray.Size()

Get the number of affine cone constraint builder objects.

Synopsis

```
int Size()
```

Return

number of affine cone constraint builder objects.

24.2.33 QuadExpr

COPT quadratic expression object. A quadratic expression consists of a linear expression, a list of variable pairs and associated coefficients of quadratic terms. Quadratic expressions are used to build quadratic constraints and objectives.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with default constant value 0.

Synopsis

```
QuadExpr(double constant)
```

Arguments

constant: optional, constant value in quadratic expression object.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with one linear term.

Synopsis

```
QuadExpr(Var var, double coeff)
```

Arguments

var: variable of the added linear term.

coeff: coefficient for the added linear term with default value 1.0.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with a linear expression.

Synopsis

```
QuadExpr(Expr expr)
```

Arguments

expr: linear expression added to the quadratic expression.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with two linear expression.

Synopsis

```
QuadExpr(Expr expr, Var var)
```

Arguments

expr: one linear expression.

var: another variable.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with two linear expression.

Synopsis

```
QuadExpr(Expr left, Expr right)
```

Arguments

left: one linear expression.

right: another linear expression.

QuadExpr.AddConstant()

Add a constant to the quadratic expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: value to be added.

QuadExpr.AddLinExpr()

Add a linear expression to self.

Synopsis

```
void AddLinExpr(Expr expr)
```

Arguments

expr: linear expression to be added.

QuadExpr.AddLinExpr()

Add a linear expression to self.

Synopsis

```
void AddLinExpr(Expr expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: multiplier constant.

QuadExpr.AddQuadExpr()

Add a quadratic expression to self.

Synopsis

```
void AddQuadExpr(QuadExpr expr)
```

Arguments

expr: quadratic expression to be added.

QuadExpr.AddQuadExpr()

Add a quadratic expression to self.

Synopsis

```
void AddQuadExpr(QuadExpr expr, double mult)
```

Arguments

expr: quadratic expression to be added.

mult: multiplier constant.

QuadExpr.AddTerm()

Add a term to quadratic expression object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: a variable of new term.

coeff: coefficient of new term.

QuadExpr.AddTerm()

Add a quadratic term to expression object.

Synopsis

```
void AddTerm(  
    Var var1,  
    Var var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.
var2: second variable of new quadratic term.
coeff: coefficient of new quadratic term.

QuadExpr.AddTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void AddTerms(Var[] vars, double coeff)
```

Arguments

vars: variables of added linear terms.
coeff: one coefficient for added linear terms.

QuadExpr.AddTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void AddTerms(Var[] vars, double[] coeffs)
```

Arguments

vars: variables of added linear terms.
coeffs: coefficients of added linear terms.

QuadExpr.AddTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void AddTerms(VarArray vars, double coeff)
```

Arguments

vars: variables of added linear terms.
coeff: one coefficient for added linear terms.

QuadExpr.AddTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void AddTerms(VarArray vars, double[] coeffs)
```

Arguments

vars: variables of added terms.
coeffs: coefficients of added terms.

QuadExpr.AddTerms()

Add quadratic terms to expression object.

Synopsis

```
void AddTerms(  
    VarArray vars1,  
    VarArray vars2,  
    double[] coeffs)
```

Arguments

vars1: first set of variables for added quadratic terms.
vars2: second set of variables for added quadratic terms.
coeffs: coefficient array for added quadratic terms.

QuadExpr.AddTerms()

Add quadratic terms to expression object.

Synopsis

```
void AddTerms(  
    Var[] vars1,  
    Var[] vars2,  
    double[] coeffs)
```

Arguments

vars1: first set of variables for added quadratic terms.
vars2: second set of variables for added quadratic terms.
coeffs: coefficient array for added quadratic terms.

QuadExpr.Clone()

Deep copy quadratic expression object.

Synopsis

```
QuadExpr Clone()
```

Return

cloned quadratic expression object.

QuadExpr.Evaluate()

evaluate quadratic expression after solving

Synopsis

```
double Evaluate()
```

Return

value of quadratic expression

QuadExpr.GetCoeff()

Get coefficient from the i-th term in quadratic expression.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in quadratic expression object.

QuadExpr.GetConstant()

Get constant in quadratic expression.

Synopsis

```
double GetConstant()
```

Return

constant in quadratic expression.

QuadExpr.GetLinExpr()

Get linear expression in quadratic expression.

Synopsis

```
Expr GetLinExpr()
```

Return

linear expression object.

QuadExpr.GetVar1()

Get first variable from the i-th term in quadratic expression.

Synopsis

```
Var GetVar1(int i)
```

Arguments

i: index of the term.

Return

first variable of the i-th term in quadratic expression object.

QuadExpr.GetVar2()

Get second variable from the i-th term in quadratic expression.

Synopsis

```
Var GetVar2(int i)
```

Arguments

i: index of the term.

Return

second variable of the i-th term in quadratic expression object.

QuadExpr.Remove()

Remove idx-th term from quadratic expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

QuadExpr.Remove()

Remove the term associated with variable from quadratic expression.

Synopsis

```
void Remove(Var var)
```

Arguments

var: a variable whose term should be removed.

QuadExpr.SetCoeff()

Set coefficient of the i-th term in quadratic expression.

Synopsis

```
void SetCoeff(int i, double val)
```

Arguments

i: index of the quadratic term.

val: coefficient of the term.

QuadExpr.SetConstant()

Set constant for the quadratic expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

QuadExpr.Size()

Get number of terms in quadratic expression.

Synopsis

```
long Size()
```

Return

number of quadratic terms.

24.2.34 QConstraint

COPT quadratic constraint object. Quadratic constraints are always associated with a particular model. User creates a quadratic constraint object by adding a quadratic constraint to a model, rather than by using constructor of QConstraint class.

QConstraint.Get()

Get information value of the quadratic constraint.

Synopsis

```
double Get(string info)
```

Arguments

info: name of the information being queried.

Return

information value.

QConstraint.GetIdx()

Get index of the quadratic constraint.

Synopsis

```
int GetIdx()
```

Return

the index of the quadratic constraint.

QConstraint.GetName()

Get name of the quadratic constraint.

Synopsis

```
string GetName()
```

Return

the name of the quadratic constraint.

QConstraint.GetRhs()

Get rhs of quadratic constraint.

Synopsis

```
double GetRhs()
```

Return

rhs of quadratic constraint.

QConstraint.GetSense()

Get rhs of quadratic constraint.

Synopsis

```
char GetSense()
```

Return

rhs of quadratic constraint.

QConstraint.Remove()

Remove this constraint from model.

Synopsis

```
void Remove()
```

QConstraint.Set()

Set information value of the quadratic constraint.

Synopsis

```
void Set(string attr, double val)
```

Arguments

attr: name of the information.

val: new information value.

QConstraint.SetName()

Set name of quadratic constraint.

Synopsis

```
void SetName(string name)
```

Arguments

name: the name to set.

QConstraint.SetRhs()

Set rhs of quadratic constraint.

Synopsis

```
void SetRhs(double rhs)
```

Arguments

rhs: rhs of quadratic constraint.

QConstraint.SetSense()

Set sense of quadratic constraint.

Synopsis

```
void SetSense(char sense)
```

Arguments

sense: sense of quadratic constraint.

24.2.35 QConstrArray

COPT quadratic constraint array object. To store and access a set of C# *QConstraint* objects, Cardinal Optimizer provides C# *QConstrArray* class, which defines the following methods.

QConstrArray.QConstrArray()

Constructor of qconstrarray object.

Synopsis

```
QConstrArray()
```

QConstrArray.GetQConstr()

Get idx-th quadratic constraint object.

Synopsis

```
QConstraint GetQConstr(int idx)
```

Arguments

idx: index of the quadratic constraint.

Return

constraint object with index 'idx'.

QConstrArray.PushBack()

Add a quadratic constraint object to array.

Synopsis

```
void PushBack(QConstraint constr)
```

Arguments

constr: a quadratic constraint object.

QConstrArray.Size()

Get the number of quadratic constraint objects.

Synopsis

```
int Size()
```

Return

number of quadratic constraint objects.

24.2.36 QConstrBuilder

COPT quadratic constraint builder object. To help building a quadratic constraint, given a quadratic expression, constraint sense and right-hand side value, Cardinal Optimizer provides C# ConeBuilder class, which defines the following methods.

QConstrBuilder.QConstrBuilder()

Constructor of qconstrbuilder object.

Synopsis

```
QConstrBuilder()
```

QConstrBuilder.GetQuadExpr()

Get quadratic expression associated with constraint.

Synopsis

```
QuadExpr GetQuadExpr()
```

Return

quadratic expression object.

QConstrBuilder.GetSense()

Get sense associated with quadratic constraint.

Synopsis

```
char GetSense()
```

Return

quadratic constraint sense.

QConstrBuilder.Set()

Set detail of a quadratic constraint to its builder object.

Synopsis

```
void Set(  
    QuadExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the quadratic constraint.

sense: quadratic constraint sense.

rhs: constant of right side of quadratic constraint.

24.2.37 QConstrBuilderArray

COPT quadratic constraint builder array object. To store and access a set of C# *QConstrBuilder* objects, Cardinal Optimizer provides C# *QConstrBuilderArray* class, which defines the following methods.

QConstrBuilderArray.QConstrBuilderArray()

QConstructor of constrbuilderarray object.

Synopsis

```
QConstrBuilderArray()
```

QConstrBuilderArray.GetBuilder()

Get idx-th quadratic constraint builder object.

Synopsis

```
QConstrBuilder GetBuilder(int idx)
```

Arguments

idx: index of the quadratic constraint builder.

Return

constraint builder object with index 'idx'.

QConstrBuilderArray.PushBack()

Add a quadratic constraint builder object to constraint builder array.

Synopsis

```
void PushBack(QConstrBuilder builder)
```

Arguments

builder: a quadratic constraint builder object.

QConstrBuilderArray.Size()

Get the number of quadratic constraint builder objects.

Synopsis

```
int Size()
```

Return

number of quadratic constraint builder objects.

24.2.38 PsdVar

COPT PSD variable object. PSD variables are always associated with a particular model. User creates a PSD variable object by adding a PSD variable to model, rather than by constructor of PsdVar class.

PsdVar.Diagonal()

Get diagonals of PSD variable.

Synopsis

```
MPsdExpr Diagonal(int offset)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

Return

one-dimensional MPsdExpr object of diagonals.

PsdVar.Get()

Get information values of PSD variable.

Synopsis

```
double[] Get(string info)
```

Arguments

info: name of information.

Return

array of information values.

PsdVar.GetDim()

Get dimension of PSD variable.

Synopsis

```
int GetDim()
```

Return

dimension of PSD variable.

PsdVar.GetIdx()

Get index of PSD variable.

Synopsis

```
int GetIdx()
```

Return

index of PSD variable.

PsdVar.GetInfo()

Get information values of PSD variable.

Synopsis

```
NdArray<double> GetInfo(string name)
```

Arguments

name: name of information.

Return

2-dimensional NdArray with related information values.

PsdVar.GetItem()

Get corresponding MPsdExpr of given index from PSD variable.

Synopsis

```
PsdExpr GetItem(int i, int j)
```

Arguments

i: row index.

j: col index.

Return

new PsdExpr object.

PsdVar.GetLen()

Get length of PSD variable.

Synopsis

```
int GetLen()
```

Return

length of PSD variable.

PsdVar.GetName()

Get name of PSD variable.

Synopsis

```
string GetName()
```

Return

name of PSD variable.

PsdVar.GetSize()

Get size or length of PSD variable.

Synopsis

```
int GetSize()
```

Return

Size of PSD variable.

PsdVar.Pick()

Given a list of indexes, pick elements of PSD variable in format of MPsdExpr.

Synopsis

```
MPsdExpr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional MPsdExpr object.

PsdVar.Remove()

Remove PSD variable from model.

Synopsis

```
void Remove()
```

PsdVar.Slice()

Get corresponding MPsdExpr of given view from PSD variable.

Synopsis

```
MPsdExpr Slice(View view)
```

Arguments

view: view of PSD variable.

Return

new MPsdExpr object.

PsdVar.Sum()

Sum of elements in PSD variable.

Synopsis

```
PsdExpr Sum()
```

Return

PsdExpr object.

PsdVar.ToExpr()

convert PSD variable to 2-dimensional MPsdExpr.

Synopsis

```
MPsdExpr ToExpr()
```

Return

2-dimensional MPsdExpr object.

24.2.39 PsdVarArray

COPT PSD variable array object. To store and access a set of *PsdVar* objects, Cardinal Optimizer provides PsdVarArray class, which defines the following methods.

PsdVarArray.PsdVarArray()

Constructor of PsdVarArray.

Synopsis

```
PsdVarArray()
```

PsdVarArray.GetPsdVar()

Get idx-th PSD variable object.

Synopsis

```
PsdVar GetPsdVar(int idx)
```

Arguments

idx: index of the PSD variable.

Return

PSD variable object with index idx.

PsdVarArray.PushBack()

Add a PSD variable object to PSD variable array.

Synopsis

```
void PushBack(PsdVar var)
```

Arguments

var: a PSD variable object.

PsdVarArray.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for PSD variable object.

PsdVarArray.Size()

Get the number of PSD variable objects.

Synopsis

```
int Size()
```

Return

number of PSD variable objects.

24.2.40 PsdExpr

COPT PSD expression object. A PSD expression consists of a linear expression, a list of PSD variables and associated coefficient matrices of PSD terms. PSD expressions are used to build PSD constraints and objectives.

PsdExpr.PsdExpr()

Constructor of a PSD expression with default constant value 0.

Synopsis

```
PsdExpr(double constant)
```

Arguments

constant: optional, constant value in PSD expression object.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(Var var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

PsdExpr.PsdExpr()

Constructor of a PSD expression with a linear expression.

Synopsis

```
PsdExpr(Expr expr)
```

Arguments

expr: input linear expression.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(PsdVar var, SymMatrix mat)
```

Arguments

var: PSD variable for the added term.

mat: coefficient matrix for the added term.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(PsdVar var, SymMatExpr expr)
```

Arguments

var: PSD variable for the added term.

expr: coefficient expression of symmetric matrices of new PSD term.

PsdExpr.AddConstant()

Add constant to the PSD expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: value to be added.

PsdExpr.AddLinExpr()

Add a linear expression to PSD expression object.

Synopsis

```
void AddLinExpr(Expr expr)
```

Arguments

expr: linear expression to be added.

PsdExpr.AddLinExpr()

Add a linear expression to PSD expression object.

Synopsis

```
void AddLinExpr(Expr expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: multiplier constant.

PsdExpr.AddPsdExpr()

Add a PSD expression to self.

Synopsis

```
void AddPsdExpr(PsdExpr expr)
```

Arguments

expr: PSD expression to be added.

PsdExpr.AddPsdExpr()

Add a PSD expression to self.

Synopsis

```
void AddPsdExpr(PsdExpr expr, double mult)
```

Arguments

expr: PSD expression to be added.

mult: multiplier constant.

PsdExpr.AddTerm()

Add a linear term to PSD expression object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: variable of new linear term.

coeff: coefficient of new linear term.

PsdExpr.AddTerm()

Add a PSD term to PSD expression object.

Synopsis

```
void AddTerm(PsdVar var, SymMatrix mat)
```

Arguments

var: PSD variable of new PSD term.

mat: coefficient matrix of new PSD term.

PsdExpr.AddTerm()

Add a PSD term to PSD expression object.

Synopsis

```
void AddTerm(PsdVar var, SymMatExpr expr)
```

Arguments

var: PSD variable of new PSD term.

expr: coefficient expression of symmetric matrices of new PSD term.

PsdExpr.AddTerms()

Add linear terms to PSD expression object.

Synopsis

```
void AddTerms(Var[] vars, double coeff)
```

Arguments

vars: variables of added linear terms.

coeff: one coefficient for added linear terms.

PsdExpr.AddTerms()

Add linear terms to PSD expression object.

Synopsis

```
void AddTerms(Var[] vars, double[] coeffs)
```

Arguments

vars: variables for added linear terms.

coeffs: coefficient array for added linear terms.

PsdExpr.AddTerms()

Add linear terms to PSD expression object.

Synopsis

```
void AddTerms(VarArray vars, double coeff)
```

Arguments

vars: variables of added linear terms.

coeff: one coefficient for added linear terms.

PsdExpr.AddTerms()

Add linear terms to PSD expression object.

Synopsis

```
void AddTerms(VarArray vars, double[] coeffs)
```

Arguments

vars: variables of added terms.

coeffs: coefficients of added terms.

PsdExpr.AddTerms()

Add PSD terms to PSD expression object.

Synopsis

```
void AddTerms(PsdVarArray vars, SymMatrixArray mats)
```

Arguments

vars: PSD variables for added PSD terms.

mats: coefficient matrixes for added PSD terms.

PsdExpr.AddTerms()

Add PSD terms to PSD expression object.

Synopsis

```
void AddTerms(PsdVar[] vars, SymMatrix[] mats)
```

Arguments

vars: PSD variables for added PSD terms.

mats: coefficient matrixes for added PSD terms.

PsdExpr.Clone()

Deep copy PSD expression object.

Synopsis

```
PsdExpr Clone()
```

Return

cloned PSD expression object.

PsdExpr.Evaluate()

Evaluate PSD expression after solving

Synopsis

```
double Evaluate()
```

Return

value of PSD expression

PsdExpr.GetCoeff()

Get coefficient from the i-th term in PSD expression.

Synopsis

```
SymMatExpr GetCoeff(int i)
```

Arguments

i: index of the PSD term.

Return

coefficient expression of the i-th PSD term.

PsdExpr.GetConstant()

Get constant in PSD expression.

Synopsis

```
double GetConstant()
```

Return

constant in PSD expression.

PsdExpr.GetLinExpr()

Get linear expression in PSD expression.

Synopsis

```
Expr GetLinExpr()
```

Return

linear expression object.

PsdExpr.GetPsdVar()

Get the PSD variable from the i-th term in PSD expression.

Synopsis

```
PsdVar GetPsdVar(int i)
```

Arguments

i: index of the term.

Return

the first variable of the i-th term in PSD expression object.

PsdExpr.Multiply()

Multiply a constant by itself.

Synopsis

```
void Multiply(double c)
```

Arguments

c: constant operand.

PsdExpr.Remove()

Remove i-th term from PSD expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

PsdExpr.Remove()

Remove the term associated with variable from PSD expression.

Synopsis

```
void Remove(Var var)
```

Arguments

var: a variable whose term should be removed.

PsdExpr.Remove()

Remove the term associated with PSD variable from PSD expression.

Synopsis

```
void Remove(PsdVar var)
```

Arguments

var: a PSD variable whose term should be removed.

PsdExpr.SetCoeff()

Set coefficient matrix of the i-th term in PSD expression.

Synopsis

```
void SetCoeff(int i, SymMatrix mat)
```

Arguments

i: index of the PSD term.

mat: coefficient matrix of the term.

PsdExpr.SetConstant()

Set constant for the PSD expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

PsdExpr.Size()

Get number of PSD terms in expression.

Synopsis

```
long Size()
```

Return

number of PSD terms.

24.2.41 PsdConstraint

COPT PSD constraint object. PSD constraints are always associated with a particular model. User creates a PSD constraint object by adding a PSD constraint to model, rather than by constructor of PsdConstraint class.

PsdConstraint.Get()

Get information value of the PSD constraint. Support related PSD informations.

Synopsis

```
double Get(string info)
```

Arguments

info: name of queried information.

Return

information value.

PsdConstraint.GetIdx()

Get index of the PSD constraint.

Synopsis

```
int GetIdx()
```

Return

the index of the PSD constraint.

PsdConstraint.GetName()

Get name of the PSD constraint.

Synopsis

```
string GetName()
```

Return

the name of the PSD constraint.

PsdConstraint.Remove()

Remove this PSD constraint from model.

Synopsis

```
void Remove()
```

PsdConstraint.Set()

Set information value of the PSD constraint. Support related PSD informations.

Synopsis

```
void Set(string info, double value)
```

Arguments

info: name of queried information.

value: new information value.

PsdConstraint.SetName()

Set name of a PSD constraint.

Synopsis

```
void SetName(string name)
```

Arguments

name: the name to set.

24.2.42 PsdConstrArray

COPT PSD constraint array object. To store and access a set of *PsdConstraint* objects, Cardinal Optimizer provides PsdConstrArray class, which defines the following methods.

PsdConstrArray.PsdConstrArray()

Constructor of PsdConstrArray object.

Synopsis

```
PsdConstrArray()
```

PsdConstrArray.GetPsdConstr()

Get idx-th PSD constraint object.

Synopsis

```
PsdConstraint GetPsdConstr(int idx)
```

Arguments

idx: index of the PSD constraint.

Return

PSD constraint object with index idx.

PsdConstrArray.PushBack()

Add a PSD constraint object to PSD constraint array.

Synopsis

```
void PushBack(PsdConstraint constr)
```

Arguments

constr: a PSD constraint object.

PsdConstrArray.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for PSD constraint objects.

PsdConstrArray.Size()

Get the number of PSD constraint objects.

Synopsis

```
int Size()
```

Return

number of PSD constraint objects.

24.2.43 PsdConstrBuilder

COPT PSD constraint builder object. To help building a PSD constraint, given a PSD expression, constraint sense and right-hand side value, Cardinal Optimizer provides PsdConstrBuilder class, which defines the following methods.

PsdConstrBuilder.PsdConstrBuilder()

Constructor of PsdConstrBuilder object.

Synopsis

```
PsdConstrBuilder()
```

PsdConstrBuilder.GetPsdExpr()

Get expression associated with PSD constraint.

Synopsis

```
PsdExpr GetPsdExpr()
```

Return

PSD expression object.

PsdConstrBuilder.GetRange()

Get range from lower bound to upper bound of range constraint.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of the constraint.

PsdConstrBuilder.GetSense()

Get sense associated with PSD constraint.

Synopsis

```
char GetSense()
```

Return

PSD constraint sense.

PsdConstrBuilder.Set()

Set detail of a PSD constraint to its builder object.

Synopsis

```
void Set(  
    PsdExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the PSD constraint.

sense: PSD constraint sense, other than COPT_RANGE.

rhs: constant at right side of the PSD constraint.

PsdConstrBuilder.SetRange()

Set a range constraint to its builder.

Synopsis

```
void SetRange(PsdExpr expr, double range)
```

Arguments

expr: PSD expression object, whose constant is negative upper bound.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

24.2.44 PsdConstrBuilderArray

COPT PSD constraint builder array object. To store and access a set of *PsdConstrBuilder* objects, Cardinal Optimizer provides PsdConstrBuilderArray class, which defines the following methods.

PsdConstrBuilderArray.PsdConstrBuilderArray()

Constructor of PsdConstrBuilderArray object.

Synopsis

```
PsdConstrBuilderArray()
```

PsdConstrBuilderArray.GetBuilder()

Get idx-th PSD constraint builder object.

Synopsis

```
PsdConstrBuilder GetBuilder(int idx)
```

Arguments

idx: index of the PSD constraint builder.

Return

PSD constraint builder object with index idx.

PsdConstrBuilderArray.PushBack()

Add a PSD constraint builder object to PSD constraint builder array.

Synopsis

```
void PushBack(PsdConstrBuilder builder)
```

Arguments

builder: a PSD constraint builder object.

PsdConstrBuilderArray.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for PSD constraint builder object.

PsdConstrBuilderArray.Size()

Get the number of PSD constraint builder objects.

Synopsis

```
int Size()
```

Return

number of PSD constraint builder objects.

24.2.45 LmiConstraint

COPT LMI constraint object. LMI constraints are always associated with a particular model. User creates a LMI constraint object by adding a LMI constraint to model, rather than by constructor of LmiConstraint class.

LmiConstraint.Get()

Get information values of LMI constraint.

Synopsis

```
double[] Get(string info)
```

Arguments

info: name of information.

Return

output array of information values.

LmiConstraint.GetDim()

Get dimension of LMI constraint.

Synopsis

```
int GetDim()
```

Return

dimension of LMI constraint.

LmiConstraint.GetIdx()

Get index of LMI constraint.

Synopsis

```
int GetIdx()
```

Return

index of LMI constraint.

LmiConstraint.GetLen()

Get length of LMI constraint.

Synopsis

```
int GetLen()
```

Return

length of LMI constraint.

LmiConstraint.GetName()

Get name of LMI constraint.

Synopsis

```
string GetName()
```

Return

name of LMI constraint.

LmiConstraint.Remove()

Remove this LMI constraint from model.

Synopsis

```
void Remove()
```

LmiConstraint.SetRhs()

Set constant term of LMI constraint.

Synopsis

```
void SetRhs(SymMatrix mat)
```

Arguments

mat: new symmetric matrix for constant term.

24.2.46 LmiConstrArray

COPT LMI constraint array object. To store and access a set of *LmiConstraint* objects, Cardinal Optimizer provides LmiConstrArray class, which defines the following methods.

LmiConstrArray.LmiConstrArray()

Constructor of LmiConstrArray.

Synopsis

```
LmiConstrArray()
```

LmiConstrArray.GetLmiConstr()

Get idx-th LMI constraint object.

Synopsis

```
LmiConstraint GetLmiConstr(int idx)
```

Arguments

idx: index of LMI constraint.

Return

LMI constraint object with index idx.

LmiConstrArray.PushBack()

Add an LMI constraint to LMI constraint array.

Synopsis

```
void PushBack(LmiConstraint constr)
```

Arguments

constr: LMI constraint object.

LmiConstrArray.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: capacity number of LMI constraint object.

LmiConstrArray.Size()

Get the number of LMI constraint objects.

Synopsis

```
int Size()
```

Return

number of LMI constraint objects.

24.2.47 LmiExpr

COPT LMI expression object. A LMI expression consists of a list of variables, associated coefficient matrices of LMI term, and constant matrices. LMI expressions are used to build LMI constraints.

LmiExpr.LmiExpr()

Default constructor of LMI expression

Synopsis

```
LmiExpr()
```

LmiExpr.LmiExpr()

Constructor of LMI expression with constant term.

Synopsis

```
LmiExpr(SymMatrix mat)
```

Arguments

mat: symmetric matrix object.

LmiExpr.LmiExpr()

Constructor of LMI expression with matrix expression.

Synopsis

```
LmiExpr(SymMatExpr expr)
```

Arguments

expr: symmetric matrix expression.

LmiExpr.LmiExpr()

Constructor of LMI expression with one term.

Synopsis

```
LmiExpr(Var var, SymMatrix mat)
```

Arguments

var: variable of the added term.

mat: coefficient matrix of the added term.

LmiExpr.LmiExpr()

Constructor of LMI expression with one term.

Synopsis

```
LmiExpr(Var var, SymMatExpr expr)
```

Arguments

var: variable of the added term.

expr: coefficient expression of symmetric matrices of new LMI term.

LmiExpr.AddConstant()

Add to constant term of the LMI expression.

Synopsis

```
void AddConstant(SymMatExpr expr)
```

Arguments

expr: matrix expression added to the constant term.

LmiExpr.AddLmiExpr()

Add an LMI expression to self.

Synopsis

```
void AddLmiExpr(LmiExpr expr, double mult)
```

Arguments

expr: LMI expression to be added.

mult: optional, constant multiplier, default value is 1.0.

LmiExpr.AddTerm()

Add a term to LMI expression object.

Synopsis

```
void AddTerm(Var var, SymMatrix mat)
```

Arguments

var: variable of new LMI term.

mat: coefficient matrix of new LMI term.

LmiExpr.AddTerm()

Add a term to LMI expression object.

Synopsis

```
void AddTerm(Var var, SymMatExpr expr)
```

Arguments

var: variable of new LMI term.

expr: coefficient expression of symmetric matrices of new LMI term.

LmiExpr.AddTerms()

Add LMI terms to LMI expression object.

Synopsis

```
void AddTerms(VarArray vars, SymMatrixArray mats)
```

Arguments

vars: variables for added LMI terms.

mats: coefficient matrices for added LMI terms.

LmiExpr.AddTerms()

Add LMI terms to LMI expression object.

Synopsis

```
void AddTerms(Var[] vars, SymMatrix[] mats)
```

Arguments

vars: variables for added LMI terms.

mats: coefficient matrices for added LMI terms.

LmiExpr.Clone()

Deep copy LMI expression.

Synopsis

```
LmiExpr Clone()
```

Return

cloned LMI expression object.

LmiExpr.GetCoeff()

Get coefficient from the i-th term in LMI expression.

Synopsis

```
SymMatExpr GetCoeff(int i)
```

Arguments

i: index of the LMI term.

Return

coefficient expression of the i-th LMI term.

LmiExpr.GetConstant()

Get constant term in LMI expression.

Synopsis

```
SymMatExpr GetConstant()
```

Return

symmetric matrix expression object.

LmiExpr.GetVar()

Get variable from the i-th term in LMI expression.

Synopsis

```
Var GetVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in LMI expression object.

LmiExpr.Multiply()

Multiply a double constant by itself.

Synopsis

```
void Multiply(double c)
```

Arguments

c: constant multiplier.

LmiExpr.Remove()

Remove i-th term from LMI expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

LmiExpr.Remove()

Remove the term associated with variable from LMI expression.

Synopsis

```
void Remove(Var var)
```

Arguments

var: a variable whose term should be removed.

LmiExpr.SetCoeff()

Set coefficient matrix of the i-th term in LMI expression.

Synopsis

```
void SetCoeff(int i, SymMatrix mat)
```

Arguments

i: index of the LMI term.

mat: coefficient matrix of the term.

LmiExpr.SetConstant()

Set constant term of the LMI expression.

Synopsis

```
void SetConstant(SymMatrix mat)
```

Arguments

mat: symmetric matrix of the constant term.

LmiExpr.Size()

Get number of LMI terms in expression.

Synopsis

```
long Size()
```

Return

number of LMI terms.

24.2.48 SymMatrix

COPT symmetric matrix object. Symmetric matrices are always associated with a particular model. User creates a symmetric matrix object by adding a symmetric matrix to model, rather than by constructor of SymMatrix class.

Symmetric matrices are used as coefficient matrices of PSD terms in PSD expressions, PSD constraints or PSD objectives.

