

ECE 5745 Complex Digital ASIC Design

Tutorial 0: Remote Access to ecelinux

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Contents

1	Introduction	3
2	Connecting to the Cornell VPN	3
3	Remote Access via PowerShell	4
3.1	Starting and Configuring PowerShell	4
3.2	Logging into ecelinux Servers with PowerShell	4
4	Remote Access via Mac Terminal	6
4.1	Starting and Configuring Mac Terminal	6
4.2	Logging into ecelinux Servers with Mac Terminal	6
5	Remote Access via VS Code	7
5.1	Installing VS Code on Your Laptop/Workstation	7
5.2	Starting and Configuring VS Code	8
5.3	Logging into ecelinux Servers with VS Code	9
5.4	Using VS Code	10
5.5	Troubleshooting Remote Access via VS Code	11
6	Remote Access via X2Go	12
6.1	Installing X2Go on Your Laptop/Workstation	12
6.2	Starting and Configuring X2Go	14
6.3	Logging into ecelinux Servers with X2Go	14
6.4	Logging out of ecelinux Servers with X2Go	14
6.5	Troubleshooting Remote Access via X2Go	17
7	Remote Access via MobaXterm	17
7.1	Installing MobaXterm on Your Windows Laptop/Workstation	17
7.2	Starting and Configuring MobaXterm	17
7.3	Logging into ecelinux Servers with MobaXterm	18

8 Remote Access via Mac Terminal with XQuartz	19
8.1 Installing XQuartz on Your Mac OS X Laptop/Workstation	19
8.2 Starting and Configuring Mac Terminal	19
8.3 Logging into <i>eceLinux</i> Servers with Mac Terminal	20
9 Linux Text Editors	20
9.1 Using the Micro Text Editor	21
9.2 Using the Geany Text Editor	22
9.3 Other Editors	23
10 Sourcing the Course Setup Script with Auto Setup	23

1. Introduction

All of the laboratory/programming assignments and the design project for this course will be completed by remotely logging into a cluster of *ecelinux* servers. The *ecelinux* servers all run the Red Hat Enterprise Linux 7 operating system, and they all use an identical setup. You do not need to do anything special to create an *ecelinux* account. You will be using your NetID and Cornell password to login, and an *ecelinux* account will be automatically created for you when you first login. Any student enrolled in any ECE class should automatically be granted access to the *ecelinux* servers. Having said this, if you cannot log into the *ecelinux* servers please reach out to the course staff for assistance.

Later tutorials will discuss how to use the Linux development environment and the Git distributed version control system. In this tutorial, we focus on how to setup remote access to the *ecelinux* servers by first connecting to the Cornell VPN and then choosing one of several different remote access options. Which remote access option to use depends on your operating system, whether or not you are planning to use Linux applications with a graphical user interface (GUI), the speed of your network connection, and your own personal preference. The following table provides a summary of these remote access options.

Remote Access Option	Operating System	Can use Linux command line?	Can use Linux applications with a GUI?	Internet Speed Requirements
Section 3: PowerShell	Windows	Yes	No	Low
Section 4: Mac Terminal	Mac OS X	Yes	No	Low
Section 5: VS Code	either	Yes	No	Very Low
Section 6: X2Go	either	Yes	Yes	Medium
Section 7: MobaXterm	Windows	Yes	Yes	High
Section 8: Mac Terminal w/ XQuartz	Mac OS X	Yes	Yes	High

We recommend at least trying to use PowerShell or the Mac Terminal as your first attempt at remote access to ensure your connection is working. Using PowerShell or the Mac Terminal can be quite primitive though, so we recommend primarily using these as backup options throughout the course in case you are having trouble with the other options. **We strongly recommend using VS Code as your primary remote access option for code development, and then using X2Go only if you need to use a Linux application with a GUI.** MobaXterm or Mac Terminal with XQuartz are also perfectly fine options, but they are only feasible if you are on a relatively high-speed internet connection to the *ecelinux* servers (i.e., on the Campus network).

2. Connecting to the Cornell VPN

If you are logging into the *ecelinux* servers from on campus (i.e., using the Cornell wired or wireless network), then you do not need to enable the Cornell virtual private network (VPN). However, if you are off campus, then you will need to enable the Cornell VPN whenever you want to log into the *ecelinux* servers. The VPN provides very secure access to all on-campus network resources. More information about the Cornell VPN is available here:

- <https://it.cornell.edu/cuvpn>

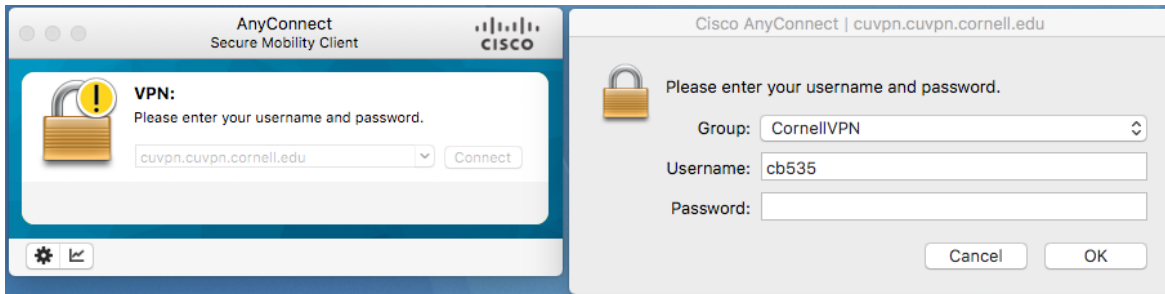


Figure 1: Running the Cisco AnyConnect Client for Cornell VPN

Simply follow the instructions at the following link to install the Cisco VPN software for the appropriate operating system you use on your laptop/workstation:

- <https://it.cornell.edu/articles/topics/2605/all/822>

Once the Cornell VPN is installed, then connect to the Cornell VPN by following these instructions and using your Cornell NetID and password:

- <https://it.cornell.edu/articles/topics/2605/all/823>

The Cornell VPN uses the Cisco AnyConnect Client, and Figure 1 illustrates running the client.

3. Remote Access via PowerShell

PowerShell is part of Windows OS, and it enables interacting with your Windows OS system from the command line (i.e., a powerful text-based environment where users type commands to manipulate files and directories and execute applications). PowerShell also enables remotely accessing other systems (e.g., the *ecelinux* servers) via the command line using SSH, a highly secure network protocol and associated client/server program. PowerShell will enable you to log into the *ecelinux* servers and to then manipulate files and directories and execute applications remotely on the *ecelinux* servers using the Linux command line. Note that PowerShell does not enable using Linux applications with a GUI. If you need to use a Linux application with a GUI, you will need to choose a different remote access option (e.g., X2Go described in Section 6 or MobaXterm described in Section 7).

3.1. Starting and Configuring PowerShell

First, if you are off campus, then you must be connected to the Cornell VPN before attempting to use X2Go to access the *ecelinux* servers (see Section 2). To start PowerShell click the *Start* menu then choose *Windows PowerShell > Windows PowerShell* (you might need to look under *_All Programs > Accessories_*), or click the *Start* menu, type *PowerShell*, and choose *Windows PowerShell*.

The default blue background for PowerShell can be a little annoying. You can change the background to black or white by right clicking on the PowerShell window's title bar and then choose *Properties > Colors*, select *Screen Background*, click the black or white color, and click *OK*.

3.2. Logging into *ecelinux* Servers with PowerShell

After starting PowerShell, type in the following command at the prompt to log into the *ecelinux* servers using SSH.

```

ra462@en-ec-ecelinux-12:~
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Users\Rohan Agarwal> ssh ra462@ecelinux.ece.cornell.edu
ra462@ecelinux.ece.cornell.edu's password:
Last login: Fri Oct 9 17:02:13 2020 from vpnuser-128-84-35-150.cuvpn.cornell.edu
*****
                THIS SERVER IS FOR INSTRUCTIONAL USE ONLY
                ABSOLUTELY NO RESEARCH SHOULD BE DONE ON THIS SERVER

                JOBS RUNNING LONGER THAN 30 MINUTES MAY BE KILLED WITHOUT WARNING

                System Maintenance
Tuesday and Thursday mornings between 5am and 7 am. System may reboot during these
times. Faculty may request postponement of this maintenance by sending an
email to itcoecis-help@cornell.edu
*****
[ra462@en-ec-ecelinux-12 ~]$ source setup-ece5745.sh
ECE5745: ~ %

```

Figure 2: PowerShell After Logging Into *ecelinux* Servers

```
% ssh netid@ecelinux.ece.cornell.edu
```

Replace *netid* with your Cornell NetID in the command above. You should not enter the % character. We use the % character to indicate what commands we should enter on the command line. Executing the command will prompt you to enter your Cornell NetID password, and then you should be connected to the *ecelinux* servers.

The very first time you log into the *ecelinux* servers you may see a warning like this:

```

The authenticity of host 'ecelinux.ece.cornell.edu (128.253.51.206)' can't be established.
ECDSA key fingerprint is SHA256:smwMnf9dyhs5zW5I279C5oJBrTFc5FLghIJMfBR1cxI.
Are you sure you want to continue connecting (yes/no)?

