**Introduction**

This guide is broken into three sections. The first section discusses how to install the custom Operating System (OS) as a virtual machine. The second section discusses Contiki and Contiki-NG tools. The last section will discuss the Network Simulator 3 (NS3) tool.

Installation

The first thing that needs to be done is downloading the InstantContikiContikiNG.ova file, and downloading then installing Oracle VM VirtualBox. The link to Oracle VM VirtalBox is provided below.

https://www.virtualbox.org/wiki/Downloads

Other virtual machines can be used to run InstantContikiContikiNG but this guide will cover the process using VirtualBox. After installing VirtualBox and having it open, the OS can be imported by going to File>Import Application as shown below in Figure 1.
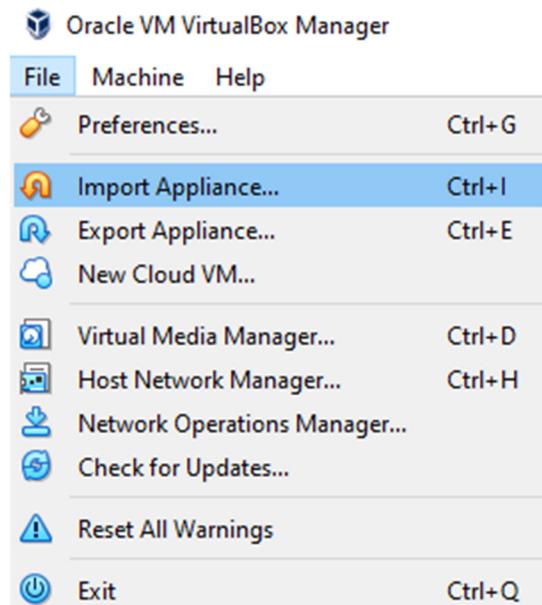
Figure 1: Importing the OS.

A window will pop up which will ask to select the OS you want to import. Choose the InstantContikiContikiNG.ova file that you downloaded previously. This step is shown below in Figure 2. Once selected, push "NEXT".

Appliance to import

Please choose the source to import appliance from. This can be a local file system to import OVF archive or one of known cloud service providers to import cloud VM from.

Source: Local File System

Please choose a file to import the virtual appliance from. VirtualBox currently supports importing appliances saved in the Open Virtualization Format (OVF). To continue, select the file to import below.

File: C:\Users\Pc\Documents\InstantContikiContikiNG.ova

Figure 2: Selecting the OS to import.

The next window will show the configuration of the virtual machine. This configuration was set when creating the image though can be changed to better fit your computer. Specifically the amount of RAM that the machine will utilize. Below in Figure 3 it is highlighted that the virtual machine will utilize 4096 MB of RAM. If your machine has 8+gigs of ram this will be good, though if you have less or much more, you may want to adjust accordingly to get the best performance. The number of CPUs can be changed as well. I only have 1 core for this virtual machine though multiple cores could be utilized. Once configured, the "Import" button can be pressed to import the OS into the Virtual Machine Manager. This may take a minute or two to fully import.

Appliance settings

These are the virtual machines contained in the appliance and the suggested settings of the imported VirtualBox machines. You can change many of the properties shown by double-clicking on the items and disable others using the check boxes below.

Virtual System 1	
Name	Instant Contiki/Contiki NG 2
Version	1.0
Description	Ubuntu 20.04 LTS with Contiki 2.7 and Contiki-NG tools installed.
Guest OS Type	Ubuntu (64-bit)
CPU	1
RAM	4096 MB
DVD	☑
USB Controller	☑
Sound Card	☑ ICH AC97
Network Adapter	☑ Intel PRO/1000 MT Desktop (82540EM)
Storage Controller (IDE)	PIIX4
Storage Controller (IDE)	PIIX4
Storage Controller (SATA)	AHCI
Virtual Disk Image	InstantContikiContikiNG-disk001.vmdk
Base Folder	C:\Users\Pc\VirtualBox VMs
Primary Group	/

Figure 3: Application Settings.

