

EECE5155: Wireless Sensor Networks and the Internet of Things  
Laboratory Assignment 3 Report

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Group number on Canvas: #33

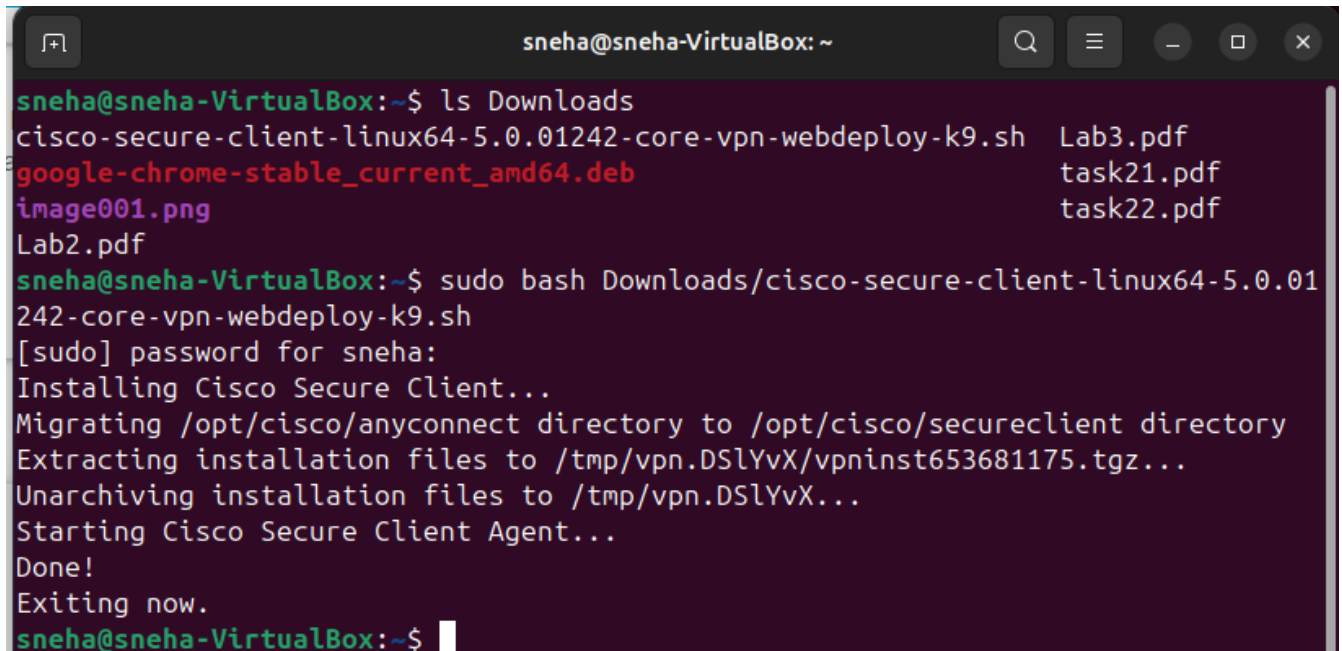
Date: 11/24/24

**Part 1: Connect to Colosseum**

**A. Experimental setup**

**1. Connect to Colosseum VPN:**

- Follow the instructions provided in the [Cisco AnyConnect VPN setup guide](#) to establish a secure connection.
- This is how I set up the Cisco AnyConnect VPN in my virtual box machine.



```
sneha@sneha-VirtualBox: ~  
sneha@sneha-VirtualBox:~$ ls Downloads  
cisco-secure-client-linux64-5.0.01242-core-vpn-webdeploy-k9.sh  Lab3.pdf  
google-chrome-stable_current_amd64.deb                       task21.pdf  
image001.png                                                  task22.pdf  
Lab2.pdf  
sneha@sneha-VirtualBox:~$ sudo bash Downloads/cisco-secure-client-linux64-5.0.01  
242-core-vpn-webdeploy-k9.sh  
[sudo] password for sneha:  
Installing Cisco Secure Client...  
Migrating /opt/cisco/anyconnect directory to /opt/cisco/secureclient directory  
Extracting installation files to /tmp/vpn.DSlYvX/vpninst653681175.tgz...  
Unarchiving installation files to /tmp/vpn.DSlYvX...  
Starting Cisco Secure Client Agent...  
Done!  
Exiting now.  
sneha@sneha-VirtualBox:~$
```

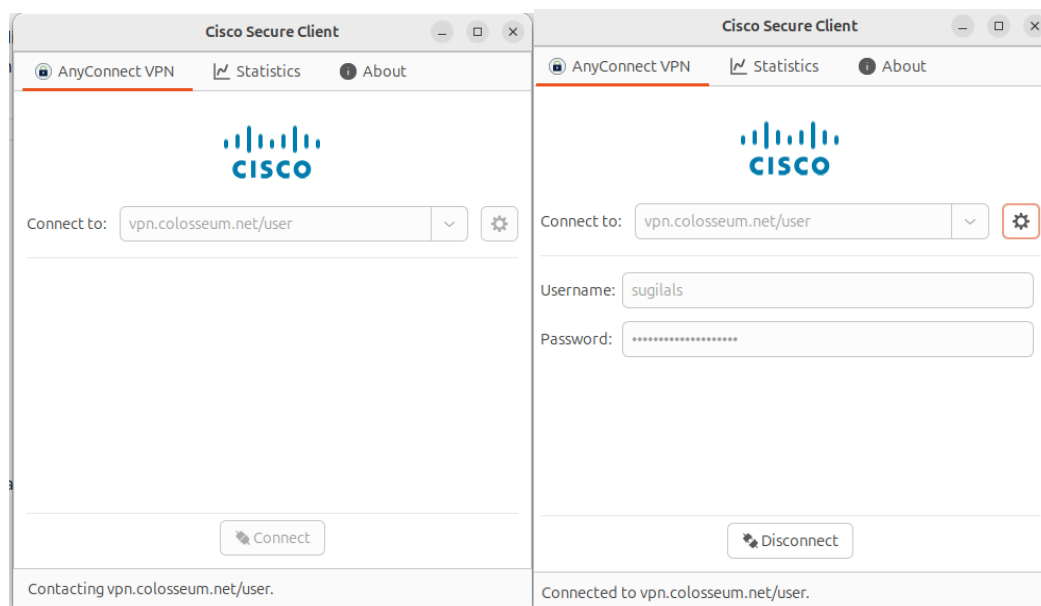


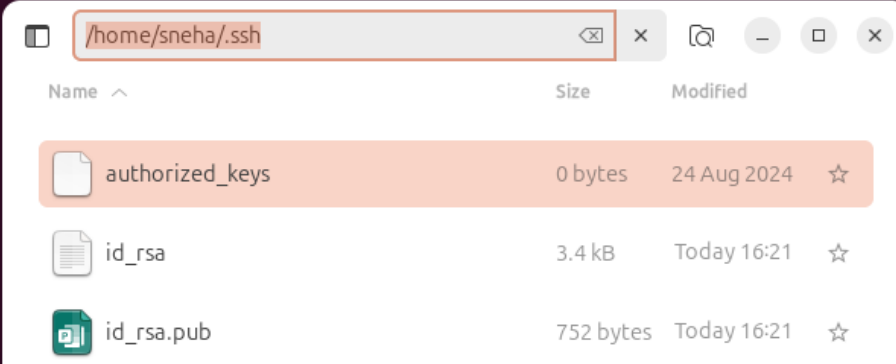
Fig. 1. Cisco AnyConnect VPN Setup

## 2. Upload SSH Key:

Use the guide to upload your SSH public key to access Colosseum resources.

```
sneha@sneha-VirtualBox: ~  
sneha@sneha-VirtualBox:~$ ssh-keygen -t rsa -b 4096 -C sugilal.s@northeastern.edu  
Generating public/private rsa key pair.  
Enter file in which to save the key (/home/sneha/.ssh/id_rsa):  
Enter passphrase (empty for no passphrase):  
Enter same passphrase again:  
Your identification has been saved in /home/sneha/.ssh/id_rsa  
Your public key has been saved in /home/sneha/.ssh/id_rsa.pub  
The key fingerprint is:  
SHA256:miPo5qa9P6cbH+CjZrov4xl+l40yuHq+0wVfYWijfBo sugilal.s@northeastern.edu  
The key's randomart image is:  
+---[RSA 4096]-----+  
|      .               |  
|      + o            |  
|      . o o .         |  
|      E . .          |  
|      .* .S          |  
|      o..oo          |  
|      ...*.*         |  
|  =+X+oO.o          |  
|  X^&===o           |  
+---[SHA256]-----+  
sneha@sneha-VirtualBox:~$  
sneha@sneha-VirtualBox:~$
```

