



# Northeastern University

## EECE5155: Wireless Sensor Networks and The Internet of Things Laboratory Assignment 3

**Elena Bernal Mor, Ph.D.**

Assistant Teaching Professor

Department of Electrical and Computer Engineering

Northeastern University

### Objective

In this assignment, we will use a GNU Radio [IEEE 802.11 a/g/p transceiver](#) to instantiate a Wi-Fi-enabled ad hoc network on the Colosseum wireless network emulator, exchange traffic between the Wi-Fi nodes, and collect some statistics.

### Submission materials:

Prepare a report answering the questions in each part and submit it on Canvas (remember to include the name(s) of your team member(s) in the report). Include the relevant screenshots in your report. The report should be a single PDF file named **Lab\_Assignments\_Team\_<number of your team>\_Lab3.pdf**.

Remember: the laboratory assignments can be conducted either individually or in couples. If you want to work in couples, only one of the team members will need to submit the assignment.

### Part 1: Connect to Colosseum

Connect to the Colosseum wireless network emulator (<https://experiments.colosseum.net/>) as shown in class. As a reminder, the setup steps are the following:

- Setup the Colosseum VPN:  
<https://colosseumneu.freshdesk.com/support/solutions/articles/61000285824-cisco-anyconnect-remote-vpn-access>
- Upload your SSH public key on Colosseum:  
<https://colosseumneu.freshdesk.com/support/solutions/articles/61000253402-upload-ssh-public-keys>
- Setup your local SSH proxy:  
<https://colosseumneu.freshdesk.com/support/solutions/articles/61000253369-ssh-proxy-setup>
- Access Colosseum resources:  
<https://colosseumneu.freshdesk.com/support/solutions/articles/61000253362-accessing-colosseum-resources>

Get familiar with the system and on how to make reservations:

- Quick start guide: <https://colosseumneu.freshdesk.com/support/solutions/articles/61000253395-quick-start-guide>
- User guide: <https://colosseumneu.freshdesk.com/support/solutions/articles/61000253387-colosseum-user-guide>

## Part 2: Make a reservation with Wi-Fi nodes on Colosseum

1. Connect to Colosseum VPN (instructions [here](#) and login to [Colosseum website](#)).
2. Make a reservation with two colosseum nodes, also called Standard Radio Nodes (SRNs), with the webinar-interactive-v1 image (see instructions on [Making a Reservation](#)). Call the reservation in a meaningful way (e.g., your-name-wifi). Two hours should suffice.
3. In the reservation page, you can find the assigned SRNs/nodes and their hostnames by hovering over nodes, as shown in class. At your scheduled reservation time, open two terminals and ssh as root user into the assigned Colosseum SRNs (the password for the webinar-interactive-v1 container is sunflower):

```
ssh root@<srn-hostname>
```

4. In this assignment, we are going to use one of the base Colosseum scenarios (1009), which supports up to 10 nodes in the reservation. The center frequency of this scenario is 1 GHz. This scenario does not add any additional channel characteristics to the RF transmissions of the nodes (besides the contributions of the hardware components of Colosseum). Read the full specifications of this scenario at the following page:  
<https://colosseumneu.freshdesk.com/support/solutions/articles/61000277641-test-scenario-all-paths-0-db-1009>.
5. Now start the scenario: in one of the terminals, run the following command to start a Colosseum Radio-frequency (RF) scenario through the Colosseum CLI API (see [here](#) for more information on this API):

```
colosseumcli rf start 1009 -c
```

The -c option ensures that the scenario automatically restarts after its completion. When the scenario starts, an output similar to the following is returned (time is in UTC):

```
Scenario Start Time is 22:30:45
```

5. This will engage the Colosseum RF Channel Emulator and make the necessary connections between the USRPs of the reserved nodes based on the parameters set in the specific RF scenario (see <https://colosseumneu.freshdesk.com/support/solutions/articles/61000277641-test-scenario-all-paths-0-db-1009>). You can check if the RF scenario is active and running by executing the following command:

```
colosseumcli rf info
```

## Part 3: Verifying the RF emulator is setup properly

In this step, we will verify that Colosseum RF emulator has been setup correctly. Note that you will need the two terminals of the previous step to run the following commands.