SymMatrix.GetDim()

Get the dimension of a symmetric matrix.

Synopsis

```
int GetDim()
```

Return

dimension of a symmetric matrix.

SymMatrix.GetIdx()

Get the index of a symmetric matrix.

Synopsis

```
int GetIdx()
```

Return

index of a symmetric matrix.

24.2.49 SymMatrixArray

COPT symmetric matrix object. To store and access a set of *SymMatrix* objects, Cardinal Optimizer provides SymMatrixArray class, which defines the following methods.

SymMatrixArray.SymMatrixArray()

Constructor of SymMatrixArray.

Synopsis

```
SymMatrixArray()
```

SymMatrixArray.GetMatrix()

Get i-th SymMatrix object.

Synopsis

```
SymMatrix GetMatrix(int idx)
```

Arguments

idx: index of the SymMatrix object.

Return

SymMatrix object with index idx.

SymMatrixArray.PushBack()

Add a SymMatrix object to SymMatrix array.

Synopsis

```
void PushBack(SymMatrix mat)
```

Arguments

mat: a SymMatrix object.

SymMatrixArray.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for symmetric matrix object.

SymMatrixArray.Size()

Get the number of SymMatrix objects.

Synopsis

```
int Size()
```

Return

number of SymMatrix objects.

24.2.50 SymMatExpr

COPT symmetric matrix expression object. A symmetric matrix expression is a linear combination of symmetric matrices, which is still a symmetric matrix. However, by doing so, we are able to delay computing the final matrix until setting PSD constraints or PSD objective.

SymMatExpr.SymMatExpr()

Constructor of a symmetric matrix expression.

Synopsis

```
SymMatExpr()
```

SymMatExpr.SymMatExpr()

Constructor of a symmetric matrix expression with one term.

Synopsis

```
SymMatExpr(SymMatrix mat, double coeff)
```

Arguments

mat: symmetric matrix of the added term.

coeff: optional, coefficient for the added term. Its default value is 1.0.

SymMatExpr.AddSymMatExpr()

Add a symmetric matrix expression to self.

Synopsis

```
void AddSymMatExpr(SymMatExpr expr, double mult)
```

Arguments

expr: symmetric matrix expression to be added.

mult: optional, constant multiplier, default value is 1.0.

SymMatExpr.AddTerm()

Add a term to symmetric matrix expression object.

Synopsis

```
bool AddTerm(SymMatrix mat, double coeff)
```

Arguments

mat: symmetric matrix of the new term.

coeff: coefficient of the new term.

Return

True if the term is added successfully.

SymMatExpr.AddTerms()

Add multiple terms to expression object.

Synopsis

```
int AddTerms(SymMatrix[] mats, double coeff)
```

Arguments

mats: symmetric matrix array object for added terms.

coeff: optional, common coefficient for added terms, default is 1.0.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr.AddTerms()

Add multiple terms to expression object.

Synopsis

```
int AddTerms(SymMatrixArray mats, double[] coeffs)
```

Arguments

mats: symmetric matrix array object for added terms.

coeffs: coefficient array for added terms.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr.AddTerms()

Add multiple terms to expression object.

Synopsis

```
int AddTerms(SymMatrix[] mats, double[] coeffs)
```

Arguments

mats: symmetric matrix array object for added terms.

coeffs: coefficient array for added terms.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr.Clone()

Deep copy symmetric matrix expression object.

Synopsis

```
SymMatExpr Clone()
```

Return

cloned expression object.

SymMatExpr.GetCoeff()

Get coefficient of the i-th term in expression object.

Synopsis

```
double GetCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term.

SymMatExpr.GetDim()

Get dimension of symmetric matrix in expression.

Synopsis

```
int GetDim()
```

Return

dimension of symmetric matrix.

SymMatExpr.GetSymMat()

Get symmetric matrix of the i-th term in expression object.

Synopsis

```
SymMatrix GetSymMat(int i)
```

Arguments

i: index of the term.

Return

the symmetric matrix of the i-th term.

SymMatExpr.Multiply()

Multiply a constant by itself.

Synopsis

```
void Multiply(double c)
```

Arguments

c: constant operand.

SymMatExpr.Remove()

Remove i-th term from expression object.

Synopsis

```
void Remove(int idx)
```

Arguments

idx: index of the term to be removed.

SymMatExpr.Remove()

Remove the term associated with the symmetric matrix.

Synopsis

```
void Remove(SymMatrix mat)
```

Arguments

mat: a symmetric matrix whose term should be removed.

SymMatExpr.Reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void Reserve(int n)
```

Arguments

n: minimum capacity for expression object.

SymMatExpr.SetCoeff()

Set coefficient for the i-th term in expression object.

Synopsis

```
void SetCoeff(int i, double val)
```

Arguments

i: index of the term.

val: coefficient of the term.

SymMatExpr.Size()

Get number of terms in expression.

Synopsis

```
long Size()
```

Return

number of terms.

24.2.51 MVar

COPT multi-dimensional variable object. It is used to construct multi-dimensional variables and support operations with the built-in multi-dimensional array *NdArray* in COPT. It can be created by calling the method `addMVar` of *Model*. The following methods are provided:

MVar.Clone()

Clone MVar object.

Synopsis

```
MVar Clone()
```

Return

new MVar object.

MVar.Diagonal()

Get diagonals of MVar object.

Synopsis

```
MVar Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MVar.

axis2: 2nd axis of MVar.

Return

(N-1)-dimensional diagonals.

MVar.Expand()

Expand shape of MVar object.

Synopsis

```
MVar Expand(int axis)
```

Arguments

axis: axis of MVar.

Return

MVar object of (N+1)-dimensional shape.

MVar.Flatten()

Flatten a MVar object to a 1-dimensional shape.

Synopsis

```
MVar Flatten()
```

Return

a MVar object collapsed into one dimension.

MVar.Get()

Get values of information associated with variables in MVar object.

Synopsis

```
NdArray<double> Get(string info)
```

Arguments

info: name of information.

Return

multi-dimensional array of information of variables.

MVar.GetBasis()

Get basis of variables in MVar object.

Synopsis

```
NdArray<int> GetBasis()
```

Return

multi-dimensional array of basis of variables.

MVar.GetDim()

Get i-th dimension of MVar object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MVar.GetIdx()

Get indexes of variables in MVar object.

Synopsis

```
NdArray<int> GetIdx()
```

Return

multi-dimensional array of indexes of variables.

MVar.GetItem()

Get variable of given index from MVar object.

Synopsis

```
Var GetItem(long idx)
```

Arguments

idx: index of variable.

Return

Var object.

MVar.GetItem()

Get sub-arrays of MVar object, given view object.

Synopsis

```
MVar GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MVar object.

MVar.GetLowerIIS()

Get IIS status of lower bound of variables in MVar object.

Synopsis

```
NdArray<int> GetLowerIIS()
```

Return

multi-dimensional array of IIS status of lower bounds of variables.

MVar.GetND()

Get number of dimensions of MVar object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MVar.GetShape()

Get shape of MVar object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MVar.GetSize()

Get size of MVar object.

Synopsis

```
long GetSize()
```

Return

number of vars.

MVar.GetType()

Get types of variables in MVar object.

Synopsis

```
NdArray<char> GetType()
```

Return

multi-dimensional array of types of variables.

MVar.GetUpperIIS()

Get IIS status of upper bound of variables in MVar object.

Synopsis

```
NdArray<int> GetUpperIIS()
```

Return

multi-dimensional array of IIS status of upper bounds of variables.

MVar.HStack()

Stack with other MVar object along horizontal axis.

Synopsis

```
MVar HStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MVar object.

MVar.Pick()

Given a list of indexes, get variables from MVar object.

Synopsis

```
MVar Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired variables.

MVar.Repeat()

Repeat each element of MVar along given axis.

Synopsis

```
MVar Repeat(long repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MVar.

Return

new MVar object.

MVar.RepeatBlock()

Repeat an MVar a number of times along given axis.

Synopsis

```
MVar RepeatBlock(long repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MVar.

Return

new MVar object.

MVar.Represent()

String representation of MVar object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MVar.Reshape()

Reshape MVar object to new shape.

Synopsis

```
MVar Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MVar object.

MVar.Set()

Set values of information associated with variables in MVar object.

Synopsis

```
void Set(string info, double val)
```

Arguments

info: name of information.

val: value of information.

MVar.Set()

Set values of information associated with variables in MVar object.

Synopsis

```
void Set(string info, NdArray<double> vals)
```

Arguments

info: name of information.

vals: multi-dimensional array of values of information.

MVar.SetItem()

Set variable of given index to MVar object.

Synopsis

```
void SetItem(long idx, Var var)
```

Arguments

idx: index of element.

var: Var object.

MVar.Squeeze()

Remove axis of length 1 from shape of MVar object.

Synopsis

```
MVar Squeeze(int axis)
```

Arguments

axis: axis of MVar, where the length is 1.

Return

MVar object of (N-1)-dimensional shape.

MVar.Stack()

Stack with other MVar object along given axis.

Synopsis

```
MVar Stack(MVar other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MVar.

Return

the result MVar object.

MVar.Sum()

Sum of all variables in MVar object.

Synopsis

```
MLinExpr Sum()
```

Return

sum in zero dimension.

MVar.Sum()

Sum of variables at given axis of MVar object.

Synopsis

```
MLinExpr Sum(int axis)
```

Arguments

axis: axis of MVar.

Return

MLinExpr object in (N-1)-dimension.

MVar.Transpose()

Perform matrix transpose of MVar object.

Synopsis

```
MVar Transpose()
```

Return

transposed MVar object.

MVar.VStack()

Stack with other MVar object along vertical axis.

Synopsis

```
MVar VStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MVar object.

24.2.52 MConstr

COPT multi-dimensional linear constraint object. It can be created by calling the method `addMConstr` of *Model*. The following methods are provided:

MConstr.Clone()

Clone MConstr object.

Synopsis

```
MConstr Clone()
```

Return

new MConstr object.

MConstr.Diagonal()

Get diagonals of MConstr object.

Synopsis

```
MConstr Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MConstr.

axis2: 2nd axis of MConstr.

Return

(N-1)-dimensional diagonals.

MConstr.Expand()

Expand shape of MConstr object.

Synopsis

```
MConstr Expand(int axis)
```

Arguments

axis: axis of MConstr.

Return

MConstr object of (N+1)-dimensional shape.

MConstr.Flatten()

Flatten a MConstr object to a 1-dimensional shape.

Synopsis

```
MConstr Flatten()
```

Return

a MConstr object collapsed into one dimension.

MConstr.Get()

Get values of information associated with constraints in MConstr object.

Synopsis

```
NdArray<double> Get(string info)
```

Arguments

info: name of information.

Return

multi-dimensional array of information of constraints.

MConstr.GetDim()

Get i-th dimension of MConstr object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MConstr.GetIdx()

Get index of constraints in MConstr object.

Synopsis

```
NdArray<int> GetIdx()
```

Return

multi-dimensional array of indexes of constraints.

MConstr.GetItem()

Get constraint of given index from MConstr object.

Synopsis

```
Constraint GetItem(long idx)
```

Arguments

idx: index of constraint.

Return

Constraint object.

MConstr.GetItem()

Get sub-arrays of MConstr object, given view object.

Synopsis

```
MConstr GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MConstr object.

MConstr.GetLowerIIS()

Get IIS status of lower bound of constraints in MConstr object.

Synopsis

```
NdArray<int> GetLowerIIS()
```

Return

multi-dimensional array of IIS status of lower bounds of constraints.

MConstr.GetND()

Get number of dimensions of MConstr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MConstr.GetShape()

Get shape of MConstr object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MConstr.GetSize()

Get size of MConstr object.

Synopsis

```
long GetSize()
```

Return

number of vars.

MConstr.GetUpperIIS()

Get IIS status of upper bound of constraints in MConstr object.

Synopsis

```
NdArray<int> GetUpperIIS()
```

Return

multi-dimensional array of IIS status of upper bounds of constraints.

MConstr.HStack()

Stack with other MConstr object along horizontal axis.

Synopsis

```
MConstr HStack(MConstr other)
```

Arguments

other: a MConstr object.

Return

the result MConstr object.

MConstr.Pick()

Given a list of indexes, get constraints from MConstr object.

Synopsis

```
MConstr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired constraints.

MConstr.Represent()

String representation of MConstr object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MConstr.Reshape()

Reshape MConstr object to new shape.

Synopsis

```
MConstr Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MConstr object.

MConstr.Set()

Set values of information associated with constraints in MConstr object.

Synopsis

```
void Set(string info, NArray<double> vals)
```

Arguments

info: name of information.

vals: multi-dimensional array of values of information.

MConstr.Set()

Set values of information associated with constraints in MConstr object.

Synopsis

```
void Set(string info, double val)
```

Arguments

info: name of information.

val: value of information.

MConstr.SetItem()

Set constraint of given index to MConstr object.

Synopsis

```
void SetItem(long idx, Constraint constr)
```

Arguments

idx: index of element.

constr: Constraint object.

MConstr.Squeeze()

Remove axis of length 1 from shape of MConstr object.

Synopsis

```
MConstr Squeeze(int axis)
```

Arguments

axis: axis of MConstr, where the length is 1.

Return

MConstr object of (N-1)-dimensional shape.

MConstr.Stack()

Stack with other MConstr object along given axis.

Synopsis

```
MConstr Stack(MConstr other, int axis)
```

Arguments

other: a MConstr object.

axis: an axis of MConstr.

Return

the result MConstr object.

MConstr.Transpose()

Perform matrix transpose of MConstr object.

Synopsis

```
MConstr Transpose()
```

Return

transposed MConstr object.

MConstr.VStack()

Stack with other MConstr object along vertical axis.

Synopsis

```
MConstr VStack(MConstr other)
```

Arguments

other: a MConstr object.

Return

the result MConstr object.

24.2.53 MConstrBuilder

COPT builder object of multi-dimensional linear constraints. It is used to generate multi-dimensional linear constraints and support operations with the built-in multi-dimensional array *NdArray* in COPT. It is recommended to create MConstrBuilder object by comparing two objects, one of which should be *MVar* object or *MLinExpr* object, by comparison operators. The following methods are provided:

MConstrBuilder.MConstrBuilder()

Construct a MConstrBuilder object with the given shape.

Synopsis

```
MConstrBuilder(Shape shp)
```

Arguments

shp: shape of MConstrBuilder.

MConstrBuilder.Flatten()

Flatten a MConstrBuilder object to a 1-dimensional shape.

Synopsis

```
MConstrBuilder Flatten()
```

Return

a MConstrBuilder object collapsed into one dimension.

MConstrBuilder.GetExpr()

Get N-dimensional linear expressions associated with N-dimensional constraints.

Synopsis

```
MLinExpr GetExpr()
```

Return

MLinExpr object.

MConstrBuilder.GetND()

Get number of dimensions of MConstrBuilder object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MConstrBuilder.GetRange()

Get range from lower bound to upper bound of N-dimensional range constraints.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of range constraints.

MConstrBuilder.GetSense()

Get sense associated with N-dimensional constraints.

Synopsis

```
char GetSense()
```

Return

constraint sense.

MConstrBuilder.Set<T>()

Set N-dimensional constraints to its builder object.

Synopsis

```
void Set<T>(  
    MLinExpr expr,  
    char sense,  
    NArray<T> rhs)
```

Arguments

expr: MLinExpr object

sense: constraint sense other than COPT_RANGE.

rhs: N-dimensional constants at right side of constraints.

MConstrBuilder.Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
void Set(  
    MLinExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: constant of right side of constraints.

MConstrBuilder.Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
void Set(  
    MLinExpr expr,  
    char sense,  
    MVar rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MVar object at right side of constraints.

MConstrBuilder.Set()

Set N-dimensional constraints to its builder object.

Synopsis

```
void Set(  
    MLinExpr expr,  
    char sense,  
    MLinExpr rhs)
```

Arguments

expr: MLinExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MLinExpr object at right side of constraints.

MConstrBuilder.SetRange()

Set N-dimensional range constraints to its builder object.

Synopsis

```
void SetRange(MLinExpr expr, double range)
```

Arguments

expr: MLinExpr object.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

24.2.54 MExpression

The MExpression class is a generalized version of *Expr*. It represents a linear expression and supports most of methods in Expr class. In addition, it supports linear combination of multi-dimensional objects, such as *MVar* object and *NdArray* object. The following methods are provided:

MExpression.MExpression()

Construct a MExpression object with the given constant.

Synopsis

```
MExpression(double constant)
```

Arguments

constant: constant number.

MExpression.MExpression()

Construct a MExpression object with the given variable.

Synopsis

```
MExpression(Var var)
```

Arguments

var: variable object.

MExpression.MExpression()

Construct a MExpression object with the given linear expression.

Synopsis

```
MExpression(Expr expr)
```

Arguments

expr: a linear expression.

MExpression.AddConstant()

Add constant for the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MExpression.AddExpr()

Add a linear expression to MExpression object.

Synopsis

```
void AddExpr(Expr expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MExpression.AddMExpr()

Add MExpression to MExpression object.

Synopsis

```
void AddMExpr(MExpression expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MExpression.AddTerm()

Add a linear term to MExpression object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MExpression.Clone()

Clone MExpression object.

Synopsis

```
MExpression Clone()
```

Return

new MExpression object.

MExpression.GetConstant()

Get constant in expression.

Synopsis

```
double GetConstant()
```

Return

constant in expression.

MExpression.Represent()

String representation of MExpression object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MExpression.SetConstant()

Set constant for the expression.

Synopsis

```
void SetConstant(double constant)
```

Arguments

constant: the value of the constant.

24.2.55 MLinExpr

COPT multi-dimensional linear expression object. It is used to construct multi-dimensional linear expressions and perform operations with the built-in multi-dimensional array *NdArray* in COPT. Its elements are *MExpression* objects. It can be created by linear combination of *MVar* objects. The following methods are provided:

MLinExpr.AddConstant()

Add constant to each expression in MLinExpr object.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MLinExpr.AddConstant()

Add constants to each expression in MLinExpr object.

Synopsis

```
void AddConstant(NdArray<double> constants)
```

Arguments

constants: N-dimension NdArray object.

MLinExpr.AddExpr()

Add a linear expression to each expression in MLinExpr object.

Synopsis

```
void AddExpr(Expr expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MLinExpr.AddMExpr()

Add MExpression to each expression in MLinExpr object.

Synopsis

```
void AddMExpr(MExpression expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MLinExpr.AddMLinExpr()

Add linear expressions to MLinExpr object.

Synopsis

```
void AddMLinExpr(MLinExpr exprs, double mult)
```

Arguments

exprs: N-dimension MLinExpr object.

mult: the same multiplier for added linear expressions, default value is 1.0.

MLinExpr.AddTerm()

Add a linear term to MLinExpr object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MLinExpr.AddTerms()

Add terms to expressions in MLinExpr object.

Synopsis

```
void AddTerms(MVar vars, NdArray<double> coeffs)
```

Arguments

vars: N-dimension MVar object for added terms.

coeffs: N-dimension NdArray object of coefficients for added terms.

MLinExpr.AddTerms()

Add terms to expressions in MLinExpr object.

Synopsis

```
void AddTerms(MVar vars, double mult)
```

Arguments

vars: N-dimension MVar object for added terms.

mult: the same coefficient for added terms, default value 1.0.

MLinExpr.Clear()

Clear MLinExpr object.

Synopsis

```
void Clear()
```

MLinExpr.Clone()

Clone MLinExpr object.

Synopsis

```
MLinExpr Clone()
```

Return

new MLinExpr object.

MLinExpr.Diagonal()

Get diagonals of MLinExpr object.

Synopsis

```
MLinExpr Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MLinExpr.

axis2: 2nd axis of MLinExpr.

Return

(N-1)-dimensional diagonals.

MLinExpr.Expand()

Expand shape of MLinExpr object.

Synopsis

```
MLinExpr Expand(int axis)
```

Arguments

axis: axis of MLinExpr.

Return

MLinExpr object of (N+1)-dimensional shape.

MLinExpr.Flatten()

Flatten a MLinExpr object to a 1-dimensional shape.

Synopsis

```
MLinExpr Flatten()
```

Return

a MLinExpr object collapsed into one dimension.

MLinExpr.GetDim()

Get i-th dimension of MLinExpr object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MLinExpr.GetItem()

Get expression of given index from MLinExpr object.

Synopsis

```
MExpression GetItem(long idx)
```

Arguments

idx: index of expression.

Return

MExpression object.

MLinExpr.GetItem()

Get sub-arrays of MLinExpr object, given view object.

Synopsis

```
MLinExpr GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MLinExpr object.

MLinExpr.GetND()

Get number of dimensions of MLinExpr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MLinExpr.GetShape()

Get shape of MLinExpr object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MLinExpr.GetSize()

Get size of MLinExpr object.

Synopsis

```
long GetSize()
```

Return

number of linear expressions.

MLinExpr.HStack<T>()

Stack with other NdArray object along horizontal axis.

Synopsis

```
MLinExpr HStack<T>(NdArray<T> other)
```

Arguments

other: a NdArray object.

Return

the result MLinExpr object.

MLinExpr.HStack()

Stack with other MLinExpr object along horizontal axis.

Synopsis

```
MLinExpr HStack(MLinExpr other)
```

Arguments

other: a MLinExpr object.

Return

the result MLinExpr object.

MLinExpr.HStack()

Stack with other MVar object along horizontal axis.

Synopsis

```
MLinExpr HStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MLinExpr object.

MLinExpr.Pick()

Given a list of indexes, get linear expressions from MLinExpr object.

Synopsis

```
MLinExpr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired linear expressions.

MLinExpr.Repeat()

Repeat each element of MLinExpr along given axis.

Synopsis

```
MLinExpr Repeat(long repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MLinExpr.

Return

new MLinExpr object.

MLinExpr.RepeatBlock()

Repeat an MLinExpr a number of times along given axis.

Synopsis

```
MLinExpr RepeatBlock(long repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MLinExpr.

Return

new MLinExpr object.

MLinExpr.Represent()

String representation of MLinExpr object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MLinExpr.Reshape()

Reshape MLinExpr object to new shape.

Synopsis

```
MLinExpr Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MLinExpr object.

MLinExpr.SetItem()

Set expression of given index to MLinExpr object.

Synopsis

```
void SetItem(long idx, MExpression expr)
```

Arguments

idx: index of element.

expr: MExpression object.

MLinExpr.Squeeze()

Remove axis of length 1 from shape of MLinExpr object.

Synopsis

```
MLinExpr Squeeze(int axis)
```

Arguments

axis: axis of MLinExpr, where the length is 1.

Return

MLinExpr object of (N-1)-dimensional shape.

MLinExpr.Stack<T>()

Stack with other NdArray object along given axis.

Synopsis

```
MLinExpr Stack<T>(NdArray<T> other, int axis)
```

Arguments

other: a NdArray object.

axis: an axis of MLinExpr.

Return

the result MLinExpr object.

MLinExpr.Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MLinExpr Stack(MLinExpr other, int axis)
```

Arguments

other: a MLinExpr object.

axis: an axis of MLinExpr.

Return

the result MLinExpr object.

MLinExpr.Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MLinExpr Stack(MVar other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MLinExpr.

Return

the result MLinExpr object.

MLinExpr.SubConstant()

Subtract constants from each expression in MLinExpr object.

Synopsis

```
void SubConstant(NdArray<double> constants)
```

Arguments

constants: N-dimension NdArray object.

MLinExpr.Sum()

Sum of all expressions in MLinExpr object.

Synopsis

```
MLinExpr Sum()
```

Return

sum in zero dimension.

MLinExpr.Sum()

Sum of variables at given axis of MLinExpr object.

Synopsis

```
MLinExpr Sum(int axis)
```

Arguments

axis: axis of MLinExpr.

Return

MLinExpr object in (N-1)-dimension.

MLinExpr.Transpose()

Perform matrix transpose of MLinExpr object.

Synopsis

```
MLinExpr Transpose()
```

Return

transposed MLinExpr object.

MLinExpr.VStack<T>()

Stack with other NdArray object along vertical axis.

Synopsis

```
MLinExpr VStack<T>(NdArray<T> other)
```

Arguments

other: a NdArray object.

Return

the result MLinExpr object.

MLinExpr.VStack()

Stack with other MLinExpr object along vertical axis.

Synopsis

```
MLinExpr VStack(MLinExpr other)
```

Arguments

other: a MLinExpr object.

Return

the result MLinExpr object.

MLinExpr.VStack()

Stack with other MVar object along vertical axis.

Synopsis

```
MLinExpr VStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MLinExpr object.

24.2.56 MPsdConstr

The *MPsdConstr* class in COPT represents multi-dimensional semidefinite constraints. It is generated through the methods `addConstrs` or `addConstr` of *Model*.

The following member methods are provided:

MPsdConstr.Clone()

Clone MPsdConstr object.

Synopsis

```
MPsdConstr Clone()
```

Return

new MPsdConstr object.

MPsdConstr.Diagonal()

Get diagonals of MPsdConstr object.

Synopsis

```
MPsdConstr Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MPsdConstr.

axis2: 2nd axis of MPsdConstr.

Return

(N-1)-dimensional diagonals.

MPsdConstr.Expand()

Expand shape of MPsdConstr object.

Synopsis

```
MPsdConstr Expand(int axis)
```

Arguments

axis: axis of MPsdConstr.

Return

MPsdConstr object of (N+1)-dimensional shape.

MPsdConstr.Flatten()

Flatten a MPsdConstr object to a 1-dimensional shape.

Synopsis

```
MPsdConstr Flatten()
```

Return

a MPsdConstr object collapsed into one dimension.

MPsdConstr.Get()

Get values of information associated with PSD constraints in MPsdConstr object.

Synopsis

```
NdArray<double> Get(string info)
```

Arguments

info: name of information.

Return

multi-dimensional array of information of PSD constraints.

MPsdConstr.GetDim()

Get i-th dimension of MPsdConstr object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MPsdConstr.GetIdx()

Get index of PSD constraints in MPsdConstr object.

Synopsis

```
NdArray<int> GetIdx()
```

Return

multi-dimensional array of indexes of PSD constraints.

MPsdConstr.GetItem()

Get PSD constraint of given index from MPsdConstr object.

Synopsis

```
PsdConstraint GetItem(long idx)
```

Arguments

idx: index of var.

Return

PsdConstraint object.

MPsdConstr.GetItem()

Get sub-arrays of MPsdConstr object, given view object.

Synopsis

```
MPsdConstr GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MPsdConstr object.

MPsdConstr.GetND()

Get number of dimensions of MPsdConstr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MPsdConstr.GetShape()

Get shape of MPsdConstr object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MPsdConstr.GetSize()

Get size of MPsdConstr object.

Synopsis

```
long GetSize()
```

Return

number of vars.

MPsdConstr.HStack()

Stack with other MPsdConstr object along horizontal axis.

Synopsis

```
MPsdConstr HStack(MPsdConstr other)
```

Arguments

other: a MPsdConstr object.

Return

the result MPsdConstr object.

MPsdConstr.Pick()

Given a list of indexes, get PSD constraints from MPsdConstr object.

Synopsis

```
MPsdConstr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired PSD constraints.

MPsdConstr.Represent()

String representation of MPsdConstr object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MPsdConstr.Reshape()

Reshape MPsdConstr object to new shape.

Synopsis

```
MPsdConstr Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MPsdConstr object.

MPsdConstr.Set()

Set values of information associated with PSD constraints in MPsdConstr object.

Synopsis

```
void Set(string info, double val)
```

Arguments

info: name of information.

val: value of information.

MPsdConstr.Set()

Set values of information associated with PSD constraints in MPsdConstr object.

Synopsis

```
void Set(string info, NArray<double> vals)
```

Arguments

info: name of information.

vals: multi-dimensional array of values of information.

MPsdConstr.SetItem()

Set PSD constraint of given index to MPsdConstr object.

Synopsis

```
void SetItem(long idx, PsdConstraint constr)
```

Arguments

idx: index of element.

constr: PsdConstraint object.

MPsdConstr.Squeeze()

Remove axis of length 1 from shape of MPsdConstr object.

Synopsis

```
MPsdConstr Squeeze(int axis)
```

Arguments

axis: axis of MPsdConstr, where the length is 1.

Return

MPsdConstr object of (N-1)-dimensional shape.

MPsdConstr.Stack()

Stack with other MPsdConstr object along given axis.

Synopsis

```
MPsdConstr Stack(MPsdConstr other, int axis)
```

Arguments

other: a MPsdConstr object.

axis: an axis of MPsdConstr.

Return

the result MPsdConstr object.

MPsdConstr.Transpose()

Perform matrix transpose of MPsdConstr object.

Synopsis

```
MPsdConstr Transpose()
```

Return

transposed MPsdConstr object.

MPsdConstr.VStack()

Stack with other MPsdConstr object along vertical axis.

Synopsis

```
MPsdConstr VStack(MPsdConstr other)
```

Arguments

other: a MPsdConstr object.

Return

the result MPsdConstr object.

24.2.57 MPsdConstrBuilder

The *MPsdConstrBuilder* class in COPT serves as a builder for multi-dimensional semidefinite constraints. It is used to generate multi-dimensional semidefinite constraints and supports operations with the built-in multi-dimensional array *NdArray*. An *MPsdConstrBuilder* object can be created through comparison operations between two objects, one of which can be an *MPsdExpr* object. The following member methods are provided:

MPsdConstrBuilder.MPsdConstrBuilder()

Construct a MPsdConstrBuilder object with the given shape.

Synopsis

```
MPsdConstrBuilder(Shape shp)
```

Arguments

shp: shape of MPsdConstrBuilder.

MPsdConstrBuilder.Flatten()

Flatten a MPsdConstrBuilder object to a 1-dimensional shape.

Synopsis

```
MPsdConstrBuilder Flatten()
```

Return

a MPsdConstrBuilder object collapsed into one dimension.

MPsdConstrBuilder.GetND()

Get number of dimensions of MPsdConstrBuilder object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MPsdConstrBuilder.GetPsdExpr()

Get N-dimensional PSD expressions associated with N-dimensional constraints.