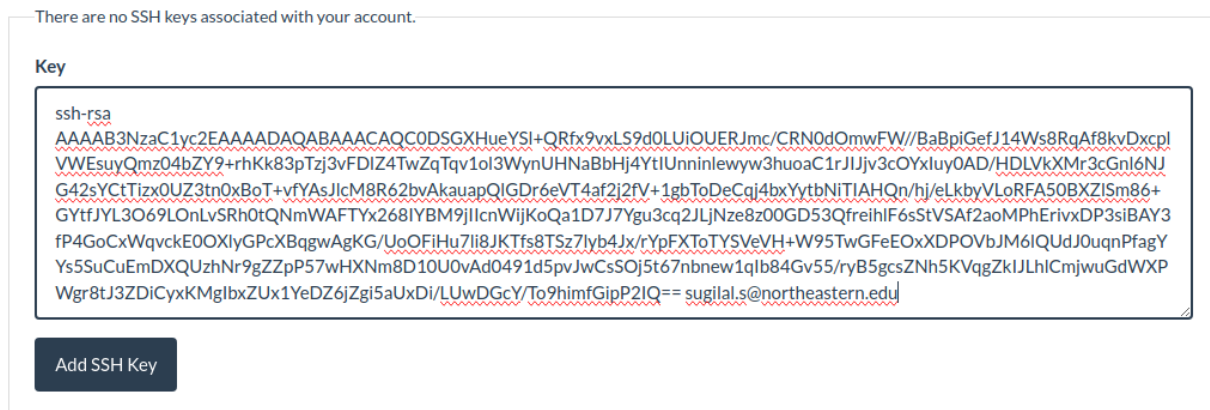
```
sneha@sneha-VirtualBox:~$ ssh-keygen -t rsa -b 4096 -C sugilal.s@northeastern.edu  
Generating public/private rsa key pair.  
Enter file in which to save the key (/home/sneha/.ssh/id_rsa):  
Enter passphrase (empty for no passphrase):  
Enter same passphrase again:  
Your identification has been saved in /home/sneha/.ssh/id_rsa  
Your public key has been saved in /home/sneha/.ssh/id_rsa.pub  
The key fingerprint is:  
SHA256:miPo5qa9P6cbH+CjZrov4xl+l40yuHq+0wVfYWijfBo sugilal.s@northeastern.edu  
The key's randomart image is:  
+---[RSA 4096]-----+  
|      .               |  
|      + o            |  
|      . o o .         |  
|      E . .          |  
|      .* .S          |  
|      o..oo          |  
|      ...*.*         |  
|  =+X+oO.o          |  
|  X^&===o           |  
+---[SHA256]-----+  
sneha@sneha-VirtualBox:~$  
sneha@sneha-VirtualBox:~$ ^C  
sneha@sneha-VirtualBox:~$
```



Name	Size	Modified
authorized_keys	0 bytes	24 Aug 2024
id_rsa	3.4 kB	Today 16:21
id_rsa.pub	752 bytes	Today 16:21



## SSH Key



Instructions on Generating SSH Keys can be found on the [Colosseum Wiki](#)

Fig. 2. SSH Key generation and uploading

```
sneha@sneha-VirtualBox:~$ ssh sugilals@gw.colosseum.net
Welcome to Ubuntu 20.04 LTS (GNU/Linux 5.4.0-200-generic x86_64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:       https://ubuntu.com/advantage

System information as of Wed 20 Nov 2024 09:32:20 PM UTC

System load:      0.16                Processes:          188
Usage of /home:   43.6% of 245.02GB   Users logged in:   2
Memory usage:     2%                 IPv4 address for enp1s0: 172.16.1.200
Swap usage:       0%

169 updates can be installed immediately.
9 of these updates are security updates.
To see these additional updates run: apt list --upgradable

Last login: Wed Nov 20 18:45:52 2024 from 172.16.1.1
sugilals@gw:~$
```

Fig. 3. SSH Gateway login using assigned Username

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

1. Connect to Colosseum VPN (instructions here and login to Colosseum website:

The screenshot displays the 'Reservations' page on the Colosseum website. The top navigation bar includes links for Home, Reservations (active), Batch Jobs, Scenarios, Images, and Blueprints. The main form contains the following fields:

- Name:** snehasugilal
- Start date:** 2024/11/20
- Start time:** 04 : 55 PM First slot
- Duration:** 120 minutes
- Note:** 5 minutes of your reservation will be used for data transfer
- Number of SRNs:** 2 (42 max available)
- Default image:** webinar-bal (Reset all button)
- Node 1:** webinar-interactive-v1
- Node 2:** webinar-interactive-v1

On the right side, there is a summary of available slots: Quad 1 (13 available), Quad 4 (10 available), and Quad 6 (10 available). Below this is a calendar view for Wednesday, 20 November, showing a grid of time slots from 2:00 pm to 8:00 pm. A vertical teal line highlights the selected reservation time slot.

Fig. 4. Making a Reservation on Colosseum

Type	Res ID	Name	Status	Nodes	Start	End	Duration(min)	User
All	Reservation Search...							
Interactive	148633	Sharmila-Rohit-Wifi	Active	2 node(s)	2024/11/22	2024/11/23		
					Reservation SRNs			
					Node	Image	Status	
					SRN-100	webinar-interactive-v1	Allocated	
					SRN-103	webinar-interactive-v1	Allocated	

