

Lab Session 1: Preparation

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Disclaimer: *These notes have not been subjected to the usual scrutiny reserved for formal publications. They may be distributed outside this class only with the permission of the Instructor.*

1.1 Introduction

In the first lab session, we are going to prepare our working environment to be able to run, develop, modify and debug software for wireless sensor nodes. In this lab we use the Contiki operating system (OS) that is designed to run on small low-power embedded devices.

ContikiOS provides a fully configured development environment that runs as a virtual machine. In this session we install and configure the free VMware Player, run the Contiki Image on it and connect sensor nodes to the Contiki environment to be able to deploy programs.

Note: The lab computers already have VMware Player installed and you should not redo the installation in the Lab.

Equipment and materials:

- ☐ Lab PC or your own computer
- ☐ An XM1000 mote (optional, not required for this lab session)
- ☐ Customized InstantContiki-2.6 image file (available in Lab PC and also online).

1.2 Learning Objectives

We expect you to know the following:

- Knowing what is a virtual machine;
- Knowing the basics of Linux operating system (including launching an application, opening a terminal, changing directory in the terminal, using a text editor, etc.)

In this lab session, you will learn:

- How to edit your code;
- How to run your code on a simulated mote in Cooja simulation;
- Cooja simulation interface;

NOTE: There are several ways you can perform the experiment. Please choose the appropriate option before continuing the experiment:

- ☐ **Option 1:** If you can attend the lab and collect an XM1000 mote, you can run InstantContiki from the PC in the lab and deploy your code to XM1000. You can also run Cooja simulation.
 - ☐ You are accessing the lab PC
 - ☐ You have collected an XM1000 mote
- ☐ **Option 2:** If you can attend the lab and collect an XM1000 mote, and you wish to run InstantContiki from your own computer, you can download our InstantContiki-2.6 image, run it from your own computer, and use it to deploy your code to XM1000. You can also run Cooja simulation.

- ☐ You are accessing the lab PC
- ☐ You have collected an XM1000 mote
- ☐ You can run InstantContiki your own computer now and wish to use it instead
- ☐ **Option 3:** If you cannot attend the lab, then you should download our InstantContiki-2.6 image, run it from your own computer, and use it to deploy your code in Cooja simulation.
 - ☐ You are not in the lab
 - ☐ You do not have an XM1000 mote
 - ☐ You have a computer with an admin account and Internet connectivity

1.3 Copying or Downloading Our Customized InstantContiki Image

It is important to use our customized Contiki image. In the image, we have installed XM1000 platform and created a compatible XM1000 virtual mote for Cooja simulation. Additionally, we have also pre-install all skeleton codes for the lab in the image. If you download InstantContiki images from other sources, you will face problems connecting a physical XM1000 mote and simulating a virtual XM1000.

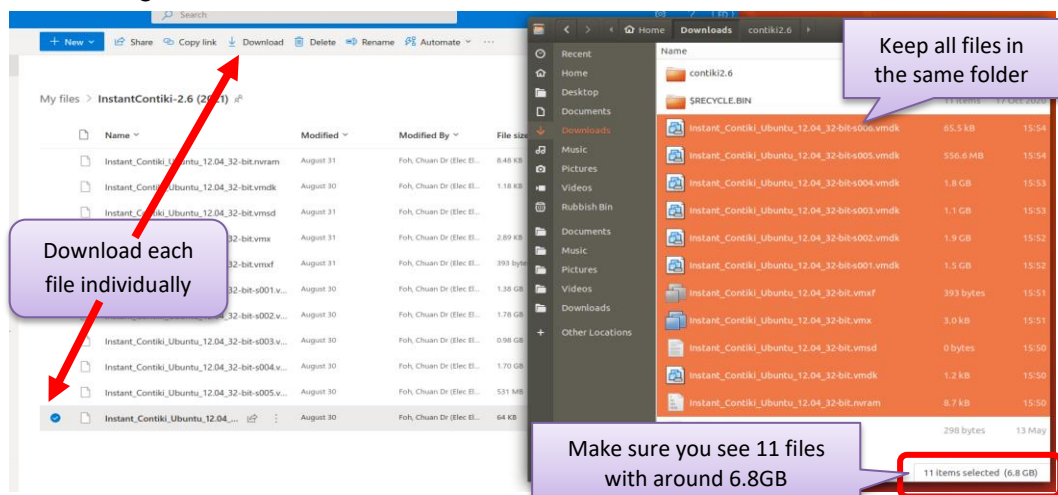
For Option 1 mentioned above, you should copy the image to your Linux user folder in the lab computer. Ideally, you want to create a new folder under your Linux home directory to keep the image, but you can simply keep it in the 'Downloads' folder. To copy to your 'Downloads' folder, open a terminal (press [Ctrl]+[Alt]+[T]) and type the following:

```
$ cp -rp /vol/research/tas_lnx_labpkgs/EEEM048 ~/Downloads
```