Synopsis

```
MPsdExpr GetPsdExpr()
```

Return

MPsdExpr object.

MPsdConstrBuilder.GetRange()

Get range from lower bound to upper bound of N-dimensional range constraints.

Synopsis

```
double GetRange()
```

Return

length from lower bound to upper bound of range constraints.

MPsdConstrBuilder.GetSense()

Get sense associated with N-dimensional PSD constraints.

Synopsis

```
char GetSense()
```

Return

PSD constraint sense.

MPsdConstrBuilder.Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
void Set(  
    MPsdExpr expr,  
    char sense,  
    NArray<double> rhs)
```

Arguments

expr: MPsdExpr object

sense: constraint sense other than COPT_RANGE.

rhs: N-dimensional constants at right side of constraints.

MPsdConstrBuilder.Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
void Set(  
    MPsdExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: MPsdExpr object

sense: constraint sense other than COPT_RANGE.

rhs: constant of right side of constraints.

MPsdConstrBuilder.Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
void Set(  
    MPsdExpr expr,  
    char sense,  
    MVar rhs)
```

Arguments

expr: MPsdExpr object

sense: constraint sense other than COPT_RANGE.

rhs: MVar object at right side of constraints.

MPsdConstrBuilder.Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
void Set(  
    MPsdExpr expr,  
    char sense,  
    MLinExpr rhs)
```

Arguments

expr: MPsdExpr object

sense: constraint sense other than COPT_RANGE.

rhs: MLinExpr object at right side of constraints.

MPsdConstrBuilder.Set()

Set N-dimensional PSD constraints to its builder object.

Synopsis

```
void Set(  
    MPsdExpr expr,  
    char sense,  
    MPsdExpr rhs)
```

Arguments

expr: MPsdExpr object

sense: PSD constraint sense other than COPT_RANGE.

rhs: MPsdExpr object at right side of PSD constraints.

MPsdConstrBuilder.SetRange()

Set N-dimensional range PSD constraints to its builder object.

Synopsis

```
void SetRange(MPsdExpr expr, double range)
```

Arguments

expr: MPsdExpr object.

range: length from lower bound to upper bound of PSD constraint. Must greater than 0.

24.2.58 MPsdExpr

The *MPsdExpr* class in COPT represents multi-dimensional semidefinite expressions. It is used to construct multi-dimensional semidefinite expressions and perform operations with the built-in multi-dimensional array *NdArray* in COPT. The elements of *MPsdExpr* are either *PsdExpr* objects or their multi-dimensional linear combinations. The following member methods are provided:

MPsdExpr.AddConstant()

Add constant to each quadratic expression in MPsdExpr object.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MPsdExpr.AddConstant()

Add constants to each PSD expression in MPsdExpr object.

Synopsis

```
void AddConstant(NdArray<double> constants)
```

Arguments

constants: N-dimension NdArray object.

MPsdExpr.AddLinExpr()

Add a linear expression to each PsdExpr in MPsdExpr object.

Synopsis

```
void AddLinExpr(Expr expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MPsdExpr.AddMExpr()

Add MExpression to each PSD expression in MPsdExpr object.

Synopsis

```
void AddMExpr(MExpression expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MPsdExpr.AddMLinExpr()

Add linear expressions to MPsdExpr object.

Synopsis

```
void AddMLinExpr(MLinExpr exprs, double mult)
```

Arguments

exprs: N-dimension MLinExpr object.

mult: the same multiplier for added linear expressions, default value is 1.0.

MPsdExpr.AddMPsdExpr()

Add PSD expressions to MPsdExpr object.

Synopsis

```
void AddMPsdExpr(MPsdExpr exprs, double mult)
```

Arguments

exprs: N-dimension MPsdExpr object.

mult: the same multiplier for added PSD expressions, default value is 1.0.

MPsdExpr.AddPsdExpr()

Add a PSD expression to each PSD expression in MPsdExpr object.

Synopsis

```
void AddPsdExpr(PsdExpr expr, double mult)
```

Arguments

expr: PSD expression object.

mult: the multiplier of PSD expression, default value is 1.0.

MPsdExpr.AddTerm()

Add a PSD term to MPsdExpr object.

Synopsis

```
void AddTerm(PsdVar var, SymMatExpr expr)
```

Arguments

var: PSD variable of new PSD term.

expr: coefficient expression of symmetric matrices of new PSD term.

MPsdExpr.AddTerm()

Add a linear term to MPsdExpr object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MPsdExpr.AddTerm()

Add a PSD term to MPsdExpr object.

Synopsis

```
void AddTerm(PsdVar var, SymMatrix mat)
```

Arguments

var: PSD variable of new PSD term.

mat: coefficient matrix of new PSD term.

MPsdExpr.AddTerms()

Add terms to PSD expressions in MPsdExpr object.

Synopsis

```
void AddTerms(MVar vars, double mult)
```

Arguments

vars: N-dimension MVar object for added terms.

mult: the same coefficient for added terms, default value 1.0.

MPsdExpr.AddTerms()

Add terms to PSD expressions in MPsdExpr object.

Synopsis

```
void AddTerms(MVar vars, NdArray<double> coeffs)
```

Arguments

vars: N-dimension MVar object for added terms.

coeffs: N-dimension NdArray object of coefficients for added terms.

MPsdExpr.Clear()

Clear MPsdExpr object.

Synopsis

```
void Clear()
```

MPsdExpr.Clone()

Clone MPsdExpr object.

Synopsis

```
MPsdExpr Clone()
```

Return

new MPsdExpr object.

MPsdExpr.Diagonal()

Get diagonals of MPsdExpr object.

Synopsis

```
MPsdExpr Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MPsdExpr.

axis2: 2nd axis of MPsdExpr.

Return

(N-1)-dimensional diagonals.

MPsdExpr.Expand()

Expand shape of MPsdExpr object.

Synopsis

```
MPsdExpr Expand(int axis)
```

Arguments

axis: axis of MPsdExpr.

Return

MPsdExpr object of (N+1)-dimensional shape.

MPsdExpr.Flatten()

Flatten a MPsdExpr object to a 1-dimensional shape.

Synopsis

```
MPsdExpr Flatten()
```

Return

a MPsdExpr object collapsed into one dimension.

MPsdExpr.GetDim()

Get i-th dimension of MPsdExpr object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MPsdExpr.GetItem()

Get PSD expression of given index from MPsdExpr object.

Synopsis

```
PsdExpr GetItem(long idx)
```

Arguments

idx: index of PSD expression.

Return

PSD expression object.

MPsdExpr.GetItem()

Get sub-arrays of MPsdExpr object, given view object.

Synopsis

```
MPsdExpr GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MPsdExpr object.

MPsdExpr.GetND()

Get number of dimensions of MPsdExpr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MPsdExpr.GetShape()

Get shape of MPsdExpr object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MPsdExpr.GetSize()

Get size of MPsdExpr object.

Synopsis

```
long GetSize()
```

Return

number of linear expressions.

MPsdExpr.HStack<T>()

Stack with other NdArray object along horizontal axis.

Synopsis

```
MPsdExpr HStack<T>(NdArray<T> other)
```

Arguments

other: a NdArray object.

Return

the result MPsdExpr object.

MPsdExpr.HStack()

Stack with other MPsdExpr object along horizontal axis.

Synopsis

```
MPsdExpr HStack(MPsdExpr other)
```

Arguments

other: a MPsdExpr object.

Return

the result MPsdExpr object.

MPsdExpr.HStack()

Stack with other MLinExpr object along horizontal axis.

Synopsis

```
MPsdExpr HStack(MLinExpr other)
```

Arguments

other: a MLinExpr object.

Return

the result MPsdExpr object.

MPsdExpr.HStack()

Stack with other MVar object along horizontal axis.

Synopsis

```
MPsdExpr HStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MPsdExpr object.

MPsdExpr.Pick()

Given a list of indexes, get PSD expressions from MPsdExpr object.

Synopsis

```
MPsdExpr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired PSD expressions.

MPsdExpr.Repeat()

Repeat each element of MPsdExpr along given axis.

Synopsis

```
MPsdExpr Repeat(long repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MPsdExpr.

Return

new MPsdExpr object.

MPsdExpr.RepeatBlock()

Repeat an MPsdExpr a number of times along given axis.

Synopsis

```
MPsdExpr RepeatBlock(long repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MPsdExpr.

Return

new MPsdExpr object.

MPsdExpr.Represent()

String representation of MPsdExpr object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MPsdExpr.Reshape()

Reshape MPsdExpr object to new shape.

Synopsis

```
MPsdExpr Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MPsdExpr object.

MPsdExpr.SetItem()

Set expression of given index to MPsdExpr object.

Synopsis

```
void SetItem(long idx, MExpression expr)
```

Arguments

idx: index of element.

expr: MExpression object.

MPsdExpr.SetItem()

Set PSD expression of given index to MPsdExpr object.

Synopsis

```
void SetItem(long idx, PsdExpr expr)
```

Arguments

idx: index of element.

expr: PSD expression object.

MPsdExpr.Squeeze()

Remove axis of length 1 from shape of MPsdExpr object.

Synopsis

```
MPsdExpr Squeeze(int axis)
```

Arguments

axis: axis of MPsdExpr, where the length is 1.

Return

MPsdExpr object of (N-1)-dimensional shape.

MPsdExpr.Stack<T>()

Stack with other NdArray object along given axis.

Synopsis

```
MPsdExpr Stack<T>(NdArray<T> other, int axis)
```

Arguments

other: a NdArray object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr.Stack()

Stack with other MPsdExpr object along given axis.

Synopsis

```
MPsdExpr Stack(MPsdExpr other, int axis)
```

Arguments

other: a MPsdExpr object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr.Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MPsdExpr Stack(MLinExpr other, int axis)
```

Arguments

other: a MLinExpr object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr.Stack()

Stack with other MPsdExpr object along given axis.

Synopsis

```
MPsdExpr Stack(MVar other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MPsdExpr.

Return

the result MPsdExpr object.

MPsdExpr.SubConstant()

Subtract constants from each PSD expression in MPsdExpr object.

Synopsis

```
void SubConstant(NdArray<double> constants)
```

Arguments

constants: N-dimension NdArray object.

MPsdExpr.Sum()

Sum of all expressions in MPsdExpr object.

Synopsis

```
MPsdExpr Sum()
```

Return

sum in zero dimension.

MPsdExpr.Sum()

Sum of variables at given axis of MPsdExpr object.

Synopsis

```
MPsdExpr Sum(int axis)
```

Arguments

axis: axis of MPsdExpr.

Return

MPsdExpr object in (N-1)-dimension.

MPsdExpr.Transpose()

Perform matrix transpose of MPsdExpr object.

Synopsis

```
MPsdExpr Transpose()
```

Return

transposed MPsdExpr object.

MPsdExpr.VStack<T>()

Stack with other NdArray object along vertical axis.

Synopsis

```
MPsdExpr VStack<T>(NdArray<T> other)
```

Arguments

other: a NdArray object.

Return

the result MPsdExpr object.

MPsdExpr.VStack()

Stack with other MPsdExpr object along vertical axis.

Synopsis

```
MPsdExpr VStack(MPsdExpr other)
```

Arguments

other: a MPsdExpr object.

Return

the result MPsdExpr object.

MPsdExpr.VStack()

Stack with other MLinExpr object along vertical axis.

Synopsis

```
MPsdExpr VStack(MLinExpr other)
```

Arguments

other: a MLinExpr object.

Return

the result MPsdExpr object.

MPsdExpr.VStack()

Stack with other MVar object along vertical axis.

Synopsis

```
MPsdExpr VStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MPsdExpr object.

24.2.59 MQConstr

The MQConstr class is a COPT multi-dimensional quadratic constraint object. It can be created by calling the method `addMQConstr` of *Model*. The following methods are provided:

MQConstr.Clone()

Clone MQConstr object.

Synopsis

```
MQConstr Clone()
```

Return

new MQConstr object.

MQConstr.Diagonal()

Get diagonals of MQConstr object.

Synopsis

```
MQConstr Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MQConstr.

axis2: 2nd axis of MQConstr.

Return

(N-1)-dimensional diagonals.

MQConstr.Expand()

Expand shape of MQConstr object.

Synopsis

```
MQConstr Expand(int axis)
```

Arguments

axis: axis of MQConstr.

Return

MQConstr object of (N+1)-dimensional shape.

MQConstr.Flatten()

Flatten a MQConstr object to a 1-dimensional shape.

Synopsis

```
MQConstr Flatten()
```

Return

a MQConstr object collapsed into one dimension.

MQConstr.Get()

Get values of information associated with quadratic constraints in MQConstr object.

Synopsis

```
NdArray<double> Get(string info)
```

Arguments

info: name of information.

Return

multi-dimensional array of information of quadratic constraints.

MQConstr.GetDim()

Get i-th dimension of MQConstr object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MQConstr.GetIdx()

Get index of quadratic constraints in MQConstr object.

Synopsis

```
NdArray<int> GetIdx()
```

Return

multi-dimensional array of indexes of quadratic constraints.

MQConstr.GetItem()

Get quadratic constraint of given index from MQConstr object.

Synopsis

```
QConstraint GetItem(long idx)
```

Arguments

idx: index of quadratic constraint.

Return

QConstraint object.

MQConstr.GetItem()

Get sub-arrays of MQConstr object, given view object.

Synopsis

```
MQConstr GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MQConstr object.

MQConstr.GetND()

Get number of dimensions of MQConstr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MQConstr.GetRhs()

Get RHS of quadratic constraints in MQConstr object.

Synopsis

```
NdArray<double> GetRhs()
```

Return

multi-dimensional array of RHS of quadratic constraints.

MQConstr.GetSense()

Get senses of quadratic constraints in MQConstr object.

Synopsis

```
NdArray<char> GetSense()
```

Return

multi-dimensional array of senses of quadratic constraints.

MQConstr.GetShape()

Get shape of MQConstr object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MQConstr.GetSize()

Get size of MQConstr object.

Synopsis

```
long GetSize()
```

Return

number of vars.

MQConstr.HStack()

Stack with other MQConstr object along horizontal axis.

Synopsis

```
MQConstr HStack(MQConstr other)
```

Arguments

other: a MQConstr object.

Return

the result MQConstr object.

MQConstr.Pick()

Given a list of indexes, get quadratic constraints from MQConstr object.

Synopsis

```
MQConstr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired quadratic constraints.

MQConstr.Represent()

String representation of MQConstr object.

Synopsis

```
string Represent(uint maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MQConstr.Reshape()

Reshape MQConstr object to new shape.

Synopsis

```
MQConstr Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MQConstr object.

MQConstr.Set()

Set values of information associated with quadratic constraints in MQConstr object.

Synopsis

```
void Set(string info, NArray<double> vals)
```

Arguments

info: name of information.

vals: multi-dimensional array of values of information.

MQConstr.Set()

Set values of information associated with quadratic constraints in MQConstr object.

Synopsis

```
void Set(string info, double val)
```

Arguments

info: name of information.

val: value of information.

MQConstr.SetItem()

Set quadratic constraint of given index to MQConstr object.

Synopsis

```
void SetItem(long idx, QConstraint constr)
```

Arguments

idx: index of element.

constr: quadratic constraint object.

MQConstr.Squeeze()

Remove axis of length 1 from shape of MQConstr object.

Synopsis

```
MQConstr Squeeze(int axis)
```

Arguments

axis: axis of MQConstr, where the length is 1.

Return

MQConstr object of (N-1)-dimensional shape.

MQConstr.Stack()

Stack with other MQConstr object along given axis.

Synopsis

```
MQConstr Stack(MQConstr other, int axis)
```

Arguments

other: a MQConstr object.

axis: an axis of MQConstr.

Return

the result MQConstr object.

MQConstr.Transpose()

Perform matrix transpose of MQConstr object.

Synopsis

```
MQConstr Transpose()
```

Return

transposed MQConstr object.

MQConstr.VStack()

Stack with other MQConstr object along vertical axis.

Synopsis

```
MQConstr VStack(MQConstr other)
```

Arguments

other: a MQConstr object.

Return

the result MQConstr object.

24.2.60 MQConstrBuilder

The MQConstrBuilder class is a COPT builder object of multi-dimensional quadratic constraints. It is used to generate multi-dimensional quadratic constraints and supports operations with the built-in multi-dimensional array *NdArray* in COPT. It can be created by comparing two objects, one of which should be *MQuadExpr* object, by comparison operators. The following methods are provided:

MQConstrBuilder.MQConstrBuilder()

Construct a MQConstrBuilder object with the given shape.

Synopsis

```
MQConstrBuilder(Shape shp)
```

Arguments

shp: shape of MQConstrBuilder.

MQConstrBuilder.Flatten()

Flatten a MQConstrBuilder object to a 1-dimensional shape.

Synopsis

```
MQConstrBuilder Flatten()
```

Return

a MQConstrBuilder object collapsed into one dimension.

MQConstrBuilder.GetND()

Get number of dimensions of MQConstrBuilder object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MQConstrBuilder.GetQuadExpr()

Get N-dimensional quadratic expressions associated with N-dimensional quadratic constraints.

Synopsis

```
MQuadExpr GetQuadExpr()
```

Return

MQuadExpr object.

MQConstrBuilder.GetSense()

Get sense associated with N-dimensional constraints.

Synopsis

```
char GetSense()
```

Return

constraint sense.

MQConstrBuilder.Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
void Set(  
    MQuadExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: MQuadExpr object
sense: constraint sense other than COPT_RANGE.
rhs: constant of right side of constraints.

MQConstrBuilder.Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
void Set(  
    MQuadExpr expr,  
    char sense,  
    MVar rhs)
```

Arguments

expr: MQuadExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MVar object at right side of quadratic constraints.

MQConstrBuilder.Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
void Set(  
    MQuadExpr expr,  
    char sense,  
    MLinExpr rhs)
```

Arguments

expr: MQuadExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MLinExpr object at right side of quadratic constraints.

MQConstrBuilder.Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
void Set(  
    MQuadExpr expr,  
    char sense,  
    MQuadExpr rhs)
```

Arguments

expr: MQuadExpr object
sense: constraint sense other than COPT_RANGE.
rhs: MQuadExpr object at right side of quadratic constraints.

MQConstrBuilder.Set()

Set N-dimensional quadratic constraints to its builder object.

Synopsis

```
void Set(  
    MQuadExpr expr,  
    char sense,  
    NdArray<double> rhs)
```

Arguments

expr: MQuadExpr object

sense: constraint sense other than COPT_RANGE.

rhs: N-dimensional constants at right side of quadratic constraints.

24.2.61 MQExpression

The MQExpression class is a generalized version of *QuadExpr*. It represents a quadratic expression and supports most of methods in QuadExpr class. In addition, it supports quadratic combination of multi-dimensional objects, such as *MVar* object and *MLinExpr* object. The following methods are provided:

MQExpression.MQExpression()

Construct a MQExpression object with the given constant.

Synopsis

```
MQExpression(double constant)
```

Arguments

constant: constant number.

MQExpression.MQExpression()

Construct a MQExpression object with the given quadratic expression.

Synopsis

```
MQExpression(QuadExpr expr)
```

Arguments

expr: a quadratic expression.

MQExpression.AddConstant()

Add constant for the expression.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MQExpression.AddExpr()

Add a linear expression to MQExpression object.

Synopsis

```
void AddExpr(Expr expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MQExpression.AddMExpr()

Add MExpression to MQExpression object.

Synopsis

```
void AddMExpr(MExpression expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MQExpression.AddMQExpr()

Add MQExpression to MQExpression object.

Synopsis

```
void AddMQExpr(MQExpression expr, double mult)
```

Arguments

expr: MQExpression object.

mult: the multiplier of MQExpression, default value is 1.0.

MQExpression.AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(MExpression left, Expr right)
```

Arguments

left: MExpression object.

right: Expr object.

MQExpression.AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(MExpression left, MExpression right)
```

Arguments

left: left MExpression object.

right: right MExpression object.

MQExpression.AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(QuadExpr expr, double mult)
```

Arguments

expr: quadratic expression object.

mult: the multiplier of quadratic expression, default value is 1.0.

MQExpression.AddQuadExpr()

Add a quadratic expression to MQExpression object.

Synopsis

```
void AddQuadExpr(MExpression expr, Var var)
```

Arguments

expr: MExpression object.

var: Var object.

MQExpression.AddTerm()

Add a linear term to MQExpression object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MQExpression.AddTerm()

Add a quadratic term to MQExpression object.

Synopsis

```
void AddTerm(  
    Var var1,  
    Var var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.

var2: second variable of new quadratic term.

coeff: coefficient of new quadratic term.

MQExpression.Clone()

Clone MQExpression object.

Synopsis

```
MQExpression Clone()
```

Return

new MQExpression object.

MQExpression.GetConstant()

Get constant in expression.

Synopsis

```
double GetConstant()
```

Return

constant in expression.

MQExpression.Represent()

String representation of MQExpression object.

Synopsis

```
string Represent(uint maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

24.2.62 MQuadExpr

COPT multi-dimensional quadratic expression object. It is used to construct multi-dimensional quadratic expressions and perform operations with the multi-dimensional array built in COPT *NdArray* . Its elements are *MQExpression* objects. It can be created by quadratic combination of *MVar* objects. The following methods are provided:

MQuadExpr.AddConstant()

Add constant to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddConstant(double constant)
```

Arguments

constant: the value of the constant.

MQuadExpr.AddConstant()

Add constants to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddConstant(NdArray<double> constants)
```

Arguments

constants: N-dimension NdArray object.

MQuadExpr.AddExpr()

Add a linear expression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddExpr(Expr expr, double mult)
```

Arguments

expr: linear expression object.

mult: the multiplier of linear expression, default value is 1.0.

MQuadExpr.AddMExpr()

Add MExpression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddMExpr(MExpression expr, double mult)
```

Arguments

expr: MExpression object.

mult: the multiplier of MExpression, default value is 1.0.

MQuadExpr.AddMLinExpr()

Add linear expressions to MQuadExpr object.

Synopsis

```
void AddMLinExpr(MLinExpr exprs, double mult)
```

Arguments

exprs: N-dimension MLinExpr object.

mult: the same multiplier for added linear expressions, default value is 1.0.

MQuadExpr.AddMQExpr()

Add MQExpression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddMQExpr(MQExpression expr, double mult)
```

Arguments

expr: MQExpression object.

mult: the multiplier of MQExpression, default value is 1.0.

MQuadExpr.AddMQuadExpr()

Add quadratic expressions to MQuadExpr object.

Synopsis

```
void AddMQuadExpr(MQuadExpr exprs, double mult)
```

Arguments

exprs: N-dimension MQuadExpr object.

mult: the same multiplier for added quadratic expressions, default value is 1.0.

MQuadExpr.AddQuadExpr()

Add a quadratic expression to each quadratic expression in MQuadExpr object.

Synopsis

```
void AddQuadExpr(QuadExpr expr, double mult)
```

Arguments

expr: quadratic expression object.

mult: the multiplier of quadratic expression, default value is 1.0.

MQuadExpr.AddTerm()

Add a linear term to MQuadExpr object.

Synopsis

```
void AddTerm(Var var, double coeff)
```

Arguments

var: variable of new term.

coeff: coefficient of new term.

MQuadExpr.AddTerm()

Add a quadratic term to MQuadExpr object.

Synopsis

```
void AddTerm(  
    Var var1,  
    Var var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.

var2: second variable of new quadratic term.

coeff: coefficient of new quadratic term.

MQuadExpr.AddTerms()

Add terms to quadratic expressions in MQuadExpr object.

Synopsis

```
void AddTerms(MVar vars, double mult)
```

Arguments

vars: N-dimension MVar object for added terms.

mult: the same coefficient for added terms, default value 1.0.

MQuadExpr.AddTerms()

Add terms to quadratic expressions in MQuadExpr object.

Synopsis

```
void AddTerms(MVar vars, NdArray<double> coeffs)
```

Arguments

vars: N-dimension MVar object for added terms.

coeffs: N-dimension NdArray object of coefficients for added terms.

MQuadExpr.Clear()

Clear MQuadExpr object.

Synopsis

```
void Clear()
```

MQuadExpr.Clone()

Clone MQuadExpr object.

Synopsis

```
MQuadExpr Clone()
```

Return

new MQuadExpr object.

MQuadExpr.Diagonal()

Get diagonals of MQuadExpr object.

Synopsis

```
MQuadExpr Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of MQuadExpr.

axis2: 2nd axis of MQuadExpr.

Return

(N-1)-dimensional diagonals.

MQuadExpr.Expand()

Expand shape of MQuadExpr object.

Synopsis

```
MQuadExpr Expand(int axis)
```

Arguments

axis: axis of MQuadExpr.

Return

MQuadExpr object of (N+1)-dimensional shape.

MQuadExpr.Flatten()

Flatten a MQuadExpr object to a 1-dimensional shape.

Synopsis

```
MQuadExpr Flatten()
```

Return

a MQuadExpr object collapsed into one dimension.

MQuadExpr.GetDim()

Get i-th dimension of MQuadExpr object.

Synopsis

```
uint GetDim(int i)
```

Arguments

i: index of dimension

Return

i-th dimension.

MQuadExpr.GetItem()

Get quadratic expression of given index from MQuadExpr object.

Synopsis

```
MQExpression GetItem(long idx)
```

Arguments

idx: index of quadratic expression.

Return

MQExpression object.

MQuadExpr.GetItem()

Get sub-arrays of MQuadExpr object, given view object.

Synopsis

```
MQuadExpr GetItem(View view)
```

Arguments

view: view of multi-dimensional array.

Return

sub-arrays of MQuadExpr object.

MQuadExpr.GetND()

Get number of dimensions of MQuadExpr object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

MQuadExpr.GetShape()

Get shape of MQuadExpr object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

MQuadExpr.GetSize()

Get size of MQuadExpr object.

Synopsis

```
uint GetSize()
```

Return

number of linear expressions.

MQuadExpr.HStack<T>()

Stack with other NdArray object along horizontal axis.

Synopsis

```
MQuadExpr HStack<T>(NdArray<T> other)
```

Arguments

other: a NdArray object.

Return

the result MQuadExpr object.

MQuadExpr.HStack()

Stack with other MQuadExpr object along horizontal axis.

Synopsis

```
MQuadExpr HStack(MQuadExpr other)
```

Arguments

other: a MQuadExpr object.

Return

the result MQuadExpr object.

MQuadExpr.HStack()

Stack with other MLinExpr object along horizontal axis.

Synopsis

```
MQuadExpr HStack(MLinExpr other)
```

Arguments

other: a MLinExpr object.

Return

the result MQuadExpr object.

MQuadExpr.HStack()

Stack with other MVar object along horizontal axis.

Synopsis

```
MQuadExpr HStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MQuadExpr object.

MQuadExpr.Pick()

Given a list of indexes, get quadratic expressions from MQuadExpr object.

Synopsis

```
MQuadExpr Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. If two dimensional, each row is position of an element.

Return

one-dimensional array of desired quadratic expressions.

MQuadExpr.Repeat()

Repeat each element of MQuadExpr along given axis.

Synopsis

```
MQuadExpr Repeat(long repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of MQuadExpr.

Return

new MQuadExpr object.

MQuadExpr.RepeatBlock()

Repeat an MQuadExpr a number of times along given axis.

Synopsis

```
MQuadExpr RepeatBlock(long repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of MQuadExpr.

Return

new MQuadExpr object.

MQuadExpr.Represent()

String representation of MQuadExpr object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

string object.

MQuadExpr.Reshape()

Reshape MQuadExpr object to new shape.

Synopsis

```
MQuadExpr Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional MQuadExpr object.

MQuadExpr.SetItem()

Set quadratic expression of given index to MQuadExpr object.

Synopsis

```
void SetItem(long idx, MQExpression expr)
```

Arguments

idx: index of element.

expr: MQExpression object.

MQuadExpr.Squeeze()

Remove axis of length 1 from shape of MQuadExpr object.

Synopsis

```
MQuadExpr Squeeze(int axis)
```

Arguments

axis: axis of MQuadExpr, where the length is 1.

Return

MQuadExpr object of (N-1)-dimensional shape.

MQuadExpr.Stack<T>()

Stack with other NdArray object along given axis.

Synopsis

```
MQuadExpr Stack<T>(NdArray<T> other, int axis)
```

Arguments

other: a NdArray object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr.Stack()

Stack with other MQuadExpr object along given axis.

Synopsis

```
MQuadExpr Stack(MQuadExpr other, int axis)
```

Arguments

other: a MQuadExpr object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr.Stack()

Stack with other MLinExpr object along given axis.

Synopsis

```
MQuadExpr Stack(MLinExpr other, int axis)
```

Arguments

other: a MLinExpr object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr.Stack()

Stack with other MQuadExpr object along given axis.

Synopsis

```
MQuadExpr Stack(MVar other, int axis)
```

Arguments

other: a MVar object.

axis: an axis of MQuadExpr.

Return

the result MQuadExpr object.

MQuadExpr.SubConstant()

Subtract constants from each quadratic expression in MQuadExpr object.

Synopsis

```
void SubConstant(NdArray<double> constants)
```

Arguments

constants: N-dimension NdArray object.

MQuadExpr.Sum()

Sum of all expressions in MQuadExpr object.

Synopsis

```
MQuadExpr Sum()
```

Return

sum in zero dimension.

MQuadExpr.Sum()

Sum of variables at given axis of MQuadExpr object.

Synopsis

```
MQuadExpr Sum(int axis)
```

Arguments

axis: axis of MQuadExpr.

Return

MQuadExpr object in (N-1)-dimension.

MQuadExpr.Transpose()

Perform matrix transpose of MQuadExpr object.

Synopsis

```
MQuadExpr Transpose()
```

Return

transposed MQuadExpr object.

MQuadExpr.VStack<T>()

Stack with other NdArray object along vertical axis.

Synopsis

```
MQuadExpr VStack<T>(NdArray<T> other)
```

Arguments

other: a NdArray object.

Return

the result MQuadExpr object.

MQuadExpr.VStack()

Stack with other MQuadExpr object along vertical axis.

Synopsis

```
MQuadExpr VStack(MQuadExpr other)
```

Arguments

other: a MQuadExpr object.

