Network Testing & Emulation Solutions

Candela Testing as a Service

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1-360-380-1618

The 3-approaches for Wi-Fi AP/Router Testing

Lab Testing with Virtual Devices

Repeatability:
Scalability :
Automation :
Realism :

Lab Testing with Real Devices

Repeatability:
Scalability :
Automation :
Realism :

Real world Testing in Test House/Enterprises

Repeatability:
Scalability :
Automation :
Realism :

Test Suite Details

S No.	Test Category	Testcase	No of Testcases
1	Basic Testing	Client Connectivity - 2.4GHz, 5GHz & 6GHz	25
2		Throughput with client capacity - 2.4GHz, 5GHz & 6GHz	
3		Multi Band Throughput	
4		Data plane - 2.4GHz & 5GHz	
5		Port Reset	
6	Advanced Testing	Quality of Service	47
7		Dynamic Frequency Selection	
8		Performance over Distance (RvR)	
9		Performance over Orientation (RvO)	
10		File Transfer Protocol	
11		Interference (ACI/CCI)	
12		MU-MIMO	
13		OFDMA	
14		Airtime Fairness	
15		Roaming	
16		Long Term Stability	
17	TR-398 Testing	TR-398 Issue-2	15
18		TR-398 Issue-3	21
19		TR-398 Issue-4	29

S No.	Test Category	Testcase	No of Testcases
20	Real Device Testing	Throughput Test	13
21		Interoperability Test	
22		QoS Test	
23		Multicast Test	
24		Ping Plotter Test	
25		Port Reset Test	
26		FTP Test	
27		HTTP Test	
28		Video Streaming Test	
29		Reak Browser Test	
30		YouTube Streaming Test	
31		Zoom call Test	
32		Mixed Traffic Test	
33	Coverage and Capacity Test House	Coverage, Roam and capacity with 40+ devices	5

Results Summary

Num	Tests	Vendor A	Vendor B
1	Basic Client connectivity – 2.4 GHz	Good	Excellent
2	Basic Client connectivity – 5 GHz	Good	Excellent
3	Client Capacity – 5 GHz TCP UL	Good	Excellent
4	Client Capacity – 5 GHz TCP DL	Good	Excellent
5	Client Capacity – 5 GHz UDP UL	Good	Excellent
6	Client Capacity – 5 GHz UDP DL	Poor	Excellent
7	Client Capacity – 2.4 GHz TCP UL	Good	Excellent
8	Client Capacity – 2.4 GHz TCP DL	Poor	Excellent
9	Client Capacity – 2.4 GHz UDP UL	Excellent	Good
10	Client Capacity – 2.4 GHz TCP DL	Poor	Excellent
11	Data Plane – 2.4 GHz	Excellent	N/A
12	Data Plane – 5 GHz	Excellent	N/A
13	Port Reset	Excellent	N/A
14	Quality of Service – 5 GHz	Good	N/A
15	Dual Band Testing – 5GHz TCP Upload	Good	Excellent
16	Dual Band Testing – 5GHz TCP Download	Poor	Excellent
17	Dual Band Testing – 5GHz UDP Upload	Poor	Excellent
18	Dual Band Testing – 5GHz UDP Download	Poor	Excellent
19	FTP – 2.4 GHz	Excellent	Excellent
20	FTP – 5 GHz	Poor	Excellent
21	DFS	Excellent	N/A
22	Rate vs Range	Good	Good
23	Rate vs Orientation	Poor	Good

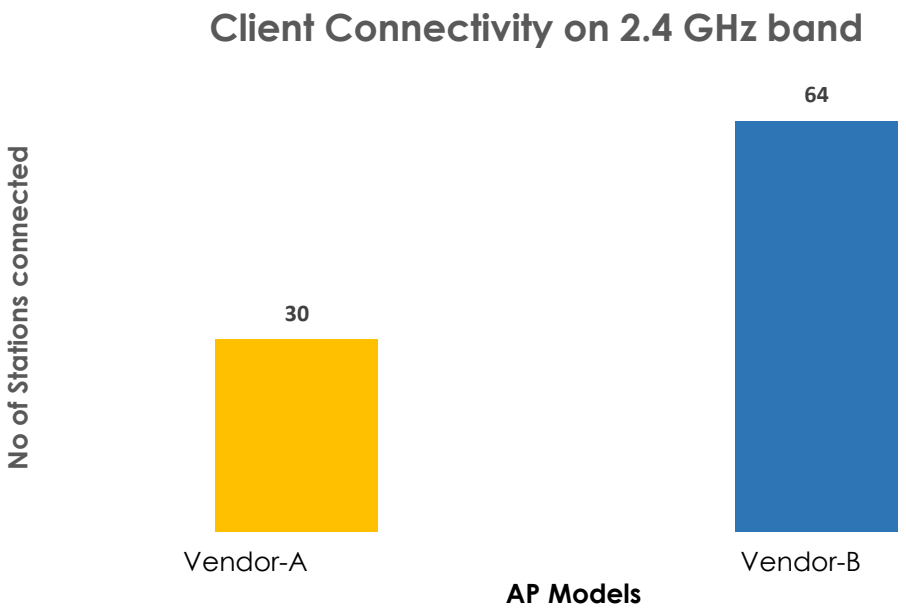
TR-398 Results Summary

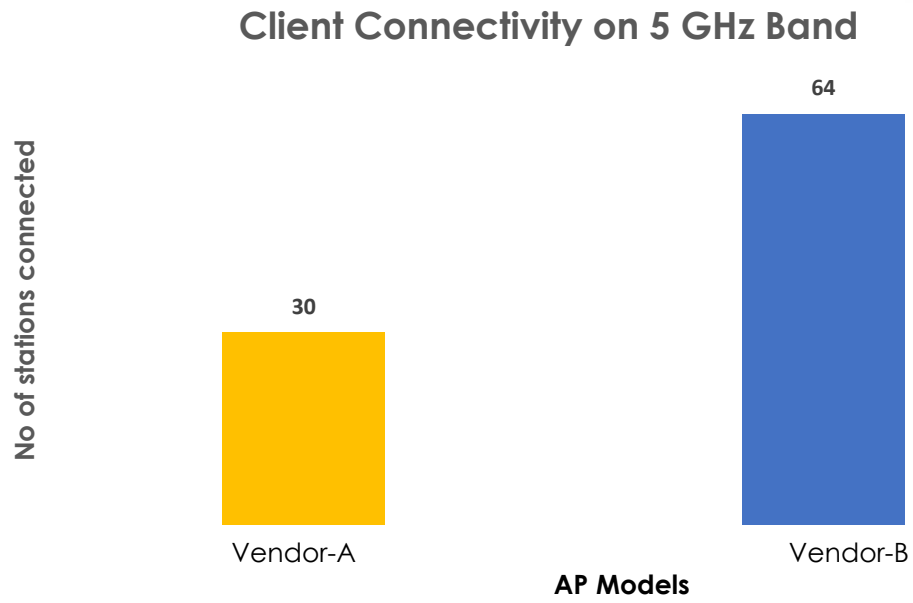
TR-398 Issue-4 - Comparison between two vendor APs							
S No.	Testcase	Vendor-A			Vendor-B		
		2.4GHz	5GHz	6GHz	2.4GHz	5GHz	6GHz
1	6.1.1 Receiver Sensitivity Test	PASS	PASS	PASS	FAIL	PASS	PASS
2	6.2.1 Maximum Connection Test	PASS	PASS	PASS	FAIL	PASS	FAIL
3	6.2.2 Maximum Throughput Test	PASS	PASS	PASS	PASS	PASS	PASS
4	6.2.3 Airtime Fairness Test	PASS	PASS	PASS	PASS	PASS	PASS
5	6.2.4 Dual-Band Throughput Test	PASS	FAIL	FAIL	FAIL	FAIL	PASS
6	6.2.5 Bi-Directional Throughput Test	PASS	PASS	PASS	PASS	PASS	FAIL
7	6.2.6 Latency Test	PASS	PASS	PASS	FAIL	PASS	FAIL
8	6.2.7 Quality of Service Test	PASS	PASS	PASS	FAIL	FAIL	FAIL
9	6.2.8 Multi-Band Throughput Test	PASS	PASS	PASS	FAIL	FAIL	FAIL
10	6.2.9 OFDMA Throughput Test	NA	PASS	FAIL	PASS	PASS	FAIL
11	6.3.1 Rate Vs Range Test	PASS	PASS	PASS	FAIL	FAIL	PASS
12	6.3.2 Spatial Consistency Test	PASS	PASS	PASS	FAIL	FAIL	PASS
13	6.3.3 Peak Performance Test	PASS	PASS	NA	PASS	PASS	NA
14	6.4.1 Multiple STAs Performance Test	PASS	PASS	PASS	FAIL	FAIL	PASS
15	6.4.2 Multiple Assoc Stability Test	PASS	PASS	PASS	PASS	PASS	FAIL
16	6.4.3 Downlink MU-MIMO Test	PASS	PASS	PASS	NA	NA	NA
17	6.4.4 Multicast Test	PASS	PASS	PASS	FAIL	FAIL	FAIL
18	6.4.5 Uplink MU-MIMO Test	PASS	PASS	FAIL	NA	NA	NA
19	6.5.1 Long Term Stability Test	PASS	PASS	PASS	PASS	PASS	PASS
20	6.5.2 AP Coexistence Test	PASS	PASS	PASS	PASS	PASS	FAIL
21	6.5.3 Automatic Channel Selection Test	PASS	PASS	PASS	FAIL	PASS	PASS
22	6.5.5 Puncturing Test	NA	NA	NA	NA	NA	NA
23	6.5.6 MLO 2-Channel Test	NA	PASS	PASS	NA	PASS	PASS

Real Device Testing Summary

Test Name	VENDOR-A	VENDOR-B
Throughput Test	Excellent	Good
Interoperability Test	Excellent	Good
QoS Test	Excellent	Good
Multicast Test	Excellent	Good
Ping Plotter Test	Excellent	Good
Port Reset Test	Good	Good
FTP Test	Good	Excellent
HTTP Test	Good	Excellent
Video Streaming	Excellent	Good
Real Browser Test	Excellent	Good
YouTube Streaming Test	Good	Good
Zoom Call Test	Excellent	Good
Mixed Traffic Test	Good	Good

Basic Client Connectivity





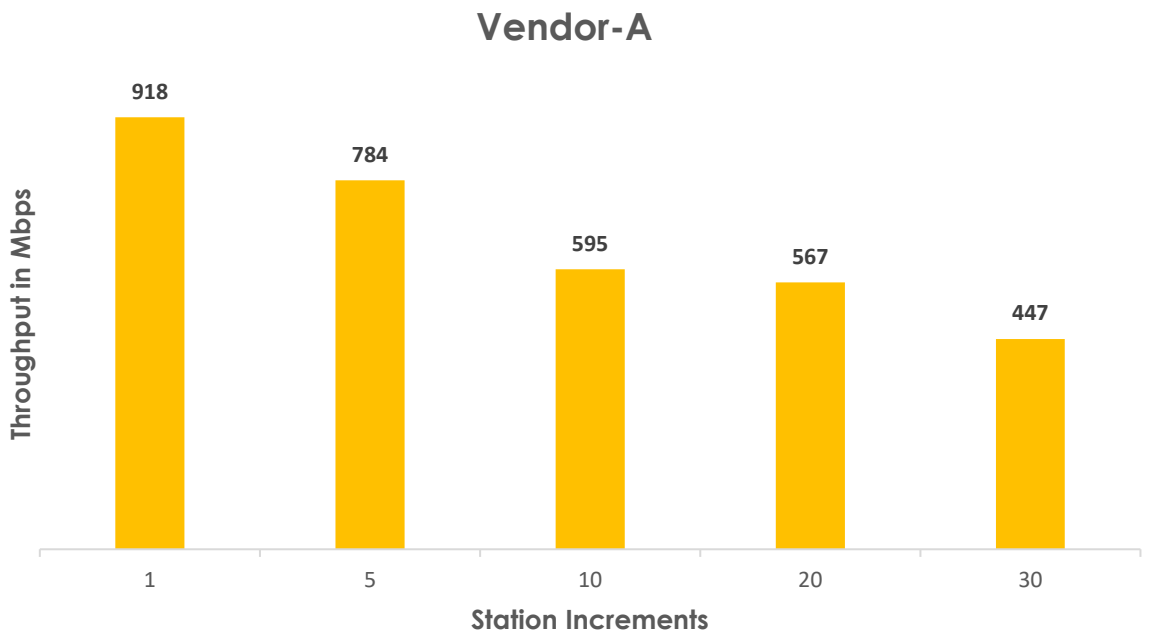
Test Description:

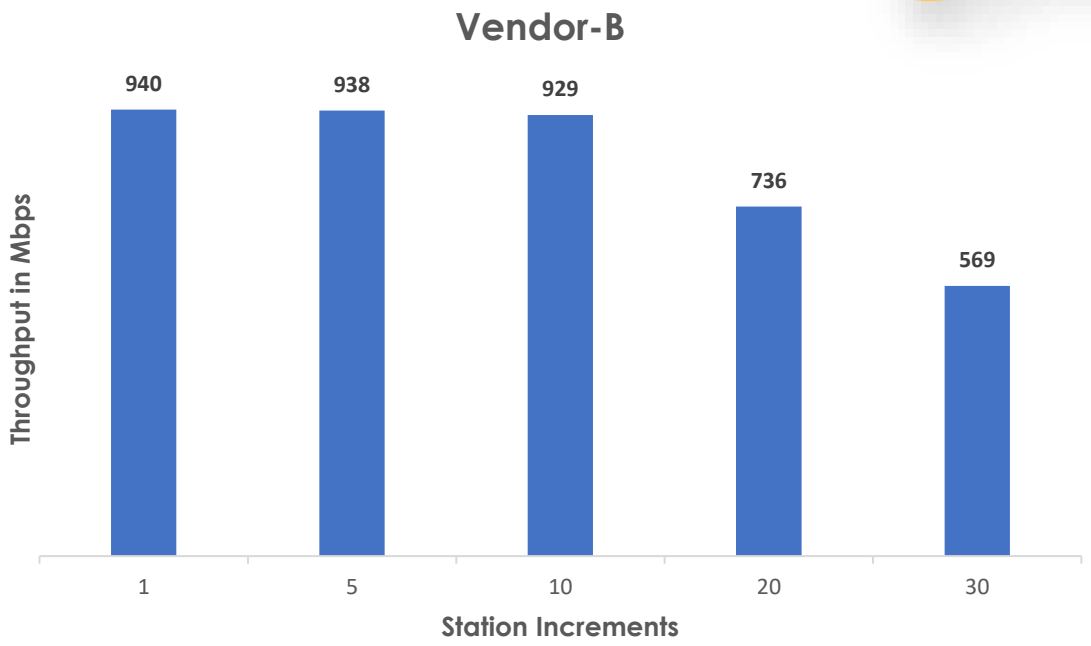
- DUT in ideal test conditions. No interfering APs and a good signal to the stations.
- All 2.4 GHz clients are connected in 3*3 with ax mode.
- All the 5 GHz clients are connected in 4*4 with ax mode.