If you face read permission issue, please download the image files instead. You can follow the instruction given in the next paragraph to download the files.

For Options 2 and 3, please download the image from [this link](#)¹ (see footnote, need Surrey Account). Note that the image contains 11 files (6.8GB), we strongly recommend you to:

- download using a wired connection. Downloading from WiFi will be problematic when you are downloading from a crowded hotspot or over a poor channel quality.
- download each file individually. It is unreliable to download the entire 6.8GB at once even with good network connection.

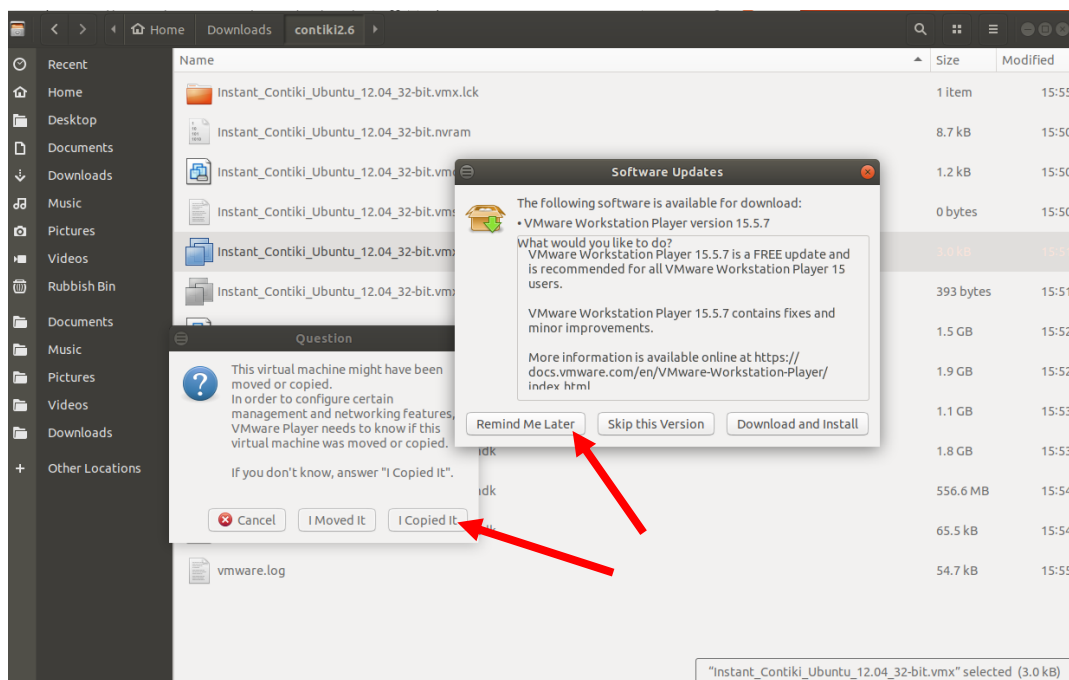


¹ https://surreyac-my.sharepoint.com/:f:/g/personal/cf0014_surrey_ac_uk/Ej0HaTlvMmhNhsigRD6gegBDIXql7nia0dtJ6mBQh9o_g?e=hNP85f

