

# Test House Report

## Objective:

This report presents the Throughput results, Throughput vs. Packet Size, Speed Test, YouTube Streaming, OFDMA Feature Validation, Ping and Connectivity Test, Packet Loss Evaluation, FTP/HTTP Test, IP Management, Coverage, RvR, and RvRvO, Set-Top Box (STB) Streaming Validation, Mesh Reliability Stress Test, IoT Stress Test, Security Camera Streaming and Online Gaming Evaluation results on Gateway (GW) and Leaf nodes with real Wi-Fi clients in the Test House. These tests help to evaluate the performance of DUTs in a real-world environment.

## DUT Specifications:

DUT Specifications	
Standard	802.11 ac/ax/be
Bands Supported	2.4GHz, 5 GHz, 6GHz
Bandwidth Supported	20, 40, 80, 160, 320 MHz
Spatial Streams	2x2

## Executed Test Cases Summary:

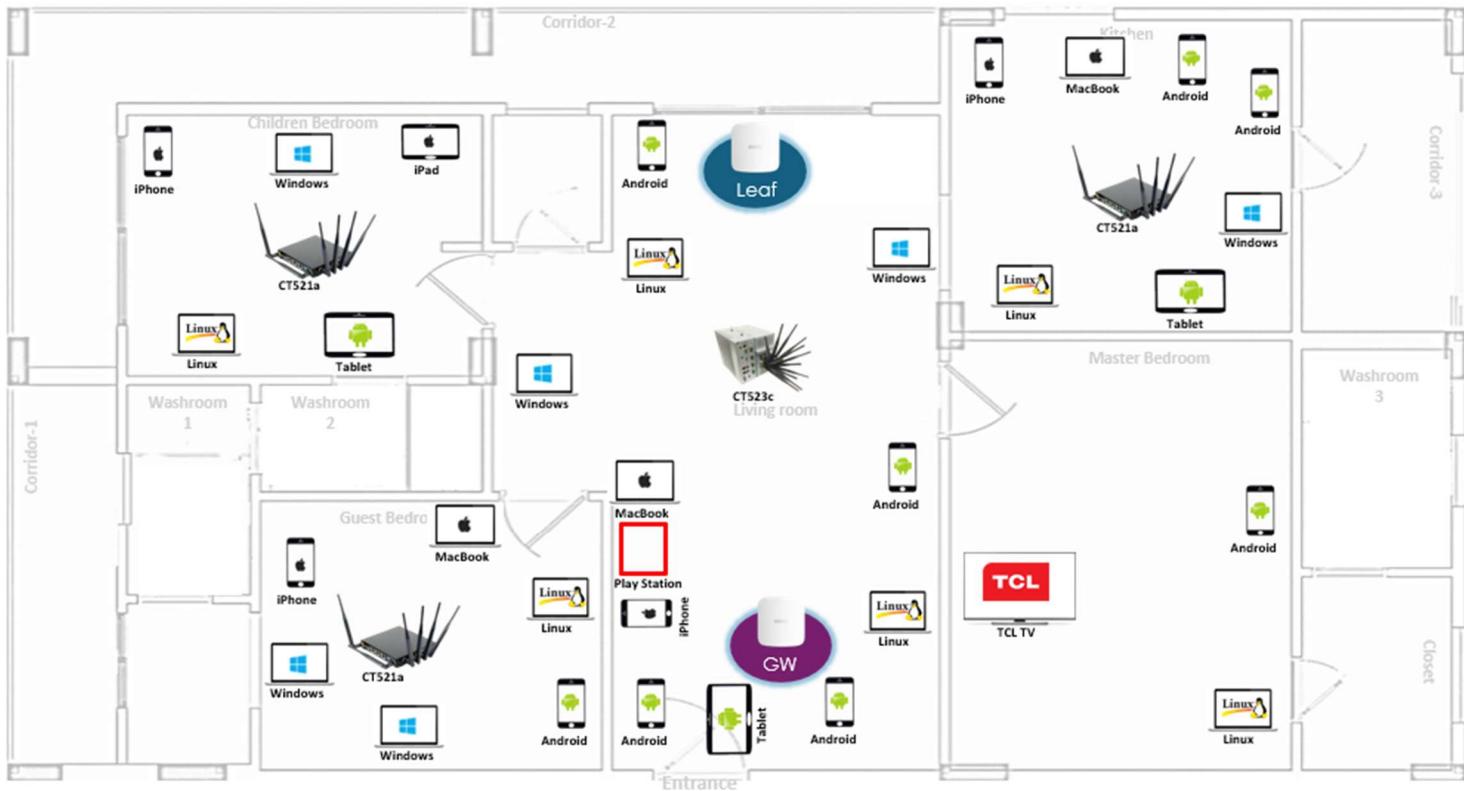
S No	Test Suite	Test case	Test Observations	Performance Rating
1	Performance Test	Throughput (Single Client)	<ul style="list-style-type: none"> <li>On the GW node, throughput with Samsung mobile is better than the throughput with the Dell Laptop in all traffic directions.</li> <li>On the leaf node, observed that the throughputs are almost 60% of the GW throughputs with the 2 Wi-Fi 7 clients.</li> </ul>	Good
		Throughput Vs Packet Size	<ul style="list-style-type: none"> <li>On both GW and Leaf nodes, observed that the throughput increases with the increase in packet size till MTU, and with jumbo frames, the throughput got reduced as expected in all traffic directions, but in TCP UL, observed good throughputs even at small packet sizes.</li> </ul>	Good
		Speed Tests (Multi-Client)	<ul style="list-style-type: none"> <li>On both GW and Leaf nodes observed that the Upload speeds are better than the Download speeds.</li> </ul>	Fair
2	Packet Loss Evaluation		<ul style="list-style-type: none"> <li>In both TCP DL and UL scenarios, observed that the HP Laptop and Samsung S25 connected to the GW obtained less throughput as they were placed inside the Guest bedroom.</li> <li>Observed low throughputs with Oppo3x mobile as well, due to a smaller number of transmitted packets.</li> </ul>	Fair
3	Feature Validation	OFDMA Impact	<ul style="list-style-type: none"> <li>Observed RU allocation for each client in trigger frames.</li> <li>As no Data frames were being captured for real clients, couldn't find EHT MU PPDU.</li> <li>But with virtual clients, there were EHT MU PPDU QoS frames, which confirm</li> </ul>	Good

			that the AP supports OFDMA.	
4	Functionality Testing	Streaming Under Load	<ul style="list-style-type: none"> <li>During the entire test, there are no buffers.</li> <li>The percentage of dropped frames when there is no channel utilization is low compared to the dropped frames when the channel utilization is 60%.</li> </ul>	Good
		FTP/HTTP Testing	<ul style="list-style-type: none"> <li>In the FTP test, observed that the Dell Laptop6RG performed well, but the Lenovo Tablet, which is placed inside the Children's bedroom, couldn't download a file.</li> <li>In the HTTP test, observed that the Samsung mobile, Lenovo Tablet, and MacBook couldn't download a file.</li> </ul>	Fair
5	Ping and Connectivity Testing		<ul style="list-style-type: none"> <li>There is a maximum ping loss of 87 seconds with the Itel mobile.</li> </ul>	Average
6	Port Forwarding and IP Management	IP Management	<ul style="list-style-type: none"> <li>After reserving the IPs from the AP side, observed that the same IPs were allocated to all the devices after rebooting the AP and after disconnecting and reconnecting all the clients.</li> </ul>	Good
7	Coverage, RvR, and RvRvO	Coverage	<ul style="list-style-type: none"> <li>There are no dead zones in the 2500 sq ft floor</li> <li>At co-ordinates 1, 2, 3, 4, and 6, clients are continuously toggling between bands and nodes.</li> <li>Observed less throughput at coordinate 4.</li> <li>Obtained the highest throughput at coordinate 13 near GW.</li> </ul>	Fair
		OTA RvR Testing	<ul style="list-style-type: none"> <li>In LoS, better throughputs were observed compared to non-LoS.</li> <li>In TCP DL, throughputs decreased with the increase in distance.</li> <li>In TCP UL, throughput increased at positions 5, 6 compared to position 4.</li> </ul>	Good
		RvRvO Testing	<ul style="list-style-type: none"> <li>In LoS, better throughputs were observed compared to non-LoS.</li> <li>At 270° orientation, the client did not steer down to 2.4 GHz at 39 ft, unlike at other orientations.</li> <li>At 270° orientation, PHY rates showed minimal fluctuation compared to other orientations.</li> <li>Across orientations, TCP throughput remained broadly similar.</li> <li>Across all orientations, a consistent slight peak in TCP throughput was observed around the 18 ft test point.</li> </ul>	Fair
8	Set-Top Box (STB) Streaming Validation	Verify STB video quality under high channel congestion	<ul style="list-style-type: none"> <li>No frames were dropped, and there were no buffers when the channel utilization was 50%.</li> <li>There were 400+ frame drops and video buffering when the channel utilization was 80%.</li> </ul>	Fair
		Validate streaming quality during IoT toggling.	<ul style="list-style-type: none"> <li>Despite continuous toggling of IoT devices, the STB video stream on YouTube showed 0 dropped frames, no buffering, and no video freezes,</li> </ul>	Good

			indicating stable performance.	
		STB video quality while transferring a 1GB file	<ul style="list-style-type: none"> <li>While downloading a 1GB file, observed 3698 Video frame drops; as a result, the YouTube Video started buffering.</li> </ul>	Fair
		STB video quality with active Multicast traffic	<ul style="list-style-type: none"> <li>While running Multicast traffic on other clients, there was no YouTube video buffering on the STB, but the Multicast server and client experienced buffering.</li> </ul>	Fair
9	Mesh Reliability Stress Testing		<ul style="list-style-type: none"> <li>The APs did not crash or reboot even under high stress.</li> <li>The throughput graph is stable across the 8-hour test, with no major drops or sudden fluctuations. Both upload and download rates are consistent.</li> </ul>	Good
10	IoT Stress Testing		<ul style="list-style-type: none"> <li>The APs did not crash or reboot while continuously toggling Wipro Next Smart tube lights, Philips Wiz Bulbs, Aziot Wi-Fi Smart Power Strip_sockets, Zebronics Smart Plugs, Wipro 16A Smart Plugs.</li> </ul>	Good
11	Security Camera Streaming		<ul style="list-style-type: none"> <li>While streaming live video when it is placed outside the house or near the GW, there is a 6-second delay to get the live feed.</li> <li>From the association response, observed that the cameras don't support the roaming feature. As a result, when we moved the camera away from the GW and moved towards the Leaf, observed that the video got stuck.</li> </ul>	Average
12	Online Gaming Evaluation		<ul style="list-style-type: none"> <li>There are no disruptions in the gameplay during the entire test. Observed average latency of 64ms.</li> </ul>	Good

## Test House Details:

- 2,500 Sq. Ft Single Level 4 Bedroom Apartment.
- 32 Real Wi-Fi devices comprising iPhones, MacBooks, TVs, Windows, Linux, and Tablets.
- Devices are spread across the Living room, 3 Bedrooms, and in Kitchen area at fixed positions.
- GW and Leaf nodes are placed in LoS (Line of Sight) at -52dBm RSSI.



## Real Devices Specifications:

S No	Room	Device Type	Platform	Model	Wi-Fi-Standard
1	Living Room	Phone	Android	iQOO Z9 Lite	Wi-Fi 5 (802.11ac)
2	Living Room	Tablet	Android	Samsung S9 FE	Wi-Fi 6 (802.11ax)
3	Living Room	Phone	Android	Itel P55 5G	Wi-Fi 5 (802.11ac)
4	Living Room	Phone	iOS	iPhone 12	Wi-Fi 6 (A14 Bionic)
5	Living Room	Laptop	macOS	MacBook	Wi-Fi 6 (Apple M1 chip)
6	Living Room	Laptop	Linux	Dell	Wi-Fi 5 (intel 9560)
7	Living Room	Phone	Android	Samsung M06	Wi-Fi 5 (802.11ac)
8	Living Room	Laptop	Windows	Dell-6RG	Wi-Fi 7 (BE200)
9	Living Room	Laptop	Windows	Dell-V9S	Wi-Fi 7 (BE200)
10	Living Room	Laptop	Linux	Lenovo ThinkPad	Wi-Fi 5 (intel 8265)
11	Living Room	Phone	Android	Oppo A3X	Wi-Fi 5 (802.11ac)
12	Children Bedroom	Tablet	Android	Lenovo M10	Wi-Fi 5 (802.11ac)
13	Children Bedroom	Laptop	Linux	Lenovo ThinkPad	Wi-Fi 5 (intel 8260)
14	Children Bedroom	Phone	iOS	iPhone 14	Wi-Fi 6 (A15 Bionic)
15	Children Bedroom	Laptop	Windows	HP	WiFi-6 (AX200)
16	Children Bedroom	IPad	iOS	iPad 13	Wi-Fi 6 (A14 Bionic)
17	Kitchen	Laptop	Linux	Lenovo ThinkPad	Wi-Fi 5 (intel 9560)
18	Kitchen	Tablet	Android	Honor X Pad	Wi-Fi 5 (802.11ac)
19	Kitchen	Laptop	Windows	Dell	WiFi-7 (Qualcomm 7800)
20	Kitchen	Phone	Android	Oppo A3X	Wi-Fi 5 (802.11ac)
21	Kitchen	Phone	Android	Samsung M14	Wi-Fi 5 (802.11ac)
22	Kitchen	Laptop	macOS	MacBook	Wi-Fi 6 (Apple M2 chip)
23	Kitchen	Phone	iOS	iPhone 12	Wi-Fi 6 (A14 Bionic)
24	Guest Bedroom	Laptop	macOS	MacBook	Wi-Fi 6 (Apple M1 chip)
25	Guest Bedroom	Phone	iOS	iPhone 13	Wi-Fi 6 (A15 Bionic)
26	Guest Bedroom	Laptop	Windows	Lenovo ThinkPad	Wi-Fi 5 (intel 8265)
27	Guest Bedroom	Laptop	Linux	HP	Wi-Fi 4 (RTL8723DE)
28	Guest Bedroom	Phone	Android	Samsung M05	Wi-Fi 5 (802.11ac)
29	Guest Bedroom	Laptop	Windows	Lenovo ThinkPad	Wi-Fi 5 (intel 8265)
30	Master Bedroom	Laptop	Linux	HP	Wi-Fi 4 (RTL8723DE)
31	Master Bedroom	Phone	Android	Samsung M06	Wi-Fi 5 (802.11ac)
32	Master Bedroom	TV	Android	TCL TV	Wi-Fi 3 (802.11 abg)

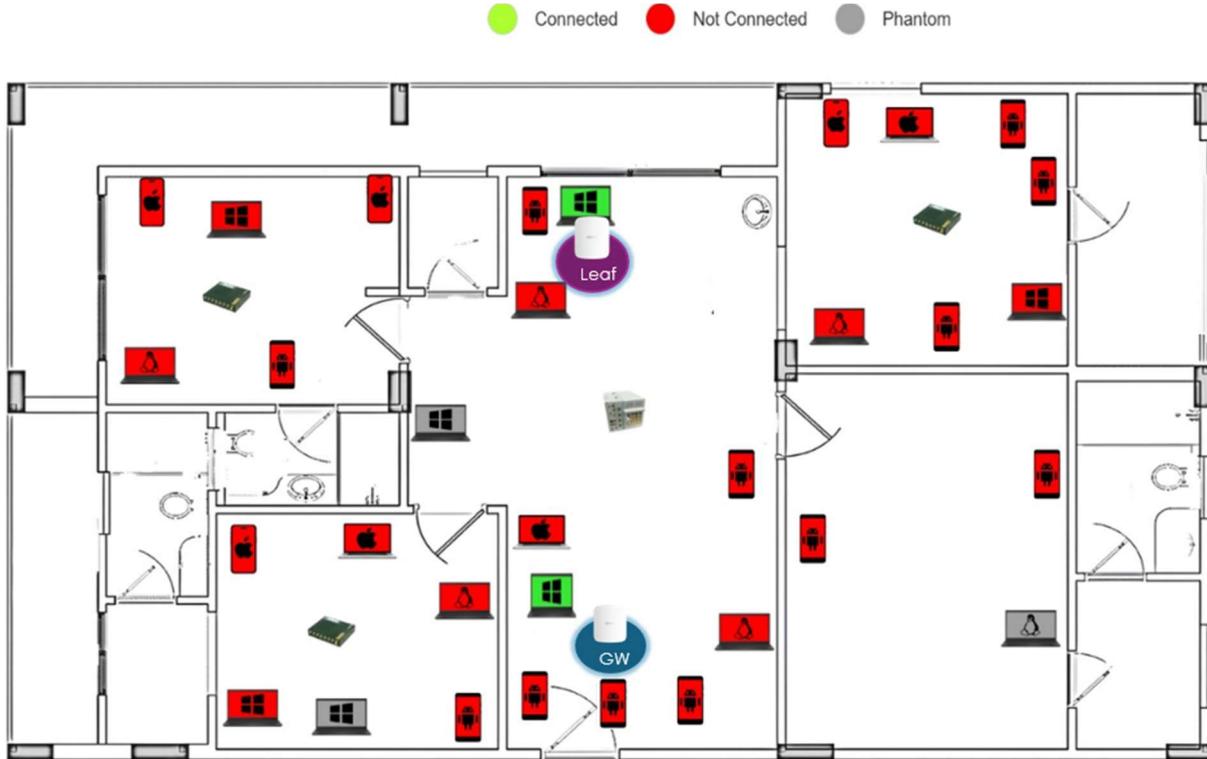
# 1. Performance Test

## 1.1 Throughput (Single Client)

### Test Description:

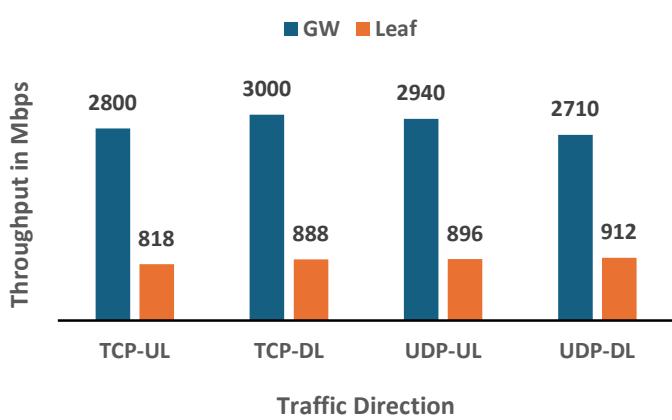
- Place the Wi-Fi7 client near the GW in such a way that it achieves full PHY rate.
- Run TCP, UDP upload/download throughput tests separately on the connected band.
- Repeat the same tests on Leaf using the same devices.

### Device Placement near GW and Leaf:

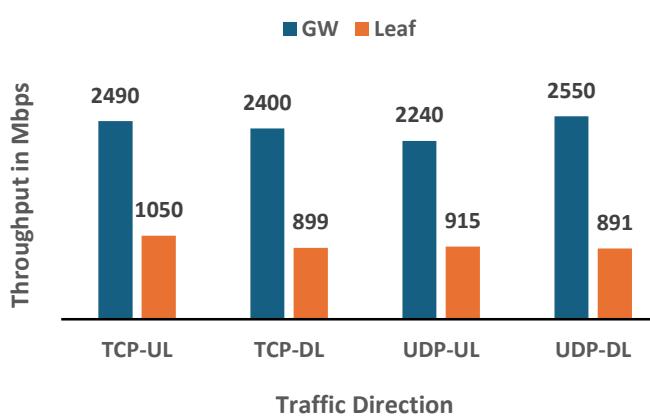


### Test Results:

Throughput Comparison between GW and Leaf with Samsung S25 on 6GHz band:



Throughput Comparison between GW and Leaf with BE200 Dell Laptop on 6GHz band:



### GW Results

S. No	Band/Bandwidth	RSSI (dBm)	Traffic type	Samsung S25 Client			
				Expected PHY-rate (Mbps)	Achieved PHY-rate (Mbps)	Achieved throughput (Mbps)	MCS
1	6GHz/320MHz	-20	TCP-UL	5764.6	5764.6	2800	13
2		-20	TCP-DL	5764.6	5764.6	3000	13
3		-20	UDP-UL	5764.6	4322	2940	8
4		-20	UDP-DL	5764.6	5764.6	2710	13

### Leaf Results

S. No	Band/Bandwidth	RSSI (dBm)	Traffic type	Samsung S25 Client			
				Expected PHY-rate (Mbps)	Achieved PHY-rate (Mbps)	Achieved throughput (Mbps)	MCS
1	6GHz/320MHz	-20	TCP-UL	5764.6	4322	818	10
2		-20	TCP-DL	5764.6	5764.6	888	13
3		-20	UDP-UL	5764.6	4322	896	10
4		-20	UDP-DL	5764.6	5764.6	912	13

### GW Results

S. No	Band/Bandwidth	RSSI (dBm)	Traffic type	Intel BE200 Client (Dell Laptop)			
				Expected PHY-rate (Mbps)	Achieved PHY-rate (Mbps)	Achieved throughput (Mbps)	MCS
1	6GHz/320MHz	-20	TCP-UL	5764.6	5764.6	2490	13
2		-21	TCP-DL	5764.6	5764.6	2400	13
3		-21	UDP-UL	5764.6	5764.6	2240	13
4		-21	UDP-DL	5764.6	5764.6	2550	13

### Leaf Results

S. No	Band/Bandwidth	RSSI (dBm)	Traffic type	Intel BE200 client (Dell Laptop)			
				Expected PHY-rate (Mbps)	Achieved PHY-rate (Mbps)	Achieved throughput (Mbps)	MCS
1	6GHz/320MHz	-21	TCP-UL	5764.6	5188	1050	12
2		-21	TCP-DL	5764.6	5764	899	13
3		-21	UDP-UL	5764.6	5188	915	12
4		-21	UDP-DL	5764.6	5764	891	13

#### Observations for Throughput (Single Client):

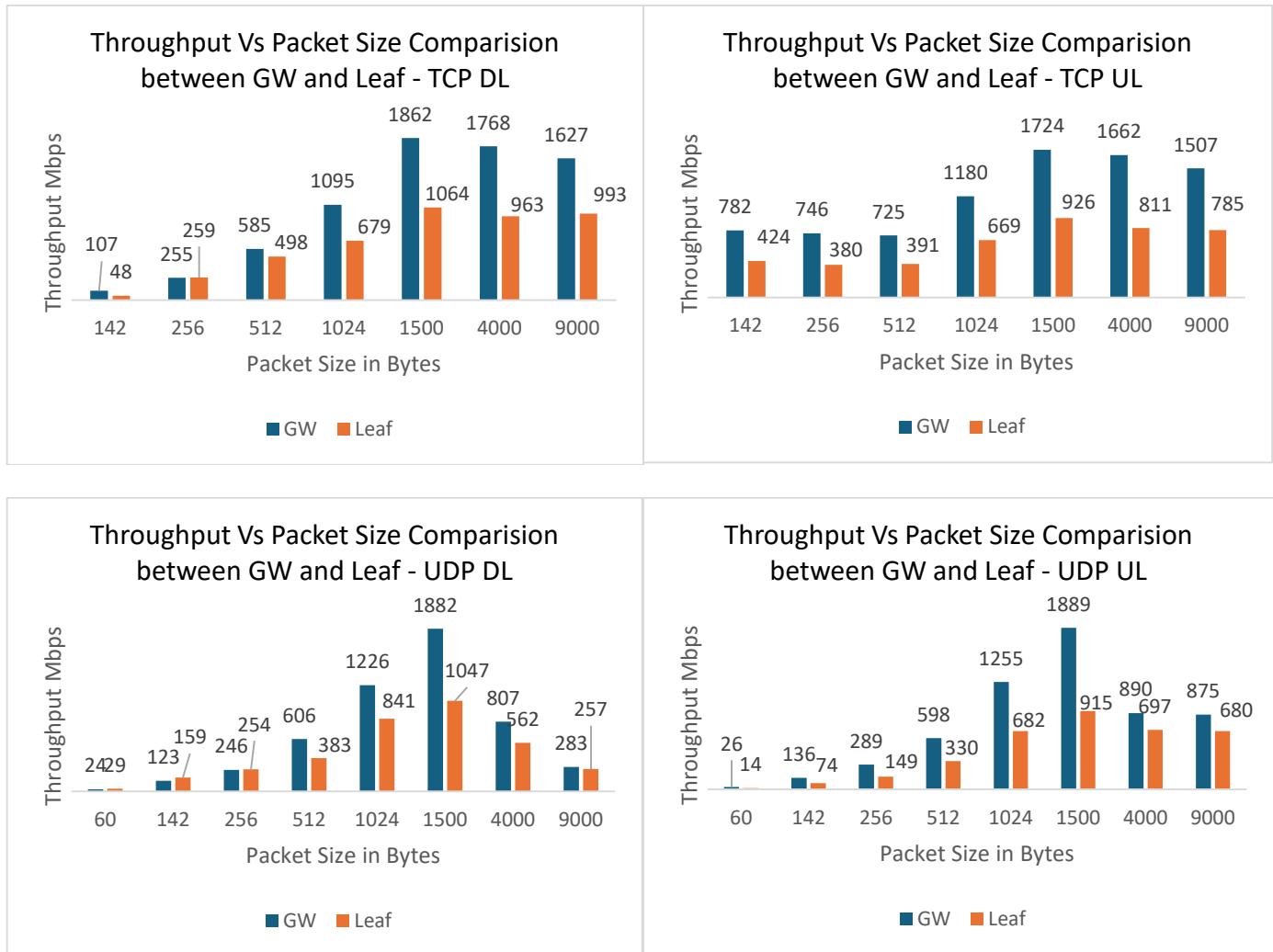
- On the GW node, observed that the Samsung mobile achieved higher throughput than the Dell Laptop in all traffic directions.
- On the leaf node, observed that the throughputs are almost 60% of the GW throughputs with the 2 Wi-Fi 7 clients.

