COMSOL Server

Manual

COMSOL

COMSOL Server Manual

Version: COMSOL 6.0

Contact Information

Visit the Contact COMSOL page at www.comsol.com/contact to submit general inquiries or search for an address and phone number. You can also visit the Worldwide Sales Offices page at www.comsol.com/contact/offices for address and contact information.

If you need to contact Support, an online request form is located at the COMSOL Access page at www.comsol.com/support/case. Other useful links include:

- Support Center: www.comsol.com/support
- Product Download: www.comsol.com/product-download
- Product Updates: www.comsol.com/support/updates
- COMSOL Blog: www.comsol.com/blogs
- Discussion Forum: www.comsol.com/forum
- Events: www.comsol.com/events
- COMSOL Video Gallery: www.comsol.com/videos
- Support Knowledge Base: www.comsol.com/support/knowledgebase

Part number: CM010010

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Introduction

With a COMSOL Server™ license, a COMSOL Multiphysics® application can be run in major web browsers on platforms such as Windows®, macOS, iOS, Linux®, and Android™. In the Windows® operating system, you can also run COMSOL applications by connecting to a COMSOL Server with an easy-to-install COMSOL® Client, available for download from www.comsol.com. On Android™ devices, you can run COMSOL applications via the COMSOL Client for Android™ app on the Google Play™ store. COMSOL Server does not include the Application Builder, Physics Builder, and Model Builder tools that come with the COMSOL Desktop® environment.

A COMSOL runnable application is a COMSOL Multiphysics MPH-file that, in addition to the model part, includes a custom user interface that you can run as a separate application or in a web client. To create such applications, use the Application Builder, which is included in the Windows® version of COMSOL Multiphysics. For more information on how to build applications, refer to the *Introduction to Application Builder* and *Application Programming Guide*.

COMSOL Multiphysics and its add-on products are used to create an application. A license for the same add-on products is required to run the application from COMSOL Server. Users can run up to four concurrent applications through a single COMSOL Server license.

COMSOL Server is a multiuser service that can be run continuously on the host computer. It can be configured to start automatically upon booting. Optionally, COMSOL Server can be run on multiple computers to support more simultaneous users and concurrent applications than a single computer would support.

COMSOL Server contains administrative tools that allow you to create user accounts and user groups. You can also create user accounts based on a preexisting database of users on your system.

Additional resources, including video tutorials, are available online at www.comsol.com/video.

USERS AND ROLES IN COMSOL SERVER

Use the COMSOL Server web interface to assign usernames and passwords and to grant privileges. The *administrator* role can add and remove users as well as stop jobs. The *power user* is a moderator of a set of groups and the members therein. Those groups are selected by an administrator or created by the power

user. The *user* role is for running and uploading applications. The *guest* role is only for running applications.

ROLE	USER MANAGEMENT	UPLOAD APPS	RUN APPS	MONITOR APPS	CLOSE OTHER APPS	EDIT PREFERENCES
Administrator	Yes	Yes	Yes	Yes	Yes	Yes
Power user	Yes[a]	Yes	Yes	Yes	Moderated groups[b]	No[c]
User	No	Yes	Yes	No	No	No
Guest[d]	No	No	Yes	No	No	No

a. There is a global preference setting that determines if power users are allowed to create and remove users and groups. The power user may only remove users that are members of the power user's moderated groups. Power users can modify the launch-on-login setting for their moderated groups.

b. Power users can close apps started by users that are members of the power user's moderated groups.

c. Power users can by default view the preferences but not save them. There is a preference setting to hide the preferences for power users.

d. Guest cannot connect using API clients and cannot set a local password for external accounts.

There is also a group concept in COMSOL Server that you can use to manage groups of users. Use groups to grant access to different categories of applications that are relevant to that particular group.

COMSOL Server can maintain its own database of users and groups. You can also configure COMSOL Server to use the login mechanism of your operating system, such as Windows® Authentication or Lightweight Directory Access Protocol (LDAP).

Installing COMSOL Server

A COMSOL Server installation is similar to a COMSOL Multiphysics installation, the only difference being an additional step called **Server**.

For detailed information on installation, license files, and license management, see the *COMSOL Multiphysics Installation Guide*.

> Before starting COMSOL Server you need to start a license manager. For more information on the FlexNet® license manager, see the *COMSOL Multiphysics Installation Guide*. You can download the document from www.comsol.com/iog. The FlexNet® license manager is installed together with COMSOL Server. A license server is not needed when running a trial license.

The default COMSOL Server installation directory for each platform is as follows:

- Windows®: `C:\Program Files\COMSOL\COMSOL60\Server`
- Linux®: `/usr/local/comsol60/server`
- macOS: `/Applications/COMSOL60/Server`

For information about installing COMSOL Server for multiple computers and sharing the installation, see Running COMSOL Server on Multiple Computers.

Installing COMSOL Server in Windows

Start the installation by using the media that you have received or by using an Internet download. In the COMSOL installer, after selecting your preferred language, choose **New COMSOL 6.0 Installation**.

LICENSE

In the next step, **License**, you are prompted for a passcode or license file. COMSOL Server will only function with a license file (that you get from your COMSOL representative). You can also use the **Port number** and **Host Name** option or **Three-server redundancy**, if your license administrator has given you these details.

At this point, the COMSOL installer detects the type of license file used. The following instructions assume that the license file used during installation corresponds to a COMSOL Server license.

PRODUCTS

In the next step, **Products,** select the installation location and which software products and components you want to install. Licensed COMSOL products are selected by default. There are options to include application libraries and software components for the add-on products.

OPTIONS

In the **Options** step, you can choose to install Start menu shortcuts (Windows®
operating system only), install COMSOL Client, add Windows Firewall rules, install LiveLink™ for Excel® (only available if you have licensed LiveLink™ *for* Excel®)for all users, enable checking for updates after installation, and specify the location for a MATLAB® installation (only available if you have licensed LiveLink™ *for* MATLAB®). You can also select the type of installation from the **Select installation type** list: **Primary** (the default) or **Secondary**. When running COMSOL Server on multiple computers, the main server will be the *primary server* and the rest will be *secondary servers*. If not installing COMSOL Server to run on multiple computers, choose **Primary**. For information about installing COMSOL Server for multiple computers, see Running COMSOL Server on Multiple Computers.

LICENSE MANAGER

The **License Manager** page appears if the COMSOL Server Installer installed the FlexNet license manager and your computer has been designated to run the license server. If this page does not appear, you can manage the license server using LMTOOLS. This page contains the following options:

- The **Install license manager as a Windows service** check box is selected by default; if you clear the check box, the license manager will not be available as a Windows service.
- The **Path to the debug log file** field contains a file path to the location of the license manager debug log file (default: `C:\comsol.log`). Click **Browse** to browse to and choose another file path.
- The **Service name** field shows the service name, `LMCOMSOL`, for information only.

- Under **Additional license manager options**, you can select any of the following check boxes:
  - Select the **Allow the lmdown command to be executed only from this computer** check box to restrict the access to the `lmdown` command, which you can use to shut down the license manger, to this computer only.
  - Select the **Disable the lmdown command** check box to make the `lmdown` command unavailable.
  - Select the **Disable the lmremove command** check box to make the `lmremove` command, which you can use to remove a user's license, unavailable.

SERVER

The next **Server** step does not have any corresponding step in the COMSOL Multiphysics installer but is unique to a COMSOL Server installation. This step makes it possible to set up COMSOL Server as a Windows® service and enables you to configure an initial user database. The **Server** page in the COMSOL Installer includes the settings in the following sections.

Settings for Launching COMSOL Server

The basic setting is the **Default COMSOL Server port**, which is set to 2036. By default, COMSOL Server uses a range of ports from 2036 and above.

There are two different ways to install COMSOL Server in Windows®. If you select the **Install COMSOL Server as a Windows service** check box (the default), then COMSOL Server is installed as a Windows® service. Otherwise, COMSOL Server is installed as a regular executable. Use the **Startup** list to configure how to start COMSOL Server when installed as a Windows® service. Choose **Disabled**, **Manual**, **Automatic** (the default), or **Automatic (Delayed Start)**. With the default choice of **Automatic**, the installed COMSOL Server service is configured to start automatically when the host computer boots or restarts. This setting provides the highest availability to users of the installed server. With **Automatic (Delayed Start)** the service also starts automatically but delayed until all automatic-start threads have finished starting. If you select **Manual** or **Disabled**, the COMSOL Server service will not be started after the installation.

In the **Service account** list, by default, the installer provides the predefined **LocalService** service account. It is recommended that you use the LocalService account to run COMSOL Server service if you run COMSOL server on a single computer; it has sufficient but limited privileges intended for running local services. Alternatively another account with limited privileges can be used. You can choose the predefined **LocalService**, **LocalSystem**, and **NetworkService** accounts in Windows®, which have no password. When using other accounts, choose Custom and provide a username and password. Consult the documentation that came with the operating system for information about service accounts; for Windows®, see

also "The Services and Service Accounts Security Planning Guide"
(https://www.microsoft.com/en-us/download/details.aspx?id=5543)

> If you choose **Manual** or **Disabled** for the COMSOL Server service's
> **Startup** setting, you can enable or start the services from the command
> line or by using the **Manage local services** shortcut installed on the **Start**
> menu in Windows®. The same configuration options are also available in
> the snap-in **Services** in the **Microsoft Management Console** (search for
> services from the Windows® **Control Panel**).

Creating a Local Administrative User for COMSOL Server

Select the **Create default local administrative user** check box to create a default
username and a temporary password for an administrator account. You can use
that account to log in to the web interface after installation to perform
administrative tasks (after changing the temporary password). In addition to this
administrator, which is local to the COMSOL Server user database, you can add
administrator accounts to that user database using Windows authentication (see
below).

If you do not create a local administrator, you cannot log in using the COMSOL
Server web interface unless at least one user is configured with Windows®
Authentication or LDAP, for Linux® and macOS, holding the administrative role.

Support Running COMSOL Server on Multiple Computers

For information about the settings for running COMSOL Server in multiple
computers, see Running COMSOL Server on Multiple Computers.

Using Windows Authentication

Select **Use Windows authentication** to use Windows® authentication in addition to
the users from the local user database and the administrator you may have chosen
to provide in the settings above. Windows® authentication is only available when
you install COMSOL Server on a computer using the Windows® operating
system. Windows® authentication adds value when you can let your users log in
with their regular domain user accounts instead of having to create custom
COMSOL Server accounts for each user.

The text fields under **Windows authentication mapping** for **Administrators**, **Power
users**, **Users**, and **Guests** associate Windows® groups or built-in security principals,
separated by semicolons, with COMSOL Server roles for administrators, power
users, users, and guests, respectively. The defaults are
BUILTIN\Administrators, BUILTIN\Power Users, BUILTIN\Users, and
BUILTIN\Guests, respectively, which refer to users in such Windows® groups on
the computer where you install COMSOL Server. Click the corresponding **Check**

Names button to verify that the group names are valid. If you type only a name (`Guests`, for example), the installer finds its location and prepends it in the text field when you click **Check Names**. You can only map a specific Windows® group to a single COMSOL Server role.

> ⚠️ You must make sure the Windows® groups you associate with the roles exist in your Windows® installation, otherwise the mapping for the missing groups will not be in effect until they are created. If you leave one of the roles text fields empty, no user will be given this role.

See Configuring COMSOL Server for more information about Windows® authentication.

Using LDAP Authentication

LDAP configuration is required after the installation. See Configuring COMSOL Server.

Troubleshooting

When you click **Next** from the **Server** step, the installer will verify some of the given settings, including employing a test service to check that the given service account details are valid and that the service account has the right permissions to access the installation directories. The following are some common warning and error messages, and suggestions on how to fix them:

• *The given service account does not seem able to start services due to a logon failure. Please verify that it has the right to log on as a service.*
The installer failed to start the test service. To verify that a custom user account has the right to log on as a service you can check **Administrative Tools>Local Security Settings>Local Policies>User Rights Assignments>Log on as a Service** in Windows.

• *The given service account does not seem to have read and write access to the given shared working directory. Please verify that the permissions of the directory are correct and that the service account has access to this path.*
The test service failed to read and write to the shared directory entered for running COMSOL Server in multiple computers. Commonly this is caused by using a location that either has security permissions that don't include the service account, or by the location being on a network share that is not mounted by the service account. Typically it is easier to use a UNC path for the shared directory, for example, `\\myserver\myshare\v60server`, than to use a mounted drive, for example, `Z:\v60server`, since otherwise the

mount has to be configured for both the service account and the account used to run the installer.