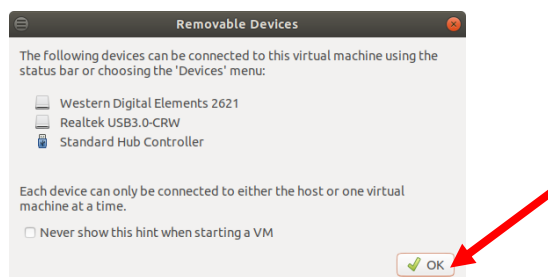
1.4 Running Contiki in the Lab (skip this if you cannot attend the lab)

To run Contiki on the lab computer, do the following:

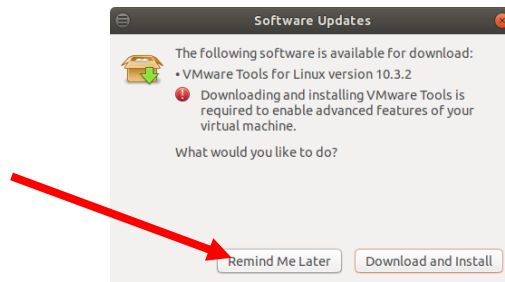
- 1) Assuming that you copy the image files to your 'Downloads' folder, open "File Managers" and navigate to your Downloads folder.
- 2) In the folder, double click the file with extension ".vmx" to launch VMware Player.
- 3) If VMware Player requests you to provide an email and perform an update, do the following:
 - For the email, you may just type: 'abc@abc.com'
 - For the additional pop-up dialog for an update, select "Remind Me Later"
- 4) If you reach the main screen of VMware Player, select "InstantContiki2.6 (2021)" image and click "Power On" at the bottom of main window to launch the virtual machine. You may not see the main screen as VMware Player may launch the virtual machine directly.
- 5) During the launch process, you may see the following pop-up dialogs:
 - Click "I Copied it" for the Question Dialog.
 - Click "Remind Me Later" for the Software Updates Dialog.



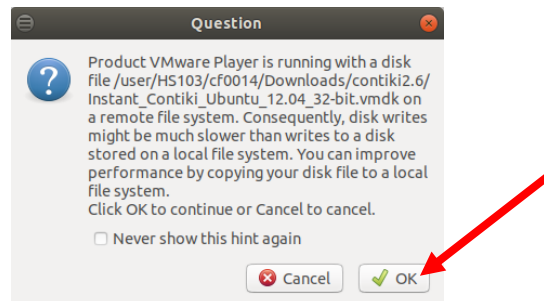
- 6) VMware Player will detect the connected USB devices and remind you that those devices can be used in your virtual machine later. Simply click "OK" to continue.



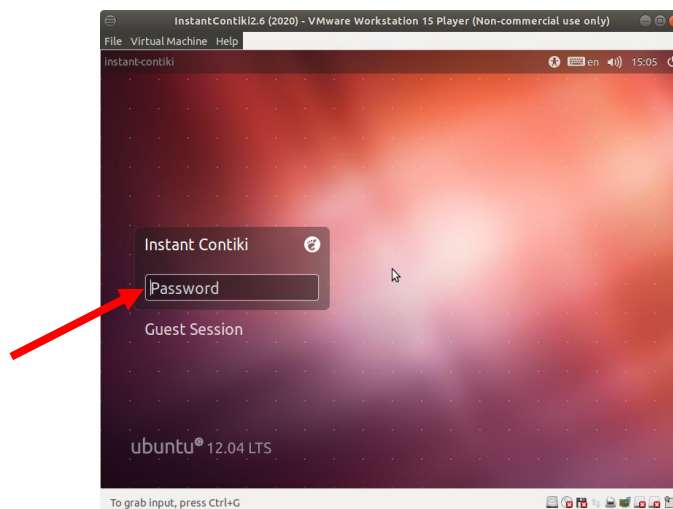
- 7) You may be asked again for Software Updates, select "Remind Me Later". DO NOT UPDATE. Updating the software may cause ContikiOS to break and create undesirable outcome.