```

The very first time you log into the *ecelinux* servers it is okay to enter *yes*, but from then on if you continue to receive this warning please contact the course staff.

Once you have opened a terminal, the very first thing you need to do after logging into the *ecelinux* servers is source the course setup script. This will ensure your environment is setup with everything you need for working on the laboratory/programming assignments. Enter the following command on the command line:

```
% source setup-ece5745.sh
```

Again, you should not enter the % character. You should now see a blue *ECE 5745* in your prompt which means your environment is setup for the course. Figure 2 shows what your prompt should look like if you have sourced the course setup script. See Section 10 for more on how to automatically source the setup script every time you log into the *ecelinux* servers, and see Section 9 for more on text editors you can use in the course.

4. Remote Access via Mac Terminal

Mac Terminal is part of Mac OS X, and it enables interacting with your Mac OS X system from the command line (i.e., a powerful text-based environment where users type commands to manipulate files and directories and execute applications). Mac Terminal also enables remotely accessing other systems (e.g., the *ecelinux* servers) via the command line using SSH, a highly secure network protocol and associated client/server program. Mac Terminal will enable you to log into the *ecelinux* servers and to then manipulate files and directories and execute programs remotely on the *ecelinux* servers using the Linux command line. Note that Mac Terminal (by default) does not enable using Linux applications with a GUI. If you need to use a Linux application with a GUI, you will need to choose a different remote access option (e.g., X2Go described in Section 6 or Mac Terminal with XQuartz described in Section 8).

4.1. Starting and Configuring Mac Terminal

First, if you are off campus, then you must be connected to the Cornell VPN before attempting to use X2Go to access the *ecelinux* servers (see Section 2). To start Mac Terminal go to your *Applications* folder and choose *Utilities > Terminal.app*, or open Spotlight, type *Terminal*, and press enter.

4.2. Logging into *ecelinux* Servers with Mac Terminal

After starting Mac Terminal, type in the following command at the prompt to log into the *ecelinux* servers using SSH.

```
% ssh netid@ecelinux.ece.cornell.edu
```

Replace *netid* with your Cornell NetID in the command above. You should not enter the % character. We use the % character to indicate what commands we should enter on the command line. Execut-

```

en-ec-ecelinux-01: ~ — e: ~ — ssh cb535@ecelinux.ece.cornell.edu — 103x25
[cbatten-mac % ssh cb535@ecelinux.ece.cornell.edu
[cb535@ecelinux.ece.cornell.edu's password:
Last login: Fri Feb 26 12:37:59 2021 from vpnuser-10-41-248-90.cuvpn.cornell.edu
*****
                THIS SERVER IS FOR INSTRUCTIONAL USE ONLY
                ABSOLUTELY NO RESEARCH SHOULD BE DONE ON THIS SERVER

                JOBS RUNNING LONGER THAN 30 MINUTES MAY BE KILLED WITHOUT WARNING

                System Maintenance
                Tuesday and Thursday mornings between 5am and 7 am. System may reboot during these
                times. Faculty may request postponement of this maintenance by sending an
                email to itcoecis-help@cornell.edu
                *****
en-ec-ecelinux-01 % source setup-ece5745.sh
ECE5745: ~ %

```

Figure 3: Mac Terminal After Logging Into *ecelinux* Servers

ing the command will prompt you to enter your Cornell NetID password, and then you should be connected to the *ecelinux* servers.

The very first time you log into the *ecelinux* servers you may see a warning like this:

```
The authenticity of host 'ecelinux.ece.cornell.edu (128.253.51.206)' can't be established.  
ECDSA key fingerprint is SHA256:smwMnf9dyhs5zW5I279C5oJBrTFc5FLghIJMfBR1cxI.  
Are you sure you want to continue connecting (yes/no)?
```

The very first time you log into the *ecelinux* servers it is okay to enter *yes*, but from then on if you continue to receive this warning please contact the course staff.

Once you have opened a terminal, the very first thing you need to do after logging into the *ecelinux* servers is source the course setup script. This will ensure your environment is setup with everything you need for working on the laboratory/programming assignments. Enter the following command on the command line:

```
% source setup-ece5745.sh
```

Again, you should not enter the % character. You should now see a blue ECE 5745 in your prompt which means your environment is setup for the course. Figure 3 shows what your prompt should look like if you have sourced the course setup script. See Section 10 for more on how to automatically source the setup script every time you log into the *ecelinux* servers, and see Section 9 for more on text editors you can use in the course.

5. Remote Access via VS Code

While combining PowerShell (see Section 3) or Mac Terminal (see Section 4) with a text-based editor such as Micro can certainly work, it is not the most productive development setup. We strongly recommend using VS Code as your primary remote access option for code development (this Section), and then using X2Go only if you need to use a Linux application with a GUI (see Section 6). VS Code offers a nice balance of productive features while also working well with moderate internet speeds.

VS Code uses a unique approach where the GUI interface runs completely on your local laptop/workshop and then automatically handles copying files back and forth between your local laptop/workshop and the *ecelinux* servers. VS Code is portable across many operating systems and has a thriving ecosystem of extensions and plugins enabling it to function as a full-featured IDE for languages from C to Javascript. More information about VS Code is here:

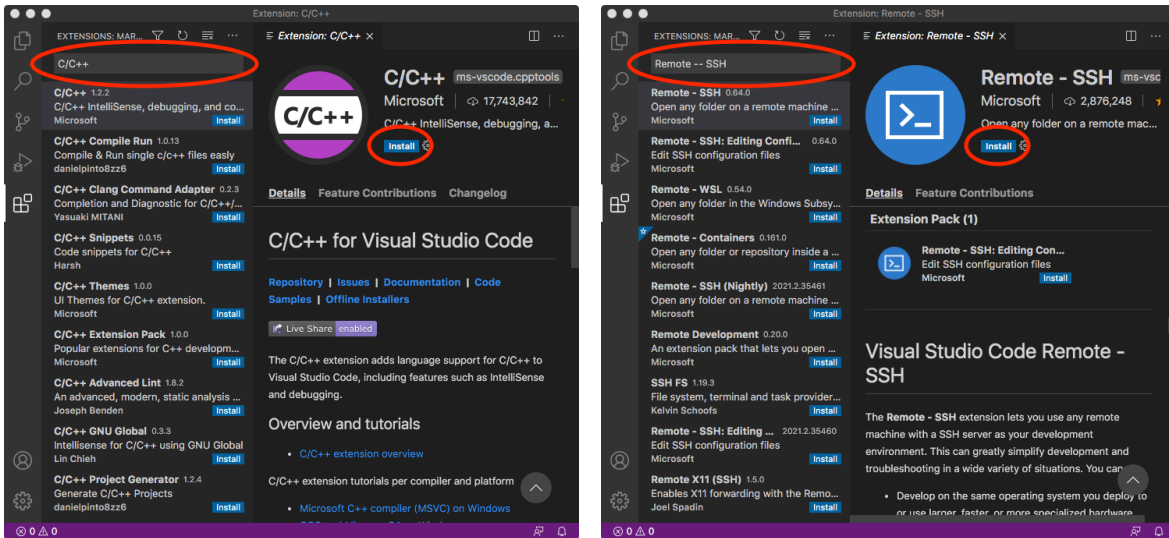
- <https://code.visualstudio.com>
- <https://code.visualstudio.com/docs>

5.1. Installing VS Code on Your Laptop/Workstation

You can download VS Code by simply going to the main VS Code webpage:

- <https://code.visualstudio.com>

There should be an obvious link that says “Download for Windows” or “Download for Mac”. Click on that link. On Mac OS X, you will need to drag the corresponding *Visual Student Code.app* to your *Applications* folder.



(a) C/C++ Extension

(b) Remote - SSH Extension

Figure 4: Installing Extensions in VS Code

5.2. Starting and Configuring VS Code

First, if you are off campus, then you must be connected to the Cornell VPN before attempting to use X2Go to access the *ecelinux* servers (see Section 2). Start by opening VS Code. The exact way you do this will depend on whether you are using a Windows or Mac OS X laptop/workstation.

