
















# Architecture & Deployment

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## Hello SSH

In this series of exercises, you will learn to use the `ssh` command to connect to a remote server, and how to copy files to and from such a server using various tools.



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## Legend

Parts of this exercise are annotated with the following icons:

-  A task you **MUST** perform to complete the exercise
-  An optional step that you may perform to make sure that everything is working correctly, or to set up additional tools that are not required but can help you

-  The end of the exercise
-  The architecture of the software you ran or deployed during this exercise.
-  Troubleshooting tips: how to fix common problems you might encounter

## ! Connect to the exercise server

---

An SSH exercise server has been prepared so that you can learn to use the `ssh` command and other SSH-based tools. You should have received a username and password for this course by email.

As we've seen, the basic syntax of the SSH command is as follows:

```
$> ssh <username>@<hostname>
```

To connect to the server:

- Determine the SSH command to connect to the exercise server. Replace the `<username>` placeholder by the username you received in your email, and the `<hostname>` placeholder by `ssh.archidep.ch`.
- Execute that command in your console.
- Since you are probably connecting to this server for the first time, you should get the initial SSH connection warning indicating that the authenticity of the host cannot be established.

Before accepting, you should verify that the key fingerprint in the warning message corresponds to one of the keys provided by the teacher.

ⓘ Answering yes without checking the key fingerprint exposes you to a potential man-in-the-middle attack. An attacker could make you connect to a

compromised server and then intercept all traffic going through the SSH connexion, including your password.

- Enter or paste your password when prompted.

### Tip

The password's characters will not appear as you type or after pasting. This is a feature, not a bug. Passwords are not displayed to make it harder for someone looking over your shoulder to read them.

You should now be connected to the server. You should see a welcome banner giving you some information about the server's operating system, and the prompt should have changed. Any command you type is now executed on the remote server.

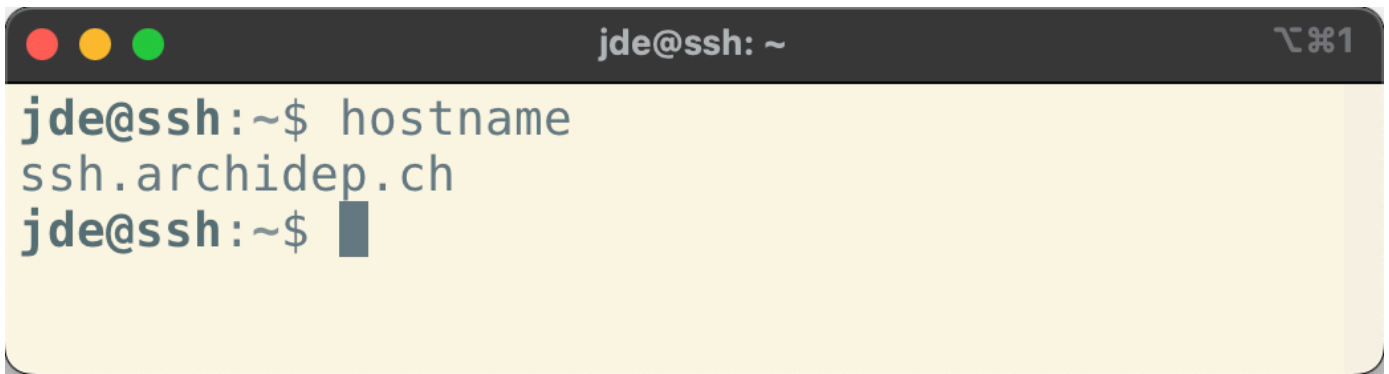
## ? Spot the difference

Run the following commands on the server:

- `hostname`
- `whoami`

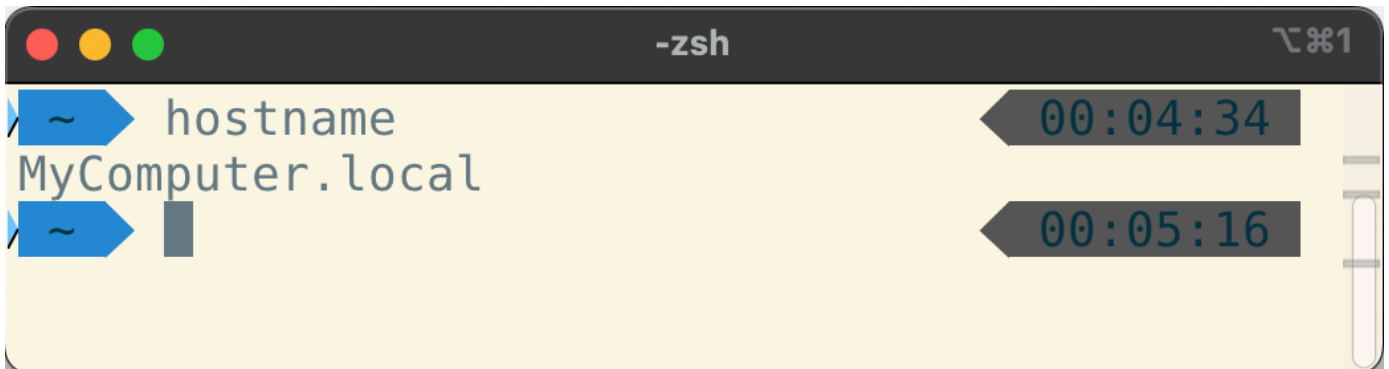
Open another console and run these commands again. Since this is a fresh console, they will be executed on your local machine this time. Observe the difference in output when you are connected to the server or running the commands on your local machine.

Connected to an SSH server



```
jde@ssh: ~  
jde@ssh:~$ hostname  
ssh.archidep.ch  
jde@ssh:~$
```

On your local machine



```
~> hostname 00:04:34  
MyComputer.local  
~>
```

### More information

The `hostname` command prints the network name of the computer you are running it on. This is likely to be different on your local machine than on the SSH exercise server.

Another interesting command to run to see the difference between your machine and the server is the `uname` command. Try running it on the server and your machine. Read the documentation and try some of its options to get more information about your machine and the server.

### Tip

If you want to quickly run a command on a remote server with SSH and immediately disconnect, you can do so by providing more arguments to the SSH command:

```
$> ssh <username>@<hostname> [command]
```

For example, assuming your username is `jde`, open a new console and execute the following commands:

```
$> ssh jde@ssh.archidep.ch hostname
ssh.archidep.ch

$> hostname
MyComputer.local
```

You can see from the output that the first command was run on the server, but that you are no longer connected by the time you ran the second command.

## ! Copy a file with the `scp` command

---

**Disconnect from the server** (with the `exit` command) or open a new console to run commands on your local machine.

Create a simple text file (using the following command or with your favorite text editor):

```
$> echo World > hello.txt
```

All Unix systems have a `cp` (copy) command that copies a file locally. Try it now:

```
$> cp hello.txt hello2.txt
```

Observe that the file has been copied (either by listing the files in your console with the following command, or simply by looking at the directory in your file explorer):

```
$> ls
hello.txt
```

```
hello2.txt
```

```
...
```

The `scp` (secure copy) command works in principle like the `cp` command, except that it can copy files to and from other computers that have an SSH server running, using SSH to transfer the files. It reuses part of the same syntax as the `ssh` command to connect to an SSH server. Try running this command now (replacing `jde` with your username on the SSH exercise server):

```
$> scp hello.txt jde@ssh.archidep.ch:hello.txt
hello.txt 100% 4 0.6KB/s 00:00
```

This command copies your local `hello.txt` file to the home directory of the `jde` user account on the remote computer.

To check that the file has indeed been copied, connect to your server and use some of the commands you have learned so far:

```
$> ssh jde@ssh.archidep.ch
```

```
$ ls
hello.txt
...
```

```
$ cat hello.txt
World
```

```
$ exit
```

You can also copy files from the remote computer to your local computer:

```
$> scp jde@ssh.archidep.ch:hello.txt hello3.txt
hello.txt 100% 4 5.7KB/s 00:00
```

```
$> cat hello3.txt
```

```
World
```

### Tip

Here's a few additional examples of how to use the `scp` command:

- `scp foo.txt jde@192.168.50.4:bar.txt`

Copy the local file `foo.txt` to a file named `bar.txt` in `jde`'s home directory on the remote computer.

- `scp foo.txt jde@192.168.50.4:`

Copy the file to `jde`'s home directory with the same file name.

- `scp foo.txt jde@192.168.50.4:/tmp/foo.txt`

Copy the file to the absolute path `/tmp/foo.txt` on the remote computer.

- `scp jde@192.168.50.4:foo.txt jsmith@192.168.50.5:bar.txt`

Copy the file from one remote computer to another.