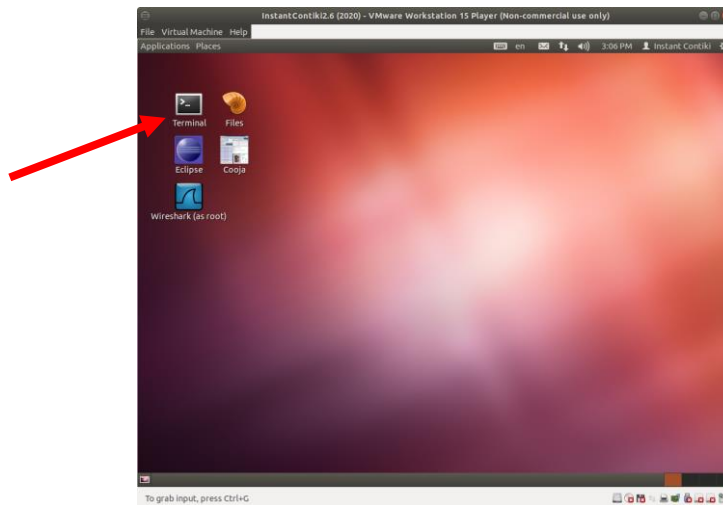
- 8) Finally, if you keep your image files in the network (for example, under your Linux Download folder), VMwave Player may warn you about the potential performance issue when accessing a remote file system. Click "OK" to continue.



- 9) You should now reach the "Instant Contiki" login screen (see below), type the password: "user" to login.



- 10) InstantContiki-2.6 virtual machine should now appear on the screen. On its desktop, you can identify a few useful applications, e.g. Terminal, Files, Cooja.



1.5 Deploying Your Code to XM1000 (skip this section if you cannot collect or have not been provided with a mote)

You will be provided a mote later in the semester. Please revisit this section when you have collected a mote.

After collecting an XM1000 mote, you can test your development environment by running “Hello World” in InstantContiki. The working environment for XM1000 in InstantContiki is installed under “contiki-2.6” folder in InstantContiki.

After running InstantContiki in your virtual machine player, you should see the login screen. Type the password “user” to login.

On the InstantContiki desktop, you can find the following three useful applications:

- Terminal: this will open a terminal window.
- Files: this will open a file manager window.
- Cooja: this will launch Cooja simulation.

Follow the instruction below to deploy your code. Please pay attention to the outcome of each command.

- 1) Open a terminal by double clicking the terminal icon on the desktop. Change the working directory to Hello World example by typing the following command:

```
$ cd /home/user/contiki-2.6/surrey/S1
```

- 2) Touch the source code to make sure that the code will be compiled next time:

```
$ touch hello-world.c
```

- 3) Compile hello-world and make sure it is successful (see also the note):

```
$ make TARGET=xm1000 hello-world
```

Note: If you compile the program for the first time, it will need to compile all related library files. This can take few seconds to complete and can end with a long message. Checking the outcome of the compilation can be difficult. To ensure the compilation is successful, you may re-type the same command again

to re-compile your program. This time, it should only re-compile those modified or those with compilation errors. Any compilation error should be easy to spot.

Note: If you face a compilation error related to missing gcc-msp430 (which is a very rare event, and it is likely that the installation in your image may have been broken), you may install it again by using the following command which may fix the problem:

```
$ sudo apt-get install gcc-msp430
```

- 4) Upload your executable binary code to the mote by typing the following command. When it is successful, you should see “Mass Erase...” and then “19408 bytes programmed” on the screen. You should also see the LED on the mote blinking during the uploading. The uploading will take a few seconds to complete. If you do not see the mentioned message on the screen, then check the notes below.

```
$ make TARGET=xm1000 hello-world.upload
```

Note: If the above step returns a “Permission denied” error, you can execute the command via super user to gain permission. The password for super user is ‘user’.

```
$ sudo make TARGET=xm1000 hello-world.upload
```

Note: If code uploading failed persistently due to timeout, and you are using a USB cable to connect the mote, please remove the cable and connect the mote directly to your USB port.

Note: If the above step returns quickly without showing the number of bytes programmed, then there may be a connection problem between your VM and the mote. There could be two reasons:

Reason #1: XM1000 is not physically or logically connected to the guest OS:

- Make sure that your mote is properly inserted into a USB port of the computer (in some occasion, you may need to remove and reinsert the mote, or try another USB port).
- Make sure that your mote is logically connected to your guest OS. You can check this by viewing the list of USB devices from your VM player and make sure that the mote “MTM-XM1000MSP” is captured in the guest OS.

