COMSOL Multiphysics®

Running COMSOL Multiphysics® and COMSOL Server™ via the EC2™ Service

5.6

COMSOL

Running COMSOL Multiphysics® and COMSOL Server® via the EC2™ Service

Version: COMSOL 5.6

Contact Information

Visit the Contact COMSOL page at www.comsol.com/contact to submit general inquiries, contact Technical Support, 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/community
- Events: www.comsol.com/events
- COMSOL Video Gallery: www.comsol.com/video
- Support Knowledge Base: www.comsol.com/support/knowledgebase

Part number: CM020013

1

Running COMSOL Multiphysics® and COMSOL Server™ via the EC2™ Service

This guide describes how to use COMSOL Multiphysics® and COMSOL Server™ with the Amazon Elastic Compute Cloud™ (EC2™) service.

Running COMSOL Multiphysics and COMSOL Server with the EC2™ Service

The Amazon Elastic Compute Cloud™ service, also known as the Amazon EC2™ service, allows you to dynamically allocate virtual computer resources at a small hourly fee. If you have access to a COMSOL® *Floating Network License (FNL)* or a *COMSOL Server License (CSL)* you can run one or several computations in the cloud. For this to work, the remote virtual computer in the cloud needs the ability to access and check out an FNL or CSL license key from an on-premise COMSOL license manager or access to a cloud-based license server. For a cloud-based license server, a dedicated license file is necessary.

> A *Floating Network License (FNL)* or C*OMSOL Server License (CSL)* for COMSOL® is required to run COMSOL® on a remote computer or cloud resources.

This tutorial explains how to create and run the COMSOL Multiphysics® software and COMSOL Server™ for use with the Amazon Elastic Compute Cloud™ (EC2™) service. The step-by-step instructions are platform independent. When instructions vary by operating system, Windows® and Linux® operating system and macOS instructions are explicitly written.

This document consists of the following sections:

- Nomenclature
- Requirements
- Introduction
- Downloading AWS CloudFormation™ Service Templates for Automatic COMSOL® Installation
- Creating a Key Pair
- Creating a Key for Use in PuTTY (Optional)
- Creating a COMSOL® License Server Instance for Use with the EC2™ Service

- Creating a login.properties File for the EC2™ Services (Optional for COMSOL Multiphysics Server Only)
- Forwarding Ports from Your On-Premise License Server
- Creating a COMSOL Multiphysics or COMSOL Server Instance
- Connecting to a COMSOL Multiphysics or COMSOL Server Instance
- Disconnecting from the COMSOL Multiphysics Instance
- Shutting Down and Deleting Your Stacks
- Troubleshooting

Nomenclature

The following terms are used in this guide:

- *AWS™ platform*, Amazon Web Services™ platform.
- *AWS CloudFormation™ service*, Amazon's tool for launching collections of AWS™ service resources from a predefined template.
- *EC2™ service*, the Amazon Elastic Compute Cloud™ service.
- *AMI*, Amazon™ Machine Image, a special type of preconfigured operating system and virtual application software, which is used to create a virtual machine within the Amazon Elastic Compute Cloud™ (EC2™) service. It serves as the basic unit of deployment with the EC2™ service.
- *Amazon S3™ bucket*, the Amazon Simple Storage Service™ bucket, an online cloud storage service.
- *Amazon VPC*, a virtual private cloud where you can launch AWS resources in a virtual network that you define.
- *ENI*, a configured *Amazon Elastic Network Interface*, which is a logical networking component in a VPC that represents a virtual network card and can include IP and MAC addresses as attributes.
- *Stack*, a collection of Amazon AWS™ service resources (EC2™ service machines, buckets, security groups, and so on) created by the AWS CloudFormation™ tool.

Requirements

The following requirements should be fulfilled for running COMSOL on the cloud:

- An Amazon™ service account activated for AWS™ services.

- Access to a Floating Network License (FNL) or a COMSOL Server License (CSL) for COMSOL Multiphysics 5.6 or later.
- Make sure your IT department has configured your organization's firewall to allow outbound traffic on port 22. This is required to access your Amazon EC2™ service instance via SSH.
- For COMSOL Multiphysics only: A local installation of COMSOL Multiphysics 5.6 or later.

Introduction

The following steps are needed to run COMSOL® with the EC2™ service and are detailed in this guide.

1. Downloading AWS CloudFormation™ Service Templates for Automatic COMSOL® Installation
2. Adding the Canonical ID
3. Creating a Key Pair
4. Creating a Key for Use in PuTTY (Optional)
5. Creating a COMSOL® License Server Instance for Use with the EC2™ Service
6. Creating a login.properties File for the EC2™ Services (Optional for COMSOL Multiphysics Server Only)
7. Forwarding Ports from Your On-Premise License Server
8. Creating a COMSOL Multiphysics or COMSOL Server Instance
9. Connecting to a COMSOL Multiphysics or COMSOL Server Instance
10. Disconnecting from the COMSOL Multiphysics Instance
11. Shutting Down and Deleting Your Stacks

Steps 1–4 and 6 are only needed the first time you create your stacks. Once created, the key pair files and the `login.properties` file can be reused.

Please note that Amazon.com Inc. charges for the time that the created instances exist, independently of whether you are connected to them or not. To avoid unnecessary costs, shut down and delete your created stacks when you are not using them.

Downloading AWS CloudFormation™ Service Templates for Automatic COMSOL® Installation

In this section, you will learn how to download the latest version of the AWS CloudFormation™ templates for automation of the COMSOL® installation.

AWS CloudFormation™ service templates provide an easy way to set up virtual machines in the cloud by specifying only a few parameters. You can download the templates for the COMSOL license server, COMSOL Multiphysics server, and the COMSOL Server by following the steps described below:

1. Open a web browser and navigate to http://cdn.comsol.com/aws/COMSOL_json.zip. When asked, save the file to your computer.
2. Unpack the ZIP file and make sure that you have the following three files available:
   - **a** `COMSOL_AmazonLicenseServer.json`
   - **b** `COMSOL_CloudLicenseServer.json`
   - **c** `COMSOL_CloudServer.json`

Now you have all of the AWS CloudFormation™ service templates that you need to proceed to the following steps.