- *The installation directory is not accessible. Please verify that the directory is correct and that the service account has access to this path.*
  The service launcher failed to locate the test service when starting it; that is, the service account either does not see that location or does not have read permissions. Common causes for this are similar to the above; that is, misconfigured security permissions or network drives are not being mounted.
- *The shared working directory is not accessible.*
  The installer could not write to the given shared working directory. Common causes for this are similar to the above; that is, misconfigured security permissions or network drives are not being mounted but for the user account running the installer. Note that under Windows, the elevated account running the installer does not automatically have access to mounted network shares for the unelevated user account.
- *The given service account is invalid or does not exist or the password is wrong.*
  The test service could not be installed or started due to a problem with the service account. Verify that the account details are correct.
- *Failed to verify the service account.*
  An unexpected error happened. If you believe that the installation settings are correct you can proceed with the installation. Further details are given in the `comsolsetup.log` file after the installation.
- *No administrative user has been defined.*
  In this configuration it will not be possible to log in as administrator. Either check the **Create default local administrative user check box**, or enable **Use Windows authentication** if available.

INSTALL

The **Install** step lets you monitor the installation progress.

If you install COMSOL Client along with COMSOL Server, a **COMSOL Client 6.0 Installer** window appears where you must accept the license agreement. It is possible to copy and paste the license agreement text if needed. You then also select the destination folder and installation options for COMSOL Client and finally install COMSOL Client.

FINISH

The last step **Finish** lets you view an installation log in the case there are warnings or errors.

Installing COMSOL Server in Linux and macOS

When installing in the Linux® and macOS operating systems the Server step contains the setting for a default administrative user account. See Starting COMSOL Server for more information about how to automatically launch COMSOL Server after installation on Linux® and macOS. You can also select to support running COMSOL Server on multiple computers (see Running COMSOL Server on Multiple Computers.

CREATING A LOCAL ADMINISTRATIVE USER FOR COMSOL SERVER

Select **Create a local administrative user for COMSOL Server** and provide a username and temporary password to create a default administrative account that is provided when COMSOL Server is started as a service.

If you do not create an administrator, you can start COMSOL Server as the user you intend COMSOL Server with and manually enter the password.

For security reasons, it is not recommended to use an account with administrative privileges to run COMSOL Server.

Modifying a COMSOL Server Installation

To modify an existing COMSOL Server installation — for example, to add or remove products or to change the port — follow these steps:

1 Stop COMSOL Server (as described under Starting COMSOL Server).
2 Start the installer (as described above) but choose **Add/Remove Products and Reinstall instead** of **New COMSOL 6.0 Installation**.
3 Specify the new configuration in the screens that follow, similarly as for a new installation.
4 When the installer has finished, start COMSOL Server again.

The new configuration will be written to the installation folder and will apply to the newly started COMSOL Server instance. Any existing users and uploaded applications will be retained.

Firewalls

You must open up firewalls that exist between the server and your users. Open up for incoming TCP connections to the port given during installation, by default 2036, or controlled by the `-serviceport` argument. To improve security, you may reduce the IP address range to known potential IP addresses for your users.

Internally COMSOL Server will launch sub-processes and communicate with them on a range of ports, by default starting from the COMSOL Server port and upwards, but configurable by the `-appserverport` argument. These additional ports do not need to be open in the firewall to users of COMSOL Server.

Starting COMSOL Server

Starting and Running COMSOL Server Locally in Windows

This section describes the steps that are necessary for starting and running COMSOL Server locally on a Windows® computer. These instructions apply if COMSOL Server will be used locally by a single user or if COMSOL Server will run on a computer that is not connected to a network.

For making COMSOL Server available to other users or for running in macOS or Linux®, see the subsequent sections.

When installing and running COMSOL Server locally according to the instructions below, you will be running as an administrative user.

Before starting COMSOL Server you need to start a license manager. For more information on the FlexNet® license manager and license files, see the *COMSOL Multiphysics Installation Guide*. You can download that document from www.comsol.com/iog. The FlexNet® license manager is installed together with COMSOL Server.

From the Start Menu, select **COMSOL Launchers>LMTOOLS**. This starts the license manager utility program.

In the first **Service/License File** page, select **Configuration using Services**.
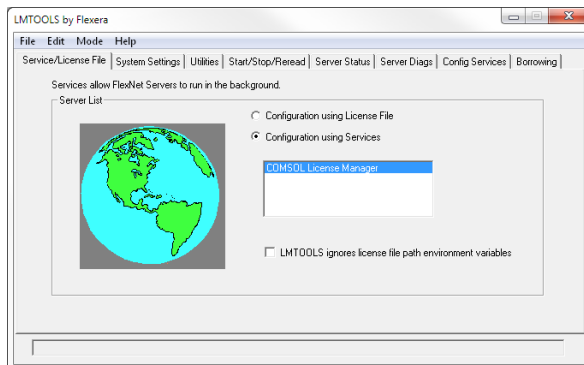
This setting allows the license manager to start automatically when your computer is rebooted.

Click the **Config Services** page.
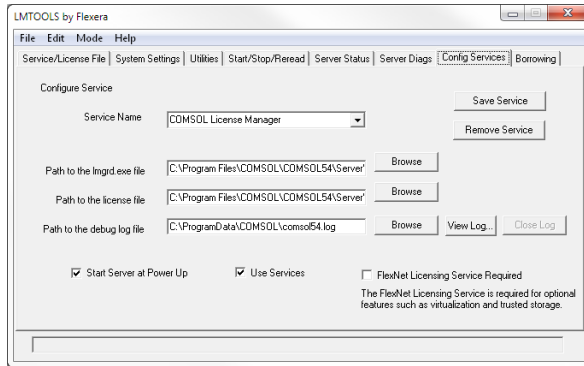
In this page you specify the path to:

- The license manager executable file `lmgrd.exe`
- The license file `license.dat`
- A debug log file

The license manager executable file and the license file are located in the installation directory. By default the locations are:

```
C:\Program Files\COMSOL\COMSOL60\Server\license\win64\lmgrd.exe
```

and

```
C:\Program Files\COMSOL\COMSOL60\Server\license\license.dat
```

respectively. Note that when browsing to the location of the license file you need to change the filter of the file browser from the default `.lic` to `.dat`, as shown in the figure below.
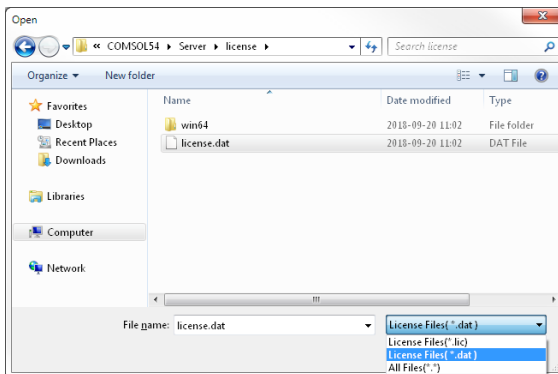
The license file is automatically copied to the license directory by the COMSOL Server installer. In addition, if the original license file given to you by your

COMSOL representative had a different name, it will automatically be changed to `license.dat`.

For the license manager to start automatically if your computer is rebooted, select the **Use Services** and **Start Server at Power Up** check boxes.

To save your settings, click **Save Service**.

The next step is to start the license manager. Go to the page **Start/Stop/Reread**. Click **Start Server**. (Server in this context refers to the license manager server software and not COMSOL Server.) If the license manager started successfully, a message **Server Start Successful** is displayed at the bottom of the window.

If the server failed to start, see the *COMSOL Multiphysics Installation Guide* for more information.
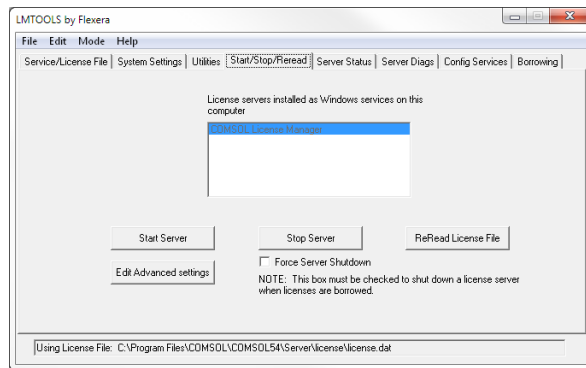
The next step is to start the COMSOL Server. From the Start menu, select **COMSOL Launchers>Start COMSOL Server**.

This will start COMSOL Server as a service, COMSOL Server 6.0 Service, which you can see in the Windows® Services window. In this case, port 2036 is used. If this port is not available, then the next available port will be used.

You can now log in to COMSOL Server from a web browser or COMSOL Client. Assuming you are logging in from a web browser, start your web browser and type `http://localhost:2036` in the address bar.

You are now prompted for the username and password that you specified during the installation. You can now continue reading the section Running Applications.

Starting COMSOL Server as a Windows Service

By default, COMSOL Server is installed as a Windows® service that is set to start automatically. In this case, a link to the COMSOL Server web interface is installed on the **Start** menu as **COMSOL Server**. See Logging in to COMSOL Server for more information about accessing the web interface.

To manually start or stop the COMSOL Server service, or to configure if it is started automatically, use the **Manage local services** shortcut installed on the **Start** menu. The same configuration options are also available in the snap-in **Services**, in the **Microsoft Management Console** (search for services from the Windows **Control Panel**).

⚠️ Before starting COMSOL Server you need to start a license manager. For more information on the FlexNet® license manager, see the *COMSOL Multiphysics Installation Guide*. You can download the document from www.comsol.com/iog. The FlexNet® license manager is installed together with COMSOL Server.

Starting COMSOL Server Manually in Windows

You can start COMSOL Server by using the shortcut installed on the **Start** menu as **COMSOL Server**, by double-clicking the Windows® executable in a file browser, or from the command window.

⚠️ When COMSOL Server has been installed as a Windows service, the shortcut for starting manually is not available on the **Start** menu. It is not recommended to start COMSOL Server manually when the service is running. Since the service runs under a special system user account, it does not share its application and user database with COMSOL Server started manually.

The COMSOL Server executable is located at:

```
<Installation directory>\bin\win64\comsolserver.exe
```

An example of a typical `<Installation directory>` is:

```
C:\Program Files\COMSOL\COMSOL60\Server\bin\win64
```

To start COMSOL Server from a command window, type

```
<Installation directory>\bin\win64\comsolserver.exe
```

For both methods of starting COMSOL Server, the command window displays a short message that COMSOL Server has started and which port number is used.

In case the default port number 2036 is busy, subsequent port numbers are searched until a free port number has been found (or you can set the port number manually).

If there is no default administrative account, you are prompted for an initial administrator when starting COMSOL Server for the first time from your current user account. You can use the administrator account to add users with the COMSOL Server web interface at `http://localhost:2036` (assuming that port number 2036 is free).

When additional users log in to COMSOL Server, information on which port numbers are used is displayed in the command window.

Once started, see Logging in to COMSOL Server for how to access the COMSOL Server web interface.

Starting COMSOL Server in Linux

To start COMSOL Server manually, type

```
<Server installation>/bin/comsol server
```

If there is no default administrative account, you are prompted for an initial administrator when starting COMSOL Server for the first time from your current user account. You can use the administrator account to add users with the COMSOL Server web interface at `http://localhost:2036` (assuming that port number 2036 is free).

To stop COMSOL Server, type `close` in the terminal window where it was started. If COMSOL Server was started with `-silent`, in which case it does not listen to input from the terminal, you can stop it by typing Ctrl+C in the terminal window to send SIGINT to the process or run `kill <pid>`, where `<pid>` is the process ID of the COMSOL Server process to send SIGTERM to the process, both of which will cleanly shut it down.