Return

the result MQuadExpr object.

MQuadExpr.VStack()

Stack with other MLinExpr object along vertical axis.

Synopsis

```
MQuadExpr VStack(MLinExpr other)
```

Arguments

other: a MLinExpr object.

Return

the result MQuadExpr object.

MQuadExpr.VStack()

Stack with other MVar object along vertical axis.

Synopsis

```
MQuadExpr VStack(MVar other)
```

Arguments

other: a MVar object.

Return

the result MQuadExpr object.

24.2.63 NdArray

The NdArray class is a built-in multi-dimensional array in COPT. It represents a table of elements of the same type, indexed by a tuple of integers. The following methods are provided:

NdArray<T>.Diagonal()

Get data type of NdArray object. Get diagonals of NdArray object.

Synopsis

```
NdArray<T> Diagonal(  
    int offset,  
    int axis1,  
    int axis2)
```

Arguments

offset: offset of the diagonal from the main diagonal. Can be positive or negative.

axis1: 1st axis of NdArray.

axis2: 2nd axis of NdArray.

Return

data type of elements. (N-1)-dimensional diagonals.

NdArray<T>.Expand()

Expand shape of NdArray object.

Synopsis

```
NdArray<T> Expand(int axis)
```

Arguments

axis: axis of NdArray.

Return

NdArray object in (N+1)-dimensions.

NdArray<T>.Fill()

Fill NdArray object with given value.

Synopsis

```
void Fill(T val)
```

Arguments

val: new value.

NdArray<T>.Flatten()

Flatten an NdArray object to a 1-dimensional shape.

Synopsis

```
NdArray<T> Flatten()
```

Return

An NdArray object collapsed into one dimension.

NdArray<T>.GetDim()

Get i-th dimension in NdArray object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimensions.

Return

the i-th dimension.

NdArray<T>.GetItem()

Get element of given index from NdArray object.

Synopsis

```
T GetItem(long idx)
```

Arguments

idx: index of element.

Return

value of element.

NdArray<T>.GetItem()

Get sub-array of NdArray object, given View object.

Synopsis

```
NdArray<T> GetItem(View view)
```

Arguments

view: View object.

Return

sub NdArray without copying underlying data.

NdArray<T>.GetND()

Get number of dimensions in NdArray object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

NdArray<T>.GetShape()

Get shape of NdArray object.

Synopsis

```
Shape GetShape()
```

Return

shape object.

NdArray<T>.GetSize()

Get size of NdArray object.

Synopsis

```
long GetSize()
```

Return

size of NdArray.

NdArray<T>.NdArray()

Constructor of NdArray object.

Synopsis

```
NdArray(Shape shp, T val)
```

Arguments

shp: shape of NdArray object.

val: initial value of elements, including int, long, float and double.

NdArray<T>.Pick()

Given a list of indexes, get elements from NdArray object.

Synopsis

```
NdArray<T> Pick(NdArray<int> indexes)
```

Arguments

indexes: one or two dimensional indexes of elements. if two dimensional, each row is position of an element.

Return

one-dimensional array of desired elements.

NdArray<T>.Repeat()

Repeat each element of an array along given axis.

Synopsis

```
NdArray<T> Repeat(long repeats, int axis)
```

Arguments

repeats: number of repetitions for each element.

axis: axis of NdArray.

Return

new NdArray object.

NdArray<T>.RepeatBlock()

Repeat an array a number of times along given axis.

Synopsis

```
NdArray<T> RepeatBlock(long repeats, int axis)
```

Arguments

repeats: number of repetitions.

axis: axis of NdArray.

Return

new NdArray object.

NdArray<T>.Represent()

String representation of NdArray object.

Synopsis

```
string Represent(int maxlen)
```

Arguments

maxlen: maximum buffer length for representations string.

Return

representation string object.

NdArray<T>.Reshape()

Reshape NdArray object to new shape.

Synopsis

```
NdArray<T> Reshape(Shape shp)
```

Arguments

shp: new shape of M-dimensions.

Return

M-dimensional NdArray object.

NdArray<T>.SetItem()

Set element of given index to NdArray object.

Synopsis

```
void SetItem(long idx, T val)
```

Arguments

idx: index of element.

val: value of element.

NdArray<T>.Squeeze()

Remove axis of length 1 from shape of NdArray object.

Synopsis

```
NdArray<T> Squeeze(int axis)
```

Arguments

axis: axis of NdArray, where the length is 1.

Return

(N-1)-dimensional NdArray object.

NdArray<T>.Sum()

Sum of all elements in NdArray object.

Synopsis

```
NdArray<T> Sum()
```

Return

sum in zero dimension.

NdArray<T>.Sum()

Sum of elements at given axis of NdArray object.

Synopsis

```
NdArray<T> Sum(int axis)
```

Arguments

axis: axis of NdArray.

Return

(N-1)-dimensional NdArray object.

NdArray<T>.Transpose()

Perform matrix transpose of NdArray object.

Synopsis

```
NdArray<T> Transpose()
```

Return

transposed NdArray object.

24.2.64 Shape

The Shape class encapsulates a tuple of integers, indicating the size of array along each dimension. It refers to dimensions of built-in *NdArray* in COPT. The following methods are provided:

Shape.Shape()

Constructor of Shape object.

Synopsis

```
Shape()
```

Shape.Expand()

Expand shape of Shape object.

Synopsis

```
Shape Expand(int axis)
```

Arguments

axis: given axis.

Return

Shape object in (N+1)-dimensions.

Shape.GetDim()

Get i-th dimension in Shape object.

Synopsis

```
long GetDim(int i)
```

Arguments

i: index of dimensions.

Return

the i-th dimension.

Shape.GetND()

Get number of dimensions in Shape object.

Synopsis

```
int GetND()
```

Return

number of dimensions.

Shape.GetSize()

Get size of Shape object.

Synopsis

```
long GetSize()
```

Return

size of shape.

Shape.GetStart()

Get the i-th start position in Shape object.

Synopsis

```
int GetStart(int i)
```

Arguments

i: index of dimensions.

Return

start position in i-th dimension.

Shape.GetStride()

Get i-th stride in Shape object.

Synopsis

```
int GetStride(int i)
```

Arguments

i: index of dimensions.

Return

stride in i-th dimension.

Shape.Rebuild()

Rebuild Shape object, that is, keep dimensions while reset strides and starts.

Synopsis

```
Shape Rebuild()
```

Return

new Shape object.

Shape.Represent()

String representation of Shape object.

Synopsis

```
string Represent(int type)
```

Arguments

type: 0: dimensions; 1: strides; 2: starts.

Return

string object.

Shape.Squeeze()

Remove axis of length 1 from Shape object.

Synopsis

```
Shape Squeeze(int axis)
```

Arguments

axis: given axis, where the length is 1.

Return

Shape object in (N-1)-dimensions.

24.2.65 View

The View class is used to perform slicing operations on multi-dimensional arrays. The following methods are provided:

View.View()

Constructor of View object.

Synopsis

```
View()
```

View.AddFull()

Create full view object at current dimension.

Synopsis

```
View AddFull()
```

Return

View object.

View.AddScalar()

Create View object of given index at current dimension.

Synopsis

```
View AddScalar(long n)
```

Arguments

n: given index.

Return

View object.

View.AddSlice()

Create view object of slice at current dimension.

Synopsis

```
View AddSlice(long start)
```

Arguments

start: start index, inclusive.

Return

View object.

View.AddSlice()

Create view object of slice at current dimension.

Synopsis

```
View AddSlice(long start, long stop)
```

Arguments

start: start index, inclusive.

stop: stop index, exclusive.

Return

View object.

View.AddSlice()

Create view object of slice at current dimension.

Synopsis

```
View AddSlice(  
    long start,  
    long stop,  
    long step,  
    int flag)
```

Arguments

start: start index, inclusive.

stop: stop index, exclusive.

step: step size between start and stop index. It can be negative.

flag: optional, flag for slicing type. Default is 0.

Return

View object.

24.2.66 CallbackBase

COPT Callback abstract base object. Users must implment its virtual method `virtual void CallbackBase::callback()` to instantiate an instance, which pass to `Model::SetCallback(CallbackBase cb, int cbctx)` as the first parameter. Subclass of `CallbackBase` inherits the following member methods:

CallbackBase.CallbackBase()

Constructor of `CallbackBase`, implementing `ICallback` interface.

Synopsis

```
CallbackBase()
```

CallbackBase.AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(  
    Expr lhs,  
    char sense,  
    double rhs)
```

Arguments

lhs: expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side value for lazy constraint.

CallbackBase.AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(  
    Expr lhs,  
    char sense,  
    Expr rhs)
```

Arguments

lhs: left hand side expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side expression for lazy constraint.

CallbackBase.AddLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void AddLazyConstr(ConstrBuilder builder)
```

Arguments

builder: builder for lazy constraint.

CallbackBase.AddLazyConstrs()

Add lazy constraints to model.

Synopsis

```
void AddLazyConstrs(ConstrBuilderArray builders)
```

Arguments

builders: array of builders for lazy constraints.

CallbackBase.AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    Expr lhs,  
    char sense,  
    double rhs)
```

Arguments

lhs: expression for user cut.
sense: sense for user cut.
rhs: right hand side value for user cut.

CallbackBase.AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(  
    Expr lhs,  
    char sense,  
    Expr rhs)
```

Arguments

lhs: left hand side expression for user cut.
sense: sense for user cut.
rhs: right hand side expression for user cut.

CallbackBase.AddUserCut()

Add a user cut to model.

Synopsis

```
void AddUserCut(ConstrBuilder builder)
```

Arguments

builder: builder for user cut.

CallbackBase.AddUserCuts()

Add user cuts to model.

Synopsis

```
void AddUserCuts(ConstrBuilderArray builders)
```

Arguments

builders: array of builders for user cuts.

CallbackBase.callback()

Pure virtual function defined in ICallback interface. User must implement it.

Synopsis

```
void callback()
```

CallbackBase.GetDbllInfo()

Get double value of given information name in callback.

Synopsis

```
double GetDbllInfo(string cbinfo)
```

Arguments

cbinfo: name of callback info.

Return

value of desired information.

CallbackBase.GetIncumbent()

Get best feasible solution of given variable in callback.

Synopsis

```
double GetIncumbent(Var var)
```

Arguments

var: given variable.

Return

best feasible solution of given variable.

CallbackBase.GetIncumbent()

Get best feasible solution of variables in callback.

Synopsis

```
double[] GetIncumbent(VarArray vars)
```

Arguments

vars: an array of variables.

Return

best feasible solution of desired variables.

CallbackBase.GetIncumbent()

Get best feasible solution of variables in callback.

Synopsis

```
double[] GetIncumbent(Var[] vars)
```

Arguments

vars: an array of variables.

Return

best feasible solution of desired variables.

CallbackBase.GetIncumbent()

Get best feasible solution of all variables in callback.

Synopsis

```
double[] GetIncumbent()
```

Return

best feasible solution of all variables.

CallbackBase.GetIntInfo()

Get integer value of given information name in callback.

Synopsis

```
int GetIntInfo(string cbinfo)
```

Arguments

cbinfo: name of callback info.

Return

value of desired information.

CallbackBase.GetRelaxSol()

Get LP-relaxation solution of given variable in callback.

Synopsis

```
double GetRelaxSol(Var var)
```

Arguments

var: given variable.

Return

LP-relaxation solution of given variable.

CallbackBase.GetRelaxSol()

Get LP-relaxation solution of variables in callback.

Synopsis

```
double[] GetRelaxSol(VarArray vars)
```

Arguments

vars: an array of variables.

Return

LP-relaxation solution of variables.

CallbackBase.GetRelaxSol()

Get LP-relaxation solution of variables in callback.

Synopsis

```
double[] GetRelaxSol(Var[] vars)
```

Arguments

vars: an array of variables.

Return

LP-relaxation solution of variables.

CallbackBase.GetRelaxSol()

Get LP-relaxation solution of all variables in callback.

Synopsis

```
double[] GetRelaxSol()
```

Return

LP-relaxation solution of all variables.

CallbackBase.GetSolution()

Get solution of given variable in callback.

Synopsis

```
double GetSolution(Var var)
```

Arguments

var: given variable.

Return

solution of given variable.

CallbackBase.GetSolution()

Get solution of variables in callback.

Synopsis

```
double[] GetSolution(VarArray vars)
```

Arguments

vars: an array of variables.

Return

solution of variables.

CallbackBase.GetSolution()

Get solution of variables in callback.

Synopsis

```
double[] GetSolution(Var[] vars)
```

Arguments

vars: an array of variables.

Return

solution of variables.

CallbackBase.GetSolution()

Get solution of all variables in callback.

Synopsis

```
double[] GetSolution()
```

Return

solution of all variables.

CallbackBase.Interrupt()

Interrupt solving problems in callback

Synopsis

```
void Interrupt()
```

CallbackBase.LoadSolution()

Load customized solution to model.

Synopsis

```
double LoadSolution()
```

Return

objective value of given solution.

CallbackBase.SetSolution()

Set solution of a given variable in callback.

Synopsis

```
void SetSolution(Var var, double val)
```

Arguments

var: a variable object.

val: double value.

CallbackBase.SetSolution()

Set solution of variables in callback.

Synopsis

```
void SetSolution(VarArray vars, double[] vals)
```

Arguments

vars: an array of variable objects.

vals: an array of double values.

CallbackBase.SetSolution()

Set solution of variables in callback.

Synopsis

```
void SetSolution(Var[] vars, double[] vals)
```

Arguments

vars: an array of variable objects.

vals: an array of double values.

CallbackBase.Where()

Get context in callback.

Synopsis

```
int Where()
```

Return

integer value of context.

24.2.67 ProbBuffer

Buffer object for COPT problem. ProbBuffer object holds the (MPS) problem in string format.

ProbBuffer.ProbBuffer()

Constructor of ProbBuffer object.

Synopsis

```
ProbBuffer(int sz)
```

Arguments

sz: initial size of the problem buffer.

ProbBuffer.GetData()

Get string of problem in problem buffer.

Synopsis

```
string GetData()
```

Return

string of problem in problem buffer.

ProbBuffer.Resize()

Resize buffer to given size, and zero-ended

Synopsis

```
void Resize(int sz)
```

Arguments

sz: new buffer size.

ProbBuffer.Size()

Get the size of problem buffer.

Synopsis

```
int Size()
```

Return

size of problem buffer.

24.2.68 CoptException

Copt exception object.

CoptException.CoptException()

Constructor of coptexception.

Synopsis

```
CoptException(int code, string msg)
```

Arguments

code: error code for exception.

msg: error message for exception.

CoptException.GetCode()

Get the error code associated with the exception.

Synopsis

```
int GetCode()
```

Return

the error code.

Chapter 25

Java API Reference

The **Cardinal Optimizer** provides a Java API library. This chapter documents all COPT Java constants and API functions for Java applications.

25.1 Constants

There are four types of constants defined in **Cardinal Optimizer**. They are general constants, information constants, attributes constants and parameters constants.

25.1.1 General Constants

For the contents of Java general constants, see *General Constants*.

General constants are defined in `Consts` class. User may refer general constants with namespace, that is, `copt.Consts.XXXX`.

25.1.2 Attributes

For the contents of Java attribute constants, see *Attributes*.

All COPT Java attributes are defined in `DbAttr` and `IntAttr` classes. User may refer double attributes by `copt.DbAttr.XXXX`, and integer attributes by `copt.IntAttr.XXXX`.

In the Java API, user can get the attribute value by specifying the attribute name. The two functions of obtaining attribute values are as follows, please refer to *Java API: Model Class* for details.

- `Model.getIntAttr()`: Get value of a COPT integer attribute.
- `Model.getDbAttr()`: Get value of a COPT double attribute.

25.1.3 Information

For the content of Java information constants, see *Information*.

In the Java API, information constants are defined in the `DbInfo` class. Users can access information constants through the prefix `copt` in the namespace (usually can be omitted) `copt.DbInfo`.

For instance, `copt.DbInfo.Obj` is the coefficients of variables in the objective function.

25.1.4 Callback Information

For the content of Java API callback information class constants, see *Callback Information*.

In the Java API, callback-related information constants are defined in the `CbInfo` class. Users can access information constants through the prefix `copt` in the namespace (usually can be omitted) `copt.CbInfo`.

For instance, `copt.CbInfo.BestObj` is the current best objective.

25.1.5 Parameters

For the contents of Java parameters constants, see *Parameters*.

All COPT Java parameters are defined in `DblParam` and `IntParam` classes. User may refer double parameters by `copt.DblParam.XXXX`, and integer parameters by `copt.IntParam.XXXX`.

In the Java API, user can get and set the parameter value by specifying the parameter name. The provided functions are as follows, please refer to *Java API: Model Class* for details.

- Get detailed information of the specified parameter (current value/max/min): `Model.getParamInfo()`
- Get the current value of the specified integer/double parameter: `Model.getIntParam()` / `Model.getDblParam()`
- Set the specified integer/double parameter value: `Model.setIntParam()` / `Model.setDblParam()`

25.2 Java Modeling Classes

This chapter documents COPT Java interface. Users may refer to Java classes described below for details of how to construct and solve Java models.

25.2.1 Envr

Essentially, any Java application using Cardinal Optimizer should start with a COPT environment. COPT models are always associated with a COPT environment. User must create an environment object before populating models. User generally only need a single environment object in program.

Envr.Envr()

Constructor of COPT Envr object.

Synopsis

```
Envr()
```

Envr.Envr()

Constructor of COPT Envr object, given a license folder.

Synopsis

```
Envr(String licDir)
```

Arguments

`licDir`: directory having local license or client config file.

Envr.Envr()

Constructor of COPT Envr object, given an Envr config object.

Synopsis

```
Envr(EnvrConfig config)
```

Arguments

config: Envr config object holding settings for remote connection.

Envr.close()

close remote connection and token becomes invalid for all problems in current envr.

Synopsis

```
void close()
```

Envr.createModel()

Create a model object.

Synopsis

```
Model createModel(String name)
```

Arguments

name: customized model name.

Return

a model object.

25.2.2 EnvrConfig

If user connects to COPT remote services, such as floating token server or compute cluster, it is necessary to add config settings with EnvrConfig object.

EnvrConfig.EnvrConfig()

Constructor of envr config object.

Synopsis

```
EnvrConfig()
```

EnvrConfig.set()

Set config settings in terms of name-value pair.

Synopsis

```
void set(String name, String value)
```

Arguments

name: keyword of a config setting.

value: value of a config setting.

25.2.3 Model

In general, a COPT model consists of a set of variables, a (linear) objective function on these variables, a set of constraints on these variables, etc. COPT model class encapsulates all required methods for constructing a COPT model.

Model.Model()

Constructor of model.

Synopsis

```
Model(Envr env, String name)
```

Arguments

env: associated environment object.

name: string of model name.

Model.addAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone addAffineCone(AffineConeBuilder builder, String name)
```

Arguments

builder: builder for new affine cone constraint.

name: name of new affine cone.

Return

new affine cone constraint object.

Model.addAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone addAffineCone(  
    Expr[] exprs,  
    int type,  
    String name)
```

Arguments

exprs: linear expressions that participate in the affine cone constraint.

type: type of an affine cone constraint.

name: name of new affine cone.

Return

new affine cone constraint object.

Model.addAffineCone()

Add an affine cone constraint to model.

Synopsis

```
AffineCone addAffineCone(  
    PsdExpr[] exprs,  
    int type,  
    String name)
```

Arguments

exprs: PSD expressions that participate in the affine cone constraint.

type: type of an affine cone constraint.

name: name of new affine cone.

Return

new affine cone constraint object.

Model.addCone()

Add a cone constraint to model.

Synopsis

```
Cone addCone(  
    int dim,  
    int type,  
    char[] pvtype,  
    String prefix)
```

Arguments

dim: dimension of the cone constraint.

type: type of a cone constraint.

pvtype: types of variables in the cone.

prefix: name prefix of variables in the cone.

Return

new cone constraint object.

Model.addCone()

Add a cone constraint to model.

Synopsis

```
Cone addCone(ConeBuilder builder)
```

Arguments

builder: builder for new cone constraint.

Return

new cone constraint object.

Model.addCone()

Add a cone constraint to model.

Synopsis

```
Cone addCone(Var[] vars, int type)
```

Arguments

vars: variables that participate in the cone constraint.

type: type of a cone constraint.

Return

new cone constraint object.

Model.addCone()

Add a cone constraint to model.

Synopsis

```
Cone addCone(VarArray vars, int type)
```

Arguments

vars: variables that participate in the cone constraint.

type: type of a cone constraint.

Return

new cone constraint object.

Model.addConstr()

Add a linear constraint to model.

Synopsis

```
Constraint addConstr(  
    Expr expr,  
    char sense,  
    double rhs,  
    String name)
```

Arguments

expr: expression for the new constraint.

sense: sense for new linear constraint, other than range sense.

rhs: right hand side value for the new constraint.

name: name of new constraint.

Return

new constraint object.

Model.addConstr()

Add a linear constraint to model.

Synopsis

```
Constraint addConstr(  
    Expr expr,  
    char sense,  
    Var var,  
    String name)
```

Arguments

expr: expression for the new constraint.

sense: sense for new linear constraint, other than range sense.

var: variable for the new constraint.

name: name of new constraint.

Return

new constraint object.

Model.addConstr()

Add a linear constraint to model.

Synopsis

```
Constraint addConstr(  
    Expr lhs,  
    char sense,  
    Expr rhs,  
    String name)
```

Arguments

lhs: left hand side expression for the new constraint.

sense: sense for new linear constraint, other than range sense.

rhs: right hand side expression for the new constraint.

name: name of new constraint.

Return

new constraint object.

Model.addConstr()

Add a linear constraint to model.

Synopsis

```
Constraint addConstr(  
    Expr expr,  
    double lb,  
    double ub,  
    String name)
```

Arguments

expr: expression for the new constraint.
lb: lower bound for the new constraint.
ub: upper bound for the new constraint
name: name of new constraint.

Return

new constraint object.

Model.addConstr()

Add a linear constraint to a model.

Synopsis

```
Constraint addConstr(ConstrBuilder builder, String name)
```

Arguments

builder: builder for the new constraint.
name: name of new constraint.

Return

new constraint object.

Model.addConstrs()

Add linear constraints to model.

Synopsis

```
ConstrArray addConstrs(  
    int count,  
    char[] senses,  
    double[] rhss,  
    String prefix)
```

Arguments

count: number of constraints added to model.
senses: sense array for new linear constraints, other than range sense.
rhss: right hand side values for new variables.

prefix: name prefix for new constraints.

Return

array of new constraint objects.

Model.addConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray addConstrs(  
    int count,  
    double[] lbs,  
    double[] ubs,  
    String prefix)
```

Arguments

count: number of constraints added to the model.

lbs: lower bounds of new constraints.

ubs: upper bounds of new constraints.

prefix: name prefix for new constraints.

Return

array of new constraint objects.

Model.addConstrs()

Add linear constraints to a model.

Synopsis

```
ConstrArray addConstrs(ConstrBuilderArray builders, String prefix)
```

Arguments

builders: builders for new constraints.

prefix: name prefix for new constraints.

Return

array of new constraint objects.

Model.addDenseMat()

Add a dense symmetric matrix to a model.

Synopsis

```
SymMatrix addDenseMat(int dim, double[] vals)
```

Arguments

dim: dimension of the dense symmetric matrix.

vals: array of non-zero elements, filled in column-wise up to len or max length of symmetric matrix.

Return

new symmetric matrix object.

Model.addDenseMat()

Add a dense symmetric matrix to a model.

Synopsis

```
SymMatrix addDenseMat(int dim, double val)
```

Arguments

dim: dimension of dense symmetric matrix.

val: value to fill dense symmetric matrix.

Return

new symmetric matrix object.

Model.addDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix addDiagMat(int dim, double val)
```

Arguments

dim: dimension of diagonal matrix.

val: value to fill diagonal elements.

Return

new diagonal matrix object.

Model.addDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix addDiagMat(int dim, double[] vals)
```

Arguments

dim: dimension of diagonal matrix.

vals: array of values of diagonal elements.

Return

new diagonal matrix object.

Model.addDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix addDiagMat(  
    int dim,  
    double val,  
    int offset)
```

Arguments

dim: dimension of diagonal matrix.

val: value to fill diagonal elements.

offset: shift distance against diagonal line.

Return

new diagonal matrix object.

Model.addDiagMat()

Add a diagonal matrix to a model.

Synopsis

```
SymMatrix addDiagMat(  
    int dim,  
    double[] vals,  
    int offset)
```

Arguments

dim: dimension of diagonal matrix.

vals: array of values of diagonal elements.

offset: shift distance against diagonal line.

Return

new diagonal matrix object.

Model.addExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone addExpCone(  
    int type,  
    char[] pvtype,  
    String prefix)
```

Arguments

type: type of an exponential cone constraint.

pvttype: types of variables in the exponential cone.

prefix: name prefix of variables in the exponential cone.

Return

new exponential cone constraint object.

Model.addExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone addExpCone(ExpConeBuilder builder)
```

Arguments

builder: builder for new exponential cone constraint.

Return

new exponential cone constraint object.

Model.addExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone addExpCone(Var[] vars, int type)
```

Arguments

vars: variables that participate in the exponential cone constraint.

type: type of an exponential cone constraint.

Return

new exponential cone constraint object.

Model.addExpCone()

Add an exponential cone constraint to model.

Synopsis

```
ExpCone addExpCone(VarArray vars, int type)
```

Arguments

vars: variables that participate in the exponential cone constraint.

type: type of an exponential cone constraint.

Return

new exponential cone constraint object.

Model.addEyeMat()

Add an identity matrix to a model.

Synopsis

```
SymMatrix addEyeMat(int dim)
```

Arguments

dim: dimension of identity matrix.

Return

new identity matrix object.

Model.addGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr addGenConstrIndicator(GenConstrBuilder builder, String  
name)
```

Arguments

builder: builder for the general constraint.

name: name of new general constraint.

Return

new general constraint object of type indicator.

Model.addGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr addGenConstrIndicator(  
    Var binvar,  
    int binval,  
    ConstrBuilder builder,  
    int type,  
    String name)
```

Arguments

binvar: binary indicator variable.

binval: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).

builder: builder for linear constraint.

type: type of general constraint.

name: name of new general constraint.

Return

new general constraint object of type indicator.

Model.addGenConstrIndicator()

Add a general constraint of type indicator to model.

Synopsis

```
GenConstr addGenConstrIndicator(  
    Var binvar,  
    int binval,  
    Expr expr,  
    char sense,  
    double rhs,  
    int type,  
    String name)
```

Arguments

binvar: binary indicator variable.

binval: value for binary indicator variable that force a linear constraint to be satisfied(0 or 1).

expr: expression for new linear constraint.

sense: sense for new linear constraint.

rhs: right hand side value for new linear constraint.

type: type of general constraint.

name: name of new general constraint.

Return

new general constraint object of type indicator.

Model.addGenConstrIndicators()

Add general constraints to a model.

Synopsis

```
GenConstrArray addGenConstrIndicators(GenConstrBuilderArray  
    builders, String prefix)
```

Arguments

builders: builders for new general constraints.

prefix: name prefix for new general constraints.

Return

array of new general constraint objects.

Model.addLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void addLazyConstr(  
    Expr lhs,  
    char sense,  
    double rhs,  
    String name)
```

Arguments

lhs: expression for lazy constraint.
sense: sense for lazy constraint.
rhs: right hand side value for lazy constraint.
name: name of lazy constraint.

Model.addLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void addLazyConstr(  
    Expr lhs,  
    char sense,  
    Expr rhs,  
    String name)
```

Arguments

lhs: left hand side expression for lazy constraint.
sense: sense for lazy constraint.
rhs: right hand side expression for lazy constraint.
name: name of lazy constraint.

Model.addLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void addLazyConstr(ConstrBuilder builder, String name)
```

Arguments

builder: builder for lazy constraint.
name: name of lazy constraint.

Model.addLazyConstrs()

Add lazy constraints to model.

Synopsis

```
void addLazyConstrs(ConstrBuilderArray builders, String prefix)
```

Arguments

builders: array of builders for lazy constraints.

prefix: name prefix of new lazy constraints.

Model.addLmiConstr()

Add an LMI constraint to model.

Synopsis

```
LmiConstraint addLmiConstr(LmiExpr expr, String name)
```

Arguments

expr: LMI expression for new LMI constraint.

name: name of new LMI constraint.

Return

new LMI constraint object.

Model.addOnesMat()

Add a dense symmetric matrix of value one to a model.

Synopsis

```
SymMatrix addOnesMat(int dim)
```

Arguments

dim: dimension of dense symmetric matrix.

Return

new symmetric matrix object.

Model.addPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint addPsdConstr(  
    PsdExpr expr,  
    char sense,  
    double rhs,  
    String name)
```

Arguments

expr: PSD expression for new PSD constraint.

sense: sense for new PSD constraint.

rhs: double value at right side of the new PSD constraint.

name: name of new PSD constraint.

Return

new PSD constraint object.