## 1.2 Throughput Vs Packet Size (Single Client)

#### Test Description:

- Place the Wi-Fi7 BE200 Dell Laptop near the GW.
- Run TCP, UDP upload/download throughput tests separately on the connected band with different packet sizes.
- Repeat the same tests on Leaf using the same device.

## Test Results:



### Observations for Throughput Vs Packet Size (Single Client):

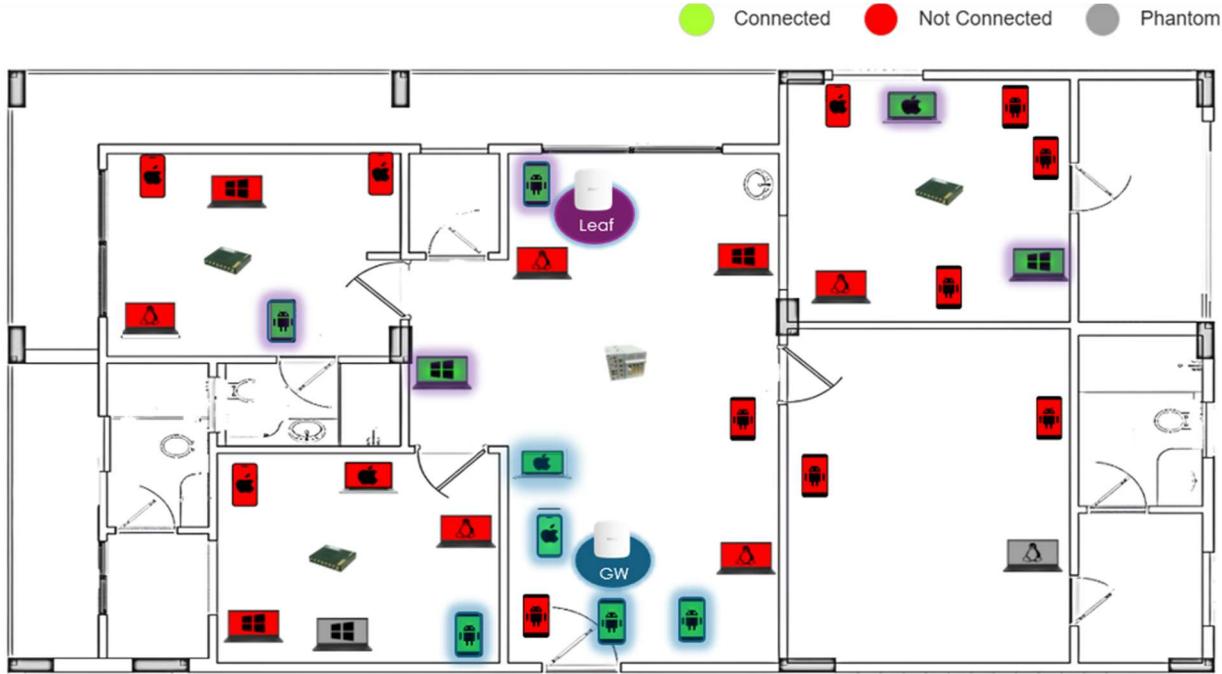
- On both GW and Leaf nodes, observed that the throughput increases with the increase in packet size till MTU, and with jumbo frames, the throughput got reduced as expected in all traffic directions, but in TCP UL, observed good throughputs even at small packet sizes.

## 1.3 Speed Test (Multi-Client)

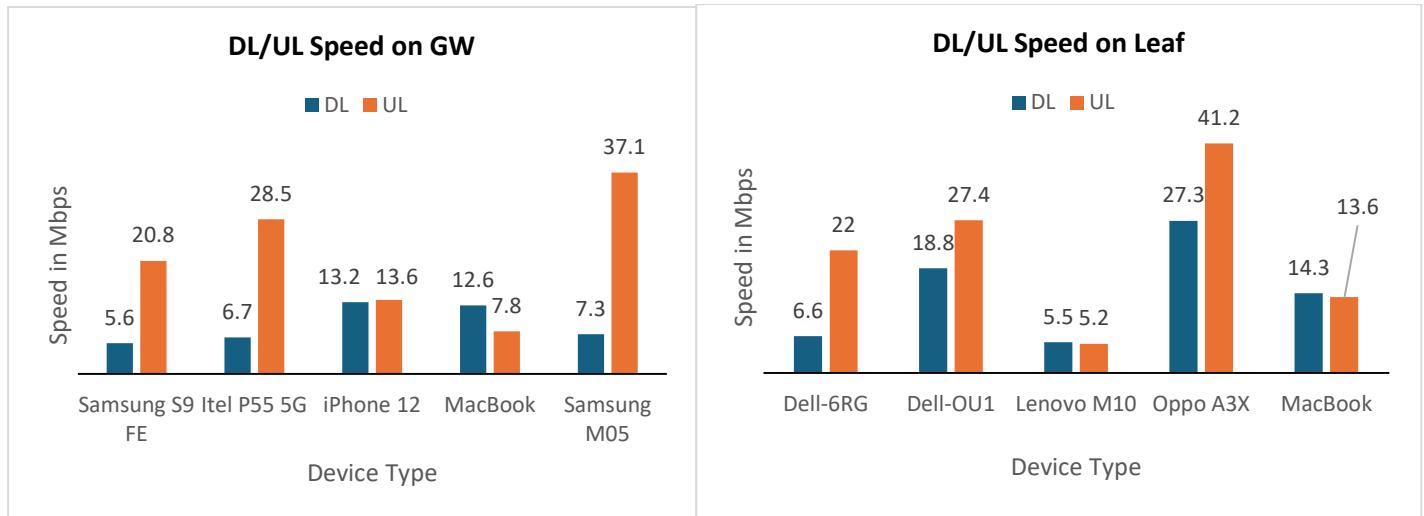
### Test Description:

- Connect 5 clients, which include Windows, Linux, Android, MacBook, and iPhone, on each node.
- Run Ookla speed test on all the devices simultaneously.

## Connected Devices:



## Test Results:



Model	Device Placement	Connected Node	Connected Band	Speed (Mbps)		Latency (ms)	
				Download	Upload	Download	Upload
Samsung S9 FE	Living Room	GW	5GHz	5.6	20.8	35	382
Itel P55 5G	Living Room	GW	5GHz	6.7	28.5	29	422
iPhone 12	Living Room	GW	5GHz	13.2	13.6	22	858
MacBook	Living Room	GW	5GHz	12.6	7.8	27	290
Samsung M05	Guest Bedroom	GW	5GHz	7.3	37.1	117	22
Dell	Living Room	Leaf	6GHz	6.6	22.0	27	5.68
Dell	Kitchen	Leaf	6GHz	18.8	27.4	22	57
Lenovo M10	Children Bedroom	Leaf	2.4GHz	5.5	5.2	35	669
Oppo A3X	Living Room	Leaf	5GHz	27.3	41.2	170	1290
MacBook	Kitchen	Leaf	5GHz	14.3	13.6	60	239

## Observations for Speed Test (Multi-Client):

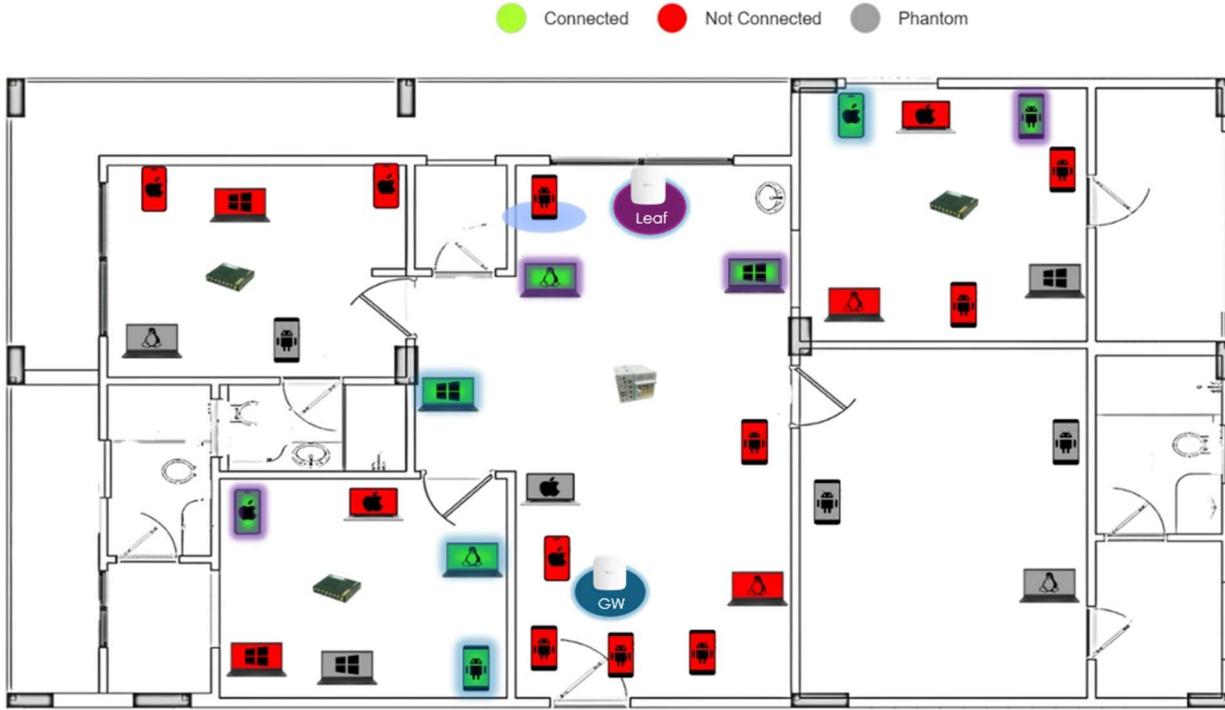
- On both GW and Leaf nodes observed that the Upload speeds are better than the Download speeds.

## 2. Packet Loss Evaluation

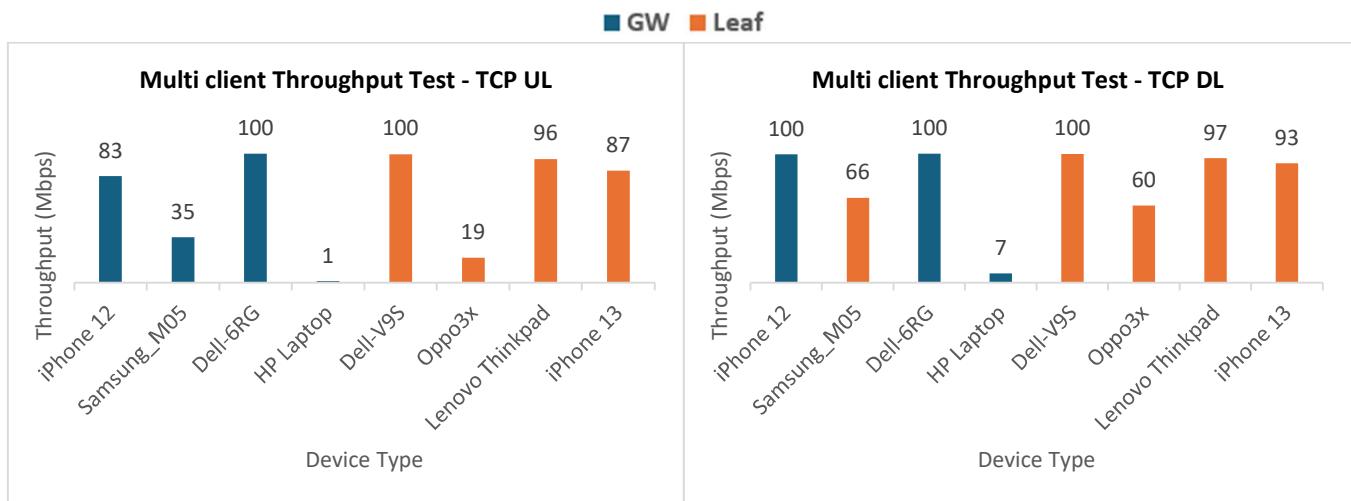
### Test Description:

- Connect 4 clients, which include Windows, Linux, Android, MacBook, and iPhone, on each node.
- Run TCP Download throughput test for 5 minutes duration on all 8 clients simultaneously with an intended load of 100Mbps.
- Run TCP Upload throughput test for 5 minutes duration on all 8 clients simultaneously with an intended load of 100Mbps.
- Record the number of packets dropped during the test for each client.

### Connected Devices:



### Test Result



Room	Device Type	Platform	Model	Connected Node	Connected Band	TCP UL (Mbps)	RSSI (dBm)	Tx Packets	Rx Packets	Packets dropped	Packet Drop%
Kitchen	Phone	iOS	iPhone 12	GW	5GHz	83	-50	15824	15822	2	0
Guest Bedroom	Phone	Android	Samsung_M05	GW	2.4GHz	35	-52	6680	6680	0	0
Living Room	Laptop	Windows	Dell-6RG	GW	6GHz	100	-52	19186	19185	1	0
Guest Bedroom	Laptop	Linux	HP Laptop	GW	5GHz	1	-18	205	203	2	1
Living Room	Laptop	Windows	Dell-V9S	Leaf	6GHz	100	-42	19126	19126	0	0

Kitchen	Phone	Android	Oppo3x	Leaf	5GHz	19	-55	3690	3690	0	0
Living Room	Laptop	Linux	Lenovo ThinkPad	Leaf	5GHz	96	-26	18452	18412	40	0
Guest Bedroom	Phone	iOS	iPhone 13	Leaf	5GHz	87	-58	16675	16675	0	0

Room	Device Type	Platform	Model	Connected Node	Connected Band	TCP DL (Mbps)	RSSI (dBm)	Tx Packets	Rx Packets	Packets dropped	Packet Drop%
Kitchen	Phone	iOS	iPhone 12	GW	5GHz	100	-50	19,037	19037	0	0
Guest Bedroom	Phone	Android	Samsung_M05	Leaf	5GHz	66	-67	12,673	12494	179	1
Living Room	Laptop	Windows	Dell-6RG	GW	6GHz	100	-52	19141	19141	0	0
Guest Bedroom	Laptop	Linux	HP Laptop	GW	5GHz	7	-36	2272	1357	915	40
Living Room	Laptop	Windows	Dell-V9S	Leaf	6GHz	100	-43	19138	19138	0	0
Kitchen	Phone	Android	Oppo3x	Leaf	2.4GHz	60	-36	11528	11501	27	0
Living Room	Laptop	Linux	Lenovo ThinkPad	Leaf	5GHz	97	-25	18601	18512	89	0
Guest Bedroom	Phone	iOS	iPhone 13	Leaf	5GHz	93	-59	18012	17862	150	1

### Observations for Packet Loss Evaluation Tests:

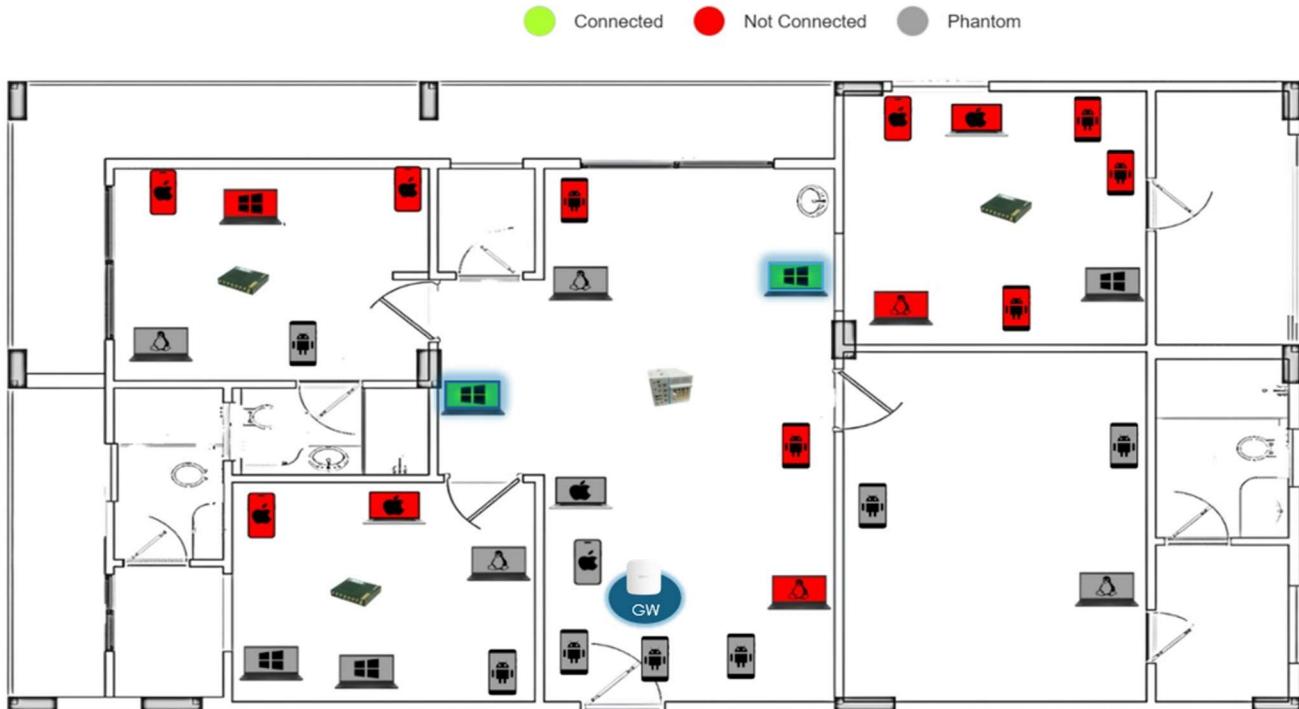
- In both TCP DL and UL scenarios, observed that the HP Laptop and Samsung S25 connected to the GW obtained less throughput as they were placed inside the Guest bedroom.
- Observed low throughputs with Oppo3x mobile as well, due to a smaller number of transmitted packets.

### 3. OFDMA Testing:

#### Test Description:

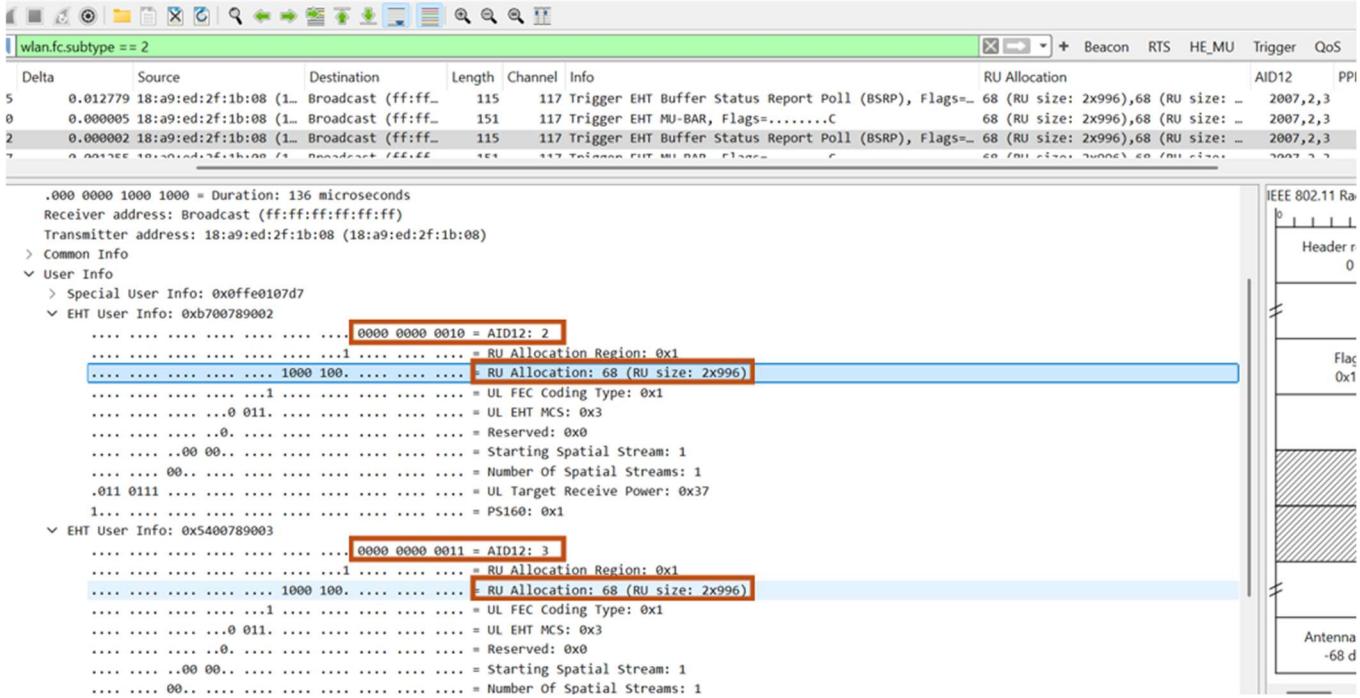
- Connect 2 Intel BE200 Wi-Fi 7 clients to the GW node.
- Run TCP Download throughput test for 5 minutes duration on both 2 clients simultaneously with an intended load of 100Mbps at different packet sizes - 64, 172, 300 bytes.
- Run TCP Upload throughput test for 5 minutes duration on both 2 clients simultaneously with an intended load of 100Mbps at different packet sizes - 64, 172, 300 bytes.
- While running the traffic, start the sniffer and check for Trigger frames, MU RTS frames for RU allocations in UL and DL directions, respectively.
- Check for EHT MU PPDU, PPDU Type, and Compression Mode.