Results Observations:

- In both bands, more clients are connecting to Vendor-B.

Client Capacity – 5 GHz *TCP UL*





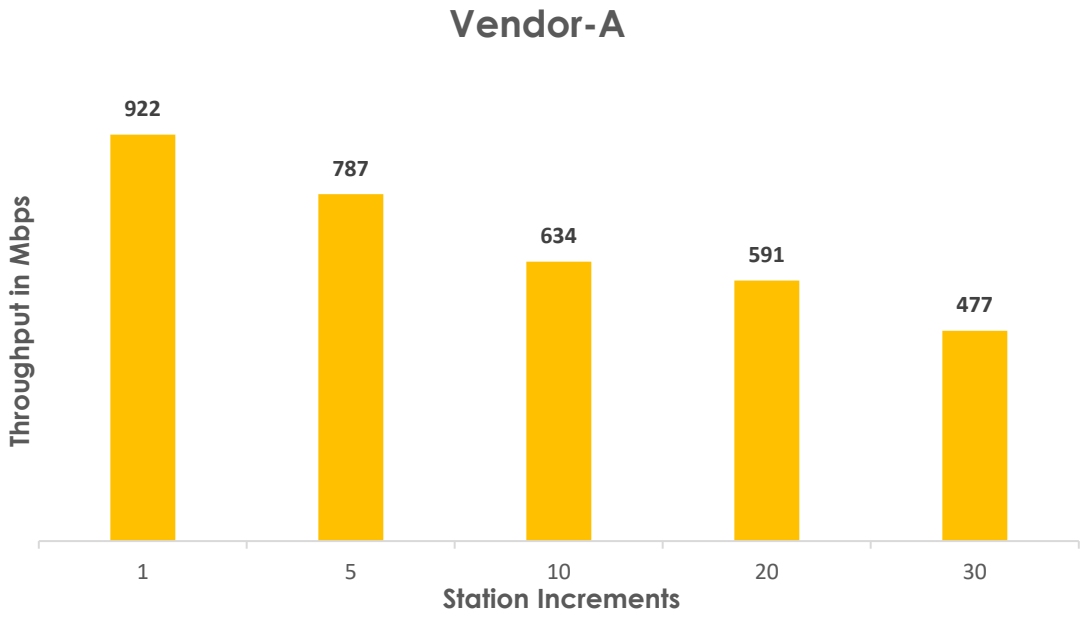
Test Description:

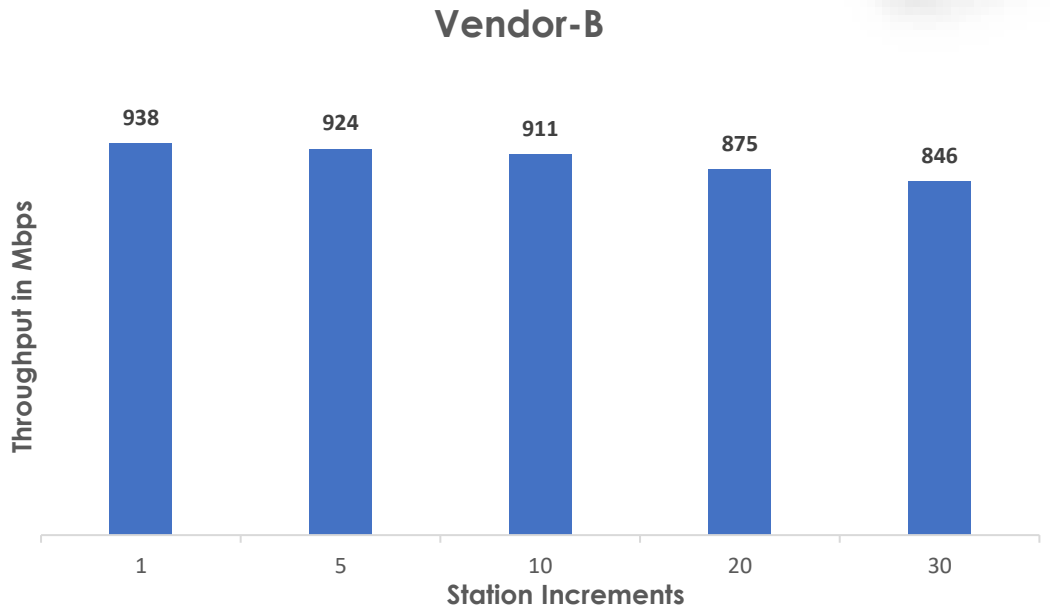
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 4NSS, 80MHz BW
- Test run for 60 sec trials for different station increments with upstream, TCP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor B AP, good achieved throughput for single station and increments as well

Client Capacity – 5 GHz *TCP DL*





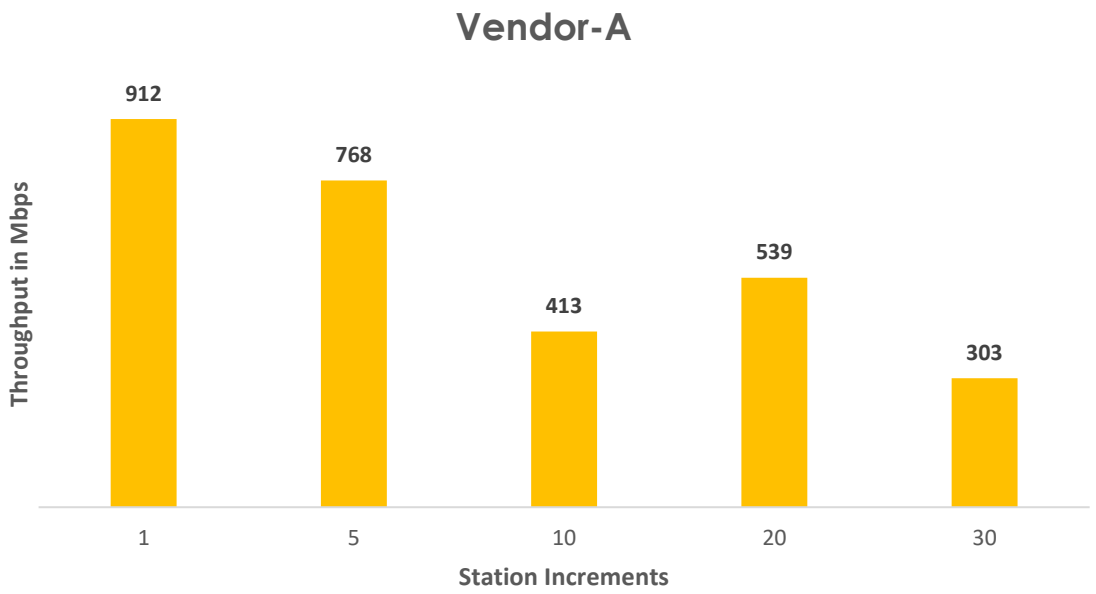
Test Description:

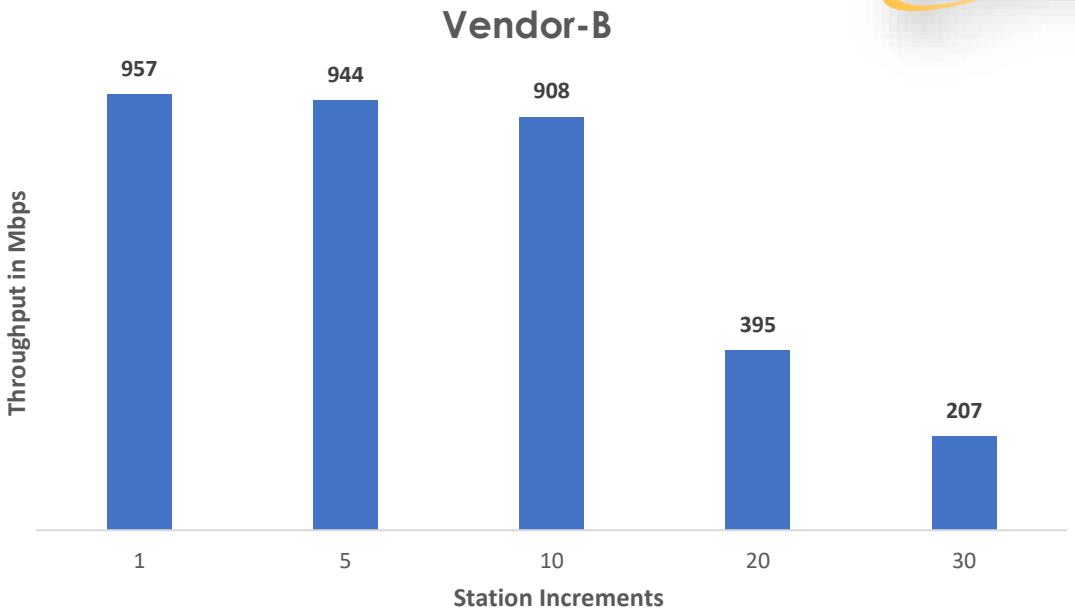
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with downstream, TCP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor B AP, good achieved throughput for single station and increments as well

Client Capacity – 5 GHz *UDP UL*





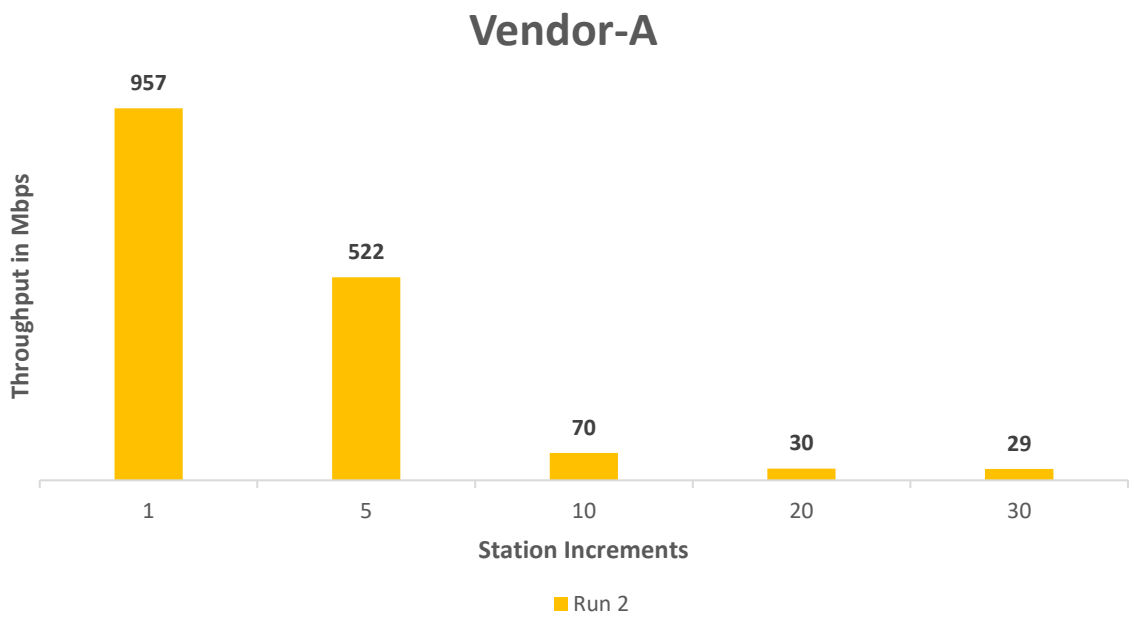
Test Description:

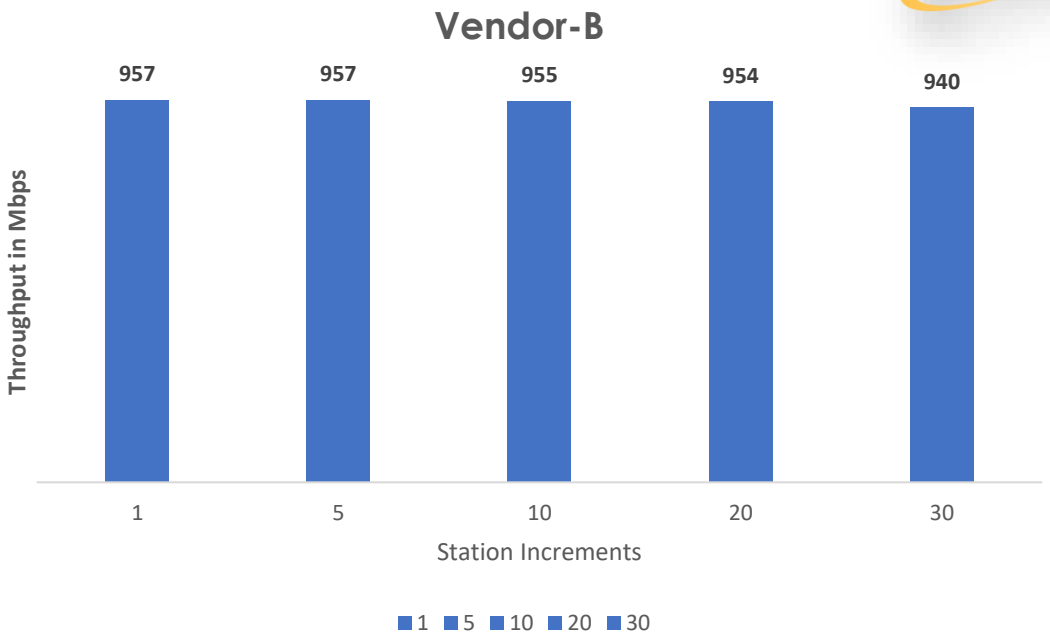
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with upstream, UDP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor B AP, good achieved throughput for single station and increments as well.
- Conflict at the point of 30 clients.