The key to VS Code is installing the correct extensions. You will need extensions for the C/C++, Python, and Verilog languages in this course. We also want to install a special extension which will enable remotely accessing the *ecelinux* servers using SSH. Choose *View > Extensions* from the menubar. Enter the name of the extension in the “Search Extensions in Marketplace” and then click the blue *Install* button. Here are the names of the extensions to install:

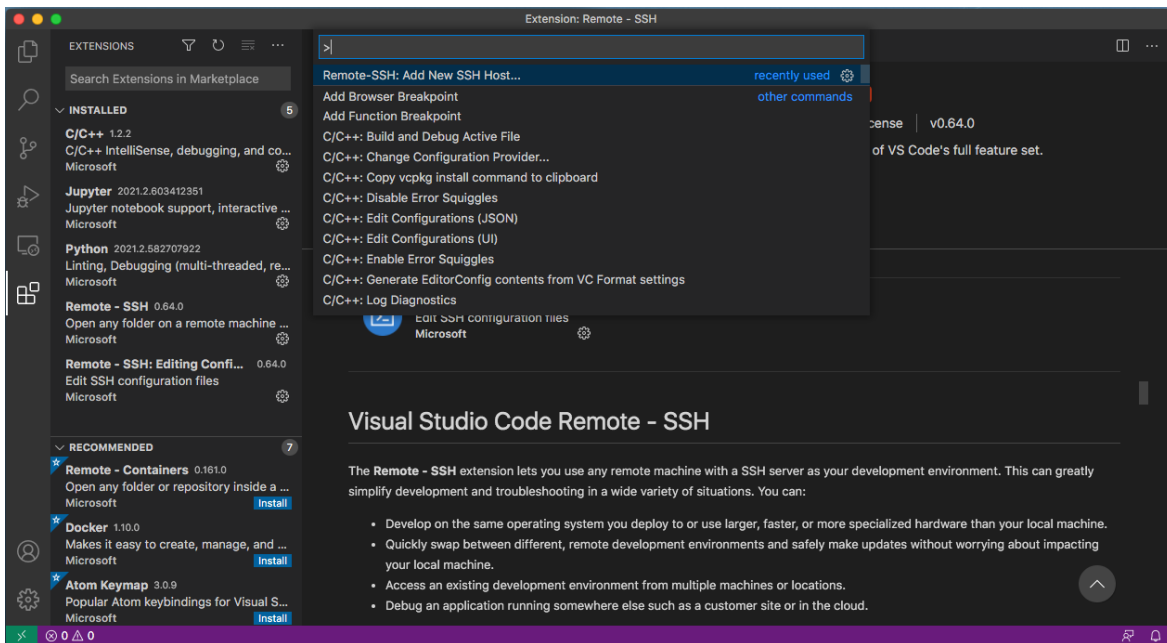
- C/C++
- Python
- Verilog
- Remote - SSH

For the C/C++, Python, and Remote - SSH extensions it is critical to choose the extension developed by Microsoft. You should see the name Microsoft in the extension description. Figure 4 illustrates how to install these extensions.

Now we need to setup the connection between VS Code which will run on your local laptop/workstation and the *ecelinux* servers. Choose *View > Command Palette* from the menubar. This will cause a little “command palette” to drop down where you can enter commands to control VS Code. Enter the following command in the command palette:

```
Remote-SSH: Add new SSH host...
```

As you start typing matching commands will be displayed and you can just click the command when you see it. VS Code will then ask you to *Enter SSH Connection Command*, and you should enter the following:

Figure 5: Logging into *ecelinux* Servers with VS Code

```
ssh netid@ecelinux.ece.cornell.edu
```

Replace *netid* with your Cornell NetID in the command above. VS Code will then ask you to *Select SSH configuration file to update* with a drop-down list of options. You should choose something like this on Windows:

```
C:\Users\username\.ssh\config
```

Or something like this on Mac OS X:

```
/Users/username/.ssh/config
```

A little pop-up dialog box in the lower right-hand corner might say *Host added!*. You can click the *X* to make this pop-up dialog box go away. You should now be all set to log into the *ecelinux* servers.

5.3. Logging into *ecelinux* Servers with VS Code

After starting VS Code, choose *View > Command Palette* from the menubar. Enter the following command in the command palette:

```
Remote-SSH: Connect Current Window to Host..
```

As you start typing matching commands will be displayed and you can just click the command when you see it. VS Code will then ask you to *Select configured SSH host or enter user@host*, and you should choose this from the drop-down list:

```
ecelinux.ece.cornell.edu
```

If you are on a Windows, then you may see a pop-up which stays that the *Windows Defender Firewall as blocked some features of this app*. This is not a problem. Simply click *Cancel*.

You might also see a drop down which asks you to choose the operating system of the remote server with options like *Linux* and *Windows*. Choose *Linux*.

Finally, the very first time you log into the *ecelinux* servers you may see a warning like this:

```
"ecelinux.ece.cornell.edu" has fingerprint
"SHA256:smwMnf9dyhs5zW5I279C5oJBrTFc5FLghIJMfBR1cxI".
Are you sure you want to continue?
Continue
Cancel
```

The very first time you log into the *ecelinux* servers it is okay to enter *yes*, but from then on if you continue to receive this warning please contact the course staff.

Hopefully, VS Code will now prompt you to enter your Cornell NetID password, and then you should be connected to the *ecelinux* servers.

Also the very first time you log into the *ecelinux* servers you will see a pop up dialog box in the lower right-hand corner which says *Setting up SSH host ecelinux.ece.cornell.edu (details) Initializing....* It might take up to a minute for everything to be setup; please be patient! Once the pop up dialog box goes away and you see *SSH: ecelinux.ece.cornell.edu* in green in the lower left-hand corner of VS Code then you know you are connected to the *ecelinux* servers.

The final step is to make sure your extensions for C/C++, Python, and Verilog are also installed on the server. Choose *View > Command Palette* from the menubar. Search for the same C/C++, Python, and Verilog extensions we installed earlier. When you find these extensions instead of saying *Install* it should now say *Install in SSH: ecelinux.ece.cornell.edu*. Install all three language extensions on the *ecelinux* servers.

5.4. Using VS Code

VS Code includes an integrated file explorer which makes it very productive to browse and open files. Choose *View > Explorer* from the menubar, and then click on *Open Folder*. VS Code will then ask you to *Open File Or Folder* with a default of `/home/netid`. Click *OK*.

You might see a pop-up which asks you *Do you trust the authors of the files in this folder?* Since you will only be browsing your own files on the *ecelinux* server, it is fine to choose *Yes, I trust the authors*.

This will reload VS Code, and you should now you will see a file explore in the left sidebar. You can easily browse your directory hierarchy, open files by clicking on them, create new files, and delete files.

VS Code includes an integrated terminal which will give you access to the Linux command line on the *ecelinux* servers. Choose *Terminal > New Terminal* from the menubar. You should see the same kind of Linux command line prompt that you saw when using either PowerShell or Mac Terminal. The very first thing you need to do after logging into the *ecelinux* servers is source the course setup script. This will ensure your environment is setup with everything you need for working on the laboratory/programming assignments. Enter the following command on the command line:

```
% source setup-ece5745.sh
```

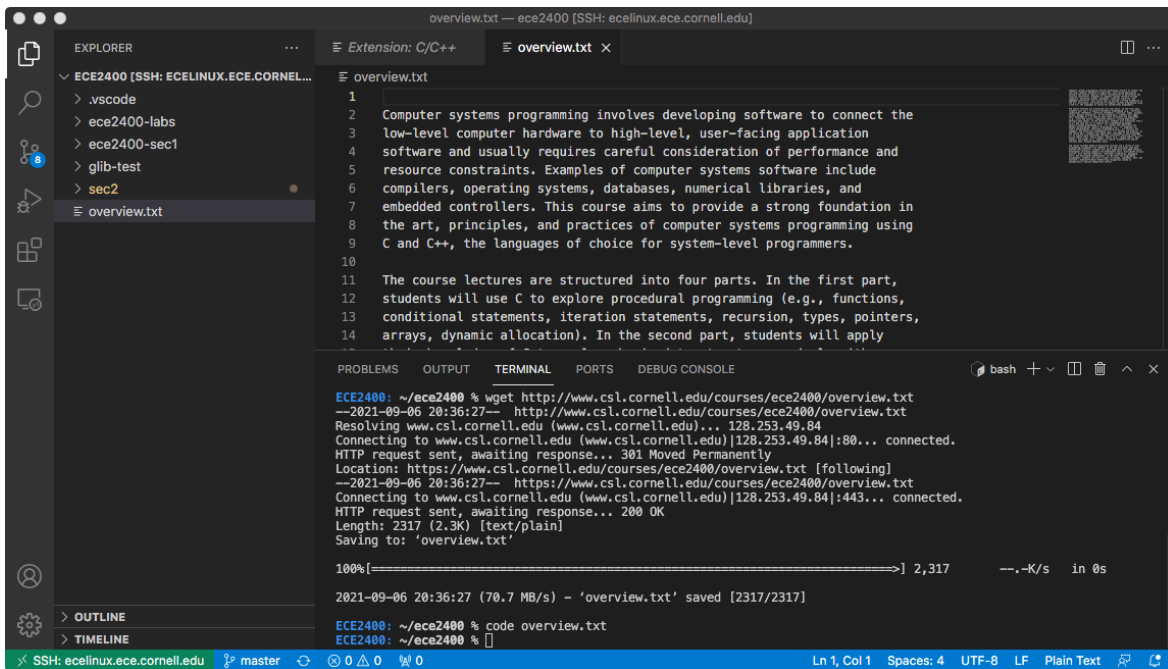


Figure 6: Typical VS Code Session with Terminal, Open File, and File Explorer

Again, you should not enter the % character. You should now see a blue ECE 5745 in your prompt which means your environment is setup for the course. See Section 10 for more on how to automatically source the setup script every time you log into the *ecelinux* servers.

To experiment with VS Code, we will first grab a text file using the `wget` command. The next tutorial discusses this command in more detail. Type the following command in the VS Code integrated terminal.

```
% wget http://www.csl.cornell.edu/courses/ece5745/overview.txt
```

You can open a file in the integrated text editor using the `code` command like this:

```
% code overview.txt
```

Figure 6 shows what VS Code should look like if you have sourced the course setup script and opened the `overview.txt` file. Notice how the `overview.txt` file opened in a new tab at the top and the terminal remains at the bottom. This enables you to have easy access to editing files and the Linux command line at the same time.