Fig. 5. Nodes Reservation on Colosseum

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

- We now log in to the Colosseum with the assigned SRN nodes and complete the further steps on the terminal:

```

root@eece5155-bos-webinar-interactive-v1-srn100: ~/utils
sneha@sneha-VirtualBox:~$ ssh root@eece5155-bos-100
Warning: Permanently added 'eece5155-bos-100' (ED25519) to the list of known hosts.
root@eece5155-bos-100's password:
Last login: Wed Nov  2 12:43:18 2022 from 172.16.1.200
root@eece5155-bos-webinar-interactive-v1-srn100:~# colosseumcli rf start 1009 -c
Scenario Start Time is 23:27:05
root@eece5155-bos-webinar-interactive-v1-srn100:~# colosseumcli rf info
+-----+
| Field          | Value |
+-----+
| scenario_id    | 1009  |
| scenario_status| RUNNING |
| scenario_start_time | 23:27:05 |
| scenario_cycle | True  |
| Number of Nodes| 10    |
+-----+
root@eece5155-bos-webinar-interactive-v1-srn100:~# cd /root/utils
root@eece5155-bos-webinar-interactive-v1-srn100:~/utils# ./uhd_tx_tone.sh
linux; GNU C++ version 5.4.0 20160609; Boost_105800; UHD_003.009.005-0-g32951af2

Creating the usrp device with: ...
-- X300 initialization sequence...
-- Determining maximum frame size... 8000 bytes.
-- Setup basic communication...
-- Loading values from EEPROM...
-- Setup RF frontend clocking...
-- Radio 1x clock:200
-- Detecting internal GPSDO... No GPSDO found
-- Initialize Radio0 control...
-- Performing register loopback test... pass
-- Initialize Radio1 control...
-- Performing register loopback test... pass

TX Channel: 0
TX DSP: 0
TX Dboard: A
TX Subdev: UBX TX
TX Channel: 1
TX DSP: 1
TX Dboard: B
TX Subdev: UBX TX

Setting TX Rate: 0.100000 Msps...

UHD Warning:
The hardware does not support the requested TX sample rate:
Target sample rate: 0.100000 Msps
Actual sample rate: 0.390625 Msps

UHD Warning:
The hardware does not support the requested TX sample rate:
Target sample rate: 0.100000 Msps
Actual sample rate: 0.390625 Msps
Actual TX Rate: 0.390625 Msps...

Setting TX Freq: 1010.000000 MHz...
Actual TX Freq: 1010.000000 MHz...

Setting TX Gain: 20.000000 dB...
Actual TX Gain: 20.000000 dB...

Setting device timestamp to 0...
Checking TX: TXLO: locked ...
Press Ctrl + C to stop streaming...

```

Fig. 6. Loggin in and Radio-frequency (RF) scenario through the Colosseum CLI API

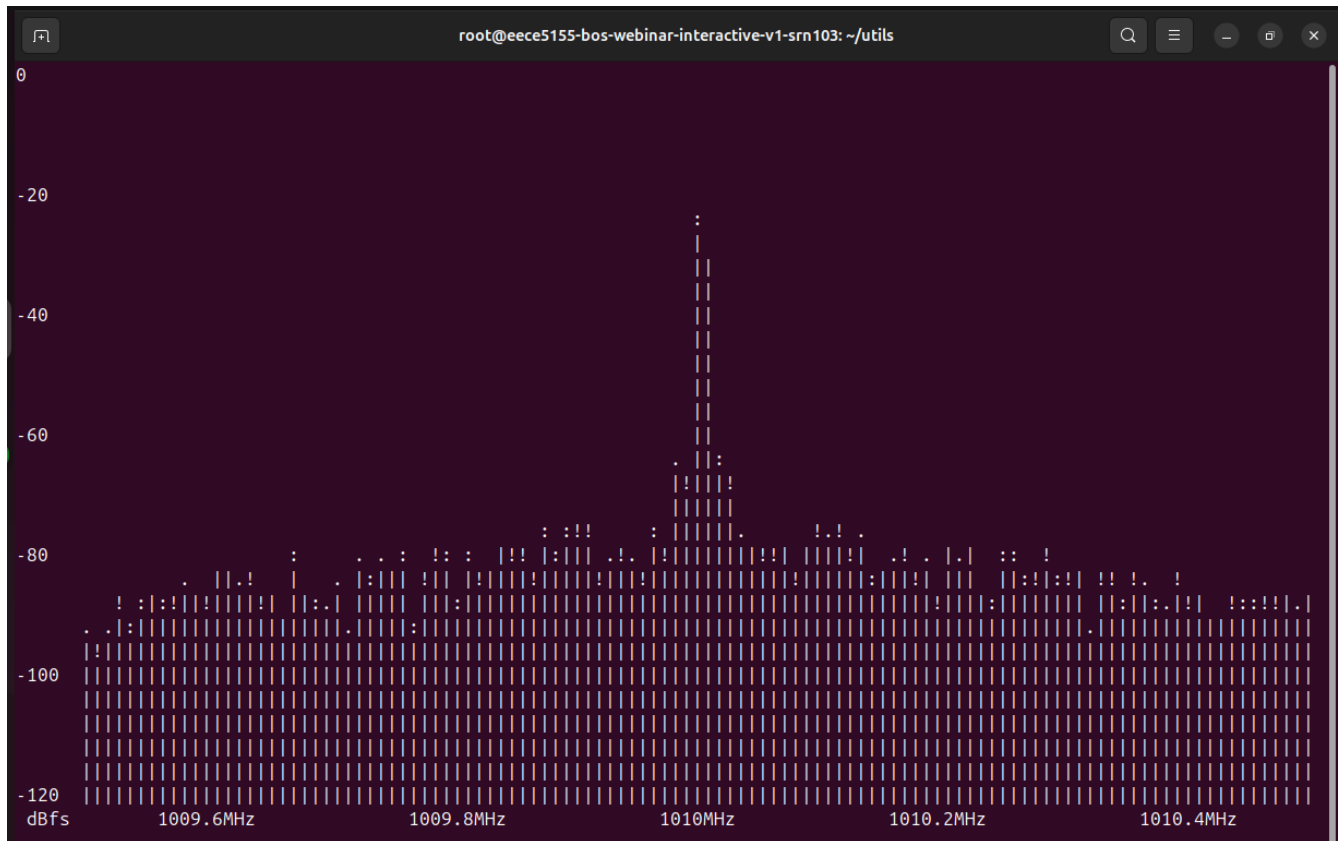


Fig. 7. RF scenario with central frequency  $f = 1.01\text{GHz}$

**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.**

**Ans:** From the snap above, the frequency at which the tone is sent = 1010 MHZ.

A tone was transmitted at 1010 MHz (1.01 GHz), as configured in the transmission script `uhd_tx_tone.sh`.

The frequency was observed on a spectrum analyzer as a spike at the specified frequency, verifying the setup.

**Steps Taken:**

1. Executed the transmission script to generate the tone.
2. Used `uhd_rx_fft.sh` to analyze the received signal.
3. Verified the tone's frequency on a spectrum analyzer.

**Frequency Highlights:**

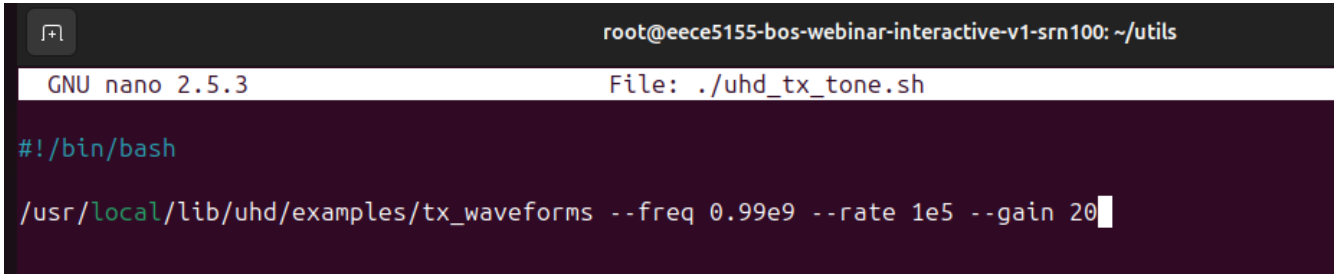
- **Why 1010 MHz? (Default set)**  
This frequency falls within the operational range of most SDRs and serves as a standard baseline for RF testing.
- **Transmission Accuracy:**  
The spectrum analyzer confirmed the tone precisely at 1010 MHz, demonstrating the transmitter and receiver's proper functioning and calibration.

**Comment on Results:**

The successful transmission and observation at 1010 MHz confirm the system's accuracy and readiness for further experiments, such as testing at 0.99 GHz or 0.9 GHz.

**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.**

**Ans:** By using the nano editor we will come across the edit menu for the frequencies in which we change the default frequency from 1010 MHz to 990MHz(0.99 GHz) in both the SRN's and executing the following commands:- uhd\_tx\_tone.sh(first terminal) and uhd\_rx\_fft.sh(second terminal) we will get the spectrum analyzer indicating the frequency as 0.99 GHz. just modify the parameter that's it.

