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.*

Acknowledgement*: The lab session follows IoT module taught by University of Surrey.*

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.

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 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 that you should first download our InstantContiki-2.6 image your own computer and use it to deploy your code in Cooja simulation. Please do not forget to bring your own computer to class for practical sessions.

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.

You can download the image from this link (need AGU 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.
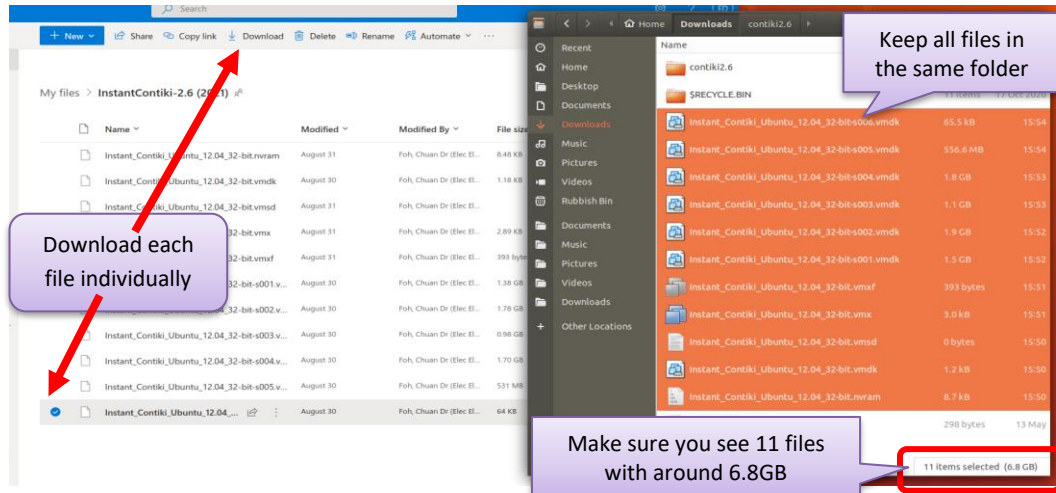
1.4 Installing Contiki 2.6 on Your Own Computer

To use 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
  - 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.

1.5 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, "labs" folder, and finally "L1" 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:
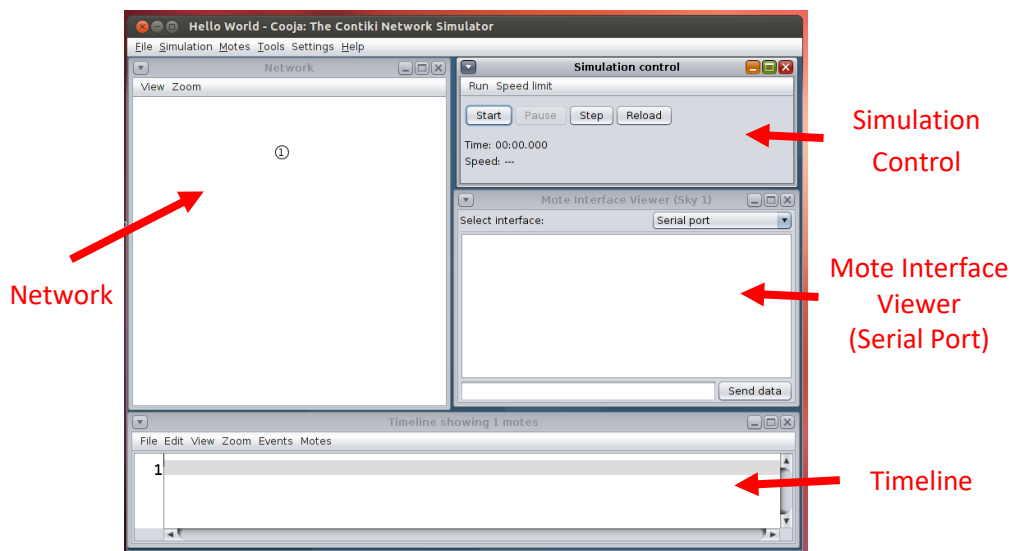
There are four panels in the interface:
- **Network**: it shows the network setup. In this setup, there is only one mote indicated by the icon ○.
- **Timeline**: it shows the events happening during a simulation run.
- **Simulation Control**: it provides several buttons for you to start, pause, run step-by-step, 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. Congratulation, you have a working simulation environment.
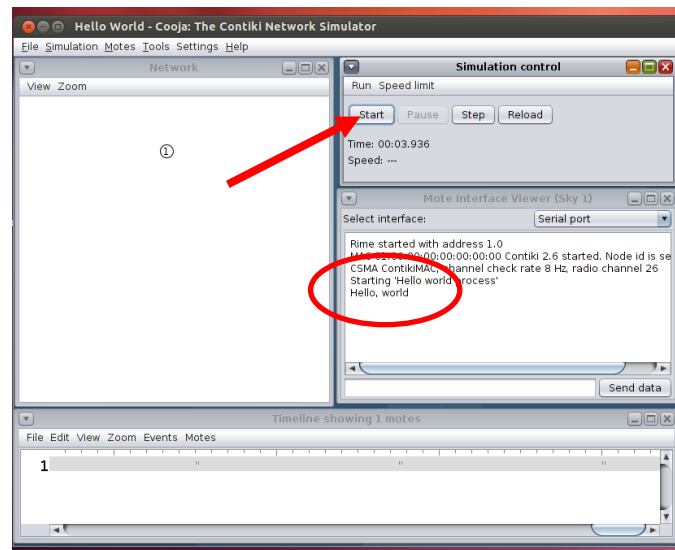
6) Now you can try to modify your code. Double click the Files icon on the desktop to open file manager. By default, the file manager will open your home folder. To open the folder containing the source code, you need to double click "contiki-2.6" folder, then "labs" folder, and finally "L1" folder.

7) In "L1" 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.