Client Capacity – 5 GHz *UDP DL*





Test Description:

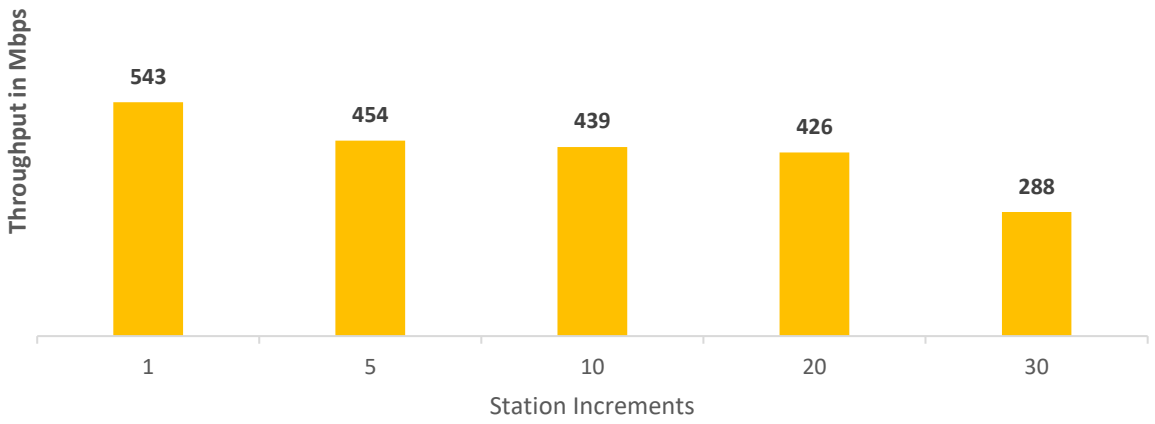
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with downstream, UDP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

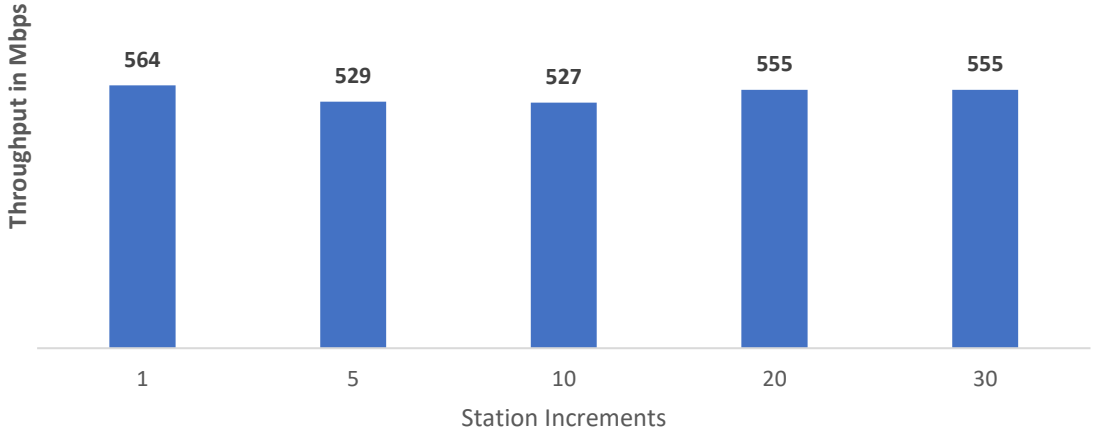
- Vendor B AP, good achieved throughput for single station and increments as well

Client capacity- 2.4GHz *TCP-UL*

Vendor-A



Vendor B



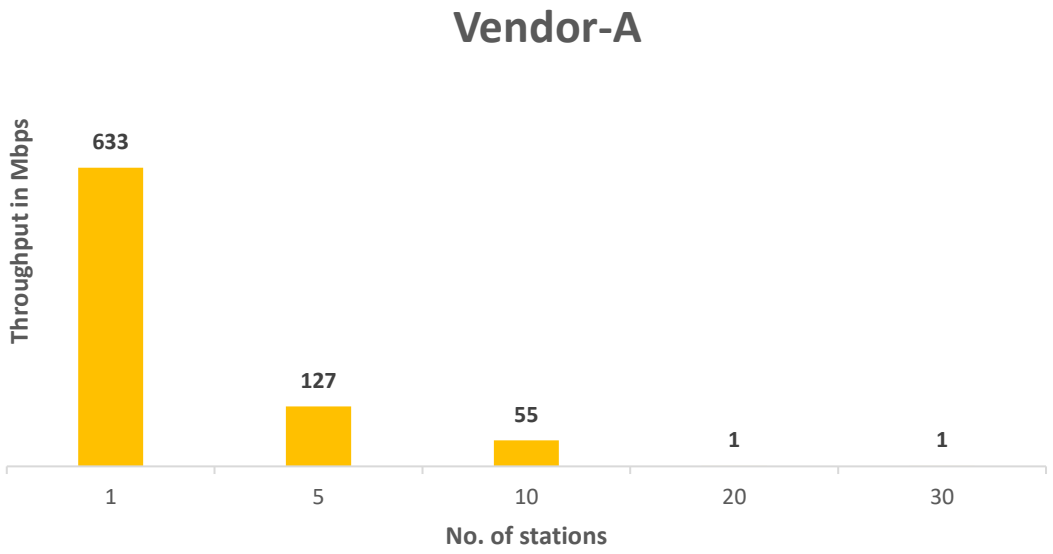
Test Description:

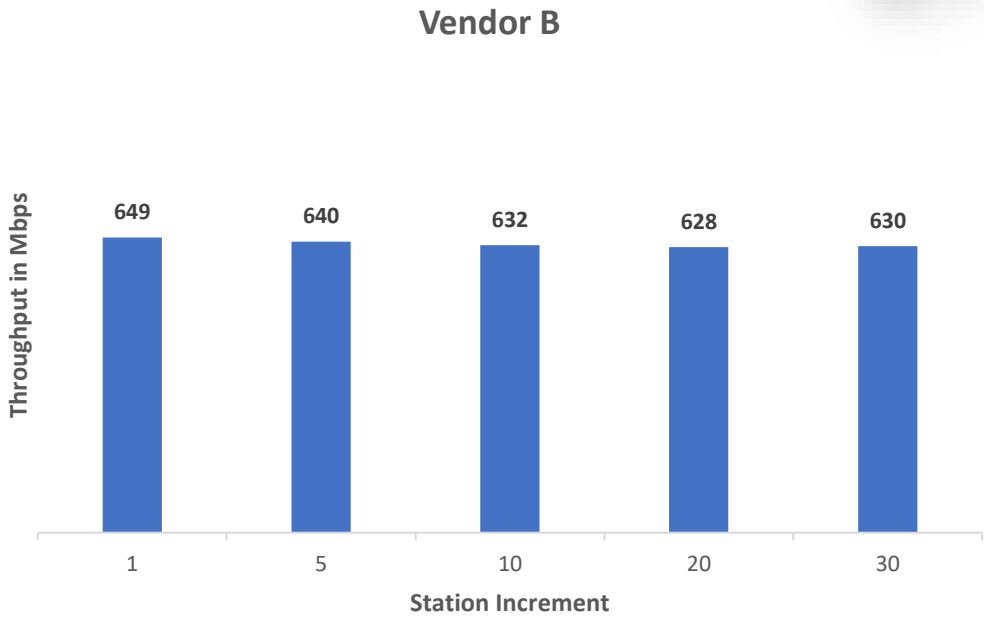
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 3NSS, 40Mhz BW
- Test run for 60 sec trials for different station increments with upstream, TCP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 2.4GHz on channel 1

Results Observations:

- Vendor B AP, good achieved throughput for single station and increments as well

Client capacity- 2.4GHz *TCP-DL*





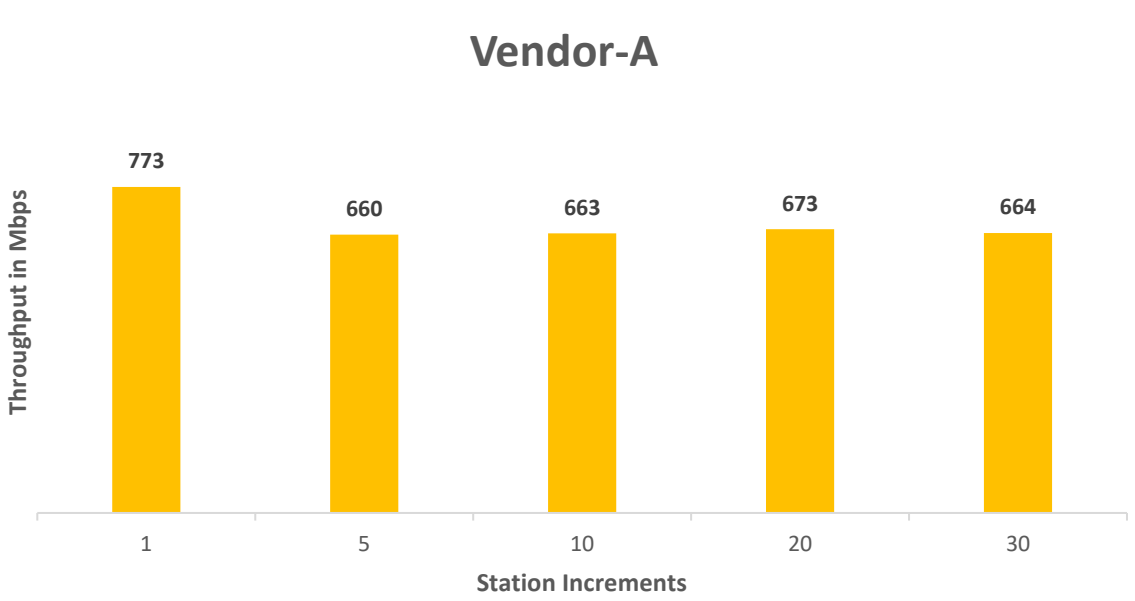
Test Description:

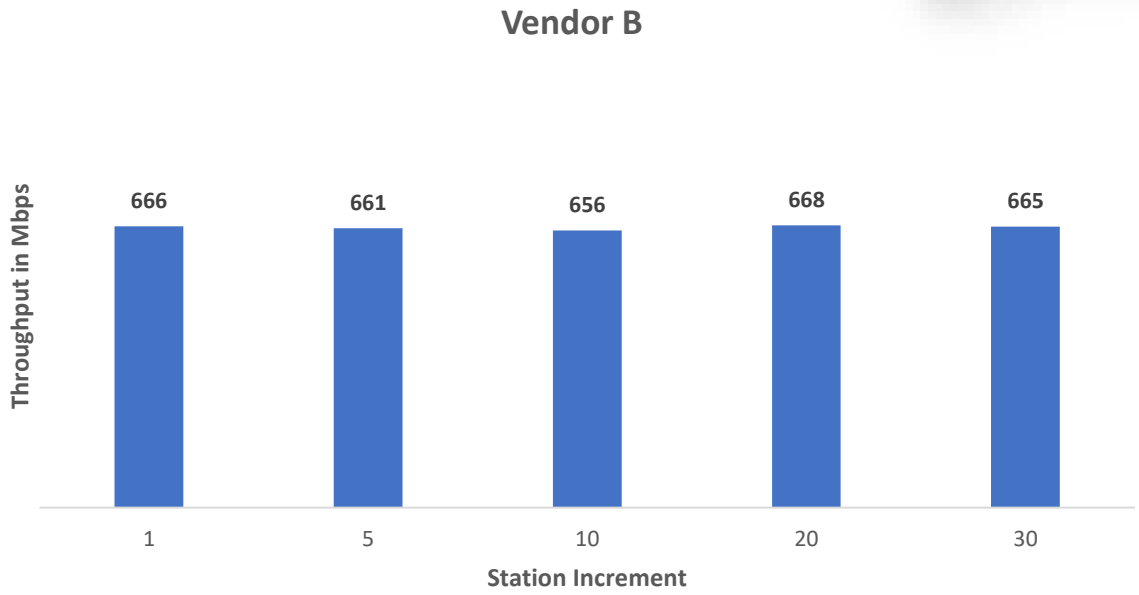
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 3NSS, 40Mhz BW
- Test run for 60 sec trials for different station increments with downstream, TCP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 2.4GHz on channel 1

Results Observations:

- Vendor B AP, good achieved throughput for single station and increments as well

Client capacity- 2.4GHz *UDP-UL*





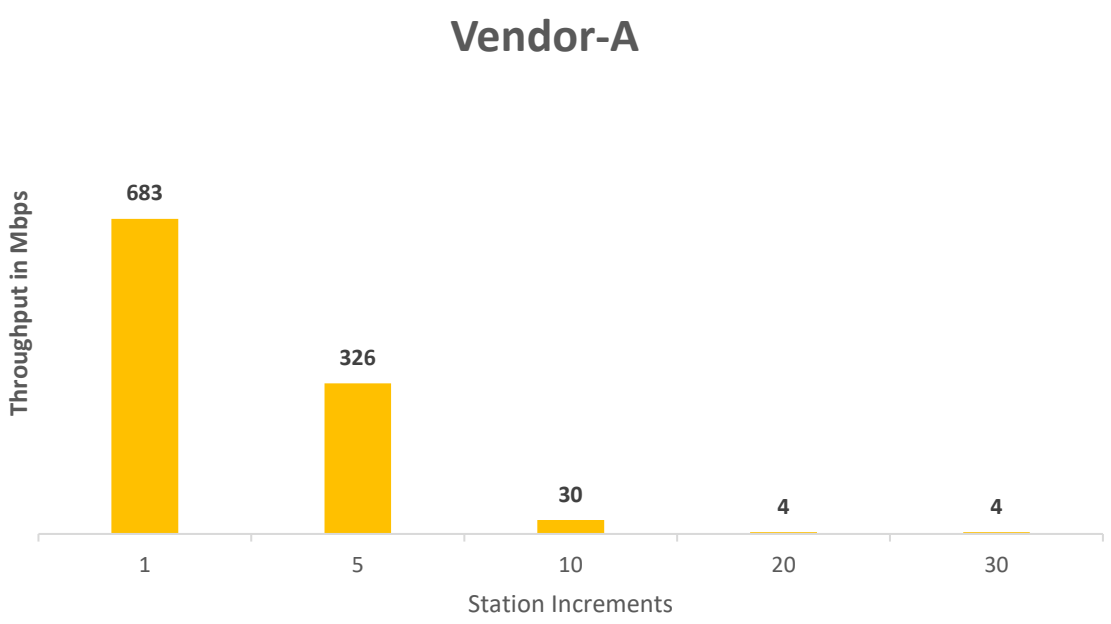
Test Description:

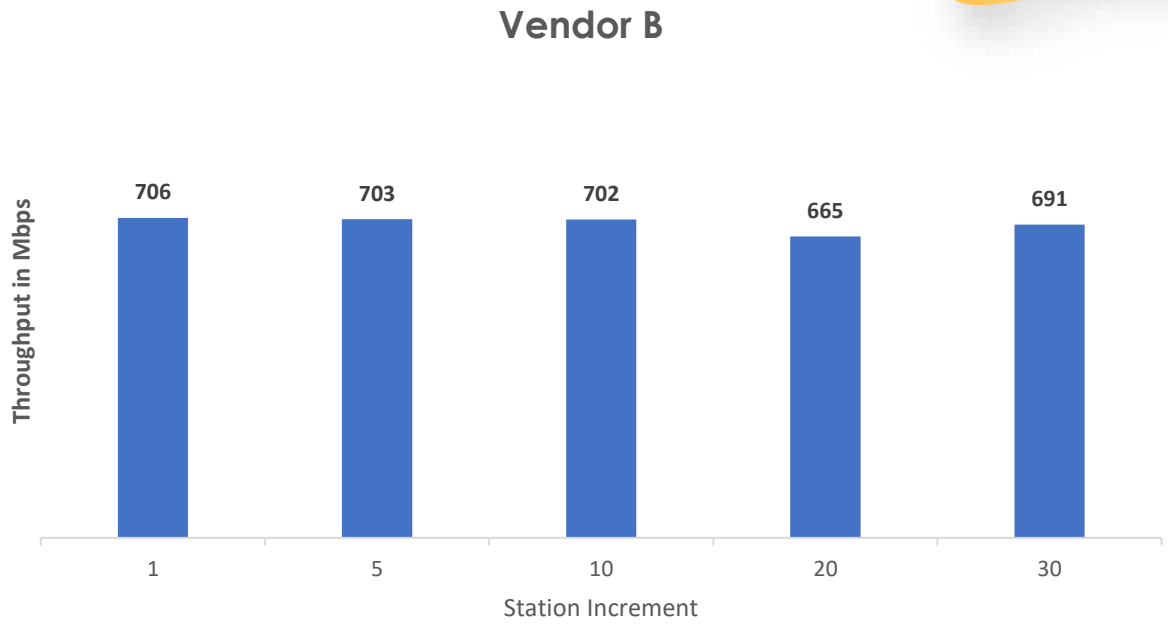
- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 3NSS, 40Mhz BW
- Test run for 60 sec trials for different station increments with upstream, UDP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 2.4GHz on channel 1

Results Observations:

- Vendor-A, good achieved throughput for single station and increments as well
- Conflict by means of increase in throughput as the stations increase.