#### Connected Devices:



#### Test Results

Room	Device Type	Platform	Model	Wi-Fi-Supports	Throughput at Different Packet Sizes		
					64 Bytes	172 Bytes	300 bytes
Living Room	Laptop	Windows	Dell-9VS	Wi-Fi 7 (BE200)	100	100	100
Living Room	Laptop	Windows	Dell-LRG	Wi-Fi 7 (BE200)	100	100	100



## Observations for OFDMA Testing:

- Observed RU allocation for each client in trigger frames.
- As no Data frames were being captured for real clients, couldn't find EHT MU PPDU.
- But with virtual clients, there were EHT MU PPDU QoS frames, which confirm that the AP supports OFDMA.

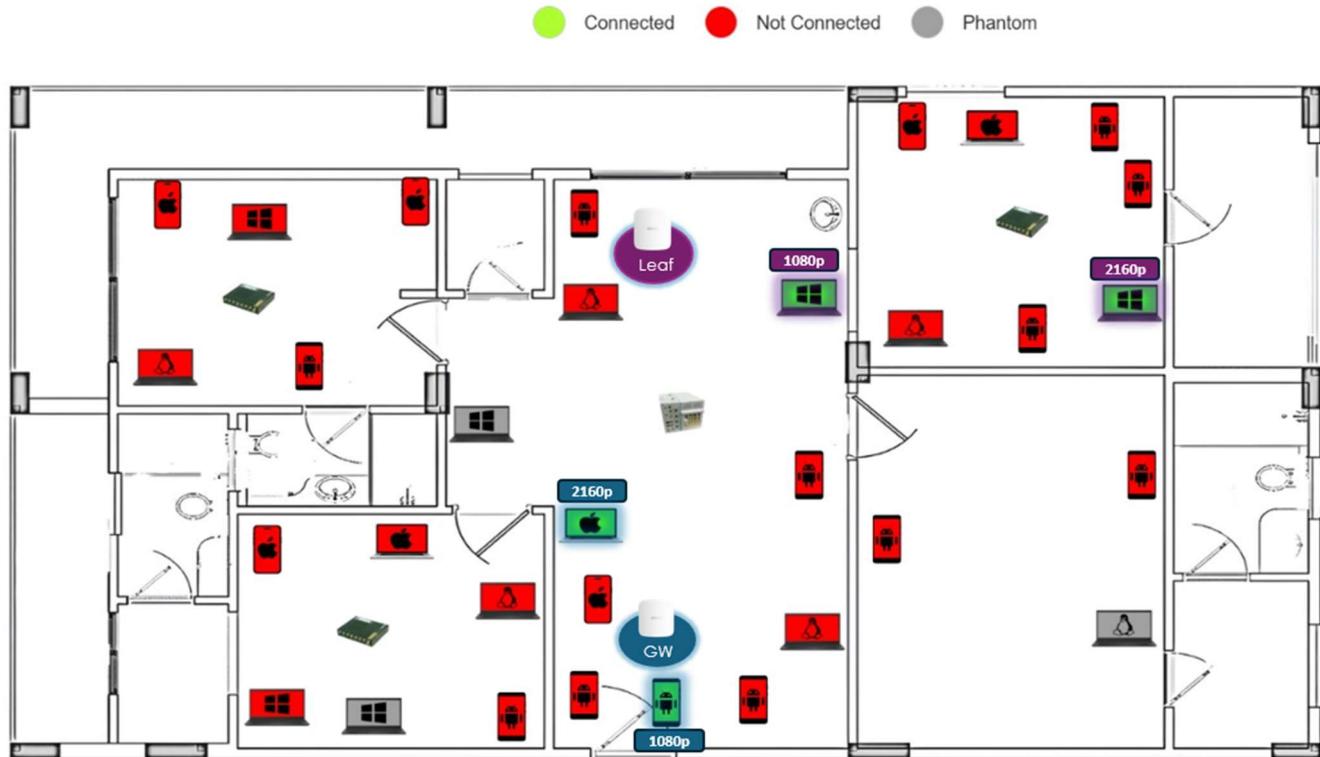
## 4. Functionality Tests

### 4.1 Streaming Under Load

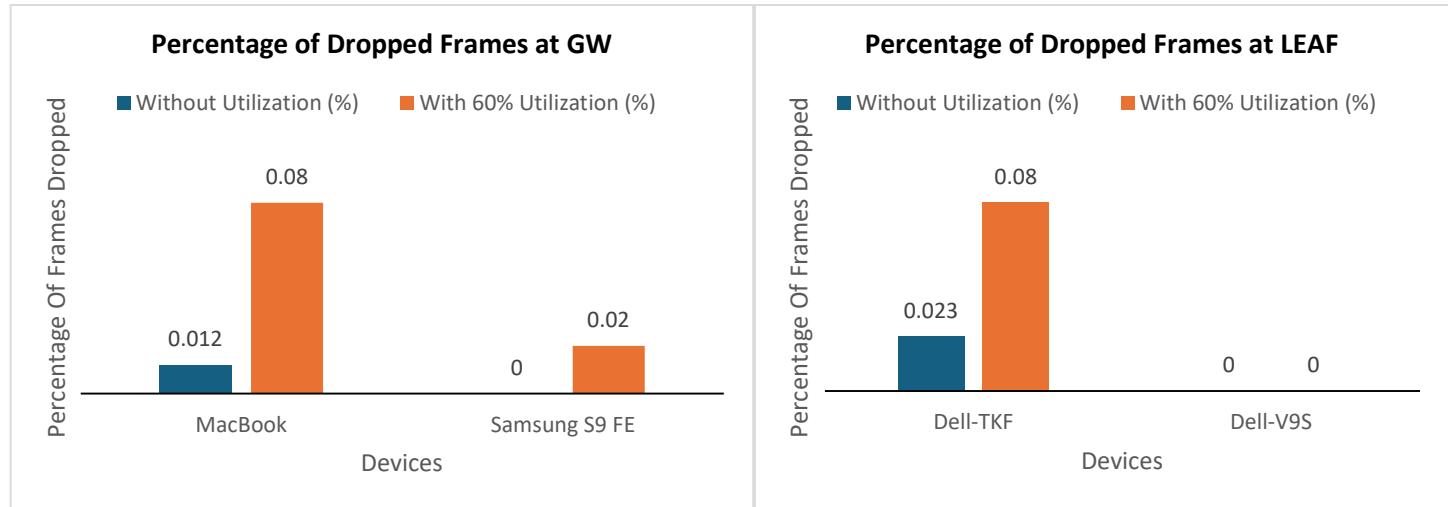
Test Description:

- Make sure the channel utilization is less than 10% on all the bands.
- Connect 2 clients on each node.
- Set full HD and 4k resolution YouTube videos on connected devices and run for 1 hour duration.
- Run the same test with 60% Channel Utilization on all the bands.

Connected Devices with 4k (2160p) and full HD (1080p) resolution:



Test Results:



Model	Device Placement	Connected Node	Connected Band		Without Utilisation		With Utilisation	
					Video Resolution	Total Frames	Dropped Frames	Total Frames
Dell-TKF	Children Bedroom	Leaf	6GHz	2160p	215550	1	215510	178
Dell-V9S	Kitchen	Leaf	5GHz	1080p	218154	51	215616	2
MacBook	Children Bedroom	GW	5GHz	2160p	216060	26	215615	173
Samsung S9 FE	Living Room	GW	5GHz	1080p	12634	0	12745	3

### Observations for YouTube Streaming Under Load:

- During the entire test, no buffering was observed.
- The percentage of dropped frames when there is no channel utilization is low compared to the dropped frames when the channel utilization is 60%.

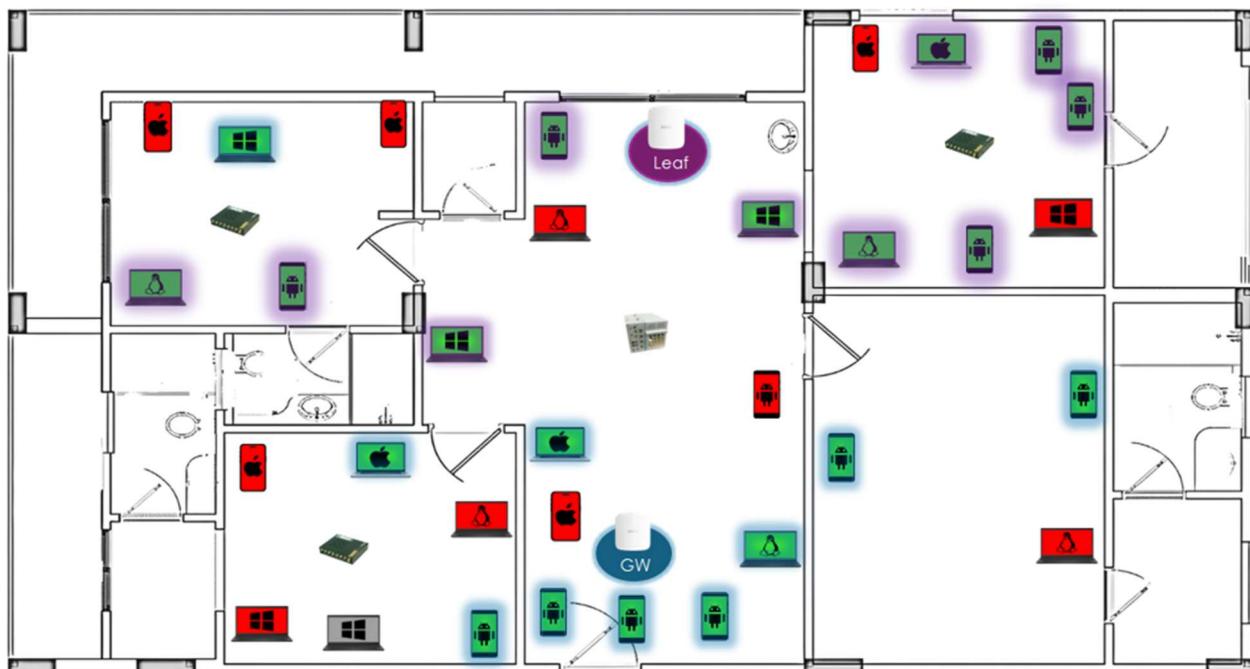
## 4.2 FTP and HTTP Test:

### Test Description:

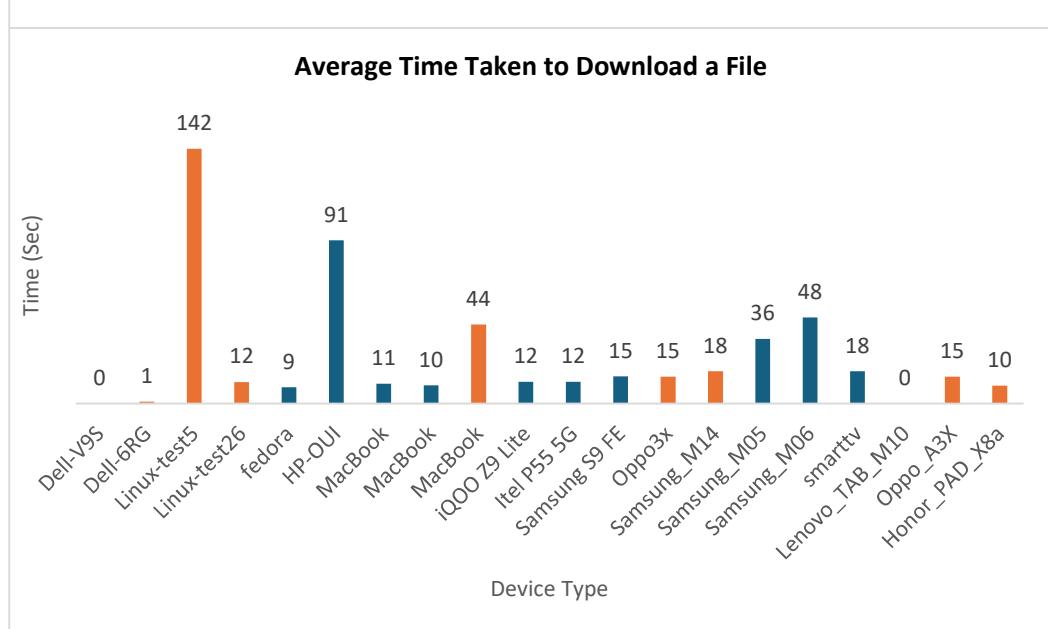
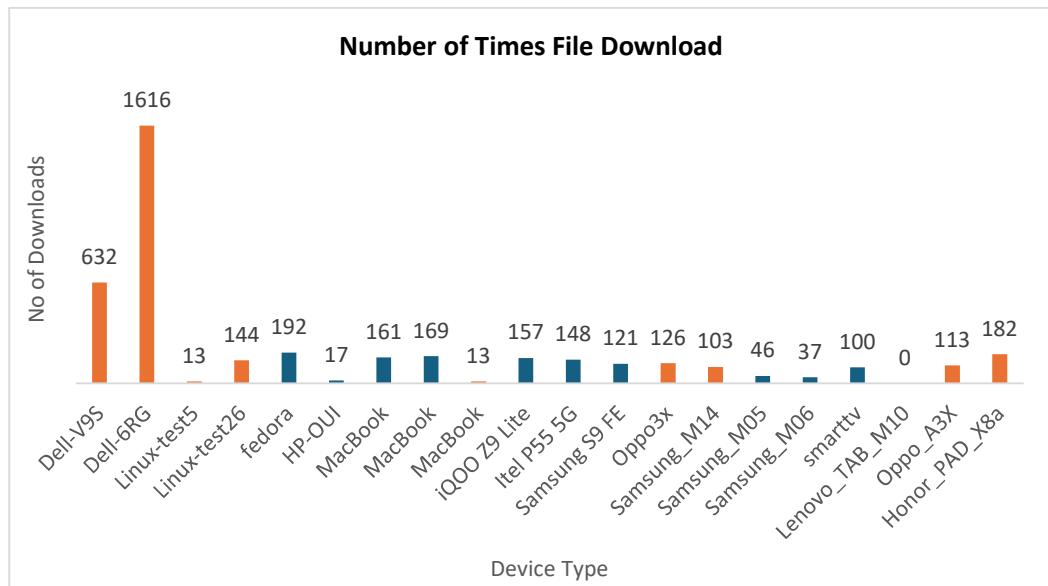
- Connect 20 clients to Wi-Fi.
- Connect one wired client to the GW and start FTP/HTTP Server on it.
- Download a 100 MB file for a 30-minute duration on all 20 clients using FTP and HTTP protocols.
- Record the number of file downloads and average time taken to download a file during the entire test.

### Connected Devices:

● Connected    ● Not Connected    ● Phantom



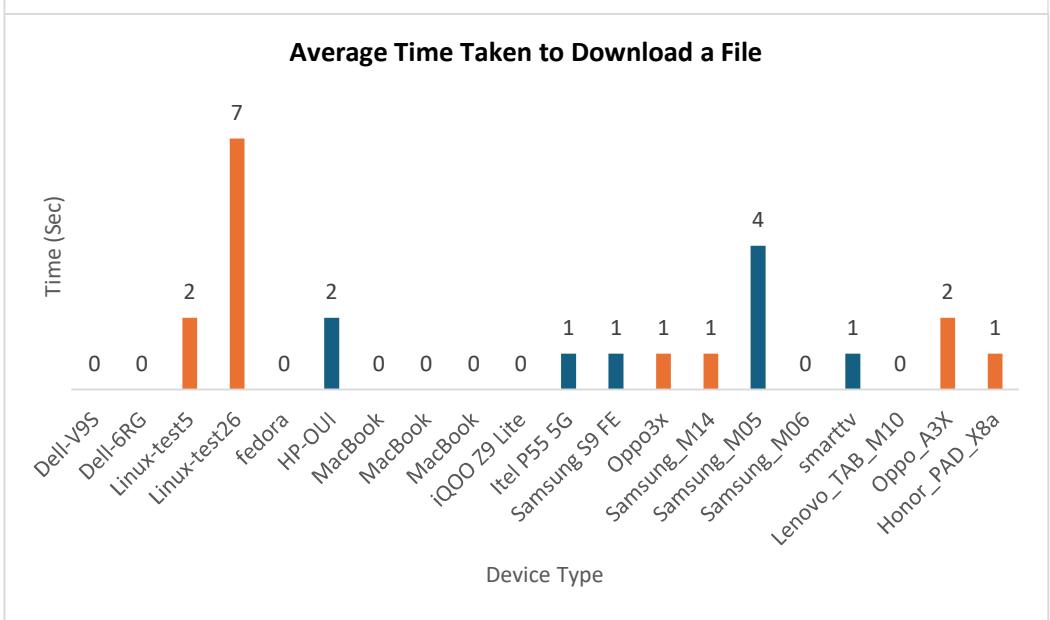
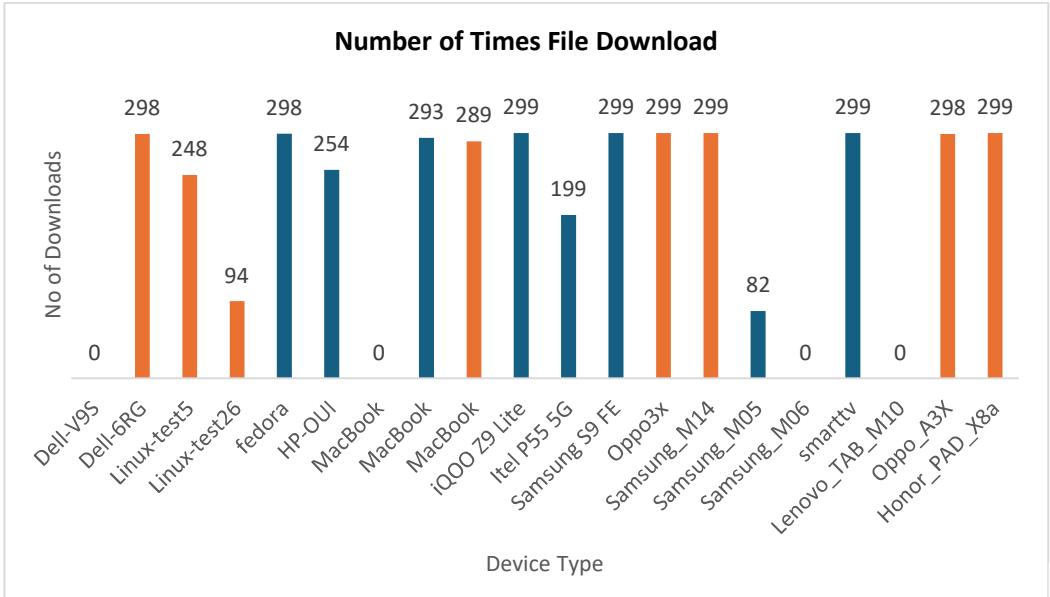
## FTP Test Result



Client Used	Device Placement	Connected Node	RSSI (dBm)	Connected Band	No of Downloads	Average Time Taken to Download File(s)
Dell-V9S	Living Room	Leaf	-43	5GHz	632	2
Dell-6RG	Living Room	Leaf	-52	5GHz	1616	1
Linux-test5	Children Bedroom	Leaf	-58	5GHz	13	142
Linux-test26	Kitchen	Leaf	-50	5GHz	144	12
fedora	Living Room	GW	-29	2.4GHz	192	9
HP-OUI	Children Bedroom	GW	-72	5GHz	17	91
MacBook	Living Room	GW	-43	2.4GHz	161	11
MacBook	Guest Bedroom	GW	-62	5GHz	169	10
MacBook	Kitchen	Leaf	-71	2.4GHz	13	44
iQOO Z9 Lite	Living Room	GW	-42	2.4GHz	157	12
Itel P55 5G	Living Room	GW	-47	5GHz	148	12
Samsung S9 FE	Living Room	GW	-46	2.4GHz	121	15
Oppo3x	Living Room	Leaf	-48	5GHz	126	15
Samsung_M14	Kitchen	Leaf	-55	2.4GHz	103	18

Samsung_M05	Guest Bedroom	GW	-46	5GHz	46	36
Samsung_M06	Master Bedroom	GW	-45	5GHz	37	48
smarttv	Master Bedroom	GW	-42	5GHz	100	18
Lenovo_TAB_M10	Children Bedroom	Leaf	-56	2.4GHz	0	0
Oppo_A3X	Kitchen	Leaf	-10	5GHz	113	15
Honor_PAD_X8a	Kitchen	Leaf	-47	5GHz	182	10

## HTTP Test Results



Client Used	Device Placement	Connected Node	RSSI (dBm)	Connected Band	No of Downloads	Average Time Taken to Download File(ms)	Average Time Taken to Download File(s)
Dell-V9S	Living Room	Leaf	-43	5GHz	295	318	0
Dell-6RG	Living Room	Leaf	-52	5GHz	298	100	0
Linux-test5	Children Bedroom	Leaf	-58	5GHz	248	1957	2
Linux-test26	Kitchen	Leaf	-50	5GHz	94	7257	7
fedora	Living Room	GW	-29	2.4GHz	298	176	0
HP-OUI	Children	GW	-72	5GHz	254	1715	2

	Bedroom						
MacBook	Living Room	GW	-43	2.4GHz	0	0	0
MacBook	Guest Bedroom	GW	-62	5GHz	293	305	0
MacBook	Kitchen	Leaf	-71	2.4GHz	289	447	0
iQOO Z9 Lite	Living Room	GW	-42	2.4GHz	299	295	0
Itel P55 5G	Living Room	GW	-47	5GHz	199	573	1
Samsung S9 FE	Living Room	GW	-46	2.4GHz	299	734	1
Oppo3x	Living Room	Leaf	-48	5GHz	299	980	1
Samsung_M14	Kitchen	Leaf	-55	2.4GHz	299	1417	1
Samsung_M05	Guest Bedroom	GW	-46	5GHz	82	3795	4
Samsung_M06	Master Bedroom	GW	-45	5GHz	0	0	0
smarttv	Master Bedroom	GW	-42	5GHz	299	925	1
Lenovo_TAB_M10	Children Bedroom	Leaf	-56	2.4GHz	0	0	0
Oppo_A3X	Kitchen	Leaf	-10	5GHz	298	1538	2
Honor_PAD_X8a	Kitchen	Leaf	-47	5GHz	299	903	1

### Observations for FTP and HTTP Tests:

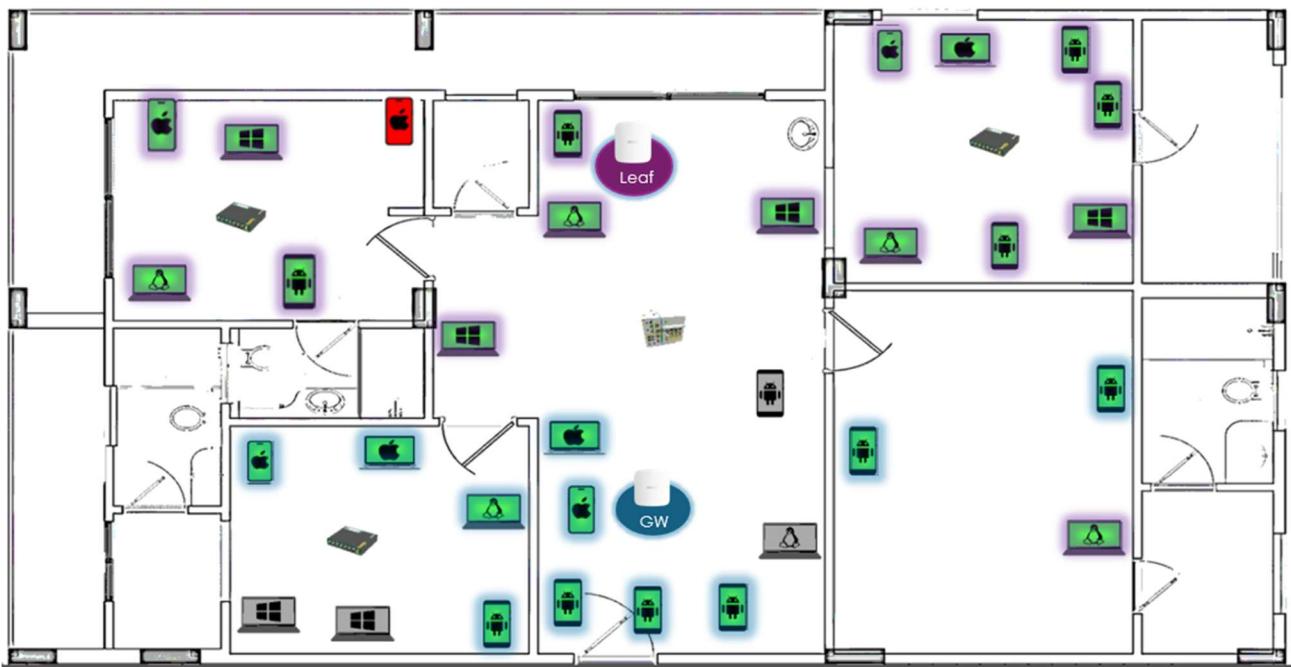
- In the FTP test, observed that the Dell Laptop6RG performed well, but the Lenovo Tablet, which is placed inside the Children's bedroom, couldn't download a file.
- In the HTTP test, observed that the Samsung mobile, Lenovo Tablet, and MacBook couldn't download a file.