The pop-up window will close and the main page will be displayed. The imported OS will be visible on the left hand side. Multiple copies of the same or different OS can be imported if desired. Select "Instant Contiki/Contiki NG", then press the "Start" arrow button, shown below in Figure 4.
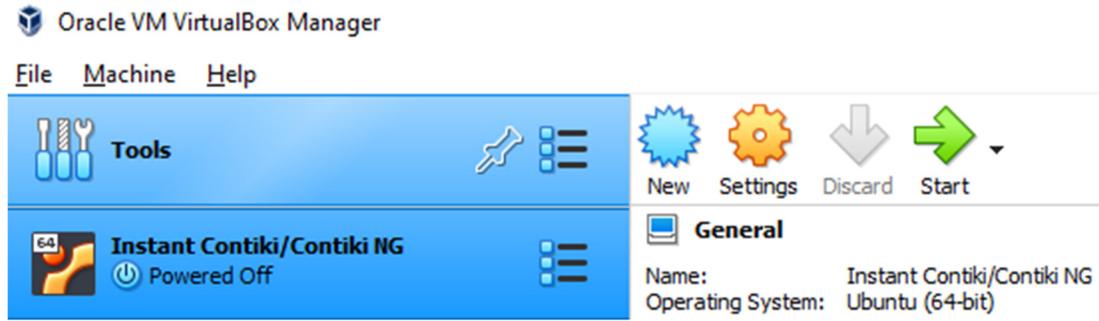
Figure 4: Starting the OS.

The virtual machine will eventually load and look like the window shown below in Figure 5.
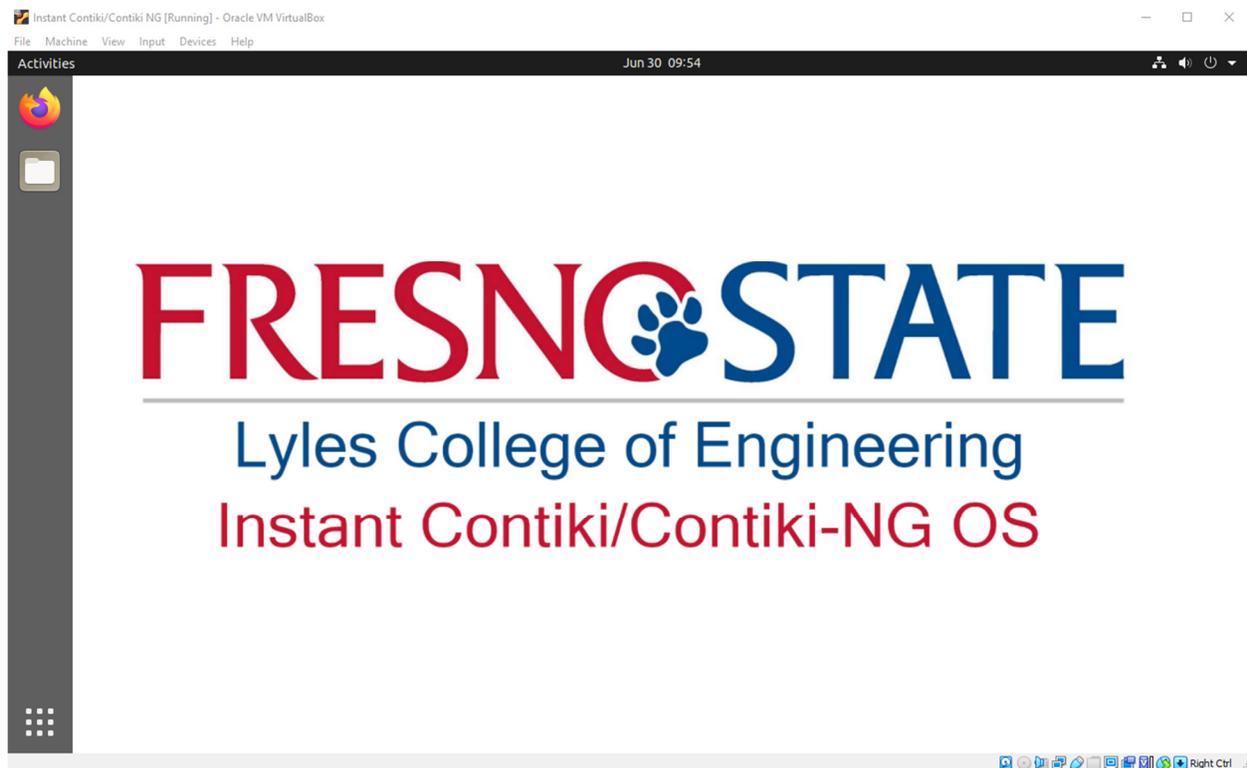
Figure 5: Instant Contiki/Contiki-NG OS.