SYSTEMD SERVICE

Use the following instructions to start COMSOL Server in a Linux version that includes `systemd`:

Create a file `/usr/lib/systemd/system/comsolserver60.service` with content similar to:

```
[Unit]
Description=COMSOL Server 6.0
Wants=network.target network-online.target
After=network.target network-online.target

[Service]
Type=forking
User=comsoluser
Group=comsolgroup
TimeoutSec=300
ProtectHome=off
ExecStart=/usr/local/comsol60/server/bin/comsol service

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

You only need to replace the values for `User` and `Group`. Then run:

```
systemctl enable /usr/lib/systemd/system/comsolserver60.service
```

to activate the service and

```
systemctl start comsolserver60
```

to start it.

To stop the COMSOL Server service cleanly, run `systemctl stop comsolserver60`.

BOOT SCRIPT

This section is applicable for older Linux versions that do not include `systemd`. For COMSOL Server to start automatically at boot up, you need to add Bourne shell commands to the appropriate boot script. You must be a superuser (root) to edit boot scripts.

> ⚠ For security reasons, it is recommended that the daemons are not started as a user with administrative privileges. Instead, use a dedicated username to start the license manager.

Add the following text to the end of the file `rc.local` in the `/etc` directory of your Linux® system:

```
FP=<Server installation>
MYUSER=username
if [ -x $FP/bin/comsol ]; then
    su $MYUSER -c "umask 022; $FP/bin/comsol server -silent -login never" &
fi
```

Replace the installation directory with your actual installation directory, and `username` with the username that you want to have to run the service.

> ⚠️ You should not use the root user or another user with system access. Create a special user for COMSOL Server with limited system access.

To stop the COMSOL Server service, run `kill <pid>`, where `<pid>` is the process ID of the COMSOL Server process to send SIGTERM to the process, which will cleanly shut it down.

Starting COMSOL Server in macOS

To start COMSOL Server manually, type
  `<Installation directory>/bin/comsol server`
If there is no default administrative account, you are prompted for an initial administrator when starting COMSOL Server for the first time from your current user account. You can use the administrator account to add users with the COMSOL Server web interface on `http://localhost:2036`.
To stop COMSOL Server, type `close` in the terminal window where it was started.

Logging in to COMSOL Server

In a web browser, go to `http://localhost:2036` (if you are accessing it remotely, use the computer name — computer name and domain, or the local IP address — of your server instead of localhost). If the port number 2036 is taken, then COMSOL Server will use the next available port number: 2136, 2236, and so on. Log in to COMSOL Server with your username and password.

Press return or click **Log in to COMSOL Server**.

The **Remember me** check box determines if the login session survives closing and reopening the browser. If this box is not checked, you have to log in again in every new browser session.

If you log in for the first time, you must also read the COMSOL Software License Agreement and click **Accept** to enter the COMSOL Server web interface. A user only needs to accept the license agreement once.

If you have specified a temporary password, you must change that temporary password to a new password.

After changing the password, you must log in again using the new password.

After five failed consecutive attempts to log in to COMSOL Server using the web interface, you will be locked out for five minutes before you can log in again.

You can log out from COMSOL Server by clicking **Log Out** in the upper-right corner of the COMSOL Server web interface.

As an alternative to logging in from a web browser, you can log in from the COMSOL Client for Windows®. For more information see Running Applications in the COMSOL Client for Windows.

COMSOL Server Administration

Overview

COMSOL Server can be managed through its web interface. Log in using an administrator username and password. Once logged in, you have access to an **Administration** section in the web interface with windows for **Monitor**, **User Database**, **Preferences**, **Appearance**, and **Login Configuration**. An administrator can also control, through preference settings, if power users can view preferences and create users and groups.

Users cannot access the Administration tools; guests cannot access the Administration tools and cannot upload applications. Power users can, depending on the preference settings, access all or parts of the Administration tools.

You can filter the applications by favorite status, application visibility (Public, All groups, Private), or by individual groups (see Searching, Sorting and Filtering Applications).

See also Setting Up COMSOL Server for Secure Connections.

At the bottom of the web interface, you can click **About COMSOL Server™** window to view some general information about COMSOL Server. From that window, click **Licensed and Used Products** to view a list of licensed products and their use.

In the **Preferences** settings, you can place the responsibility for authenticating users external to COMSOL Server by activating the L**og in users automatically without requiring passwords** check box. These users are referred to as automatic users.

Monitor

On the **Monitor** page you find information including the local IP address; OS and architecture; the start time and uptime; and CPU and memory use. There is also an overview of the running application sessions with the session ID; application; user; start time, runtime, and idle time; and memory and CPU usage. Click the column header for a session property to sort the application sessions alphabetically based on that property. Click **Close** to stop a session.

In the upper-right corner, you can click **Servers** for monitoring server processes, or click **Sessions** for monitoring application sessions.

For **Servers**, the **Monitor** page shows monitoring data for all COMSOL Server processes (primary and secondary server processes) as well as the application server processes running on these COMSOL Servers. The application server processes include both processes that currently are running application sessions, as well as application server processes that are prelaunched. An administrator or power user can choose to either end an application server process (physically stop the process) or, if applicable, close the application session using the process. In the latter case, the process is freed to be reused by another application session. To do so, click the **X** under **End**. A **Close Session or End Process** dialog box then opens.

Selecting the **Show all processes** check box enables the display of prelaunched application processes in the list of **Processes**. A prelaunched application process is used to speed up the launch of new applications and does not check out any COMSOL Server license.

You can hide parts of the information on the **Monitor** page using two buttons in the upper-right part of the page:

- Click the **Hide system information** button to only show CPU usage and free memory instead of the full information under **System information**.
- Click the **Hide processes** button to hide the information under **Processes**.

For **Sessions**, the **Monitor** page shows monitoring data for all currently running application sessions. The information shown here is the same as that which can be shown for running applications in the Application Library. Similar to the **Servers** display, administrators and power users can close application sessions for users by clicking the **X** under **Close**, which opens a **Close Sessions** dialog box.

User Database

On the **User Database** page, you can add users and groups to the server's user database. You can also send notifications. See Adding and Editing Users and Groups

> ⚠️ If, for example, a new user logs in, you need to click refresh in browser to update the **User Database** page.

Preferences

On the **Preferences** page you access server administrative preferences and settings. Administrators and, depending on the preference settings, power users have access to the **Preferences** page, but only administrators can change preference settings. At the bottom of the COMSOL Server window, click **Save** to store the changes to the preferences. You can also click **Revert to Saved** to restore the settings to those that were most recently saved. If you have unsaved changes to preferences settings, those settings appear with a red asterisk. To restore the original preference settings, click **Factory Settings**.

IMPORTING AND EXPORTING PREFERENCES

You can export and import the preference settings. The exported preferences are automatically migrated to the current version on import. To export the current preferences, click **Export** to export the current preference settings to `comsol-server.prefs` file. Click **Import** to import preference settings from a `.prefs` file.

GENERAL

Under **General**, you can control the following settings:

- Choose the language to use for COMSOL Server from the **Language** list. COMSOL Server supports the same languages as the COMSOL Desktop user interface.
- Choose a web rendering type from the **Web rendering** list: **WebGL**™ (the default) or **Images from server**. WebGL is a standard for interactive 3D and 2D graphics in web browsers. The option **Images from server** is used for browsers that do not support WebGL. It renders by generating images instead of offering interactive graphics. The COMSOL Client for the Windows® operating system provides the same interactive graphics rendering options as the COMSOL Desktop user interface: OpenGL, DirectX, and Software. These options are chosen from the COMSOL Desktop Startup menu icons.

In addition, the settings in the following tables are available:

SESSIONS

The table below summarizes the settings in the **Sessions** section.

SETTING	DEFAULT	DESCRIPTION
Max number of concurrent applications per user	4	The maximum number of concurrently running applications per user.
Idle timeout (s)	0	The maximum idle time in seconds before idle applications are closed. This option makes it possible to reduce resources and licenses required on the server. The default (0) is an infinite timeout time.
Runtime timeout (s)	0	The maximum total elapsed time in seconds before running applications are closed. This option makes it possible to reduce resources and licenses required on the server. The default (0) is an infinite timeout time.
Username for license checkout	From operating system	Controls what username is logged for checking out licenses when running applications. Select *From operating system* to use the name of the user account used to launch COMSOL Server. Select *From COMSOL Server* to use the name of the COMSOL Server account, which can make it easier to track license usage among users.
Default action on close	Leave running	Determines what happens to a running application when a user exits the application. Can either be *Leave running* or *Shut down*.
Show side menu for applications	On	Enable or disable the side menu that is available when running applications in a web browser.

PROCESSES

To allow faster launching of applications, application processes are prelaunched and reused on the server. Additionally, a number of applications are preloaded in these processes. The following table summarizes the settings in the **Processes** section.

SETTING	DEFAULT	DESCRIPTION
With secondary servers connected, launch processes on	Only secondary servers	Choose to launch application processes on only secondary servers or on both primary and secondary servers.
Enable prelaunching and reuse of processes	On	The default setting allow for a specified number of processes that can be used for prelaunching and reuse. Choose Off to disable prelaunching and reuse of application processes. The following three settings apply when this option is set to On.
Minimum number of processes	1	The minimum number of processes to prelaunch and reuse.
Maximum number of processes	4	The maximum number of processes to prelaunch and reuse.
Process keep alive timeout (s)	0	The time (in seconds) that a process should be kept alive when they are not claimed by an application session. The default (0) means that the processes will never be shut down.
Under Preloaded Applications:		
Recently run	1	This setting allows an administrator to manually set the number of prelaunched application processes that should be available for launching applications.
Preloaded applications	No selected application.	Select the applications to be preloaded. The selected applications are explicitly preloaded. If there is overlap with the most recently run applications, the overlapping applications are still only loaded once.

A guideline for choosing these values is that the **Minimum number of processes** value should correspond to the expected number of applications being started simultaneously in a narrow time span, while the **Maximum number of processes** value should correspond to the expected median number of applications that will run simultaneously at any point in time. You can also set a **Process keep alive timeout**, after which prelaunched processes in excess of the minimum number of processes are shut down by COMSOL Server if they are not claimed by an application session before that timeout is reached. When secondary servers are connected, the settings for number of processes are counted per server. For

example, if you have 4 secondary servers you by default get a minimum of 4 prelaunched processes in total, or 5 processes if set to launch processes on **Both primary and secondary servers**.

EMAIL

In the **Email** section you can define the settings for sending emails from applications and notifications:

SETTING	DESCRIPTION
Host	The email server's host name.
Port	The port number (default: 25).
Connection security	Use no connection security (None; the default), or use an encrypted connection for emails sent from applications by selecting STARTTLS or TLS/SSL.
User	The user account for logging in to the email server, if required by the server.
Password	Password for the user account, if required by the server.
From address	The sender's email address for emails sent from applications.

PERMISSIONS

In this section, and administrator can control the following permission rights: Select or clear the **Allow Power users to create and delete users and groups** and **Allow Power users to view preferences** check boxes to control or restrict the access for power users to these administrative tools. By default, these check boxes are selected. Also, select the **Allow Users and Guests to view license information** check box to allow uses and guests to click **Licensed and Used Products** in the **About COMSOL Server™** window and view a list of licensed products and their use on the **Licensed and Used Products** page.

AUTOMATIC LOGIN

In this section you can place the responsibility for authenticating users external to COMSOL Server by activating the **Log in users automatically without requiring passwords** check box. These users are referred to as automatic users.

There are several options available in the **Username** list to pass the username of the automatic user to COMSOL Server. These options are summarized in the following table.