## 5. Ping and Connectivity Testing

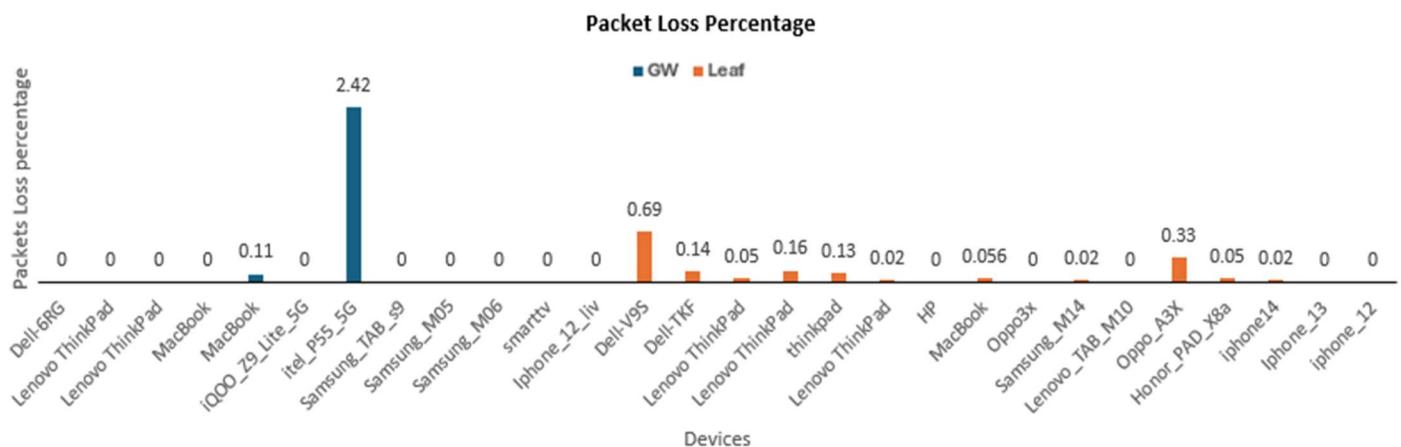
### Test Description:

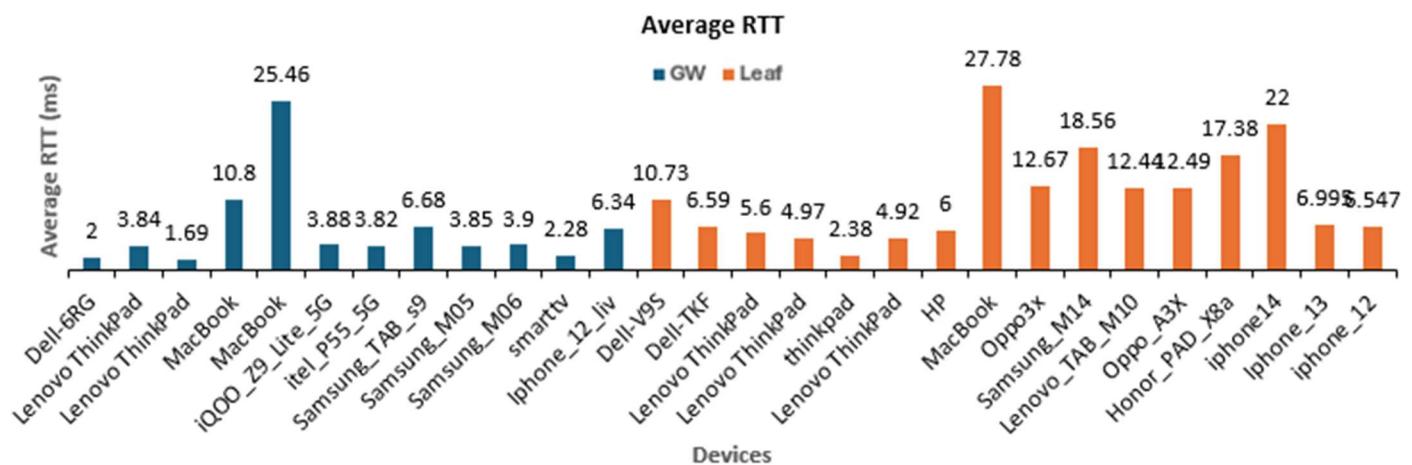
- Connect 27 clients to both GW and Leaf nodes.
- Connect one wired client to the GW.
- Ping from the Wi-Fi devices to the wired client with a 1-second ping interval for a 1-hour duration, and note down the Latency.

### Connected Devices:



### Test Results:





Wireless Clients	Band	Connected Node	Min RTT (ms)	Average RTT (ms)	Max RTT (ms)	Packets Sent	Packets Received	Packets Loss	Loss Percentage
Dell-6RG	6GHz	GW	1	2	121	3600	3600	0	0
linuxtest	5GHz	GW	1.39	3.84	105	3600	3600	0	0
Lenovo ThinkPad	5GHz	GW	1.11	1.69	42.8	3600	3600	0	0
MacBook	5GHz	GW	2.79	10.8	95.96	0	0	0	0
MacBook	5GHz	GW	0	25.46	554.21	3570	3566	4	0.112045
iQOO_Z9_Lite_5G	5GHz	GW	1.32	3.88	111	3591	3591	0	0
itel_P55_5G	5GHz	GW	0	3.82	104	3591	3504	87	2.422723
Samsung_TAB_s9_	5GHz	GW	1.74	6.68	80	3592	3592	0	0
Samsung_M05	5GHz	GW	1.13	3.85	115	3593	3593	0	0
Samsung_M06	5GHz	GW	1.45	3.9	81.3	3593	3593	0	0
smarttv	2.4GHz	GW	1.23	2.28	176	3594	3594	0	0
Iphone_12_liv	5GHz	GW	2.644	6.345	116.336	3600	3600	0	0
Dell-V9S	6GHz	Leaf	0	10.73	125	3572	3547	25	0.699888
Dell-TKF	6GHz	Leaf	0	6.59	293	3570	3565	5	0.140056
Lenovo ThinkPad	2.4GHz	Leaf	0	5.6	284	3600	3598	2	0.055556
Lenovo ThinkPad	2.4GHz	Leaf	0	4.97	287	3600	3594	6	0.166667
Lenovo ThinkPad	5GHz	Leaf	0	2.38	227	3600	3595	5	0.138889
Lenovo ThinkPad	5GHz	Leaf	0	4.92	192	3600	3599	1	0.027778
HP	5GHz	Leaf	3	6	134	3600	3599	1	0
MacBook	5GHz	Leaf	0	27.78	274.75	3571	3569	2	0.056007
Oppo3x	2.4GHz	Leaf	3.14	12.67	161	3593	3593	0	0
Samsung_M14	5GHz	Leaf	0	18.56	194	3592	3591	1	0.02784
Lenovo_TAB_M10	2.4GHz	Leaf	3.55	12.44	140	3593	3593	0	0
Oppo_A3X	2.4GHz	Leaf	0	12.49	261	3592	3580	12	0.334076
Honor_PAD_X8a	5GHz	Leaf	0	17.38	150	3592	3590	2	0.055679
iphone14	5GHz	Leaf	4.165	22.015	329.763	3600	3599	1	0.027778
Iphone_13	5GHz	Leaf	2.483	6.995	107.175	3600	3600	0	0
Iphone_12	5GHz	Leaf	2.697	6.547	91.44	3600	3600	0	0

## Observations for Ping and Connectivity Tests:

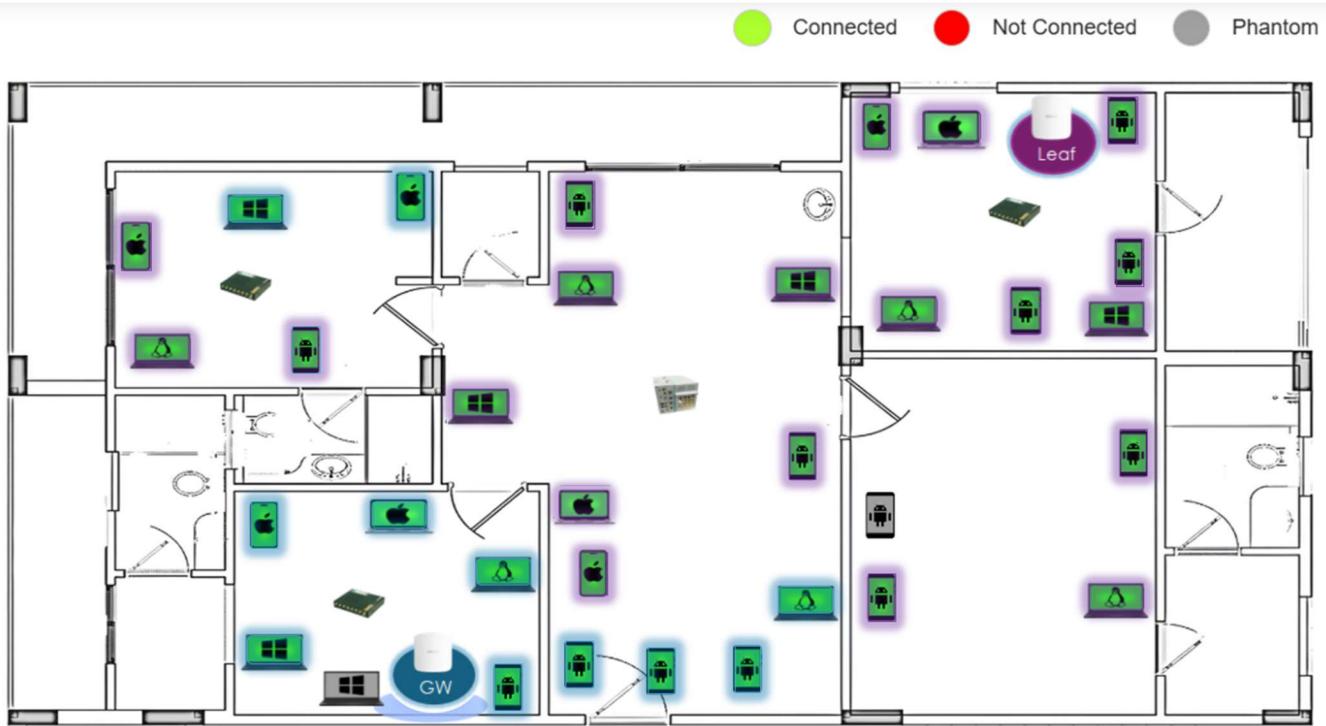
- During the Ping test, it was observed that there is a maximum ping loss of 87 seconds with itel mobile.

## 6. IP Management:

### Test Description:

- Ensure the AP is powered on, DHCP is enabled, and the pool range is known.
- Connect a client device to the AP and record the IP assigned by DHCP.
- In the AP's management UI, create a DHCP reservation for the client's MAC address with a chosen IP from the pool.
- Disconnect and reconnect the client; verify the reserved IP is assigned.
- Reboot the AP while the client is connected; verify the reserved IP is still assigned and there are no IP conflicts.

### Connected Devices:



### Test Results:

S No	Room	Platform	Model	Connected Node	DHCP IP	Static IP	After Reconnection: Connected node	After Reconnection: Connected IP	After Reboot: Reconnected Node	After Reboot: Reconnected IP
1	Living Room	Android	iQOO Z9 Lite	GW	192.168.4.26	192.168.4.26	GW	192.168.4.26	GW	192.168.4.26
2	Living Room	Android	Samsung S9 FE	GW	192.168.4.27	192.168.4.27	GW	192.168.4.27	GW	192.168.4.27
3	Living Room	Android	Itel P55 5G	GW	192.168.4.34	192.168.4.34	GW	192.168.4.34	GW	192.168.4.34
4	Living Room	iOS	iPhone 12	leaf	192.168.4.57	192.168.4.57	GW	192.168.4.57	GW	192.168.4.57
5	Living Room	macOS	MacBook	leaf	192.168.4.180	192.168.4.180	leaf	192.168.4.180	leaf	192.168.4.180
6	Living Room	Linux	Dell	GW	192.168.4.175	192.168.4.175	GW	192.168.4.175	leaf	192.168.4.175
7	Living Room	Android	Samsung M06	leaf	192.168.4.47	192.168.4.47	GW	192.168.4.47	leaf	192.168.4.47
8	Living Room	Windows	Dell	leaf	192.168.4.183	192.168.4.183	leaf	192.168.4.183	leaf	192.168.4.183
9	Living Room	Windows	Dell	leaf	192.168.4.48	192.168.4.48	leaf	192.168.4.48	leaf	192.168.4.48
10	Living Room	Linux	Lenovo ThinkPad	leaf	192.168.4.181	192.168.4.181	leaf	192.168.4.181	leaf	192.168.4.181
11	Living Room	Android	Oppo A3X	leaf	192.168.4.45	192.168.4.45	leaf	192.168.4.45	leaf	192.168.4.45
12	Children Bedroom	Android	Lenovo M10	leaf	192.168.4.35	192.168.4.35	leaf	192.168.4.35	leaf	192.168.4.35
13	Children Bedroom	Linux	Lenovo ThinkPad	leaf	192.168.4.182	192.168.4.182	leaf	192.168.4.182	leaf	192.168.4.182

14	Children Bedroom	iOS	iPhone 14	leaf	192.168.4.21	192.168.4.21	leaf	192.168.4.21	GW	192.168.4.21
15	Children Bedroom	Windows	HP	GW	192.168.4.32	192.168.4.32	GW	192.168.4.32	GW	192.168.4.32
16	Children Bedroom	iOS	iPad 13	GW	192.168.4.24	192.168.4.24	GW	192.168.4.24	GW	192.168.4.24
17	Kitchen	Linux	Lenovo ThinkPad	leaf	192.168.4.178	192.168.4.178	leaf	192.168.4.178	GW	192.168.4.178
18	Kitchen	Android	Honor X Pad	leaf	192.168.4.43	192.168.4.43	leaf	192.168.4.43	leaf	192.168.4.43
19	Kitchen	Windows	Dell	leaf	192.168.4.140	192.168.4.140	leaf	192.168.4.140	leaf	192.168.4.140
20	Kitchen	Android	Oppo A3X	leaf	192.168.4.44	192.168.4.44	leaf	192.168.4.44	leaf	192.168.4.44
21	Kitchen	Android	Samsung M14	leaf	192.168.4.36	192.168.4.36	leaf	192.168.4.36	leaf	192.168.4.36
22	Kitchen	macOS	MacBook	leaf	192.168.4.50	192.168.4.50	leaf	192.168.4.50	leaf	192.168.4.50
23	Kitchen	iOS	iPhone 12	leaf	192.168.4.22	192.168.4.22	leaf	192.168.4.22	leaf	192.168.4.22
24	Guest Bedroom	macOS	MacBook	GW	192.168.4.177	192.168.4.177	GW	192.168.4.177	GW	192.168.4.177
25	Guest Bedroom	iOS	iPhone 13	GW	192.168.4.90	192.168.4.90	GW	192.168.4.90	GW	192.168.4.90
26	Guest Bedroom	Windows	Lenovo ThinkPad	GW	192.168.4.38	192.168.4.38	GW	192.168.4.38	GW	192.168.4.38
27	Guest Bedroom	Linux	HP	GW	192.168.4.176	192.168.4.176	GW	192.168.4.176	GW	192.168.4.176
28	Guest Bedroom	Android	Samsung M05	GW	192.168.4.37	192.168.4.37	GW	192.168.4.37	leaf	192.168.4.37
29	Master Bedroom	Linux	HP	leaf	192.168.4.174	192.168.4.174	leaf	192.168.4.174	GW	192.168.4.174
30	Master Bedroom	Android	Samsung M06	leaf	192.168.4.46	192.168.4.46	leaf	192.168.4.46	leaf	192.168.4.46
31	Master Bedroom	Android	STB	leaf	192.168.4.169	192.168.4.169	leaf	192.168.4.169	leaf	192.168.4.169

### Observations for IP Management Test:

- After reserving the IPs from the AP side, observed that the same IPs were allocated to all the devices after rebooting the AP and after disconnecting and reconnecting all the clients.

## 7. Coverage, RvR, and RvRvO:

### 7.1 Coverage:

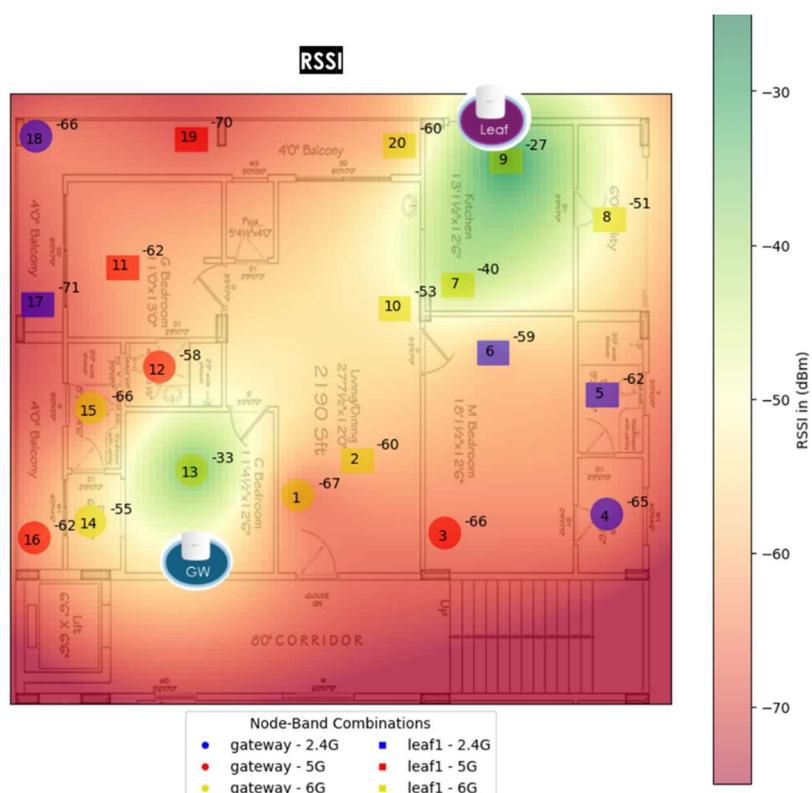
Test Description:

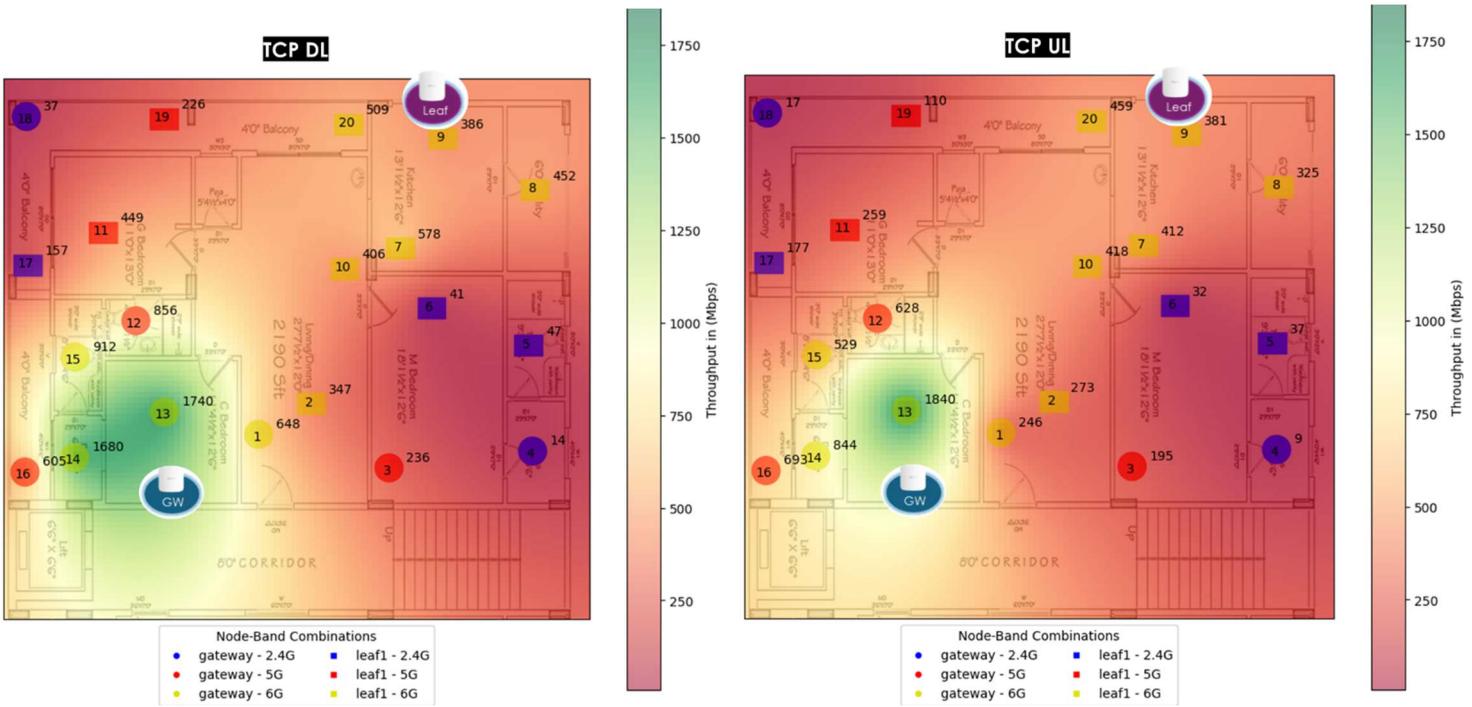
- Turn on both the GW and Leaf nodes.
- Mark 20 test points evenly distributed across the 2,500 sq. ft. area.
- At each point, connect the test client to the AP.
- Record the RSSI at the test point using a Wi-Fi analyzer or AP management tool.
- Perform TCP uplink and downlink throughput tests (e.g., iPerf) for a fixed duration (e.g., 60s).
- Note down the results for each point.
- Check for any coverage dead zones or weak areas