When you plug in a device via USB, you need to allow access to that USB port. To do so, right click on the USB at the bottom right corner and select the component you want to connect to. Once selected you then have access to the USB device.

Contiki/Contiki NG Tools

Both Contiki 2.7 and Contiki NG tools are installed on this OS. To access either, open the terminal (CTRL+ALT+T), then type in the command "ls" to list the files/directories shown below in Figure 6.
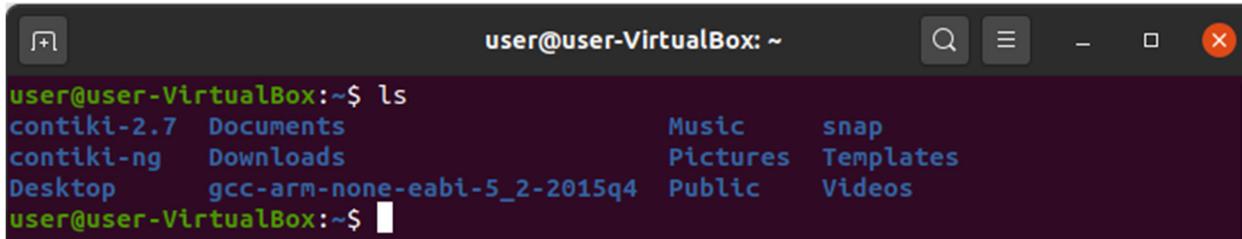
Figure 6: List of files/directories from location /home/user.

For this example we will work with contiki-2.7, but the same steps will work with contiki-ng. To go into the directory use the change directory command "cd" followed by the directory you wish to go into. Since we want to go into the directory contiki-2.7 we will type the command "cd contiki-2.7" and press enter.

Tip: Pressing TAB while typing in a command will autocomplete the word you're typing. For example if we type in "cd c" then press TAB, it'll autocomplete the command to "cd contiki-". It stops here since there are two directories and it'll require you to fill in the rest. If there is only one directory it will complete it completely. For example if the command "cd M" was entered then pressed TAB, it would autocomplete to "cd Music".

Once inside the contiki-2.7 directory , the list command ("ls") can be used again to see the files/directories available. At this time go into the directory examples ("cd examples"). Inside is full of examples you may use to develop your project, some work on the SKY mote. Go into the rime directory (cd rime).

You will now upload a program onto the SKY mote. Plug the mote into the computer via USB, and allow access to it as discussed during the installation. While in the rime directory type the following command: "sudo make TARGET=sky example-broadcast.upload". Type in the root password when prompted. Then the example-broadcast.c file will be uploaded to the mote. You should see the motes lights flashing, and when the terminal gives you back access to the prompt without any errors then the file is successfully uploaded. Remove the mote (no safely remove hardware is necessary) and plug in a different SKY mote. Type the following command: "sudo make TARGET=sky example-broadcast.upload login". This is similar to the previous one, except we are logging into the mote to view its output after successfully writing to it. Power the first mote via USB or 2-AA batteries. You should soon see the broadcast example working by receiving the message "Hello" shown in the terminal. To exit the mote, press CTRL+c.