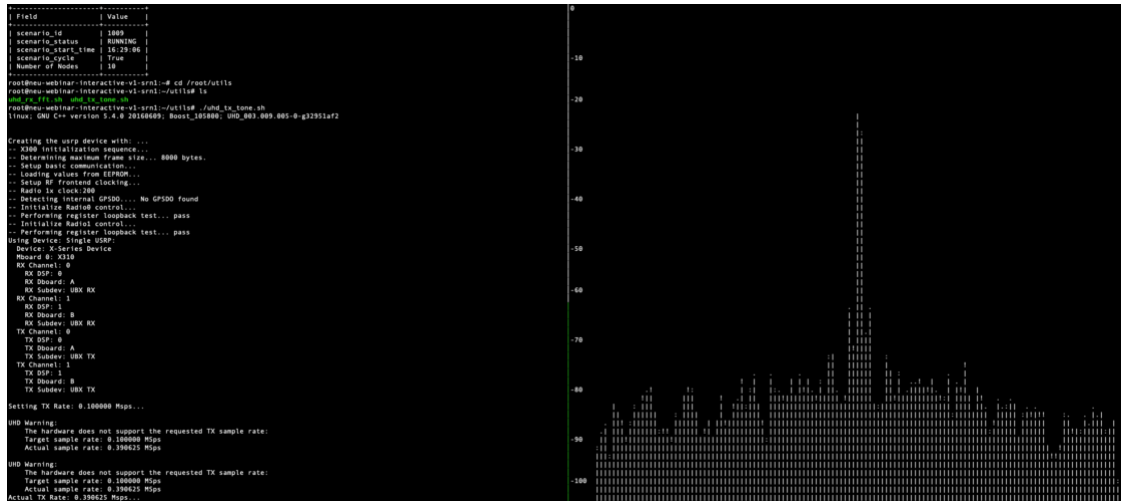
1. In both terminals, cd to (move to) the /root/utls directory.
2. Execute the uhd\_tx\_tone.sh script in the first terminal:

```
./uhd_tx_tone.sh
```

3. Execute the uhd\_rx\_fft.sh in the second terminal:

```
./uhd_rx_fft.sh
```

- This will send a tone at a set frequency from the first SRN and it will display a spectrum analyzer in the second SRN. If the RF emulator is set appropriately as explained in the previous section, the signal generated by the first SRN (left terminal in the figure below) will propagate through Colosseum RF emulator and reach the second SRN (right terminal). The results should look similar to the following:



- Once done, hit Ctrl+C in both terminals to stop the `uhd_tx_tone.sh` and `uhd_rx_fft.sh` example scripts.

**Question 1:** What is the frequency at which the tone is sent? Report your findings, including a screenshot similar to the one above. Comment your results. **(15 points)**

**Question 2:** Edit `uhd_tx_tone.sh` and the `uhd_rx_fft.sh` scripts to change the center frequency to 0.99 GHz. Repeat the previous steps. Which modifications are necessary to work with the new center frequency? Report your findings and a screenshot similar to the one above. Comment your results. **(20 points)**

**Question 3:** Do the same as asked in Question 2 but set the center frequency to 0.9 GHz. Report your findings and a screenshot similar to the one above. Comment your results. **(5 points)**

## Part 4: Start the Wi-Fi nodes

In this step, we will use the Wi-Fi nodes reserved in the previous steps. Note that you will need the two terminals of the previous step to run the following commands.