5.5. Troubleshooting Remote Access via VS Code

There may be issues where sometimes VS Code just keeps asking you for your password or VS Code just hangs when you try and connect to the *ecelinux* servers. This might mean VS Code is getting wedged. You can definitely ask the course staff to help, but you can also try to fix it on your own. One thing to try is to delete the `.vscode-server` directory on the sever. Of course, how can you delete this directory if you cannot use VS Code to access the *ecelinux* servers? You can use PowerShell (see Section 3) or Mac Terminal (see Section 4) to log into the *ecelinux* servers.

Once you have gained access to the Linux command line on the *ecelinux* servers using either PowerShell or Mac Terminal, then you can delete the `.vscode-server` directory like this:

```
% rm -rf .vscode-server
```

Be very careful with the `rm` command since it can permanently delete files!

Sometimes VS Code can take a very long time to save a C/C++ file. This is usually because VS Code is trying to auto-format the C/C++ file on the *ecelinux* servers. To turn off auto-formatting, open the VS Code settings menu. On Windows, choose *File > Preferences > Settings* from the menubar. On Mac OS X, choose *Code > Preferences > Settings* from the menubar. Click on *Text Editor* and then *Formatting*. Make sure *Format On Save* is not checked.

6. Remote Access via X2Go

The X2Go remote access option is useful when you want to run a Linux application with a GUI. So for example, if you want to look at waveforms using GTKWave, look at layout using KLayout, or look at your chip using Cadence Innovus. X2Go is a separate application that you install on your local laptop or workstation. Then you setup a session, and you can use X2Go to log into the *ecelinux* servers. X2Go will provide students with a Linux remote desktop on the *ecelinux* server and enable students to open terminals for working at the command line, use text editors for developing code, and run other GUI programs for analyzing and/or evaluating your code. More information about X2Go is available here:

- <https://wiki.x2go.org>

6.1. Installing X2Go on Your Laptop/Workstation

On Mac OS X, you will need to install XQuartz first. Go to this page, download the DMG, and then install XQuartz.

- <https://www.xquartz.org>

After installing, you should reboot your laptop/workstation and then try starting XQuartz. The very first time you might need to right click on the XQuartz application and explicitly choose *open* from the pop-up menu. This tells Mac OS X that you really do want to run this application even though you downloaded it from the internet. After doing this once, you can open XQuartz just by double clicking it, and/or X2Go will start it automatically if necessary.

The next step for both Windows and Mac OS X is to download and install the X2Go client for the appropriate operating system you use on your laptop/workstation. Here are direct links for the Windows and Mac OS X operating systems:

- Windows: http://code.x2go.org/releases/X2GoClient_latest_mswin32-setup.exe
- Mac OS X: http://code.x2go.org/releases/X2GoClient_latest_macosx_10_13.dmg

For more information about the installation process, for versions of the X2Go client that can work on older operating systems, or for versions of the X2Go client that work on Linux please see the X2Go documentation:

- <https://wiki.x2go.org/doku.php/download:start>

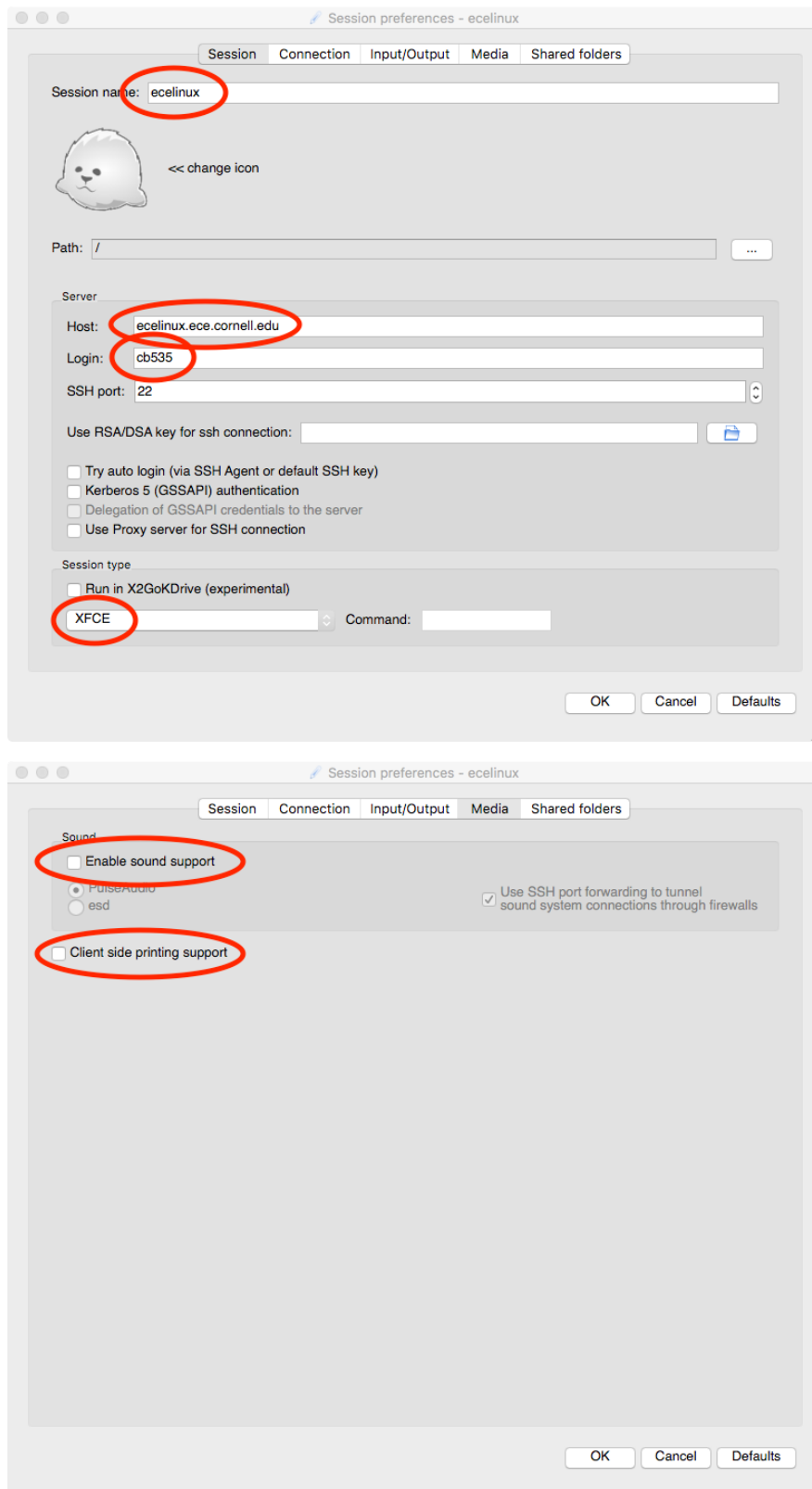


Figure 7: Configuring X2Go to Access ecelinux Servers

6.2. Starting and Configuring X2Go

First, if you are off campus, then you must be connected to the Cornell VPN before attempting to use X2Go to access the *ecelinux* servers (see Section 2). Start by opening the X2Go Client. The exact way you do this will depend on whether you are using a Windows or Mac OS X laptop/workstation.

On Mac OS X, the very first time you might need to right click on the X2Go application and explicitly choose *open* from the pop-up menu. This tells Mac OS X that you really do want to run this application even though you downloaded it from the internet. After doing this once, you can open X2Go just by double clicking it, and/or X2Go will start it automatically if necessary.

After starting X2Go for the first time, a window will appear to set up a new session. Configure the options on the *Session* and *Media* tabs as shown in Figure 7, making sure you carefully change every circled field. In the *Session* tab, for *Session name* enter *ecelinux*; for *Host* enter *ecelinux.ece.cornell.edu*; for *Login* enter your NetID; and choose *XFCE* under *Session type*. In the *Media* tab, make sure *Enable sound support* and *Client side printing support* are not checked. Once you have configured all settings, click *OK*.

6.3. Logging into *ecelinux* Servers with X2Go

After starting X2Go, enter *ecelinux* at the prompt as shown in Figure 8, press enter/return, and enter your NetID password. If you are asked to trust a certificate for the *ecelinux* servers, you must click *yes*. If you receive any kind of warnings on Windows related to firewall configuration you should just cancel that warning.

Once you have successfully logged into the *ecelinux* servers, you should see the Linux remote desktop shown in Figure 9. Note that the Linux remote desktop is running on the *ecelinux* server, so anything you do in the Linux remote desktop is actually happening on the server and not on your local laptop/workstation.

To get to the Linux command line you need to open a new terminal on the Linux remote desktop. You can open a new terminal by choosing *Applications > Terminal Emulator* from the *Applications* menu in the upper-left corner of the Linux remote desktop.