Cooja

Contiki's simulation program Cooja is another tool that is useful. Navigate back to the home directory by typing in the command "cd". Followed by the command "cd contiki-2.7/tools/cooja" to navigate through multiple directories at once. At this time type the command "sudo ant run" to run Cooja. The Cooja window will open as shown below in Figure 7, in which you should select "New simulation..." under the "File" menu.
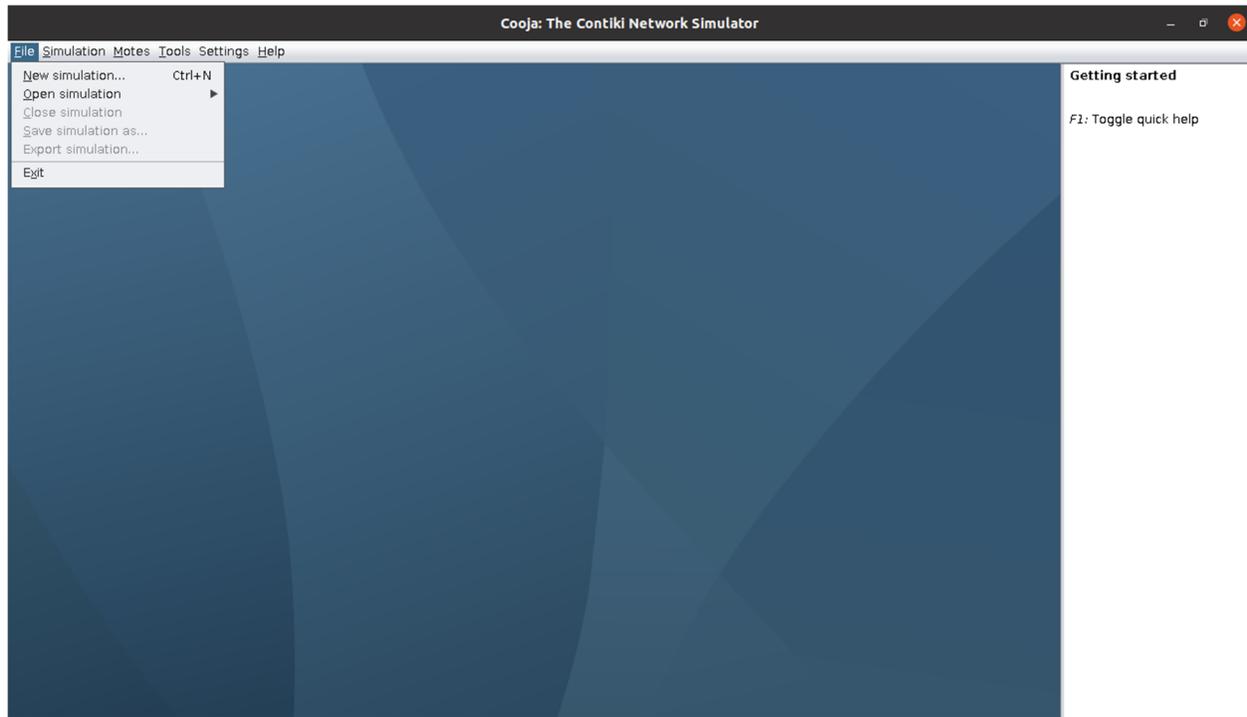

Figure 7: Cooja program.