Model.addPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint addPsdConstr(  
    PsdExpr expr,  
    double lb,  
    double ub,  
    String name)
```

Arguments

expr: expression for new PSD constraint.

lb: lower bound for ew PSD constraint.

ub: upper bound for new PSD constraint

name: name of new PSD constraint.

Return

new PSD constraint object.

Model.addPsdConstr()

Add a PSD constraint to model.

Synopsis

```
PsdConstraint addPsdConstr(  
    PsdExpr lhs,  
    char sense,  
    PsdExpr rhs,  
    String name)
```

Arguments

lhs: PSD expression at left side of new PSD constraint.

sense: sense for new PSD constraint.

rhs: PSD expression at right side of new PSD constraint.

name: name of new PSD constraint.

Return

new PSD constraint object.

Model.addPsdConstr()

Add a PSD constraint to a model.

Synopsis

```
PsdConstraint addPsdConstr(PsdConstrBuilder builder, String name)
```

Arguments

builder: builder for new PSD constraint.

name: name of new PSD constraint.

Return

new PSD constraint object.

Model.addPsdVar()

Add a new PSD variable to model.

Synopsis

```
PsdVar addPsdVar(int dim, String name)
```

Arguments

dim: dimension of new PSD variable.

name: name of new PSD variable.

Return

PSD variable object.

Model.addPsdVars()

Add new PSD variables to model.

Synopsis

```
PsdVarArray addPsdVars(  
    int count,  
    int[] dims,  
    String prefix)
```

Arguments

count: number of new PSD variables.

dims: array of dimensions of new PSD variables.

prefix: name prefix of new PSD variables.

Return

array of PSD variable objects.

Model.addQConstr()

Add a quadratic constraint to model.

Synopsis

```
QConstraint addQConstr(  
    QuadExpr expr,  
    char sense,  
    double rhs,  
    String name)
```

Arguments

expr: quadratic expression for the new constraint.

sense: sense for new quadratic constraint.

rhs: double value at right side of the new quadratic constraint.

name: name of new quadratic constraint.

Return

new quadratic constraint object.

Model.addQConstr()

Add a quadratic constraint to model.

Synopsis

```
QConstraint addQConstr(  
    QuadExpr lhs,  
    char sense,  
    QuadExpr rhs,  
    String name)
```

Arguments

lhs: quadratic expression at left side of new quadratic constraint.

sense: sense for new quadratic constraint.

rhs: quadratic expression at right side of new quadratic constraint.

name: name of new quadratic constraint.

Return

new quadratic constraint object.

Model.addQConstr()

Add a quadratic constraint to a model.

Synopsis

```
QConstraint addQConstr(QConstrBuilder builder, String name)
```

Arguments

builder: builder for the new quadratic constraint.

name: name of new quadratic constraint.

Return

new quadratic constraint object.

Model.addSos()

Add a SOS constraint to model.

Synopsis

```
Sos addSos(SosBuilder builder)
```

Arguments

builder: builder for new SOS constraint.

Return

new SOS constraint object.

Model.addSos()

Add a SOS constraint to model.

Synopsis

```
Sos addSos(  
    Var[] vars,  
    double[] weights,  
    int type)
```

Arguments

vars: variables that participate in the SOS constraint.

weights: weights for variables in the SOS constraint.

type: type of SOS constraint.

Return

new SOS constraint object.

Model.addSos()

Add a SOS constraint to model.

Synopsis

```
Sos addSos(  
    VarArray vars,  
    double[] weights,  
    int type)
```

Arguments

vars: variables that participate in the SOS constraint.

weights: weights for variables in the SOS constraint.

type: type of SOS constraint.

Return

new SOS constraint object.

Model.addSparseMat()

Add a sparse symmetric matrix to a model.

Synopsis

```
SymMatrix addSparseMat(  
    int dim,  
    int nElems,  
    int[] rows,  
    int[] cols,  
    double[] vals)
```

Arguments

dim: dimension of the sparse symmetric matrix.

nElems: number of non-zero elements in the sparse symmetric matrix.

rows: array of row indexes of non-zero elements.

cols: array of col indexes of non-zero elements.

vals: array of values of non-zero elements.

Return

new symmetric matrix object.

Model.addSymMat()

Given a symmetric matrix expression, add results matrix to model.

Synopsis

```
SymMatrix addSymMat(SymMatExpr expr)
```

Arguments

expr: symmetric matrix expression object.

Return

results symmetric matrix object.

Model.addUserCut()

Add a user cut to model.

Synopsis

```
void addUserCut(  
    Expr lhs,  
    char sense,  
    double rhs,  
    String name)
```

Arguments

lhs: expression for user cut.

sense: sense for user cut.

rhs: right hand side value for user cut.

name: name of user cut.

Model.addUserCut()

Add a user cut to model.

Synopsis

```
void addUserCut(  
    Expr lhs,  
    char sense,  
    Expr rhs,  
    String name)
```

Arguments

lhs: left hand side expression for user cut.

sense: sense for user cut.

rhs: right hand side expression for user cut.

name: name of user cut.

Model.addUserCut()

Add a user cut to model.

Synopsis

```
void addUserCut(ConstrBuilder builder, String name)
```

Arguments

builder: builder for user cut.

name: name of user cut.

Model.addUserCuts()

Add user cuts to model.

Synopsis

```
void addUserCuts(ConstrBuilderArray builders, String prefix)
```

Arguments

builders: array of builders for user cuts.

prefix: name prefix of new user cuts.

Model.addVar()

Add a variable and the associated non-zero coefficients as column.

Synopsis

```
Var addVar(  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    String name)
```

Arguments

lb: lower bound for new variable.

ub: upper bound for new variable.

obj: objective coefficient for new variable.

vtype: variable type for new variable.

name: name for new variable.

Return

new variable object.

Model.addVar()

Add a variable and the associated non-zero coefficients as column.

Synopsis

```
Var addVar(  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    Column col,  
    String name)
```

Arguments

lb: lower bound for new variable.

ub: upper bound for new variable.

obj: objective coefficient for new variable.

vtype: variable type for new variable.

col: column object for specifying a set of constraints to which the variable belongs.

name: name for new variable.

Return

new variable object.

Model.addVars()

Add new variables to model.

Synopsis

```
VarArray addVars(  
    int count,  
    char vtype,  
    String prefix)
```

Arguments

count: the number of variables to add.

vtype: variable types for new variables.

prefix: prefix part for names of new variables.

Return

array of new variable objects.

Model.addVars()

Add new variables to model.

Synopsis

```
VarArray addVars(  
    int count,  
    double lb,  
    double ub,  
    double obj,  
    char vtype,  
    String prefix)
```

Arguments

count: the number of variables to add.
lb: lower bound for new variables.
ub: upper bound for new variables.
obj: objective coefficient for new variables.
vtype: variable type for new variables.
prefix: prefix part for names of new variables.

Return

array of new variable objects.

Model.addVars()

Add new variables to model.

Synopsis

```
VarArray addVars(  
    int count,  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    String prefix)
```

Arguments

count: the number of variables to add.
lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.
ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.
objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.
types: variable types for new variables. if NULL, variable types are continuous.
prefix: prefix part for names of new variables.

Return

array of new variable objects.

Model.addVars()

Add new variables to model.

Synopsis

```
VarArray addVars(  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    Column[] cols,  
    String prefix)
```

Arguments

lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.

ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

types: variable types for new variables. if NULL, variable types are continuous.

cols: column objects for specifying a set of constraints to which each new variable belongs.

prefix: prefix part for names of new variables.

Return

array of new variable objects.

Model.addVars()

Add new variables to model.

Synopsis

```
VarArray addVars(  
    double[] lbs,  
    double[] ubs,  
    double[] objs,  
    char[] types,  
    ColumnArray cols,  
    String prefix)
```

Arguments

lbs: lower bounds for new variables. if NULL, lower bounds are 0.0.

ubs: upper bounds for new variables. if NULL, upper bounds are infinity or 1 for binary variables.

objs: objective coefficients for new variables. if NULL, objective coefficients are 0.0.

types: variable types for new variables. if NULL, variable types are continuous.

cols: columnarray for specifying a set of constraints to which each new variable belongs.

prefix: prefix part for names of new variables.

Return

array of new variable objects.

Model.clear()

Clear all settings including problem itself.

Synopsis

```
void clear()
```

Model.clone()

Deep copy COPT model.

Synopsis

```
Model clone()
```

Return

cloned model object.

Model.computeIIS()

Compute IIS for infeasible model.

Synopsis

```
void computeIIS()
```

Model.delPsdObj()

delete PSD part of objective in model.

Synopsis

```
void delPsdObj()
```

Model.delQuadObj()

delete quadratic part of objective in model.

Synopsis

```
void delQuadObj()
```

Model.feasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void feasRelax(  
    VarArray vars,  
    double[] colLowPen,  
    double[] colUppPen,  
    ConstrArray cons,  
    double[] rowBndPen,  
    double[] rowUppPen)
```

Arguments

vars: an array of variables.
colLowPen: penalties for lower bounds of variables.
colUppPen: penalties for upper bounds of variables.
cons: an array of constraints.
rowBndPen: penalties for right hand sides of constraints.
rowUppPen: penalties for upper bounds of range constraints.

Model.feasRelax()

Compute feasibility relaxation for infeasible model.

Synopsis

```
void feasRelax(int ifRelaxVars, int ifRelaxCons)
```

Arguments

ifRelaxVars: whether to relax variables.
ifRelaxCons: whether to relax constraints.

Model.get()

Query values of information associated with variables.

Synopsis

```
double[] get(String name, Var[] vars)
```

Arguments

name: name of information.
vars: a list of interested variables.

Return

values of information.

Model.get()

Query values of information associated with variables.

Synopsis

```
double[] get(String name, VarArray vars)
```

Arguments

name: name of information.

vars: array of interested variables.

Return

values of information.

Model.get()

Query values of information associated with constraints.

Synopsis

```
double[] get(String name, Constraint[] constrs)
```

Arguments

name: name of information.

constrs: a list of interested constraints.

Return

values of information.

Model.get()

Query values of information associated with constraints.

Synopsis

```
double[] get(String name, ConstrArray constrs)
```

Arguments

name: name of information.

constrs: array of interested constraints.

Return

values of information.

Model.get()

Query values of information associated with quadratic constraints.

Synopsis

```
double[] get(String name, QConstraint[] constrs)
```

Arguments

name: name of information.

constrs: a list of interested quadratic constraints.

Return

values of information.

Model.get()

Query values of information associated with quadratic constraints.

Synopsis

```
double[] get(String name, QConstrArray constrs)
```

Arguments

name: name of information.

constrs: array of interested quadratic constraints.

Return

values of information.

Model.get()

Query values of information associated with PSD constraints.

Synopsis

```
double[] get(String name, PsdConstraint[] constrs)
```

Arguments

name: name of information.

constrs: a list of desired PSD constraints.

Return

output array of information values.

Model.get()

Query values of information associated with PSD constraints.

Synopsis

```
double[] get(String name, PsdConstrArray constrs)
```

Arguments

name: name of information.

constrs: a list of desired PSD constraints.

Return

output array of information values.

Model.getAffineCone()

Get an affine cone constraint of given index in model.

Synopsis

```
AffineCone getAffineCone(int idx)
```

Arguments

idx: index of the desired affine cone constraint.

Return

the desired affine cone constraint object.

Model.GetAffineConeBuilder()

Get builder of given affine cone constraint in model.

Synopsis

```
AffineConeBuilder GetAffineConeBuilder(AffineCone cone)
```

Arguments

cone: affine cone constraint.

Return

desired affine cone constraint builder.

Model.GetAffineConeBuilders()

Get builders of all affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray GetAffineConeBuilders()
```

Return

array object of affine cone constraint builders.

Model.getAffineConeBuilders()

Get builders of given affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray getAffineConeBuilders(AffineCone[] cones)
```

Arguments

cones: array of affine cone constraints.

Return

array object of desired affine cone constraint builders.

Model.getAffineConeBuilders()

Get builders of given affine cone constraints in model.

Synopsis

```
AffineConeBuilderArray getAffineConeBuilders(AffineConeArray cones)
```

Arguments

cones: array of affine cone constraints.

Return

array object of desired affine cone constraint builders.

Model.getAffineConeByName()

Get an affine cone constraint of given name in model.

Synopsis

```
AffineCone getAffineConeByName(String name)
```

Arguments

name: name of the desired affine cone constraint.

Return

the desired affine cone constraint object.

Model.getAffineCones()

Get all affine cone constraints in model.

Synopsis

```
AffineConeArray getAffineCones()
```

Return

array object of affine cone constraints.

Model.getCoeff()

Get the coefficient of variable in linear constraint.

Synopsis

```
double getCoeff(Constraint constr, Var var)
```

Arguments

constr: The requested constraint.

var: The requested variable.

Return

The requested coefficient.

Model.getCol()

Get a column object that have a list of constraints in which the variable participates.

Synopsis

```
Column getCol(Var var)
```

Arguments

var: a variable object.

Return

a column object associated with a variable.

Model.getColBasis()

Get status of column basis.

Synopsis

```
int[] getColBasis()
```

Return

basis status.

Model.getCone()

Get a cone constraint of given index in model.

Synopsis

```
Cone getCone(int idx)
```

Arguments

idx: index of the desired cone constraint.

Return

the desired cone constraint object.

Model.getConeBuilders()

Get builders of all cone constraints in model.

Synopsis

```
ConeBuilderArray getConeBuilders()
```

Return

array object of cone constraint builders.

Model.getConeBuilders()

Get builders of given cone constraints in model.

Synopsis

```
ConeBuilderArray getConeBuilders(Cone[] cones)
```

Arguments

cones: array of cone constraints.

Return

array object of desired cone constraint builders.

Model.getConeBuilders()

Get builders of given cone constraints in model.

Synopsis

```
ConeBuilderArray getConeBuilders(ConeArray cones)
```

Arguments

cones: array of cone constraints.

Return

array object of desired cone constraint builders.

Model.getCones()

Get all cone constraints in model.

Synopsis

```
ConeArray getCones()
```

Return

array object of cone constraints.

Model.getConstr()

Get a constraint of given index in model.

Synopsis

```
Constraint getConstr(int idx)
```

Arguments

idx: index of the desired constraint.

Return

the desired constraint object.

Model.getConstrBuilder()

Get builder of a constraint in model, including variables and associated coefficients, sense and RHS.

Synopsis

```
ConstrBuilder getConstrBuilder(Constraint constr)
```

Arguments

`constr`: a constraint object.

Return

constraint builder object.

Model.getConstrBuilders()

Get builders of all constraints in model.

Synopsis

```
ConstrBuilderArray getConstrBuilders()
```

Return

array object of constraint builders.

Model.getConstrByName()

Get a constraint of given name in model.

Synopsis

```
Constraint getConstrByName(String name)
```

Arguments

`name`: name of the desired constraint.

Return

the desired constraint object.

Model.getConstrLowerIIS()

Get IIS status of lower bounds of constraints.

Synopsis

```
int[] getConstrLowerIIS(ConstrArray constrs)
```

Arguments

`constrs`: Array of constraints.

Return

IIS status of lower bounds of constraints.

Model.getConstrLowerIIS()

Get IIS status of lower bounds of constraints.

Synopsis

```
int[] getConstrLowerIIS(Constraint[] constra)
```

Arguments

constra: Array of constraints.

Return

IIS status of lower bounds of constraints.

Model.getConstrs()

Get all constraints in model.

Synopsis

```
ConstrArray getConstrs()
```

Return

array object of constraints.

Model.getConstrUpperIIS()

Get IIS status of upper bounds of constraints.

Synopsis

```
int[] getConstrUpperIIS(ConstrArray constra)
```

Arguments

constra: Array of constraints.

Return

IIS status of upper bounds of constraints.

Model.getConstrUpperIIS()

Get IIS status of upper bounds of constraints.

Synopsis

```
int[] getConstrUpperIIS(Constraint[] constra)
```

Arguments

constra: Array of constraints.

Return

IIS status of upper bounds of constraints.

Model.getDblAttr()

Get value of a COPT double attribute.

Synopsis

```
double getDblAttr(String attr)
```

Arguments

attr: name of double attribute.

Return

value of double attribute.

Model.getDblParam()

Get value of a COPT double parameter.

Synopsis

```
double getDblParam(String param)
```

Arguments

param: name of double parameter.

Return

value of double parameter.

Model.getDblParamInfo()

Get current, default, minimum, maximum of COPT double parameter.

Synopsis

```
double[] getDblParamInfo(String name)
```

Arguments

name: name of integer parameter.

Return

current, default, minimum, maximum of COPT double parameter.

Model.getExpCone()

Get an exponential cone constraint of given index in model.

Synopsis

```
ExpCone getExpCone(int idx)
```

Arguments

idx: index of the desired exponential cone constraint.

Return

the desired exponential cone constraint object.

Model.getExpConeBuilders()

Get builders of all exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray getExpConeBuilders()
```

Return

array object of exponential cone constraint builders.

Model.getExpConeBuilders()

Get builders of given exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray getExpConeBuilders(ExpCone[] cones)
```

Arguments

cones: array of exponential cone constraints.

Return

array object of desired exponential cone constraint builders.

Model.getExpConeBuilders()

Get builders of given exponential cone constraints in model.

Synopsis

```
ExpConeBuilderArray getExpConeBuilders(ExpConeArray cones)
```

Arguments

cones: array of exponential cone constraints.

Return

array object of desired exponential cone constraint builders.

Model.getExpCones()

Get all exponential cone constraints in model.

Synopsis

```
ExpConeArray getExpCones()
```

Return

array object of exponential cone constraints.

Model.getGenConstr()

Get a general constraint of given index in model.

Synopsis

```
GenConstr getGenConstr(int idx)
```

Arguments

idx: index of the desired general constraint.

Return

the desired general constraint object.

Model.getGenConstrByName()

Get a general constraint of given name in model.

Synopsis

```
GenConstr getGenConstrByName(String name)
```

Arguments

name: name of the desired general constraint.

Return

the desired general constraint object.

Model.getGenConstrIndicator()

Get builder of given general constraint of type indicator.

Synopsis

```
GenConstrBuilder getGenConstrIndicator(GenConstr indicator)
```

Arguments

indicator: a general constraint of type indicator.

Return

builder object of general constraint of type indicator.

Model.getGenConstrIndicators()

Get builders of all general constraints in model.

Synopsis

```
GenConstrBuilderArray getGenConstrIndicators()
```

Return

array object of general constraint builders.

Model.getGenConstrs()

Get all general constraints in model.

Synopsis

```
GenConstrArray getGenConstrs()
```

Return

array object of general constraints.

Model.getIndicatorIIS()

Get IIS status of indicator constraints.

Synopsis

```
int[] getIndicatorIIS(GenConstrArray genconstrs)
```

Arguments

genconstrs: Array of indicator constraints.

Return

IIS status of indicator constraints.

Model.getIndicatorIIS()

Get IIS status of indicator constraints.

Synopsis

```
int[] getIndicatorIIS(GenConstr[] genconstrs)
```

Arguments

genconstrs: Array of indicator constraints.

Return

IIS status of indicator constraints.

Model.getIntAttr()

Get value of a COPT integer attribute

Synopsis

```
int getIntAttr(String attr)
```

Arguments

attr: name of integer attribute.

Return

value of integer attribute.

Model.getIntParam()

Get value of a COPT integer parameter.

Synopsis

```
int getIntParam(String param)
```

Arguments

param: name of integer parameter.

Return

value of integer parameter.

Model.getIntParamInfo()

Get current, default, minimum, maximum of COPT integer parameter.

Synopsis

```
int[] getIntParamInfo(String name)
```

Arguments

name: name of integer parameter.

Return

current, default, minimum, maximum of COPT integer parameter.

Model.getLmiCoeff()

Get the symmetric matrix of variable in LMI constraint.

Synopsis

```
SymMatrix getLmiCoeff(LmiConstraint constr, Var var)
```

Arguments

constr: The desired LMI constraint.

var: The desired variable.

Return

The associated coefficient matrix.

Model.getLmiConstr()

Get LMI constraint of given index in model.

Synopsis

```
LmiConstraint getLmiConstr(int idx)
```

Arguments

idx: index of desired LMI constraint.

Return

LMI constraint object.

Model.getLmiConstrByName()

Get LMI constraint of given name in model.

Synopsis

```
LmiConstraint getLmiConstrByName(String name)
```

Arguments

name: name of desired LMI constraint.

Return

LMI constraint object.

Model.getLmiConstrs()

Get all LMI constraints in model.

Synopsis

```
LmiConstrArray getLmiConstrs()
```

Return

array object of LMI constraints.

Model.getLmiRhs()

Get the symmetric matrix of constant of LMI constraint.

Synopsis

```
SymMatrix getLmiRhs(LmiConstraint constr)
```

Arguments

constr: The desired LMI constraint.

Return

matrix of constant term.

Model.getLmiRow()

Get variables and associated symmetric matrices that participate in a LMI constraint.

Synopsis

```
LmiExpr getLmiRow(LmiConstraint constr)
```

Arguments

constr: given LMI constraint object.

Return

LMI expression object of the LMI constraint.

Model.getLmiSolution()

Get LMI solution.

Synopsis

```
Object[] getLmiSolution()
```

Return

slack and dual values.

Model.getLpSolution()

Get LP solution.

Synopsis

```
Object[] getLpSolution()
```

Return

solution, slack, dual and reduced values.

Model.getObjective()

Get linear expression of objective for model.

Synopsis

```
Expr getObjective()
```

Return

an linear expression object.

Model.getPoolObjVal()

Get the idx-th objective value in solution pool.

Synopsis

```
double getPoolObjVal(int idx)
```

Arguments

idx: Index of solution.

Return

The requested objective value.

Model.getPoolSolution()

Get the idx-th solution in solution pool.

Synopsis

```
double[] getPoolSolution(int idx, VarArray vars)
```

Arguments

idx: Index of solution.

vars: The requested variables.

Return

The requested solution.

Model.getPoolSolution()

Get the idx-th solution in solution pool.

Synopsis

```
double[] getPoolSolution(int idx, Var[] vars)
```

Arguments

idx: Index of solution.

vars: The requested variables.

Return

The requested solution.

Model.getPsdCoeff()

Get the symmetric matrix of PSD variable in a PSD constraint.

Synopsis

```
SymMatrix getPsdCoeff(PsdConstraint constr, PsdVar var)
```

Arguments

constr: The desired PSD constraint.

var: The desired PSD variable.

Return

The associated coefficient matrix.

Model.getPsdConstr()

Get PSD constraint of given index in model.

Synopsis

```
PsdConstraint getPsdConstr(int idx)
```

Arguments

idx: index of desired PSD constraint.

Return

PSD constraint object.

Model.getPsdConstrBuilder()

Get builder of a PSD constraint in model, including PSD variables, sense and associated symmetric matrix.

Synopsis

```
PsdConstrBuilder getPsdConstrBuilder(PsdConstraint constr)
```

Arguments

constr: a PSD constraint object.

Return

PSD constraint builder object.

Model.getPsdConstrBuilders()

Get builders of all PSD constraints in model.

Synopsis

```
PsdConstrBuilderArray getPsdConstrBuilders()
```

Return

array object of PSD constraint builders.

Model.getPsdConstrByName()

Get PSD constraint of given name in model.

Synopsis

```
PsdConstraint getPsdConstrByName(String name)
```

Arguments

name: name of desired PSD constraint.

Return

PSD constraint object.

Model.getPsdConstrs()

Get all PSD constraints in model.

Synopsis

```
PsdConstrArray getPsdConstrs()
```

Return

array object of PSD constraints.

Model.getPsdObjective()

Get PSD objective of model.

Synopsis

```
PsdExpr getPsdObjective()
```

Return

a PSD expression object.

Model.getPsdRow()

Get PSD variables and associated symmetric matrices that participate in a PSD constraint.

Synopsis

```
PsdExpr getPsdRow(PsdConstraint constr)
```

Arguments

`constr`: a PSD constraint object.

Return

PSD expression object of the PSD constraint.

Model.getPsdSolution()

Get PSD solution.

Synopsis

```
Object[] getPsdSolution()
```

Return

solution, slack, dual and reduced values.

Model.getPsdVar()

Get a PSD variable of given index in model.

Synopsis

```
PsdVar getPsdVar(int idx)
```

Arguments

`idx`: index of the desired PSD variable.

Return

the desired PSD variable object.

Model.getPsdVarByName()

Get a PSD variable of given name in model.

Synopsis

```
PsdVar getPsdVarByName(String name)
```

Arguments

`name`: name of the desired PSD variable.

Return

the desired PSD variable object.

Model.getPsdVars()

Get all PSD variables in model.

Synopsis

```
PsdVarArray getPsdVars()
```

Return

array object of PSD variables.

Model.getQConstr()

Get a quadratic constraint of given index in model.

Synopsis

```
QConstraint getQConstr(int idx)
```

Arguments

idx: index of the desired quadratic constraint.

Return

the desired quadratic constraint object.

Model.getQConstrBuilder()

Get builder of a quadratic constraint in model, including variables and associated coefficients, sense and RHS.

Synopsis

```
QConstrBuilder getQConstrBuilder(QConstraint constr)
```

Arguments

constr: a constraint object.

Return

constraint builder object.

Model.getQConstrBuilders()

Get builders of all constraints in model.

Synopsis

```
QConstrBuilderArray getQConstrBuilders()
```

Return

array object of constraint builders.

Model.getQConstrByName()

Get a quadratic constraint of given name in model.

Synopsis

```
QConstraint getQConstrByName(String name)
```

Arguments

name: name of the desired constraint.

Return

the desired quadratic constraint object.

Model.getQConstrs()

Get all quadratic constraints in model.

Synopsis

```
QConstrArray getQConstrs()
```

Return

array object of quadratic constraints.

Model.getQuadObjective()

Get quadratic objective of model.

Synopsis

```
QuadExpr getQuadObjective()
```

Return

a quadratic expression object.

Model.getQuadRow()

Get quadratic expression that participate in quadratic constraint.

Synopsis

```
QuadExpr getQuadRow(QConstraint constr)
```

Arguments

constr: a quadratic constraint object.

Return

quadratic expression object of the constraint.

Model.getRow()

Get variables that participate in a constraint, and the associated coefficients.

Synopsis

```
Expr getRow(Constraint constr)
```

Arguments

`constr`: a constraint object.

Return

expression object of the constraint.

Model.getRowBasis()

Get status of row basis.

Synopsis

```
int[] getRowBasis()
```

Return

basis status.

Model.getSolution()

Get MIP solution.

Synopsis

```
double[] getSolution()
```

Return

solution values.

Model.getSos()

Get a SOS constraint of given index in model.

Synopsis

```
Sos getSos(int idx)
```

Arguments

`idx`: index of the desired SOS constraint.

Return

the desired SOS constraint object.

Model.getSosBuilders()

Get builders of all SOS constraints in model.

Synopsis

```
SosBuilderArray getSosBuilders()
```

Return

array object of SOS constraint builders.

Model.getSosBuilders()

Get builders of given SOS constraints in model.

Synopsis

```
SosBuilderArray getSosBuilders(Sos[] soss)
```

Arguments

soss: array of SOS constraints.

Return

array object of desired SOS constraint builders.

Model.getSosBuilders()

Get builders of given SOS constraints in model.

Synopsis

```
SosBuilderArray getSosBuilders(SosArray soss)
```

Arguments

soss: array of SOS constraints.

Return

array object of desired SOS constraint builders.

Model.getSOSIIS()

Get IIS status of SOS constraints.

Synopsis

```
int[] getSOSIIS(SosArray soss)
```

Arguments

soss: Array of SOS constraints.

Return

IIS status of SOS constraints.

Model.getSOSIIS()

Get IIS status of SOS constraints.

Synopsis

```
int[] getSOSIIS(Sos[] soss)
```

Arguments

soss: Array of SOS constraints.

Return

IIS status of SOS constraints.

Model.getSoss()

Get all SOS constraints in model.

Synopsis

```
SosArray getSoss()
```

Return

array object of SOS constraints.

Model.getSymMat()

Get a symmetric matrix of given index in model.

Synopsis

```
SymMatrix getSymMat(int idx)
```

Arguments

idx: index of the desired symmetric matrix.

Return

the desired symmetric matrix object.

Model.getVar()

Get a variable of given index in model.

Synopsis

```
Var getVar(int idx)
```

Arguments

idx: index of the desired variable.

Return

the desired variable object.

Model.getVarByName()

Get a variable of given name in model.

Synopsis

```
Var getVarByName(String name)
```

Arguments

name: name of the desired variable.

Return

the desired variable object.

Model.getVarLowerIIS()

Get IIS status of lower bounds of variables.

Synopsis

```
int[] getVarLowerIIS(VarArray vars)
```

Arguments

vars: Array of variables.

Return

IIS status of lower bounds of variables.

Model.getVarLowerIIS()

Get IIS status of lower bounds of variables.

Synopsis

```
int[] getVarLowerIIS(Var[] vars)
```

Arguments

vars: Array of variables.

Return

IIS status of lower bounds of variables.

Model.getVars()

Get all variables in model.

Synopsis

```
VarArray getVars()
```

Return

variable array object.

Model.getVarUpperIIS()

Get IIS status of upper bounds of variables.

Synopsis

```
int[] getVarUpperIIS(VarArray vars)
```

Arguments

vars: Array of variables.

Return

IIS status of upper bounds of variables.

Model.getVarUpperIIS()

Get IIS status of upper bounds of variables.

Synopsis

```
int[] getVarUpperIIS(Var[] vars)
```

Arguments

vars: Array of variables.

Return

IIS status of upper bounds of variables.

Model.interrupt()

Interrupt optimization of current problem.

Synopsis

```
void interrupt()
```

Model.loadMipStart()

Load final initial values of variables to the problem.

Synopsis

```
void loadMipStart()
```

Model.loadTuneParam()

Load specified tuned parameters into model.

Synopsis

```
void loadTuneParam(int idx)
```

Arguments

idx: Index of tuned parameters.

Model.read()

Read problem, solution, basis, MIP start or COPT parameters from file.

Synopsis

```
void read(String filename)
```

Arguments

filename: an input file name.

Model.readBasis()

Read basis from file.

Synopsis

```
void readBasis(String filename)
```

Arguments

filename: an input file name.

Model.readBin()

Read problem in COPT binary format from file.

Synopsis

```
void readBin(String filename)
```

Arguments

filename: an input file name.

Model.readCbf()

Read problem in CBF format from file.

Synopsis

```
void readCbf(String filename)
```

Arguments

filename: an input file name.

Model.readLp()

Read problem in LP format from file.

Synopsis

```
void readLp(String filename)
```

Arguments

filename: an input file name.

Model.readMps()

Read problem in MPS format from file.

Synopsis

```
void readMps(String filename)
```

Arguments

filename: an input file name.

Model.readMst()

Read MIP start information from file.

Synopsis

```
void readMst(String filename)
```

Arguments

filename: an input file name.

Model.readParam()

Read COPT parameters from file.

Synopsis

```
void readParam(String filename)
```

Arguments

filename: an input file name.

Model.readSdpa()

Read problem in SDPA format from file.