Client capacity- 2.4GHz *UDP-DL*





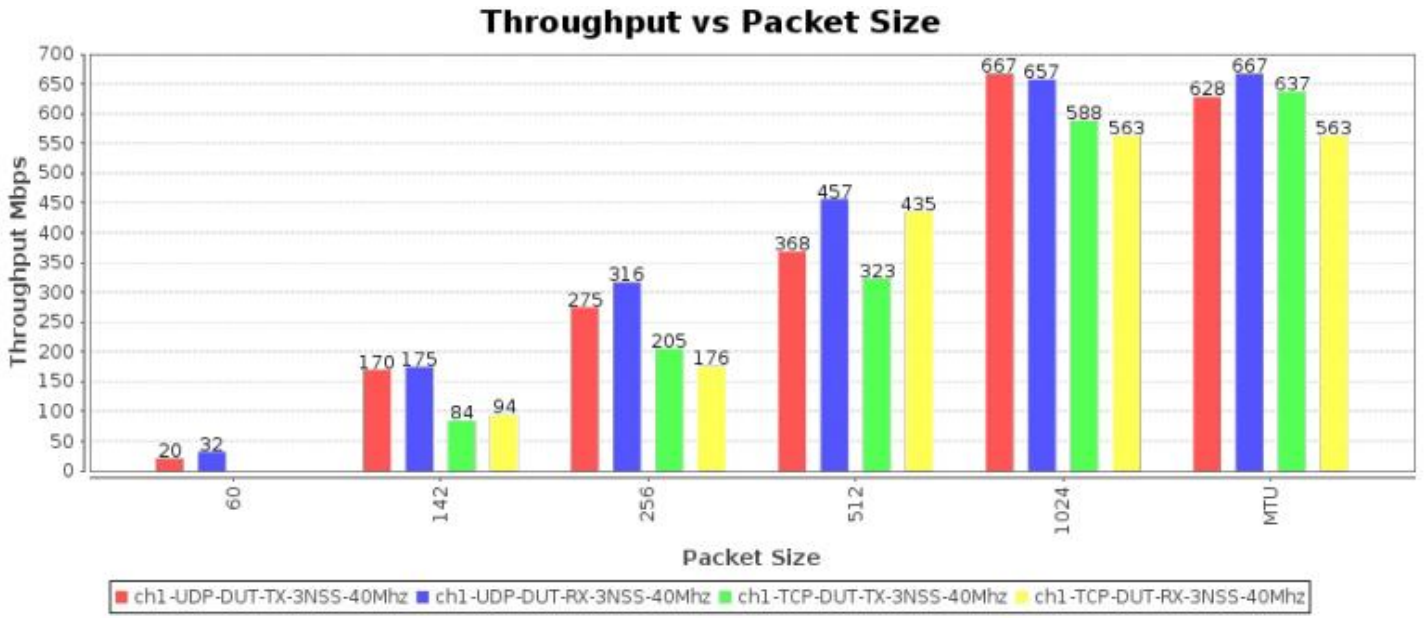
Test Description:

- DUT in ideal test conditions. No interfering APs and a good signal to the stations
- Intended load set to 1 Gbps rate for 3NSS, 40Mhz BW
- Test run for 60 sec trials for different station increments with downstream, TCP traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 2.4GHz on channel 1

Results Observations:

- Vendor B AP, good achieved throughput for single station and increments as well

Data-Plane test 2.4GHz



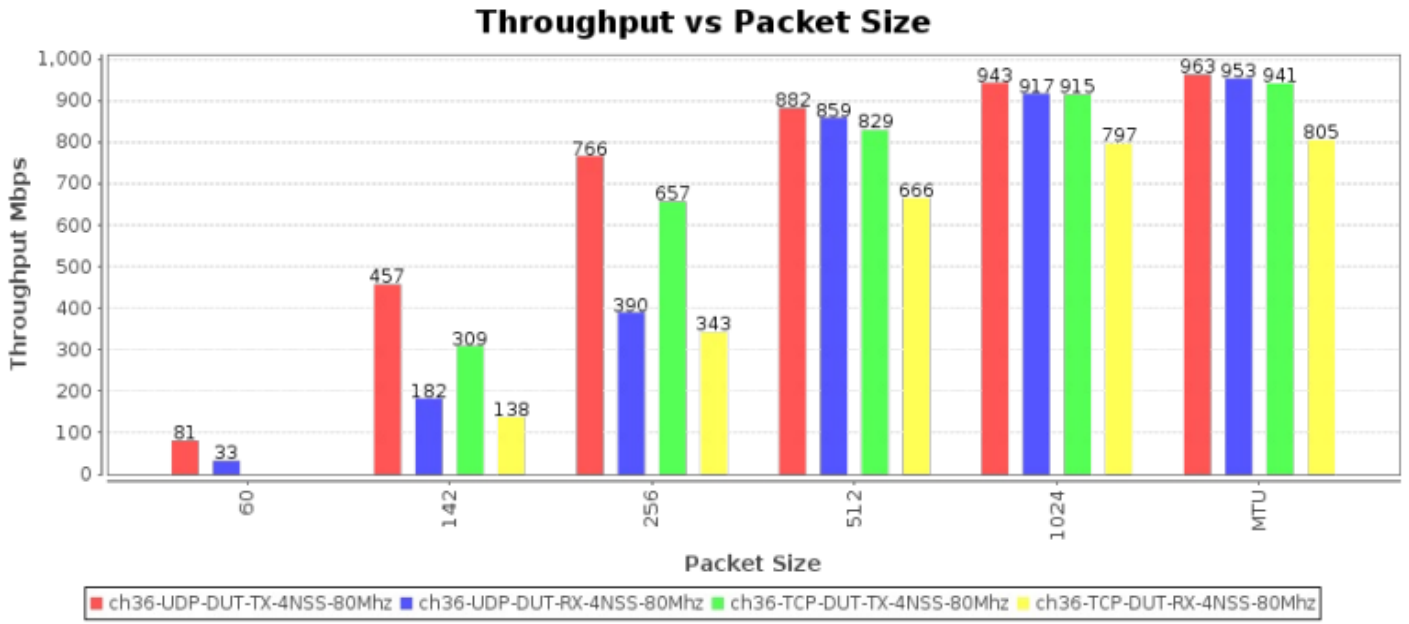
Test Description:

- In this scenario, the throughput is calculated by means of various kinds of packet sizes.
- Here we create a single client and check what is the maximum throughput at each point.
- Test run for 60 sec trials for different station increments with downstream and upstream traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 2.4GHz on channel 1, 3NSS.

Results Observations:

- Vendor-A, is performing good at the data-plane test but is relatively not as per MCS index.

Data-Plane test 5GHz



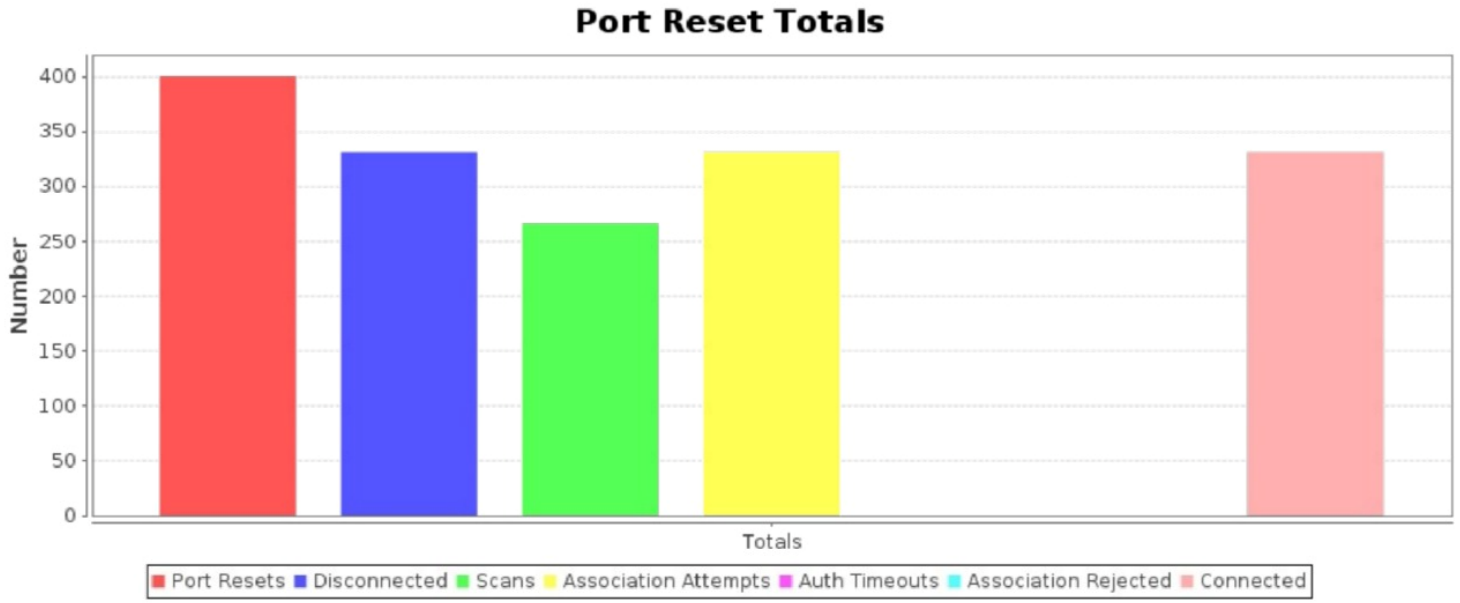
Test Description:

- In this scenario, the throughput is calculated by means of various kinds of packet sizes.
- Here we create a single client and check what is the maximum throughput at each point.
- Test run for 60 sec trials for different station increments with downstream and upstream traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36, 4NSS.

Results Observations:

- Vendor-A, is performing good at the data-plane test but is relatively not as per MCS index.

Port Reset-2.4GHz



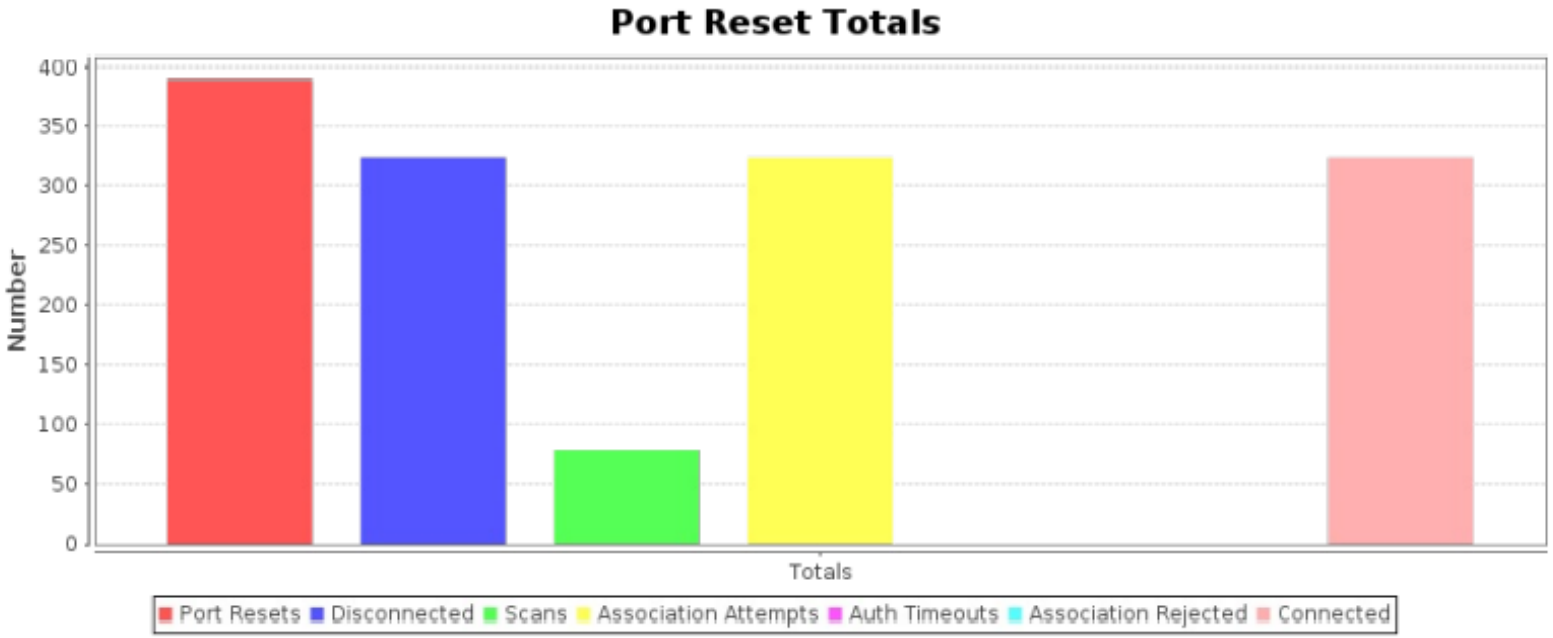
Test Description:

- In this scenario, the port reset time and association time is calculated
- Here we create 30-clients and check what is the maximum rate of port reset at each point.
- Test run for 60 sec(min) and 120(max) trials for different port intervals.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Port reset test run in 2.4GHz on channel 1, 3NSS.

Results Observations:

- Vendor-A, is following good port reset count for 30-clients in the span of 1 hour.