- `scp -r foo jde@192.168.50.4:foo`

**Recursively** (the `-r` option) copy the contents of directory `foo` to the remote computer (a recursive copy means that the directory and all its subdirectories are copied).

# ! Copy a file using the SFTP protocol

---

SFTP is an alternative to the original FTP protocol to transfer files. Since FTP is insecure (e.g. passwords are sent unencrypted), SFTP is an alternative that goes through SSH's secure channel and therefore poses fewer security risks.

Most modern FTP clients support SFTP. Here's a couple:

- [FileZilla](#)
- [WinSCP](#)
- [Cyberduck](#)

Many code editors also have SFTP support available through plugins.

Install one of these applications (or use your favorite SFTP application if you already have one) and connect to the SSH exercise server. You will need to configure a connection with the following information:

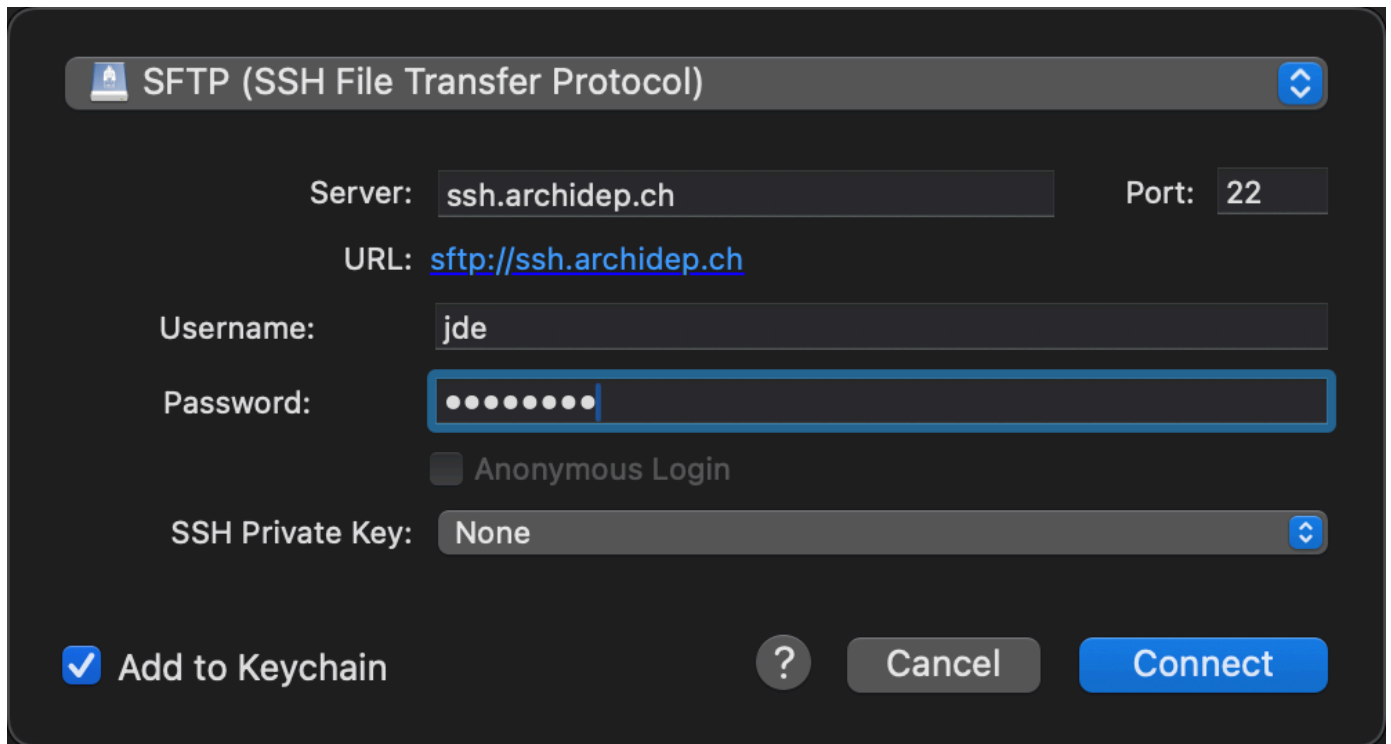
- **Protocol:** SFTP
- **Host, hostname or server address:** `ssh.archidep.ch`
- **Username:** the username you received by email
- **Password:** the password you received by email
- **Port:** 22 (the standard SSH port)

## Tip

How to use these parameters depends on which application you use. They may not be named exactly like this.