Synopsis

```
void readSdpa(String filename)
```

Arguments

filename: an input file name.

Model.readSol()

Read solution from file.

Synopsis

```
void readSol(String filename)
```

Arguments

filename: an input file name.

Model.readTune()

Read tuning parameters from file.

Synopsis

```
void readTune(String filename)
```

Arguments

filename: an input file name.

Model.remove()

Remove an array of variables from model.

Synopsis

```
void remove(Var[] vars)
```

Arguments

vars: a list of variables.

Model.remove()

Remove array of variables from model.

Synopsis

```
void remove(VarArray vars)
```

Arguments

vars: an array of variables.

Model.remove()

Remove a list of constraints from model.

Synopsis

```
void remove(Constraint[] constra)
```

Arguments

constra: a list of constraints.

Model.remove()

Remove a list of constraints from model.

Synopsis

```
void remove(ConstrArray constra)
```

Arguments

constra: an array of constraints.

Model.remove()

Remove a list of SOS constraints from model.

Synopsis

```
void remove(Sos[] soss)
```

Arguments

soss: a list of SOS constraints.

Model.remove()

Remove a list of SOS constraints from model.

Synopsis

```
void remove(SosArray soss)
```

Arguments

soss: an array of SOS constraints.

Model.remove()

Remove a list of cone constraints from model.

Synopsis

```
void remove(Cone[] cones)
```

Arguments

cones: a list of cone constraints.

Model.remove()

Remove a list of cone constraints from model.

Synopsis

```
void remove(ConeArray cones)
```

Arguments

cones: an array of cone constraints.

Model.remove()

Remove a list of exponential cone constraints from model.

Synopsis

```
void remove(ExpCone[] cones)
```

Arguments

cones: a list of exponential cone constraints.

Model.remove()

Remove a list of exponential cone constraints from model.

Synopsis

```
void remove(ExpConeArray cones)
```

Arguments

cones: an array of exponential cone constraints.

Model.remove()

Remove a list of affine cone constraints from model.

Synopsis

```
void remove(AffineCone[] cones)
```

Arguments

cones: a list of affine cone constraints.

Model.remove()

Remove an array of affine cone constraints from model.

Synopsis

```
void remove(AffineConeArray cones)
```

Arguments

cones: an array of affine cone constraints.

Model.remove()

Remove a list of gernal constraints from model.

Synopsis

```
void remove(GenConstr[] genConstrs)
```

Arguments

genConstrs: a list of general constraints.

Model.remove()

Remove a list of gernal constraints from model.

Synopsis

```
void remove(GenConstrArray genConstrs)
```

Arguments

genConstrs: an array of general constraints.

Model.remove()

Remove a list of quadratic constraints from model.

Synopsis

```
void remove(QConstraint[] qconstrs)
```

Arguments

qconstrs: an array of quadratic constraints.

Model.remove()

Remove a list of quadratic constraints from model.

Synopsis

```
void remove(QConstrArray qconstrs)
```

Arguments

qconstrs: an array of quadratic constraints.

Model.remove()

Remove a list of PSD variables from model.

Synopsis

```
void remove(PsdVar[] vars)
```

Arguments

vars: an array of PSD variables.

Model.remove()

Remove a list of PSD variables from model.

Synopsis

```
void remove(PsdVarArray vars)
```

Arguments

vars: an array of PSD variables.

Model.remove()

Remove a list of PSD constraints from model.

Synopsis

```
void remove(PsdConstraint[] constrs)
```

Arguments

constrs: an array of PSD constraints.

Model.remove()

Remove a list of PSD constraints from model.

Synopsis

```
void remove(PsdConstrArray constrs)
```

Arguments

constrs: an array of PSD constraints.

Model.remove()

Remove a list of LMI constraints from model.

Synopsis

```
void remove(LmiConstrArray constrs)
```

Arguments

constrs: an array of LMI constraints.

Model.remove()

Remove a list of LMI constraints from model.

Synopsis

```
void remove(LmiConstraint[] constrs)
```

Arguments

constrs: an array of LMI constraints.

Model.reset()

Reset solution of problem only.

Synopsis

```
void reset()
```

Model.resetAll()

Reset solution of problem, and additional information such as MIP start, etc.

Synopsis

```
void resetAll()
```

Model.resetParam()

Reset parameters to default settings.

Synopsis

```
void resetParam()
```

Model.set()

Set values of information associated with variables.

Synopsis

```
void set(  
    String name,  
    Var[] vars,  
    double[] vals)
```

Arguments

name: name of information.

vars: a list of interested variables.

vals: values of information.

Model.set()

Set values of information associated with variables.

Synopsis

```
void set(  
    String name,  
    VarArray vars,  
    double[] vals)
```

Arguments

name: name of information.

vars: array of interested variables.

vals: values of information.

Model.set()

Set values of information associated with constraints.

Synopsis

```
void set(  
    String name,  
    Constraint[] constrs,  
    double[] vals)
```

Arguments

name: name of information.

constrs: a list of interested constraints.

vals: values of information.

Model.set()

Set values of information associated with constraints.

Synopsis

```
void set(  
    String name,  
    ConstrArray constra,  
    double[] vals)
```

Arguments

name: name of information.

constra: array of interested constraints.

vals: values of information.

Model.set()

Set values of information associated with PSD constraints.

Synopsis

```
void set(  
    String name,  
    PsdConstraint[] constra,  
    double[] vals)
```

Arguments

name: name of information.

constra: a list of desired PSD constraints.

vals: array of values of information.

Model.set()

Set values of information associated with PSD constraints.

Synopsis

```
void set(  
    String name,  
    PsdConstrArray constra,  
    double[] vals)
```

Arguments

name: name of information.

constra: a list of desired PSD constraints.

vals: array of values of information.

Model.setBasis()

Set column and row basis status to model.

Synopsis

```
void setBasis(int[] colbasis, int[] rowbasis)
```

Arguments

colbasis: status of column basis.

rowbasis: status of row basis.

Model.setCallback()

Set user callback to COPT model.

Synopsis

```
void setCallback(CallbackBase cb, int cbctx)
```

Arguments

cb: user callback instance, inheriting from CallbackBase class.

cbctx: COPT callback context.

Model.setCoeff()

Set the coefficient of a variable in a linear constraint.

Synopsis

```
void setCoeff(  
    Constraint constr,  
    Var var,  
    double newVal)
```

Arguments

constr: The requested constraint.

var: The requested variable.

newVal: New coefficient.

Model.setCoeffs()

Set a list of coefficients in the model.

Synopsis

```
void setCoeffs(  
    Constraint[] constrs,  
    Var[] vars,  
    double[] vals)
```

Arguments

constrs: Array of constraints for coefficients to be set.

vars: Array of vars for coefficients to be set.

vals: New values for coefficients.

Model.setCoeffs()

Set a list of coefficients in the model.

Synopsis

```
void setCoeffs(  
    ConstrArray constrs,  
    VarArray vars,  
    double[] vals)
```

Arguments

constrs: A list of constraints for coefficients to be set.

vars: A list of vars for coefficients to be set.

vals: New values for coefficients.

Model.setDblParam()

Set value of a COPT double parameter.

Synopsis

```
void setDblParam(String param, double val)
```

Arguments

param: name of double parameter.

val: double value.

Model.setIntParam()

Set value of a COPT integer parameter.

Synopsis

```
void setIntParam(String param, int val)
```

Arguments

param: name of integer parameter.

val: integer value.

Model.setLmiCoeff()

Set the coefficient matrix of a variable in LMI constraint.

Synopsis

```
void setLmiCoeff(  
    LmiConstraint constr,  
    Var var,  
    SymMatrix mat)
```

Arguments

constr: The desired LMI constraint.

var: The desired variable.

mat: new coefficient matrix.

Model.setLmiRhs()

Set constant matrix of LMI constraint.

Synopsis

```
void setLmiRhs(LmiConstraint constr, SymMatrix mat)
```

Arguments

constr: The desired LMI constraint.

mat: new constant matrix.

Model.setLpSolution()

Set LP solution.

Synopsis

```
void setLpSolution(  
    double[] value,  
    double[] slack,  
    double[] rowDual,  
    double[] redCost)
```

Arguments

value: solution of variables.

slack: slack of constraints.

rowDual: dual value of constraints.

redCost: dual value of variables.

Model.setMipStart()

Set initial values for variables of given number, starting from the first one.

Synopsis

```
void setMipStart(int count, double[] vals)
```

Arguments

count: the number of variables to set.

vals: values of variables.

Model.setMipStart()

Set initial value for the specified variable.

Synopsis

```
void setMipStart(Var var, double val)
```

Arguments

var: an interested variable.

val: initial value of the variable.

Model.setMipStart()

Set initial value for the specified variable.

Synopsis

```
void setMipStart(Var[] vars, double[] vals)
```

Arguments

vars: a list of interested variables.

vals: initial values of the variables.

Model.setMipStart()

Set initial values for an array of variables.

Synopsis

```
void setMipStart(VarArray vars, double[] vals)
```

Arguments

vars: a list of interested variables.

vals: initial values of variables.

Model.setNames()

Set names for given variables in model.

Synopsis

```
void setNames(Var[] vars, String[] names)
```

Arguments

vars: Array of variables.

names: String array of names for variables.

Model.setNames()

Set names for given variables in model.

Synopsis

```
void setNames(VarArray vars, String[] names)
```

Arguments

vars: A list of variables.

names: string array of names for variables.

Model.setNames()

Set names for given constraints in model.

Synopsis

```
void setNames(Constraint[] cons, String[] names)
```

Arguments

cons: array of constraints.

names: string array of names for constraints.

Model.setNames()

Set names for given constraints in model.

Synopsis

```
void setNames(ConstrArray cons, String[] names)
```

Arguments

cons: a list of constraints.

names: string array of names for constraints.

Model.setNames()

Set names for given general constraints in model.

Synopsis

```
void setNames(GenConstr[] genConstrs, String[] names)
```

Arguments

genConstrs: array of general constraints.

names: string array of names for general constraints.

Model.setNames()

Set names for given general constraints in model.

Synopsis

```
void setNames(GenConstrArray genConstrs, String[] names)
```

Arguments

genConstrs: a list of general constraints.

names: string array of names for general constraints.

Model.setNames()

Set names for given quadratic constraints in model.

Synopsis

```
void setNames(QConstraint[] cons, String[] names)
```

Arguments

cons: array of quadratic constraints.

names: string array of names for quadratic constraints.

Model.setNames()

Set names for given quadratic constraints in model.

Synopsis

```
void setNames(QConstrArray cons, String[] names)
```

Arguments

cons: a list of quadratic constraints.

names: string array of names for quadratic constraints.

Model.setNames()

Set names for given PSD variables in model.

Synopsis

```
void setNames(PsdVar[] vars, String[] names)
```

Arguments

vars: array of PSD variables.

names: string array of names for PSD variables.

Model.setNames()

Set names for given PSD variables in model.

Synopsis

```
void setNames(PsdVarArray vars, String[] names)
```

Arguments

vars: a list of PSD variables.

names: string array of names for PSD variables.

Model.setNames()

Set names for given PSD constraints in model.

Synopsis

```
void setNames(PsdConstraint[] cons, String[] names)
```

Arguments

cons: array of PSD constraints.

names: string array of names for PSD constraints.

Model.setNames()

Set names for given PSD constraints in model.

Synopsis

```
void setNames(PsdConstrArray cons, String[] names)
```

Arguments

cons: a list of PSD constraints.

names: string array of names for PSD constraints.

Model.setNames()

Set names for given LMI constraints in model.

Synopsis

```
void setNames(LmiConstraint[] cons, String[] names)
```

Arguments

cons: array of LMI constraints.

names: string array of names for LMI constraints.

Model.setNames()

Set names for given LMI constraints in model.

Synopsis

```
void setNames(LmiConstrArray cons, String[] names)
```

Arguments

cons: a list of LMI constraints.

names: string array of names for LMI constraints.

Model.setNames()

Set names for given affine cone constraints in model.

Synopsis

```
void setNames(AffineConeArray cones, String[] names)
```

Arguments

cones: an array of affine cone constraints.

names: string array of names for affine cone constraints.

Model.setObjConst()

Set objective constant.

Synopsis

```
void setObjConst(double constant)
```

Arguments

constant: constant value to set.

Model.setObjective()

Set objective for model.

Synopsis

```
void setObjective(Expr expr, int sense)
```

Arguments

expr: expression of the objective.

sense: optimization sense, which is either `copt.Consts.MINIMIZE` or `copt.Consts.MAXIMIZE`. Set sense to 0 if do not change current sense.

Model.setObjSense()

Set objective sense for model.

Synopsis

```
void setObjSense(int sense)
```

Arguments

sense: the objective sense.

Model.setPsdCoeff()

Set the coefficient matrix of a PSD variable in a PSD constraint.

Synopsis

```
void setPsdCoeff(  
    PsdConstraint constr,  
    PsdVar var,  
    SymMatrix mat)
```

Arguments

constr: The desired PSD constraint.

var: The desired PSD variable.

mat: new coefficient matrix.

Model.setPsdObjective()

Set PSD objective for model.

Synopsis

```
void setPsdObjective(PsdExpr expr, int sense)
```

Arguments

expr: PSD expression of the objective.

sense: optimization sense, which is either `copt.Consts.MINIMIZE` or `copt.Consts.MAXIMIZE`. Set sense to 0 if do not change current sense.

Model.setQuadObjective()

Set quadratic objective for model.

Synopsis

```
void setQuadObjective(QuadExpr expr, int sense)
```

Arguments

expr: quadratic expression of the objective.

sense: optimization sense, which is either `copt.Consts.MINIMIZE` or `copt.Consts.MAXIMIZE`. Set sense to 0 if do not change current sense.

Model.setSlackBasis()

Set slack basis to model.

Synopsis

```
void setSlackBasis()
```

Model.setSolverLogFile()

Set log file for COPT.

Synopsis

```
void setSolverLogFile(String filename)
```

Arguments

filename: log file name.

Model.solve()

Solve the model as MIP.

Synopsis

```
void solve()
```

Model.solveLp()

Solve the model as LP.

Synopsis

```
void solveLp()
```

Model.tune()

Tune model.

Synopsis

```
void tune()
```

Model.write()

Output problem, solution, basis, MIP start or modified COPT parameters to file.

Synopsis

```
void write(String filename)
```

Arguments

filename: an output file name.

Model.writeBasis()

Output optimal basis to a file of type '.bas'.

Synopsis

```
void writeBasis(String filename)
```

Arguments

filename: an output file name.

Model.writeBin()

Output problem to a file as COPT binary format.

Synopsis

```
void writeBin(String filename)
```

Arguments

filename: an output file name.

Model.writeIIS()

Output IIS to file.

Synopsis

```
void writeIIS(String filename)
```

Arguments

filename: Output file name.

Model.writeLp()

Output problem to a file as LP format.

Synopsis

```
void writeLp(String filename)
```

Arguments

filename: an output file name.

Model.writeMps()

Output problem to a file as MPS format.

Synopsis

```
void writeMps(String filename)
```

Arguments

filename: an output file name.

Model.writeMpsStr()

Output MPS problem to problem buffer.

Synopsis

```
ProbBuffer writeMpsStr()
```

Return

problem buffer for string of MPS problem.

Model.writeMst()

Output MIP start information to a file of type '.mst'.

Synopsis

```
void writeMst(String filename)
```

Arguments

filename: an output file name.

Model.writeParam()

Output modified COPT parameters to a file of type '.par'.

Synopsis

```
void writeParam(String filename)
```

Arguments

filename: an output file name.

Model.writePoolSol()

Output selected pool solution to a file of type '.sol'.

Synopsis

```
void writePoolSol(int idx, String filename)
```

Arguments

idx: index of pool solution.

filename: an output file name.

Model.writeRelax()

Output feasibility relaxation problem to file.

Synopsis

```
void writeRelax(String filename)
```

Arguments

filename: Output file name.

Model.writeSol()

Output solution to a file of type ‘.sol’.

Synopsis

```
void writeSol(String filename)
```

Arguments

filename: an output file name.

Model.writeTuneParam()

Output specified tuned parameters to a file of type ‘.par’.

Synopsis

```
void writeTuneParam(int idx, String filename)
```

Arguments

idx: Index of tuned parameters.

filename: Output file name.

25.2.4 Var

COPT variable object. Variables are always associated with a particular model. User creates a variable object by adding a variable to a model, rather than by using constructor of Var class.

Var.get()

Get information value of the variable. Support informations of “Value”, “RedCost”, “LB”, “UB”, and “Obj”.

Synopsis

```
double get(String info)
```

Arguments

info: information name.

Return

information value.

Var.getBasis()

Get basis status of the variable.

Synopsis

```
int getBasis()
```

Return

Basis status.

Var.getIdx()

Get index of the variable.

Synopsis

```
int getIdx()
```

Return

variable index.

Var.getLowerIIS()

Get IIS status for lower bound of the variable.

Synopsis

```
int getLowerIIS()
```

Return

IIS status.

Var.getName()

Get name of the variable.

Synopsis

```
String getName()
```

Return

variable name.

Var.getType()

Get type of the variable.

Synopsis

```
char getType()
```

Return

variable type.

Var.getUpperIIS()

Get IIS status for upper bound of the variable.

Synopsis

```
int getUpperIIS()
```

Return

IIS status.

Var.remove()

Remove variable from model.

Synopsis

```
void remove()
```

Var.set()

Set information value of the variable. Support informations of “LB”, “UB” and “Obj”.

Synopsis

```
void set(String info, double val)
```

Arguments

info: information name.

val: new information value.

Var.setName()

Set name of the variable.

Synopsis

```
void setName(String name)
```

Arguments

name: variable name.

Var.setType()

Set type of the variable.

Synopsis

```
void setType(char vtype)
```

Arguments

vtype: variable type.

25.2.5 VarArray

COPT variable array object. To store and access a set of Java *Var* objects, Cardinal Optimizer provides Java VarArray class, which defines the following methods.

VarArray.VarArray()

Constructor of vararray.

Synopsis

```
VarArray()
```

VarArray.getVar()

Get idx-th variable object.

Synopsis

```
Var getVar(int idx)
```

Arguments

idx: index of the variable.

Return

variable object with index idx.

VarArray.pushBack()

Add a variable object to variable array.

Synopsis

```
void pushBack(Var var)
```

Arguments

var: a variable object.

VarArray.size()

Get the number of variable objects.

Synopsis

```
int size()
```

Return

number of variable objects.

25.2.6 Expr

COPT linear expression object. A linear expression consists of a constant term, a list of terms of variables and associated coefficients. Linear expressions are used to build constraints.

Expr.Expr()

Constructor of a constant linear expression with constant 0.0

Synopsis

```
Expr()
```

Expr.Expr()

Constructor of a constant linear expression.

Synopsis

```
Expr(double constant)
```

Arguments

constant: constant value in expression object.

Expr.Expr()

Constructor of a linear expression with one term.

Synopsis

```
Expr(Var var)
```

Arguments

var: variable for the added term.

Expr.Expr()

Constructor of a linear expression with one term.

Synopsis

```
Expr(Var var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

Expr.addConstant()

Add extra constant to the expression.

Synopsis

```
void addConstant(double constant)
```

Arguments

constant: delta value to be added to expression constant.

Expr.addExpr()

Add a linear expression to self.

Synopsis

```
void addExpr(Expr expr)
```

Arguments

expr: linear expression to be added.

Expr.addExpr()

Add a linear expression to self.

Synopsis

```
void addExpr(Expr expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: multiplier constant.

Expr.addTerm()

Add a term to expression object.

Synopsis

```
void addTerm(Var var, double coeff)
```

Arguments

var: a variable for new term.

coeff: coefficient for new term.

Expr.addTerms()

Add terms to expression object.

Synopsis

```
void addTerms(Var[] vars, double coeff)
```

Arguments

vars: variables for added terms.

coeff: one coefficient for added terms.

Expr.addTerms()

Add terms to expression object.

Synopsis

```
void addTerms(Var[] vars, double[] coeffs)
```

Arguments

vars: variables for added terms.

coeffs: coefficients array for added terms.

Expr.addTerms()

Add terms to expression object.

Synopsis

```
void addTerms(VarArray vars, double coeff)
```

Arguments

vars: variables for added terms.

coeff: one coefficient for added terms.

Expr.addTerms()

Add terms to expression object.

Synopsis

```
void addTerms(VarArray vars, double[] coeffs)
```

Arguments

vars: variables for added terms.

coeffs: coefficients array for added terms.

Expr.clone()

Deep copy linear expression object.

Synopsis

```
Expr clone()
```

Return

cloned linear expression object.

Expr.evaluate()

evaluate linear expression after solving

Synopsis

```
double evaluate()
```

Return

value of linear expression

Expr.getCoeff()

Get coefficient from the i-th term in expression.

Synopsis

```
double getCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in expression object.

Expr.getConstant()

Get constant in expression.

Synopsis

```
double getConstant()
```

Return

constant in expression.

Expr.getVar()

Get variable from the i-th term in expression.

Synopsis

```
Var getVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in expression object.

Expr.remove()

Remove idx-th term from expression object.

Synopsis

```
void remove(int idx)
```

Arguments

idx: index of the term to be removed.

Expr.remove()

Remove the term associated with variable from expression.

Synopsis

```
void remove(Var var)
```

Arguments

var: a variable whose term should be removed.

Expr.setCoeff()

Set coefficient for the i-th term in expression.

Synopsis

```
void setCoeff(int i, double val)
```

Arguments

i: index of the term.

val: coefficient of the term.

Expr.setConstant()

Set constant for the expression.

Synopsis

```
void setConstant(double constant)
```

Arguments

constant: the value of the constant.

Expr.size()

Get number of terms in expression.

Synopsis

```
long size()
```

Return

number of terms.

25.2.7 Constraint

COPT constraint object. Constraints are always associated with a particular model. User creates a constraint object by adding a constraint to a model, rather than by using constructor of Constraint class.

Constraint.get()

Get information value of the constraint. Support informations of “Dual”, “Slack”, “LB”, “UB”.

Synopsis

```
double get(String info)
```

Arguments

info: name of the information being queried.

Return

information value.

Constraint.getBasis()

Get basis status of this constraint.

Synopsis

```
int getBasis()
```

Return

basis status.

Constraint.getIdx()

Get index of the constraint.

Synopsis

```
int getIdx()
```

Return

the index of the constraint.

Constraint.getLowerIIS()

Get IIS status for lower bound of the constraint.

Synopsis

```
int getLowerIIS()
```

Return

IIS status.

Constraint.getName()

Get name of the constraint.

Synopsis

```
String getName()
```

Return

the name of the constraint.

Constraint.getUpperIIS()

Get IIS status for upper bound of the constraint.

Synopsis

```
int getUpperIIS()
```

Return

IIS status.

Constraint.remove()

Remove this constraint from model.

Synopsis

```
void remove()
```

Constraint.set()

Set information value of the constraint. Support informations of “LB” and “UB”.

Synopsis

```
void set(String info, double val)
```

Arguments

info: name of the information.

val: new information value.

Constraint.setName()

Set name for the constraint.

Synopsis

```
void setName(String name)
```

Arguments

name: the name to set.

25.2.8 ConstrArray

COPT constraint array object. To store and access a set of Java *Constraint* objects, Cardinal Optimizer provides Java ConstrArray class, which defines the following methods.

ConstrArray.ConstrArray()

Constructor of constrarray object.

Synopsis

```
ConstrArray()
```

ConstrArray.getConstr()

Get idx-th constraint object.

Synopsis

```
Constraint getConstr(int idx)
```

Arguments

idx: index of the constraint.

Return

constraint object with index idx.

ConstrArray.pushBack()

Add a constraint object to constraint array.

Synopsis

```
void pushBack(Constraint constr)
```

Arguments

constr: a constraint object.

ConstrArray.size()

Get the number of constraint objects.

Synopsis

```
int size()
```

Return

number of constraint objects.

25.2.9 ConstrBuilder

COPT constraint builder object. To help building a constraint, given a linear expression, constraint sense and right-hand side value, Cardinal Optimizer provides Java ConstrBuilder class, which defines the following methods.

ConstrBuilder.ConstrBuilder()

Constructor of constrbuilder object.

Synopsis

```
ConstrBuilder()
```

ConstrBuilder.getExpr()

Get expression associated with constraint.

Synopsis

```
Expr getExpr()
```

Return

expression object.

ConstrBuilder.getRange()

Get range from lower bound to upper bound of range constraint.

Synopsis

```
double getRange()
```

Return

length from lower bound to upper bound of the constraint.

ConstrBuilder.getSense()

Get sense associated with constraint.

Synopsis

```
char getSense()
```

Return

constraint sense.

ConstrBuilder.set()

Set detail of a constraint to its builder object.

Synopsis

```
void set(  
    Expr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the constraint

sense: constraint sense other than COPT_RANGE.

rhs: constant of right side of the constraint.

ConstrBuilder.setRange()

Set a range constraint to its builder.

Synopsis

```
void setRange(Expr expr, double range)
```

Arguments

expr: expression object, whose constant is negative upper bound.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

25.2.10 ConstrBuilderArray

COPT constraint builder array object. To store and access a set of Java *ConstrBuilder* objects, Cardinal Optimizer provides Java *ConstrBuilderArray* class, which defines the following methods.

ConstrBuilderArray.ConstrBuilderArray()

Constructor of constrbuilderarray object.

Synopsis

```
ConstrBuilderArray()
```

ConstrBuilderArray.getBuilder()

Get idx-th constraint builder object.

Synopsis

```
ConstrBuilder getBuilder(int idx)
```

Arguments

idx: index of the constraint builder.

Return

constraint builder object with index idx.

ConstrBuilderArray.pushBack()

Add a constraint builder object to constraint builder array.

Synopsis

```
void pushBack(ConstrBuilder builder)
```

Arguments

builder: a constraint builder object.

ConstrBuilderArray.size()

Get the number of constraint builder objects.

Synopsis

```
int size()
```

Return

number of constraint builder objects.

25.2.11 Column

COPT column object. A column consists of a list of constraints and associated coefficients. Columns are used to represent the set of constraints in which a variable participates, and the associated coefficients.

Column.Column()

Constructor of column.

Synopsis

```
Column()
```

Column.addColumn()

Add a column to self.

Synopsis

```
void addColumn(Column col, double mult)
```

Arguments

col: column object to be added.

mult: multiply constant.

Column.addColumn()

Add a column to self.

Synopsis

```
void addColumn(Column col)
```

Arguments

col: column object to be added.

Column.addTerm()

Add a term to column object.

Synopsis

```
void addTerm(Constraint constr, double coeff)
```

Arguments

constr: a constraint for new term.

coeff: coefficient for new term.

Column.addTerms()

Add terms to column object.

Synopsis

```
void addTerms(Constraint[] constra, double coeff)
```

Arguments

constra: constraints for added terms.

coeff: coefficient for added terms.

Column.addTerms()

Add terms to column object.

Synopsis

```
void addTerms(Constraint[] constra, double[] coeffs)
```

Arguments

constra: constraints for added terms.

coeffs: coefficients for added terms.

Column.addTerms()

Add terms to column object.

Synopsis

```
void addTerms(ConstrArray constra, double coeff)
```

Arguments

constra: constraints for added terms.

coeff: coefficient for added terms.

Column.addTerms()

Add terms to column object.

Synopsis

```
void addTerms(ConstrArray constra, double[] coeffs)
```

Arguments

constra: constraints for added terms.

coeffs: coefficients for added terms.

Column.clear()

Clear all terms.

Synopsis

```
void clear()
```

Column.clone()

Deep copy column object.

Synopsis

```
Column clone()
```

Return

cloned column object.

Column.getCoeff()

Get coefficient from the i-th term in column object.

Synopsis

```
double getCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in column object.

Column.getConstr()

Get constraint from the i-th term in column object.

Synopsis

```
Constraint getConstr(int i)
```

Arguments

i: index of the term.

Return

constraint of the i-th term in column object.

Column.remove()

Remove i-th term from column object.

Synopsis

```
void remove(int idx)
```

Arguments

idx: index of the term to be removed.

Column.remove()

Remove the term associated with constraint from column object.

Synopsis

```
void remove(Constraint constr)
```

Arguments

constr: a constraint whose term should be removed.

Column.size()

Get number of terms in column object.

Synopsis

```
int size()
```

Return

number of terms.

25.2.12 ColumnArray

COPT column array object. To store and access a set of Java *Column* objects, Cardinal Optimizer provides Java ColumnArray class, which defines the following methods.

ColumnArray.ColumnArray()

Constructor of columnarray object.

Synopsis

```
ColumnArray()
```

ColumnArray.clear()

Clear all column objects.

Synopsis

```
void clear()
```

ColumnArray.getColumn()

Get idx-th column object.

Synopsis

```
Column getColumn(int idx)
```

Arguments

idx: index of the column.

Return

column object with index idx.

ColumnArray.pushBack()

Add a column object to column array.

Synopsis

```
void pushBack(Column col)
```

Arguments

col: a column object.

ColumnArray.size()

Get the number of column objects.

Synopsis

```
int size()
```

Return

number of column objects.

25.2.13 Sos

COPT SOS constraint object. SOS constraints are always associated with a particular model. User creates an SOS constraint object by adding an SOS constraint to a model, rather than by using constructor of Sos class.

An SOS constraint can be type 1 or 2 (COPT_SOS_TYPE1 or COPT_SOS_TYPE2).

Sos.getIdx()

Get the index of SOS constraint.

Synopsis

```
int getIdx()
```

Return

index of SOS constraint.

Sos.getIIS()

Get IIS status of the SOS constraint.

Synopsis

```
int getIIS()
```

Return

IIS status.

Sos.remove()

Remove the SOS constraint from model.

Synopsis

```
void remove()
```

25.2.14 SosArray

COPT SOS constraint array object. To store and access a set of Java *Sos* objects, Cardinal Optimizer provides Java SosArray class, which defines the following methods.

SosArray.SosArray()

Constructor of sosarray object.

Synopsis

```
SosArray()
```

SosArray.getSos()

Get idx-th SOS object.

Synopsis

```
Sos getSos(int idx)
```

Arguments

idx: index of SOS.

Return

SOS object with index idx.