Coordinates Position:



Test Results:





Position	TCP-UL (Mbps)	TCP-DL (Mbps)	RSSI (dBm)	Connected node	Channel	Band	PHY rate UL	PHY rate DL
1	246	648	-67	GW	117	6GHz	576	1729
2	273		-64	Leaf	117	6GHz	1153	
		347	-49	Leaf	128	5GHz		2305
3	195		-57	Leaf	11	2.4GHz	432	
		236	-65	GW	128	5GHz		432
4	9.48		-72	Leaf	11	2.4GHz	44	
		14	-62	GW	11	2.4GHz		34
5	36.9	46.9	-62	Leaf	11	2.4GHz	65	138
6	32.1	41.4	-59	Leaf	11	2.4GHz	138	228
7	412	578	-40	Leaf	117	6GHz	2594	2882
8	325	452	-51	Leaf	117	6GHz	2305	2594
9	381	386	-27	Leaf	117	6GHz	2882	2882
10	418	406	-53	Leaf	117	6GHz	1441	1729
11	259	449	-62	Leaf	128	5GHz	576	865
12	628	856	-58	GW	128	5GHz	1361	1729
13	1840	1740	-33	GW	117	6GHz	5764	5188
14	844	1680	-55	GW	117	6GHz	1729	2822
15	529	912	-66	GW	117	6GHz	1153	1729
16	693	605	-62	GW	128	5GHz	1297	961
17	177	157	-71	Leaf	11	2.4GHz	432	310
18	17.2	36.8	-66	GW	11	2.4GHz	69	103
19	110	226	-70	Leaf	128	5GHz	432	649
20	459	509	-60	Leaf	117	6GHz	1153	2305

## Observations for Coverage Test:

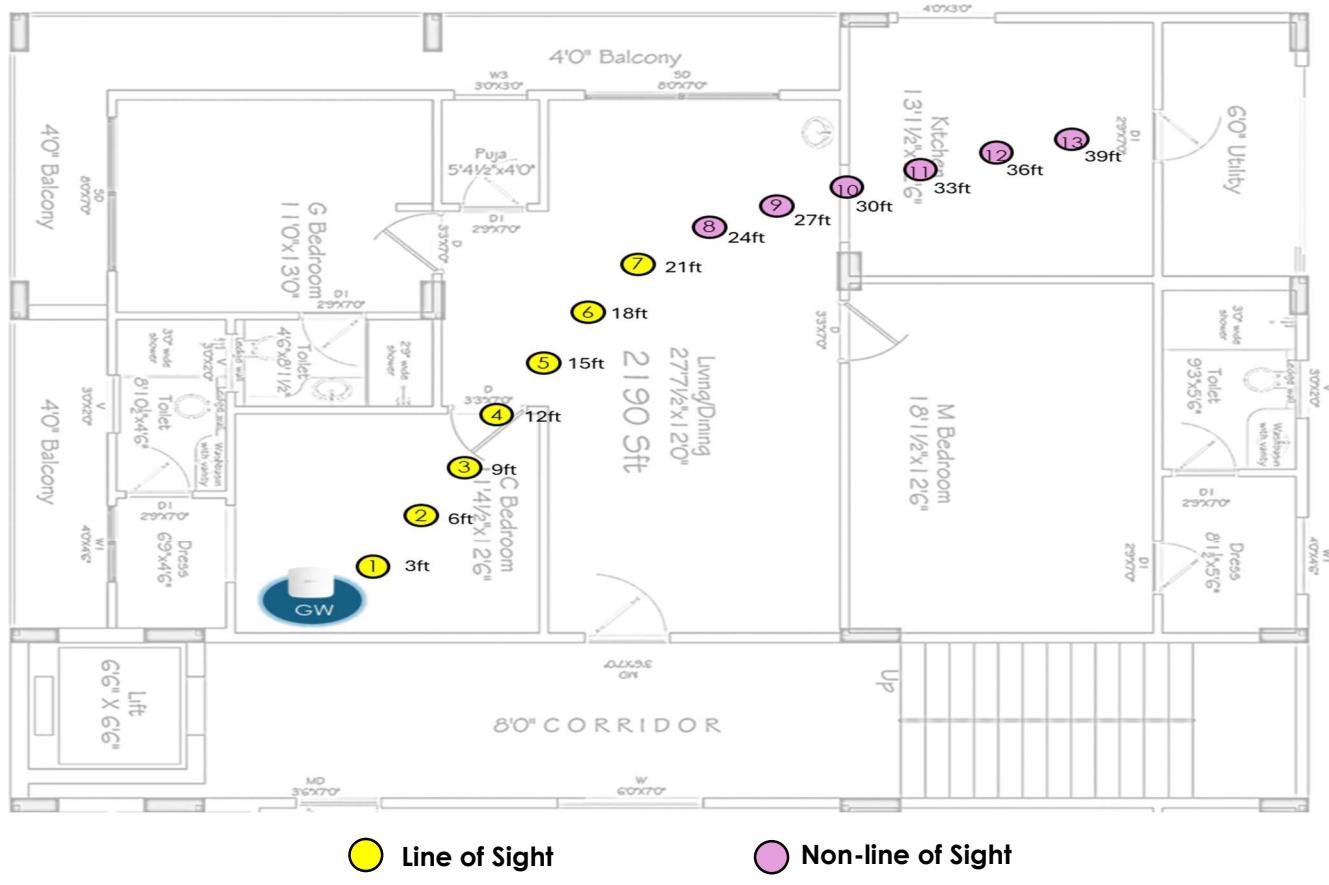
- There are no dead zones in the 2500 sq ft floor.
- At co-ordinates 1, 2, 3, 4, and 6, clients are continuously toggling between bands and nodes.
- Observed less throughput at coordinate 4.
- Obtained the highest throughput at coordinate 13 near GW.

## 7.2 Rate Versus Range (RvR):

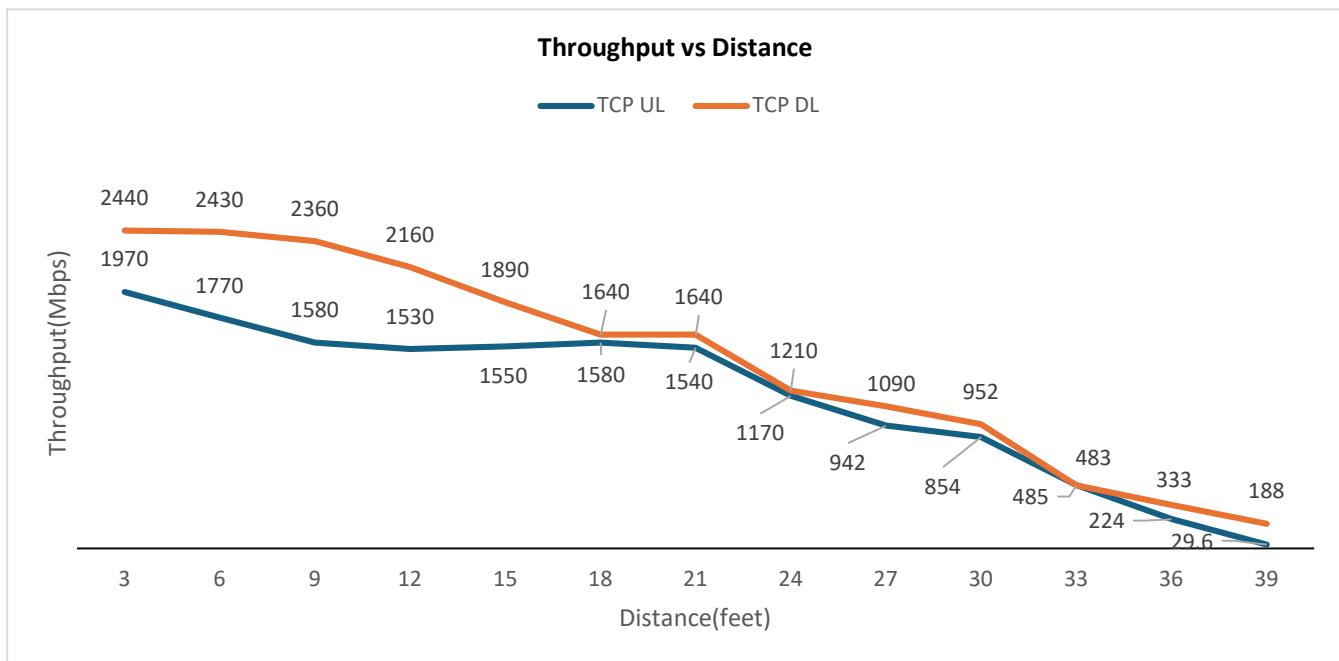
### Test Description:

- Place the client at 3 ft from the AP in LOS conditions.
- Measure RSSI and perform TCP throughput tests at 3-ft incremental distances until the signal drops below a usable threshold.
- Repeat the same test in NLOS conditions (e.g., through walls/obstructions).
- Record distance, RSSI, and throughput for each point.

### Coordinates Position:



## Test Results:



Position	Distance (ft)	Connected Band(GHZ)	Channel	RSSI (dBm)	PHY Rate (Mbps)	TCP UL (Mbps)	PHY Rate (Mbps)	TCP DL (Mbps)	Line-of-Sight (LoS)
1	3	6	117	-29	4323	1970	5764	2440	Yes
2	6	6	117	-32	4803	1770	4323	2430	Yes
3	9	6	117	-39	3843	1580	4323	2360	Yes
4	12	6	117	-42	2882	1560	3843	2160	Yes
5	15	6	117	-43	3458	1550	3843	1890	Yes
6	18	6	117	-45	3843	1580	3458	1640	Yes
7	21	6	117	-46	3458	1540	2882	1640	Yes
8	24	5	100	-48	1922	1170	2162	1210	No
9	27	5	100	-52	1441	942	1724	1090	No
10	30	5	100	-53	1441	854	1441	952	No
11	33	5	100	-57	721	485	721	483	No
12	36	5	100	-65	432	224	576	333	No
13	39	2.4	11	-55	77	29.6	432	188	No

## Observations for RvR Test:

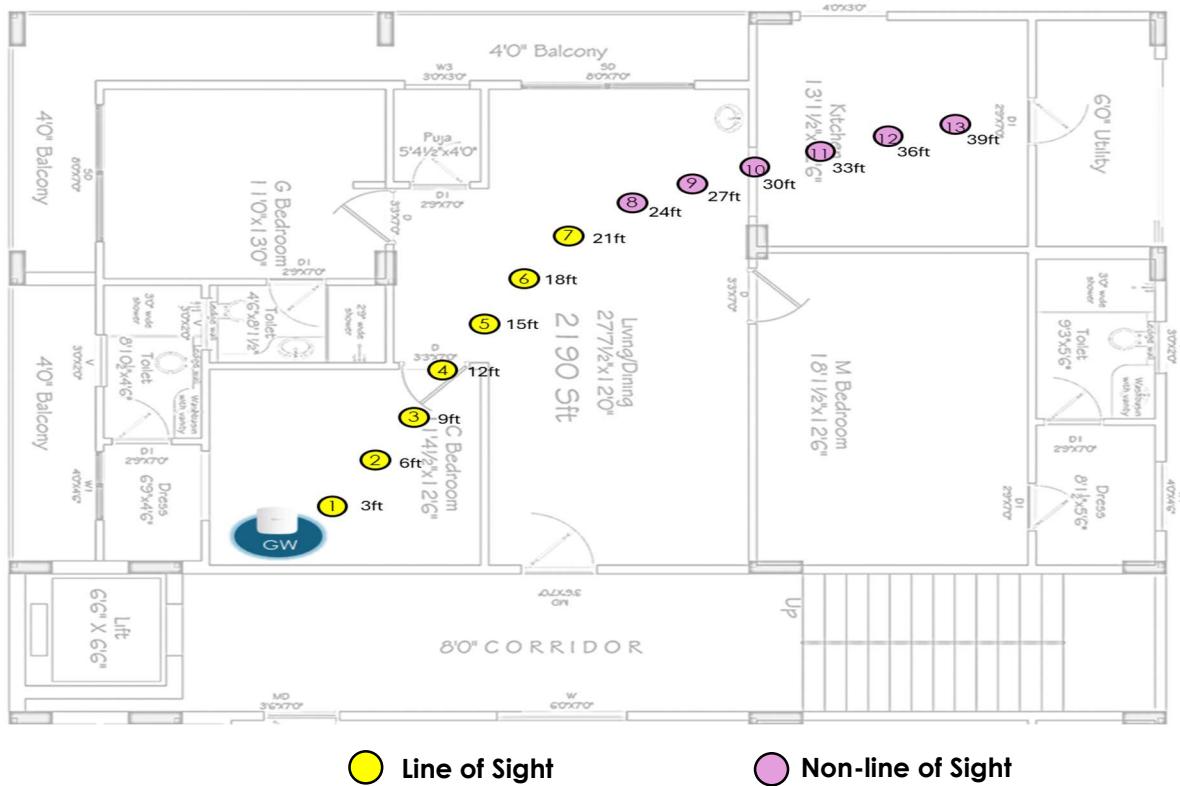
- In LoS, better throughputs were observed compared to non-LoS.
- In TCP DL, throughputs decreased with the increase in distance.
- In TCP UL, throughput increased at positions 5, 6 compared to position 4.
- With the increase in distance, the client steered from 6GHz to 5GHz and then to 2.4GHz bands as expected.

## 7.3 Rate Versus Range Versus Orientation (RvRvO):

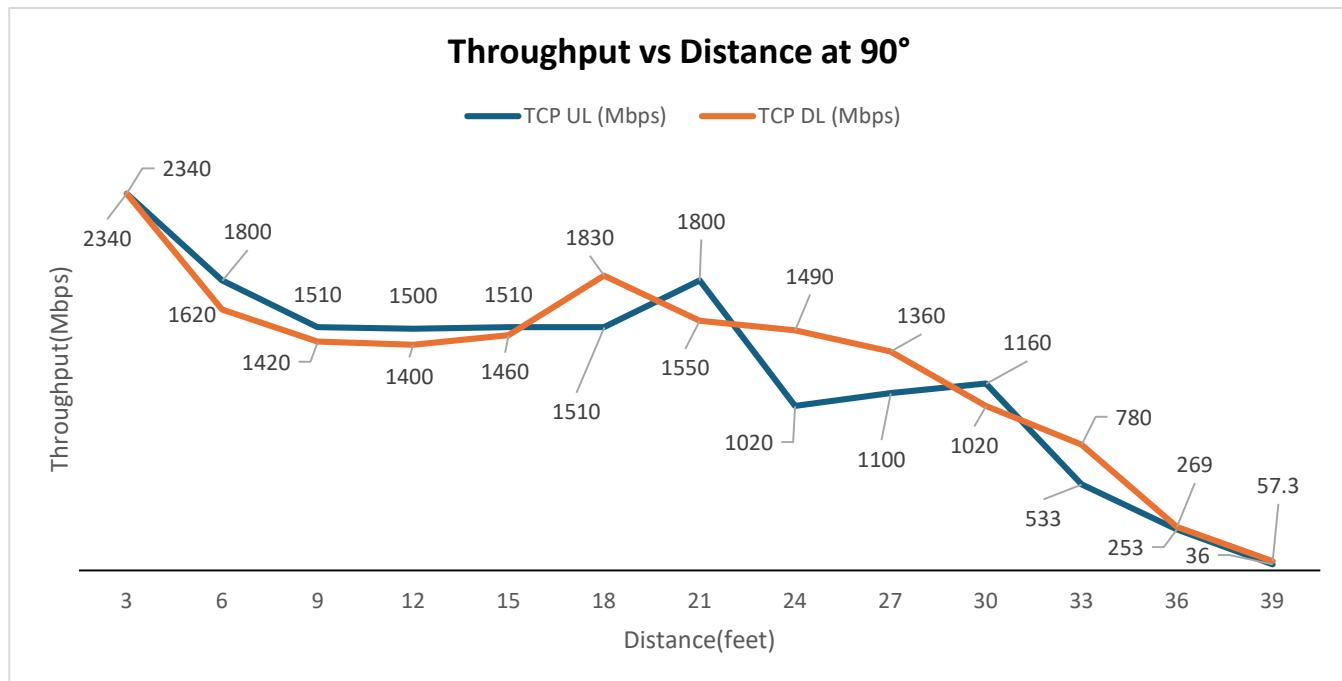
### Test Description:

- Repeat the LOS and NLOS RvR test with AP rotated at 0°, 90°, 180°, and 270°.
- At each orientation, record distance, RSSI, and throughput for every test point.
- Compare orientation results to determine the impact on performance.

### Coordinates Position:

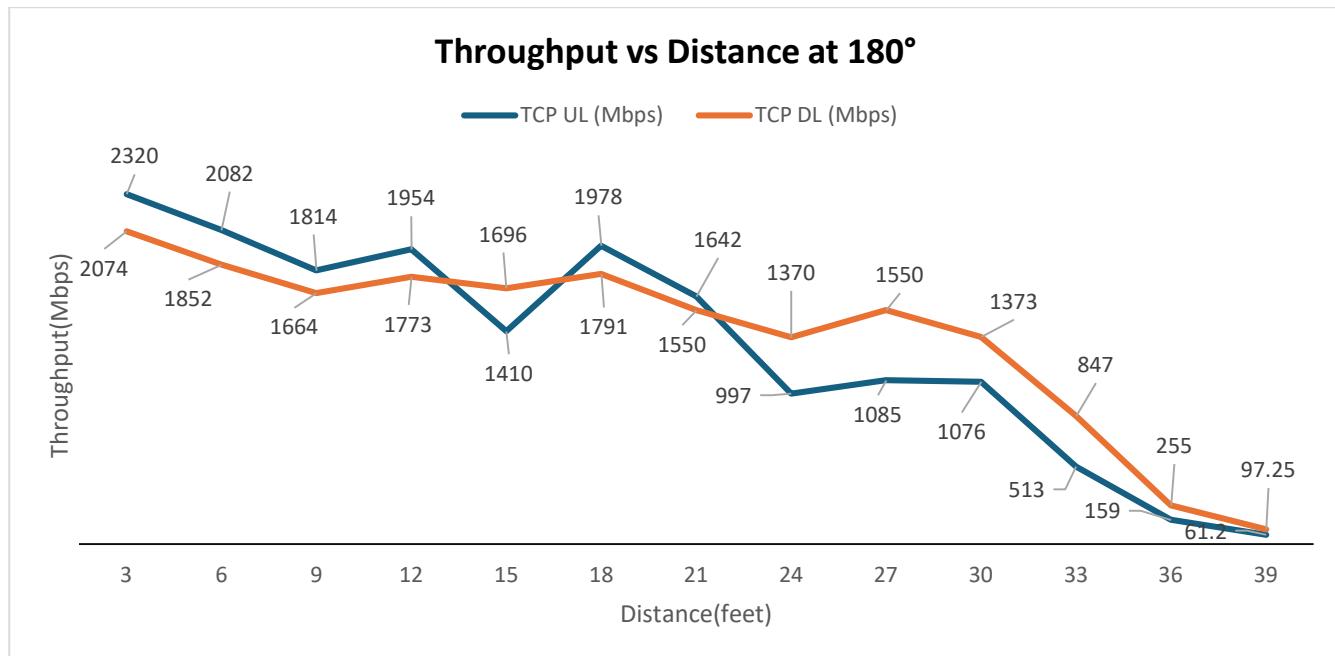


### Test Results:

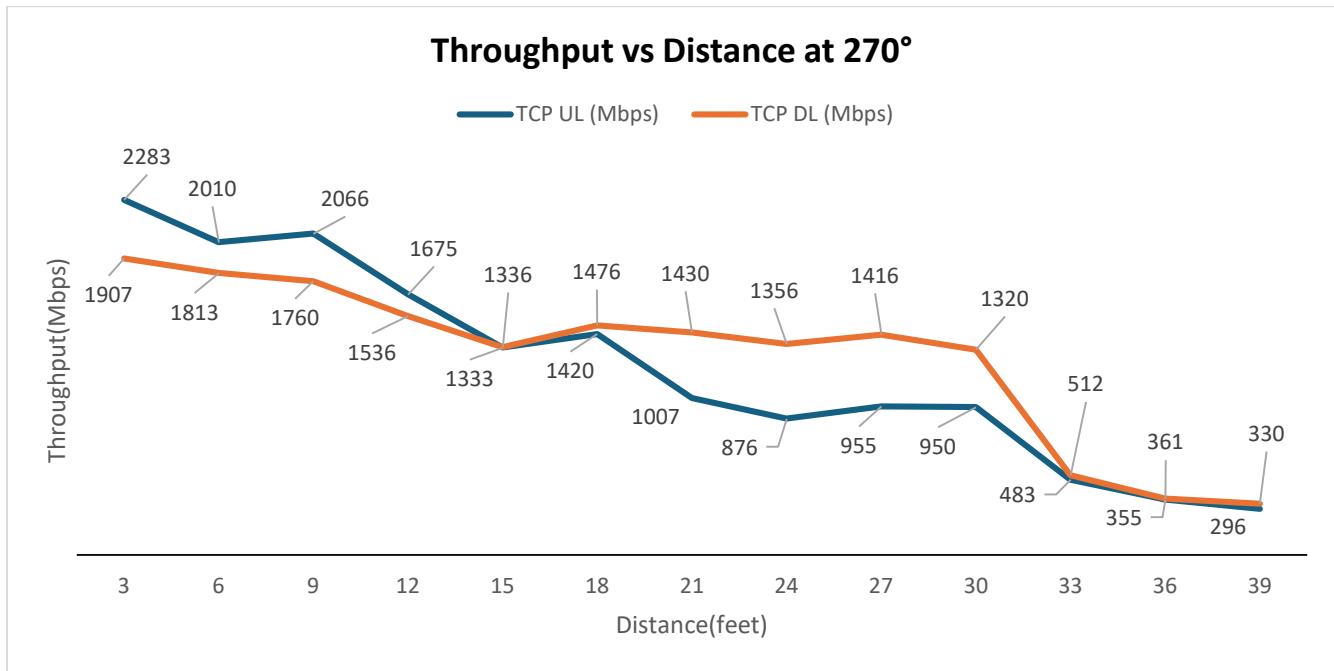


Position	Distance (ft)	Connected Band(GHz)	Channel	RSSI (dBm)	PHY Rate (Mbps)	TCP UL (Mbps)	PHY Rate (Mbps)	TCP DL (Mbps)	Line-of-Sight (LoS)
1	3	6	117	-24	4,803	2340	4,323	2340	Yes
2	6	6	117	-30	3083	1800	2882	1620	Yes