Name the simulation whatever you want and press the "Create" button. Once the simulation is created new motes can be added to the simulation. Do this by going to the "Motes" menu, and selecting "Add motes", then select the "Sky mote…" or whichever mote you are working with. This is shown in Figure 8 below.
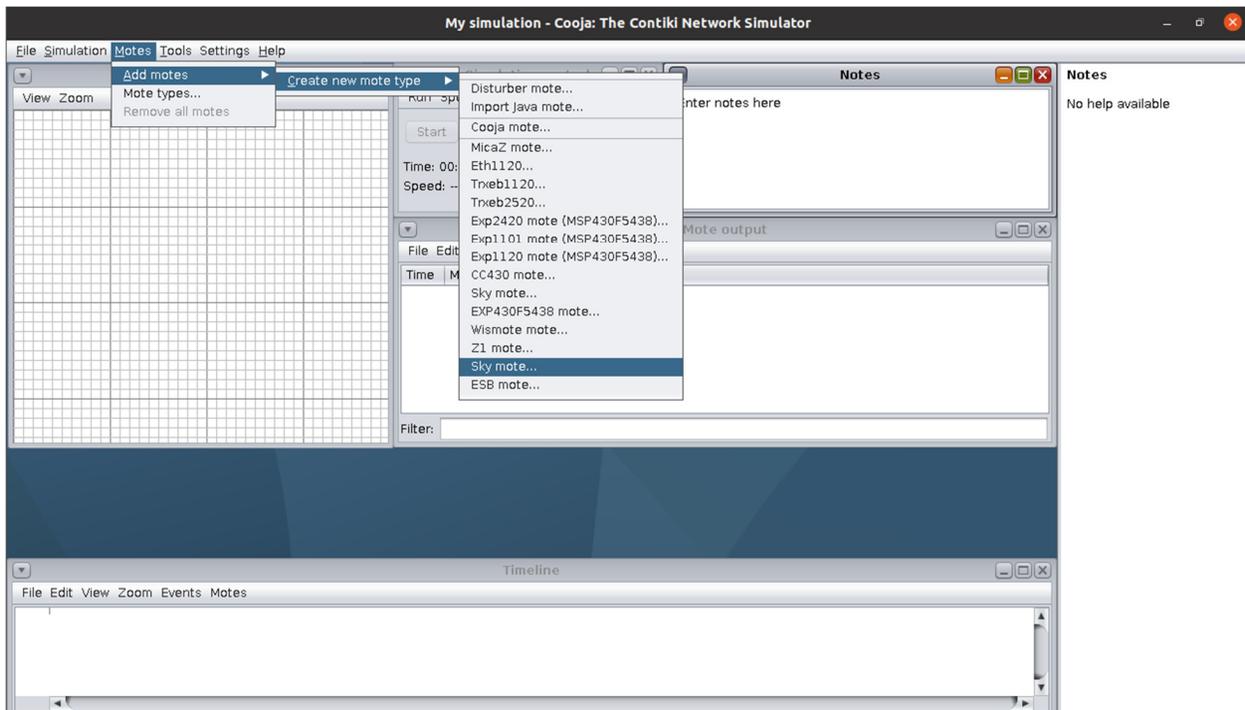
Figure 8: Adding motes to the simulation.

For this example the broadcast example will be used again. Browse and select the file that will be uploaded to the motes, then press the Compile button. Once the file has been compiled successfully it will look like Figure 9 below. If there are any errors they will need to be addressed, otherwise the motes can be created.
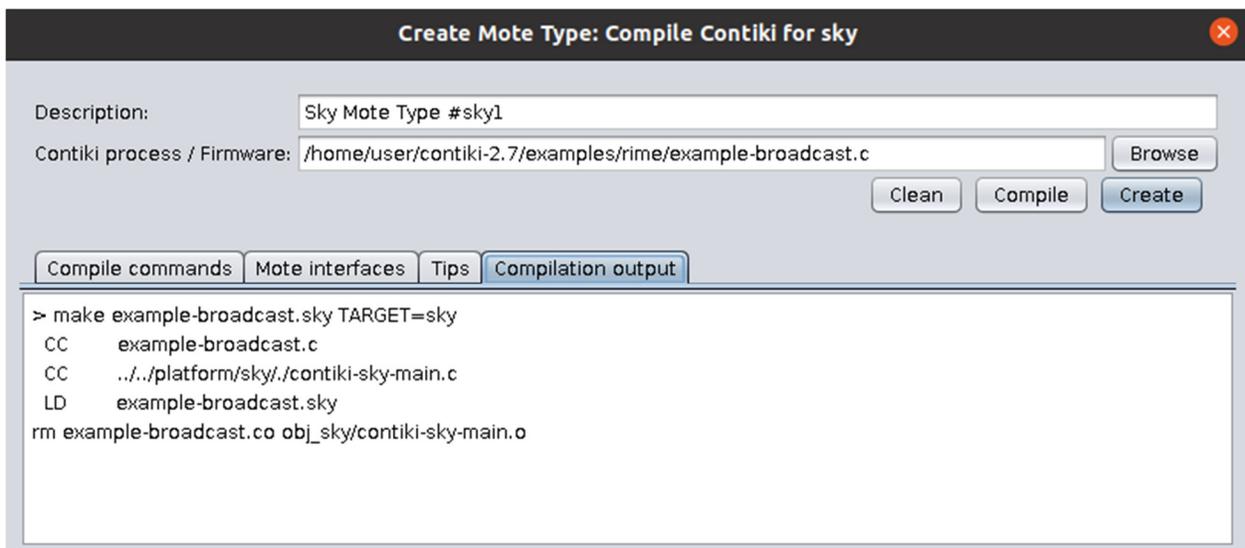
Figure 9: Uploading code to the simulation motes.