Reason #2: XM1000 is associated to a non-default USB port:

- After capturing your mote in your guest OS, you can type the following command in the terminal to check the port associated to the mote:

```
$ dmesg | grep FTDI
```

and you should see the port associated with the mote.

- The default USB port is “/dev/ttyUSB0”. If your mote is using a different USB port (for example: “/dev/ttyS0”), then you need to specify the port in your “make” command as follows:

```
$ sudo make TARGET=xm1000 MOTES=/dev/ttyS0 hello-world.upload
```

- 5) Login to the mote via USB to see the result. First, type the following command:

```
$ make TARGET=xm1000 login
```

or use the following if permission is needed:

```
$ sudo make TARGET=xm1000 login
```

or specify the USB port if your mote uses a different port:

```
$ sudo make TARGET=xm1000 MOTES=/dev/ttyS0 login
```

Now you should see some random characters. Press the **red button** on the mote to reset the mote. Your code will be re-run.

You should now see "Hello, world" on the screen. Congratulation, you have a working environment.

- 6) Use [CTRL]+[C] to logout from the mote. You should return back to your command prompt.
- 7) Now you can try to modify your code. Double click the Files icon on the desktop to open file manager. By default, the file manager will open your home folder. To open the folder containing the source code, you need to double click "contiki-2.6" folder, then "surrey" folder, and finally "S1" folder.
- 8) In "S1" folder, you should find "hello-world.c". Double click it to open the text editor to modify the source code. After modifying and saving it, you may repeat the above step to deploy your modified code.

1.6 Installing Contiki 2.6 on Your Own Computer (skip this section if you only plan to use the PC in the lab to do experiment)

If you cannot physically attend the lab, or you wish to run Contiki outside the labs, you can install Contiki on your own computer. You may follow the instruction given below to install Contiki onto your computer:

- Install a Virtual Machine Player. Two popular options are:
 - Oracle VM VirtualBox (recommended)
 - VMware Workstation Player
 - If you have no clue, watch this tutorial:
<https://www.youtube.com/watch?v=9QXXyG0hKtI>
- Download a copy of InstantContiki version 2.6 from the link given earlier. You need to download all files. In the version, we have already preinstalled all necessary XM1000 platform files and laboratory skeleton codes in this image. It is ready to use.
- Place all downloaded files in the same folder. The should be about 7GB in total.
- Run the VM player, create a VM and attach the downloaded image file to the VM.

You should now see your VM loading up Ubuntu OS in the virtual machine. When asked for a password, type 'user'.

You should first identify your Contiki folder which is at "/home/user/contiki-2.6/"

You may now test your environment by deploying your code based on the instructions given in the other sections.

1.7 Deploying Your Code in Cooja Simulation

By now, you should have InstantContiki running either on the lab PC or on your own computer. You can learn how to code XM1000 mote by running simulation. InstantContiki comes with a simulation called “Cooja”. You can deploy and test your code in Cooja. You do not need a mote for the simulation.

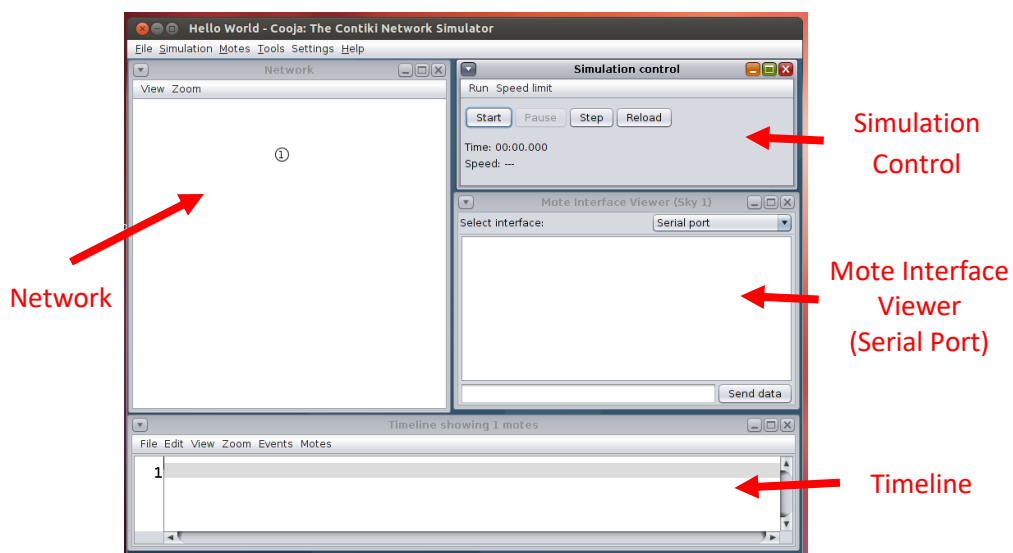
If you have not run InstantContiki in your virtual machine player, please do so now. After that, you should see the login screen. Type the password “user” to login.