SosArray.pushBack()

Add a SOS constraint object to SOS constraint array.

Synopsis

```
void pushBack(Sos sos)
```

Arguments

sos: a SOS constraint object.

SosArray.size()

Get the number of SOS constraint objects.

Synopsis

```
int size()
```

Return

number of SOS constraint objects.

25.2.15 SosBuilder

COPT SOS constraint builder object. To help building an SOS constraint, given the SOS type, a set of variables and associated weights, Cardinal Optimizer provides Java SosBuilder class, which defines the following methods.

SosBuilder.SosBuilder()

Constructor of sosbuilder object.

Synopsis

```
SosBuilder()
```

SosBuilder.getSize()

Get number of terms in SOS constraint.

Synopsis

```
int getSize()
```

Return

number of terms.

SosBuilder.getType()

Get type of SOS constraint.

Synopsis

```
int getType()
```

Return

type of SOS constraint.

SosBuilder.getVar()

Get variable from the idx-th term in SOS constraint.

Synopsis

```
Var getVar(int idx)
```

Arguments

idx: index of the term.

Return

variable of the idx-th term in SOS constraint.

SosBuilder.GetVars()

Get all variables in a SOS constraint.

Synopsis

```
VarArray GetVars()
```

Return

variables in a SOS constraint.

SosBuilder.getWeight()

Get weight from the idx-th term in SOS constraint.

Synopsis

```
double getWeight(int idx)
```

Arguments

idx: index of the term.

Return

weight of the idx-th term in SOS constraint.

SosBuilder.getWeights()

Get weights of all terms in SOS constraint.

Synopsis

```
double[] getWeights()
```

Return

array of weights.

SosBuilder.set()

Set variables and weights of SOS constraint.

Synopsis

```
void set(  
    VarArray vars,  
    double[] weights,  
    int type)
```

Arguments

vars: variable array object.

weights: array of weights.

type: type of SOS constraint.

25.2.16 SosBuilderArray

COPT SOS constraint builder array object. To store and access a set of Java *SosBuilder* objects, Cardinal Optimizer provides Java SosBuilderArray class, which defines the following methods.

SosBuilderArray.SosBuilderArray()

Constructor of sosbuilderarray object.

Synopsis

```
SosBuilderArray()
```

SosBuilderArray.getBuilder()

Get idx-th SOS constraint builder object.

Synopsis

```
SosBuilder getBuilder(int idx)
```

Arguments

idx: index of the SOS constraint builder.

Return

SOS constraint builder object with index idx.

SosBuilderArray.pushBack()

Add a SOS constraint builder object to SOS constraint builder array.

Synopsis

```
void pushBack(SosBuilder builder)
```

Arguments

builder: a SOS constraint builder object.

SosBuilderArray.size()

Get the number of SOS constraint builder objects.

Synopsis

```
int size()
```

Return

number of SOS constraint builder objects.

25.2.17 GenConstr

COPT general constraint object. General constraints are always associated with a particular model. User creates a general constraint object by adding a general constraint to a model, rather than by using constructor of GenConstr class.

GenConstr.getIdx()

Get the index of the general constraint.

Synopsis

```
int getIdx()
```

Return

index of the general constraint.

GenConstr.getIIS()

Get IIS status of the general constraint.

Synopsis

```
int getIIS()
```

Return

IIS status.

GenConstr.getName()

Get name of general constraint.

Synopsis

```
String getName()
```

Return

the name of general constraint.

GenConstr.remove()

Remove the general constraint from model.

Synopsis

```
void remove()
```

GenConstr.setName()

Set name for general constraint.

Synopsis

```
void setName(String name)
```

Arguments

name: the name to set.

25.2.18 GenConstrArray

COPT general constraint array object. To store and access a set of Java *GenConstr* objects, Cardinal Optimizer provides Java GenConstrArray class, which defines the following methods.

GenConstrArray.GenConstrArray()

Constructor of genconstrarray.

Synopsis

```
GenConstrArray()
```

GenConstrArray.getGenConstr()

Get idx-th general constraint object.

Synopsis

```
GenConstr getGenConstr(int idx)
```

Arguments

idx: index of the general constraint.

Return

general constraint object with index idx.

GenConstrArray.pushBack()

Add a general constraint object to general constraint array.

Synopsis

```
void pushBack(GenConstr genconstr)
```

Arguments

genconstr: a general constraint object.

GenConstrArray.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: capacity number of general constraint object.

GenConstrArray.size()

Get the number of general constraint objects.

Synopsis

```
int size()
```

Return

number of general constraint objects.

25.2.19 GenConstrBuilder

COPT general constraint builder object. To help building a general constraint, given a binary variable and associated value, a linear expression and constraint sense, Cardinal Optimizer provides Java GenConstrBuilder class, which defines the following methods.

GenConstrBuilder.GenConstrBuilder()

Constructor of genconstrbuilder.

Synopsis

```
GenConstrBuilder()
```

GenConstrBuilder.getBinVal()

Get binary value associated with general constraint.

Synopsis

```
int getBinVal()
```

Return

binary value.

GenConstrBuilder.getBinVar()

Get binary variable associated with general constraint.

Synopsis

```
Var getBinVar()
```

Return

binary variable object.

GenConstrBuilder.getExpr()

Get expression associated with general constraint.

Synopsis

```
Expr getExpr()
```

Return

expression object.

GenConstrBuilder.getIndType()

Get type of general constraint.

Synopsis

```
int getIndType()
```

Return

type of general constraint.

GenConstrBuilder.getSense()

Get sense associated with general constraint.

Synopsis

```
char getSense()
```

Return

constraint sense.

GenConstrBuilder.set()

Set binary variable, binary value, expression and sense of general constraint.

Synopsis

```
void set(  
    Var binvar,  
    int binval,  
    Expr expr,  
    char sense)
```

Arguments

binvar: binary variable.

binval: binary value.

expr: expression object.

sense: general constraint sense.

GenConstrBuilder.set2()

Set binary variable, binary value, expression and sense of general constraint.

Synopsis

```
void set(  
    Var binvar,  
    int binval,  
    Expr expr,  
    char sense,  
    int type)
```

Arguments

binvar: binary variable.
binval: binary value.
expr: expression object.
sense: general constraint sense.
type: type of general constraint.

25.2.20 GenConstrBuilderArray

COPT general constraint builder array object. To store and access a set of Java *GenConstrBuilder* objects, Cardinal Optimizer provides Java *GenConstrBuilderArray* class, which defines the following methods.

GenConstrBuilderArray.GenConstrBuilderArray()

Constructor of *genconstrbuilderarray*.

Synopsis

```
GenConstrBuilderArray()
```

GenConstrBuilderArray.getBuilder()

Get idx-th general constraint builder object.

Synopsis

```
GenConstrBuilder getBuilder(int idx)
```

Arguments

idx: index of the general constraint builder.

Return

general constraint builder object with index *idx*.

GenConstrBuilderArray.pushBack()

Add a general constraint builder object to general constraint builder array.

Synopsis

```
void pushBack(GenConstrBuilder builder)
```

Arguments

builder: a general constraint builder object.

GenConstrBuilderArray.size()

Get the number of general constraint builder objects.

Synopsis

```
int size()
```

Return

number of general constraint builder objects.

25.2.21 Cone

COPT cone constraint object. Cone constraints are always associated with a particular model. User creates a cone constraint object by adding a cone constraint to a model, rather than by using constructor of Cone class.

A cone constraint can be regular or rotated (COPT_CONE_QUAD or COPT_CONE_RQUAD).

Cone.getIdx()

Get the index of a cone constraint.

Synopsis

```
int getIdx()
```

Return

index of a cone constraint.

Cone.remove()

Remove the cone constraint from model.

Synopsis

```
void remove()
```

25.2.22 ConeArray

COPT cone constraint array object. To store and access a set of Java [Cone](#) objects, Cardinal Optimizer provides Java ConeArray class, which defines the following methods.

ConeArray.ConeArray()

Constructor of ConeArray object.

Synopsis

```
ConeArray()
```

ConeArray.getCone()

Get idx-th cone object.

Synopsis

```
Cone getCone(int idx)
```

Arguments

idx: index of cone.

Return

cone object with index idx.

ConeArray.pushBack()

Add a cone constraint object to cone constraint array.

Synopsis

```
void pushBack(Cone cone)
```

Arguments

cone: a cone constraint object.

ConeArray.size()

Get the number of cone constraint objects.

Synopsis

```
int size()
```

Return

number of cone constraint objects.

25.2.23 ConeBuilder

COPT cone constraint builder object. To help building a cone constraint, given the cone type and a set of variables, Cardinal Optimizer provides Java ConeBuilder class, which defines the following methods.

ConeBuilder.ConeBuilder()

Constructor of ConeBuilder object.

Synopsis

```
ConeBuilder()
```

ConeBuilder.getSize()

Get number of variables in a cone constraint.

Synopsis

```
int getSize()
```

Return

number of vars.

ConeBuilder.getType()

Get type of a cone constraint.

Synopsis

```
int getType()
```

Return

type of a cone constraint.

ConeBuilder.getVar()

Get idx-th variable in a cone constraint.

Synopsis

```
Var getVar(int idx)
```

Arguments

idx: index of variables.

Return

the idx-th variable in a cone constraint.

ConeBuilder.getVars()

Get all variables in a cone constraint.

Synopsis

```
VarArray getVars()
```

Return

variables in a cone constraint.

ConeBuilder.set()

Set variables and type of a cone constraint.

Synopsis

```
void set(VarArray vars, int type)
```

Arguments

vars: variable array object.

type: type of a cone constraint.

25.2.24 ConeBuilderArray

COPT cone constraint builder array object. To store and access a set of Java *ConeBuilder* objects, Cardinal Optimizer provides Java ConeBuilderArray class, which defines the following methods.

ConeBuilderArray.ConeBuilderArray()

Constructor of ConeBuilderArray object.

Synopsis

```
ConeBuilderArray()
```

ConeBuilderArray.getBuilder()

Get idx-th cone constraint builder object.

Synopsis

```
ConeBuilder getBuilder(int idx)
```

Arguments

idx: index of the cone constraint builder.

Return

cone constraint builder object with index idx.

ConeBuilderArray.pushBack()

Add a cone constraint builder object to cone constraint builder array.

Synopsis

```
void pushBack(ConeBuilder builder)
```

Arguments

builder: a cone constraint builder object.

ConeBuilderArray.size()

Get the number of cone constraint builder objects.

Synopsis

```
int size()
```

Return

number of cone constraint builder objects.

25.2.25 ExpCone

COPT exponential cone constraint object. ExpCone constraints are always associated with a particular model. User creates an exponential cone constraint object by adding an exponential cone constraint to a model, rather than by using constructor of ExpCone class.

ExpCone.getIdx()

Get the index of an exponential cone constraint.

Synopsis

```
int getIdx()
```

Return

index of an exponential cone constraint.

ExpCone.remove()

Remove the exponential cone constraint from model.

Synopsis

```
void remove()
```

25.2.26 ExpConeArray

COPT exponential cone constraint array object. To store and access a set of Java *ExpCone* objects, Cardinal Optimizer provides Java ExpConeArray class, which defines the following methods.

ExpConeArray.ExpConeArray()

Constructor of ExpConeArray object.

Synopsis

```
ExpConeArray()
```

ExpConeArray.getCone()

Get idx-th exponential cone object.

Synopsis

```
ExpCone getCone(int idx)
```

Arguments

idx: index of exponential cone.

Return

exponential cone object with index idx.

ExpConeArray.pushBack()

Add an exponential cone constraint object to exponential cone constraint array.

Synopsis

```
void pushBack(ExpCone cone)
```

Arguments

cone: an exponential cone constraint object.

ExpConeArray.size()

Get the number of exponential cone constraint objects.

Synopsis

```
int size()
```

Return

number of exponential cone constraint objects.

25.2.27 ExpConeBuilder

COPT exponential cone constraint builder object. To help building an exponential cone constraint, given the exponential cone type and a set of variables, Cardinal Optimizer provides Java ExpConeBuilder class, which defines the following methods.

ExpConeBuilder.ExpConeBuilder()

Constructor of ExpConeBuilder object.

Synopsis

```
ExpConeBuilder()
```

ExpConeBuilder.getSize()

Get number of variables in an exponential cone constraint.

Synopsis

```
int getSize()
```

Return

number of vars.

ExpConeBuilder.getType()

Get type of an exponential cone constraint.

Synopsis

```
int getType()
```

Return

type of an exponential cone constraint.

ExpConeBuilder.getVar()

Get idx-th variable in an exponential cone constraint.

Synopsis

```
Var getVar(int idx)
```

Arguments

idx: index of variables.

Return

the idx-th variable in an exponential cone constraint.

ExpConeBuilder.getVars()

Get all variables in an exponential cone constraint.

Synopsis

```
VarArray getVars()
```

Return

variables in an exponential cone constraint.

ExpConeBuilder.set()

Set variables and type of an exponential cone constraint.

Synopsis

```
void set(VarArray vars, int type)
```

Arguments

vars: variable array object.

type: type of an exponential cone constraint.

25.2.28 ExpConeBuilderArray

COPT exponential cone constraint builder array object. To store and access a set of Java *ExpConeBuilder* objects, Cardinal Optimizer provides Java *ExpConeBuilderArray* class, which defines the following methods.

ExpConeBuilderArray.ExpConeBuilderArray()

Constructor of *ExpConeBuilderArray* object.

Synopsis

```
ExpConeBuilderArray()
```

ExpConeBuilderArray.getBuilder()

Get idx-th exponential cone constraint builder object.

Synopsis

```
ExpConeBuilder getBuilder(int idx)
```

Arguments

idx: index of the exponential cone constraint builder.

Return

exponential cone constraint builder object with index idx.

ExpConeBuilderArray.pushBack()

Add an exponential cone constraint builder object to exponential cone constraint builder array.

Synopsis

```
void pushBack(ExpConeBuilder builder)
```

Arguments

builder: an exponential cone constraint builder object.

ExpConeBuilderArray.size()

Get the number of exponential cone constraint builder objects.

Synopsis

```
int size()
```

Return

number of exponential cone constraint builder objects.

25.2.29 AffineCone Class

The *AffineCone* class in COPT encapsulates operations related to affine cones. The following methods are provided:

AffineCone.getIdx()

Get the index of an affine cone constraint.

Synopsis

```
int getIdx()
```

Return

index of an affine cone constraint.

AffineCone.getName()

Get name of the affine cone.

Synopsis

```
String getName()
```

Return

affine cone name.

AffineCone.remove()

Remove the affine cone constraint from model.

Synopsis

```
void remove()
```

AffineCone.setName()

Set name of the affine cone.

Synopsis

```
void setName(String name)
```

Arguments

name: affinecone name.

25.2.30 AffineConeArray Class

To facilitate user operations on a group of Java *AffineCone Class* objects, the Java interface of COPT introduces the *AffineConeArray* class. The following methods are provided:

AffineConeArray.AffineConeArray()

Constructor of AffineConeArray object.

Synopsis

```
AffineConeArray()
```

AffineConeArray.getCone()

Get idx-th affine cone object.

Synopsis

```
AffineCone getCone(int idx)
```

Arguments

idx: index of affine cone.

Return

affine cone object with index idx.

AffineConeArray.pushBack()

Add an affine cone constraint object to affine cone constraint array.

Synopsis

```
void pushBack(AffineCone cone)
```

Arguments

cone: an affine cone constraint object.

AffineConeArray.size()

Get the number of affine cone constraint objects.

Synopsis

```
int size()
```

Return

number of affine cone constraint objects.

25.2.31 AffineConeBuilder Class

The *AffineConeBuilder* class in COPT encapsulates the builder for constructing affine cones. The following methods are provided:

AffineConeBuilder.AffineConeBuilder()

Constructor of AffineConeBuilder object.

Synopsis

```
AffineConeBuilder()
```

AffineConeBuilder.getExpr()

Get idx-th linear expression in an affine cone constraint.

Synopsis

```
Expr getExpr(int idx)
```

Arguments

idx: index of linear expression.

Return

the idx-th linear expression in an affine cone constraint.

AffineConeBuilder.getExprs()

Get all linear expressions in an affine cone constraint.

Synopsis

```
Expr[] getExprs()
```

Return

array of linear expressions.

AffineConeBuilder.getPsdExpr()

Get idx-th PSD expression in an affine cone constraint.

Synopsis

```
PsdExpr getPsdExpr(int idx)
```

Arguments

idx: index of PSD expression.

Return

the idx-th PSD expression in an affine cone constraint.

AffineConeBuilder.getPsdExprs()

Get all PSD expressions in an affine cone constraint.

Synopsis

```
PsdExpr[] getPsdExprs()
```

Return

array of PSD expressions.

AffineConeBuilder.getSize()

Get number of variables in an affine cone constraint.

Synopsis

```
int getSize()
```

Return

number of vars.

AffineConeBuilder.getType()

Get type of an affine cone constraint.

Synopsis

```
int getType()
```

Return

type of an affine cone constraint.

AffineConeBuilder.hasPsdTerm()

Check whether affine cone has PSD terms.

Synopsis

```
Boolean hasPsdTerm()
```

Return

flag to indicate whether affine cone has PSD terms.

AffineConeBuilder.set()

Set linear expressions and type of an affine cone constraint.

Synopsis

```
void set(Expr[] exprs, int type)
```

Arguments

exprs: array of linear expressions.

type: type of an affine cone constraint.

AffineConeBuilder.set()

Set PSD expressions and type of an affine cone constraint.

Synopsis

```
void set(PsdExpr[] exprs, int type)
```

Arguments

exprs: array of PSD expressions.

type: type of an affine cone constraint.

25.2.32 AffineConeBuilderArray Class

To facilitate operations on a group of Java *AffineConeBuilder Class* objects, the Java interface of COPT introduces the *AffineConeBuilderArray* class. The following methods are provided:

AffineConeBuilderArray.AffineConeBuilderArray()

Constructor of AffineConeBuilderArray object.

Synopsis

```
AffineConeBuilderArray()
```


AffineConeBuilderArray.getBuilder()

Get idx-th affine cone constraint builder object.

Synopsis

```
AffineConeBuilder getBuilder(int idx)
```

Arguments

idx: index of the affine cone constraint builder.

Return

affine cone constraint builder object with index idx.

AffineConeBuilderArray.pushBack()

Add an affine cone constraint builder object to affine cone constraint builder array.

Synopsis

```
void pushBack(AffineConeBuilder builder)
```

Arguments

builder: an affine cone constraint builder object.

AffineConeBuilderArray.size()

Get the number of affine cone constraint builder objects.

Synopsis

```
int size()
```

Return

number of affine cone constraint builder objects.

25.2.33 QuadExpr

COPT quadratic expression object. A quadratic expression consists of a linear expression, a list of variable pairs and associated coefficients of quadratic terms. Quadratic expressions are used to build quadratic constraints and objectives.

QuadExpr.QuadExpr()

Constructor of a constant quadratic expression with constant 0.0

Synopsis

```
QuadExpr()
```

QuadExpr.QuadExpr()

Constructor of a constant quadratic expression.

Synopsis

```
QuadExpr(double constant)
```

Arguments

constant: constant value in expression object.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with one term.

Synopsis

```
QuadExpr(Var var)
```

Arguments

var: variable for the added term.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with one term.

Synopsis

```
QuadExpr(Var var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with a linear expression.

Synopsis

```
QuadExpr(Expr expr)
```

Arguments

expr: linear expression added to the quadratic expression.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with two linear expression.

Synopsis

```
QuadExpr(Expr expr, Var var)
```

Arguments

expr: one linear expression.

var: another variable.

QuadExpr.QuadExpr()

Constructor of a quadratic expression with two linear expression.

Synopsis

```
QuadExpr(Expr left, Expr right)
```

Arguments

left: one linear expression.

right: another linear expression.

QuadExpr.addConstant()

Add a constant to the quadratic expression.

Synopsis

```
void addConstant(double constant)
```

Arguments

constant: value to be added.

QuadExpr.addLinExpr()

Add a linear expression to self.

Synopsis

```
void addLinExpr(Expr expr)
```

Arguments

expr: linear expression to be added.

QuadExpr.addLinExpr()

Add a linear expression to self.

Synopsis

```
void addLinExpr(Expr expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: multiplier constant.

QuadExpr.addQuadExpr()

Add a quadratic expression to self.

Synopsis

```
void addQuadExpr(QuadExpr expr)
```

Arguments

expr: quadratic expression to be added.

QuadExpr.addQuadExpr()

Add a quadratic expression to self.

Synopsis

```
void addQuadExpr(QuadExpr expr, double mult)
```

Arguments

expr: quadratic expression to be added.

mult: multiplier constant.

QuadExpr.addTerm()

Add a term to quadratic expression object.

Synopsis

```
void addTerm(Var var, double coeff)
```

Arguments

var: a variable of new term.

coeff: coefficient of new term.

QuadExpr.addTerm()

Add a quadratic term to expression object.

Synopsis

```
void addTerm(  
    Var var1,  
    Var var2,  
    double coeff)
```

Arguments

var1: first variable of new quadratic term.

var2: second variable of new quadratic term.

coeff: coefficient of new quadratic term.

QuadExpr.addTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void addTerms(Var[] vars, double coeff)
```

Arguments

vars: variables of added linear terms.

coeff: one coefficient for added linear terms.

QuadExpr.addTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void addTerms(Var[] vars, double[] coeffs)
```

Arguments

vars: variables of added linear terms.

coeffs: coefficients of added linear terms.

QuadExpr.addTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void addTerms(VarArray vars, double coeff)
```

Arguments

vars: variables of added linear terms.

coeff: one coefficient for added linear terms.

QuadExpr.addTerms()

Add linear terms to quadratic expression object.

Synopsis

```
void addTerms(VarArray vars, double[] coeffs)
```

Arguments

vars: variables of added terms.

coeffs: coefficients of added terms.

QuadExpr.addTerms()

Add quadratic terms to expression object.

Synopsis

```
void addTerms(  
    VarArray vars1,  
    VarArray vars2,  
    double[] coeffs)
```

Arguments

vars1: first set of variables for added quadratic terms.

vars2: second set of variables for added quadratic terms.

coeffs: coefficient array for added quadratic terms.

QuadExpr.addTerms()

Add quadratic terms to expression object.

Synopsis

```
void addTerms(  
    Var[] vars1,  
    Var[] vars2,  
    double[] coeffs)
```

Arguments

vars1: first set of variables for added quadratic terms.

vars2: second set of variables for added quadratic terms.

coeffs: coefficient array for added quadratic terms.

QuadExpr.clone()

Deep copy quadratic expression object.

Synopsis

```
QuadExpr clone()
```

Return

cloned quadratic expression object.

QuadExpr.evaluate()

evaluate quadratic expression after solving

Synopsis

```
double evaluate()
```

Return

value of quadratic expression

QuadExpr.getCoeff()

Get coefficient from the i-th term in quadratic expression.

Synopsis

```
double getCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term in quadratic expression object.

QuadExpr.getConstant()

Get constant in quadratic expression.

Synopsis

```
double getConstant()
```

Return

constant in quadratic expression.

QuadExpr.getLinExpr()

Get linear expression in quadratic expression.

Synopsis

```
Expr getLinExpr()
```

Return

linear expression object.

QuadExpr.getVar1()

Get first variable from the i-th term in quadratic expression.

Synopsis

```
Var getVar1(int i)
```

Arguments

i: index of the term.

Return

first variable of the i-th term in quadratic expression object.

QuadExpr.getVar2()

Get second variable from the i-th term in quadratic expression.

Synopsis

```
Var getVar2(int i)
```

Arguments

i: index of the term.

Return

second variable of the i-th term in quadratic expression object.

QuadExpr.remove()

Remove idx-th term from quadratic expression object.

Synopsis

```
void remove(int idx)
```

Arguments

idx: index of the term to be removed.

QuadExpr.remove()

Remove the term associated with variable from quadratic expression.

Synopsis

```
void remove(Var var)
```

Arguments

var: a variable whose term should be removed.

QuadExpr.setCoeff()

Set coefficient of the i-th term in quadratic expression.

Synopsis

```
void setCoeff(int i, double val)
```

Arguments

i: index of the quadratic term.

val: coefficient of the term.

QuadExpr.setConstant()

Set constant for the quadratic expression.

Synopsis

```
void setConstant(double constant)
```

Arguments

constant: the value of the constant.

QuadExpr.size()

Get number of terms in quadratic expression.

Synopsis

```
long size()
```

Return

number of quadratic terms.

25.2.34 QConstraint

COPT quadratic constraint object. Quadratic constraints are always associated with a particular model. User creates a quadratic constraint object by adding a quadratic constraint to a model, rather than by using constructor of QConstraint class.

QConstraint.get()

Get information value of the quadratic constraint.

Synopsis

```
double get(String info)
```

Arguments

info: name of the information being queried.

Return

information value.

QConstraint.getIdx()

Get index of the quadratic constraint.

Synopsis

```
int getIdx()
```

Return

the index of the quadratic constraint.

QConstraint.getName()

Get name of the constraint.

Synopsis

```
String getName()
```

Return

the name of the constraint.

QConstraint.getRhs()

Get rhs of quadratic constraint.

Synopsis

```
double getRhs()
```

Return

rhs of quadratic constraint.

QConstraint.getSense()

Get rhs of quadratic constraint.

Synopsis

```
char getSense()
```

Return

rhs of quadratic constraint.

QConstraint.remove()

Remove this constraint from model.

Synopsis

```
void remove()
```

QConstraint.set()

Set information value of the quadratic constraint.

Synopsis

```
void set(String info, double val)
```

Arguments

info: name of the information.

val: new information value.

QConstraint.setName()

Set name of quadratic constraint.

Synopsis

```
void setName(String name)
```

Arguments

name: the name to set.

QConstraint.setRhs()

Set rhs of quadratic constraint.

Synopsis

```
void setRhs(double rhs)
```

Arguments

rhs: rhs of quadratic constraint.

QConstraint.setSense()

Set sense of quadratic constraint.

Synopsis

```
void setSense(char sense)
```

Arguments

sense: sense of quadratic constraint.

25.2.35 QConstrArray

COPT quadratic constraint array object. To store and access a set of Java *QConstraint* objects, Cardinal Optimizer provides Java QConstrArray class, which defines the following methods.

QConstrArray.QConstrArray()

QConstructor of constrarray object.

Synopsis

```
QConstrArray()
```

QConstrArray.getQConstr()

Get idx-th constraint object.

Synopsis

```
QConstraint getQConstr(int idx)
```

Arguments

idx: index of the constraint.

Return

constraint object with index idx.

QConstrArray.pushBack()

Add a constraint object to constraint array.

Synopsis

```
void pushBack(QConstraint constr)
```

Arguments

constr: a constraint object.

QConstrArray.size()

Get the number of constraint objects.

Synopsis

```
int size()
```

Return

number of constraint objects.

25.2.36 QConstrBuilder

COPT quadratic constraint builder object. To help building a quadratic constraint, given a quadratic expression, constraint sense and right-hand side value, Cardinal Optimizer provides Java ConeBuilder class, which defines the following methods.

QConstrBuilder.QConstrBuilder()

QConstructor of constrbuilder object.

Synopsis

```
QConstrBuilder()
```

QConstrBuilder.getQuadExpr()

Get expression associated with constraint.

Synopsis

```
QuadExpr getQuadExpr()
```

Return

quadratic expression object.

QConstrBuilder.getSense()

Get sense associated with quadratic constraint.

Synopsis

```
char getSense()
```

Return

quadratic constraint sense.

QConstrBuilder.set()

Set detail of a quadratic constraint to its builder object.

Synopsis

```
void set(  
    QuadExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the quadratic constraint.

sense: quadratic constraint sense.

rhs: constant of right side of quadratic constraint.

25.2.37 QConstrBuilderArray

COPT quadratic constraint builder array object. To store and access a set of Java *QConstrBuilder* objects, Cardinal Optimizer provides Java *QConstrBuilderArray* class, which defines the following methods.

QConstrBuilderArray.QConstrBuilderArray()

QConstructor of constrbuilderarray object.

Synopsis

```
QConstrBuilderArray()
```

QConstrBuilderArray.getBuilder()

Get idx-th constraint builder object.

Synopsis

```
QConstrBuilder getBuilder(int idx)
```

Arguments

idx: index of the constraint builder.

Return

constraint builder object with index idx.

QConstrBuilderArray.pushBack()

Add a constraint builder object to constraint builder array.

Synopsis

```
void pushBack(QConstrBuilder builder)
```

Arguments

builder: a constraint builder object.

QConstrBuilderArray.size()

Get the number of constraint builder objects.

Synopsis

```
int size()
```

Return

number of constraint builder objects.

25.2.38 PsdVar

COPT PSD variable object. PSD variables are always associated with a particular model. User creates a PSD variable object by adding a PSD variable to model, rather than by constructor of PsdVar class.

PsdVar.get()

Get information values of PSD variable.

Synopsis

```
double[] get(String info)
```

Arguments

info: information name.

Return

array of information values.

PsdVar.getDim()

Get dimension of PSD variable.

Synopsis

```
int getDim()
```

Return

dimension of PSD variable.

PsdVar.getIdx()

Get index of PSD variable.

Synopsis

```
int getIdx()
```

Return

index of PSD variable.

PsdVar.getLen()

Get length of PSD variable.

Synopsis

```
int getLen()
```

Return

length of PSD variable.

PsdVar.getName()

Get name of PSD variable.

Synopsis

```
String getName()
```

Return

name of PSD variable.

PsdVar.remove()

Remove PSD variable from model.

Synopsis

```
void remove()
```

25.2.39 PsdVarArray

COPT PSD variable array object. To store and access a set of *PsdVar* objects, Cardinal Optimizer provides *PsdVarArray* class, which defines the following methods.

PsdVarArray.PsdVarArray()

Constructor of *PsdVarArray*.

Synopsis

```
PsdVarArray()
```

PsdVarArray.getPsdVar()

Get idx-th PSD variable object.

Synopsis

```
PsdVar getPsdVar(int idx)
```

Arguments

idx: index of the PSD variable.

Return

PSD variable object with index idx.

PsdVarArray.pushBack()

Add a PSD variable object to PSD variable array.

Synopsis

```
void pushBack(PsdVar var)
```

Arguments

var: a PSD variable object.

PsdVarArray.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: minimum capacity for PSD variable object.

PsdVarArray.size()

Get the number of PSD variable objects.

Synopsis

```
int size()
```

Return

number of PSD variable objects.

25.2.40 PsdExpr

COPT PSD expression object. A PSD expression consists of a linear expression, a list of PSD variables and associated coefficient matrices of PSD terms. PSD expressions are used to build PSD constraints and objectives.

PsdExpr.PsdExpr()

Constructor of a PSD expression with default constant value 0.

Synopsis

```
PsdExpr(double constant)
```

Arguments

constant: constant value in PSD expression object.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(Var var)
```

Arguments

var: variable for the added term.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(Var var, double coeff)
```

Arguments

var: variable for the added term.

coeff: coefficient for the added term.

PsdExpr.PsdExpr()

Constructor of a PSD expression with a linear expression.

Synopsis

```
PsdExpr(Expr expr)
```

Arguments

expr: input linear expression.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(PsdVar var, SymMatrix mat)
```

Arguments

var: PSD variable for the added term.

mat: coefficient matrix for the added term.