For example, here's how to do it with Cyberduck:





SFTP (SSH File Transfer Protocol)

Server:  Port:

URL: <sftp://ssh.archidep.ch>

Username:

Password:

☐ Anonymous Login

SSH Private Key:

☒ Add to Keychain ? Cancel Connect

### Warning

When connecting for the first time, the application may issue the same initial connection warning as when you connect using the command line. Be sure to check the key fingerprint.

Once you have successfully connected to the server, copy another file to the server using the SFTP application this time. These applications will usually allow you to drag-and-drop files to and from the server. Play with it a bit and see what you can do.

Now you know another way to copy files over SSH.

## Set up public key authentication

The goal of this step is to generate a public/private key pair on your machine and to configure SSH to use public key authentication instead of password authentication on the SSH exercise server.

This will improve security and avoid having to type your password on each SSH connection.

## ? Do I already have a key pair?

By default, SSH keys are stored in the `.ssh` directory in your home directory:

```
$> ls ~/.ssh  
id_ed25519  id_ed25519.pub
```

If you have the `id_ed25519` and `id_ed25519.pub` files, you're good to go, since SSH expects to find your main `Ed25519` private key at `~/.ssh/id_ed25519`. You might also have a default key pair using another algorithm, such as an `ECDSA` key pair with files named `id_ecdsa` and `id_ecdsa.pub`, or an `RSA` key pair with files named `id_rsa` and `id_rsa.pub` if your system has an older SSH client.

### Tip

On Windows, you can toggle the display of hidden files in the View tab of the explorer to access your `.ssh` directory manually.

On macOS, type `open ~/.ssh` in your Terminal or use the `Cmd-Shift-.` shortcut to display hidden files.

On most Linux distributions, the file manager will have an option to show hidden files under its menu.

If the directory doesn't exist or is empty, you don't have a key pair yet.

### Note

You may have a key with a different name, e.g. `github_rsa` & `github_rsa.pub`, as it is sometimes generated by some software. You can use this key if you want, but since it doesn't have the default name, you will have to add a `-i ~/.ssh/github_rsa` option to all your SSH commands. Generating a new key with the default name for command line use would probably be easier.

# ! Generate a private-public key pair



Perform this step on your local machine, not on the SSH exercise server.

If you do not already have a key pair, you should generate one for the rest of the exercise and the course. You will use the `ssh-keygen` command.



## More information

The `ssh-keygen` command is usually installed along with SSH and can generate a key pair for you. It will ask you a couple of questions about the key:

- Where do you want to save it? Simply press enter to use the proposed default location (`~/.ssh/id_ed25519` for an Ed25519 key, `~/.ssh/id_rsa` for an RSA key, etc).
- What password do you want to protect the key with? Enter a password or simply press enter to use no password.

Simply running `ssh-keygen` with no arguments will ask you the required information and generate a new key pair using your SSH client's default algorithm:

```
$> ssh-keygen
Generating public/private ed25519 key pair.
Enter file in which to save the key (/home/jde/.ssh/id_ed25519):
Created directory '/home/jde/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/jde/.ssh/id_ed25519.
Your public key has been saved in /home/jde/.ssh/id_ed25519.pub.
The key fingerprint is:
SHA256:MmwL9n4K0UCuLoyvGJ7nWRDXjTSGAX08AcCNVqmDJH0 jde@497820feb22a
The key's randomart image is:
```

```

+---[ED25519 256]---+
|.0===00+          |
|.=.0E++ +         |
|= 00 .00 .        |
|. = 00             |
| +.0 = S           |
| . 0.= +           |
|= +.0              |
|*0..0+ .           |
|+*+0 00            |
+-----[SHA256]-----+

```

### Tip

If you choose to enter a passphrase, you will not see anything in your terminal when you type it. This is intentional, so that no one looking over your shoulder can read it.



### Should I protect my key with a password?

If you enter no password, your key will be stored **in the clear**. This will be convenient as you will not have to enter a password when you use it. However, any malicious code you allow to run on your machine could easily steal it.

If your key is protected by a password, you can run an SSH agent to unlock it only once per session instead of every time you use it.

You can verify that a key has indeed been created by listing the contents of the SSH directory:

```

$> ls ~/.ssh
id_ed25519 id_ed25519.pub

```

## ! Use `ssh-copy-id` to copy your public key to the server

---

The `ssh-copy-id` command uses the same syntax as the `ssh` command to connect to another computer (e.g. `ssh-copy-id jde@example.com`). Instead of opening a new shell, however, it will **copy your local public key(s) to your user account's `authorized_keys` file** on the target computer.