Adding the Canonical ID

In order to install COMSOL® software on Amazon EC2, you need to be able to access the `comsol-install-media` Amazon S3 Bucket. You will get this access by submitting the canonical user ID of your account on our web page. A canonical user ID is a 64-character-long string.

This section shows you how to retrieve your canonical user ID related to your AWS account and how to transfer it to our web page.

1. Go to https://console.aws.amazon.com/. If you are not logged into the AWS™ service, you will be redirected to the AWS™ service login screen. Log in with your AWS™ service account and navigate to https://console.aws.amazon.com/.
2. Click your username in the upper-right corner of the screen and select **My Security Credentials**.
3. Click **Continue to Security Credentials**.
4. Expand the **Account Identifiers** section and copy the canonical user ID to a text document. Your canonical user ID is a 64-character-long string containing numbers and alpha characters from *a* to *f*.

5 Go to https://www.comsol.com/add-canonical-id. If you are not logged into your COMSOL Access account, enter your username and password.
6 Enter your canonical user ID at AWS Canonical ID. Click **SUBMIT FOR ACCESS TO OUR S3 BUCKET**.

If everything works, you should see the message *Success — Your Canonical ID has been added*, highlighted in green. This means that your canonical ID has been successfully transferred to the COMSOL web page and that you have full access to the COMSOL installation files located in the `comsol-install-media` Amazon S3 Bucket. You can immediately proceed with the following steps of this instruction.

Creating a Key Pair

In this section, you will learn how to create a key pair on the AWS™ service in order to be able to connect to it with SSH and COMSOL.

To connect securely with your Amazon™ virtual machines, you need a key pair for authentication. You can create a key pair using the following steps:

1 Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Compute** section and click **EC2**.
2 At the EC2 Dashboard on the left, locate the **Network & Security** section and click **Key Pairs**.
3 Click **Create Key Pair**.
4 Give the key pair a name (for example, *My_Keypair*) and click **Create**.

Do not rename the key pair after its creation. Renaming the key pair will later result in its rejection.

5 Save the file *My_Keypair.pem* to your computer.

Creating a Key for Use in PuTTY (Optional)

For Windows® operating system users, one option to connect to a remote machine via SSH is to use the freely available software PuTTY (available for download at http://www.putty.org). To be able to connect to your newly created Amazon™ virtual machine with PuTTY, you need to convert your `pem` key file to the PuTTY format. To do this, follow the steps below:

1. Open the application *PuTTYgen*.
2. Click **File>Load Private Key**.
3. In the lower-right corner, change the shown file type from **PuTTY Private Key Files (*.ppk)** to **All Files (*.*)**.
4. Navigate to the folder where you saved your key pair file, select it, and click **Open**.
5. A dialog window appears, telling you that you need to save the key as a PuTTY private key. Click **OK**.
6. If you want to protect the key file with an extra layer of security, enter a passphrase in the **Key passphrase** and **Confirm passphrase** fields. This step is optional.
7. Click **Save Private Key**.
8. If you chose not to enter a passphrase in step 6, a dialog window will show up, telling you that your key is not protected by a passphrase. Click **Yes** to save the key without a passphrase.
9. Save the file to your computer as, for example, *My_Keypair.ppk*.
10. Close PuTTYgen.

Creating a COMSOL® License Server Instance for Use with the EC2™ Service

In this section, you will learn how to use the AWS CloudFormation™ service to create a COMSOL® license server for use with the EC2™ service.

To start a COMSOL® instance for use with the Amazon EC2™ service, you need a license server. There are two possible ways to start a COMSOL license server in the cloud. One way is to create a license server through which you access your on-premise license server. This approach requires that you forward ports from your on-premise license server to the cloud. An alternative approach is to create a cloud-based license server, using a dedicated license file. This approach does not require forwarding ports to the Amazon™ cloud service but requires that a license file is created for a network interface on Amazon™ cloud services. If you want to use your COMSOL network license to only occasionally perform simulations on Amazon™ cloud services, then forwarding ports is most likely the preferable approach.

FORWARD YOUR ON-PREMISE LICENSE SERVER TO THE EC2™ SERVICE

The following steps describe how to use the CloudFormation™ tool to create a cloud-based license server through which you can access your on-premise license server:

1. Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Management & Governance** section and click **CloudFormation**.
2. Click the **Create Stack** button in the upper-right corner. From the drop-down list choose *With new resources (standard)*.
3. Choose the *Upload a template file* option. After that, a *Choose file* button will appear. Click this button.
4. Navigate to the folder where you saved the AWS CloudFormation™ tool templates and choose the file `COMSOL_CloudLicenseServer.json`.
5. Click **Next**.
6. Now you need to specify some details and parameters controlling the creation of the COMSOL license server.
   a. *DefaultAMIID* — Default AMI ID. You can leave the default value unchanged.
   b. *Stack Name* — Enter a name for your stack — for example, *My-COMSOL-License-Server*. The name must only contain letters, numbers, and dashes and start with an alpha character.
   c. *InstanceType* — The instance type that is used for your COMSOL license server. This value is already set to *t2.micro*. To find more information, please refer to http://aws.amazon.com/ec2/instance-types/.
   d. *KeyDir* — Specify the local directory where your key pair file resides. Note that a trailing backslash `\` is needed if you use Windows® and a trailing slash `/` if you use Linux® or macOS.
   e. *KeyName* — From the drop-down list, choose one of the key pairs that you created earlier.
   f. *LicenseServerPort* — Specify the first TCP/IP port of your on-premise license server, typically `1718`. You can find this port by inspecting your `license.dat`. There should be a line similar to:
      `SERVER localhost 123456789abc 1718`
      The last number of this line is the first port of your on-premise license server.
   g. *LicenseServerPort2* — Specify the second TCP/IP port of your on-premise license server, typically `1719`. You can find this port by inspecting your `license.dat`. There should be a line similar to:

`VENDOR LMCOMSOL port=1719`

The last number of this line is the second port of your on-premise license server.

h *LocalLicenseServer* — Specify the host name of your local license server; for example, `licenseserver.company.com`.

i *LoginBucket* — Specify if you want to automatically create an Amazon S3™ bucket for the `login.properties` file or not. Creating an Amazon S3™ bucket makes it possible to automatically start the COMSOL Multiphysics® server when creating the stack. This option is not relevant for creating a COMSOL Server instance. Choose *yes* to create such an Amazon S3™ bucket; otherwise, choose *no*. If you later plan to create a COMSOL Multiphysics® server as *comsol-user*, the COMSOL Multiphysics server needs to start automatically, so you need a LoginBucket for your `login.properties` in any case (you will find the corresponding option in section Creating a COMSOL Multiphysics or COMSOL Server Instance as parameter 6.ac).

j *SSHFrom* — Specify an IP range to restrict access to the license server that you created for use with the EC2™ service. To find your external IP address, use your preferred search engine and search for *My IP Address*. The IP range must be specified in the format `x.x.x.x/x`. For example, if your external IP address is `192.168.0.1`, then the following notations result in the following IP address range access permissions:

`192.168.0.1/32` — access only to `192.168.0.1`

`192.168.0.1/24` — access to `192.168.0.*`

`192.168.0.1/16` — access to `192.168.*.*`

`192.168.0.1/8` — access to `192.*.*`

To allow access from all hosts, type `0.0.0.0/0`. Note that allowing access from other hosts than your current IP address might lead to potential security issues.

7 Click **Next**.

8 Click **Next**.

9 Review your settings and make sure that they are correct.

10 At the bottom of the page, select the check box for the text *I acknowledge that this template might cause AWS CloudFormation™ to create IAM resources.*

11 Click **Create stack**.

12 The creation process has started. Wait until it is done. It can take 5 minutes or longer. For keeping track of the detailed progress of the stack creation, you will find a button with a refresh symbol in the upper-right corner. If the creation has been successful, you will see the status *CREATE_COMPLETE* highlighted in green.

Otherwise, you will see the status *ROLLBACK_COMPLETE* highlighted in red. In this case, please check your details and parameters or refer to the *Troubleshooting* section.

After the stack has been created, switch from the *Events* to the *Outputs* tab. Here, you will find some helpful information and commands. It is recommended that you save all of the output in a document for future use. The different output data are described in the following list:

a *Instructions* — Instructions on how to forward the ports to the license server.

b *LicenseSecurityGroup* — The security group created for your servers.

c *LicenseServer* — The host name of the license server.

d *LicenseServerIP* — The IP address of the license server.

e *LoginBucketID* — The name of the Amazon S3™ bucket created for the `login.properties` file. This output will only be available if the property *LoginBucket* has been set to *yes* during the stack creation.

f *SSHAccess* — Command for forwarding ports using SSH.

g *PuTTYAccess* — Command for forwarding ports using PuTTY.

You can now proceed to the section Creating a login.properties File for the EC2™ Services (Optional for COMSOL Multiphysics Server Only).

CREATING A CLOUD-BASED LICENSE SERVER

The steps below describe how to use the AWS CloudFormation™ tool to create a COMSOL® license server instance running in the cloud. To do this, you need the following:

- A Security Group (SG) limiting access to the COMSOL license server. A security group acts as a virtual firewall for your instance to control inbound and outbound traffic. To learn how to create an SG, see the instructions below.
- A configured Amazon Elastic Network Interface (ENI). An ENI is a logical networking component in a VPC that represents a virtual network card. To learn how to create such an ENI, see the instructions below.
- A COMSOL FNL or CSL license file prepared for the host ID of your ENI. You can either decide to move your current license to a machine on the cloud or purchase a new license dedicated for the cloud. For more information, contact your

local COMSOL office. For a list of COMSOL offices, see http://www.comsol.com/contact/offices/.

- An Amazon S3™ Bucket, representing a cloud storage that contains your COMSOL® FNL or CSL license file (and optionally your login credentials). To learn how to create such a bucket, see the instructions below.

To create a *Security Group*, follow the steps below:

1. Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Compute** section and click **EC2**.
2. At the dashboard menu on the left, locate the **Network & Security** section and click **Security Groups**.
3. Click **Create Security Group**.
4. Enter a security group name (for example, *COMSOL security group*) and a description (for example, *My COMSOL security group*), and choose the Amazon Virtual Private Cloud™ group (VPC) that your security group should belong to.
5. Click **Create**.

You have now created a security group. You will now need to create an *Elastic Network Interface* in your security group. To do so, follow the steps below:

1. Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Compute** section and click **EC2**.
2. At the dashboard menu on the left, locate the **Network & Security** section and click **Network Interfaces**.
3. Click **Create Network Interface**.

   If wanted, enter a description for the ENI — for example, *ENI for my COMSOL license server*.
4. Choose a subnet from the list in order to use this with your ENI.
5. For the *IPv4 Private IP* option, select *Auto-assign* to automatically create an IPv4 IP address for your ENI.
6. Choose the security group that you created in the previous step. We called ours *COMSOL security group*.
7. Click **Create**.

You have now created an Elastic Network Interface, and you can contact your local COMSOL office to either move your current license to the cloud or purchase a dedicated COMSOL Multiphysics floating network license (FNL) or a COMSOL

Server license (CSL). To do this, you need to specify a hostname and a host ID. The hostname can be *localhost*; the host ID is the MAC address of your ENI. To access this information, go to the **Network Interfaces** section and then, from the **Network interface** list, click the check box of the ENI whose information you want to extract and take a look at the **Details** tab below the **Network Interface** list. Also note the *Network interface ID*, *VPC ID*, and *Security group name*. This information is needed when creating the license server.