3	9	6	117	-36	2882	1510	2882	1420	Yes
4	12	6	117	-40	3458	1500	2401	1400	Yes
5	15	6	117	-45	2882	1510	2882	1460	Yes
6	18	6	117	-48	3458 (fluctuating)	1510	3843	1830	Yes
7	21	6	117	-48	2882	1800	3458	1550	Yes
8	24	6	117	-55	1729	1020	2594	1490	No
9	27	6	117	-56	1729	1100	2305	1360	No
10	30	6	117	-47	1921	1160	1729	1020	No
11	33	5	100	-58	865	533	1297	780	No
12	36	5	100	-65	432	253	432	269	No
13	39	2.4	6	-60	86	36	138	57.3	No



Position	Distance (ft)	Connected Band (GHz)	Channel	RSSI (dBm)	PHY Rate (Mbps)	TCP UL (Mbps)	PHY Rate (Mbps)	TCP DL (Mbps)	Line-of-Sight (LoS)
1	3	6	117	-28	4,803	2320	3,843	2074	Yes
2	6	6	117	-36	4323	2082	3843	1852	Yes
3	9	6	117	-40	3843	1814	2882	1664	Yes
4	12	6	117	-41	3458	1954	3458	1773	Yes
5	15	6	117	-45	2882	1410	2882	1696	Yes
6	18	6	117	-45	3458	1978	2882	1791	Yes
7	21	6	117	-47	2882	1642	2882	1550	Yes
8	24	6	117	-49	1729	997	2594	1370	No
9	27	6	117	-51	2305	1085	2594	1550	No
10	30	6	117	-45	1921	1076	2305	1373	No
11	33	6	117	-66	864	513	1729	847	No
12	36	5	100	-71	288	159	432	255	No
13	39	2.4	6	-55	163	61.2	206	97.25	No



Position	Distance (ft)	Connected Band (GHz)	Channel	RSSI (dBm)	PHY Rate (Mbps)	TCP UL (Mbps)	PHY Rate (Mbps)	TCP DL (Mbps)	Line-of-Sight (LoS)
1	3	6	117	-29	5,188	2283	4,803	1907	Yes
2	6	6	117	-35	3843	2010	3843	1813	Yes
3	9	6	117	-41	3843	2066	3843	1760	Yes
4	12	6	117	-44	3458	1675	2882	1536	Yes
5	15	6	117	-46	2882	1333	2882	1336	Yes
6	18	6	117	-46	2882	1420	2594	1476	Yes
7	21	6	117	-47	2161	1007	2594	1430	Yes
8	24	6	117	-48	2305	876	2594	1356	No
9	27	6	117	-52	1729	955	2594	1416	No
10	30	6	117	-55	1729	950	2594	1320	No
11	33	5	128	-62	865	483	961	512	No
12	36	5	128	-70	576	355	576	361	No
13	39	5	128	-71	432	296	576	330	No

#### Observations for RvRvO Test:

- In LoS, better throughputs were observed compared to non-LoS.
- At 270° orientation, the client did not steer down to 2.4 GHz at 39 ft, unlike at other orientations.
- Observed minimum PHY rate fluctuations at 270° orientation compared to other orientations.
- Across all orientations, a slight peak in TCP throughput was observed at the 18 ft test point due to an increase in PHY rates and better RSSI.

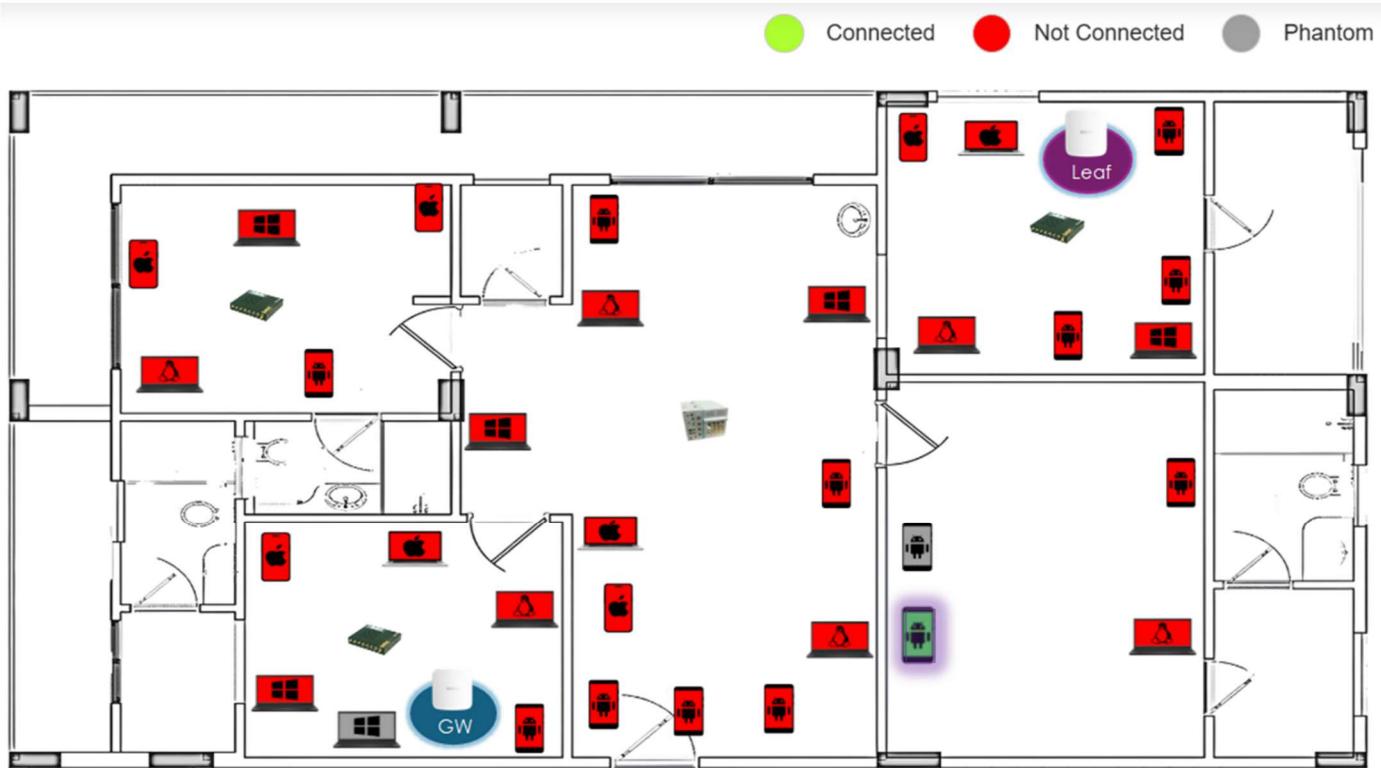
## 8. Set-Top Box (STB) Streaming Validation:

### 8.1 Verify STB video quality under high channel congestion:

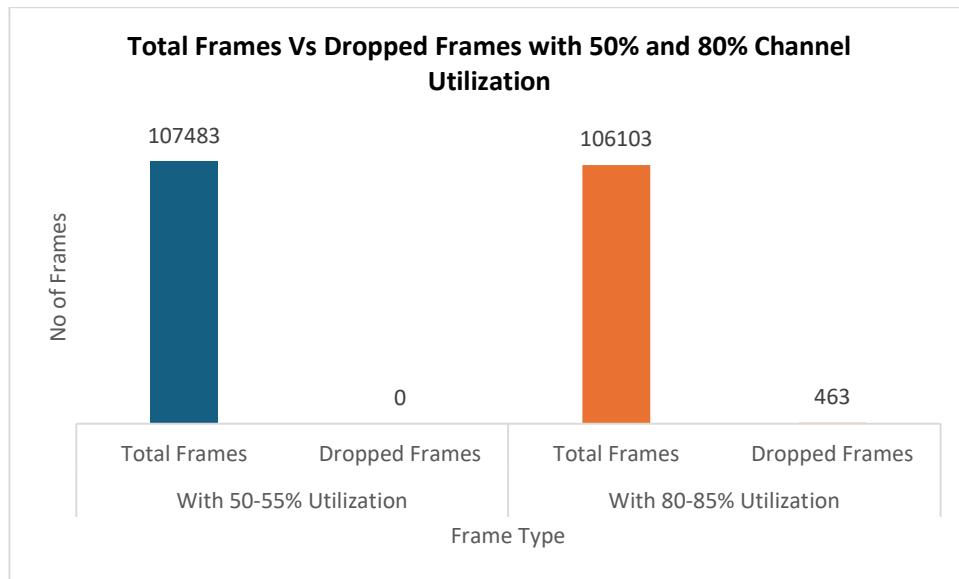
Test Description:

- Simulate high channel congestion, i.e., 50% channel utilization.
- Connect the STB to the network and start a YouTube video stream for a 30-minute duration.
- Monitor the STB for buffering, no.of dropped frames, and video freezes.
- Repeat steps 2 to 3 with 80% channel utilization.

Connected Devices:



Test Results:



Model	Device Placement	Connected Node	Connected Band	RSSI (dBm)		With 50-55% Utilization		With 80-85% Utilization		
						Video Resolution	Total Frames	Dropped Frames	Total Frames	Dropped Frames
TCL TV`	Master Bedroom	Leaf	5GHz	-64		4k (2160p)	107483	0	106103	463

## Observations:

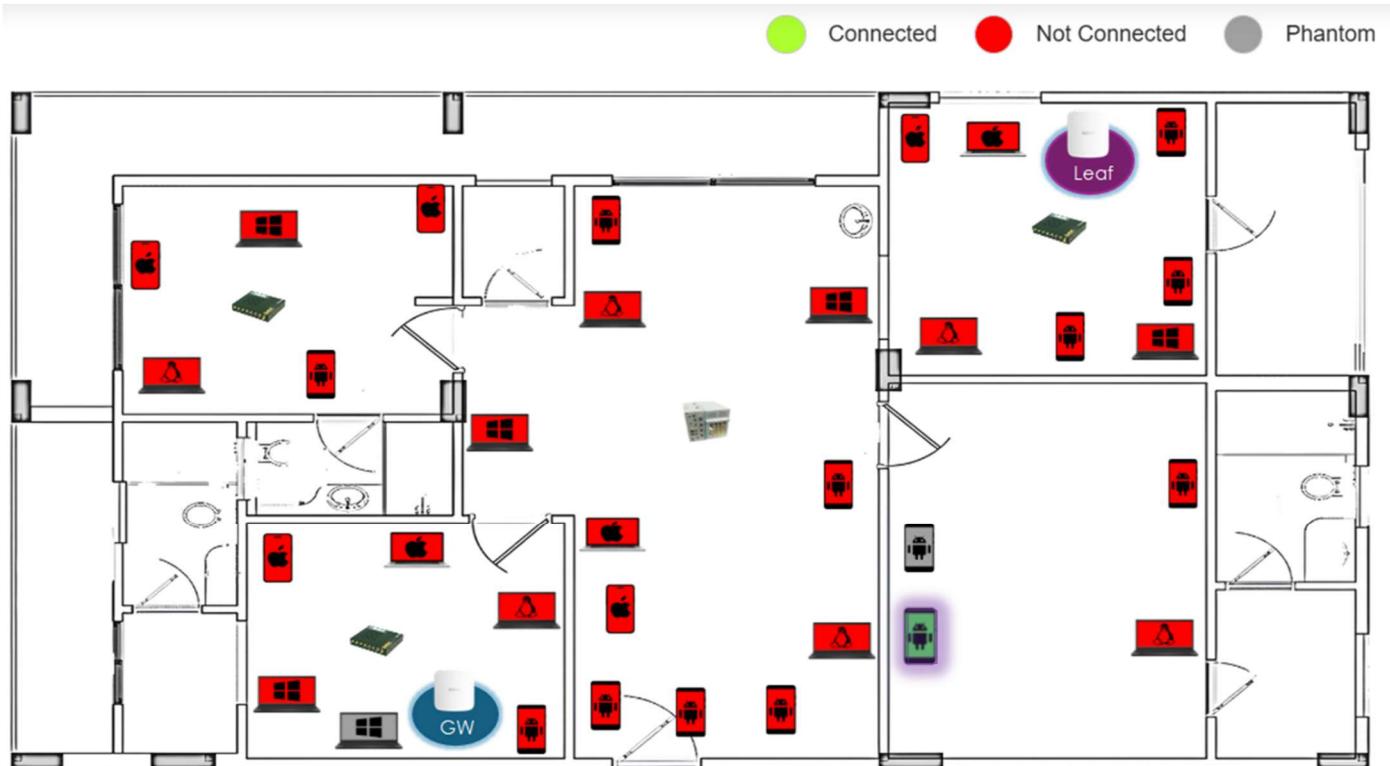
- During the entire test, no frames were dropped, and there were no buffers when the channel utilization was 50%.
- There were 400+ frame drops and video buffering when the channel utilization was 80%.

## 8.2 Assess STB video quality while transferring a 1GB file:

### Test Description:

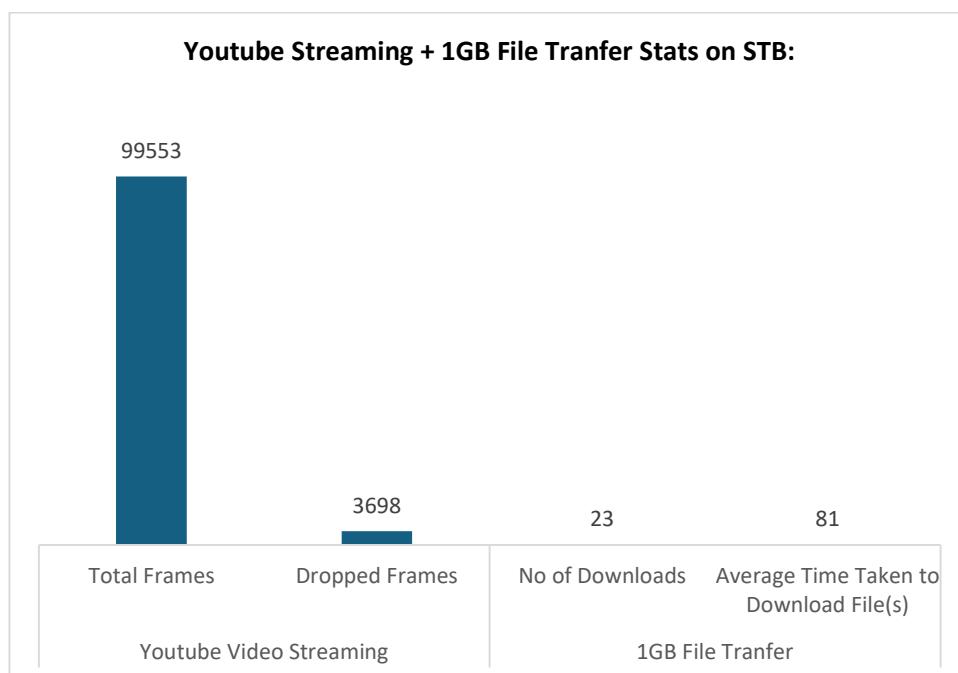
- Connect the STB to the network and start a YouTube video stream for a 30-minute duration.
- Simultaneously download a large file ( $\geq 1\text{GB}$ ) using the FTP protocol.
- Monitor the STB for buffering, no.of dropped frames, and video freezes.

### Connected Devices:



### Test Results

**Youtube Streaming + 1GB File Tranfer Stats on STB:**



Model	Device Placement	Connected Node	Connected Band	RSSI (dBm)	Metrics	Value
TCL TV	Master Bedroom	Leaf	5GHz	-64	Video Resolution	4k (2160p)
					Total Frames	99553
					Dropped Frames	3698
					No of Downloads	23
					Average Time Taken to Download File(ms)	80545
					Average Time Taken to Download File(s)	81

#### Observations:

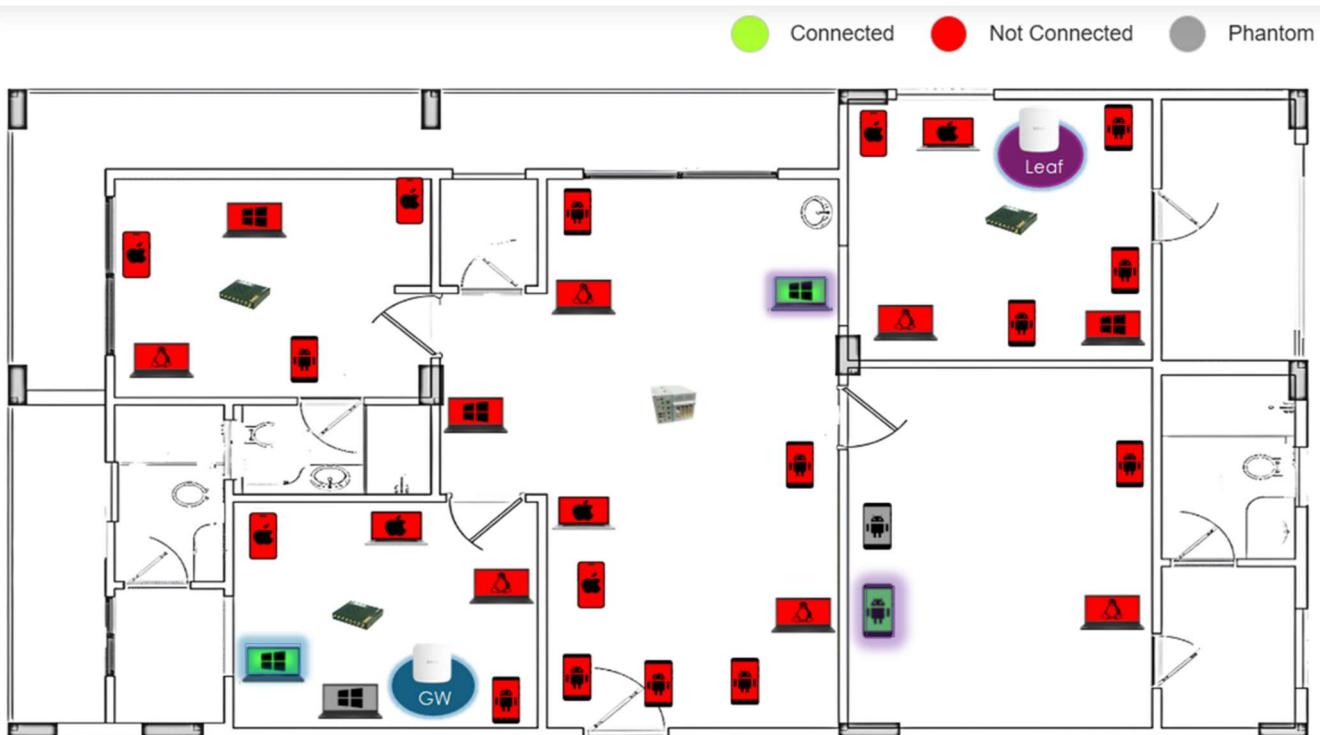
- While downloading a 1GB file observed 3698 Video frame drops, as a result YouTube Video started buffering.

### 8.3 Assess STB video quality while with active multicast traffic in the same network:

#### Test Description:

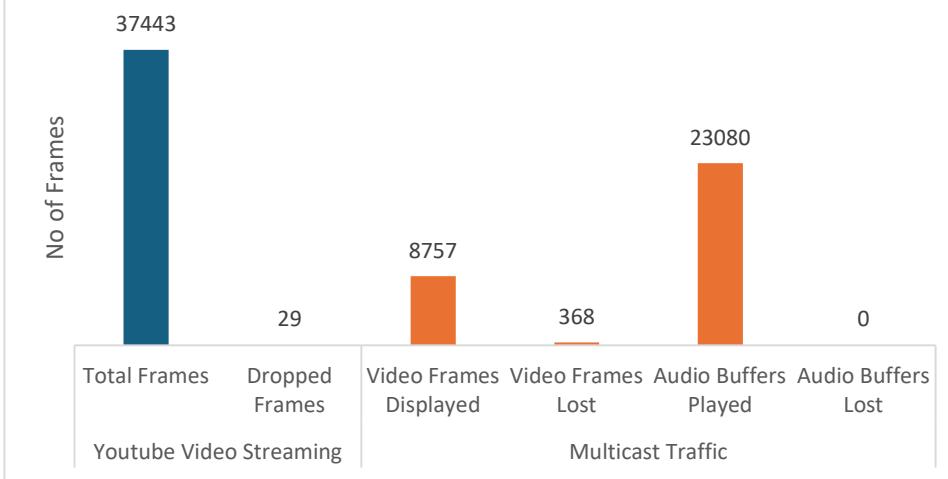
- Connect the STB to the network and stream a YouTube video for a 10-minute duration.
- Connect another 2 clients to the server.
- On one client, run the VLC server, and on another client, run the VLC client and start streaming the video.
- Start the Multicast traffic and YouTube Video simultaneously.
- Monitor the STB for buffering, no.of dropped frames, and video freezes.