- For each SRN, navigate to the directory `/root/interactive_scripts` and execute the `tap_setup.sh` script to setup a tap interface for the SRN (see [Traffic Generation](#) for more information on routing traffic in Colosseum):

```
/root/interactive_scripts/tap_setup.sh
```

- For each SRN, execute the `route_setup.sh` script (located in the `/root/interactive_scripts` directory) to setup the routing tables:

```
/root/interactive_scripts/route_setup.sh <ID of the other SRN>
```

**NOTE:** In each of the SRN, you need to setup the route to the other SRN. The SRN IDs are created by adding 100 to the SRN number assigned to your reservation. As an example, SRN-015 will have ID 115, hence the IP address of the tr0 interface of this node will be 192.168.115.1. In this example, the above command becomes:

```
/root/interactive_scripts/route_setup.sh 115
```

3. In each SRN, execute the `modem_start.sh` script to start the Wi-Fi modem:

```
/root/interactive_scripts/modem_start.sh
```

4. If the interfaces and routes are setup correctly, the results should look similar to:

**NOTE:** we will need to leave these two processes running to be able to communicate between the Wi-Fi nodes, and perform the following steps.

**Question 4:** What is going on in the two nodes? What kind of messages are the two nodes exchanging? Report your findings, including a screenshot similar to the one above. Comment your results. **(20 points)**

5. Now, open **two new terminals** and ssh into the same SRNs as before (this is to keep the other terminals with the modem running).
6. From each SRN, in the newly opened terminals, ping the tr0 interface of the other SRN:

```
ping 192.168.<other-srn-ID>.1
```

This transmits ICMP packets over the RF emulator. If the ping is successful, it means that you have configured your SRNs in the correct way and you have an emulated channel between them. Also observe new Wi-Fi packets being generated and sent in the previous two terminals.

7. Once done, hit Ctrl+C to stop the ping in both SRNs.

**Question 5:** What is the average round-trip time between the two Wi-Fi nodes? What is the one-way delay? What is the packet loss experienced by the two nodes? Report your findings and comment your results. **(20 points)**

## Part 5: Start Colosseum Traffic Generator (TGEN)

In this step, we will use the Wi-Fi nodes reserved in the previous steps. Note that you will need the two terminals of the previous step to run the following commands.

1. In one of the terminals, execute the following command to start a traffic scenario through the Colosseum traffic emulator:

```
colosseumcli tg start 10090
```

2. This will engage the Colosseum [Traffic Generator \(TGEN\)](#) and start packet flows between Colosseum and the SRNs of your reservation based on the parameters specified in the traffic scenario (see <https://colosseumneu.freshdesk.com/support/solutions/articles/61000277641-test-scenario-all-paths-0-db-1009>). You can check if the traffic scenario is active (and running) by executing the following command:

colosseumcli tg info

- Now you can monitor the packet flow on the tr0 interface (i.e., the interface in which the SRNs receive/forward packets from/to TGEN) of each SRN by running the following command on each SRN:

```
tcpdump -i tr0
```

Note that it takes a few minutes (~5 mins) for TGEN to initialize the traffic scenario and start transmitting packets to the SRNs.

4. In the container used in this assignment, a *correctly configured* SRN will forward the packets to the other SRN through the RF channel emulator. A bidirectional transmit/receive flow of packets can be seen in the output of the above tcpdump command, and it should be similar to the following:

[illegible]

**Question 6:** What are the characteristics of the traffic flows of this scenario (i.e., packet size and rate)? Report your findings, including a screenshot similar to the one above. Comment your results. **(20 points)**

- Once done, hit Ctrl+C in all four terminals to stop the Wi-Fi applications and the tcpdump.

## Part 6: Clean up

This concludes Colosseum Wi-Fi assignment.

1. After you are done with your experiments, it is good practice to stop the traffic and RF and TGEN scenarios by running the following commands from in one of the previous terminals:

```
colosseumcli rf stop  
colosseumcli tg stop
```

2. Close all the previous terminals.
3. Log into the Colosseum website and terminate your reservation by clicking the red X button next to your reservation:

Colosseum Website Reservation Management Interface

Calendar View: Thu 24 March, Fri 25 March

Reservation Details Table:

Type	Res ID	Name	Status	SRNs	Start	End	Duration(min)	User
Interactive	124457	test-reservation	Future	2 node(s)	2022/03/25 - 6:05:00 PM	2022/03/25 - 7:05:00 PM	60	[Red X Button]