Once you have opened a terminal, the very first thing you need to do after logging into the *ecelinux* servers is source the course setup script. This will ensure your environment is setup with everything you need for working on the laboratory/programming assignments. Enter the following command on the command line:

```
% source setup-ece5745.sh
```

You should not enter the % character. We use the % character to indicate what commands we should enter on the command line. You should now see a blue *ECE 5745* in your prompt which means your environment is setup for the course. Figure 10 shows what your prompt should look like if you have sourced the course setup script. See Section 10 for more on how to automatically source the setup script every time you log into the *ecelinux* servers, and see Section 9 for more on text editors you can use in the course.

6.4. Logging out of *ecelinux* Servers with X2Go

When you are finished working on the *ecelinux* servers you need to explicitly log out. Choose *Applications > Log Out* from the *Applications* menu in the upper-left corner of the Linux remote desktop. Make sure *Save session for future logins* is not checked. Then click on *Log out* to cleanly log out from

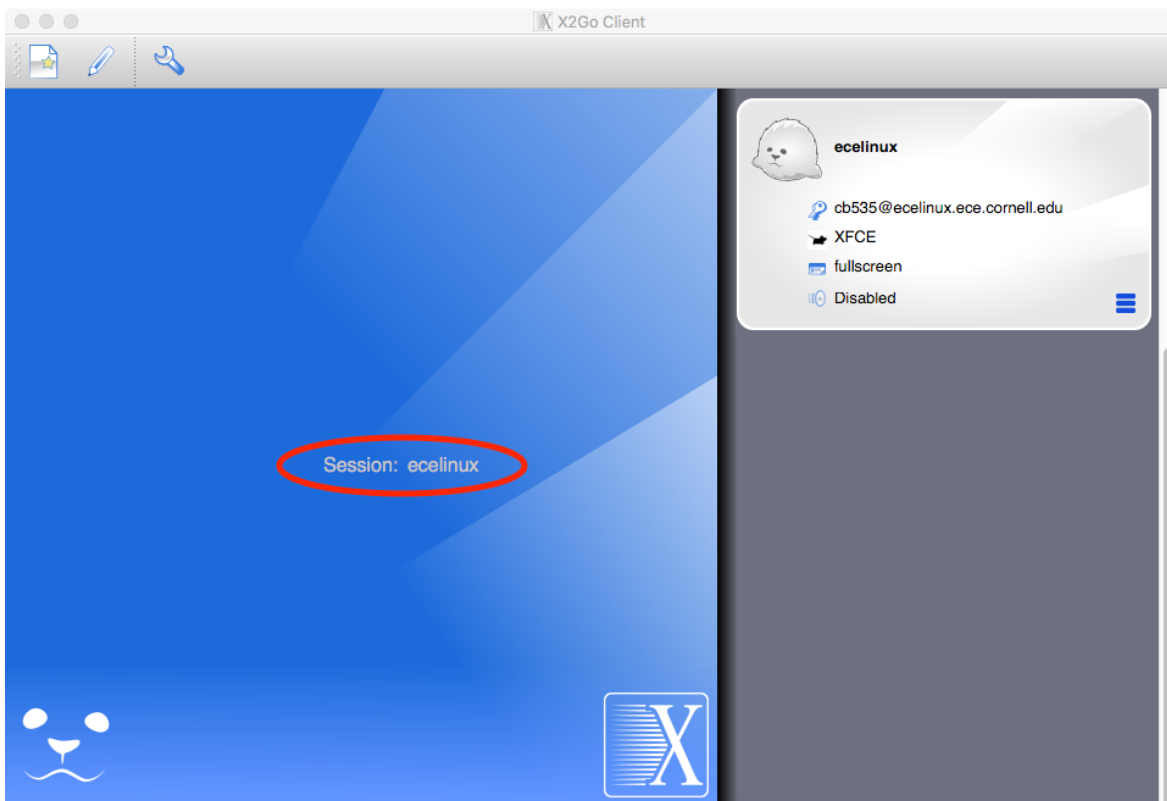


Figure 8: Logging into *ecelinux* Servers with X2Go

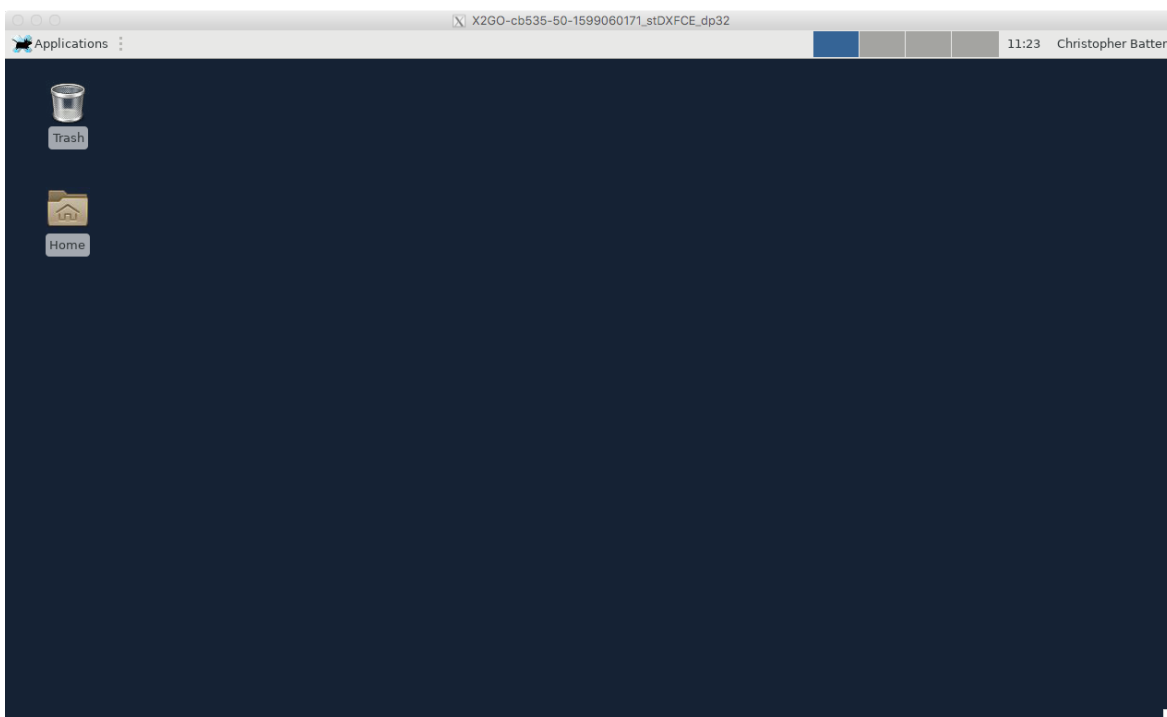


Figure 9: Linux Remote Desktop on *ecelinux* Servers with X2Go

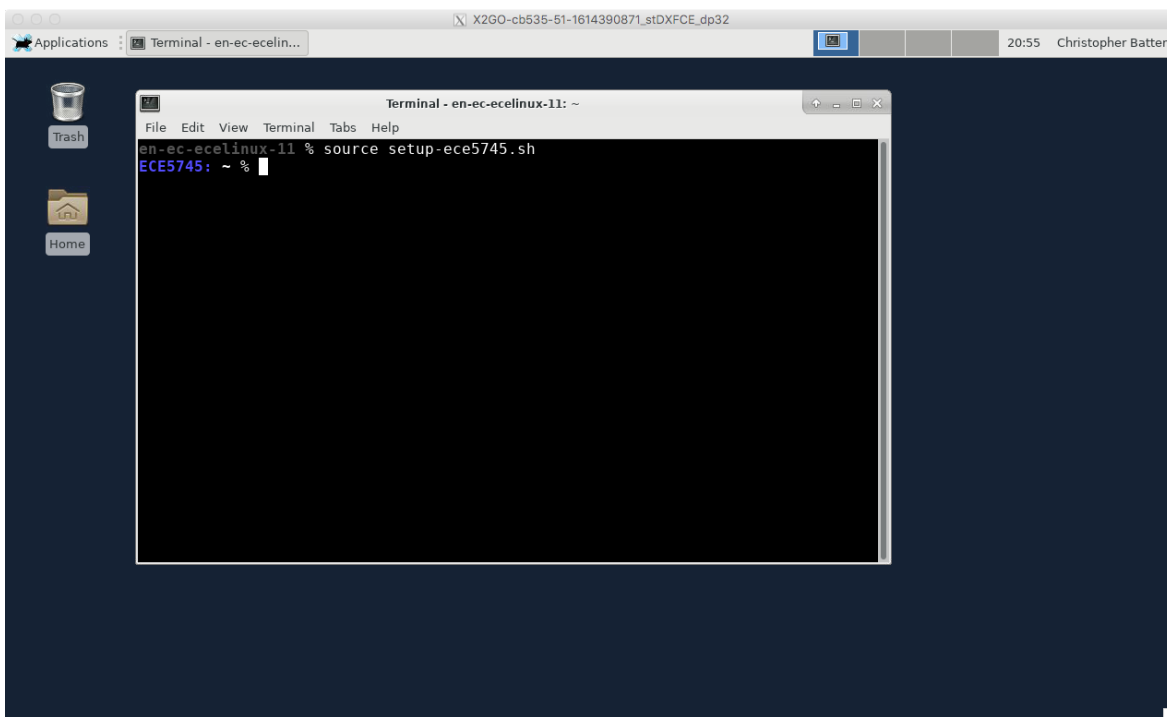


Figure 10: X2Go Terminal After Logging into *eceLinux* Servers

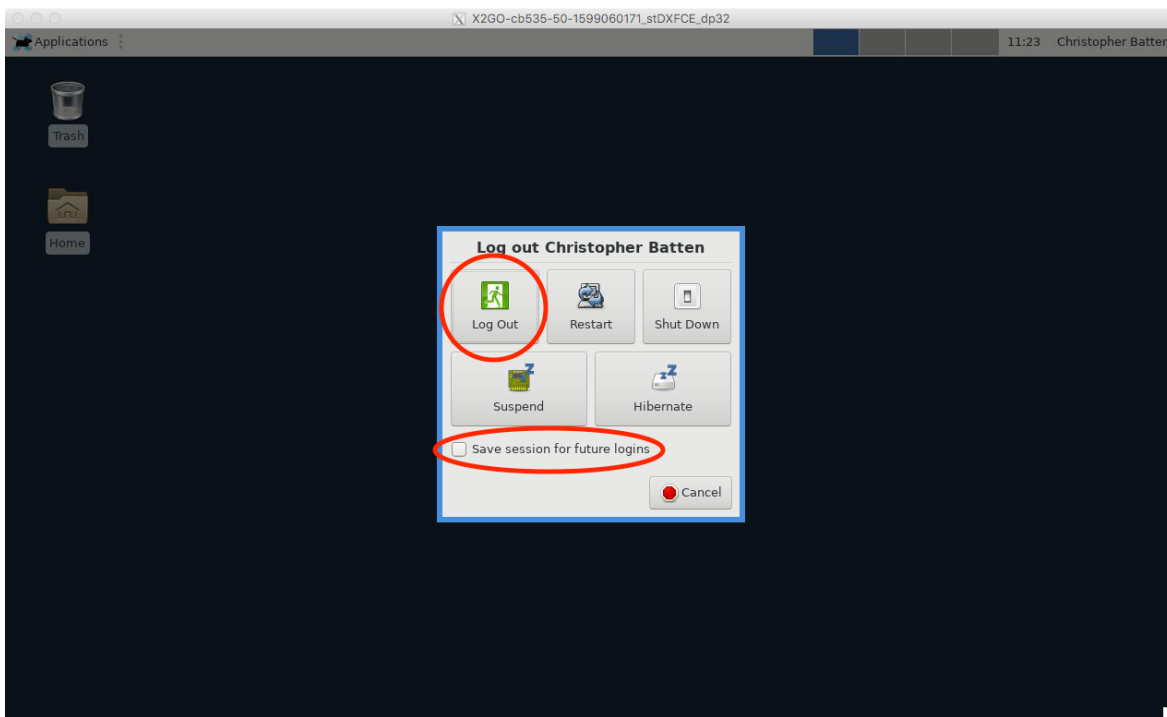


Figure 11: X2Go Logout Dialog Box on *eceLinux* Servers

the *ecelinux* servers (see Figure 11). Obviously, you should save all of your work frequently and before you log out of the *ecelinux* servers.

6.5. Troubleshooting Remote Access via X2Go

The above instructions should work assuming you have a default `.bashrc` file on the *ecelinux* servers. However, if you have taken other courses that use the *ecelinux* servers, then your `.bashrc` may be setup in such a way that it prevents X2Go from connecting to the *ecelinux* servers. The key is that X2Go does not like any output printed to the console when you log into the *ecelinux* servers. So if anything in your `.bashrc` uses `echo` or `print` statements that can cause connections to hang.

You can use Windows PowerShell or Mac Terminal to remotely access the *ecelinux* servers to fix this issue. Once you have used Windows PowerShell or Mac Terminal to get to the Linux command line, you can use the Micro text editor to comment out everything in your `.bashrc` file. Then try remote access via X2Go again. If you are now able to connect, you can try uncommenting parts of your `.bashrc` file to find what setup actions are the culprit.