The number of motes can be determined, the default number is one but it can be whatever number you desire. As well as the physical location of those motes. Note that you will be able to

add more motes by following these steps again if you so choose so. Also moving the motes is possible after creating them. For this example we will change the "Number of new motes" to 3, then press "Add motes" shown in Figure 10.

Figure 10: Add motes.

We can see that the motes are added to the simulation area. By clicking on one of the motes, it displays the range of each one. The green radius represents a valid range in which the motes can communicate with each other directly. While outside that range they wont be able to communicate or require multiple hopes depending on the protocol. A snippet of the simulation at this state is shown below in Figure 11. Here mote 1 is selected showing that mote 3 is within range, while mote 2 is not.
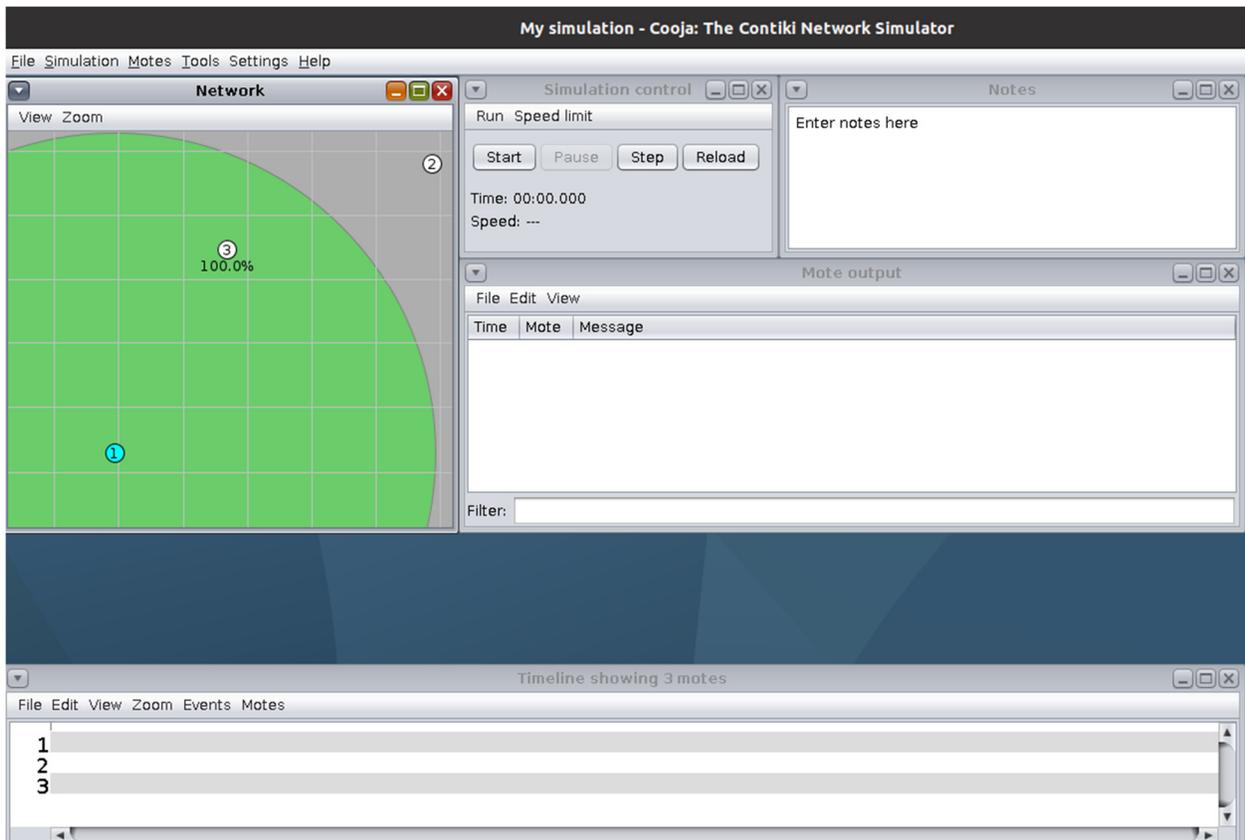
Figure 11: Simulation setup with motes.