#### Connected Devices:



## Test Results:

### Youtube Streaming Stats on STB + Multicast Traffic Stats on 2 WiFi Laptops:



Model	Device Placement	Connected Node	Connected Band	RSSI (dBm)	Operating Mode	Metrics	Value
Dell-V9S	Living Room	Leaf	6GHz	-55	VLC Server	-	-
Lenovo ThinkPad	Guest Bedroom	GW	5GHz	-33	VLC Client	Video Frames Displayed	8757
						Video Frames Lost	368
						Audio Buffers Played	23080
						Audio Buffers Lost	0

### Observations:

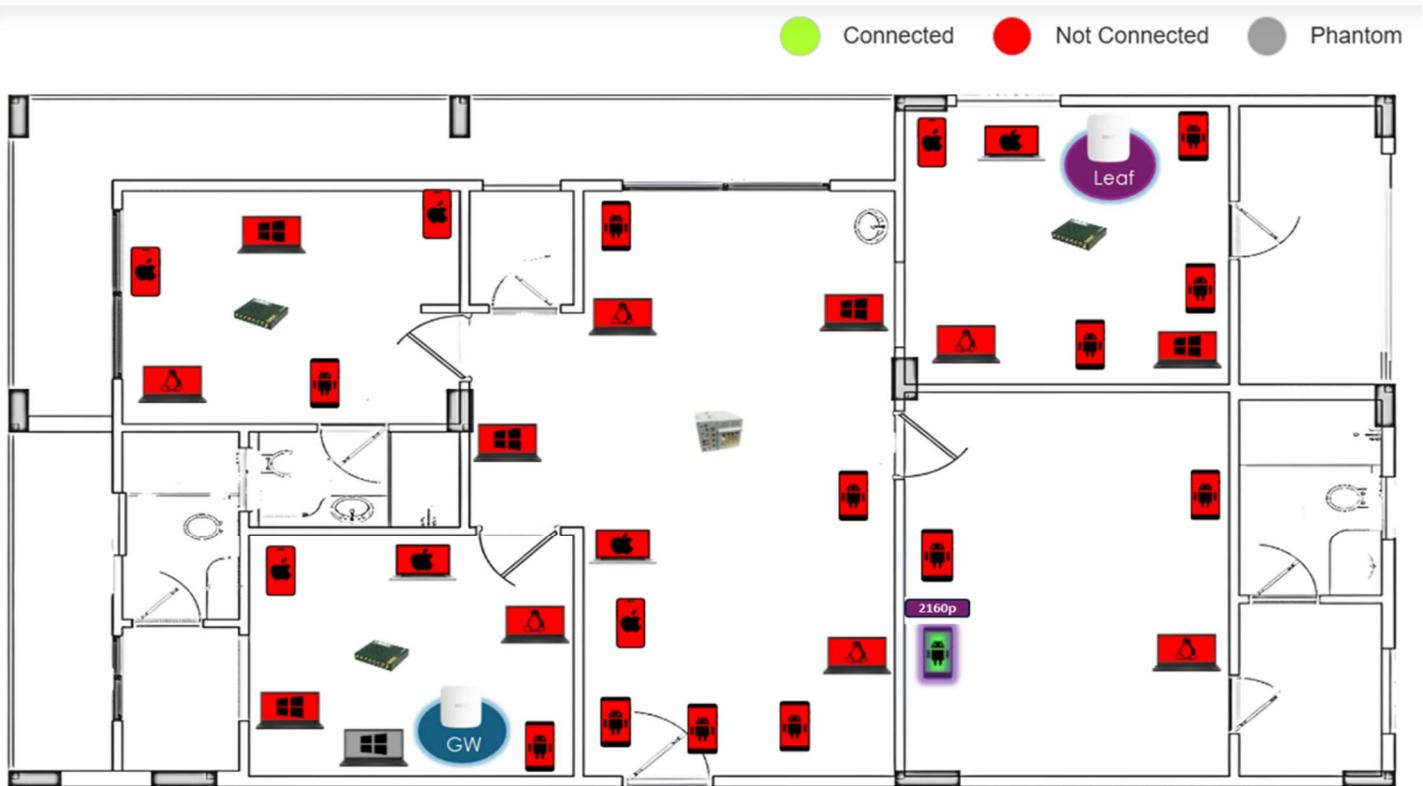
- While running Multicast traffic on other clients, there was no YouTube video buffering on the STB, but the Multicast server and client experienced buffering.

## 8.4 Validate streaming quality during IoT toggling:

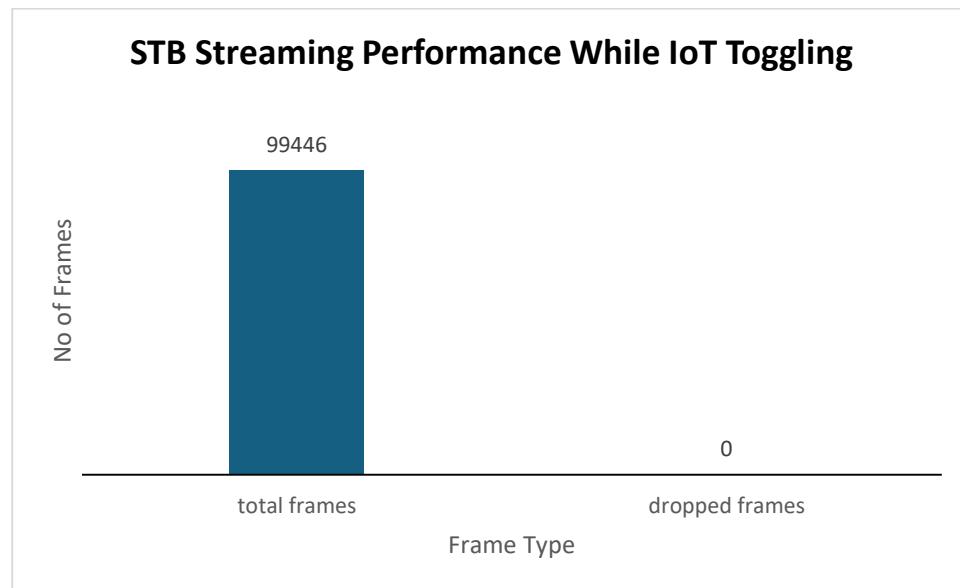
### Test Description:

- Connect the STB to the network and start a YouTube video stream.
- Continuously toggle multiple IoT devices on/off for 30 minutes.
- Monitor the STB for buffering, no.of dropped frames, and video freezes.

### Connected Devices:



### Test Results:



### Observations:

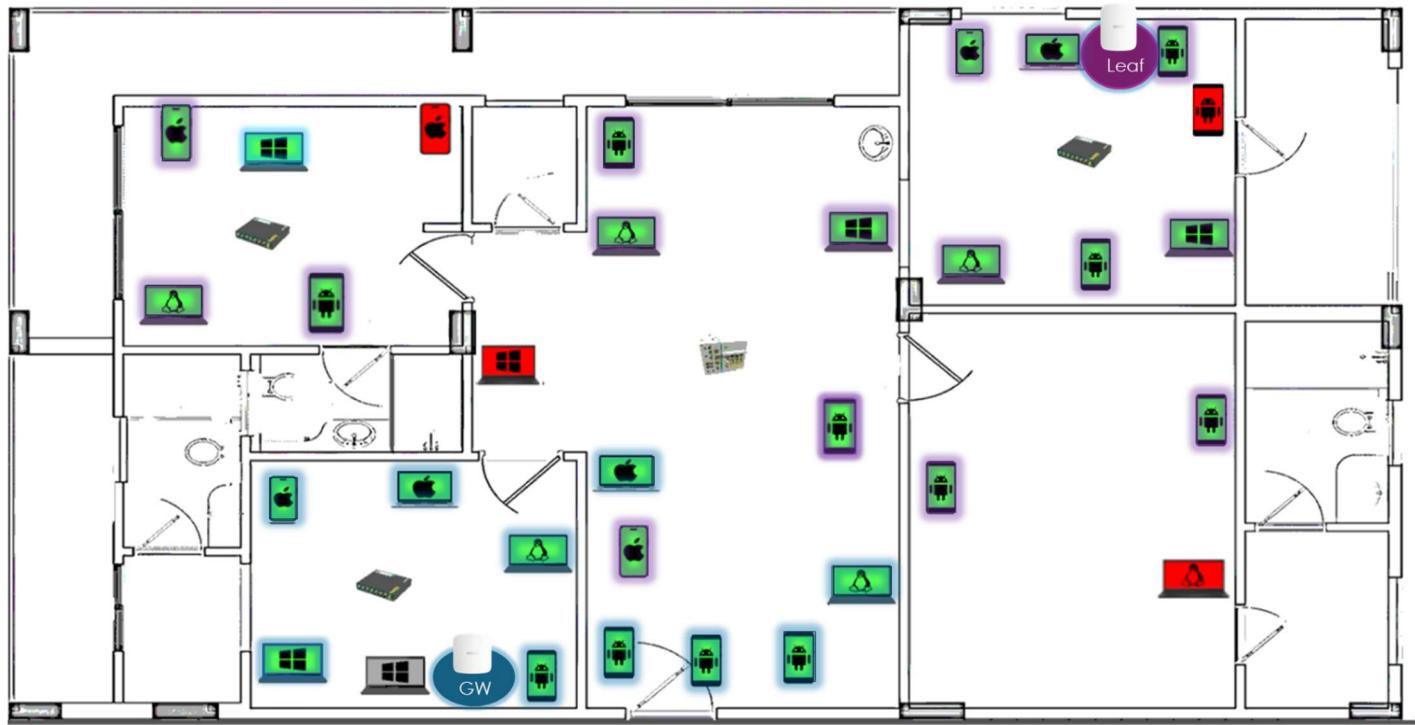
- Despite continuous toggling of IoT devices, the STB video stream on YouTube showed 0 dropped frames, no buffering, and no video freezes, indicating stable performance.

## 9. Mesh Reliability Stress Testing:

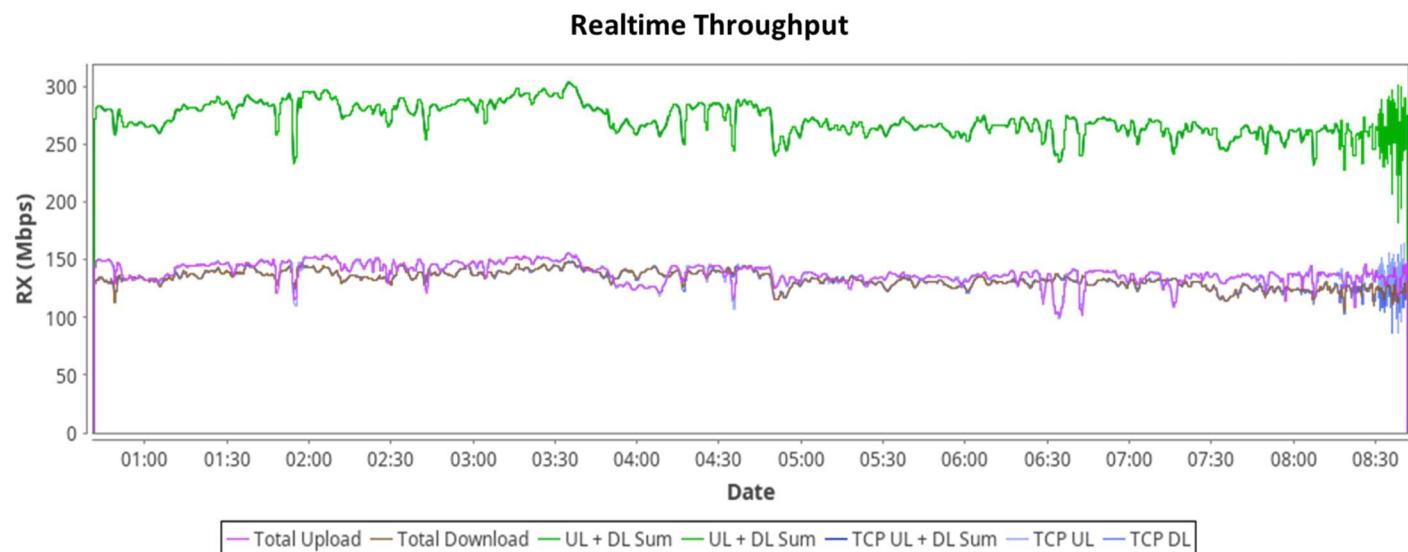
### Test Description:

- Ensure the mesh network is set up with the GW and Leaf-1 operational.
- Connect a total of 50 clients, distributed between GW and Leaf-1
- Maintain the stress test for 8 continuous hours.
- Measure throughput on both uplink and downlink during the test at regular intervals.

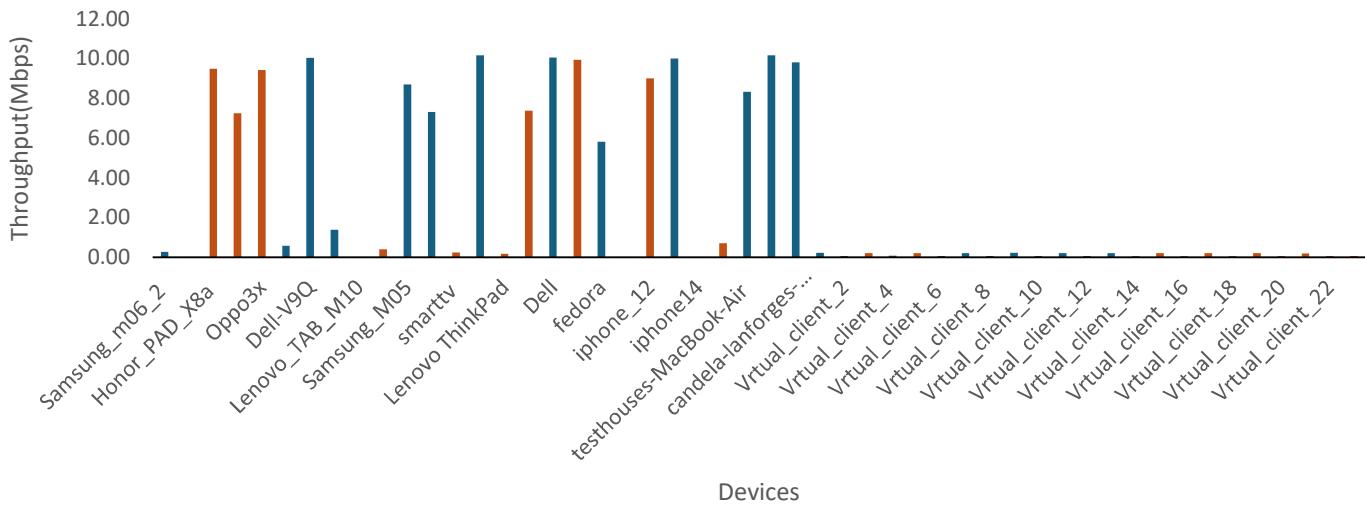
### Connected Devices:



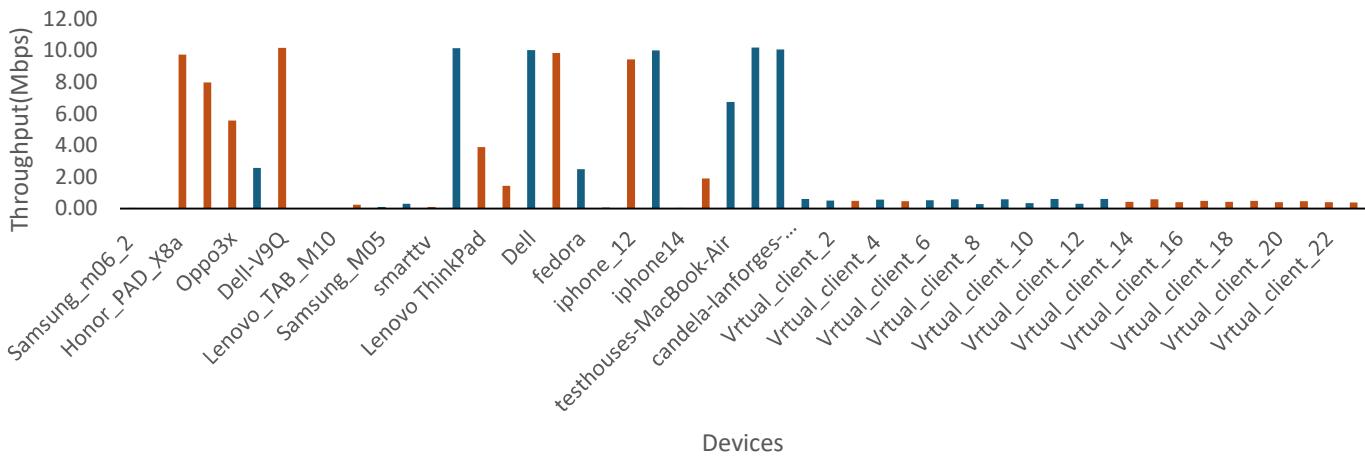
### Test Results:



## Per Client Throughput of TCP-UL



## Per Client Throughput of TCP-DL



Device	RSSI (dBm)	Node	Band (GHz)	TCP-Download (Mbps)	TCP-Upload (Mbps)	Total Throughput (Mbps)
Samsung_m06_2	-68	Leaf	2.4	0.04	0.27	0.31
Samsung_M06	-69	Leaf	2.4	0.03	0.12	0.15
Honor_PAD_X8a	-30	Leaf	5	9.75	9.49	19.23
Dell-V9S	-51	Leaf	5	7.98	7.26	15.24
Oppo3x	-35	Leaf	5	5.58	9.43	15.01
Samsung_TAB_s9	-63	GW	5	2.56	0.57	3.13
Dell-V9Q	-42	Leaf	6	10.18	10.03	20.21
iQOO_Z9_Lite_5G	-44	GW	2.4	0.02	1.38	1.40
Lenovo_TAB_M10	-51	Leaf	2.4	0.05	0.08	0.13
Oppo_A3X	-43	Leaf	2.4	0.25	0.41	0.66
Samsung_M05	-30	GW	2.4	0.10	8.69	8.79
itel_P55_5G	-39	GW	2.4	0.30	7.31	7.61
smarttv	-51	Leaf	2.4	0.11	0.24	0.35
linuxtest	-36	GW	5	10.14	10.16	20.29
test5	-68	Leaf	5	3.88	0.19	4.07
thinkpad	-59	Leaf	2.4	1.45	7.38	8.82
test	-30	GW	5	10.03	10.04	20.07
test26	-30	Leaf	5	9.85	9.94	19.79
fedora	-58	GW	5	2.49	5.81	8.30
Dell-OU1	-55	GW	2.4	0.06	0.01	0.07
iphone_12	-37	Leaf	5	9.44	9.01	18.46

Iphone_13	-39	GW	5	10.01	9.99	20.00
iphone14	-56	GW	2.4	0.04	0.01	0.05
Iphone_12_liv	-68	Leaf	5	1.91	0.72	2.63
testhouses-MacBook-Air	-36	GW	5	6.75	8.32	15.07
macbooks-MacBook-Air	-37	GW	5	10.19	10.16	20.35
candela-lanforges-MacBook-Pro	-34	Leaf	5	10.07	9.80	19.88
Vrtual_client_1	-65	GW	2.4	0.59	0.22	0.82
Vrtual_client_2	-74	GW	5	0.51	0.07	0.58
Vrtual_client_3	-77	Leaf	2.4	0.48	0.22	0.70
Vrtual_client_4	-74	GW	5	0.56	0.07	0.64
Vrtual_client_5	-76	Leaf	2.4	0.48	0.21	0.69
Vrtual_client_6	-74	GW	5	0.52	0.07	0.59
Vrtual_client_7	-65	GW	2.4	0.59	0.21	0.80
Vrtual_client_8	-74	GW	5	0.28	0.07	0.35
Vrtual_client_9	-65	GW	2.4	0.59	0.22	0.81
Vrtual_client_10	-74	GW	5	0.34	0.07	0.41
Vrtual_client_11	-65	GW	2.4	0.60	0.21	0.81
Vrtual_client_12	-74	GW	5	0.29	0.07	0.36
Vrtual_client_13	-65	GW	2.4	0.60	0.22	0.81
Vrtual_client_14	-72	Leaf	5	0.43	0.07	0.50
Vrtual_client_15	-64	Leaf	2.4	0.58	0.22	0.81
Vrtual_client_16	-72	Leaf	5	0.41	0.07	0.48
Vrtual_client_17	-76	Leaf	2.4	0.48	0.21	0.69
Vrtual_client_18	-72	Leaf	5	0.43	0.07	0.50
Vrtual_client_19	-76	Leaf	2.4	0.48	0.21	0.69
Vrtual_client_20	-72	Leaf	5	0.41	0.07	0.48
Vrtual_client_21	-76	Leaf	2.4	0.48	0.21	0.69
Vrtual_client_22	-72	Leaf	5	0.40	0.07	0.48
Vrtual_client_23	-72	Leaf	5	0.40	0.07	0.47

### Observations:

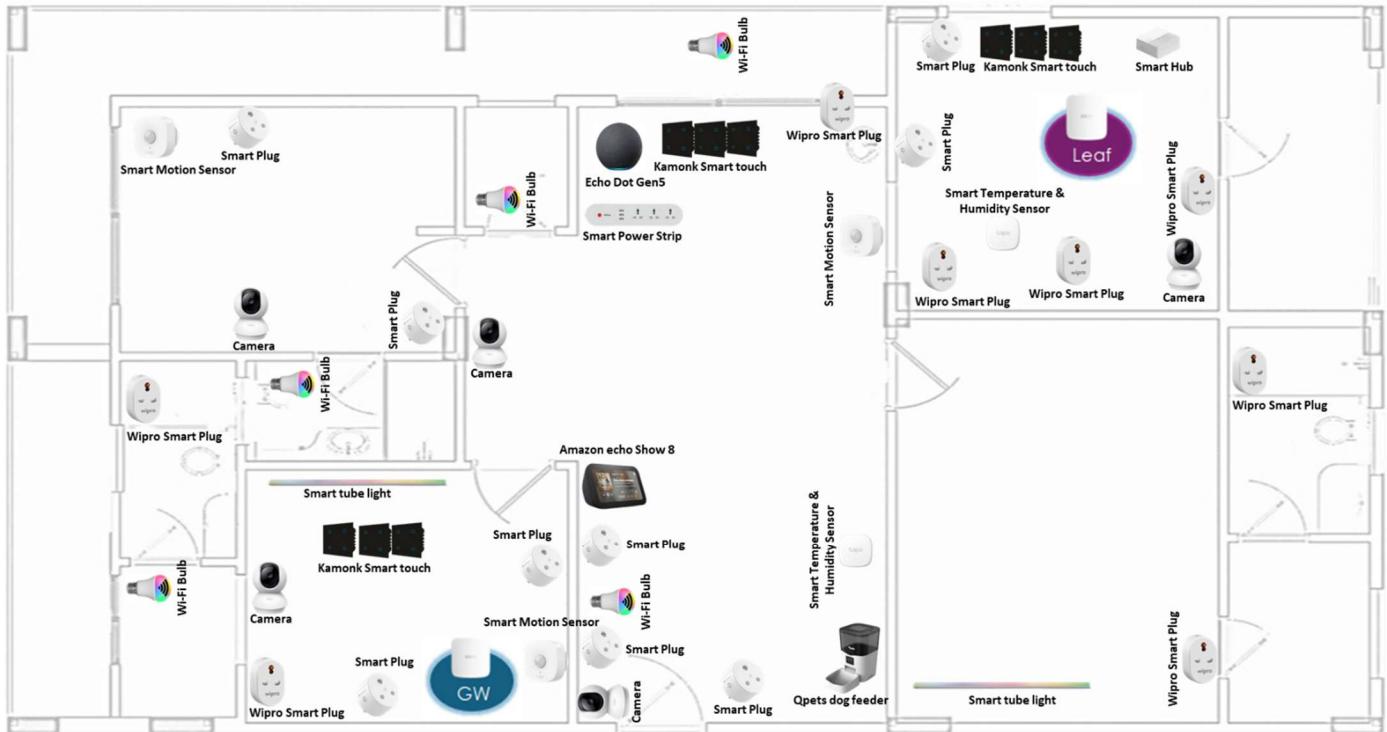
- The APs did not crash or reboot even under high stress.
- The throughput is stable during the 8-hour test, with no major drops or sudden fluctuations. Both upload and download rates are consistent.