SETTING	DESCRIPTION
Anonymous	A random username will be generated. Since the username is randomly generated, an anonymous user cannot continue using the same session after they log out. All running applications will be shutdown.
IP address	The IP address of the users machine will be used.
Hostname	The hostname of the users machine will be used.
HTTP cookie	The username will be taken from a named cookie provided outside of COMSOL Server.
HTTP header	The username will be taken from a HTTP header provided outside of COMSOL Server.

The last two username methods, HTTP cookie and HTTP header, require additional steps by the COMSOL Server administrator. COMSOL Server only looks for this information and does not provide a way to generate it. For example, if HTTP cookie is used and there is no cookie set by the system administrator, the automatic login functionality will not be activated, and users will have to log in as normal.

The **Role** setting allows you to assign a role to users that log onto COMSOL Server automatically.

A username provided by the automatic login functionality cannot be the same as an existing local user. In this case, the option to log in automatically will not be available.

It may be useful to set the idle time out for application sessions when automatic login is enabled as it is less likely that users will explicitly log out of their sessions. See Sample Configurations for Single Sign On for an example of how reverse proxies can be configured for single sign on.

REMEMBER ME

In this section you can control if users have the ability to log in using a persistent cookie by checking the **Remember me** check box on the login page. If the **Show "Remember me" check box on the login form** check box is unchecked, all user are logged in with non-persistent session cookies; that is, they need to log in again if

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they close the browser window. The lifetime of the persistent session cookies is controlled by the **Timeout (days)** option.

ERROR MESSAGES

The default license error message, shown when there are not enough seats available to run an application, can be overridden with a custom error message. This can be useful when the details of the license handling should not be exposed to the users of the COMSOL Server instance or if you want to direct them to a specific contact. To add a custom error message, select the **Use custom license error message** check box and enter the message in the **Error message** field.

FILES

The table below summarizes the settings in the **Files** section..

SETTING	DESCRIPTION
Folder for uploaded applications	Folders for MPH-files. COMSOL Server needs to be restarted before changing the folder path takes any effect. (`-appdir`)
Folder for user files (user:///)	Folders for files referred to in MPH-files. (`-userdir`)
Folder for common files (common:///)	Common storage area for files created by applications. (`-commondir`)
Folder for temporary files (temp:///)	Storage area for temporary files created by applications. (`-tempdir`)
Application upload max file size in MB	The largest size of any application that can be uploaded (in MB). The default is 4096 MB.

The locations specified here only apply to the primary server. When running on multiple computers, it's not recommended to modify the locations in the preferences, but rather use the corresponding command line arguments indicated above.

SECURITY

The following security settings are available on the **Preferences** page in the COMSOL Server web interface when you are logged in as an administrator. (The corresponding settings in COMSOL Multiphysics can be found on the **Security** page in the **Preferences** dialog box, which you open from the COMSOL Desktop.)

• Select the **Allow batch jobs** check box to allow applications to run detachable batch jobs. These are separate COMSOL Server processes where the

simulation is stored on file when the computation is finished. This functionality is used in the Batch, Batch Sweep, Cluster Computing, and Cluster Sweep nodes in the COMSOL Desktop model tree.

- Select **Allow external processes** to allow applications to start external processes on the computer hosting COMSOL Server. This includes using the built-in `executeOS()` method. The security settings do not extend to methods used to access the model object.

- Select **Allow external libraries** to allow external C libraries to be called from methods in an application.

- Select **Allow external MATLAB**® **functions** to allow MATLAB® functions to be called from methods in an application.

Under **Methods and Java libraries**:

- The **Enforce security restrictions** check box is selected by default. If selected, this check box enforces the following restrictions on methods and Java libraries:

  - Select the **Allow access to system properties** check box to read and write values to system properties such as `System.getProperty("cs.np")` which can be used to determine the number of cores that COMSOL Server currently uses.

  - Select the **Allow changes to the runtime system** check box to allow methods and Java libraries to change the runtime system — for instance, by modifying class loaders.

  - From the **File system access** list, select **Temporary and application files** (the default) to restrict methods and Java libraries to only have access to such files, or select **All files** to allow methods and Java libraries to access all files that the account used to start the COMSOL Server service (default: LocalService) has permissions to access on the file system.

  - Select the **Allow access to network sockets** check box to allow methods and Java libraries to open sockets for network access.

  - Select the **Allow control of the network authentication method** check box to allow methods and Java libraries to control the network authentication method used.

  - Select the **Allow access to classes through reflection** check box to allow access to all members in a class through reflection.

  - Select the **Allow access to runtime security settings** check box to allow methods and Java libraries to access security settings.

All check boxes above are cleared by default, enforcing those security restrictions.

RECOVERY FOR APPLICATION BUILDER

The table below summarizes the settings in the **Recovery for Application Builder** section.

SETTING	DEFAULT	DESCRIPTION
Save recovery file	Off	Determines if launched applications should be configured to automatically use recovery files. This means that failed applications can be recovered by accessing these files.
Folder for recovery files	HOME\.comsol\ v60server\recoveries	Common storage area for recovery files.

Click **Save** to store the updated preference settings.

MULTICORE

The table below summarizes the settings in the **Multicore** section.

SETTING	DEFAULT	DESCRIPTION
Number of cores	Auto	Determines if the number of cores assigned to each application is determined automatically (Auto) or by manual input (Manual). The automatic number of cores is balanced for allowing four apps to run at the same time on each server.
Manual	All cores	Number of cores assigned to each application in the manual case. The default number is 1.

Adjust the **Number of cores** setting accordingly with respect to expected number of concurrent users, concurrently running applications, and the number of cores on the computer hosting COMSOL Server.

CLUSTER

The cluster computing preference settings are the same as the ones on the **Multicore and Cluster Computing** preferences page in COMSOL Multiphysics. See the *COMSOL Multiphysics Reference Manual* for more information. The settings here apply whenever a cluster feature is set to **Preferences controlled**.

REMOTE COMPUTING

The remote computing preference settings are the same as the ones on the **Remote Computing** preferences page in COMSOL Multiphysics. See the *COMSOL Multiphysics Reference Manual* for more information.

RUN APPLICATION ON LOGIN

In the **Run application on login** section, select the application to run from the **Application** list. The default is **None** (no application is launched and run). If an application is selected here, it is automatically started when a non-administrative user logs in. Only administrators and power users can the see the full Application Library.

APPLICATION LIBRARY

In this section you can specify which applications that appear and what application information to show.

Clear the **Show demo application** check box to remove the demo applications from the Application Library window.

Select the **Hide application properties** check box for guests so that guest can run applications but not view their properties.

Under **Running Applications**, you can control which application information to show. You can select and sort the properties by dragging and dropping properties or using the buttons: up arrow to move a property up; down arrow to move a property down; minus sign to remove a property from the application information; and plus sign to add a removed property. The first five of the selected properties appear directly on the application information cards; the rest are included in the properties and description information.

Clear the **Show progress** check box if you do not want progress information to appear.

Appearance

On the **Appearance** page you access settings for the look and feel of COMSOL Server. Available customizations include colors, logos, login screen content, and custom HTML. Administrators and, depending on the preference settings, power users have access the **Appearance** page, but only administrators can change the settings. At the bottom of the COMSOL Server window, click **Save** to store the changes to the appearance; click **Factory Settings** to restore the settings to the ones used when starting COMSOL Server the first time; or click **Revert to Saved** to restore the appearance settings from the most recently saved version.

GENERAL

Select an overall color scheme for the COMSOL Server user interface from the **Color scheme** list: **Default**, **Light**, or **Dark**.

Under **Top Bar, Login Button, and Divider,** you can specify the colors to use for those user interface components on the login screen and the main COMSOL Server user interface. Specify a hexadecimal RGB value (0–255) or click the color picker to specify the colors to use for the primary color, accent color, and text color.

IMAGES

Here you can add images files for the following images:

• **Header image** in the COMSOL Server user interface. This image or logo will appear on the top bar. Because it will be displayed above your primary color, an image with a transparent background is recommended. The image format can be .png or .gif, the maximum dimension is 250x40 pixels, and the file size must be smaller than 500 KB.

• **Default application thumbnail** for applications. This image will be used for uploaded applications without a thumbnail defined during their creation. The image format can be .png or .gif, and the file size must be smaller than 500 KB.

• **Favicon** (shortcut icon or website icon) for your installation of COMSOL Server. This image appears in the user's browser tab. This image must be an .ico file with a size of 16x16 pixels.

In all cases, click **Browse** to locate and choose an image to use.

LOGIN PAGE

Here you can specify the contents and look of the login page.

From the **Login screen content** list, choose **Image only** (the default), **Text only**, or **Image and text**.

For the image, click **Browse** under **Login screen image** to choose another image than the default COMSOL Server image.

For the text, enter a text to display on the login screen in the **Text** field. Any URLs in the text, e.g. `https://example.com/toc`, are made into links on the login screen, and double line breaks can be used to divide the text into paragraph.

For all content types, choose a style for the divider from the **Divider** list: Pulse (the default) or one of the other available divider styles. Also, if desired, use another text for the login button. In the **Login button text** field, Log in to COMSOL Server appears by default.

CUSTOM HTML

In this section you can add custom HTML to the following parts of the COMSOL Server screen HTML:

- In the **End of <head>** field, add HTML code to appear at the end of the `<head>` section.
- In the **Beginning of <body>** field, add HTML code to appear at the start of the `<body>` section.
- In the **End of <body>** field, add HTML code to appear at the end of the `<body>` section.

Login Configuration

On the **Login Configuration** page you can view, edit, and test the login configuration used by COMSOL Server.

To edit the configuration, click the **Custom** button in the **Login configuration** section. Example template login configurations can be shown by clicking **Show Configuration Templates** below the configuration text area.

See the sections on Configuring Windows Authentication and Configuring Active Directory or LDAP for more information about the login configuration syntax.

TESTING THE LOGIN CONFIGURATION

The login configuration can be tested by entering user credentials into the **Test Configuration With Credentials** section and clicking the **Test Authentication** button.

If the login configuration is valid and the user details supplied can be successfully authenticated, you will see a notice stating what role that the user was assigned. If the user has been mapped to any groups in the **Configuration Text** area, they will be listed under the **External Groups** section that then appears. If you require more informative output, click the **Verbose** check box. The additional sections **Debug Output** and **All Authenticated Principals** will be displayed.

If there was a problem with the configuration or the user was not authenticated, appropriate information and error messages will be displayed.

The following table summarizes the various output sections.

SECTION	DESCRIPTION
External Groups	Lists the groups the user has been mapped to by the login configuration.
Debug Output (verbose only)	Additional and verbose information is output from most login configuration modules. This output is displayed here.
All Authenticated Principals (verbose only)	Principals returned by the login modules used in the configuration are listed here.

SAVING THE LOGIN CONFIGURATION

To save the login configuration, click the **Save** button on bottom of the COMSOL Server window. You can also click **Revert to Saved** to restore the settings to those that were most recently saved. If you have unsaved changes, those settings appear with a red asterisk. To restore the original settings, click **Factory Settings**.

Users that are currently logged in can continue to use COMSOL Server. However, any login attempts after saving the configuration will be authenticated against the new login configuration. It is not required to restart COMSOL Server for the saved login configuration to take effect.

Application Usage

On the **Application Usage** page you can view a log of all finished application sessions that have been run on the server. You can also download a copy of the whole log as a comma separate values file or a file that can be opened as a spreadsheet. For a detailed list of the information available in this log, see Logs of Application Usage.

COMSOL Server Commands

The general syntax of the COMSOL commands is