The motes location can be changed by dragging them to a new location. Relocate the motes so that they are within valid range of each other. At this time the simulation can begin by pressing the "Start" button under the "Simulation Control" window.

At this time we can analyze as the simulation progresses, or we can pause it at any time. Below in Figure 12, the simulation is paused and it is shown that mote 1 is sending a message to mote 3. It can be viewed in the "Mote Output" window the exact time (11.802s) the mote that is receiving the message (mote 3) and the message it received ("broadcast message received from 1.0: 'Hello' ").
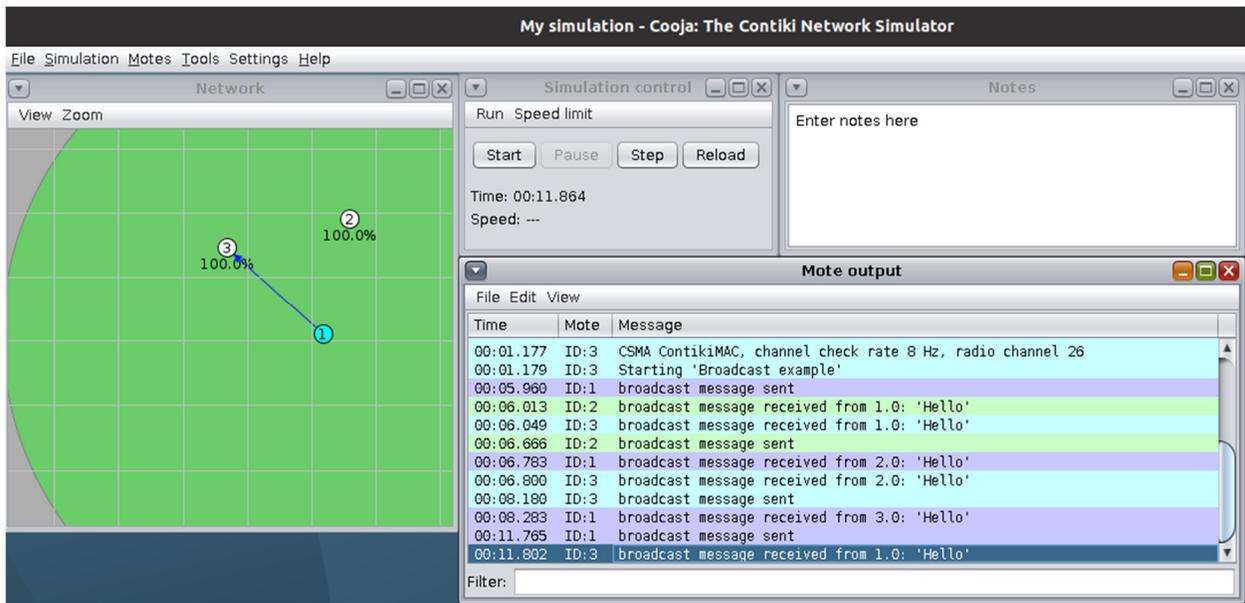
Figure 12: Simulation analysis.

Suggestions

- Add NS3 software
- Cooja_to_csv.py dependencies
- Use Forked repository instead of official one