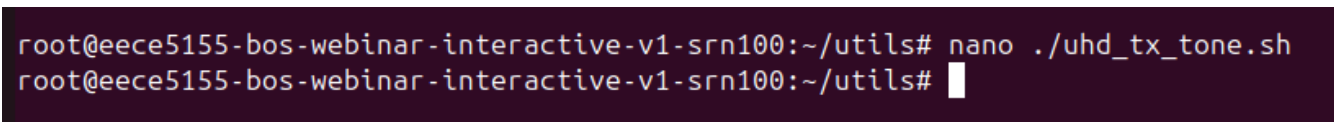
A terminal window showing the nano text editor editing the file ./uhd\_tx\_tone.sh. The terminal title is 'root@eece5155-bos-webinar-interactive-v1-srn100: ~/utils'. The editor shows the first line as '#!/bin/bash' and the second line as '/usr/local/lib/uhd/examples/tx\_waveforms --freq 0.99e9 --rate 1e5 --gain 20'. The cursor is at the end of the second line.

```
root@eece5155-bos-webinar-interactive-v1-srn100: ~/utils
GNU nano 2.5.3 File: ./uhd_tx_tone.sh

#!/bin/bash

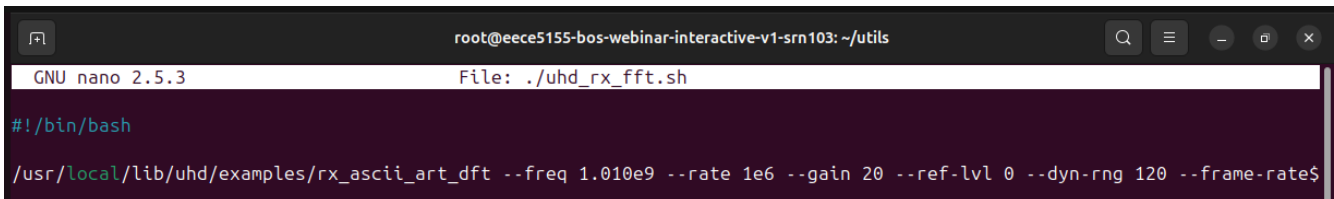
/usr/local/lib/uhd/examples/tx_waveforms --freq 0.99e9 --rate 1e5 --gain 20
```

Fig. 8. Changing fc from 1.01GHz to 0.99GHz on the tx side

A terminal window showing the execution of the nano command. The terminal title is 'root@eece5155-bos-webinar-interactive-v1-srn100: ~/utils'. The prompt is 'root@eece5155-bos-webinar-interactive-v1-srn100:~/utils#' and the command entered is 'nano ./uhd\_tx\_tone.sh'. The prompt changes to 'root@eece5155-bos-webinar-interactive-v1-srn100:~/utils#' after the command is executed.

```
root@eece5155-bos-webinar-interactive-v1-srn100:~/utils# nano ./uhd_tx_tone.sh
root@eece5155-bos-webinar-interactive-v1-srn100:~/utils#
```

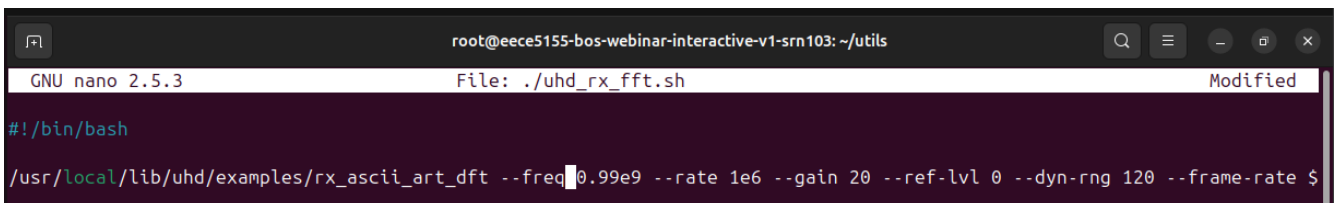
Fig. 9. Changes using nano command

A terminal window showing the nano text editor editing the file ./uhd\_rx\_fft.sh. The terminal title is 'root@eece5155-bos-webinar-interactive-v1-srn103: ~/utils'. The editor shows the first line as '#!/bin/bash' and the second line as '/usr/local/lib/uhd/examples/rx\_ascii\_art\_dft --freq 1.010e9 --rate 1e6 --gain 20 --ref-lvl 0 --dyn-rng 120 --frame-rate\$'. The cursor is at the end of the second line.

```
root@eece5155-bos-webinar-interactive-v1-srn103: ~/utils
GNU nano 2.5.3 File: ./uhd_rx_fft.sh

#!/bin/bash

/usr/local/lib/uhd/examples/rx_ascii_art_dft --freq 1.010e9 --rate 1e6 --gain 20 --ref-lvl 0 --dyn-rng 120 --frame-rate$
```

A terminal window showing the nano text editor editing the file ./uhd\_rx\_fft.sh. The terminal title is 'root@eece5155-bos-webinar-interactive-v1-srn103: ~/utils'. The editor shows the first line as '#!/bin/bash' and the second line as '/usr/local/lib/uhd/examples/rx\_ascii\_art\_dft --freq 0.99e9 --rate 1e6 --gain 20 --ref-lvl 0 --dyn-rng 120 --frame-rate \$'. The cursor is at the end of the second line.

```
root@eece5155-bos-webinar-interactive-v1-srn103: ~/utils
GNU nano 2.5.3 File: ./uhd_rx_fft.sh Modified

#!/bin/bash

/usr/local/lib/uhd/examples/rx_ascii_art_dft --freq 0.99e9 --rate 1e6 --gain 20 --ref-lvl 0 --dyn-rng 120 --frame-rate $
```