Port Reset 5GHz



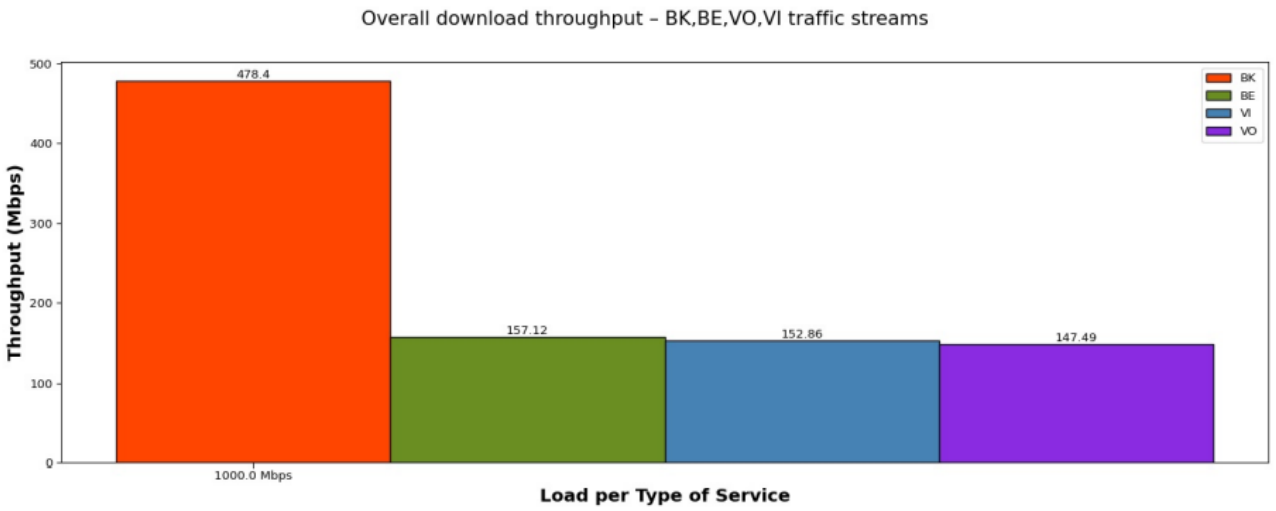
Test Description:

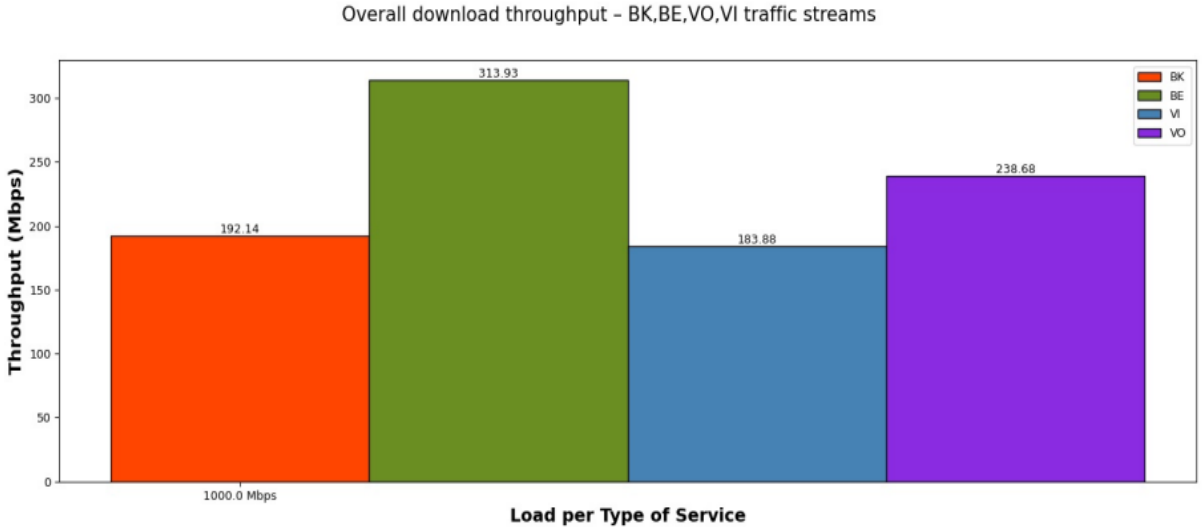
- In this scenario, the port reset time and association time is calculated
- Here we create 30-clients and check what is the maximum rate of port reset at each point.
- Test run for 60 sec(min) and 120(max) trials for different port intervals.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Port reset test run in 5GHz on channel 36, 4NSS.

Results Observations:

- Vendor-A, is following good port reset count for 30-clients in the span of 1 hour.

Quality of Service for 5GHz 1-Client and 2-clients





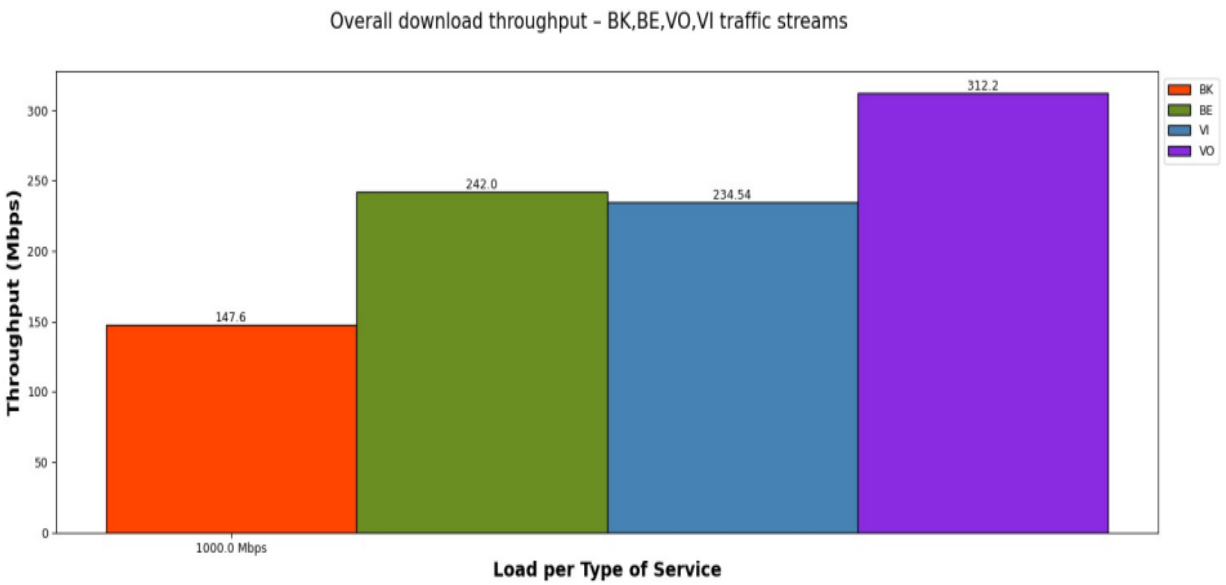
Test Description:

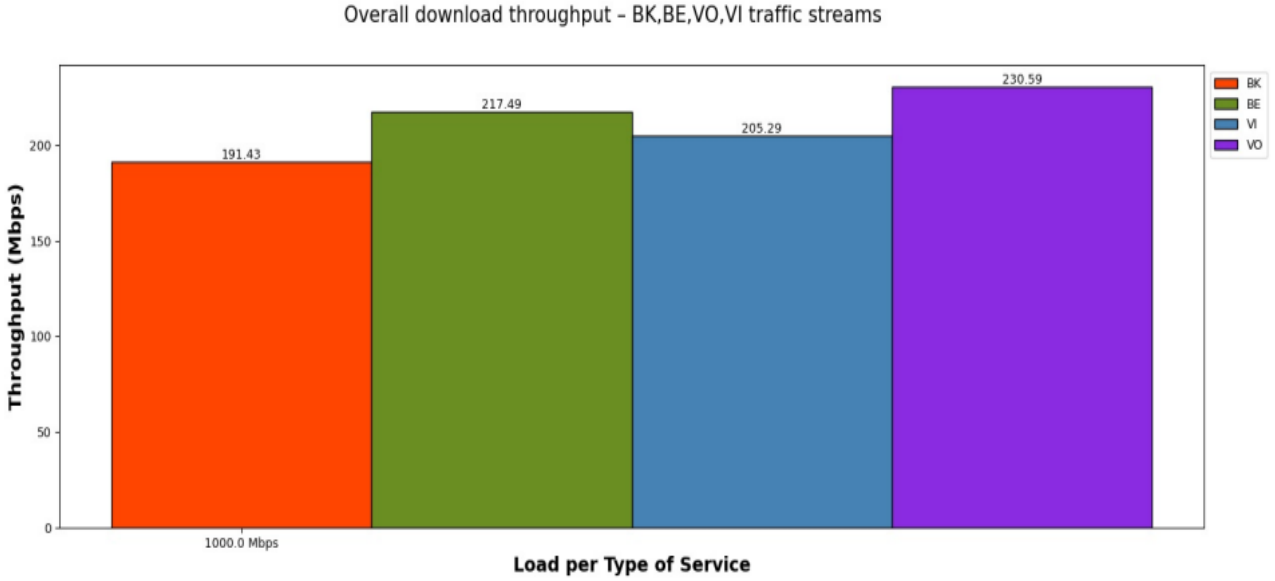
- In this scenario, the Quality of Service is observed by means of running various kinds of traffic:- VOICE,VIDEO,BACKEND,BEST EFFORT.
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with downstream, QoS traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor-A, is not following the precedence of QoS for both 1-client and 2-clients.

Quality of Service for 5GHz 5-Clients and 7-clients





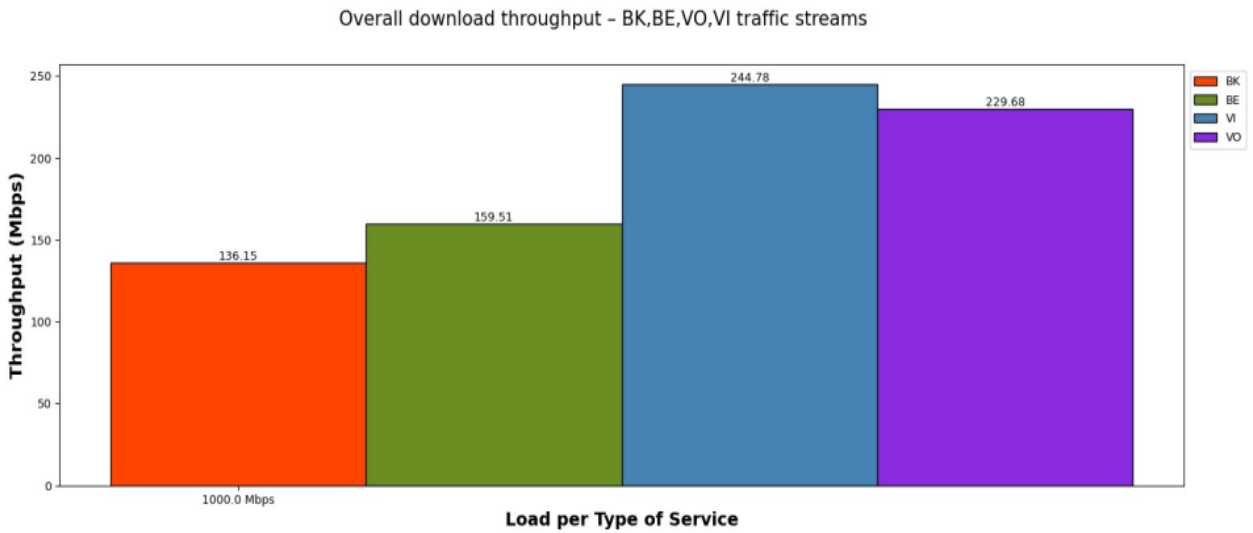
Test Description:

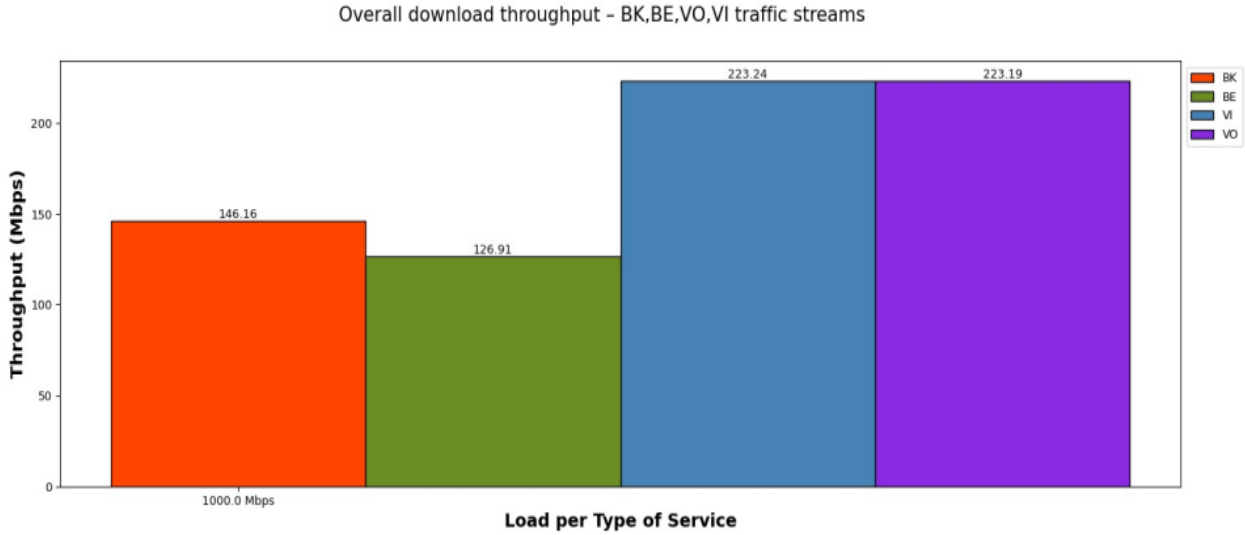
- In this scenario, the Quality of Service is observed by means of running various kinds of traffic:- VOICE,VIDEO,BACKEND,BEST EFFORT.
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with downstream, QoS traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor-A, is not following the precedence of QoS for both 5-client and 7-clients.