```
<command> [<target>] [<options>] [<target arguments>]
```

where square brackets indicate optional arguments. The main command to start COMSOL Server is `comsolserver` (Windows) or `comsol server` (Linux and Mac).

OPTIONS

You can enter various options after the COMSOL Server command and target. The table below lists the options (See [`<options>`] in the command syntax) available for the `comsol server` command. Always issue these options between the command and the target (if any).

COMSOL SERVER OPTIONS (CURLY BRACKETS INDICATE DEFAULT VALUES)

COMSOL SERVER OPTION	DESCRIPTION
`-np` *<no. of processors>*	Number of processors.
`-ipv6`	Activate IPv6 support.
`-c` *<path>*	License file path.
`-prefsdir` *<path>*	Preference directory.
`-tmpdir` *<path>*	Temporary file directory.
`-autosave {on}|off`	Control saving of recovery files.
`-recoverydir` *<path>*	Path to recovery directories.
`-comsolinifile`	Specify custom path to .ini-file used when starting COMSOL Server.
`-forcegcc`	Force load of GCC libraries (Linux).
`-forcecomsolgcc`	Force load of GCC libraries shipped with COMSOL (Linux).

For the `-tmpdir` option, the COMSOL software uses the specified directory to store temporary files. By default, the system temporary directory is used. It is currently not recommended to run cleanup scripts in the temporary directory based only on creation date, as that could remove temporary files that were created when COMSOL Server and its application processes were launched but that are still required.

Running Applications

COMSOL applications can be run by connecting to COMSOL Server from a web browser, or from a COMSOL Client for Windows®. The COMSOL Client for Windows® allows a user to run applications that require a LiveLink™ product for CAD, as described in Running Applications in the COMSOL Client for Windows. In addition, the COMSOL Client for Windows® supports interactive graphics in 1D, 2D, and 3D.

Running applications in a web browser does not require any installation and no web browser plug-ins are needed. Running an application in a web browser supports interactive graphics in 3D using WebGL™ technology. However, selecting objects in graphics using mouse clicks in not supported when running in a web browser.

After launching an application in the Application Library, it will become available under **Running Applications** and can be reconnected to, even if the original browser tab or COMSOL Client window housing the application has been closed. To shut down the running application, click its close button in the Application Library or use the side menu available in the top-right corner if running in a web browser. Administrators can shut down applications from the **Monitor** page.

You can create shortcuts to quickly access the most used applications from your desktop. First, open up an application's detailed view by clicking on its name or image. From there, you have the option to create a shortcut link that opens the application, either in COMSOL Client or in your browser.

Logs of Application Usage

COMSOL Server provides a text-based log file that lists application usage information and that can be imported into, for example, Microsoft® Excel® for further processing. After an application has been stopped, a line with information is appended to a log file, `app_usage.log`, that is created in the `.comsol\v60server\statistics` directory.

The following information is included for each application run under the following labels:

- **Username**: the username
- **Server**: the server name
- **Application**: the name of the application

- **Application filename**: the filename for the application
- **Start time**: the time when the application was started
- **End time**: the time when the application was stopped
- **Session time**: the session time (wall clock)
- **CPU time**: the CPU time (process time)
- **Number of cores**: The number of cores used

The log can also be downloaded from the administrative Application Usage web page.

Running Applications in a Web Browser

Using a web browser you can point directly to the computer name and port number of a COMSOL Server web interface — for example, `http://abc.mycorp.com:2036`. You need to provide a username and password to log in using the web interface.

When logged in, the **Application Library** page displays a list of applications to run. If logged in as user or guest, the Administration options, in the panel to the left, are not visible.

Click **Run in browser** to run an application in a web browser. Applications are run in separate tabs in the browser.

You can also click the down arrow in the lower-right corner to choose **Run in COMSOL Client**, to run the application using COMSOL Client instead.

Users can upload applications and determine which groups have access. Guests can only run applications.

In the **Application Library**, when you have running applications, you can click **Grid View** and **List View** in the upper-right corner to display the running application as a grid with information about each running application or as a list of running applications.

The information for an application is extended with live data for the running application sessions. An administrator can select the type of live data shown for a running application as well as the order in which they appear, by choosing from the following predefined information items: **Session time**, **Connected in**, **Idle time**, **Process CPU**, **Start time**, **CPU time**, **Physical memory**, and **Virtual memory**. At most five of the selected items are shown directly on the running applications in this view.

An administrator can also select to display a progress bar showing the completed percentage of an on-going computation. The selection and sorting of items is done on the **Preference** page under **Application Library**.

Click on the application icon or name to show a description and some general information about that application. For a running application, all the available data information appears.

In the information display, under **Products used**, you find the COMSOL products used to create and run the application. From this display, you can also launch the application and create a shortcut for running the application in a browser or using COMSOL Client.

Click the **Add to Favorites** button (star) to add that application as a favorite application. You can filter the list of applications in the Application Library to only include favorite applications. For an application already marked as a favorite, click the star next to the application under **Favorites** to remove it from the set of favorite applications.

SIDE MENU FOR APPLICATIONS

When running applications in a web browser, users can access some actions directly by pointing to the top-right corner.

The following options are available, depending on the preference settings for reconnecting to running applications and launching applications on login:

- **Close Session**: Close the application and navigate to the Application Library, if **Run application on login** is set to **None**, or just close the application, if **Run application on login** is active (an application is selected from the **Application** list).

- **Disconnect from Application**: Leave the application running, so that it is possible to reconnect to it later. The web browser tab is closed if possible.

- **Notifications**: To access any notifications that have been published.

- **Log Out**: Leave the application running and log off the current user, or close the application and log off the current user, if **Run application on login** is active (an application is selected from the **Application** list) or if **Default action on close** is set to **Shut down** in the **Preferences** settings.

UPLOADING AND EDITING APPLICATIONS

As a user or administrator, you can expand the Application Library by uploading applications (MPH-files). Click **Upload**, in the panel to the left, to open the **Upload Application** dialog box.

Drag and drop application files to upload, or click **Choose applications** to browse and select the applications to upload. Then select an option under **Visibility**: **Public**, **Group**, or **Private** (the default). A public application is available to all users.

An application with a group visibility is available to members of the groups that you select under **Groups**. A private application is available only to the user who uploads it.

Click **Upload** to upload the selected applications. The uploaded application gets an orange border to identify that it has recently been uploaded.

To edit user applications (demo applications cannot be edited), click the application icon and then click the **Edit** button in the lower-left corner of the information window to open the **Edit Application** dialog box.

You can change the title, description, and thumbnail of the application, if desired. You can also change its visibility.

This dialog box contains a **Delete** button to delete the application from the Application Library, a **Replace** button to replace the original application with the updated application, and a **Save** button to save any new settings. Click the Restore button to restore the title, description, and thumbnail to those in the original application.

SEARCHING, SORTING AND FILTERING APPLICATIONS

The menu at the top of the Application Library window contains options for sorting and filtering the applications:

- In the search field to the left, type a search string to show only applications with matching titles. The search is done word by word, for example `tun for` will match the **Tuning Fork** application.
- From the **Filter** list, choose **All** (the default); **Favorites**; or one of **Public**, **All groups**, or **Private**, or any available group.
- From the **Sort By** list, choose to sort the applications by **Name** (alphabetically), which is the default, **Date uploaded**, or **Author**. The **Ascending** and **Descending** options determine the sort order.

CHANGING PASSWORD

Under **Your Settings** in the menu to the left, click **Change Password** to open a **Change Password** dialog box where you can change the password used to log in to COMSOL Server.

CHANGING DEFAULT EMAIL ADDRESS

Under **Your Settings** in the menu to the left, click **Change Default Email** to open a **Change Default Email** dialog box where you can change the default email address that is used for notifications and applications that send email.

LIMITATIONS WHEN RUNNING APPLICATIONS IN WEB BROWSERS

When you create applications for running in a web browser, make sure you use the grid layout mode in the Application Builder. This will ensure that the user interface layout adapts to the size and aspect ratio of the browser window. For low-resolution displays, make sure to test the user interface layout in the target platform to check that all form objects are visible. Applications that contain resizable graphics forms may not fit in low-resolution displays. In such cases, use graphics with fixed width and height to make sure all form objects fit in the target browser window.

When running in a web browser, the interactive selection of domains, boundaries, edges, and points is not supported. The LiveLink™ products for CAD software packages are not supported when running in a web browser.

When running COMSOL applications in web browsers for smartphones and certain tablets, not all functionality is supported. Typical limitations include the ability to play sounds or open documents. In addition, file upload and download may not be supported.

Running Applications in the COMSOL Client for Windows

As an alternative to using a web browser for running applications, the COMSOL Client for Windows® can be used to connect to COMSOL Server and run applications natively in the Windows® operating system. This typically gives better graphics performance and supports interactive graphics in 1D, 2D, and 3D. In addition, the COMSOL Client for Windows® allows applications that require a LiveLink™ product for CAD, as listed below.

You can install the COMSOL Client together with COMSOL Server. You can also download the COMSOL Client from www.comsol.com/client-download as `COMSOL60_client_win64.exe`.

Double-click the download file to start the COMSOL Client installer

In the next few steps of the installer, accept the license agreement and choose the installation folder. In the step **Select Installation Options** you select options for the installation.

The following LiveLink™ products are available in the COMSOL Client:

- LiveLink™ *for* AutoCAD®
- LiveLink™ *for* Excel®
- LiveLink™ *for* Inventor® (One Window interface not available)
- LiveLink™ *for* PTC® Creo® Parametric™
- LiveLink™ *for* PTC® Pro/ENGINEER®
- LiveLink™ *for* Revit®
- LiveLink™ *for* Solid Edge®
- LiveLink™ *for* SOLIDWORKS® (One Window interface not available)

Once installed, double-click the Desktop or use the **Start** menu icon to start.

There are three **Start** menu options depending on the graphics renderer you want to use: **DirectX**, **OpenGL**, and **Software**. When clicking the Desktop icon, the default **OpenGL** renderer will be used. If the **OpenGL** renderer fails to function properly — for example, due to limitations in the graphics card — then the COMSOL Client shuts down. The next time you start the COMSOL Client, **Software** rendering will be used as a fallback renderer. The **OpenGL** and **DirectX** options use hardware graphics acceleration and give higher performance on supported graphics cards.

The installation options also let you associate the MPH-file type with the COMSOL Client installation.

Before you can use the COMSOL Client to run applications, you must log in to the COMSOL Server web interface with a valid username and password.

Logging in from the COMSOL Client displays a COMSOL Server web interface identical to that seen when logging in from a web browser. Using the COMSOL Client, applications run as native Windows® applications in separate windows that have a Windows® look-and-feel. For example, applications run in the COMSOL Client may have a Windows® specific ribbon with tabs. When run in a web browser, ribbons are represented by a toolbar.

You can launch an application directly in the COMSOL Client through the COMSOL Server interface in a web browser by clicking the menu at the lower-right side of the application in the Application Library and selecting **Run in COMSOL Client**. In this case, the user and server details are already filled in.

For more information on running applications, see Running Applications in a Web Browser.

Running Applications that use LiveLink Products

Most of the LiveLink™ products can be used in applications run with COMSOL Server. However, in some cases the functionality is limited compared to running with a COMSOL Multiphysics license that includes the COMSOL Desktop. Depending on the LiveLink product, software components are installed with the COMSOL Client or COMSOL Server. The table below summarizes where the software components are installed and which functionality is available.

LIVELINK PRODUCT	LOCATION OF SOFTWARE COMPONENTS	FUNCTIONALITY
LiveLink™ *for* MATLAB®	Server	Support within applications is limited to function calls from the Global Definitions node in the model tree, which can be used only when accessing an application in a web browser. LiveLink™ for MATLAB® also supports connecting from MATLAB® to COMSOL Server using the COMSOL API.
LiveLink™ *for* Excel®	Client	Loading and saving files are supported.
LiveLink™ *for* SOLIDWORKS®	Client	Same as COMSOL Desktop, with the exception that the One Window interface is not supported. Not supported when running applications in a web browser.
LiveLink™ *for* Inventor®	Client	Same as COMSOL Desktop, with the exception that the One Window interface is not supported. Not supported when running applications in a web browser.
LiveLink™ *for* AutoCAD®	Client	Same as COMSOL Desktop. Not supported when running applications in a web browser.
LiveLink™ *for* Revit®	Client	Same as COMSOL Desktop. Not supported when running applications in a web browser.

LIVELINK PRODUCT	LOCATION OF SOFTWARE COMPONENTS	FUNCTIONALITY
LiveLink™ *for* PTC® Creo® Parametric™	Client	Same as COMSOL Desktop. Not supported when running applications in a web browser.
LiveLink™ *for* PTC® Pro/ENGINEER®	Client	Same as COMSOL Desktop. Not supported when running applications in a web browser.
LiveLink™ *for* Solid Edge®	Client	Same as COMSOL Desktop. Not supported when running applications in a web browser.

Running COMSOL Server on Multiple Computers

Running COMSOL Server on multiple computers allows for supporting more simultaneous users and concurrent applications than a single computer would support. The main COMSOL Server instance is called Primary and the rest are called Secondary. The Primary server is used for all incoming connections — for example, to show the web interface or to run applications in a web browser or with COMSOL Client. The actual work of running the applications is offloaded to the Secondary server computers (you can also specify it as a preference and run applications on the primary sever; see Processes).

A prerequisite for running COMSOL Server on multiple computers is that there is a Shared working directory on the network that is accessible by all Primary and Secondary servers. The user account that is used to run the COMSOL Server instances should have read and write access to this directory. See Setting up a Shared Working Directory for information about how to do this using the Windows operating system, and refer to other documentation sources for sharing a directory on Linux or macOS.

Installing COMSOL Server on Multiple Computers

The installation of COMSOL Server on multiple computers is similar to a regular COMSOL Server installation. You first install the Primary COMSOL Server on one computer and then install Secondary COMSOL Servers on the other computers. During the installation you point out a Shared working directory on the network that must be accessible for COMSOL Server on all of the installed computers.

Optionally it is possible to share a common installation folder on the network for all computers running COMSOL Server, both Primary and Secondary. See the Sharing a COMSOL Server Installation for more information.

Installing the Primary COMSOL Server

On the **Options** page of the installer, choose **Primary**. On the **Server** page of the installer, select the **Support running COMSOL Server on multiple computers** check box and browse to your **Shared working directory**. The subdirectory `v60server` will be appended to the working directory path to keep different versions of COMSOL Server apart. Under **Primary server hostname**, the installer fills in a guess for the hostname that the Secondary servers should use to contact the Primary server. This should be a valid hostname that resolves to the primary computer's IP address.

When installing the primary COMSOL Server as a Windows service, the service account must be able to access the shared working directory on the network. For this reason, the default **Service account** changes from **LocalService** to **NetworkService** when you select the **Support running COMSOL Server on multiple computers** check box on the **Server** page. The NetworkService account presents itself as the computer's credential on the network, allowing it to access network shares without a regular user account.

> ⚠️ If installing COMSOL Server as a Windows service on a computer that is not joined to a domain, the NetworkService account cannot be used because computer credentials are not valid on work group networks. A local user account should be entered instead in the **Service account** field.

Installing the Secondary COMSOL Server

On the **Options** page of the installer, choose **Secondary**. On the **Server** page of the installer, browse to your **Shared working directory** under **Secondary COMSOL Server settings** to automatically load the settings used during the primary installation for the **Primary server hostname** and **Primary server port** fields. If the loaded settings are not correct you can edit them before continuing, for example if the secondary server would have to use a different hostname to reach the primary server.

The path to the **Shared working directory** does not necessarily have to be identical for the primary and secondary installation, as long as it points to the same directory on all installations. For example, the path could be written as `\\ServerName\shared\v60server` on Windows and `/mnt/servername/shared/v60server` on Linux.

Starting COMSOL Server on Multiple Computers

The primary COMSOL Server is started similarly to a regular COMSOL Server installation, either automatically or manually, which is described in Starting COMSOL Server. Once the primary COMSOL Server has started, you can log in with an administrative user and check on the **Monitor** page that the secondary COMSOL Servers have connected.

Secondary COMSOL Servers are also started similarly to a regular COMSOL Server installation. Once the secondary COMSOL Servers are started they periodically try to connect to the primary COMSOL Server. This means that the starting order of the primary and secondary COMSOL Servers is not important

Setting up a Shared Working Directory

SHARING A DIRECTORY IN WINDOWS

The following steps provide a basic procedure for setting up a Shared working directory in Windows® for installing COMSOL Server on multiple computers:

1 Create a new folder in a convenient location on the computer that should host the share. For performance reasons, we recommend using a shared working directory located on the same computer as the primary server.

2 Right-click the folder and choose **Share with>Specific people**.

3 Type `Everyone` and click **Add**.

4 Change **Read** to **Read/Write** next to `Everyone`.

5 Click **Share**.

6 Note the network path to the shared folder (for example, `\\ServerName\shared`). This is what you will use during the installation.

Note that this procedure will give anyone on the network access to the share. Once you know which user accounts and server computers that need to access the share it is recommended to limit the access to those. Exactly how the shares should be set up depends on for which user account COMSOL Server has been installed. The default on Windows is the `NetworkService` user in the multiple computer case. This is a special account with limited capabilities, which presents itself as the computer on the network, not any specific user. In this case, the shares can be secured as follows:

1 Right-click the shared folder and choose **Properties**, then switch to the **Security** tab.

2 Click **Edit**, make sure `Everyone` is selected and click the **Remove** button to remove access to everyone.

3 Click **Add**, then **Object Types** and make sure **Computers** is selected in the list.

4 Click **OK** and type a semicolon-separated list of all the computers where COMSOL Server runs under the `NetworkService` account. (Alternatively, if `NetworkService` has not been used, enter the accounts that COMSOL Server runs under.)

5 Click **OK** and verify that the entries are added to the list.

6 Select the new entries and select the **Full control** check box (under **Allow**) for each one.

7 Click **OK** and **Close**.

Network administrators can also make use of groups to more easily manage access to the shared directory.

SHARING A DIRECTORY IN LINUX OR MAC

Consult the documentation that came with the operating system for information about sharing directories on the network.

Sharing a COMSOL Server Installation

As an alternative to installing the secondary COMSOL Servers separately on each computer, it is possible to launch the secondary COMSOL Server processes from the primary installation directory. To do this, first make sure that the computers that should run the secondary COMSOL Servers have read access to the primary installation directory over the network. Then use the procedure described in the following subsections to launch the secondary COMSOL Server.

When secondary COMSOL Servers are launched from the primary installation directory, their settings are read from a separate set of secondary `.ini` files, which are created during the primary installation. This is similar to the automatic loading of settings from the **Shared working directory** during a separate secondary installation. Network-wise, the primary and secondary computers must be able to connect to each other both through the main port of the COMSOL Server (default: 2036) and through the temporary ports used for running applications, which are in a range from port 2036 to at most port 10406. If the main port is

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changed to a lower value (for example, port 80), the range of temporary ports remains, whereas if the main port is increased above 2036, the range of temporary ports is translated. The easiest way to set up the network is to put all computers running COMSOL Server on a common network behind any firewall. To the outside, the firewall only needs the main port of the COMSOL Server to be open.

LAUNCHING THROUGH A SHORTCUT IN WINDOWS

On the computer that should run the secondary COMSOL Server, do the following:

1 Navigate to the primary installation directory (for example, `\\ServerName\installation\COMSOL60\Server\bin\win64`).

2 Right-click `comsolserver.exe` and choose **Create Shortcut**. Accept to have it on the desktop because you cannot write to the installation directory.

3 Locate the new shortcut, right-click, and open the **Properties**. Add `-secondary` to the end of the **Target** field.

4 Double-click the shortcut to launch the secondary COMSOL Server.

INSTALLING AS A SERVICE IN WINDOWS

On the computer that should run the secondary COMSOL Server, do the following:

1 Open an administrative console (Windows-key + type `cmd` + right-click it and choose **Run as Administrator**).

2 Enter the following command (notice that the spaces after, but not before, the equal signs are mandatory; adapt the network path to match your installation):