Once you have an FNL for your ENI, you need to create an *Amazon S3™ bucket* to upload the license file to the cloud. To do this, follow these steps:

1. Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Storage** section and click **S3**.
2. Click **Create Bucket**.
3. Choose a name for your bucket — for example, *comsol-license-bucket*. Please note that your buckets must have unique names within the Amazon S3™ bucket namespace. Furthermore, the name must only contain letters, numbers, and dashes and start with an alpha character.

   Later, you will need to enter the Amazon S3™ bucket ID during the creation of the cloud-based license server itself. That is why it is recommended to also save the Amazon S3™ bucket ID in a text document.
4. Click the **Create** button in the lower-left corner of the window.
5. Click the name of the bucket that you just created.
6. Click **Upload**.
7. Click **Add Files**.
8. In the pop-up window, navigate to the local folder containing the *license.dat* file created for your ENI.
9. Click **Upload** in the lower-left corner of the window.

> Do not name your license file anything different from the default `license.dat` file. Renaming the license file will make the COMSOL installation fail.

Now you have uploaded your license file to Amazon S3™ bucket, and you can proceed to create your COMSOL® license server.

1. Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Management & Governance** section and click **CloudFormation**.

2 Click the **Create Stack** button in the upper-right corner. From the drop-down list, choose *With new resources (standard)*.

3 Choose the *Upload a template file* option. After that, a *Choose file* button will appear. Click this button.

4 Navigate to the folder where you saved the Cloud Formation service templates and choose the file *COMSOL_AmazonLicenseServer.json*.

5 Click **Next**.

6 You now need to specify some details and parameters controlling the creation of the COMSOL license server:

   a *Stack name* — Enter a name for your stack — for example, *My-COMSOL-License-Server*.

   b *AMIID* — If you have created a custom COMSOL AMI, enter the ID of the AMI here; otherwise, leave it blank. This input is optional.

   c *AcceptLicense* — Enter *yes* if you have read through and accept the COMSOL Software License Agreement, which is available at https://www.comsol.com/documentation/5.6/COMSOL_SoftwareLicenseAgreement.pdf.

> You need to accept the COMSOL Software License Agreement to be able to create a COMSOL License Server in the cloud.

   d *COMSOLBucket* — Specify in what Amazon S3™ bucket the image of the COMSOL installation DVD is stored. If you have created a custom bucket, enter its ID here; otherwise, leave the default ID *comsol-install-media* unchanged. It contains images provided by COMSOL.

   e *COMSOLRegion* — Specify in what region your Amazon S3™ bucket is located. If you have created a custom bucket, enter its region here; otherwise, leave the default region *us-east-1* to point to the region where the bucket *comsol-install-media* is located.

f *COMSOLVersion* — What version of COMSOL Multiphysics or COMSOL Server you want to provide a license server for.

g *Company* — Specify your company name.

h *DefaultAMIID* — The default AMI ID. You can leave this value unchanged.

i *ENISecurityGroup* — The name of the security group in which the ENI resides, created in the earlier steps of this section.

j *ENIVPCId* — The ID of the Amazon Virtual Private Cloud™ group in which the ENI resides, created in the earlier steps of this section.

k *ElasticNetworkInterface* — The ID of your Elastic Network Interface (the VPCID of your ENI), created in the earlier steps of this section.

l *InstanceType* — The instance type that is used for your COMSOL license server. This value is already set to *t2.micro*. For more information, see http://aws.amazon.com/ec2/instance-types/.

m *KeyDir* — Specify the local directory where your key pair file resides. Note that a trailing backslash `\` is needed if you use Windows® and a trailing slash `/` if you use Linux® or macOS.

n *KeyName* — From the drop-down list, choose one of the key pairs that you created earlier.

o *LicenseBucketId* — The name of the Amazon S3™ bucket created in the step described earlier.

p *LicenseServerPort* — Specify the first TCP/IP port of your on-premise license server, typically `1718`. You can find this port by inspecting your `license.dat` file. There should be a line similar to:

```
SERVER localhost 123456789abc 1718
```

The last number of this line is the first port of your on-premise license server.

q *LicenseServerPort2* — Specify the second TCP/IP port of your on-premise license server, typically `1719`. You can find this port by inspecting your `license.dat` file. There should be a line similar to:

```
VENDOR LMCOMSOL port=1719
```

The last number of this line is the second port of your on-premise license server.

r *Name* — Specify your name.

s *UserName* — Choose whether the user account `ec2-user` or `comsol-user` should be used. The user account `ec2-user` is the default user account of the Amazon Linux 2™ operating system. It can establish SSH connections and SSH tunnels to the virtual machine and can use `sudo` without password protection. `comsol-user` cannot establish SSH connections or SSH tunnels and thus does not offer direct access to the virtual machines. If the license server settings should be modified in the future, choose the user account `ec2-user`; otherwise, you can use `comsol-user`.

7 Click **Next**.

8 Click **Next**.

9 Review your settings and make sure that they are correct.

10 At the bottom of the page, select the check box next to the text “*I acknowledge that this template might cause AWS CloudFormation to create IAM resources.*”

11 Click **Create stack**.

12 The creation process has started. Wait until it is done. It can take up to 10 minutes or longer. For keeping track of the detailed progress of the stack creation, you will find a button with a refresh symbol in the upper-right corner.
If the creation has been successful, you will see the status *CREATE_COMPLETE* highlighted in green. Otherwise, you will see the status *ROLLBACK_COMPLETE* highlighted in red. In this case, please check your details and parameters or refer to the *Troubleshooting* section.