Quality of Service for 5GHz 10-Clients and 15-clients





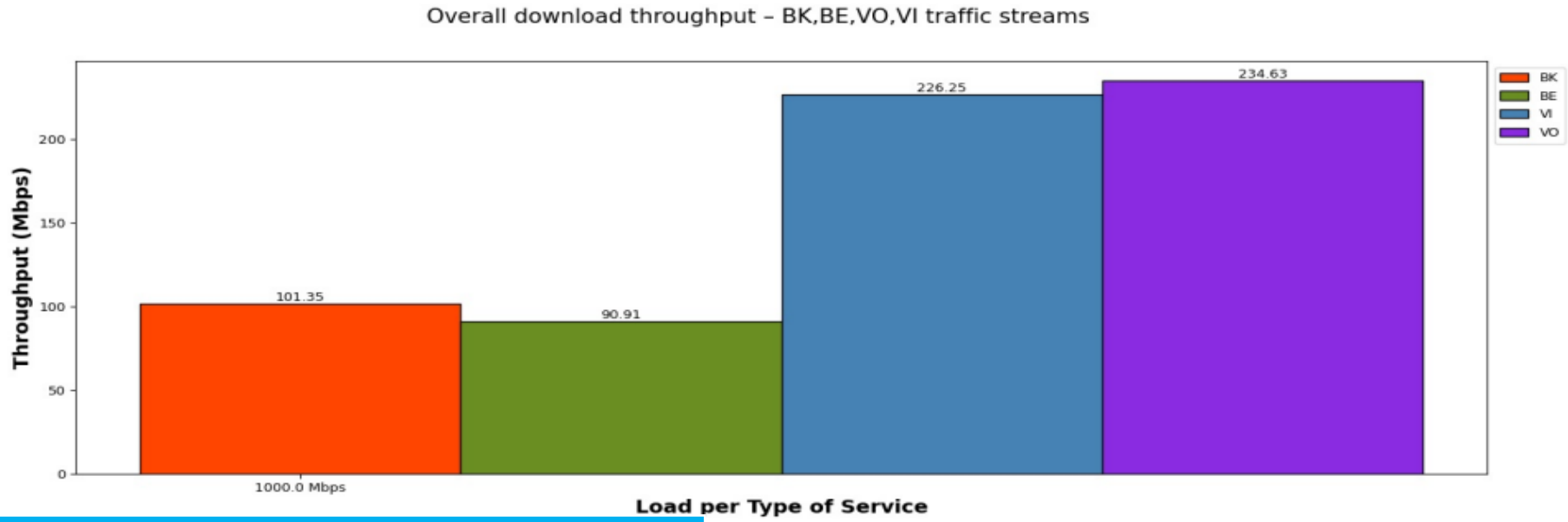
Test Description:

- In this scenario, the Quality of Service is observed by means of running various kinds of traffic:- VOICE,VIDEO,BACKEND,BEST EFFORT.
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with downstream, QoS traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor-A, is not following the precedence of QoS for 10-clients and is following for 15-clients.

Quality of Service for 5GHz 19-clients



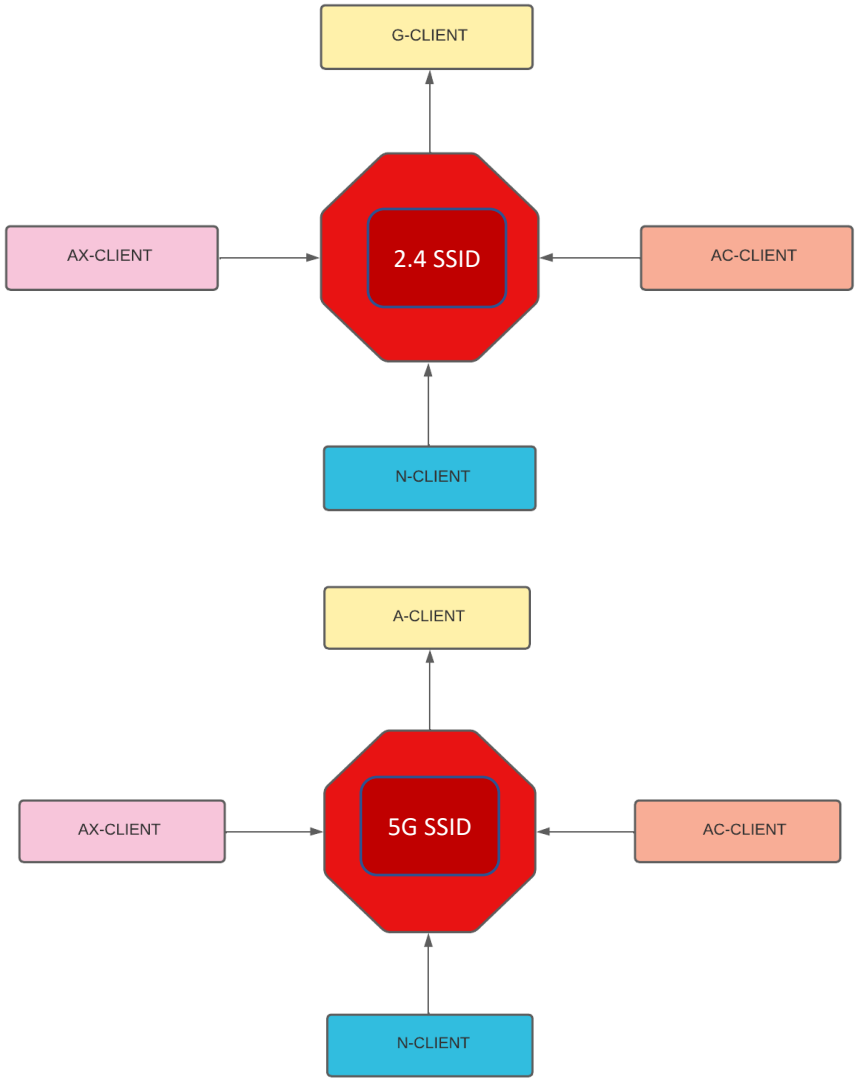
Test Description:

- In this scenario, the Quality of Service is observed by means of running various kinds of traffic:- VOICE,VIDEO,BACKEND,BEST EFFORT.
- Intended load set to 1 Gbps rate for 4NSS, 80Mhz BW
- Test run for 60 sec trials for different station increments with downstream, QoS traffic.
- DUT-TX is from AP to Client and DUT-Rx is from Client to AP.
- Throughput test run in 5GHz on channel 36

Results Observations:

- Vendor-A, is following the precedence of QoS for 19-clients.

Airtime Fairness testing:

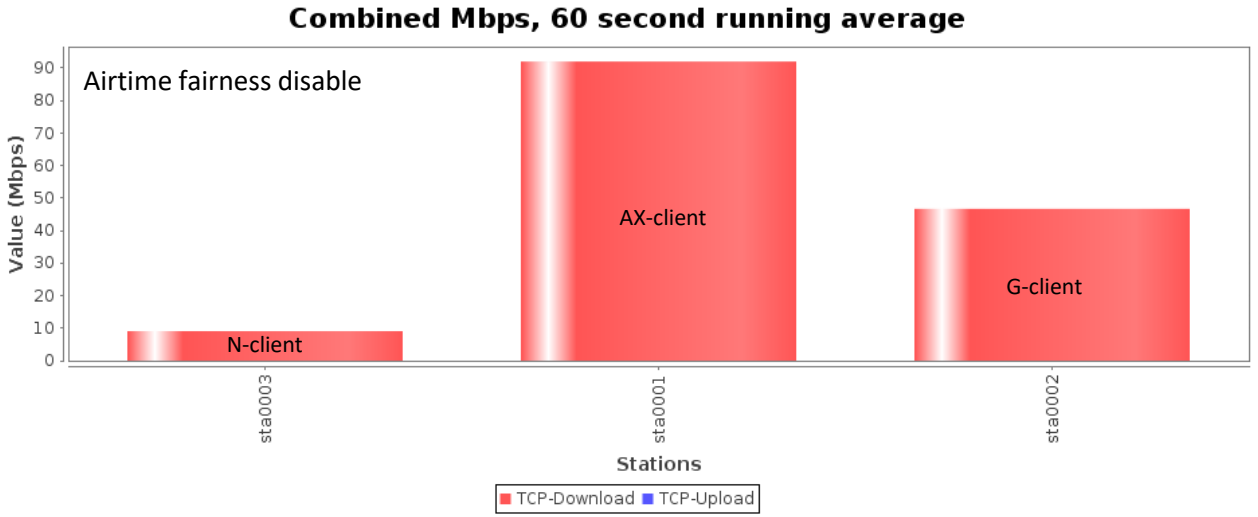


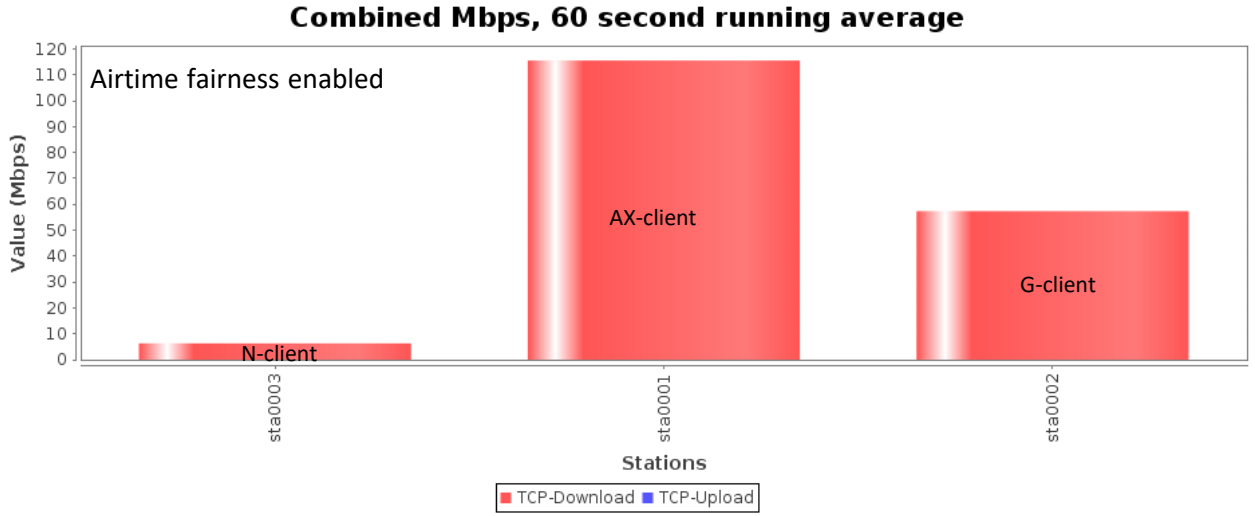
Test procedure for Airtime fairness test:

- In this testcase we create 4 different kind of clients, and connect them to the Vendor-A at the same time.
- We set the maximum traffic as 1Gbps, and run the traffic together for all the 4 clients.
- We also consider the network time as a constraint and monitor the throughput difference when Airtime Fairness is enabled.
- Airtime fairness can be observed only in the downlink traffic.

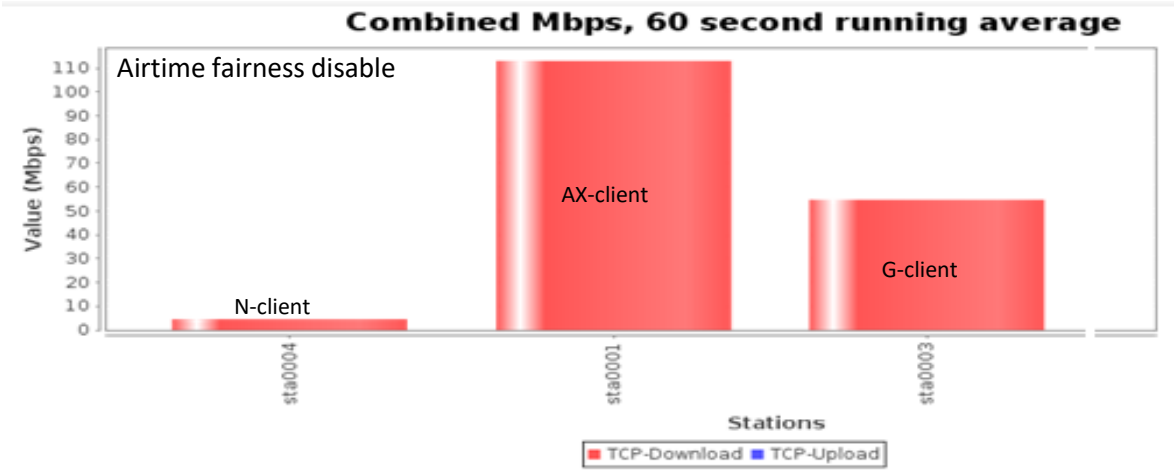
Airtime Fairness : TCP-DL[2.4GHz]