Note that copy-and-paste from your local laptop to/from X2Go may not work. You might be able to explicitly use the menus to copy-and-paste. This is a known issue without any real work arounds.

If you are using Mac OS X, and you see `â€œSession startedâ€œ` immediately followed by a `â€œConnection timeout, abortingSessionâ€œ` message make sure you have upgraded to the latest version of XQuartz.

7. Remote Access via MobaXterm

Section 3 described how to access the *ecelinux* servers using PowerShell, but this option does not permit using a Linux application with a GUI. If you have not tried the remote access option described in Section 3 then do that now. Linux uses the X11 client/server system to manage GUI applications, so to use a Linux application with a GUI we need to setup an X11 client/server. On Windows we will install the MobaXterm client/server system. Once MobaXterm is installed then we can use it to log into the *ecelinux* servers and start GUI applications. **Note that we actually recommend using X2Go as described in Section 6 if you want to use a Linux application with a GUI, but some students may prefer MobaXterm.**

7.1. Installing MobaXterm on Your Windows Laptop/Workstation

Go to this page, download the installer, then install MobaXterm.

- <http://mobaxterm.mobatek.net/download-home-edition.html>

We recommend using the *Installer Edition*. Right click on the downloaded ZIP archive and choose *Extract all*. Then double click on `MobaXterm_installer`, click *Next* to start the installation, agree to the EULA and click *Next*, click *Next* to install in the default location, click *Install* to start the installation, and click *Finish* to finish the installation.

7.2. Starting and Configuring MobaXterm

First, if you are off campus, then you must be connected to the Cornell VPN before attempting to use MobaXterm to access the *ecelinux* servers (see Section 2). To start MobaXterm click the *Start* menu then choose *All Programs > MobaXterm > MobaXterm*, or click the *Start* menu, type *MobaXterm*, and choose *MobaXterm*.

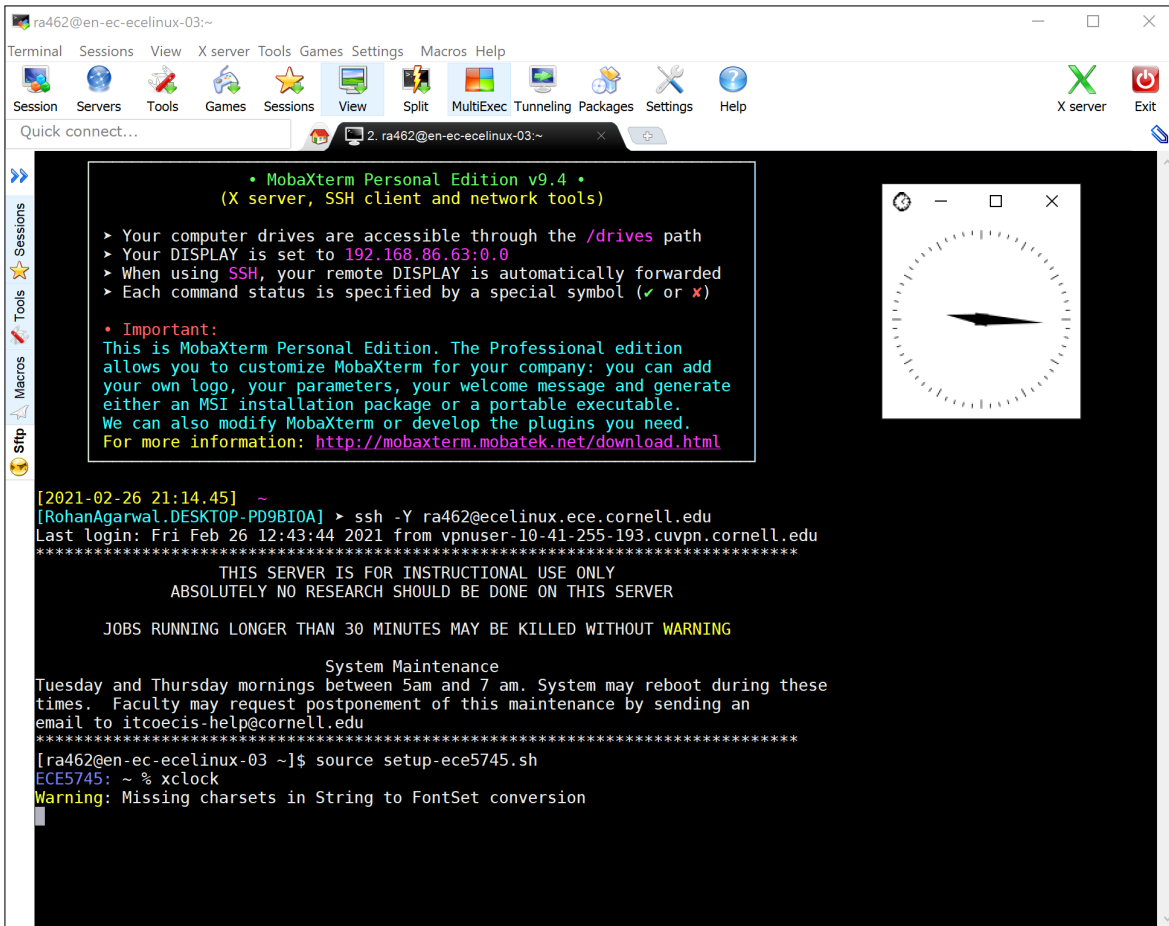


Figure 12: MobaXterm After Logging Into *ecelinux* Servers and Starting `xclock`

We recommend setting the SSH “keep alive signal” to avoid dropping your connection if you are inactive for a certain amount of time. After starting MobaXterm, choose *Settings > Configuration* from the menu, select the *SSH* tab, and make sure the *SSH keepalive* option is checked.