## 10. IoT Stress Testing:

### Test Description:

- Power on GW and Leaf nodes.
- Connect 50 IoT devices (smart plugs, bulbs, switches, etc.) to the nodes.
- Initiate an automated script or control application to continuously toggle all IoT devices ON/OFF at defined intervals.
- Monitor AP connection stability and device responsiveness.
- Observe for any device disconnections, command delays, or failures to respond.
- Maintain the toggling process for a sustained duration (e.g., 8 hours).
- After the test, verify that all devices reconnect automatically if disconnected during stress.
- Record any AP crashes, reboots, or performance degradation.

### IoT Devices Placement:

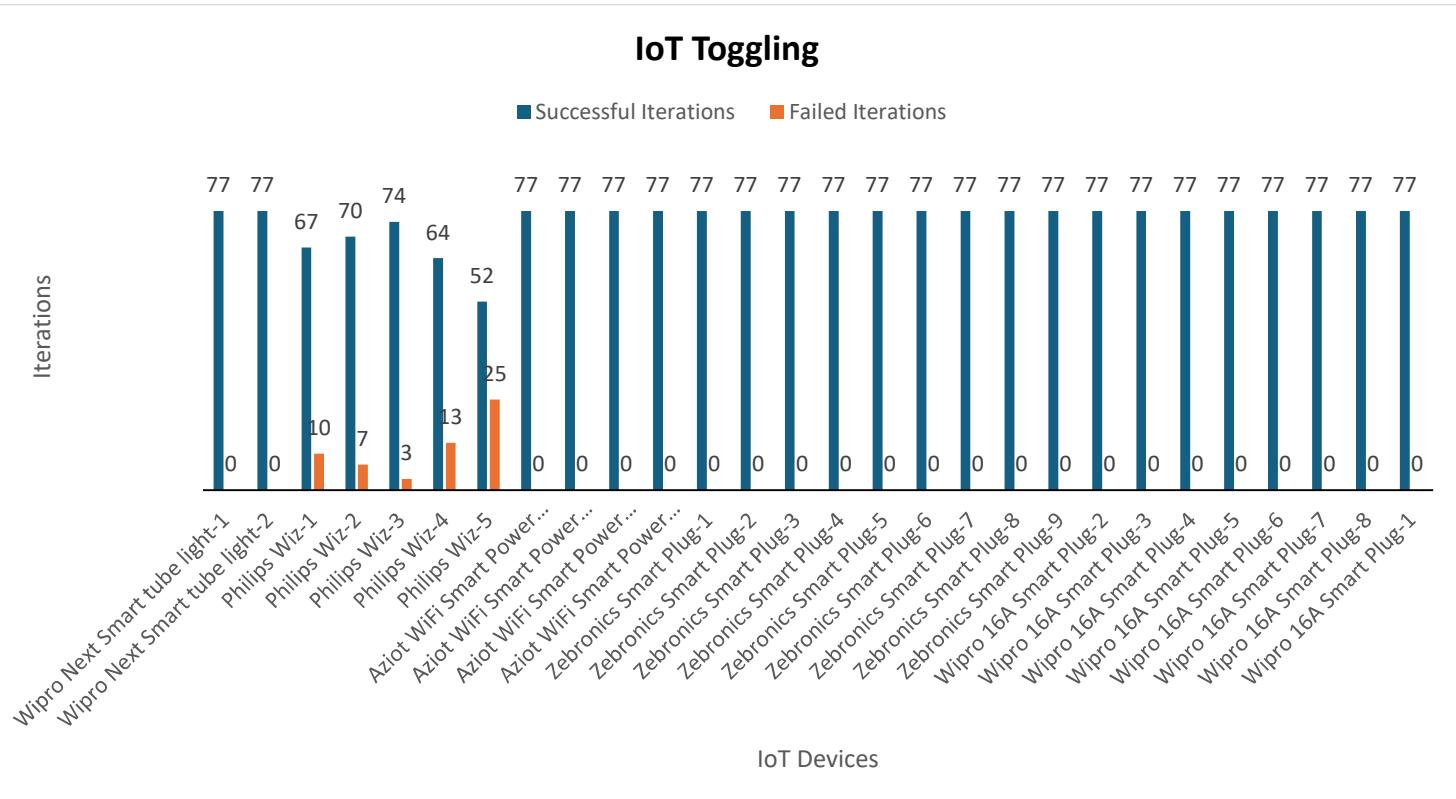


### IoT devices List:

S No	Device category	Device Type	Device Model	Band (GHz)
1	Multimedia	Amazon Echo	Amazon Echo Show 8 Gen 2	5
2	Smart home	Switch	Kamonk Smart Touch-1	2.4
3	Smart home	Switch	Kamonk Smart touch-2	2.4
4	Smart home	Switch	Kamonk Smart Touch-3	2.4
5	Smart home	Switch	Kamonk Smart touch-4	2.4
6	Smart home	Switch	Kamonk Smart Touch-5	2.4
7	Smart home	Switch	Kamonk Smart touch-6	2.4
8	Smart home	Switch	Kamonk Smart touch-7	2.4
9	Smart home	Switch	Kamonk Smart touch-8	2.4
10	Smart home	Switch	Kamonk Smart touch-9	2.4
11	Smart home	Plug	Wipro 16A Smart Plug-1	2.4
12	Smart home	Plug	Wipro 16A Smart Plug-2	2.4
13	Smart home	Plug	Wipro 16A Smart Plug-3	2.4
14	Smart home	Plug	Wipro 16A Smart Plug-4	2.4
15	Smart home	Plug	Wipro 16A Smart Plug-5	2.4
16	Smart home	Plug	Wipro 16A Smart Plug-6	2.4
17	Smart home	Plug	Wipro 16A Smart Plug-7	2.4
18	Smart home	Plug	Wipro 16A Smart Plug-8	2.4
19	Smart home	Plug	Wipro 16A Smart Plug-9	2.4
20	Surveillance	Camera	TP-Link Tapo 360-1	2.4

21	Surveillance	Camera	TP-Link Tapo 360-2	2.4
22	Surveillance	Camera	TP-Link Tapo 360-3	2.4
23	Surveillance	Camera	TP-Link Tapo 360-4	2.4
24	Surveillance	Camera	TP-Link Tapo 360-5	2.4
25	Surveillance	Camera	TP-Link Tapo 360-6	2.4
26	Smart home	Plug	Zebronics Smart Plug-1	2.4
27	Smart home	Plug	Zebronics Smart Plug-2	2.4
28	Smart home	Plug	Zebronics Smart Plug-3	2.4
29	Smart home	Plug	Zebronics Smart Plug-4	2.4
30	Smart home	Plug	Zebronics Smart Plug-5	2.4
31	Smart home	Plug	Zebronics Smart Plug-6	2.4
32	Smart home	Plug	Zebronics Smart Plug-7	2.4
33	Smart home	Plug	Zebronics Smart Plug-8	2.4
34	Smart home	Plug	Zebronics Smart Plug-9	2.4
35	Smart home	Dog feeder	Qpets dog feeder	2.4
36	Smart home	Echo DoT	Echo DOT gen5	5
37	Surveillance	Sensor	Tapo TP-Link T100 120° Pir Smart Motion Sensor-1	2.4
38	Surveillance	Sensor	Tapo TP-Link T100 120° Pir Smart Motion Sensor-2	2.4
39	Surveillance	Sensor	Tapo TP-Link T100 120° Pir Smart Motion Sensor-3	2.4
40	Smart home	Bulb	Philips Wiz-1	2.4
41	Smart home	Bulb	Philips Wiz-2	2.4
42	Smart home	Bulb	Philips Wiz-3	2.4
43	Smart home	Bulb	Philips Wiz-4	2.4
44	Smart home	Bulb	Philips Wiz-5	2.4
45	Smart home	Light	Wipro Next Smart tube light-1	2.4
46	Smart home	Light	Wipro Next Smart tube light-2	2.4
47	Smart home	Smart Hub	Tapo TP-Link H200 Smart Hub	2.4
48	Smart home	Power Strip	Aziot Wi-Fi Smart Power Strip	2.4
49	Smart home	Thermostat	Tapo TP-Link Smart Temperature & Humidity Sensor-1	2.4
50	Smart home	Thermostat	Tapo TP-Link Smart Temperature & Humidity Sensor-2	2.4

### Test Results:



S No	Device	Successful Iterations	Failed Iterations
1	Wipro Next Smart tube light-1	77	0
2	Wipro Next Smart tube light-2	77	0
3	Philips Wiz Bulb-1	67	10
4	Philips Wiz Bulb -2	70	7
5	Philips Wiz Bulb -3	74	3
6	Philips Wiz Bulb -4	64	13
7	Philips Wiz Bulb -5	52	25
8	Aziot Wi-Fi Smart Power Strip_socket_1	77	0
9	Aziot Wi-Fi Smart Power Strip_socket_2	77	0
10	Aziot Wi-Fi Smart Power Strip_socket_3	77	0
11	Aziot Wi-Fi Smart Power Strip_socket_4	77	0
12	Zebronics Smart Plug-1	77	0
13	Zebronics Smart Plug-2	77	0
14	Zebronics Smart Plug-3	77	0
15	Zebronics Smart Plug-4	77	0
16	Zebronics Smart Plug-5	77	0
17	Zebronics Smart Plug-6	77	0
18	Zebronics Smart Plug-7	77	0
19	Zebronics Smart Plug-8	77	0
20	Zebronics Smart Plug-9	77	0
21	Wipro 16A Smart Plug-2	77	0
22	Wipro 16A Smart Plug-3	77	0
23	Wipro 16A Smart Plug-4	77	0
24	Wipro 16A Smart Plug-5	77	0
25	Wipro 16A Smart Plug-6	77	0
26	Wipro 16A Smart Plug-7	77	0
27	Wipro 16A Smart Plug-8	77	0
28	Wipro 16A Smart Plug-1	77	0

#### Observations for IoT Stress Testing:

- The APs did not crash or reboot while continuously toggling Wipro Next Smart tube lights, Philips Wiz Bulbs, Aziot Wi-Fi Smart Power Strip sockets, Zebronics Smart Plugs, Wipro 16A Smart Plugs, and the remaining devices are in a connected state.

## 11. Security Camera Streaming:

### Test Description:

- Connect the Security Camera to the network.
- Start live streaming from cameras.
- Monitor latency, buffering from the live stream.

### Arlo Camera Details:

Specifications	Arlo Essential 2nd GEN
Mode	802.11b/g/n
Bands supported	2.4GHz
Spatial Streams	1x1
Bandwidth	20MHz
Security	WPA2
Video Recording	1080p Video with Color Night vision
Field of View	130°
Protocol for video/audio	TCP

### Coordinates Position:



### Test Results:

- From the pcap, it is observed that there are no Extended capabilities and RM capabilities Info, which indicates that there is no support for roaming in Arlo cameras.

wlan.fc.type_subtype==0					
No.	Time	Delta	Source	Destination	Info
661	13:48:00.052567	0.000000	ArloTechnolo_d1:01:a5	18:a9:ed:2f:1b:06	Association Request,
> Frame 661: 168 bytes on wire (1344 bits), 168 bytes captured (1344 bits)					
> Radiotap Header v0, Length 54					
> 802.11 radio information					
> IEEE 802.11 Association Request, Flags: .....					
< IEEE 802.11 Wireless Management					
> Fixed parameters (4 bytes)					
< Tagged parameters (86 bytes)					
> Tag: SSID parameter set: "Testhouse"					
> Tag: Supported Rates 1(B), 2(B), 5.5(B), 11(B), 6, 9, 12, 18, [Mbit/sec]					
> Tag: Extended Supported Rates 24, 36, 48, 54, [Mbit/sec]					
> Tag: RSN Information					
> Tag: HT Capabilities (802.11n D1.10)					
> Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Information Element					

Position	RSSI (dBm)	Connected Node	Video Delay (Seconds)	Video Struck (Yes/No)
1	-55	GW	6	No
2	-29	GW	5	No
3	-62	GW	27	Yes
4	-72	GW	34	Yes

### Observations for Security Camera Testing:

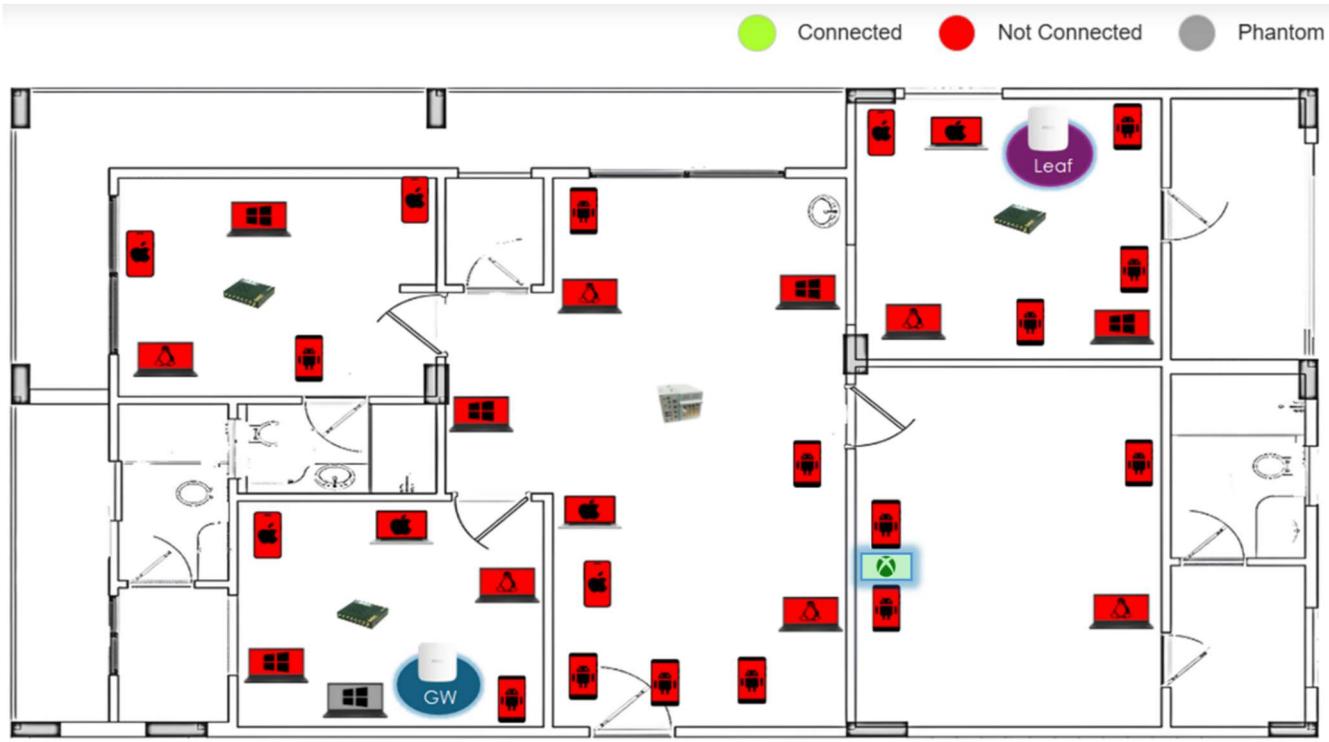
- While streaming live video when it is placed outside the house or near the GW, there is a 6-second delay to get the live feed.
- From the association response, observed that the cameras don't support the roaming feature as a result when we moved the camera away from the GW and moved towards the Leaf, observed that the video got stuck.

## 12. Online Gaming Evaluation:

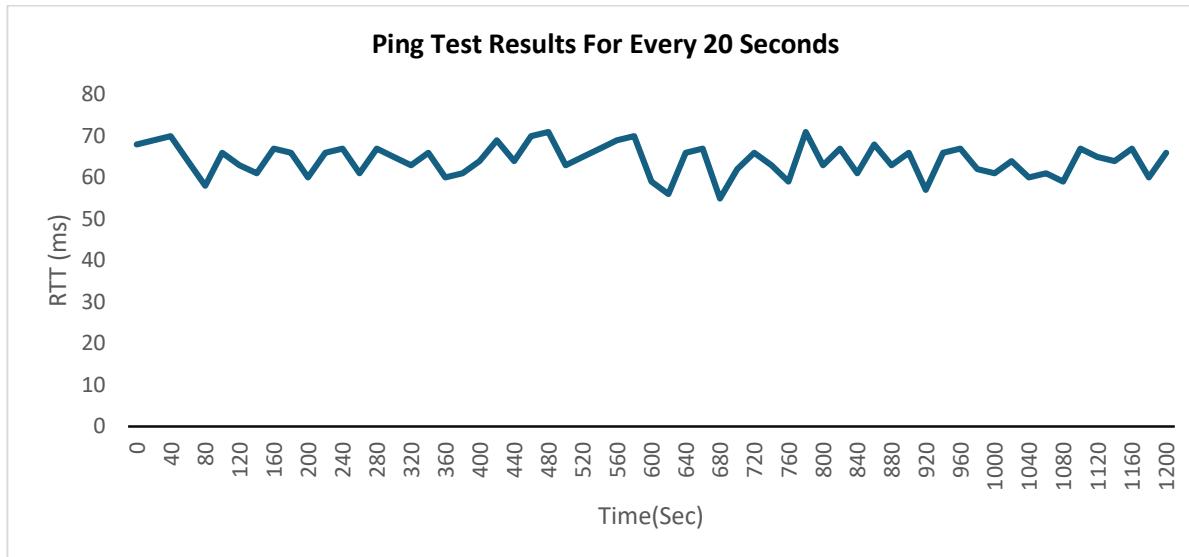
### Test Description:

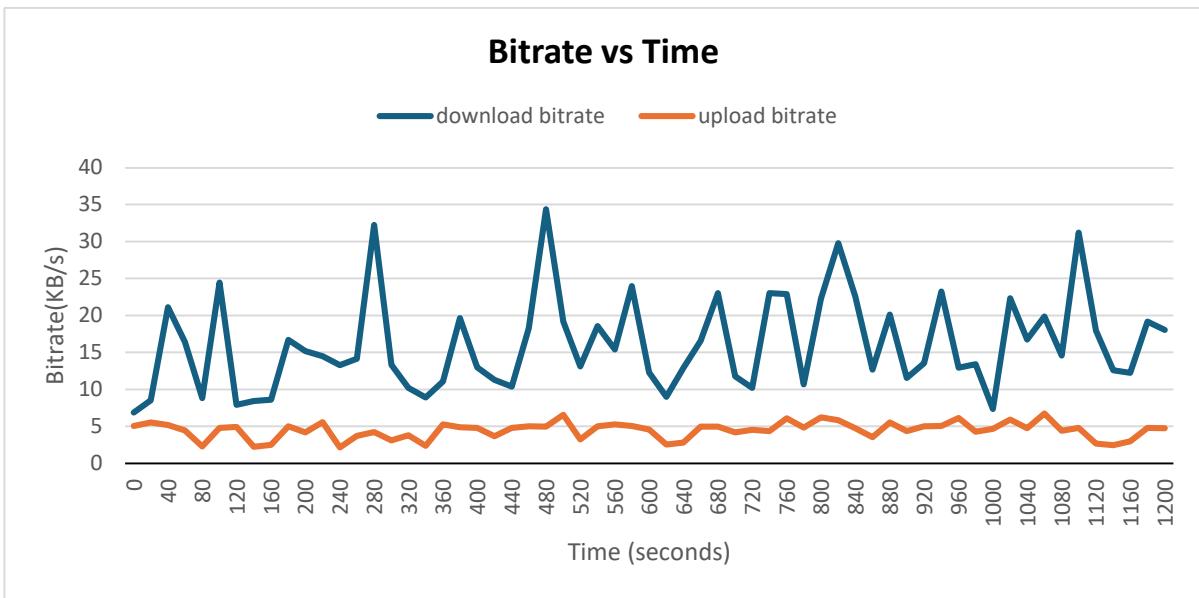
- Connect a gaming console (Xbox Series) to the network.
- Measure baseline network latency and record results while playing a game for a 20-minute duration.

### Connected Devices:



### Test Results:





Time (sec)	Ping Latency (ms)	Download Bit Rate (KB/s)	No of Downloaded Packets in that Second	Upload Bit Rate (KB/s)	No of Uploaded Packets in that Second	Upload Packet Loss	Download Packet Loss
0	68	6.91	30	5.05	48	0	0
20	69	8.53	30	5.52	42	0	0
40	70	21.1	47	5.18	59	0	0
60	64	16.41	39	4.44	46	0	0
80	58	8.81	29	2.29	37	0	0
100	66	24.46	45	4.81	44	0	0
120	63	7.9	29	4.93	52	0	0
140	61	8.44	29	2.25	36	0	0
160	67	8.59	29	2.49	39	0	0
180	66	16.7	39	5.02	57	0	0
200	60	15.19	34	4.18	40	0	0
220	66	14.48	31	5.58	52	0	0
240	67	13.26	29	2.18	35	0	0
260	61	14.14	36	3.7	47	0	0
280	67	32.27	54	4.21	43	0	0
300	65	13.34	35	3.12	38	0	0
320	63	10.22	28	3.78	55	0	0
340	66	8.9	33	2.37	35	0	0
360	60	11.06	28	5.28	56	0	0
380	61	19.64	45	4.88	48	0	0
400	64	12.99	33	4.79	46	0	0
420	69	11.27	29	3.68	37	0	0
440	64	10.36	30	4.78	43	0	0
460	70	18.25	38	4.99	59	0	0
480	71	34.41	62	4.95	55	0	0
500	63	19.15	40	6.58	57	0	0
520	65	13.12	30	3.25	43	0	0

540	67	18.57	36	4.99	59	0	0
560	69	15.42	31	5.27	58	0	0
580	70	23.97	50	5.06	46	0	0
600	59	12.29	31	4.58	42	0	0
620	56	9	30	2.52	41	0	0
640	66	12.88	29	2.78	36	0	0
660	67	16.58	29	4.98	56	0	0
680	55	23.02	38	4.98	51	0	0
700	62	11.78	38	4.2	50	0	0
720	66	10.22	33	4.51	40	0	0
740	63	23.01	40	4.36	47	0	0
760	59	22.89	48	6.1	54	0	0
780	71	10.66	29	4.82	59	0	0
800	63	22.28	41	6.24	55	0	0
820	67	29.8	64	5.81	51	0	0
840	61	22.6	38	4.76	49	0	0
860	68	12.68	29	3.54	51	0	0
880	63	20.12	48	5.51	57	0	0
900	66	11.55	35	4.34	39	0	0
920	57	13.52	38	5.01	59	0	0
940	66	23.22	45	5.06	52	0	0
960	67	12.93	36	6.13	51	0	0
980	62	13.41	32	4.27	53	0	0
1000	61	7.36	29	4.67	59	0	0
1020	64	22.32	40	5.93	59	0	0
1040	60	16.73	34	4.76	59	0	0
1060	61	19.87	40	6.76	49	0	0
1080	59	14.57	37	4.42	44	0	0
1100	67	31.23	58	4.77	60	0	0
1120	65	17.94	39	2.66	39	0	0
1140	64	12.6	38	2.43	42	0	0
1160	67	12.22	32	2.98	42	0	0
1180	60	19.18	42	4.81	56	0	0
1200	66	18.03	41	4.75	48	0	0
Average	64.23	16.14	37.03	4.48	48.56	0.00	0.00

### Observations for Online Gaming Evaluation Test:

- There are no disruptions in the gameplay during the entire test.
- Observed average latency of 64ms.