13 After the stack has been created, switch from the *Events* tab to the *Outputs* tab. Here, you will find some helpful information and commands. It is recommended to save all of the output in a text document for future use. The different output data are described in the list below.

   a *LicenseSecurityGroup* — The security group created for your servers.

   b *LicenseServerIP* — The IP address of the license server.

   c *VPCId* — The ID of the Amazon Virtual Private Cloud™ group.

   d *LoginBucketID* — The name of the Amazon S3™ bucket used for the license file.

   e *SSHAccess (*`ec2-user` *only)* — SSH command for forwarding your local port `2036` to the COMSOL Multiphysics server in the cloud in order to be able to connect to it.

   f *PuTTYAccess (*`ec2-user` *only)* — PuTTY command for forwarding your local port `2036` to the COMSOL Multiphysics server in the cloud in order to be able to connect to it.

   g *Instructions (*`ec2-user` *only)* — Short instructions on how to access the license server.

   h *EC2User (*`ec2-user` *only)* — A reminder that `ec2-user` has been chosen.

Creating a login.properties File for the EC2™ Services (Optional for COMSOL Multiphysics Server Only)

In this section, you will learn how to create the file `login.properties` for your COMSOL Multiphysics server instance in order to allow for automatic start of the server. You can skip this section if you want to run a COMSOL Server instead.

The `login.properties` file is created when starting the COMSOL Multiphysics server for the first time and contains encrypted information about the username and password that is needed to log into the server. Creating and uploading a `login.properties` file is mandatory when a COMSOL Multiphysics server should later be run as `comsol-user` and thus needs to be started automatically (see section

Creating a COMSOL Multiphysics or COMSOL Server Instance, parameter 6.ac and 6.f). When running a COMSOL Multiphysics server as `ec-user` instead, it can still be started manually, and creating a `login.properties` file is not absolutely necessary now.

> Do not give this file any different name than `login.properties`; otherwise, it cannot be used to automatically start a COMSOL Multiphysics server.

The file `login.properties` is, when using default settings, located in your home folder and can therefore be found in the folder `C:\Users\<USERNAME>\.comsol\v56` on Windows® operating systems, where you should replace `<USERNAME>` with your own username. On Linux® operating systems, the file is, when using default settings, located in the folder `$HOME/.comsol/v56`. On macOS, the file is located in the folder `LIBRARY/Preferences/COMSOL/v56`.

If you have no `login.properties` file in the folder specified above, you need to create one to be able to start the COMSOL Multiphysics server automatically. If you want to reset the username and password, simply delete the old file and create a new one. To create a `login.properties` file, follow the steps below. Otherwise, proceed to the section Uploading login.properties to your Amazon S3™ bucket.

CREATE LOGIN.PROPERTIES (WINDOWS® OPERATING SYSTEMS)

1 Locate the directory where COMSOL Multiphysics is installed (typically: `C:\Program Files\COMSOL\COMSOL56\Multiphysics` under Windows®) and browse to its subdirectory `bin\win64`. Click the `comsolmphserver.exe`. This will launch a command prompt window in which the COMSOL Multiphysics server will run.

2 Enter a username and password of your choice when prompted. If you are not prompted for a username and password, a `login.properties` file already exists in your home folder.

3 Type `close` in the **Command Prompt** window to close the COMSOL Multiphysics server.

Now you have created a `login.properties` file.

CREATE LOGIN.PROPERTIES (LINUX® AND MACOS)

1 Open a terminal window.

2 Navigate to the COMSOL installation directory.

3 Depending on whether you want to run a COMSOL Multiphysics server, run the command `./bin/comsol mphserver`.
4 Enter a username and password of your choice when prompted. If you are not prompted for a username and password, a `login.properties` file already exists in your home folder.
5 Type *close* in the Command Prompt window to close the COMSOL Multiphysics server.
6 Close the terminal window.

You have now created a `login.properties` file.

UPLOADING LOGIN.PROPERTIES TO YOUR AMAZON S3™ BUCKET

You are now ready to upload your `login.properties` file to the Amazon S3™ bucket created with your license server instance.

1 Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Storage** section and click **S3**.
2 If you created a cloud-based license server as described in Creating a cloud-based license server, then you will see the Amazon S3™ bucket created in that section. In case you followed the instructions from section Forward your on-premise license server to the EC2™ service instead, you will find an automatically created Amazon S3™ bucket if you set the option 6.i *LoginBucket* to *yes* during the license server creation. Otherwise, you can still create an Amazon S3™ bucket manually by clicking **Create Bucket**, entering a valid bucket name in the following window, and then clicking the **Create** button in the lower-left corner.
In the list, click on the bucket that has been created.
3 Click **Upload**.
4 Click **Add Files**.
5 In the pop-up window, navigate to the local folder containing `login.properties` and choose the file `login.properties`.
6 Click **Upload** in the lower-left corner of the window.

You have now prepared your Amazon S3™ bucket with a username and password and can use this bucket to automatically start the COMSOL Multiphysics® server with the EC2™ service.

Forwarding Ports from Your On-Premise License Server

In this section, you will learn how to use an SSH client to forward access to your on-premise license server. This step is only necessary if you have chosen to forward your on-premise license server as described in the section Forward your on-premise license server to the EC2™ service. If you created a cloud-based license server as described in the section Creating a cloud-based license server, you can skip this section.

The port forwarding is needed to give the Amazon Cloud™ service access to your on-premise license server. The easiest way to start the port forwarding is to use the command listed in the *Outputs for the COMSOL license* server stack. To start the port forwarding, follow the steps below:

1. Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Management & Governance** section and click **CloudFormation**.
2. Select the stack you created for the COMSOL license server.
3. Click the **Outputs** tab.
4. Find the row with the Key value of *SSHAccess* or *PuTTYAccess*. The one you choose is dependent on the SSH software you have installed. Select the text in the **Value** column and copy it, either by right-clicking it and choosing **Copy** or by using the Ctrl+C shortcut.
5. Open a command prompt and navigate to the PuTTY or SSH installation folder.
6. Paste the command that you copied in Step 4 into the command prompt window and press **Enter**.
7. If asked *Store key in cache?*, type `y` and press **Enter**.
8. Leave the window open until you are finished with your computations. Your ports are only forwarded as long as the SSH session is active, and closing the command prompt will deactivate the session.