```
sc create "COMSOLSecondaryService" binpath=
\\ServerName\installation\COMSOL60\Server\bin\win64\
comsolservicesecondary.exe
obj= "NT AUTHORITY\NetworkService" password= "" start= auto
```

3 The service is now installed. Enter this command to start it:

```
sc start "COMSOLSecondaryService"
```

LAUNCHING ON LINUX AND MAC

Use the procedure described in Starting COMSOL Server but append the `-secondary` flag to the command.

Configuring COMSOL Server

To operate COMSOL Server, you must set up user authentication (password validation) and authorization (groups and roles) for your users.

One administrator account can be added during installation. You can also create an administrator after installation using `comsolserver.exe` in the Windows® operating system or `comsol server` in the macOS and Linux® operating systems.

COMSOL Server can maintain its own local user database. This is the easiest way to set up the server. In addition, you can use your operating system's user authentication method.

Using the authentication method of your operating system is supported when accessing COMSOL Server from a web browser or from COMSOL Client over a secure connection.

Configuring a Local User Database

Using the COMSOL Server installer, you can set up an initial administrator account. When no administrator account has been set up for COMSOL Server, the initial administrator account is created the first time it is started.

You can add more users to the local user database as soon as COMSOL Server is started. These users are automatically added to the local user database of your COMSOL Server installation.

In a web browser, go to `http://localhost:2036` (if you are accessing it remotely, use the computer name — computer name and domain, or the local IP address — of your server instead of localhost). If the port number 2036 is taken, then COMSOL Server will use the next available port number: 2136, 2236, and so on. Log in to COMSOL Server with your username and password.

Press return or click **Log in to COMSOL Server**. If you log in for the first time, you must also read the COMSOL Software License Agreement and click **Accept** to enter the COMSOL Server web interface.

You can log out from COMSOL Server by clicking **Logout** in the upper-right corner of the COMSOL Server web interface.

ADDING AND EDITING USERS AND GROUPS

When you run COMSOL Server as administrator or power user, you have access to a **User Database** page under **Administration** in the menu on the left side of the COMSOL Server web interface.

From this page, you can manage users and groups for running and accessing applications. Under **Users**, you see all users with their username, role, groups they belong to, and status (if the user is logged in or not). Click a column header for a user property to sort the users in alphabetical order based on that property. Click the **Edit User** button (the pen icon) to open an **Edit User** dialog box for a user, where you can change the password, role, and which groups the user moderates (power users only) and belongs to.

Click **Save** to store the new user properties. You can also click **Log Out User** to log out a user that is currently logged in, or click **Delete** to remove a user from the list.

Adding a New User

To add a new user, click the **Add New User** button.

In the **New User** dialog box, specify the **Username** and **Password** (you need to confirm the password in the **Repeat password** field). Under **Role**, click **Administrator**, **Power user**, **User** (the default), or **Guest**, depending on the role that you want the user to have (see Users and Roles in COMSOL Server). If you are logged in as a power user, you can only add users and guests. Under **Groups**, select the check boxes for the available groups that you want the new user to belong to. Finally, click **Save** to store the new user and its properties. The new user then appears in the list under **Users**.

Adding Groups

You can use groups to ensure that users assigned to the same group can view and run the same applications. Available groups appear on the **User Database** page under **Groups**. To add a new group, click the **Add New Group** button.

In the **New Group** dialog box, enter a **Group name**. You can also specify an application to run when logging in as a member of this group. Such a setting, if chosen, overrides the global preference for which application to run. From the Run application on login list, choose **Use global preference (None)**, **Disable for this group**, or choose any of the available applications listed below. Click **Save** to add the new group. The added group then appears in the list under **Groups**.

You can control the visibility of the applications so that they are available only for users within a certain group (or groups). Click on a group to open a dialog box

where you can change the setting for running an application on login. You can also click **Delete** to remove that group.

Notifying Users

Administrators and power users can send notifications to users. On the **User Database** page, you can click **Notify Users** at the bottom of the list of users, for sending messages to all users, and there is a **Notify User** button next to each user's name in the list, to send a message to that user.

Administrators can notify users as a direct message, send messages to specific groups, and send a message to all users. Power users can send direct messages to users in groups they moderate and to all group members of groups that they moderate.

Add the message in the **Summary** and **Description** fields.

The notifications can be set to expire in the **Number of days until notifications expires** field.

Select the **Show notifications of screen** check box to show the notification on the COMSOL Server screen after you have clicked **Publish**.

Select the **Also send notifications as email** check box to send the notifications via email to all uses with a default email address. This option is only available when sending emails has been configured in the **Preferences**.

Click **Show History** to see previously published notifications. Such notifications can be deleted or republished.

Users who are not logged in and new accounts will see notifications sent to their group, direct messages, and message to all users the next time they log on (as long as the notification has not expired).

Only notifications set to show on screen are shown in the native COMSOL Client. Such notifications are shown in a dialog window — one for each received notification.

Configuring Windows Authentication

In addition to the local user database, the COMSOL Server installer for the Windows® operating system makes it possible to use Windows® authentication. To determine which Windows users are allowed to log in, and which COMSOL Server roles they should have, you set up a mapping between Windows® groups and COMSOL Server roles. The easiest way to do this is to set the proper groups

during the installation. You can also later edit the configuration using the **Login Configuration** page.

The default login configuration for Windows® authentication looks like this:

```
ComsolServerLogin {
waffle.jaas.WindowsLoginModule optional
                  principalFormat=both
                        roleFormat=fqn;
com.comsol.jaas.ComsolServiceLoginModule optional
  authenticate=true
  "BUILTIN\\Administrators"=ComsolServerAdministrator
          "BUILTIN\\Users"=ComsolServerUser
                "Everyone"=ComsolServerGuest;


};
```

The lines

```
  "BUILTIN\\Administrators"=ComsolServerAdministrator
          "BUILTIN\\Users"=ComsolServerUser
                "Everyone"=ComsolServerGuest;
```

map the Windows® groups `Administrators`, `Users`, and `Everyone` to the role identifiers. The available role identifiers are `ComsolServerAdministrator`, `ComsolServerPowerUser`, `ComsolServerUser`, and `ComsolServerGuest`, corresponding to the COMSOL Server roles administrator, power user, user, and guest, respectively.

You can also use this syntax to map Windows® groups to COMSOL Server groups, for example to map `COMPANY\Engineering Department` to the `Engineering` group:

```
  "COMPANY\\Engineering Department"=Engineering;
```

Note the escaping of \ as \\ and the quotation marks needed for groups with spaces in the name. There must not be any space before or after the = sign.

For the details about settings in the configuration file, see the section Advanced Login Configuration in this chapter.

Finally, use administration tools in Windows® to set up users and groups. For example, use the Control Panel and the User Accounts settings in the control panel.

> ⚠️ Using the authentication method of your Windows® operating system is supported when accessing COMSOL Server from a web browser or from COMSOL Client over a secure connection.

Configuring Active Directory or LDAP

In addition to the local user database and to the Windows Authentication available on the Windows® operating system, it is possible to use a Windows® Active Directory® or LDAP server to authenticate users. This means that you can use your Active Directory® or LDAP usernames and passwords to log in to COMSOL Server. Use the **Login Configuration** page to edit and test the configuration.

There is a sample configuration for Active Directory® authentication:

```
ComsolServerLogin {
    com.sun.security.auth.module.LdapLoginModule OPTIONAL
    userProvider="ldap://ldap.example.com:3268/DC=example,DC=com"
    authIdentity="{USERNAME}@example.com"
    userFilter="(&(sAMAccountName={USERNAME})(objectclass=user))"
    authzIdentity="{MEMBEROF}"
    useSSL=false;
    com.comsol.jaas.ComsolServiceLoginModule OPTIONAL
    authenticate=true;
};
```

And similarly a sample configuration for OpenLDAP:

```
ComsolServerLogin {
} com.sun.security.auth.module.LdapLoginModule REQUIRED
    userProvider="ldap://ldap.example.com/ou=People,dc=example"
    userFilter="(&(uid={USERNAME})(objectClass=inetOrgPerson))"
    authzIdentity="{MAIL}"
    useSSL=false;
    com.comsol.jaas.ComsolServiceLoginModule required
    authenticate=false;
};
```

You need to replace `ldap.example.com`, `example`, and `com` with the name of your Active Directory® or LDAP server and `DC=example`, `DC=com` with the settings of your Active Directory® or LDAP server, respectively.

You should also add one or more statements to the configuration for the `ComsolServiceLoginModule` to map users the roles. The simplest is to use the special `everyone` mapping:

```
everyone=ComsolServerUser
```

This will map any user that could be authenticated within the given `userFilter` to the given role (in this case **User**). A recommendation is to use the program **Apache Directory Studio** to look at the LDAP objects and learn how to configure the filter to select which users should be allowed access.

You can also use the attribute given in `authzIdentity` for mapping rules. Then the syntax for the mapping rule is `value=role`, where value is the value of the LDAP attribute and role is e.g. `ComsolServerUser`. Note that only the first value

encountered for the LDAP attribute is used, so, for example, the MEMBEROF attribute can only be used to map the first LDAP group assigned to a user.

The LDAP login module that COMSOL Server uses does not allow direct mappings from Active Directory groups to COMSOL Server roles.

For the details about settings in the configuration file, see the section Advanced Login Configuration in this chapter.

> Active Directory® and LDAP authentication is supported when accessing COMSOL Server from a web browser or from COMSOL Client over a secure connection.

Advanced Login Configuration

COMSOL Server uses the pluggable authentication mechanisms of JAAS (Java® Authentication and Authorization Services). Using JAAS configuration files you can configure to use Windows® authentication and LDAP authentication. You can also combine local database users and operating system users by merging configurations.

> Using the operating system authentication method is supported when accessing COMSOL Server from a web browser or from COMSOL Client over a secure connection.

LOGIN MODULE CONFIGURATION

Use the **Login Configuration** page to edit and test login module configuration.

COMSOL LOGIN MODULE

Configurable login modules are used to achieve the desired mechanism, and you can combine multiple modules in an authentication and authorization chain.

A local user database is used by the default JAAS configuration for both authentication (password validation) and authorization (groups and roles). A local user account with administrative privileges can be created during the installation process to allow subsequent login. It is also possible to configure COMSOL Server to allow logins using nonlocal accounts optionally with a mapping from nonlocal to local groups and roles as a part of the installation process.

The `COMSOLServiceLoginModule` can be used to perform authentication and authorization of users based on the local user database or to perform mapping of nonlocal to local roles and groups. This login module is what gives all authenticated users the principal *Authenticated*, which gives access to the COMSOL Server web interface, so it must always be present.

COMSOLServiceLoginModule Configuration Options

OPTION	VALUES	DESCRIPTION
debug	true/false	Debug information will be printed to the console. (This is automatically applied for the **Verbose** mode of the **Login Configuration** page.)
authenticate	true/false	Determines if the module is used for authentication or only for mapping of roles and groups.
<non-local-principal>	<local-principal>	Any number of mappings from nonlocal role and group names to local; note that multiple nonlocal roles and groups can map to the same local roles or groups but there can be only one mapping per nonlocal role or group. Multiple roles or groups should be separated by commas, in which case the whole value must be enclosed in quotation marks ("). The special non-local-principal name "everyone" (lowercase) can be used for mapping roles and groups to all authenticated users.

> ⚠️ Other login modules: Any JAAS-compliant login modules can be used as a part of the authentication sequence, but configuration sometimes requires detailed knowledge about the authentication server setup and IT system administrator skills.

JAAS CONFIGURATION FILE SYNTAX

The configuration file is a text file with an arbitrary name and extension containing any number of entries of the form

```
COMSOLServerLogin {
  LoginModuleClassName <behavior>
  <option1> = <value1>
  <option2> = <value2>;
}
```

`LoginModuleClassName` is the full name of a class implementing the `LoginModule` interface, and in addition to those provided in the Java distribution

(like `com.sun.security.auth.module.LdapLoginModule`), COMSOL Server provides `com.comsol.jaas.ComsolServiceLoginModule`.

For integrated Windows® authentication the `waffle.jaas.WindowsLoginModule` is also included in the installation.

The `<behavior>` can be one of the following keywords:

- `required` — must authenticate the user
- `requisite` — no subsequent login modules will run if this fails
- `sufficient` — continues to run the other login modules in the list on failure
- `optional` — at least one optional module must succeed if all are optional

The `<option>` is one of the valid options for the login module, and `<value>` is a valid selection for this option. The configuration entry for one login module is terminated by a semicolon, after which any number of additional login module configuration entries can appear. However, there can be only one configuration entry per login module.

A configuration example for integrated Windows® authentication:

```
ComsolServerLogin {
  waffle.jaas.WindowsLoginModule required
  principalFormat=both
  roleFormat=fqn;
  com.comsol.jaas.ComsolServiceLoginModule required
  authenticate=false
  "BUILTIN\\Administrators"=ComsolServerAdministrator
  "BUILTIN\\Users"=ComsolServerUser
  "Everyone"=ComsolServerGuest;
};
```

In this case, the user must be authenticated by the `waffle.jaas.WindowsLoginModule`, and the `com.comsol.jaas.ComsolServiceLoginModule` performs a mapping of groups from the Windows® account to COMSOL Server roles without authenticating the user.

The following is a configuration example using either the LDAP interface of an Active Directory server for authentication or the COMSOL Server local user database:

```
ComsolServerLogin {
  com.sun.security.auth.module.LdapLoginModule optional
  userProvider="ldap://ldap.example.com:3268/DC=example,DC=com"
  authIdentity="{USERNAME}@example.com"
  userFilter="(&(sAMAccountName={USERNAME})(objectclass=user))"
  authzIdentity="{MEMBEROF}"
  useSSL=false;
  com.comsol.jaas.ComsolServiceLoginModule optional
```

```
      authenticate=true
      examplegroup=ComsolServerAdministrator
      everyone=ComsolServerGuest
      ;
   };
```

If login is successful with the `LdapLoginModule`, the users belonging to the group `examplegroup` get the `ComsolServerAdministrator` role and everyone else gets the `ComsolServerGuest` role.

If login is successful with the `ComsolServiceLoginModule`, only the local user database is used to assign roles to the user.

Running COMSOL Server Behind a Reverse Proxy

In some cases it is advantageous to use a reverse proxy server as an intermediary between COMSOL Server and its users. Use cases of a reverse proxy server include:

• Providing many web services with the same host name, for example serving COMSOL Server from `http://example.com/comsolserver` and another web mail server at `http://example.com/webmail`.

• Offloading SSL encryption onto the reverse proxy server, either for using hardware-accelerated encryption or simply to not have to configure encryption for each web service separately.

• Firewall features that protect the web service from attacks.

To support serving COMSOL Server at the path `/comsolserver` (as in the example above), the reverse proxy must be configured as follows:

1 Pass any regular HTTP requests to `http://example.com/comsolserver/foo` on to the primary COMSOL Server as, for example, `http://comsolserver.com:2036/foo`.

2 Correctly forward web socket requests (RFC 6455) in the same way as HTTP requests.

It is not necessary to let the reverse proxy server adjust the Location, Content-Location, and URI headers for redirected responses, since COMSOL Server responds with relative URI paths even for redirects. It should also normally not be necessary to adjust any proxy timeouts, since COMSOL Server periodically sends some bytes on open network connections to keep them alive.

Sample Configuration for NGINX

The following configuration directives allow for running COMSOL Server behind
the NGINX reverse proxy server:

```
map $http_upgrade $connection_upgrade {
default upgrade;
  ''      close;
}

client_max_body_size 0;

server {
  listen      80;
  server_name  example.com;

  location /comsolserver {
    if ($request_uri ~ "^/comsolserver(/.*)$") {
      proxy_pass http://127.0.0.1:2036$1;
      break;
    }
    rewrite (.*) $1/ permanent; # add missing slash

    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection $connection_upgrade;
  }
}
```

To enable SSL encryption (that is, `https://example.com/comsolserver`), a
redirect should be added to another entry for the secure port:

```
server {
listen      80;
  server_name  example.com;

  location /comsolserver {
    return 301 https://$host$request_uri;
  }
}

server {
  listen      443;
  server_name example.com;

  ssl on;
  ... # SSL settings

  location /comsolserver {
    if ($request_uri ~ "^/comsolserver(/.*)$") {
      proxy_pass http://127.0.0.1:2036$1;
      break;
    }
    rewrite (.*) $1/ permanent; # add missing slash
```

```
    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection $connection_upgrade;
}
```

In both of the above examples, 127.0.0.1:2036 is the IP address and port of the primary COMSOL Server installation.

SAMPLE CONFIGURATION FOR APACHE MOD_PROXY

The following configuration directives allow for running COMSOL Server behind an Apache mod_proxy reverse proxy server:

```
<VirtualHost *:80>
RewriteEngine On

  RewriteCond %{HTTP:Connection} Upgrade [NC]
  RewriteCond %{HTTP:Upgrade} websocket [NC]
  RewriteRule ^/comsolserver/(.*) ws://127.0.0.1:2036/$1 [P]

  RewriteRule ^/comsolserver$ /comsolserver/ [R=301]

  ProxyPass /comsolserver/ http://127.0.0.1:2036/ nocanon
</VirtualHost>
```

To enable SSL encryption (that is, https://example.com/comsolserver), a redirect should be added to another entry for the secure port:

```
<VirtualHost *:80>
RewriteEngine On
  RewriteRule ^/comsolserver(.*) https://%{SERVER_NAME}/comsolserver$1
[R=301]
</VirtualHost>

<VirtualHost *:443>
  RewriteEngine On

  RewriteCond %{HTTP:Connection} Upgrade [NC]
  RewriteCond %{HTTP:Upgrade} websocket [NC]
  RewriteRule ^/comsolserver/(.*) ws://127.0.0.1:2036/$1 [P]

  RewriteRule ^/comsolserver$ https://%{SERVER_NAME}/comsolserver/ [R=301]

  ProxyPass /comsolserver/ http://127.0.0.1:2036/ nocanon
</VirtualHost>
```

In both of the above examples, 127.0.0.1:2036 is the IP address and port of the primary COMSOL Server installation.

The modules mod_proxy, mod_proxy_http, and mod_proxy_wstunnel must be loaded by the Apache configuration.

SAMPLE CONFIGURATIONS FOR SINGLE SIGN ON

This is an example of how to configure reverse proxies for single sign on for Apache `mod_proxy` with `mod_authnz_sspi` on Windows:

```
# For Windows, a single child process hosts all threads.
# Increase the number of threads to support more concurrently
# running apps. Each app uses about 2-16 threads, depending
# on the number of graphics windows in the app.
ThreadsPerChild 1024

<VirtualHost *:80>
  RewriteEngine On
  RewriteCond %{HTTP:Connection} Upgrade [NC]
  RewriteCond %{HTTP:Upgrade} websocket [NC]
  RewriteRule ^/comsolserver/(.*) ws://127.0.0.1:2036/$1 [P]
  RewriteRule ^/comsolserver$ /comsolserver/ [R=301]
  ProxyPass /comsolserver/ http://127.0.0.1:2036/ nocanon

  <If "%{HTTP:Connection} != 'Upgrade' && %{HTTP:Upgrade} != 'websocket'">
    AuthName "COMSOL Server"
    AuthType SSPI
    SSPIAuth On
    <RequireAll>
      Require valid-user
      Require not user "NT AUTHORITY\\ANONYMOUS LOGON"
    </RequireAll>

    RequestHeader set cs_auto_auth %{REMOTE_USER}s
  </If>
</VirtualHost>
```

This is an example of how to configure reverse proxies for single sign on for Apache `mod_auth_kerb` on Linux:

```
<VirtualHost *:80>
  RewriteEngine On
  RewriteCond %{HTTP:Connection} Upgrade [NC]
  RewriteCond %{HTTP:Upgrade} websocket [NC]
  RewriteRule ^/comsolserver/(.*) ws://127.0.0.1:2036/$1 [P]
  RewriteRule ^/comsolserver$ /comsolserver/ [R=301]
  ProxyPass /comsolserver/ http://127.0.0.1:2036/ nocanon