Execute that command now (replacing `jde` with your username):

```
$> ssh-copy-id jde@ssh.archidep.ch
```

You will probably have to enter your password, so that `ssh-copy-id` can log in and copy your key. But once that is done, **SSH should switch to public key authentication** and you should not have to enter your password again to log in. SSH will use your private key to authenticate you instead. (You may have to enter your private key's password though, if it is protected by one.)

### More information

Once you have set up public key authentication for an SSH server, that server is in possession of your public key. Your SSH client can then use your private key to prove that you are the owner of this public key, using the mathematical relationship between the two. Your private key is never sent to the server during this process.

Connect with the `ssh` command again to see public key authentication in action:

```
$> ssh jde@ssh.archidep.ch
```

If it worked, the connection should now open without asking for a password. Your user account is still secured: authentication was performed transparently by your SSH client, using your private key.

## ? The `authorized_keys` file

Now that you are connected to the server, you can check that your public key was added to your user's `authorized_keys` file:

```
$> ls ~/.ssh  
authorized_keys
```

```
$> cat ~/.ssh/authorized_keys  
ssh-rsa AAAAB3NzaC1yc2EAA... example
```

When your SSH client connects to the SSH server, the server will look for your public key (or keys) in this file and ask the SSH client to prove that it owns one of the keys (using the corresponding private key which rests on your local machine) using asymmetric cryptography.

The private key is never transmitted, and this new authentication process is transparent, handled automatically for you by the SSH client and server, hence why you no longer have to enter a password.



You can also create the `authorized_keys` file manually. Note that both the file and its parent directory must have permissions that make it accessible only to your user account, or the SSH server will refuse to use it for security reasons. The following commands can set up the file on the target machine:

```
$> mkdir -p ~/.ssh && chmod 700 ~/.ssh  
$> touch ~/.ssh/authorized_keys  
$> chmod 600 ~/.ssh/authorized_keys
```

The `chmod` command changes the permission of files. We will learn more about this command later on in the course.

# ! Configure your SFTP application to use public key authentication

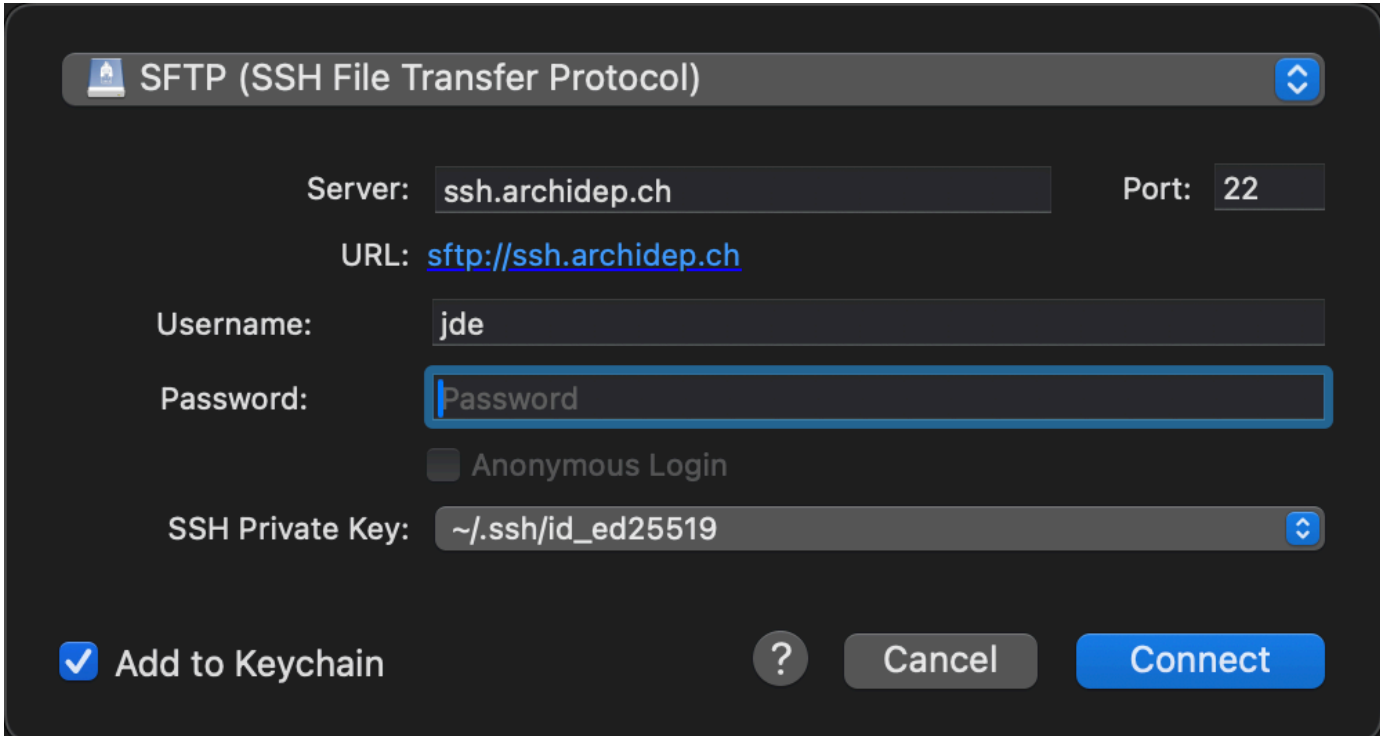
Most SFTP applications also support SSH public key authentication instead of password authentication. Open the SFTP application you used earlier, find out how to replace your password by public key authentication, and try it.