7.3. Logging into *ecelinux* Servers with MobaXterm

After starting MobaXterm, type the following to configure your local laptop/workstation to avoid dropping your connection if you are inactive for a certain amount of time.

```
% echo "Host *.ece.cornell.edu" >> ~/.ssh/config
% echo " ServerAliveInterval 180" >> ~/.ssh/config
```

Then type in the following command at the prompt to log into the *ecelinux* servers using SSH.

```
% ssh -Y netid@ecelinux.ece.cornell.edu
```

Replace `netid` with your Cornell NetID in the command above. This is very similar to what was discussed in Section 3 with the key difference being the `-Y` command line option which enables the X11 client/server system. This system means when you start a GUI application on the *ecelinux*

server, the GUI application is displayed on your laptop/workstation, but the GUI application itself is running on the *ecelinux* servers.

As always, once you have opened a terminal, the very first thing you need to do after logging into the *ecelinux* servers is source the course setup script.

```
% source setup-ece5745.sh
```

You should now see a blue ECE 5745 in your prompt which means your environment is setup for the course. See Section 10 for more on how to automatically source the setup script every time you log into the *ecelinux* servers, and see Section 9 for more on text editors you can use in the course.

To test out the X11 client/server system, we will start a very basic GUI analog clock application on the *ecelinux* server. Type in the following command at the prompt to start the clock application.

```
% xclock
```

Hopefully, you should see a window pop up on your local laptop/workstation displaying an analog clock window. It is critical to understand that while the GUI application is being *displayed* on your local laptop/workstation, the GUI application itself is running on the *ecelinux* servers. Figure 12 shows what your prompt should look like if you have sourced the course setup script and what the analog clock window looks like.

After logging into an *ecelinux* server you will notice that a sidebar appears on the left that shows you the files in your home directory. You can drag files to/from the sidebar and the desktop to easily move files to/from your local Windows laptop/workstation and the *ecelinux* servers. To hide the sidebar choose *View > Show/hide sidebar* from the menu.

8. Remote Access via Mac Terminal with XQuartz

Section 4 described how to access the *ecelinux* servers using Mac Terminal, but this option does not permit using a Linux application with a GUI. If you have not tried the remote access option described in Section 4 then do that now. Linux uses the X11 client/server system to manage GUI applications, so to use a Linux application with a GUI we need to setup an X11 client/server. On Mac OS X we will install the XQuartz client/server system. Once XQuartz is installed then we can use Mac Terminal with a slightly different command line to log into the *ecelinux* servers. **Note that we actually recommend using X2Go as described in Section 6 if you want to use a Linux application with a GUI, but some students may prefer Mac Terminal with XQuartz.**

8.1. Installing XQuartz on Your Mac OS X Laptop/Workstation

Go to this page, download the DMG, and then install XQuartz.

- <https://www.xquartz.org>

After installing, you should reboot your laptop/workstation and then try starting XQuartz. The very first time you might need to right click on the XQuartz application and explicitly choose *open* from the pop-up menu. This tells Mac OS X that you really do want to run this application even though you downloaded it from the internet. After doing this once, you can open XQuartz just by double clicking it, and/or XQuartz will start automatically when necessary.

8.2. Starting and Configuring Mac Terminal

First, if you are off campus, then you must be connected to the Cornell VPN before attempting to use X2Go to access the *ecelinux* servers (see Section 2). To start Mac Terminal go to your *Applications* folder and choose *Utilities > Terminal.app*, or open Spotlight, type *Terminal*, and press enter.

We recommend setting the SSH “keep alive signal” to avoid dropping your connection if you are inactive for a certain amount of time. After starting Mac Terminal, type the following to configure your local laptop/workstation to avoid dropping your connection if you are inactive for a certain amount of time.

```
% echo "Host *.ece.cornell.edu"    >> ~/.ssh/config
% echo "  ServerAliveInterval 180" >> ~/.ssh/config
```

You should only need to do this once.

8.3. Logging into *ecelinux* Servers with Mac Terminal

After starting Mac Terminal, type in the following command at the prompt to log into the *ecelinux* servers using SSH.

```
% ssh -Y netid@ecelinux.ece.cornell.edu
```

Replace *netid* with your Cornell NetID in the command above. This is very similar to what was discussed in Section 4 with the key difference being the *-Y* command line option which enables the X11 client/server system. This system means when you start a GUI application on the *ecelinux* server, the GUI application is displayed on your laptop/workstation, but the GUI application itself is running on the *ecelinux* servers.

As always, once you have opened a terminal, the very first thing you need to do after logging into the *ecelinux* servers is source the course setup script.

```
% source setup-ece5745.sh
```

You should now see a blue *ECE 5745* in your prompt which means your environment is setup for the course. See Section 10 for more on how to automatically source the setup script every time you log into the *ecelinux* servers, and see Section 9 for more on text editors you can use in the course.

To test out the X11 client/server system, we will start a very basic GUI analog clock application on the *ecelinux* server. Type in the following command at the prompt to start the clock application.

```
% xclock
```

Hopefully, you should see a window pop up on your local laptop/workstation displaying an analog clock window. It is critical to understand that while the GUI application is being *displayed* on your local laptop/workstation, the GUI application itself is running on the *ecelinux* servers. Figure 13 shows what your prompt should look like if you have sourced the course setup script and what the analog clock window looks like.

9. Linux Text Editors

Once you have successfully logged into the *ecelinux* servers, gained access to the Linux command line, and sourced the setup script, one of the first things you will want to do is choose a text editor for

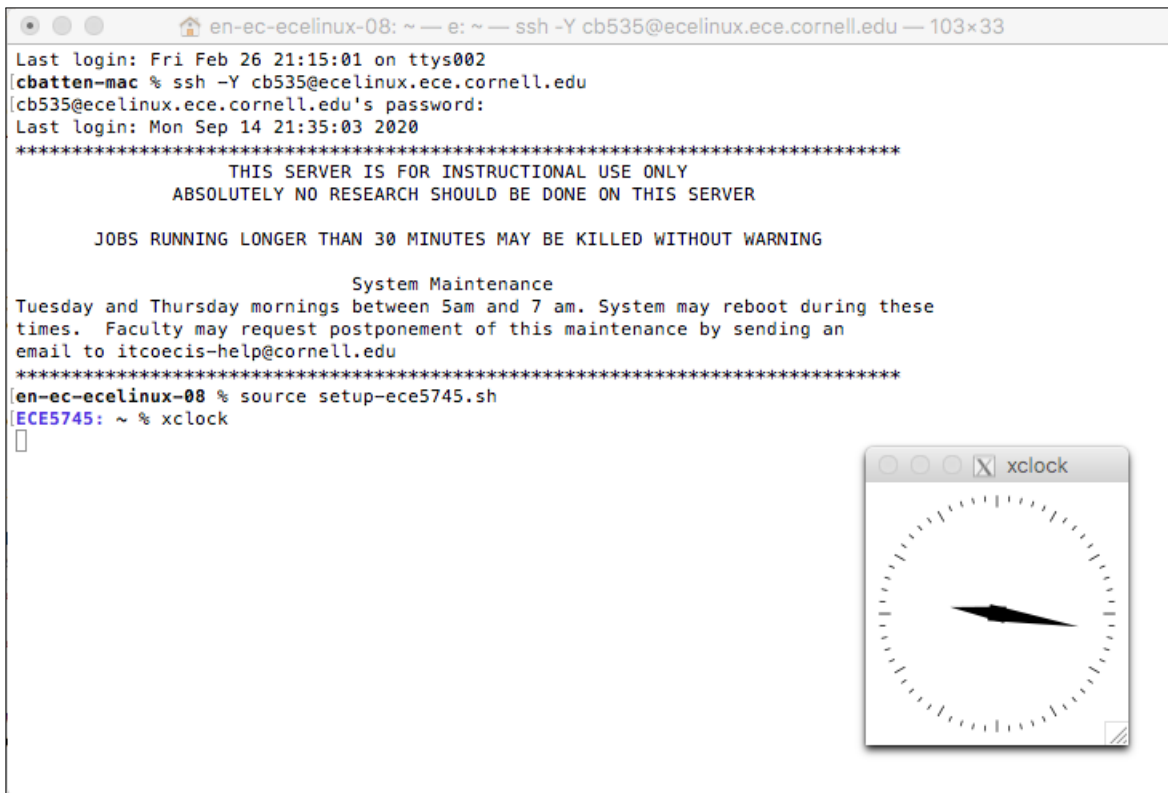


Figure 13: Mac Terminal with XQuartz After Logging Into *ecelinux* Servers and Starting *xclock*

editing code. If you have not gone through one of the remote access options described in Sections 3–8 then do that now. There are two kinds of editors: text-based editors and GUI-based editors. The *text-based editors* work by opening files through the command line and then using the keyboard to navigate the file system, open files, save files, search within files, etc. The *GUI-based editors* work by providing a graphical user interface so that the user can use a mouse to interact with the editor. If you have chosen to use the PowerShell (see Section 3) or Mac Terminal (see Section 4) remote access options then you must use a text-based editor (e.g., Micro). If instead you have used one of the other remote access options then you can use either a text-based editor or a GUI-based editor. Note that if you have chosen to use the VS Code remote access option then there is no need to use a Linux text editor; you can directly use VS Code to remotely edit files on the *ecelinux* servers as described in Section 5.