PsdExpr.PsdExpr()

Constructor of a PSD expression with one term.

Synopsis

```
PsdExpr(PsdVar var, SymMatExpr expr)
```

Arguments

var: PSD variable for the added term.

expr: coefficient expression of symmetric matrices of new PSD term.

PsdExpr.addConstant()

Add constant to the PSD expression.

Synopsis

```
void addConstant(double constant)
```

Arguments

constant: value to be added.

PsdExpr.addLinExpr()

Add a linear expression to PSD expression object.

Synopsis

```
void addLinExpr(Expr expr)
```

Arguments

expr: linear expression to be added.

PsdExpr.addLinExpr()

Add a linear expression to PSD expression object.

Synopsis

```
void addLinExpr(Expr expr, double mult)
```

Arguments

expr: linear expression to be added.

mult: multiplier constant.

PsdExpr.addPsdExpr()

Add a PSD expression to self.

Synopsis

```
void addPsdExpr(PsdExpr expr)
```

Arguments

expr: PSD expression to be added.

PsdExpr.addPsdExpr()

Add a PSD expression to self.

Synopsis

```
void addPsdExpr(PsdExpr expr, double mult)
```

Arguments

expr: PSD expression to be added.

mult: multiplier constant.

PsdExpr.addTerm()

Add a linear term to PSD expression object.

Synopsis

```
void addTerm(Var var, double coeff)
```

Arguments

var: variable of new linear term.

coeff: coefficient of new linear term.

PsdExpr.addTerm()

Add a PSD term to PSD expression object.

Synopsis

```
void addTerm(PsdVar var, SymMatrix mat)
```

Arguments

var: PSD variable of new PSD term.

mat: coefficient matrix of new PSD term.

PsdExpr.addTerm()

Add a PSD term to PSD expression object.

Synopsis

```
void addTerm(PsdVar var, SymMatExpr expr)
```

Arguments

var: PSD variable of new PSD term.

expr: coefficient expression of symmetric matrices of new PSD term.

PsdExpr.addTerms()

Add linear terms to PSD expression object.

Synopsis

```
void addTerms(Var[] vars, double coeff)
```

Arguments

vars: variables of added linear terms.

coeff: one coefficient for added linear terms.

PsdExpr.addTerms()

Add linear terms to PSD expression object.

Synopsis

```
void addTerms(Var[] vars, double[] coeffs)
```

Arguments

vars: variables for added linear terms.

coeffs: coefficient array for added linear terms.

PsdExpr.addTerms()

Add linear terms to PSD expression object.

Synopsis

```
void addTerms(VarArray vars, double coeff)
```

Arguments

vars: variables of added linear terms.

coeff: one coefficient for added linear terms.

PsdExpr.addTerms()

Add linear terms to PSD expression object.

Synopsis

```
void addTerms(VarArray vars, double[] coeffs)
```

Arguments

vars: variables of added terms.

coeffs: coefficients of added terms.

PsdExpr.addTerms()

Add PSD terms to PSD expression object.

Synopsis

```
void addTerms(PsdVarArray vars, SymMatrixArray mats)
```

Arguments

vars: PSD variables for added PSD terms.

mats: coefficient matrixes for added PSD terms.

PsdExpr.addTerms()

Add PSD terms to PSD expression object.

Synopsis

```
void addTerms(PsdVar[] vars, SymMatrix[] mats)
```

Arguments

vars: PSD variables for added PSD terms.

mats: coefficient matrixes for added PSD terms.

PsdExpr.clone()

Deep copy PSD expression object.

Synopsis

```
PsdExpr clone()
```

Return

cloned PSD expression object.

PsdExpr.evaluate()

Evaluate PSD expression after solving

Synopsis

```
double evaluate()
```

Return

Value of PSD expression

PsdExpr.getCoeff()

Get coefficient from the i-th term in PSD expression.

Synopsis

```
SymMatExpr getCoeff(int i)
```

Arguments

i: index of the PSD term.

Return

coefficient expression of the i-th PSD term.

PsdExpr.getConstant()

Get constant in PSD expression.

Synopsis

```
double getConstant()
```

Return

constant in PSD expression.

PsdExpr.getLinExpr()

Get linear expression in PSD expression.

Synopsis

```
Expr getLinExpr()
```

Return

linear expression object.

PsdExpr.getPsdVar()

Get the PSD variable from the i-th term in PSD expression.

Synopsis

```
PsdVar getPsdVar(int i)
```

Arguments

i: index of the term.

Return

the first variable of the i-th term in PSD expression object.

PsdExpr.multiply()

Multiply a PSD expression and a constant.

Synopsis

```
void multiply(double c)
```

Arguments

c: constant operand.

PsdExpr.remove()

Remove i-th term from PSD expression object.

Synopsis

```
void remove(int idx)
```

Arguments

idx: index of the term to be removed.

PsdExpr.remove()

Remove the term associated with variable from PSD expression.

Synopsis

```
void remove(Var var)
```

Arguments

var: a variable whose term should be removed.

PsdExpr.remove()

Remove the term associated with PSD variable from PSD expression.

Synopsis

```
void remove(PsdVar var)
```

Arguments

var: a PSD variable whose term should be removed.

PsdExpr.setCoeff()

Set coefficient matrix of the i-th term in PSD expression.

Synopsis

```
void setCoeff(int i, SymMatrix mat)
```

Arguments

i: index of the PSD term.

mat: coefficient matrix of the term.

PsdExpr.setConstant()

Set constant for the PSD expression.

Synopsis

```
void setConstant(double constant)
```

Arguments

constant: the value of the constant.

PsdExpr.size()

Get number of PSD terms in expression.

Synopsis

```
long size()
```

Return

number of PSD terms.

25.2.41 PsdConstraint

COPT PSD constraint object. PSD constraints are always associated with a particular model. User creates a PSD constraint object by adding a PSD constraint to model, rather than by constructor of PsdConstraint class.

PsdConstraint.get()

Get information value of the PSD constraint. Support related PSD informations.

Synopsis

```
double get(String info)
```

Arguments

info: name of queried information.

Return

information value.

PsdConstraint.getIdx()

Get index of the PSD constraint.

Synopsis

```
int getIdx()
```

Return

the index of the PSD constraint.

PsdConstraint.getName()

Get name of the PSD constraint.

Synopsis

```
String getName()
```

Return

the name of the PSD constraint.

PsdConstraint.remove()

Remove this PSD constraint from model.

Synopsis

```
void remove()
```

PsdConstraint.set()

Set information value of the PSD constraint. Support related PSD informations.

Synopsis

```
void set(String info, double value)
```

Arguments

info: name of queried information.

value: new information value.

PsdConstraint.setName()

Set name of a PSD constraint.

Synopsis

```
void setName(String name)
```

Arguments

name: the name to set.

25.2.42 PsdConstrArray

COPT PSD constraint array object. To store and access a set of *PsdConstraint* objects, Cardinal Optimizer provides PsdConstrArray class, which defines the following methods.

PsdConstrArray.PsdConstrArray()

Constructor of PsdConstrArray object.

Synopsis

```
PsdConstrArray()
```

PsdConstrArray.getPsdConstr()

Get idx-th PSD constraint object.

Synopsis

```
PsdConstraint getPsdConstr(int idx)
```

Arguments

idx: index of the PSD constraint.

Return

PSD constraint object with index idx.

PsdConstrArray.pushBack()

Add a PSD constraint object to PSD constraint array.

Synopsis

```
void pushBack(PsdConstraint constr)
```

Arguments

constr: a PSD constraint object.

PsdConstrArray.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: minimum capacity for PSD constraint objects.

PsdConstrArray.size()

Get the number of PSD constraint objects.

Synopsis

```
int size()
```

Return

number of PSD constraint objects.

25.2.43 PsdConstrBuilder

COPT PSD constraint builder object. To help building a PSD constraint, given a PSD expression, constraint sense and right-hand side value, Cardinal Optimizer provides PsdConstrBuilder class, which defines the following methods.

PsdConstrBuilder.PsdConstrBuilder()

Constructor of PsdConstrBuilder object.

Synopsis

```
PsdConstrBuilder()
```

PsdConstrBuilder.getPsdExpr()

Get expression associated with PSD constraint.

Synopsis

```
PsdExpr getPsdExpr()
```

Return

PSD expression object.

PsdConstrBuilder.getRange()

Get range from lower bound to upper bound of range constraint.

Synopsis

```
double getRange()
```

Return

length from lower bound to upper bound of the constraint.

PsdConstrBuilder.getSense()

Get sense associated with PSD constraint.

Synopsis

```
char getSense()
```

Return

PSD constraint sense.

PsdConstrBuilder.set()

Set detail of a PSD constraint to its builder object.

Synopsis

```
void set(  
    PsdExpr expr,  
    char sense,  
    double rhs)
```

Arguments

expr: expression object at one side of the PSD constraint.

sense: PSD constraint sense, other than COPT_RANGE.

rhs: constant at right side of the PSD constraint.

PsdConstrBuilder.setRange()

Set a range constraint to its builder.

Synopsis

```
void setRange(PsdExpr expr, double range)
```

Arguments

expr: PSD expression object, whose constant is negative upper bound.

range: length from lower bound to upper bound of the constraint. Must greater than 0.

25.2.44 PsdConstrBuilderArray

COPT PSD constraint builder array object. To store and access a set of *PsdConstrBuilder* objects, Cardinal Optimizer provides PsdConstrBuilderArray class, which defines the following methods.

PsdConstrBuilderArray.PsdConstrBuilderArray()

Constructor of PsdConstrBuilderArray object.

Synopsis

```
PsdConstrBuilderArray()
```

PsdConstrBuilderArray.getBuilder()

Get idx-th PSD constraint builder object.

Synopsis

```
PsdConstrBuilder getBuilder(int idx)
```

Arguments

idx: index of the PSD constraint builder.

Return

PSD constraint builder object with index idx.

PsdConstrBuilderArray.pushBack()

Add a PSD constraint builder to PSD constraint builder array.

Synopsis

```
void pushBack(PsdConstrBuilder builder)
```

Arguments

builder: a PSD constraint builder object.

PsdConstrBuilderArray.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: minimum capacity for PSD constraint builder object.

PsdConstrBuilderArray.size()

Get the number of PSD constraint builder objects.

Synopsis

```
int size()
```

Return

number of PSD constraint builder objects.

25.2.45 LmiConstraint

COPT LMI constraint object. LMI constraints are always associated with a particular model. User creates a LMI constraint object by adding a LMI constraint to model, rather than by constructor of LmiConstraint class.

LmiConstraint.get()

Get information values of LMI constraint.

Synopsis

```
double[] get(String info)
```

Arguments

info: information name.

Return

array of information values.

LmiConstraint.getDim()

Get dimension of LMI constraint.

Synopsis

```
int getDim()
```

Return

dimension of LMI constraint.

LmiConstraint.getIdx()

Get index of LMI constraint.

Synopsis

```
int getIdx()
```

Return

index of LMI constraint.

LmiConstraint.getLen()

Get length of LMI constraint.

Synopsis

```
int getLen()
```

Return

length of LMI constraint.

LmiConstraint.getName()

Get name of LMI constraint.

Synopsis

```
String getName()
```

Return

name of LMI constraint.

LmiConstraint.remove()

Remove this LMI constraint from model.

Synopsis

```
void remove()
```

LmiConstraint.setRhs()

Set constant term of LMI constraint.

Synopsis

```
void setRhs(SymMatrix mat)
```

Arguments

mat: new symmetric matrix for constant term.

25.2.46 LmiConstrArray

COPT LMI constraint array object. To store and access a set of *LmiConstraint* objects, Cardinal Optimizer provides LmiConstrArray class, which defines the following methods.

LmiConstrArray.LmiConstrArray()

Constructor of LmiConstrArray.

Synopsis

```
LmiConstrArray()
```

LmiConstrArray.getLmiConstr()

Get idx-th LMI constraint object.

Synopsis

```
LmiConstraint getLmiConstr(int idx)
```

Arguments

idx: index of the LMI constraint.

Return

LMI constraint object with index idx.

LmiConstrArray.pushBack()

Add an LMI constraint to LMI constraint array.

Synopsis

```
void pushBack(LmiConstraint constr)
```

Arguments

constr: LMI constraint object.

LmiConstrArray.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: capacity number of LMI constraint objects.

LmiConstrArray.size()

Get the number of LMI constraint objects.

Synopsis

```
int size()
```

Return

number of LMI constraint objects.

25.2.47 LmiExpr

COPT LMI expression object. A LMI expression consists of a list of variables, associated coefficient matrices of LMI term, and constant matrices. LMI expressions are used to build LMI constraints.

LmiExpr.LmiExpr()

Default constructor of a LMI expression.

Synopsis

```
LmiExpr()
```

LmiExpr.LmiExpr()

Constructor of LMI expression with constant term.

Synopsis

```
LmiExpr(SymMatrix mat)
```

Arguments

mat: symmetric matrix object.

LmiExpr.LmiExpr()

Constructor of LMI expression with constant term.

Synopsis

```
LmiExpr(SymMatExpr expr)
```

Arguments

expr: matrix expression object.

LmiExpr.LmiExpr()

Constructor of LMI expression with one term.

Synopsis

```
LmiExpr(Var var, SymMatrix mat)
```

Arguments

var: variable of the added term.

mat: coefficient matrix of the added term.

LmiExpr.LmiExpr()

Constructor of LMI expression with one term.

Synopsis

```
LmiExpr(Var var, SymMatExpr expr)
```

Arguments

var: variable of the added term.

expr: coefficient expression of symmetric matrices of new LMI term.

LmiExpr.addConstant()

Add to constant term of the LMI expression.

Synopsis

```
void addConstant(SymMatExpr expr)
```

Arguments

expr: matrix expression added to the constant term.

LmiExpr.addLmiExpr()

Add an LMI expression to self.

Synopsis

```
void addLmiExpr(LmiExpr expr)
```

Arguments

expr: LMI expression to be added.

LmiExpr.addLmiExpr()

Add an LMI expression to self.

Synopsis

```
void addLmiExpr(LmiExpr expr, double mult)
```

Arguments

expr: LMI expression to be added.

mult: multiplier constant.

LmiExpr.addTerm()

Add an LMI term to LMI expression object.

Synopsis

```
void addTerm(Var var, SymMatrix mat)
```

Arguments

var: LMI variable of new LMI term.

mat: coefficient matrix of new LMI term.

LmiExpr.addTerm()

Add an LMI term to LMI expression object.

Synopsis

```
void addTerm(Var var, SymMatExpr expr)
```

Arguments

var: variable of new LMI term.

expr: coefficient expression of symmetric matrices of new LMI term.

LmiExpr.addTerms()

Add LMI terms to LMI expression object.

Synopsis

```
void addTerms(VarArray vars, SymMatrixArray mats)
```

Arguments

vars: variables for added LMI terms.

mats: coefficient matrices for added LMI terms.

LmiExpr.addTerms()

Add LMI terms to LMI expression object.

Synopsis

```
void addTerms(Var[] vars, SymMatrix[] mats)
```

Arguments

vars: variables for added LMI terms.

mats: coefficient matrices for added LMI terms.

LmiExpr.clone()

Deep copy LMI expression.

Synopsis

```
LmiExpr clone()
```

Return

cloned LMI expression object.

LmiExpr.getCoeff()

Get coefficient from the i-th term in LMI expression.

Synopsis

```
SymMatExpr getCoeff(int i)
```

Arguments

i: index of the LMI term.

Return

coefficient expression of the i-th LMI term.

LmiExpr.getConstant()

Get constant term in LMI expression.

Synopsis

```
SymMatExpr getConstant()
```

Return

symmetric matrix expression object.

LmiExpr.getVar()

Get variable from the i-th term in LMI expression.

Synopsis

```
Var getVar(int i)
```

Arguments

i: index of the term.

Return

variable of the i-th term in LMI expression object.

LmiExpr.multiply()

Multiply a double constant by itself.

Synopsis

```
void multiply(double c)
```

Arguments

c: constant multiplier.

LmiExpr.remove()

Remove i-th term from LMI expression object.

Synopsis

```
void remove(int idx)
```

Arguments

idx: index of the term to be removed.

LmiExpr.remove()

Remove the term associated with variable from LMI expression.

Synopsis

```
void remove(Var var)
```

Arguments

var: variable whose term should be removed.

LmiExpr.setCoeff()

Set coefficient matrix of the i-th term in LMI expression.

Synopsis

```
void setCoeff(int i, SymMatrix mat)
```

Arguments

i: index of the LMI term.

mat: coefficient matrix of the term.

LmiExpr.setConstant()

Set constant term of the LMI expression.

Synopsis

```
void setConstant(SymMatrix mat)
```

Arguments

mat: symmetric matrix of the constant term.

LmiExpr.size()

Get number of LMI terms in expression.

Synopsis

```
long size()
```

Return

number of LMI terms.

25.2.48 SymMatrix

COPT symmetric matrix object. Symmetric matrices are always associated with a particular model. User creates a symmetric matrix object by adding a symmetric matrix to model, rather than by constructor of SymMatrix class.

Symmetric matrices are used as coefficient matrices of PSD terms in PSD expressions, PSD constraints or PSD objectives.

SymMatrix.getDim()

Get the dimension of a symmetric matrix.

Synopsis

```
int getDim()
```

Return

Dimension of a symmetric matrix.

SymMatrix.getIdx()

Get the index of a symmetric matrix.

Synopsis

```
int getIdx()
```

Return

Index of a symmetric matrix.

25.2.49 SymMatrixArray

COPT symmetric matrix object. To store and access a set of *SymMatrix* objects, Cardinal Optimizer provides SymMatrixArray class, which defines the following methods.

SymMatrixArray.SymMatrixArray()

Constructor of SymMatrixArray.

Synopsis

```
SymMatrixArray()
```

SymMatrixArray.getMatrix()

Get i-th SymMatrix object.

Synopsis

```
SymMatrix getMatrix(int idx)
```

Arguments

idx: index of the SymMatrix object.

Return

SymMatrix object with index idx.

SymMatrixArray.pushBack()

Add a SymMatrix object to SymMatrix array.

Synopsis

```
void pushBack(SymMatrix mat)
```

Arguments

mat: a SymMatrix object.

SymMatrixArray.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: minimum capacity for symmetric matrix object.

SymMatrixArray.size()

Get the number of SymMatrix objects.

Synopsis

```
int size()
```

Return

number of SymMatrix objects.

25.2.50 SymMatExpr

COPT symmetric matrix expression object. A symmetric matrix expression is a linear combination of symmetric matrices, which is still a symmetric matrix. However, by doing so, we are able to delay computing the final matrix until setting PSD constraints or PSD objective.

SymMatExpr.SymMatExpr()

Constructor of a symmetric matrix expression.

Synopsis

```
SymMatExpr()
```

SymMatExpr.SymMatExpr()

Constructor of a symmetric matrix expression with one term.

Synopsis

```
SymMatExpr(SymMatrix mat, double coeff)
```

Arguments

mat: symmetric matrix of the added term.

coeff: coefficient for the added term.

SymMatExpr.addSymMatExpr()

Add a symmetric matrix expression to self.

Synopsis

```
void addSymMatExpr(SymMatExpr expr, double mult)
```

Arguments

expr: symmetric matrix expression to be added.

mult: constant multiplier.

SymMatExpr.addTerm()

Add a term to symmetric matrix expression object.

Synopsis

```
Boolean addTerm(SymMatrix mat, double coeff)
```

Arguments

mat: symmetric matrix of the new term.

coeff: coefficient of the new term.

Return

True if the term is added successfully.

SymMatExpr.addTerms()

Add multiple terms to expression object.

Synopsis

```
int addTerms(SymMatrix[] mats, double coeff)
```

Arguments

mats: symmetric matrix array object for added terms.

coeff: common coefficient for added terms.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr.addTerms()

Add multiple terms to expression object.

Synopsis

```
int addTerms(SymMatrixArray mats, double[] coeffs)
```

Arguments

mats: symmetric matrix array object for added terms.

coeffs: coefficient array for added terms.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr.addTerms()

Add multiple terms to expression object.

Synopsis

```
int addTerms(SymMatrix[] mats, double[] coeffs)
```

Arguments

mats: symmetric matrix array object for added terms.

coeffs: coefficient array for added terms.

Return

Number of added terms. If negative, fail to add one of terms.

SymMatExpr.clone()

Deep copy symmetric matrix expression object.

Synopsis

```
SymMatExpr clone()
```

Return

cloned expression object.

SymMatExpr.getCoeff()

Get coefficient of the i-th term in expression object.

Synopsis

```
double getCoeff(int i)
```

Arguments

i: index of the term.

Return

coefficient of the i-th term.

SymMatExpr.getDim()

Get dimension of symmetric matrix in expression.

Synopsis

```
int getDim()
```

Return

dimension of symmetric matrix.

SymMatExpr.getSymMat()

Get symmetric matrix of the i-th term in expression object.

Synopsis

```
SymMatrix getSymMat(int i)
```

Arguments

i: index of the term.

Return

the symmetric matrix of the i-th term.

SymMatExpr.multiply()

multiply a symmetric matrix expression and a constant.

Synopsis

```
void multiply(double c)
```

Arguments

c: constant operand.

SymMatExpr.remove()

Remove i-th term from expression object.

Synopsis

```
void remove(int idx)
```

Arguments

idx: index of the term to be removed.

SymMatExpr.remove()

Remove the term associated with the symmetric matrix.

Synopsis

```
void remove(SymMatrix mat)
```

Arguments

mat: a symmetric matrix whose term should be removed.

SymMatExpr.reserve()

Reserve capacity to contain at least n items.

Synopsis

```
void reserve(int n)
```

Arguments

n: minimum capacity for expression object.

SymMatExpr.setCoeff()

Set coefficient for the i-th term in expression object.

Synopsis

```
void setCoeff(int i, double val)
```

Arguments

i: index of the term.

val: coefficient of the term.

SymMatExpr.size()

Get number of terms in expression.

Synopsis

```
long size()
```

Return

number of terms.

25.2.51 CallbackBase

COPT Callback abstract base object. Users must implment its virtual method `virtual void CallbackBase::callback()` to instantiate an instance, which pass to `Model::SetCallback(CallbackBase cb, int cbctx)` as the first parameter. Subclass of `CallbackBase` inherits the following member methods:

CallbackBase.CallbackBase()

Constructor of `CallbackBase`, implementing `ICallback` interface.

Synopsis

```
CallbackBase()
```

CallbackBase.addLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void addLazyConstr(  
    Expr lhs,  
    char sense,  
    double rhs)
```

Arguments

lhs: expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side value for lazy constraint.

CallbackBase.addLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void addLazyConstr(  
    Expr lhs,  
    char sense,  
    Expr rhs)
```

Arguments

lhs: left hand side expression for lazy constraint.

sense: sense for lazy constraint.

rhs: right hand side expression for lazy constraint.

CallbackBase.addLazyConstr()

Add a lazy constraint to model.

Synopsis

```
void addLazyConstr(ConstrBuilder builder)
```

Arguments

builder: builder for lazy constraint.

CallbackBase.addLazyConstrs()

Add lazy constraints to model.

Synopsis

```
void addLazyConstrs(ConstrBuilderArray builders)
```

Arguments

builders: array of builders for lazy constraints.

CallbackBase.addUserCut()

Add a user cut to model.

Synopsis

```
void addUserCut(  
    Expr lhs,  
    char sense,  
    double rhs)
```

Arguments

lhs: expression for user cut.
sense: sense for user cut.
rhs: right hand side value for user cut.

CallbackBase.addUserCut()

Add a user cut to model.

Synopsis

```
void addUserCut(  
    Expr lhs,  
    char sense,  
    Expr rhs)
```

Arguments

lhs: left hand side expression for user cut.
sense: sense for user cut.
rhs: right hand side expression for user cut.

CallbackBase.addUserCut()

Add a user cut to model.

Synopsis

```
void addUserCut(ConstrBuilder builder)
```

Arguments

builder: builder for user cut.

CallbackBase.addUserCuts()

Add user cuts to model.

Synopsis

```
void addUserCuts(ConstrBuilderArray builders)
```

Arguments

builders: array of builders for user cuts.

CallbackBase.callback()

Pure virtual function defined in ICallback interface. User must implement it.

Synopsis

```
void callback()
```

CallbackBase.getDbInfo()

Get double value of given information name in callback.

Synopsis

```
double getDbInfo(String cbinfo)
```

Arguments

cbinfo: name of callback info.

Return

value of desired information.

CallbackBase.getIncumbent()

Get best feasible solution of given variable in callback.

Synopsis

```
double getIncumbent(Var var)
```

Arguments

var: given variable.

Return

best feasible solution of given variable.

CallbackBase.getIncumbent()

Get best feasible solution of variables in callback.

Synopsis

```
double[] getIncumbent(VarArray vars)
```

Arguments

vars: an array of variables.

Return

best feasible solution of desired variables.

CallbackBase.getIncumbent()

Get best feasible solution of variables in callback.

Synopsis

```
double[] getIncumbent(Var[] vars)
```

Arguments

vars: an array of variables.

Return

best feasible solution of desired variables.

CallbackBase.getIncumbent()

Get best feasible solution of all variables in callback.

Synopsis

```
double[] getIncumbent()
```

Return

best feasible solution of all variables.

CallbackBase.getIntInfo()

Get integer value of given information name in callback.

Synopsis

```
int getIntInfo(String cbinfo)
```

Arguments

cbinfo: name of callback info.

Return

value of desired information.

CallbackBase.getRelaxSol()

Get LP-relaxation solution of given variable in callback.

Synopsis

```
double getRelaxSol(Var var)
```

Arguments

var: given variable.

Return

LP-relaxation solution of given variable.

CallbackBase.getRelaxSol()

Get LP-relaxation solution of variables in callback.

Synopsis

```
double[] getRelaxSol(VarArray vars)
```

Arguments

vars: an array of variables.

Return

LP-relaxation solution of variables.

CallbackBase.getRelaxSol()

Get LP-relaxation solution of variables in callback.

Synopsis

```
double[] getRelaxSol(Var[] vars)
```

Arguments

vars: an array of variables.

Return

LP-relaxation solution of variables.

CallbackBase.getRelaxSol()

Get LP-relaxation solution of all variables in callback.

Synopsis

```
double[] getRelaxSol()
```

Return

LP-relaxation solution of all variables.

CallbackBase.getSolution()

Get solution of given variable in callback.

Synopsis

```
double getSolution(Var var)
```

Arguments

var: given variable.

Return

solution of given variable.

CallbackBase.getSolution()

Get solution of variables in callback.

Synopsis

```
double[] getSolution(VarArray vars)
```

Arguments

vars: an array of variables.

Return

solution of variables.

CallbackBase.getSolution()

Get solution of variables in callback.

Synopsis

```
double[] getSolution(Var[] vars)
```

Arguments

vars: an array of variables.

Return

solution of variables.

CallbackBase.getSolution()

Get solution of all variables in callback.

Synopsis

```
double[] getSolution()
```

Return

solution of all variables.

CallbackBase.interrupt()

Interrupt solving problems in callback

Synopsis

```
void interrupt()
```

CallbackBase.loadSolution()

Load customized solution to model.

Synopsis

```
double loadSolution()
```

Return

objective value of given solution.

CallbackBase.setSolution()

Set solution of a given variable in callback.

Synopsis

```
void setSolution(Var var, double val)
```

Arguments

var: a variable object.

val: double value.

CallbackBase.setSolution()

Set solution of variables in callback.

Synopsis

```
void setSolution(VarArray vars, double[] vals)
```

Arguments

vars: an array of variable objects.

vals: an array of double values.

CallbackBase.setSolution()

Set solution of variables in callback.

Synopsis

```
void setSolution(Var[] vars, double[] vals)
```

Arguments

vars: an array of variable objects.

vals: an array of double values.

CallbackBase.where()

Get context in callback.

Synopsis

```
int where()
```

Return

integer value of context.

25.2.52 ProbBuffer

Buffer object for COPT problem. ProbBuffer object holds the (MPS) problem in string format.

ProbBuffer.ProbBuffer()

Constructor of ProbBuffer object.

Synopsis

```
ProbBuffer(int sz)
```

Arguments

sz: initial size of the problem buffer.

ProbBuffer.getData()

Get string of problem in problem buffer.

Synopsis

```
String getData()
```

Return

string of problem in problem buffer.

ProbBuffer.resize()

Resize buffer to given size, and zero-ended.

Synopsis

```
void resize(int sz)
```

Arguments

sz: new buffer size.

ProbBuffer.size()

Get the size of problem buffer.

Synopsis

```
int size()
```

Return

size of problem buffer.

25.2.53 CoptException

Copt exception object.

CoptException.CoptException()

Constructor of coptexception.

Synopsis

```
CoptException(int code, String msg)
```

Arguments

code: error code for exception.

msg: error message for exception.

CoptException.getCode()

Get the error code associated with the exception.

Synopsis

```
int getCode()
```

Return

the error code.