Creating a COMSOL Multiphysics or COMSOL Server Instance

In this section, you will learn how to use the AWS CloudFormation™ tool to create a COMSOL Multiphysics® instance on the cloud to which you can connect with the COMSOL Multiphysics client-server functionality, and how to create a COMSOL Server™ instance in which you can run COMSOL® applications.

If you are forwarding the ports from your on-premise license server as described in the last section, make sure that the SSH session is active during the following steps.

Otherwise, your COMSOL Multiphysics server or COMSOL Server instance creation will fail later.

To create a COMSOL Multiphysics® server or a COMSOL Server™ instance, use the AWS CloudFormation™ tool and the script `COMSOL_CloudServer.json`, which is provided by COMSOL.

1 Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Management & Governance** section and click **CloudFormation**.
2 Click the **Create Stack** button in the upper-right corner. From the drop-down list, choose *With new resources (standard)*.
3 Choose the *Upload a template file* option. After that, a *Choose file* button will appear. Click this button.
4 Navigate to the folder where you saved the AWS CloudFormation™ tool templates and choose the file *COMSOL_CloudServer.json*.
5 Click **Next**.
6 Specify the needed details and parameters.
   a *Stack name* — Enter a name for your stack, for example, *My-Server*. The name must only contain letters, numbers, and dashes and start with an alpha character.
   b *AMIID* — If you have created an AMI with a custom COMSOL installation, enter the ID of the AMI here. This input is optional.
   c *AcceptLicense* — Type *yes* if you have read through and accept the COMSOL Software License Agreement, available at https://www.comsol.com/documentation/5.6/COMSOL_SoftwareLicenseAgreement.pdf. *Please note that if you do not answer yes to this question, you will not be able to create a COMSOL Multiphysics server instance in the cloud.*
   d *AdditionalNodes* — Specify the number of additional nodes when you want to start more than one node and connect them together to a cluster. This is particularly useful for running parametric sweeps in parallel. Please note that when not running a distributed sweep, it is not recommended to start any additional nodes; instead, create a single node instance of an appropriate size, as described in step l (*InstanceType*; see setting m below).
   e *AllowHTTP* — Specify when you want to allow HTTP access to your EC2™ service instance. This setting *must* be set to *yes* if one chooses to run the instance as `comsol-user` (*UserName*; see setting ac below).

It is furthermore necessary to enable HTTP access when you want to run COMSOL Server on the instance and access it later through a web browser.

f *Autostart* — Specify when you want the COMSOL Multiphysics server to start automatically after launch. The options *cluster*, *yes*, and *no* are available. If you specify *cluster*, COMSOL will launch the COMSOL Multiphysics server or COMSOL Server in cluster mode. This is necessary when you are creating additional nodes.

g *COMSOLBucket* — Specify in what Amazon S3™ bucket the image of the COMSOL installation DVD is stored. If you have created a custom bucket, enter its ID here; otherwise, leave the default ID *comsol-install-media* unchanged. This bucket contains images provided by COMSOL.

h *COMSOLRegion* — Specify in what region your Amazon S3™ bucket is located. If you have created a custom bucket, enter its region here; otherwise, leave the default region *us-east-1* to point to the region where the bucket *comsol-install-media* is located.

i *COMSOLServerPort* — Specify which port the COMSOL Multiphysics server or COMSOL Server installation should use. The default is 2036.

j *COMSOLVersion* — Specify which version of COMSOL you want to install.

k *Company* — Specify your company name.

l *DefaultAMIID* — The default AMI ID. You can leave this value unchanged.

m *InstanceType* — Specify which instance type you want to use to run your COMSOL Multiphysics server or COMSOL Server installation. Different instance types have different hardware specifications and costs. To find more information, please refer to http://aws.amazon.com/ec2/instance-types/.

> For a new user, Amazon™ service provides microinstances free of charge (Free Usage Tier). These are useful for experimenting and verifying that everything works as expected.

- **n** *KeyDir* — Specify the local directory where your key pair file resides. Observe that a trailing backslash `\` is needed if you use Windows®, or a trailing slash `/` if you use Linux® or macOS.
- **o** *KeyName* — From the drop-down list, choose one of the key pairs that you created earlier.
- **p** *LicenseSecurityGroup* — Specify the name of the security group created with the COMSOL license server.
- **q** *LicenseServerIP* — Specify the IP address of the COMSOL license server.
- **r** *LicenseServerPort* — Specify the first TCP/IP port of your on-premise license server, typically `1718`. You can find this port by inspecting your `license.dat` file. There should be a line similar to:

  `SERVER localhost 123456789abc 1718`

  The last number of this line is the first port of your on-premise license server.
- **s** *LicenseServerPort2* — Specify the second TCP/IP port of your on-premise license server, typically `1719`. You can find this port by inspecting your `license.dat` file. There should be a line similar to:

  `VENDOR LMCOMSOL port=1719`

  The last number of this line is the second port of your on-premise license server.
- **t** *LicenseType* — Specify whether you want to install COMSOL Multiphysics or COMSOL Server.
- **u** *LoginBucketID* — Specify the ID of the Amazon S3™ bucket created with the COMSOL® license server. This option is only necessary if you chose to create a login bucket when creating the license server (either automatically as described in the previous section Forward your on-premise license server to the EC2™ service or manually as shown in the previous section Creating a cloud-based license server).
- **v** *Name* — Specify your name.
- **w** *PlacementGroupLaunch* — Specify if instances should be launched into a placement group if possible. The default option is *yes*.
- **x** *RestrictIP* — Specify an IP or UP range to restrict access to the COMSOL® license server running with the Amazon EC2™ service. To find your external IP address, use your preferred search engine and search for *My IP Address*. The IP range must be specified in the format `x.x.x.x/x`. As an example, if your external IP address is `192.168.0.1`, then the following notations will result in the following IP address range access permissions:

  `192.168.0.1/32` — access only to `192.168.0.1`

`192.168.0.1/24` — access to `192.168.0.*`

`192.168.0.1/16` — access to `192.168.*.*`

`192.168.0.1/8` — access to `192.*.*`

To allow access from all hosts, type `0.0.0.0/0`. Please note that allowing access from other hosts than your current IP address might lead to potential security issues.