To experiment with these editors, we will first grab a text file using the `wget` command. The next tutorial discusses this command in more detail.

```
% wget http://www.csl.cornell.edu/courses/ece5745/overview.txt
```

9.1. Using the Micro Text Editor

Micro is a simple text-based editor installed on the *ecelinux* servers. The editor is easy to learn and use. More information about Micro is here:

- <https://micro-editor.github.io>

You can start Micro by typing the command `micro` at the Linux command line and optionally specifying the filename you want to view and edit.

```
% micro overview.txt
```

Use the arrow keys to move the cursor position. Notice that the editor specifies most of the useful commands at the bottom of the terminal screen. The symbol `^` indicates the CONTROL key. To type any text you want, just move the cursor to the required position and use the keyboard. To save your changes press CONTROL+S (i.e., press the CONTROL key and the S key at the same time) and press the <ENTER> key after specifying the filename you want to save to. You can quit by pressing CONTROL+Q. Use CONTROL+G for help.

9.2. Using the Geany Text Editor

Geany (pronounced like “genie”) is a simple GUI-based editor installed on the *ecelinux* servers. Actually, Geany can also be used as an integrated development environment, but in this course we will only use it as a basic text editor. More information about Geany is here:

- <https://www.geany.org>

You can start Geany by typing the command `geany` at the Linux command line and optionally specifying the filename you want to view and edit.

```
% geany overview.txt &
```

This should open a new GUI window. If you get an error about your display, you probably do not have your X11 client/server system setup correctly. Please revisit either Sections 6, 7, or 8 depending on which remote access option you are using. Note that we have added a `&` symbol at the end of the command. This special symbol starts the graphical program in the background enabling you to continue to use the terminal. Navigating, editing, and saving files is very simple in Geany.

See Figure 14 for a screenshot of a typical Geany session. Geany has a relatively straight-forward GUI. You can open and save files using the *File* menu or toolbar. We recommend you take the following steps to configure Geany for use in this course:

- Make sure *View > Show message window* is unchecked. We will not need the message window in this course.
- Choose *Edit > Preferences* from the menu, then *Editor > Features*, and set the *Line breaking column* to be 74. Then click OK.
- Choose *Edit > Preferences* from the menu, then *Editor > Indentation*, and set the *Width* to be two and the *Type* to be *Spaces*. Then click OK.
- Choose *Tools > Plugin Manager* from the menu, and make sure *File Browser* and *Split Window* are checked. Then click *Close*.
- Choose *Edit > Preferences* from the menu, then *Interface > Interface*, and set the font family and size next to *Editor* based on your own personal preference (or leave the default for now).

After completing these configuration step, the side panel includes an integrated file browser. You can display the file browser by clicking on the *Files* tab at the top of the sidebar. If the *Files* tab is not visible, you may need to click on the small right/left arrows at either side of the tabs (see Figure 14). Double-clicking on a file in the file browser will open the file in a new tab.

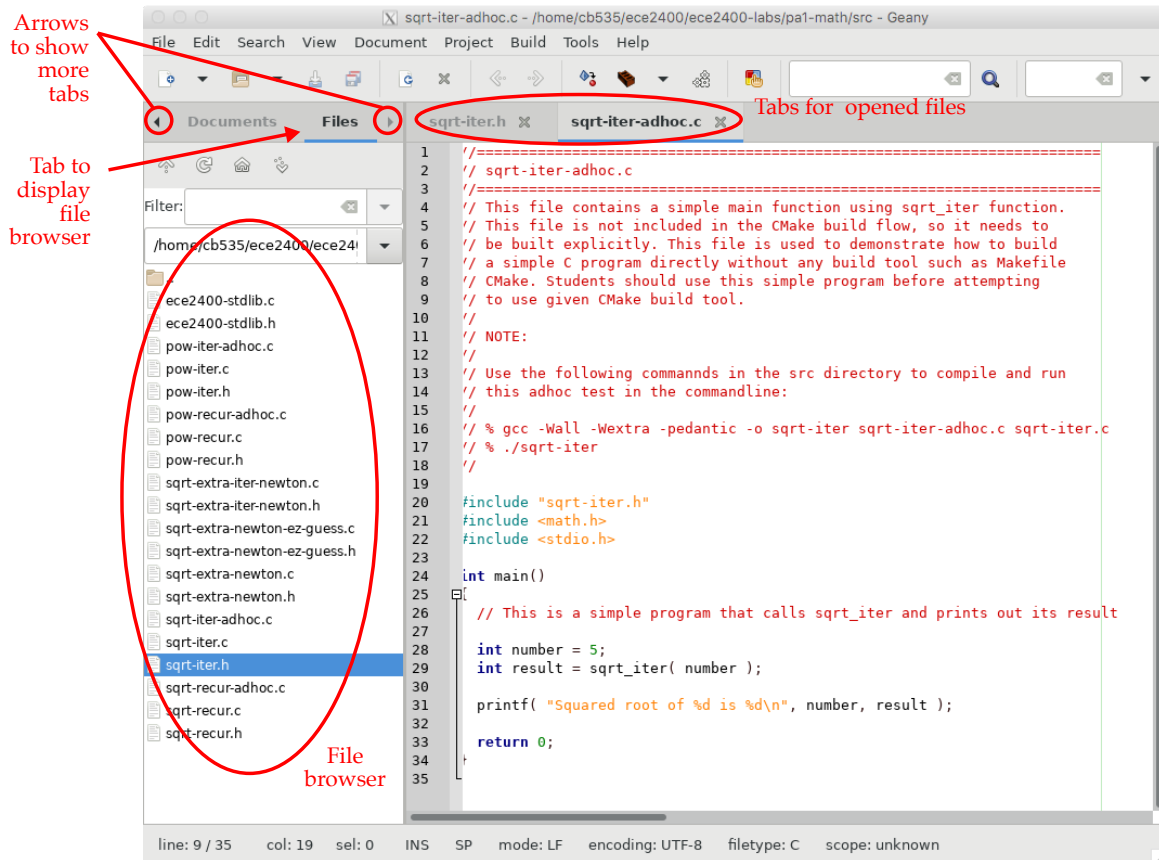


Figure 14: Geany GUI-Based Editor

Geany has a nice feature where it can enable splitting the window into two side-by-side panels with different files opened in each panel. To turn on split windowing, choose *Tools > Split Window > Side by Side* from the menu. Then click on the small downward arrow in the right-hand panel and choose an open file to display in this extra panel. You can also of course just open two Geany windows. Having both your source and testing code open at the same, side-by-side, can be very powerful.

9.3. Other Editors

While Micro and Geany editors are easy to learn, students that anticipate using Linux in the future beyond this course might want to use a more powerful text-based editor such as `emacs` or `vim`. Both also have GUI equivalents. By default `emacs` will start the GUI, while using the `-nw` command line option will enable non-graphical mode. `vim` is purely non-graphical, but `gvim` is the graphical equivalent. It is beyond the scope of this tutorial to teach you the usage of these editors, but most advanced Linux users use one of these more powerful text editors for development.

10. Sourcing the Course Setup Script with Auto Setup

Each of the previous sections have demonstrated how to remotely access the *ecelinux* servers, get to the Linux command line, and source the course setup script. **Again, you must source the course**

setup script before doing any work related to this course! The course setup script configures everything so you have the right environment to work on the laboratory/programming assignments.

Since it can be tedious to always remember to source the course setup script, you can also use auto setup which will automatically source the course setup for you when you open a terminal. Note that if the environment for ECE 5745 conflicts with the environment required by a different course then you will need to manually source the setup script when you are working on this course. Enter the following command on the command line to use auto setup:

```
% source setup-ece5745.sh --enable-auto-setup
```

Now completely logout of the *ecelinux* servers then log back in and get to the Linux command line. The exact way to do this depends on which remote access option you using. You should see ECE 5745 in the prompt meaning your environment is automatically setup for the course. If at anytime you need to disable auto setup you can use the following command:

```
% source setup-ece5745.sh --disable-auto-setup
```

Again, if for any reason running the setup script prevents you from using tools for another course, you cannot use the auto setup. You will need to run the setup script manually every time you want to work on a laboratory/programming assignment for this course.

Acknowledgments

This tutorial was developed for the ECE 2400 Computer Systems Programming and ECE 5745 Complex Digital ASIC Design courses at Cornell University by Christopher Batten.