On the InstantContiki desktop, you can find the following three useful applications:

- Terminal: this will open a terminal window.
- Files: this will open a file manager window.
- Cooja: this will launch Cooja simulation.

Follow the instruction below to deploy your code in Cooja.

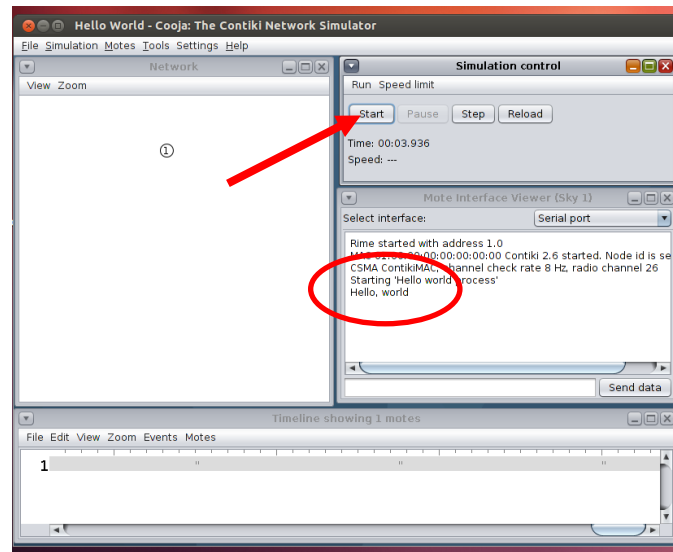
- 1) Double click Cooja icon on the desktop to open Cooja Simulation. You should see the Cooja window.
- 2) From Cooja window, click “File” from the file menu, then “Open simulation”, and then “Browse...”. You should see the “Open” dialog.
- 3) From the “Open” dialog, click “Home” icon to jump to your home folder. Then double click “contiki-2.6” folder, “surrey” folder, and finally “S1” folder.
- 4) Double click “cooja_helloworld.csc” in the “Open dialog” to open the saved hello world simulation environment. You should see the following Cooja interface:



There are four panels in the interface:

- **Network:** it shows the network setup. In this setup, there is only one mote indicated by the icon O.
- **Timeline:** it shows the events happening during a simulation run.
- **Simulation Control:** it provides several buttons for you to start, pause, run step-by-step, or reload to restart the simulation.
- **Mote Interface Viewer:** it provides user interface to control the mote. In the current setting, we control the USB of the mote via virtual serial port. This way, we can capture the logging messages and show the messages on this panel.

- 5) Click the [Start] button to run the simulation. You should see “Hello, world” message showing on the serial port panel. Congratulations, you have a working simulation environment.



- 6) Now you can try to modify your code. Double click the Files icon on the desktop to open file manager. By default, the file manager will open your home folder. To open the folder containing the source code, you need to double click “contiki-2.6” folder, then “surrey” folder, and finally “S1” folder.
- 7) In “S1” folder, you should find “hello-world.c”. Double click it open the source code on the default text editor. You may now modify your source code.
- 8) After modifying the source code, make sure that you save it. You may return to Cooja and click [Reload] button in the simulation control panel to reload the modified source code to the virtual mote. Reloading will force Cooja to recompile the code. If the compilation is successful, you should see the interface again. Otherwise, Cooja will show a window with the compilation error messages. You can then correct the source code and retry the compilation until your code is successfully compiled.