Vendor-A

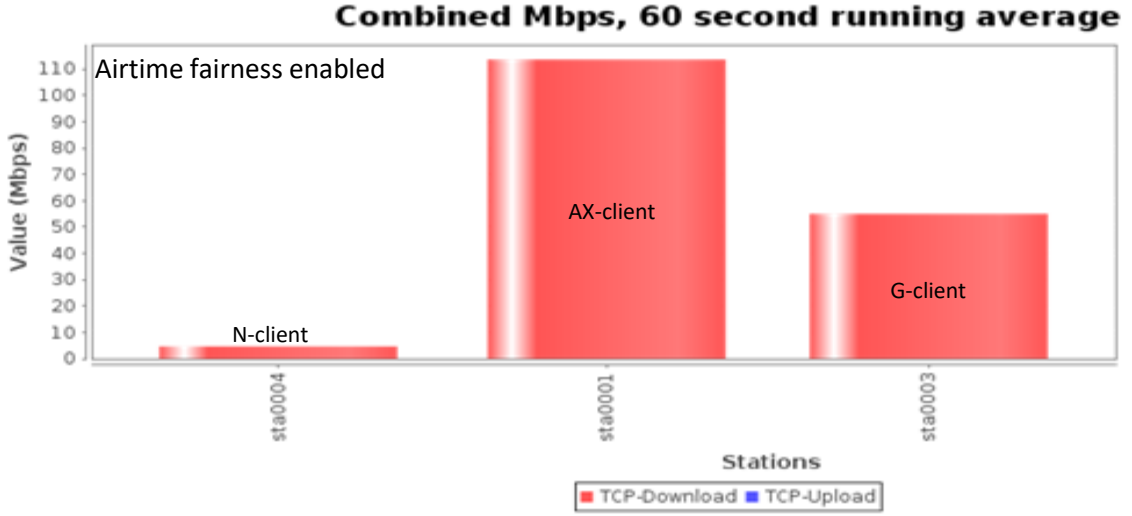




Vendor-B

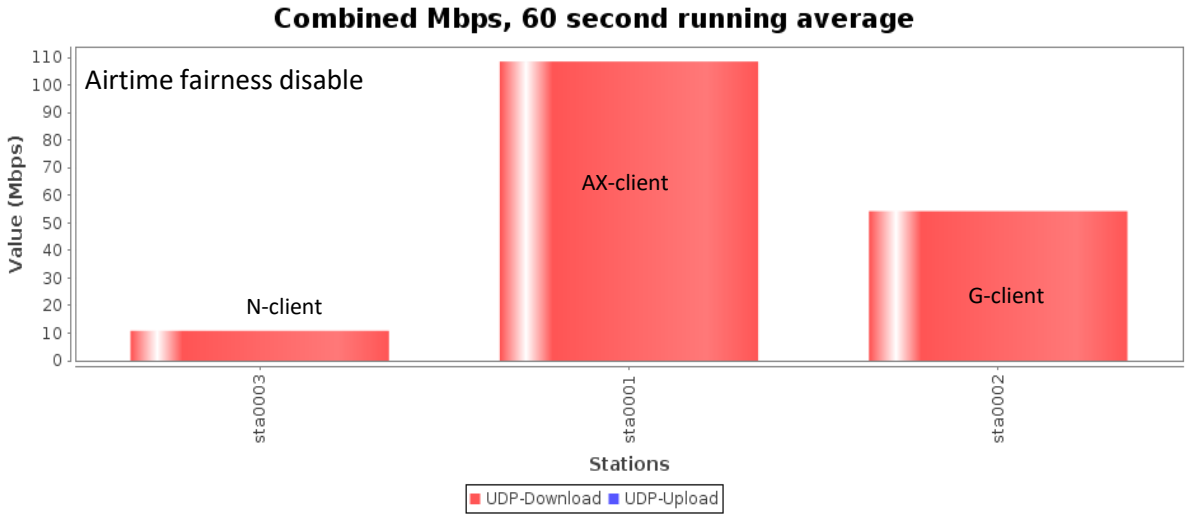


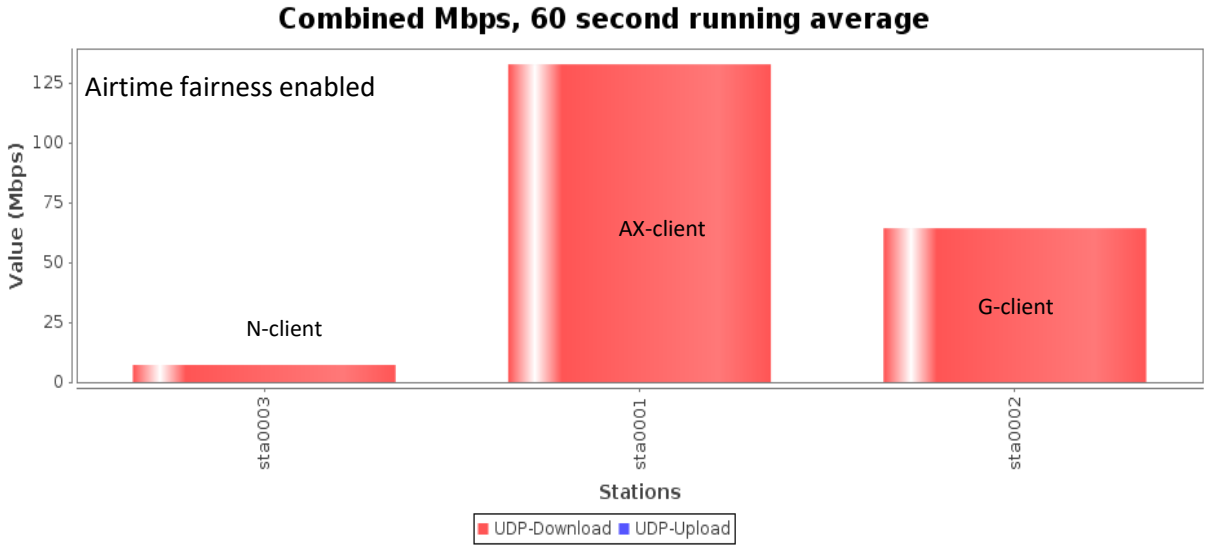
AC-client



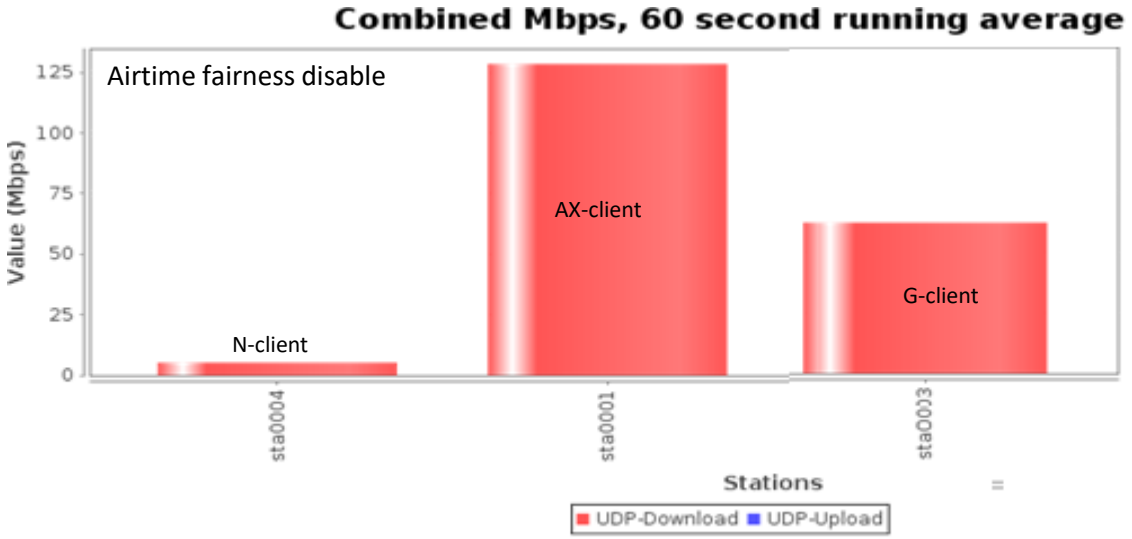
Airtime Fairness : UDP-DL[2.4GHz]

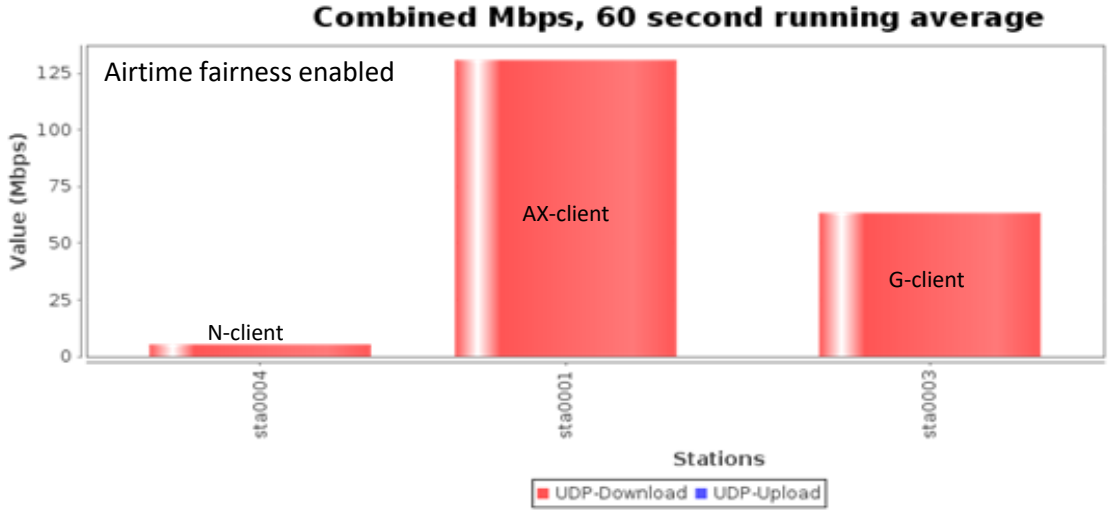
Vendor-A



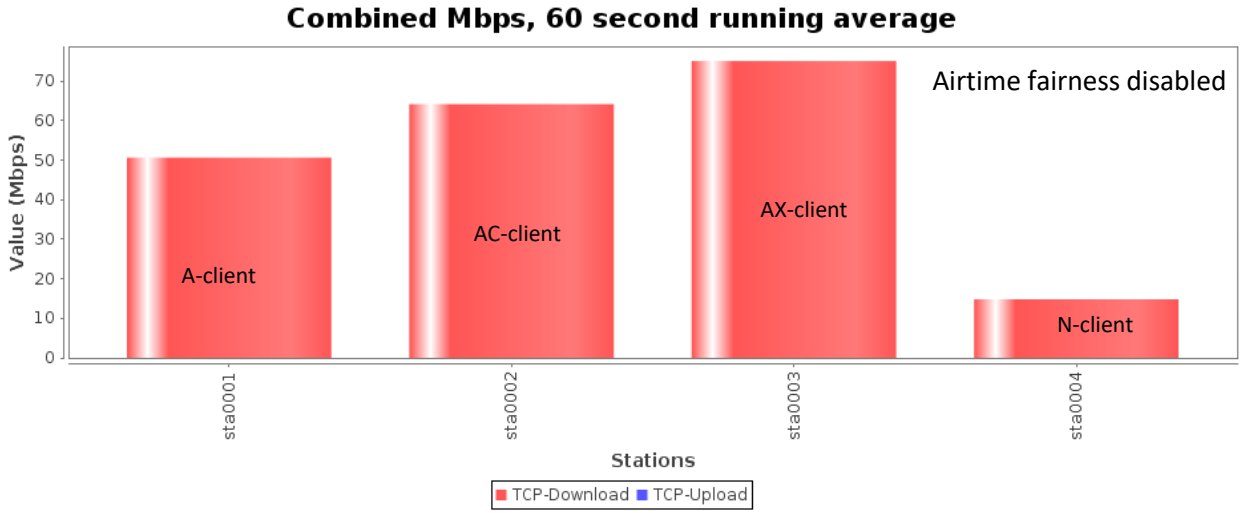


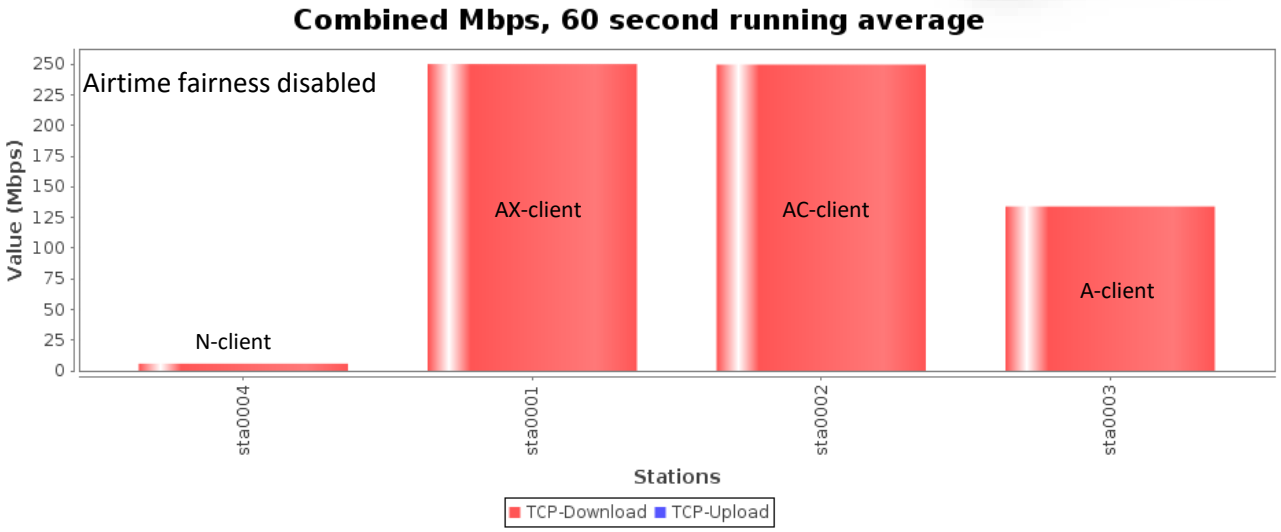
Vendor-B

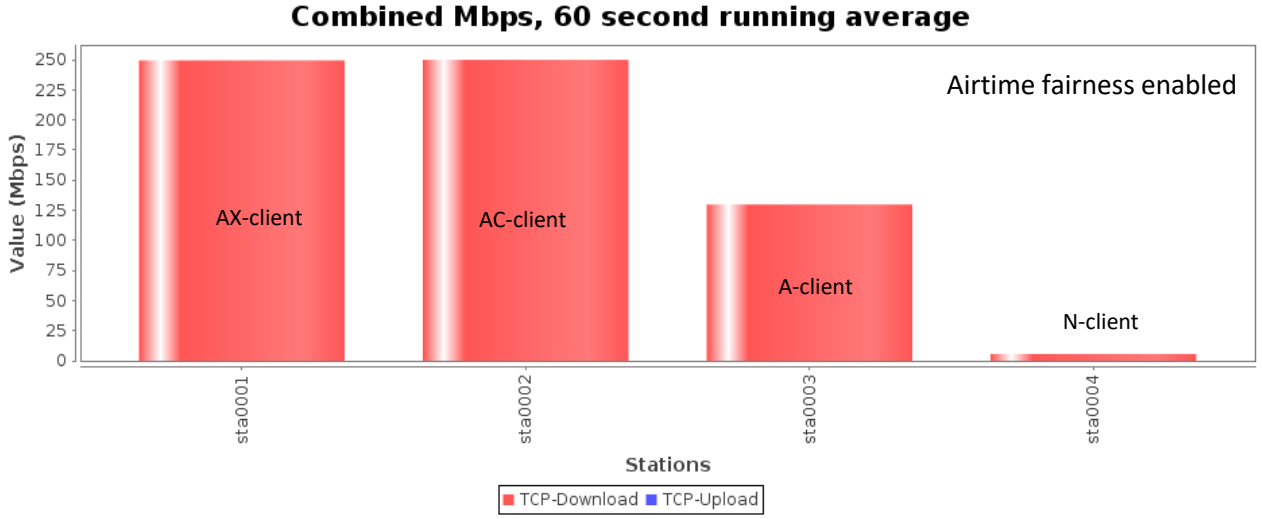


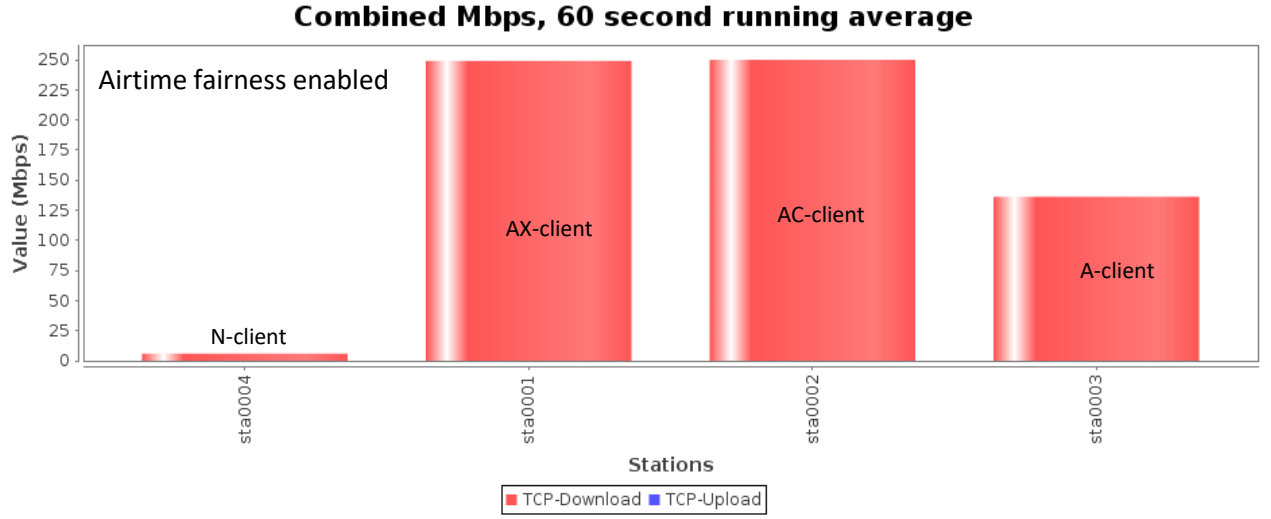


Airtime Fairness : TCP-DL[5GHz]