You can remove your password once you have selected your private key, since public key authentication will be used instead of your password.

## Tip

You will need to provide the SFTP application with the location of your **private key**. The application will use the private key to prove that it owns the public key located in the server's `authorized_keys` file.

For example, Cyberduck allows you to select your default key file:



SFTP (SSH File Transfer Protocol)

Server:  Port:

URL: <sftp://ssh.archidep.ch>

Username:

Password:

☐ Anonymous Login

SSH Private Key:

☒ Add to Keychain

## Tip

On macOS, depending on which application you use, you may not see hidden files and directories (file names starting with a dot `.`) when browsing the file system. Use the `Cmd-Shift-.` shortcut to display them.

On Windows, you can toggle the display of hidden files in the View tab of the explorer.

On most Linux distributions, the file manager will have an option to show hidden files under its menu.

## ? SSH agent

If you use a **private key that is password-protected**, you lose part of the convenience of public key authentication: you don't have to enter a password to authenticate to the server, but **you still have to enter the key's password** to unlock it.

### Tip

If you did not set a passphrase when generating your key, you can also [add a passphrase afterwards](#).

The `ssh-agent` command can help you there. It runs a helper program that will let you unlock your private key(s) once, then use it multiple times without entering the password again each time.



There are several ways to run an SSH agent:

- [How to use ssh-agent for authentication on Linux / Unix](#)
- [Generating a new SSH key and adding it to the ssh-agent \(GitHub\)](#)
- [Single sign-on using SSH](#)



You may already have an SSH agent running. Run the `ssh-add -l` command to `list (-l)` unlocked keys:

- If you get an error message, it probably means that SSH agent is not running, for example:

```
$> ssh-add -l
Could not open a connection to your authentication agent.
```

- If it tells you that you have no identities, it means that SSH agent is running but that you have not unlocked any keys yet:

```
$> ssh-add -l
The agent has no identities.
```

If SSH agent is not already running, follow one of the guides above or run an agent and have it start a new shell for you:

```
$> ssh-agent bash
```

The advantage of this last technique is that the agent will automatically quit when you exit the shell, which is good since it's not necessarily a good idea to keep an SSH agent running forever for security reasons.

Once you have your agent running, the associated `ssh-add` command will take your default private key (e.g. `~/.ssh/id_ed25519`) and prompt you for your password to unlock it:

```
$> ssh-add
Enter passphrase for /Users/jde/.ssh/id_ed25519:
Identity added: /Users/jde/.ssh/id_ed25519 (...)
```

The **unlocked key** is now **kept in memory by the agent**. The `ssh` command (and other SSH-related commands like `scp`) will not prompt you for that key's password as long as the agent keeps running.

If you want to load another key than the default one, you can specify its path:

```
$> ssh-add /path/to/custom_id_ed25519
```

## What have I done?

---

You have learned to use the `ssh` command to connect to a remote server, and also to use the SSH protocol through other tools such as `scp` or your favorite SFTP client to copy files.

You have learned to configure and use public key authentication instead of the less secure password-based authentication mechanism.

If you are more security-minded, you may have also learned to protect your private key with a passphrase and to use SSH agent to make it more convenient to use SSH.

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