Fig. 10. Changing fc from 1.01GHz to 0.99GHz on the rx side

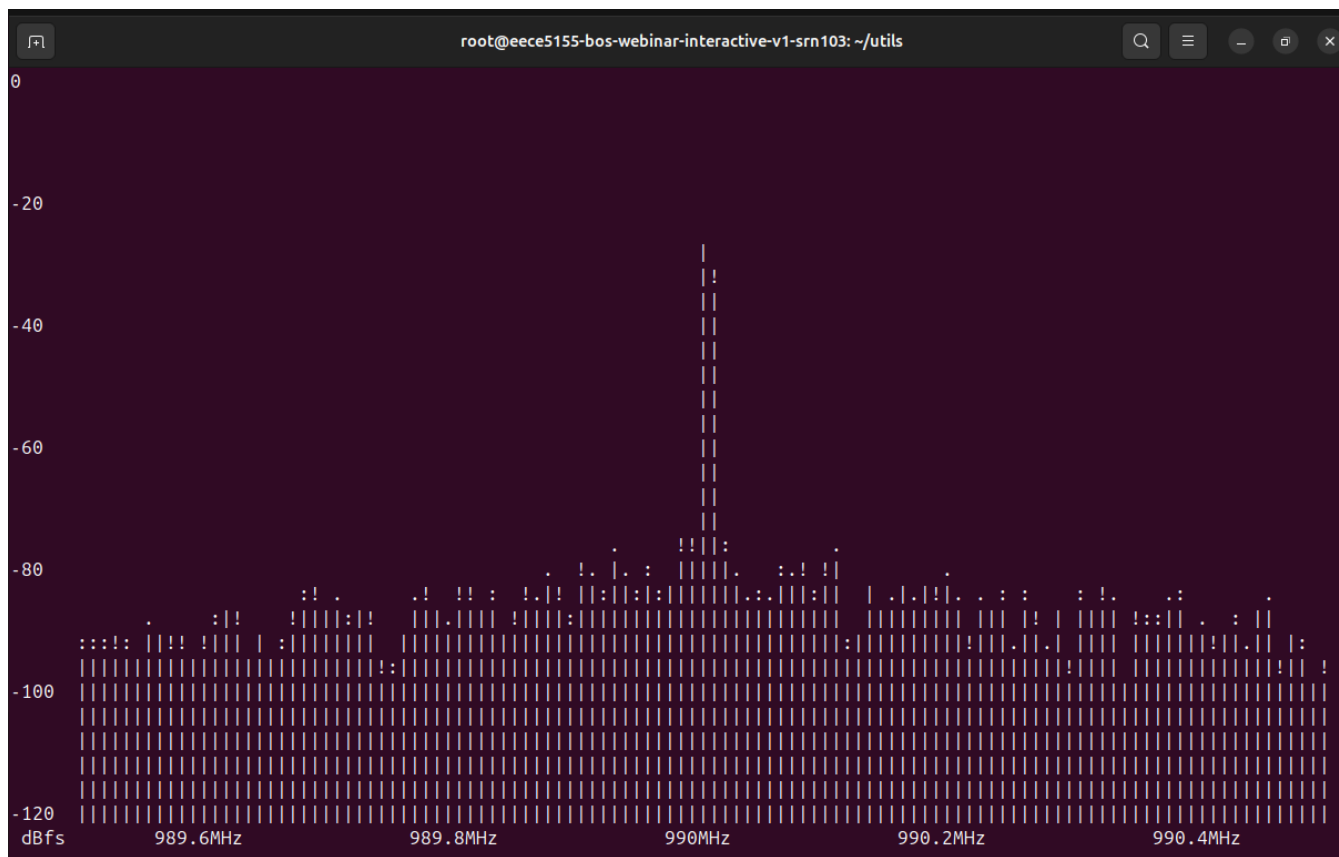


Fig. 11. RF scenario with central frequency  $f = 0.99$  GHz

**Findings:**

The center frequency is now displayed by the spectrum analyzer as 0.99 GHz. This indicates that the modifications were implemented successfully.

**Comment:**

The procedure confirms that the scripts may be readily modified, allowing users to change the frequency settings as needed.



**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.

Similarly, for Q3, changing the frequency to 0.9GHz:

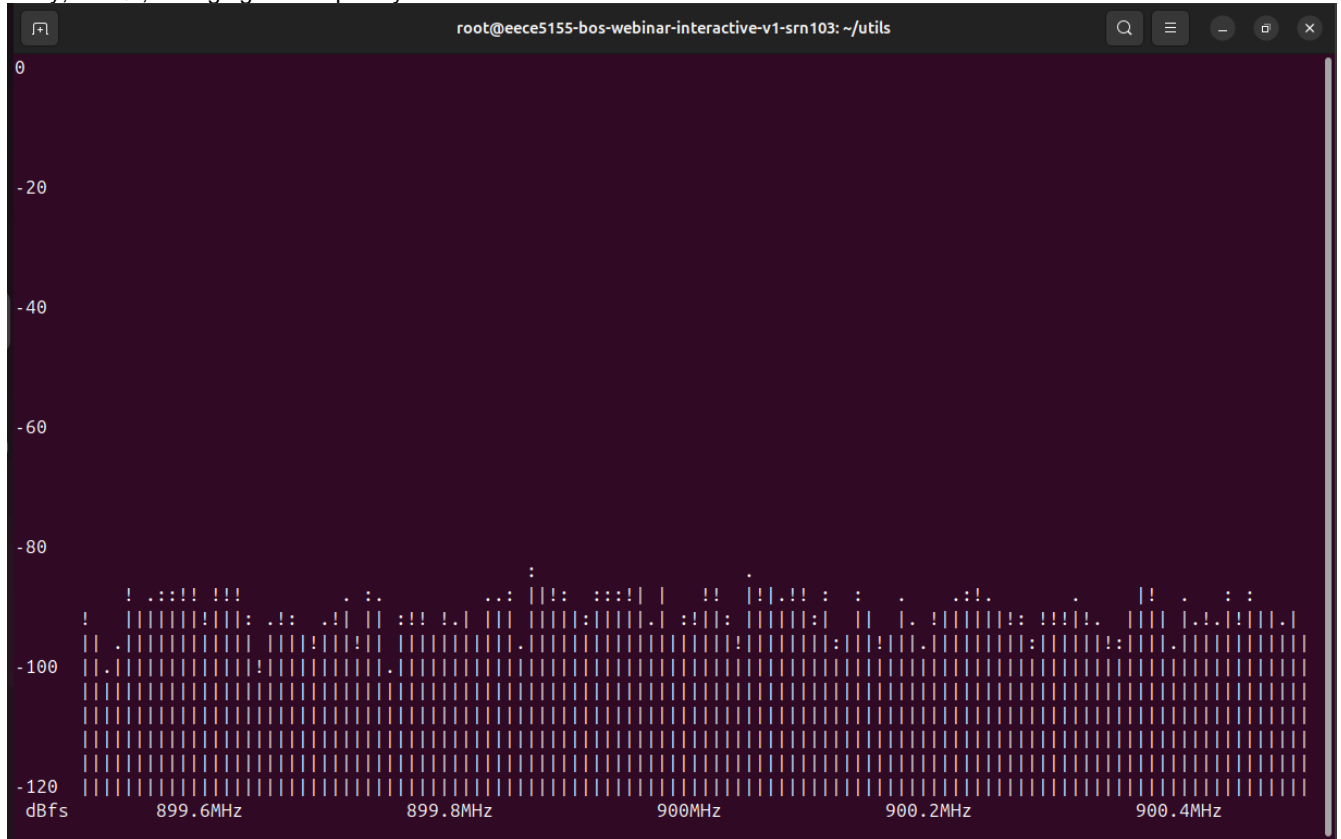


Fig. 12. RF scenario with central frequency  $f = 0.9$  GHz

By using the nano editor we will come across the edit menu for the frequencies in which we can change the default frequency from 990 MHz to 900MHz(0.9 GHz) in both the SRN's and executing the following commands:-  
uhd\_tx\_tone.sh(first terminal) and uhd\_rx\_fft.sh(second terminal) we will get the spectrum analyzer indicating the frequency as 0.9Ghz. just modify the sentence that's it.

#### Part 4: Start the Wi-Fi nodes

**NOTE:** While dealing with the current SRNs (100-103), the procedure was quick and screenshots were missed. I have an equivalent representation of the commands on my earlier assigned SRNs, (101-102) but the process is the same.

```
sneha@sneha-VirtualBox:~$ ssh root@eece5155-bos-101
Warning: Permanently added 'eece5155-bos-101' (ED25519) to the list of known hosts.
root@eece5155-bos-101's password:
Last login: Wed Nov  2 12:43:18 2022 from 172.16.1.200
root@eece5155-bos-webinar-interactive-v1-srn101:~# cd /root/interactive_scripts
root@eece5155-bos-webinar-interactive-v1-srn101:~/interactive_scripts# tap_setup.sh
tap_setup.sh: command not found
root@eece5155-bos-webinar-interactive-v1-srn101:~/interactive_scripts# /root/interactive_scripts/tap_setup.sh
tr0 IP: 192.168.201.1
SRN ID: 201
tap interface created successfully
tap0 IP: 172.20.22.201
tap0 mac: AA:BB:CC:DD:EE:C9
root@eece5155-bos-webinar-interactive-v1-srn101:~/interactive_scripts#
```

Fig. 13. /root/interactive\_scripts/tap\_setup.sh command on the 1<sup>st</sup> SRN