y *ServerUserName — Only relevant for a COMSOL Server installation:* The name of the COMSOL Server administrator.

z *ServerUserNamePassword — Only relevant for a COMSOL Server installation:* The temporary COMSOL Server administrator password.

aa *ServerUserNamePassword2 — Only relevant for a COMSOL Server installation:* Repeat the temporary COMSOL Server administrator password.

ab *TempVolumeSize* — Specify the size of the hard drive volume to contain the temporary files. The default size is 20 GB. This value might need to be increased when you plan to compute large models, large parametric sweeps, or run many simultaneous applications.

ac *UserName* — Choose whether the user account `ec2-user` or `comsol-user` should be used. The user account `ec2-user` is the default user account of the Amazon Linux 2™ operating system. It permits SSH connections and SSH tunneling to the virtual machine and is able to use `sudo` without password protection. For these reasons, the `ec2-user` allows to perform future changes on the server.

`comsol-user` does not permit SSH connections or SSH tunneling and thus does not offer direct access to the server. This makes it impossible to later start the COMSOL Multiphysics server or COMSOL Server manually, so the *Autostart* option from the previous step f must be set to *yes*. Please note that in order for the *Autostart* option to work for a COMSOL Multiphysics server, you also need to have created a `login.properties` file and upload it to the bucket that you specified at the previous step *LoginBucketID*.

7 Click **Next**.

8 Click **Next**.

9 Review your settings and make sure that they are correct.

10 At the bottom of the page, select the check box next to the text "*I acknowledge that this template might cause AWS CloudFormation to create IAM resources.*"

11 Click **Create stack**.

12 The creation process has started. Wait until it is done. It can take up to 10 minutes or longer. For keeping track of the detailed progress of the stack creation, you will find a button with a refresh symbol in the upper-right corner.
If the creation has been successful, you will see the status *CREATE_COMPLETE* highlighted in green. Otherwise, you will see the status *ROLLBACK_COMPLETE* highlighted in red. In this case, please check your details and parameters or refer to the *Troubleshooting* section.

13 After the stack has been created, switch from the *Events* tab to the *Outputs* tab. Here, you will find some helpful information and commands. It is recommended that you save all of the output in a text document for future use. The different output data are described in the list below.

   a *PublicDNSName* — The public DNS name.

   b *Instructions (*`ec2-user` *only)* — Short instructions on how to access the COMSOL installation.

   c *PuTTYAccess (*`ec2-user` *only)* — PuTTY command for forwarding your local port `2036` to the COMSOL Multiphysics server in the cloud in order to be able to connect to it.

   d *SSHAccess (*`ec2-user` *only)* — SSH command for forwarding your local port `2036` to the COMSOL Multiphysics server in the cloud in order to be able to connect to it.

   e *HTTPAccess (COMSOL Server only)* — The website address through which you can access your COMSOL Server installation, if you chose to allow HTTP access to your installation.

   f *HTTPInstructions (COMSOL Server only)* — Instructions for connecting to the COMSOL server.

If you did not choose to start the COMSOL Multiphysics server or COMSOL Server automatically after creating the stack, you need to start it manually. To do this, log into the server via SSH and follow the instructions in the *COMSOL Multiphysics Reference Manual* in the *Running COMSOL Multiphysics* chapter (this is only possible when the stack has been created with the user account `ec2-user`).

Connecting to a COMSOL Multiphysics or COMSOL Server Instance

In this section, you will learn how to connect to the COMSOL Multiphysics server or COMSOL Server.

To connect to a COMSOL Server installation from your local computer, you can either use a web browser (possible if you chose to allow HTTP access when creating your COMSOL Server) or you can connect to your COMSOL Server with the COMSOL Client. To connect through a web browser, use the address given as output when the instance was created (see Creating a COMSOL Multiphysics or COMSOL Server Instance, output 13.e).

To connect a COMSOL Multiphysics® server installation from your local computer with the COMSOL Client, there are two possible options depending on whether you have chosen `ec2-user` or `comsol-user` as *UserName* (see Creating a COMSOL Multiphysics or COMSOL Server Instance, parameter 6.ac).

CONFIGURE PORT FORWARDING (EC2-USER ONLY)

The following steps show how to forward your local port 2036 to the COMSOL Multiphysics® server port in the Amazon™ cloud. They will only work if you selected the user account `ec2-user` during the COMSOL Multiphysics or COMSOL Server instance creation in the previous section Creating a COMSOL Multiphysics or COMSOL Server Instance, parameter 6.ac. In case you chose the user account `comsol-user`, you can skip this section.

1 Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Management & Governance** section and click **CloudFormation**.
2 Select the stack you created for the COMSOL Multiphysics server or COMSOL Server in section Creating a COMSOL Multiphysics or COMSOL Server Instance.
3 Click the **Outputs** tab.
4 Find the row with the Key value of *SSHAccess* or *PuTTYAccess*. The one you choose is dependent on the SSH software you have installed. Select the text in the **Value** column and copy it, either by right-clicking it and choosing **Copy** or by using the shortcut Ctrl+C.
5 Open a command prompt and navigate to the PuTTY or SSH installation folder.
6 Paste the command that you copied in step 4 into the command prompt window and press Enter.
7 If asked *Store key in cache?* type `y` and press Enter.
8 Leave the window open until you are finished with your computations. Your ports are only forwarded as long as the SSH session is active, and closing the command prompt will deactivate the session.
9 If you chose *No* as the *Autostart* setting or did not provide a `login.properties` file, you now need to start the COMSOL Multiphysics server manually. To do so,

enter `comsol mphserver` into the command line that has just opened. After entering the command, you are asked to enter a username and a password for your COMSOL Multiphysics server.

ESTABLISH A CONNECTION (COMSOL-USER AND EC2-USER)

You are now ready to connect to the server you have created in the cloud.