  <If "%{HTTP:Connection} != 'Upgrade' && %{HTTP:Upgrade} != 'websocket'">
    AuthName "COMSOL Server"
    AuthType Kerberos
    Krb5Keytab /path/to/krb5/keytab #apache needs permissions to read this
file
    KrbAuthRealm example.com
    KrbMethodK5Passwd off
    KrbLocalUserMapping off #Set to on to strip the realm from the usernames
    KrbServiceName Any
    <RequireAll>
      Require valid-user
```

```
      Require not user "NT AUTHORITY\\ANONYMOUS LOGON"
    </RequireAll>
    RequestHeader set cs_auto_auth expr=%{REMOTE_USER}s
  </If>
</VirtualHost>
```

Setting Up COMSOL Server for Secure Connections

There are two ways to set up COMSOL Server for secure connections:

- Use a reverse proxy with SSL configured. Then no particular configuration of COMSOL Server itself is required. The communication between the reverse proxy server and COMSOL Server will not be encrypted. See Running COMSOL Server Behind a Reverse Proxy for more information.
- Configure COMSOL Server to use a server certificate, as described below.

CONFIGURING A SERVER CERTIFICATE

COMSOL Server can be configured to use a server certificate from a keystore file with a password through the `-keystorefile`, `-keystorepass`, `-keypass`, and `-keyalias` command line switches. The default keystore file location is `{COMSOL60}/bin/tomcat/conf/keystore.jks` (where in the following `{COMSOL60}` refers to the version 6.0 installation directory), the default password is `changeit` (both for the store and the key), and the default key alias is `COMSOLServer`. If the keystore file is successfully loaded, web browsers are automatically redirected to use a HTTPS connection and COMSOL Client can connect with the Encryption check box selected. The port used for HTTPS can be configured with the `-sslport` command line switch.

CREATING A SELF-SIGNED CERTIFICATE

To create a self-signed certificate on your computer, start a command window and run

```
keytool -genkey -alias COMSOLServer -keypass <password> -storepass
<password> -dname "cn=<ServerHostName>, ou=<Org>, o=<Unit>,
c=<CountryCode>" -ext SAN=dns:<ServerHostName> -keyalg RSA -keystore
{COMSOL60}/bin/tomcat/conf/keystore.jks
```

after having replaced the `<*>` entries with the information and the passwords that you want to use. A copy of the keytool command is available in `{COMSOL60}/java/[architecture]/jre/bin` if it is not included on your system path, where `[architecture]` is `win64`, `glnxa64`, or `maci64` depending on your platform.

See also below for configuring the keystore and key passwords.

Self-signed certificates are typically not trusted by web browsers and COMSOL Client. The public part of the certificate therefore needs to be added to the trust-store of users' computers. On Windows this can be done using the Certificate snapin module for the Microsoft Management Console (run `certmgr.msc`) by importing the server certificate to the trusted root certificate issuers category, or via other centralized computer management tools. Web browsers may also offer their own method of adding security exceptions for self-signed certificates. COMSOL Client only supports certificates trusted by the Windows trust-store.

IMPORTING AN EXISTING CERTIFICATE

To use an existing certificate from a trusted certificate authority, you have to import both the certificate and its chain or root certificate into the keystore file. If you can get the certificate in a single file that contains both the certificate and its chain, such as `.p12` or `.pfx`, then you can import it by adapting the command

```
keytool -importkeystore -srcalias SRCALIAS -destalias COMSOLServer
-destkeypass changeit -deststorepass changeit -srckeystore cert.p12
-srcstoretype pkcs12 -destkeystore {COMSOL60}/bin/tomcat/conf/keystore.jks
```

where `SRCALIAS` is the name of the certificate in `cert.p12`. If you do not know the certificate alias in the source file, remove the `-srcalias` and `-destalias` parameters from the command, see which alias the certificate gets in the destination keystore, and finally use the keytool `-changealias` command to change it to `COMSOLServer`.

If you have the certificate and its chain certificate in separate files, such as `.cer` or `.key`, you should first import the chain certificate with

```
keytool -import -alias COMSOLServerRoot -keystore
{COMSOL60}/bin/tomcat/conf/keystore.jks -trustcacerts -file cert.key
```

and then finally import the certificate:

```
keytool -import -alias COMSOLServer -keystore
{COMSOL60}/bin/tomcat/conf/keystore.jks -file cert.cer
```

See also below for configuring the keystore and key passwords.

The tool `openssl` can be used to convert other certificate formats to `.pfx`, for example using the following syntax:

```
openssl pkcs12 -export -out out.pfx -inkey in.key -in in.pem
```

CONFIGURING KEYSTORE AND KEY PASSWORDS

Note that any custom passwords used for the keystore and key by COMSOL Server must be specified with the `-keystorepass` and `-keypass` switches in the

command used to start COMSOL Server. If installed as a Windows service, you should run

```
sc config "COMSOL Service" binpath= "{COMSOL60}/bin/win64/comsolservice.exe
-keystorepass password"
```

in an administrative console to modify the command. If installed as a `systemd` service on Linux (see Starting COMSOL Server in Linux), you would modify the `ExecStart` command.

Resetting the Administrator Password

How to reset the administrator password of COMSOL Server depends on if it was installed as a Windows service (default for Windows) or as a Regular executable.

WINDOWS SERVICE

1 Stop the COMSOL Server service using the **Manage Local Services** shortcut on the **Start** menu.
2 Run the COMSOL Server installer in **Add/Remove Products and Reinstall** mode and enter a new **Default local administrative user**.
3 Normally the COMSOL Server service is configured to start automatically; otherwise, start it again using **Manage Local Services**.

REGULAR EXECUTABLE

1 Stop the COMSOL Server executable by typing `close` in the console window, or killing its process.
2 Run the COMSOL Server installer in **Add/Remove Products and Reinstall** mode and enter a new **Default local administrative user**.
3 Start COMSOL Server again.

Migrating from a Previous COMSOL Server Version

By default, preferences and uploaded applications are automatically migrated from a previous COMSOL Server version when updating to the current version. See below for how to manually migrate from a previous version, when the automatic

migration is not available. Note that any custom server certificates in `keystore.jks` always need to be manually migrated, as well as any custom JAAS login configuration done in the `login.config` file (configurations edited on the **Login Configuration** page are automatically migrated).

AUTOMATIC MIGRATION

COMSOL Server performs the automatic migration from the previous version when it's launched the first time. The settings directory of the previous version is located automatically, as long as it is adjacent to the current version's settings directory. If you have specified a custom shared working directory in previous versions, e.g. `\\shared\v55server`, you should use a similar directory, for example, `\\shared\v60server`, for the current version.

MANUAL MIGRATION

If needed, preferences and files of previous versions can be manually migrated to the new version as needed by copying certain files after the installation. The manual migration is different from version 5.3a, since many of the text files have been replaced by an SQLite database file. The following table shows which files and directories to copy to manually migrate from 5.3a and beyond:

FILES TO COPY	DESCRIPTION
`{vXXserver}/db`	SQLite database
`{vXXserver}/applications`	Uploaded applications and files created by applications
`{vXXserver}/appearance`	Custom appearance files
`{installation}/bin/tomcat/conf/login.config`	Any custom JAAS login configuration (if modified directly in the files and not through the **Login Configuration** page)
`{installation}/bin/tomcat/conf/keystore.jks`	Any custom server certificates

The following table shows how to manually migrate from 5.3 and earlier:

FILES TO COPY	DESCRIPTION
`{vXXserver}/login.properties` `{vXXserver}/service/roles.properties`	Local user database
`{vXXserver}/server.prefs`	Preferences
`{vXXserver}/service/favorites.properties`	Favorites

FILES TO COPY	DESCRIPTION
`{vXXserver}/service/web-user-preferences.properties`	User email addresses
`{vXXserver}/applications`	Uploaded applications and files created by applications
`{vXXserver}/group-preferences.properties`	Group preferences
`{vXXserver}/moderated-groups.properties`	Moderated group preferences
`{vXXserver}/appearance`	Custom appearance files
`{installation}/bin/tomcat/conf/login.config`	Any custom JAAS login configuration (such as LDAP)
`{installation}/bin/tomcat/conf/keystore.jks`	Any custom server certificates

In the table, the path `{vXXserver}` refers to the settings directory for version XX. For COMSOL Server 6.0, it is typically `%USERPROFILE%\.comsol\v60server` on Windows or `C:\Windows\ServiceProfiles\LocalService\.comsol\v60server` if installed as a Windows service, `~/.comsol/v60server` on Linux, and `~/Library/Preferences/COMSOL/v60server` on macOS. The path `{installation}` refers to the installation directory. For COMSOL Server 6.0 it is typically `C:\Program Files\COMSOL\COMSOL60\Server` on Windows, `/usr/local/comsol60/server` on Linux, and `/Applications/COMSOL60/Server` on macOS.

To perform the migration, perform these steps:

1 Stop both versions of COMSOL Server.

2 In the later version of COMSOL Server, move the directory `{vXXServer}\db` (if present) and all its content to a backup location.

3 Copy the files according to the table above from the old version to the new version, overwriting the files if needed.

4 Start the new version of COMSOL Server.

It is recommended to make a backup copy of any file that you overwrite in case you want to undo the migration at some point.

When the new version of COMSOL Server is started, the content of the files `login.properties`, `roles.properties`, `server.prefs`, `favorites.properties`, `web-user-preferences.properties`, `group-preferences.properties`, `moderated-groups.properties`, and all files of type `.access` in `{vXXServer}/applications`, is automatically imported into COMSOL Server's database and then moved to a backup folder called `{vXXserver}/migr`. These files are not used by COMSOL Server at this point.

Security

The following guidelines summarize the best practices for running COMSOL Server in a secure way:

- Set up COMSOL Server to use transport layer security (that is, HTTPS) when connecting from web browsers and COMSOL Client. This increases the protection of passwords sent when logging in and reduces the risk of data leaks. The easiest way to get transport layer security is to use a reverse proxy with a certificate, which might already have been set up for other systems. It is also possible to configure COMSOL Server to use a server certificate directly. See Setting Up COMSOL Server for Secure Connections for more information.

- Keep the defaults for the security preference settings for apps running on COMSOL Server, unless all apps come from a trusted source. See Permissions for more information.

- Use a low privilege account when running the COMSOL Server process. This reduces the risk of escalation attacks to the system. See Installing COMSOL Server for more information.

- Configure the firewall of the computer or network segment where COMSOL Server runs to only expose the main port of COMSOL Server to the outside, or the port of the reverse proxy if running behind it. If you use secondary COMSOL Server instances they do not need to be accessible from the outside but must be able to communicate with the primary COMSOL Server instance. See Running COMSOL Server on Multiple Computers.

- If you expose COMSOL Server to the internet, make sure to operate COMSOL Server on a network isolated from your regular corporate network. One option for implementing this is to install COMSOL Server on a computer in a so called DMZ network located between the Internet and your regular corporate network. Another option is to install COMSOL Server utilizing a cloud service provider.

- Ensure that the preference directory of COMSOL Server, typically located in the home directory of the user account running the process, is not accessible by untrusted parties. As described below, COMSOL Server will itself set appropriate file system permissions on files containing critical data.

- When connecting to untrusted COMSOL Server instances, prefer using a web browser instead of COMSOL Client. Web browsers by default implement very strong sandboxing that protect against rogue servers. COMSOL Client will warn users the first time they connect to a new server to only proceed if the server is trusted.

PASSWORD SECURITY

Local passwords stored by COMSOL Server are hashed by several iterations of the SHA256 algorithm. This means that an adversary that gets access to your password file will not easily be able to obtain the original passwords. However, if an adversary gets access to the local passwords, the adversary could log in to the COMSOL Server.

By default, COMSOL Server writes the hashed local password to the file `/db/comsolserver.db` in the preference directory. It will attempt to make the database file inaccessible for other users by introducing access restrictions. When using COMSOL Client or the COMSOL API to connect to COMSOL Server, local passwords are protected by using a challenge handshake authentication protocol (CHAP) for the connection, which means that the password cannot be easily obtained by an adversary that can eavesdrop the network traffic between client and server.

In addition to local passwords, COMSOL Server also allows the use of external authentication see Configuring Windows Authentication and Configuring Active Directory or LDAP). To protect the external password, transport layer security is mandatory when connecting using COMSOL Client or the COMSOL API, since the CHAP protocol is not applicable in this case.

As mentioned above, it is recommended to use transport layer security to protect the password when logging in using a web browser. This applies equally to local passwords and external password, as the browser will send both in cleartext otherwise.

COMSOL MULTIPHYSICS SECURITY

For information about COMSOL Multiphysics security, see the section *COMSOL Security* in the *COMSOL Multiphysics Installation Guide*.

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