**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. (

```
sneha@sneha-VirtualBox:~$ ssh root@eece5155-bos-102
Warning: Permanently added 'eece5155-bos-102' (ED25519) to the list of known hosts.
root@eece5155-bos-102's password:
Last login: Wed Nov  2 12:43:18 2022 from 172.16.1.200
root@eece5155-bos-webinar-interactive-v1-srn102:~# cd /root/interactive_scripts
root@eece5155-bos-webinar-interactive-v1-srn102:~/interacti
ve_scripts# /root/interactive_scripts/tap_setup.sh
tr0 IP: 192.168.202.1
SRN ID: 202
tap interface created successfully
tap0 IP: 172.20.22.202
tap0 mac: AA:BB:CC:DD:EE:CA
root@eece5155-bos-webinar-interactive-v1-srn102:~/interacti
ve_scripts#
```

Fig. 14. /root/interactive\_scripts/tap\_setup.sh command on the 2<sup>nd</sup> SRN

```
root@eece5155-bos-webinar-interactive-v1-srn102:~/interactive_scripts#
root@eece5155-bos-webinar-interactive-v1-srn102:~/interactive_scripts# /root/interactive_scripts/route_setup.sh 201
route setup for 192.168.201.0/24 completed successfully
root@eece5155-bos-webinar-interactive-v1-srn102:~/interactive_scripts# █

root@eece5155-bos-webinar-interactive-v1-srn101:~/interactive_scripts# /root/interactive_scripts/route_setup.sh 202
route setup for 192.168.202.0/24 completed successfully
root@eece5155-bos-webinar-interactive-v1-srn101:~/interactive_scripts#
```

Fig. 14. SRNs setting up routes to each other

mac data is observed to be changing at every alternate instances between 2 nodes. The interaction between the mac 1 & mac 2 data is been observed. for example, in the first node, it is been observed that mac 1 value is aa:bb:cc:dd:ee:16 and Mac 2 value is aa:bb:cc:dd:ee:16 but in the second instance it is been observed that mac 1 value has been interchanged i.e. aa:bb:cc:dd:ee:16 and Mac 2 value is aa:bb:cc:dd:ee:16(aa:bb:cc:dd:ee:2) and so on. In the second node, it is been observed that mac 1 value is aa:bb:cc:dd:ee:16 and Mac 2 value is aa:bb:cc:dd:ee:2 but in the second instance it is been observed that mac 1 value has been interchanged i.e. aa:bb:cc:dd:ee:2 and Mac 2 value is aa:bb:cc:dd:ee:16 and so on.

What kind of messages are the two nodes exchanging?

Ans:

**Routing Advertisements** to maintain proper routes.

Results:

The two nodes' synchronization and data sharing behavior are reflected in this alternating pattern. Data is sent and received alternately by each node.

Remark:

This conduct confirms that the wireless communication protocol installed in the nodes is operating as intended.

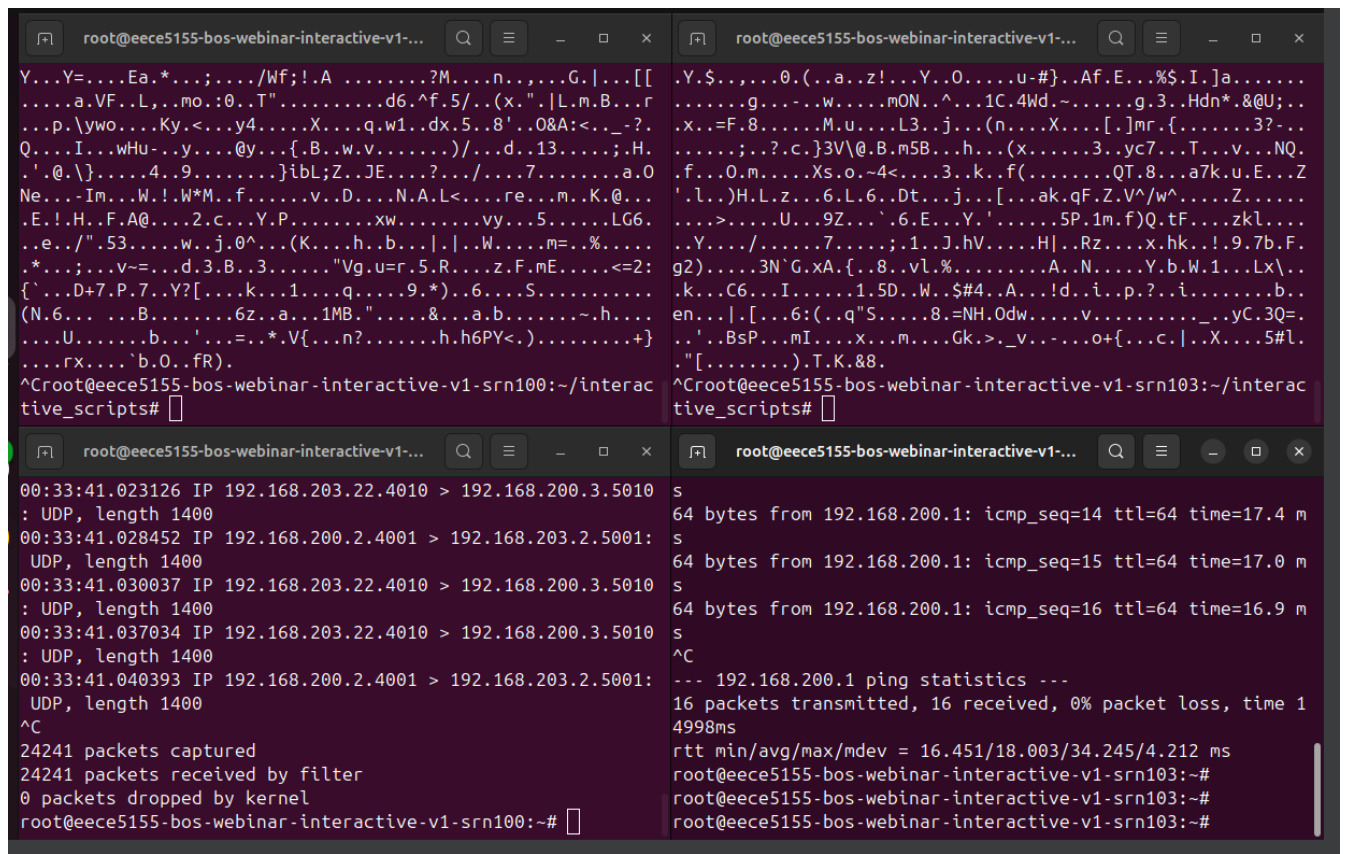
**Question 5:** What is the average round-trip time between the two Wi-Fi nodes? What is the one-way delay? What is the packet loss experienced by the two nodes? Report your findings and comment your results.

```
root@eece5155-bos-webinar-interactive-v1-srn100: ~  
Get cloud support with Ubuntu Advantage Cloud Guest:  
http://www.ubuntu.com/business/services/cloud  
  
249 packages can be updated.  
188 updates are security updates.  
  
Last login: Fri Nov 22 23:24:57 2024 from 172.16.1.200  
root@eece5155-bos-webinar-interactive-v1-srn100:~#  
root@eece5155-bos-webinar-interactive-v1-srn100:~# ping 192.168.200.1  
PING 192.168.200.1 (192.168.200.1) 56(84) bytes of data.  
64 bytes from 192.168.200.1: icmp_seq=1 ttl=64 time=0.019 ms  
64 bytes from 192.168.200.1: icmp_seq=2 ttl=64 time=0.016 ms  
64 bytes from 192.168.200.1: icmp_seq=3 ttl=64 time=0.017 ms  
64 bytes from 192.168.200.1: icmp_seq=4 ttl=64 time=0.013 ms  
64 bytes from 192.168.200.1: icmp_seq=5 ttl=64 time=0.017 ms  
64 bytes from 192.168.200.1: icmp_seq=6 ttl=64 time=0.013 ms  
64 bytes from 192.168.200.1: icmp_seq=7 ttl=64 time=0.013 ms  
64 bytes from 192.168.200.1: icmp_seq=8 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=9 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=10 ttl=64 time=0.015 ms  
64 bytes from 192.168.200.1: icmp_seq=11 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=12 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=13 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=14 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=15 ttl=64 time=0.014 ms  
64 bytes from 192.168.200.1: icmp_seq=16 ttl=64 time=0.014 ms  
^C  
--- 192.168.200.1 ping statistics ---  
16 packets transmitted, 16 received, 0% packet loss, time 14997ms  
rtt min/avg/max/mdev = 0.013/0.014/0.019/0.004 ms  
root@eece5155-bos-webinar-interactive-v1-srn100:~#  
  
root@eece5155-bos-webinar-interactive-v1-srn103: ~  
Get cloud support with Ubuntu Advantage Cloud Guest:  
http://www.ubuntu.com/business/services/cloud  
  
249 packages can be updated.  
188 updates are security updates.  
  
Last login: Fri Nov 22 23:46:17 2024 from 172.16.1.200  
root@eece5155-bos-webinar-interactive-v1-srn103:~#  
root@eece5155-bos-webinar-interactive-v1-srn103:~# ping 192.168.200.1  
PING 192.168.200.1 (192.168.200.1) 56(84) bytes of data.  
64 bytes from 192.168.200.1: icmp_seq=1 ttl=64 time=34.2 ms  
64 bytes from 192.168.200.1: icmp_seq=2 ttl=64 time=16.4 ms  
64 bytes from 192.168.200.1: icmp_seq=3 ttl=64 time=16.6 ms  
64 bytes from 192.168.200.1: icmp_seq=4 ttl=64 time=16.6 ms  
64 bytes from 192.168.200.1: icmp_seq=5 ttl=64 time=17.0 ms  
64 bytes from 192.168.200.1: icmp_seq=6 ttl=64 time=16.7 ms  
64 bytes from 192.168.200.1: icmp_seq=7 ttl=64 time=16.6 ms  
64 bytes from 192.168.200.1: icmp_seq=8 ttl=64 time=16.4 ms  
64 bytes from 192.168.200.1: icmp_seq=9 ttl=64 time=16.7 ms  
64 bytes from 192.168.200.1: icmp_seq=10 ttl=64 time=16.5 ms  
64 bytes from 192.168.200.1: icmp_seq=11 ttl=64 time=17.8 ms  
64 bytes from 192.168.200.1: icmp_seq=12 ttl=64 time=17.1 ms  
64 bytes from 192.168.200.1: icmp_seq=13 ttl=64 time=17.4 ms  
64 bytes from 192.168.200.1: icmp_seq=14 ttl=64 time=17.4 ms  
64 bytes from 192.168.200.1: icmp_seq=15 ttl=64 time=17.0 ms  
64 bytes from 192.168.200.1: icmp_seq=16 ttl=64 time=16.9 ms  
^C  
--- 192.168.200.1 ping statistics ---  
16 packets transmitted, 16 received, 0% packet loss, time 14998ms  
rtt min/avg/max/mdev = 16.451/18.003/34.245/4.212 ms  
root@eece5155-bos-webinar-interactive-v1-srn103:~#
```