1 Open COMSOL Multiphysics 5.6 if you are connecting to a COMSOL Multiphysics server instance or COMSOL Client if you are connecting to a COMSOL Server instance.

2 If you are connecting to a COMSOL Multiphysics installation, follow the two steps below. If you are connecting to a COMSOL Server instance, proceed to step 3 below.

  a Click **File**.

  b Navigate to **COMSOL Multiphysics Server** and click **Connect to Server**.

3 If you have forwarded your port 2036 as shown in the previous section, type `localhost` in the field **Server** and `2036` in the field **Port** (`ec2-user only`). If you set up your instance for HTTP access, type the public DNS name in the field **Server** and `80` in the field **Port** (mandatory for `comsol-user`).

4 Enter the username and password that you used when creating your `login.properties` file or that you specified when starting the COMSOL Multiphysics server manually.

5 Click **OK**.

6 You are now connected. If you get an error message, please refer to the *Troubleshooting* section at the end of this guide.

You can now use COMSOL as you normally would with the added power of the cloud while working as if you were using your local computer.

Disconnecting from the COMSOL Multiphysics Instance

To disconnect from the COMSOL Multiphysics server, follow the steps described below:

1 Click **File**.

2 Navigate to **COMSOL Multiphysics Server** and click **Disconnect from Server**.

3 Choose whether or not you want to save the changes made to your model.

4 If you started the COMSOL Multiphysics server manually, you will be asked if you want to shut down or leave the server running when disconnecting. Click **Shut Down** to shut down the COMSOL Multiphysics server instance.

You have now disconnected from the server.

Shutting Down and Deleting Your Stacks

In this section, you will learn how to remove the instances you have created.

When you are done with your computations, you will need to shut down in order to avoid unnecessary costs. The servers that you have created can also be deleted all at once.

> Deleting the CloudFormation™ stacks will also delete all data on the Amazon™-service-based machines. Remember to save any data that you want to keep.

To be able to delete the license manager stack automatically, you will need to remove all files from the login bucket if you chose to create one when creating the license server. To do this, follow the steps described below.

1 Go to https://console.aws.amazon.com/. Expand the **All services** section. Locate the **Storage** section and click **S3**. Open the Amazon S3™ bucket created with the license server.

2 Click the Amazon S3™ bucket created with your license server.

3 Delete all files in the bucket.

You can now continue to the process of removing the servers. The steps described below need to be made for both the COMSOL Multiphysics server stack and the COMSOL license server stack.

1 Go to https://console.aws.amazon.com/. Locate the **Management & Governance** section and click **CloudFormation**.

2 Select the stack you want to delete and click the **Delete Stack** button.

3 Confirm the deletion of the stack by clicking **Yes, Delete**.

4 The deletion process will start and your stack will be removed.

Troubleshooting

- An error message, “The key 'My_KeyPair' does not exist” or “Parameter validation failed: parameter value for parameter name KeyName does not exist.”, occurs when creating a COMSOL license server or COMSOL Multiphysics server.
  The reason for this error is that the AWS™ service did not find any key with the name My_KeyPair. There are three probable causes of this:
  - No key pair has been created yet. For instructions on how to create a key pair, please refer to Step 1 of this guide.
  - You did not select a KeyName from the drop-down list.
  - You are trying to start a COMSOL license server instance or COMSOL Multiphysics server instance in another availability zone than where you created your key pair. Make sure that you are using the same availability zone as you used when creating your key pair. You can change the availability zone with the help of the menu in the upper-right corner of the AWS™ services console.
- The error message “The specified instance type can only be used in a VPC. A subnet ID or network interface ID is required to carry out the request” occurs when creating a COMSOL license server.
  The reason for this error is that when using a t2.micro instance for your COMSOL license server, you need to have a default Virtual Private Cloud™ (VPC™) service configured for your account. You can solve this in one of the following two ways:
  - Change the instance type of your COMSOL license server to t1.micro by entering the value `t1.micro` in the **InstanceType** field (see section Creating a COMSOL® License Server Instance for Use with the EC2™ Service).
  - Contact AWS™ service support to configure a default VPC™ service for your AWS™ service account. For information on how to do this, refer to http://aws.amazon.com/vpc/faqs/ and the question “I really want a default VPC for my existing EC2 account. Is that possible?”
- The error message: “The following resource(s) failed to create: [COMSOLInstanceWaitCondition]. Rollback requested by user.” occurs when creating a COMSOL Multiphysics or COMSOL Server instance.
  The most common cause of this error message is that the COMSOL Multiphysics or COMSOL Server installer is unable to contact the license server. This is, in most cases, solved in one of the following two ways. First make sure to have submitted the canonical ID of your AWS account to the COMSOL web page as described in section Adding the Canonical ID. Unless you have done this, you will not be able

to install COMSOL software on Amazon EC2 and see the error message from above.

- If you are forwarding access to your on-premise license server, make sure that the SSH tunnel and the port forwarding are active. If you have closed the command prompt window or terminal window where the port forwarding was active, restart it to provide the COMSOL Multiphysics or COMSOL Server instance with access to your on-premise license server.
- If you are using a cloud-based license server with a dedicated license file, make sure that you have uploaded the license file to the Amazon S3™ bucket that you specified in the CloudFormation template. Also make sure that the license file is named `license.dat` using all lowercase letters, since the CloudFormation scripts are case sensitive.
- Make sure that you chose the correct *LicenseType* during the COMSOL Multiphysics or COMSOL Server instance creation. Choosing a *Multiphysics* license type for a COMSOL Server license and vice versa will result in the error message from above.

• When trying to connect to your COMSOL Multiphysics server, this takes a lot of time and you finally get the error message “Failed to connect to server”.
  - If you specified any different port than the HTTP port 80, check whether your local network permits outbound traffic on that particular port.
  - If you specified HTTP port 80, check if you put parameter 6.e *Allow HTTP* to *yes* during the creation of your COMSOL Multiphysics server instance in the section Creating a COMSOL Multiphysics or COMSOL Server Instance.