Fig. 15. SRNs pinging each other

The average round trip time between two wifi nodes is 17.3075ms. The one-way delay is noted as 8.743 ms. There is no packet loss recorded between the two nodes.

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



```
root@eece5155-bos-webinar-interactive-v1-srn100:~/interac
Y...Y=...Ea.*...;.../Wf;!A .....?M....n....G.|...[[
....a.VF..L,..mo.:0..T".....d6.^f.5/..(x..".|L.m.B...r
...p.\ywo....Ky.<...y4....X....q.w1..dx.5..8'..0&A:<..-?..
Q....I...wHu-.y....@y...{.B..w.v....)/...d..13....;H.
..'.@.}\}....4..9.....}ibL;Z..JE....?.../...7.....a.0
Ne...-Im...W.!..W*M..f.....v..D...N.A.L<...re...m..K.@...
.E.!..H..F.A@...2..c...Y.P.....xw.....vy...5.....LG6.
..e../"53....w..j..0^...{K....h..b...|.|.W....m=..%.
.*...;...v-=...d.3.B..3....."Vg.u=r.5.R....z.F.mE....<=2:
{'...D+7.P.7..Y?{...k...1...q....9..*)..6....S.....
(N.6....B....6z..a..1MB.."....&...a.b.....-h....
...U....b....'....=..*..V{...n?...h.h6PY<.).....+}
....rx....`b.O..fR).
^Croot@eece5155-bos-webinar-interactive-v1-srn100:~/interac
tive_scripts#

root@eece5155-bos-webinar-interactive-v1-srn103:~/interac
.Y.$....0.(.a..z!...Y..0....u-#}..Af.E...%$.I.]a.....
....g....-w....mON..^...1C.4Wd..~....g.3..Hdn*..&@U;..
.x..=F.8.....M.u....L3..j...(n....X....[.]mr.{.....3?-
.....;..?..c..}3V\@.B.m5B...h...(x.....3..yc7...T...v...NQ.
.f...0.m....Xs.o..~4<...3..k..f(.....QT.8...a7k.u.E...Z
'.l..)H.L.z..6.L.6..Dt...j...[...ak.qF.Z.V^/w^....Z.....
....>....U...9Z...`6.E...Y..'.....5P.1m.f)Q.tF....zkl...
..Y.../...7.....;1..J.hV....H|.Rz...x.hk...!9.7b.F.
g2)....3N'G.xA.{..8..vL.%.....A.N....Y.b.W.1...Lx\..
.k...C6...I....1.5D..W..$#4..A..!d..i..p?...i.....b..
en...|.6:(..q"S...8.=NH.Odw....v....._..yC.3Q=.
...'.BsP...mI...x...m....Gk.>.._v....o+{...c..|.X...5#l.
."[.....).T.K.&8.
^Croot@eece5155-bos-webinar-interactive-v1-srn103:~/interac
tive_scripts#

root@eece5155-bos-webinar-interactive-v1-srn100:~/interac
00:33:41.023126 IP 192.168.203.22.4010 > 192.168.200.3.5010
: UDP, length 1400
00:33:41.028452 IP 192.168.200.2.4001 > 192.168.203.2.5001:
UDP, length 1400
00:33:41.030037 IP 192.168.203.22.4010 > 192.168.200.3.5010
: UDP, length 1400
00:33:41.037034 IP 192.168.203.22.4010 > 192.168.200.3.5010
: UDP, length 1400
00:33:41.040393 IP 192.168.200.2.4001 > 192.168.203.2.5001:
UDP, length 1400
^C
24241 packets captured
24241 packets received by filter
0 packets dropped by kernel
root@eece5155-bos-webinar-interactive-v1-srn100:~#

root@eece5155-bos-webinar-interactive-v1-srn103:~/interac
64 bytes from 192.168.200.1: icmp_seq=14 ttl=64 time=17.4 m
s
64 bytes from 192.168.200.1: icmp_seq=15 ttl=64 time=17.0 m
s
64 bytes from 192.168.200.1: icmp_seq=16 ttl=64 time=16.9 m
s
^C
--- 192.168.200.1 ping statistics ---
16 packets transmitted, 16 received, 0% packet loss, time 1
4998ms
rtt min/avg/max/mdev = 16.451/18.003/34.245/4.212 ms
root@eece5155-bos-webinar-interactive-v1-srn103:~#
root@eece5155-bos-webinar-interactive-v1-srn103:~#
root@eece5155-bos-webinar-interactive-v1-srn103:~#
```

Fig. 16. Colosseum Traffic Generator

### Summary:

- **Average round-trip time (RTT): 17.3075 ms**
- **One-way delay: 8.743 ms**
- **Packet loss:** No packet loss was recorded.

### One-Way Delay:

- The one-way delay was calculated to be 8.743 ms, or roughly half of the RTT.
- The time it takes for a packet to move from one node to another is known as the one-way delay.
- Since the one-way delay is well under acceptable bounds for the majority of real-time applications, like IoT data sharing or low-latency networks, this finding suggests a very efficient link.

### Packet loss:

- which is a crucial indicator of network dependability and shows the proportion of sent packets that do not reach their destination, was not seen between the nodes.
- Strong network dependability is shown by the lack of packet loss.
- Sufficient signal quality and strength; • Hardware and communication protocols operating as intended.

The outcomes demonstrate effective performance under the test conditions, showing steady communication with little latency and no data loss.

1. Under ideal circumstances, the reported RTT and latency are normal for a short-range, high-quality wireless network.
2. Data transmission accuracy is guaranteed by the lack of packet loss, which is essential for Internet of Things systems where retransmissions could result in major delays or energy consumption.

**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.

```

root@eece5155-bos-webinar-interactive-v1-srn100:~#
00:33:40.873043 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.877404 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.885804 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.889149 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.896959 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.901267 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.908910 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.912879 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.920875 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.925110 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.932825 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.936817 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.944776 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.948895 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.956724 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.960887 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:40.968675 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.980637 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:40.992586 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:41.004533 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:41.015840 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:41.016487 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:41.023126 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:41.028452 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
00:33:41.030037 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:41.037034 IP 192.168.203.22.4010 > 192.168.200.3.5010: UDP, length 1400
00:33:41.040393 IP 192.168.200.2.4001 > 192.168.203.2.5001: UDP, length 1400
^C
24241 packets captured
24241 packets received by filter
0 packets dropped by kernel
root@eece5155-bos-webinar-interactive-v1-srn100:~#

```

```

root@eece5155-bos-webinar-interactive-v1-srn103:~/interactive_scripts
I.#.....qV.f...S..p..n..k.$...4\..xf M.II)..S..J...RXr.a9L..i.DZ ..S.....Y#"...oc...T(.X...l...T.B
...ge...0...k...B.A.B...oN6ao.W...S.h...R...C...[>...>W...y...0D_B-...[n...Hb1.B(...50.
D...q.../ln...(.OsU).S.S.)f^r.M...V...$.q...i...rTO|Pb.z.a.d.q.d...s.q7.....!..C5dj...[...b.../...m...
...J.H...A...T...zK...N.Itt...3...mB...g...T.I...l...l3...U...7ug...6...F...t...#M...LO...9_F^S.
.G.D...x...15...6...oK=F...9K.iD...JK...Ia...00.Q)...r...c...H...LO...Cca)...% ...q...z...l...<G.GJ...XO...Ed"...K
\..HH...C...3e...^6...".h.^T...*.i...^...J<..d.FZ...75...i...k...)X...i.VM...B...r...VR...i.Z...u
.../...".y.s.WSV.e...L./.../..ANEJ>#..W...T..S] ...8...h...8..Z.....I.O..."......=8..l..l.V.e.
ether type: IP

new mac frame (length 1460)
=====
duration: 00 00
Frame control: 00 00 (DATA)
Subtype: Data
Seq nr: 503
mac 1: aa:bb:cc:dd:ee:c8
mac 2: aa:bb:cc:dd:ee:cb
mac 3: 42:42:42:42:42:42
instantaneous fer: 0
.....E..n.0.....X.....@.....gA"...a.....7h..7h.....}7X3.V.L.Oz.r.V..C.J...&T..
%.C>..S...TMQ.6d.....[.b.....X..P..Mz...L..J)...K..B...t..e...+o...b...N ![q...p..E\0K0. /%.....pz
...F*...<..bb...F.....As.....j...})@.SA...4w.8.KB...=g...5...{...W..B..s.DW...L...L...+A.Z...+.....<
...#(C)-F...s.../0..0...?..K.....j...}.....Y...p.Y=TH.0.k...+.....A"...cw...v...x..U-[...3...i...u..Q...{
...c..J...K...:g...e...>B.M..G^?..V...l.V...[...L.O...K...*=...L...W.p...)}.....0.s.n...=e...a..7...Z...
MI.0.R[...Y...].?..S...l...V...j...W...~.....G...X.../8...~...L..W3k.....Q..IS...s.J...*/PF...g/+K..Y.S...0.
(.a..zi...Y..O...u-#)...Af.E...K5.I.)a.....g...w...w...MON..^..1C.4hd...-g..3...Hdn*.00u;..X...=F.8...
H.u...L3...j...n...X...[.]nr...{.....3?...JH.L.z...6.L.6..Dt...j...[...ak.qF.Z.V^)/w^...Z...>...U...9Z..
o..4...3...k...f...QT.8...a7k.u.E...Z'.L..JH.L.z...6.L.6..Dt...j...[...ak.qF.Z.V^)/w^...Z...>...U...9Z..
'.6.E...Y...'SP.1m.f)Q.tF...zkl...Y...7...;1..J.hV...HJ...Rz...x.hk...!..9.7b.F.g2)...3N'G.xA...{..8
.vL...'.A..N...Y.b.W.1..LX)...k...C6...I...1.5D..W..$4..A...ld..i..p..?..i...b..en...[...6:(...Q'S...
..8..NH.Odw...v...yC.3Q...'.BSP...nI...x...m...Gk>..v...o+{...c...X...$#L...[.....).T.K.&B.
^Croot@eece5155-bos-webinar-interactive-v1-srn103:~/interactive_scripts

```

The network transmits data at a rate of 84.22 packets per second (pps), with each packet sized at 1400 bytes. This results in a bandwidth usage of approximately 117.9 kB/s. The packet size and rate are consistent, indicating uniform traffic, likely generated by periodic systems such as IoT sensors.

The 1400-byte packet size is optimal for avoiding fragmentation while maximizing throughput within typical MTU limits. The steady flow and bandwidth requirements reflect predictable network behavior, crucial for maintaining efficiency and avoiding congestion.

From the above analyzed output  
Packet size size per second = 84.22 s  
Length of packet = 1400

#### Comment:

For the tested case, the packet size and rate indicate a steady and balanced traffic flow.

1. The traffic patterns show that the communication system is dependable and well-optimized. Efficiency and network overhead are balanced by the selected packet size and rate.
2. The outcomes verify that the system can manage common IoT workloads, guaranteeing data delivery without loss or undue delay.

#### Part 6L Clean up

```

^C
24241 packets captured
24241 packets received by filter
0 packets dropped by kernel
root@eece5155-bos-webinar-interactive-v1-srn100:~# colosseumcli rf stop
root@eece5155-bos-webinar-interactive-v1-srn100:~# colosseumcli tg stop
Traffic Scenario Stopped
root@eece5155-bos-webinar-interactive-v1-srn100:~#

```

Now delete as shown below:

Interactive	148544	Sneha	Complete	2 node(s)	2024/11/20 - 6:35:00 PM	2024/11/20 - 8:35:00 PM	120	sugilals	
Interactive	148542	101	Complete	2 node(s)	2024/11/20 - 6:15:00 PM	2024/11/20 - 7:15:00 PM	60	soudug	Delete Reservation