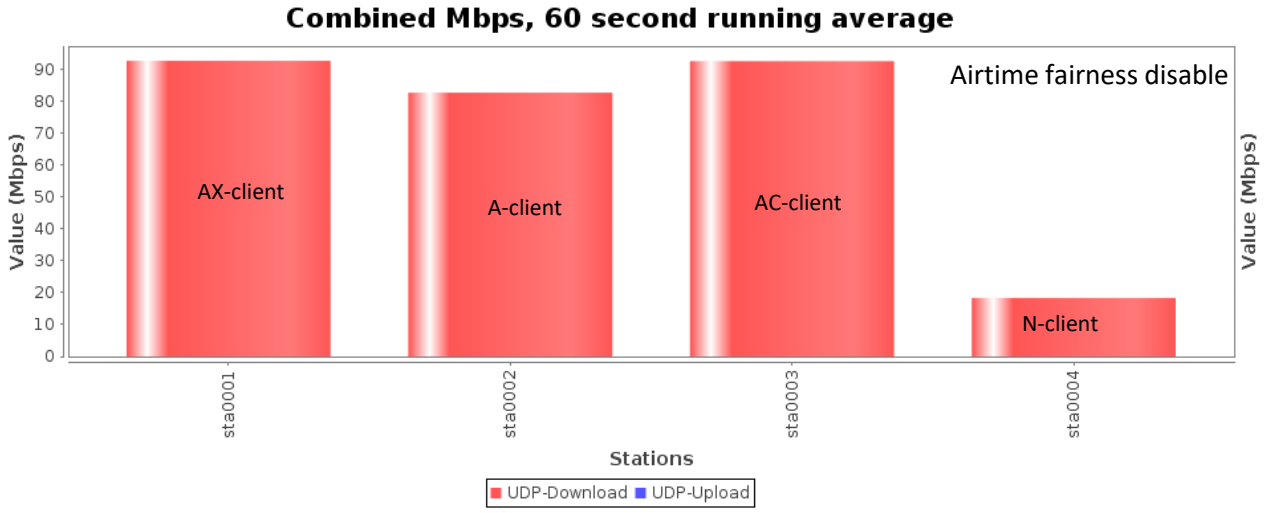


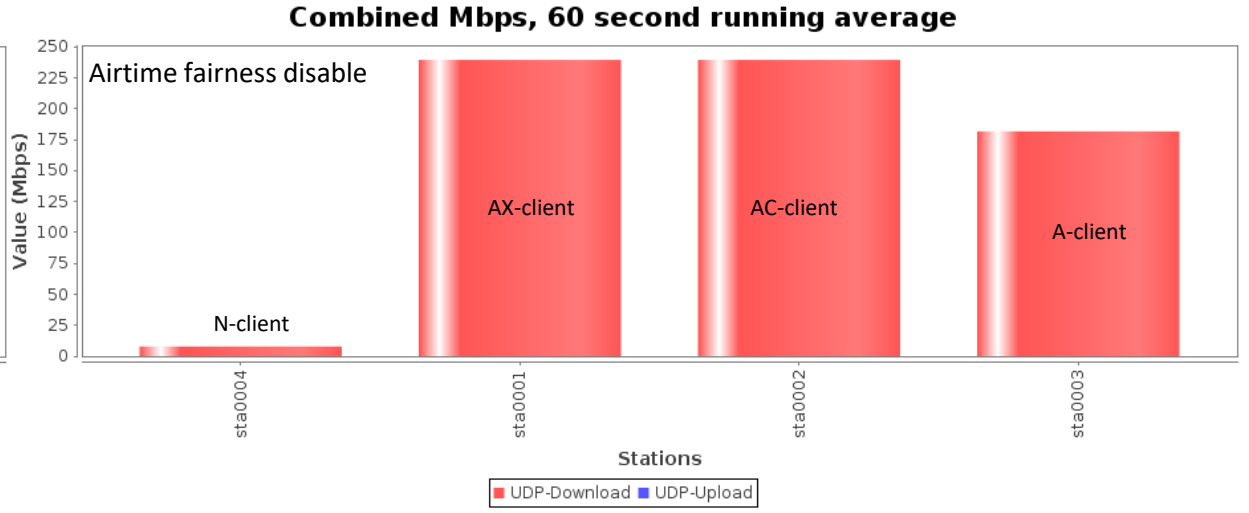


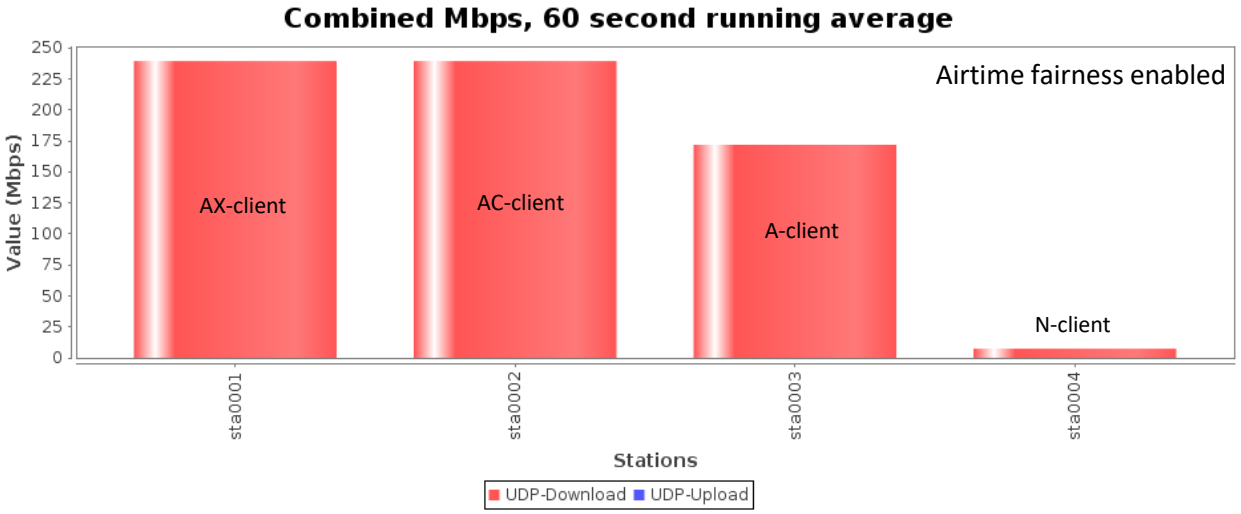


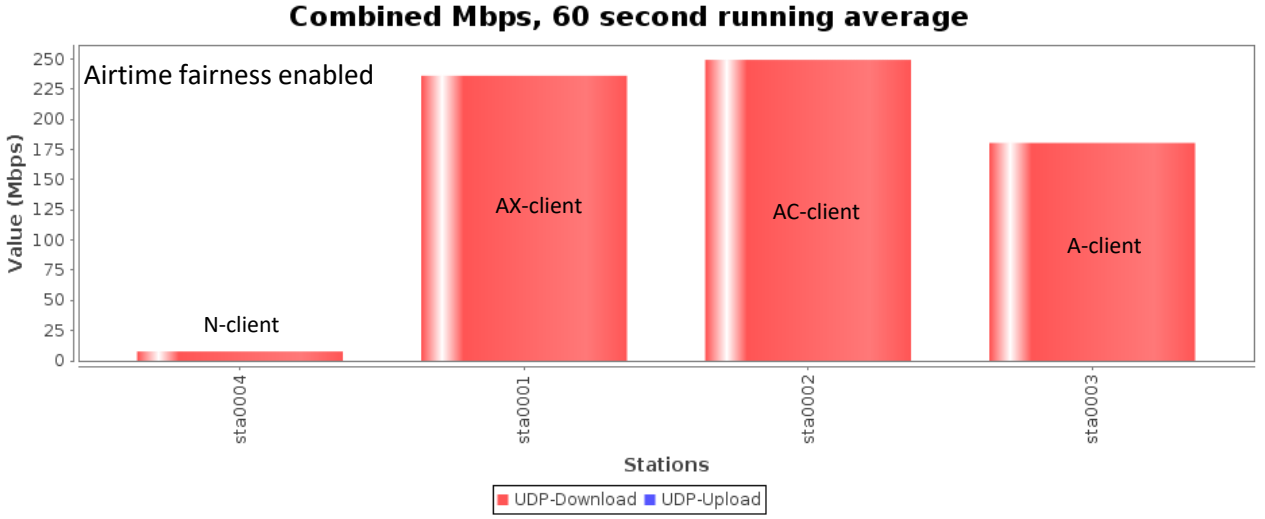


Airtime Fairness : UDP-DL[5GHz]

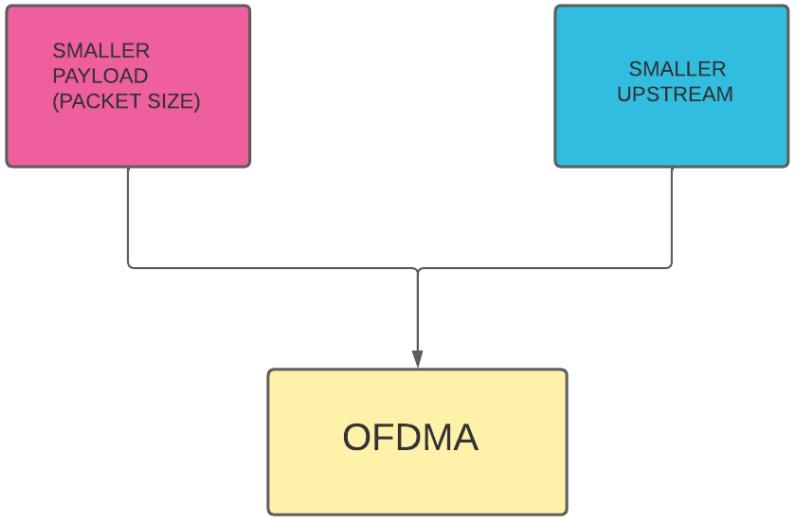








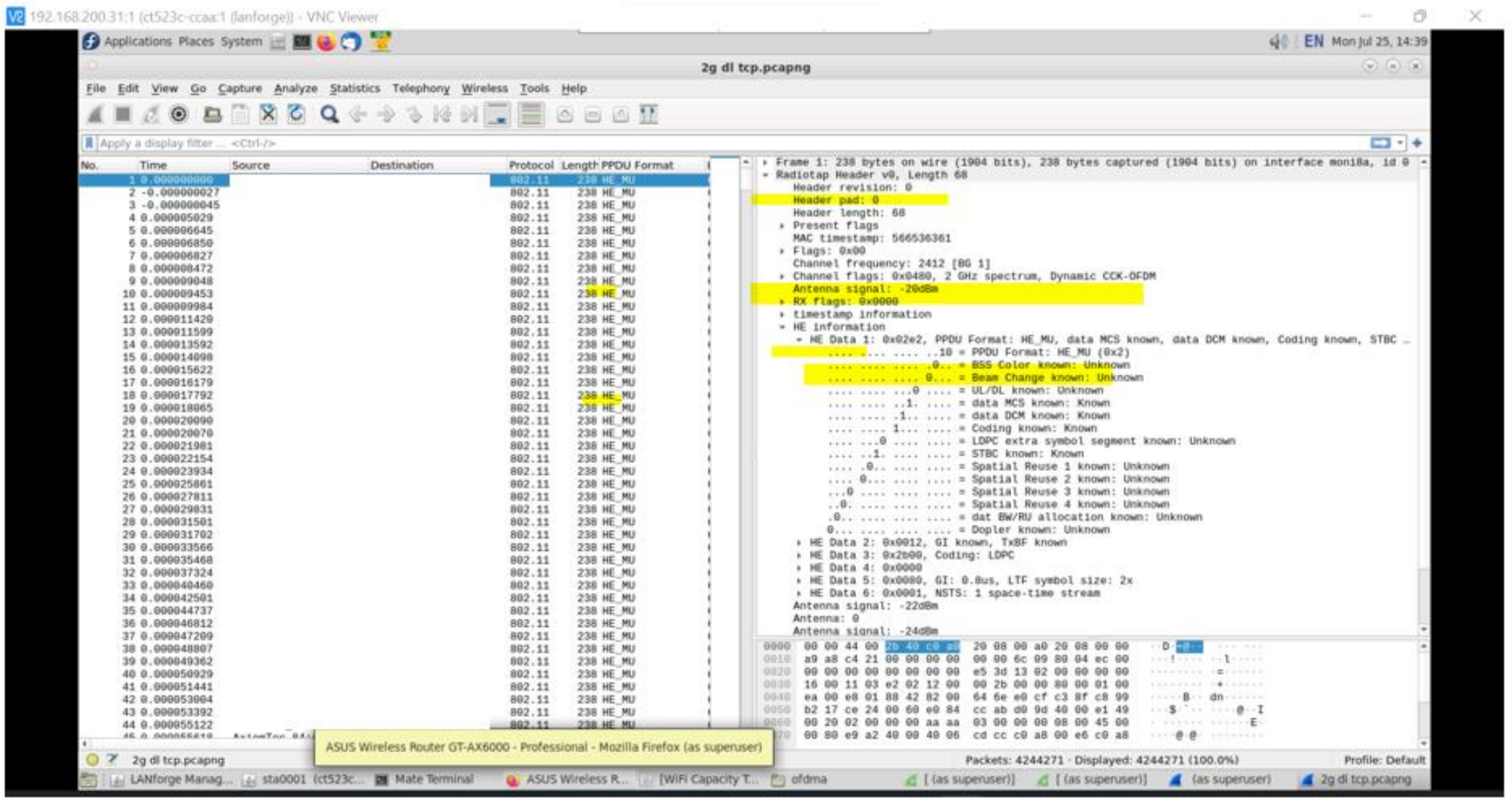
OFDMA testing:



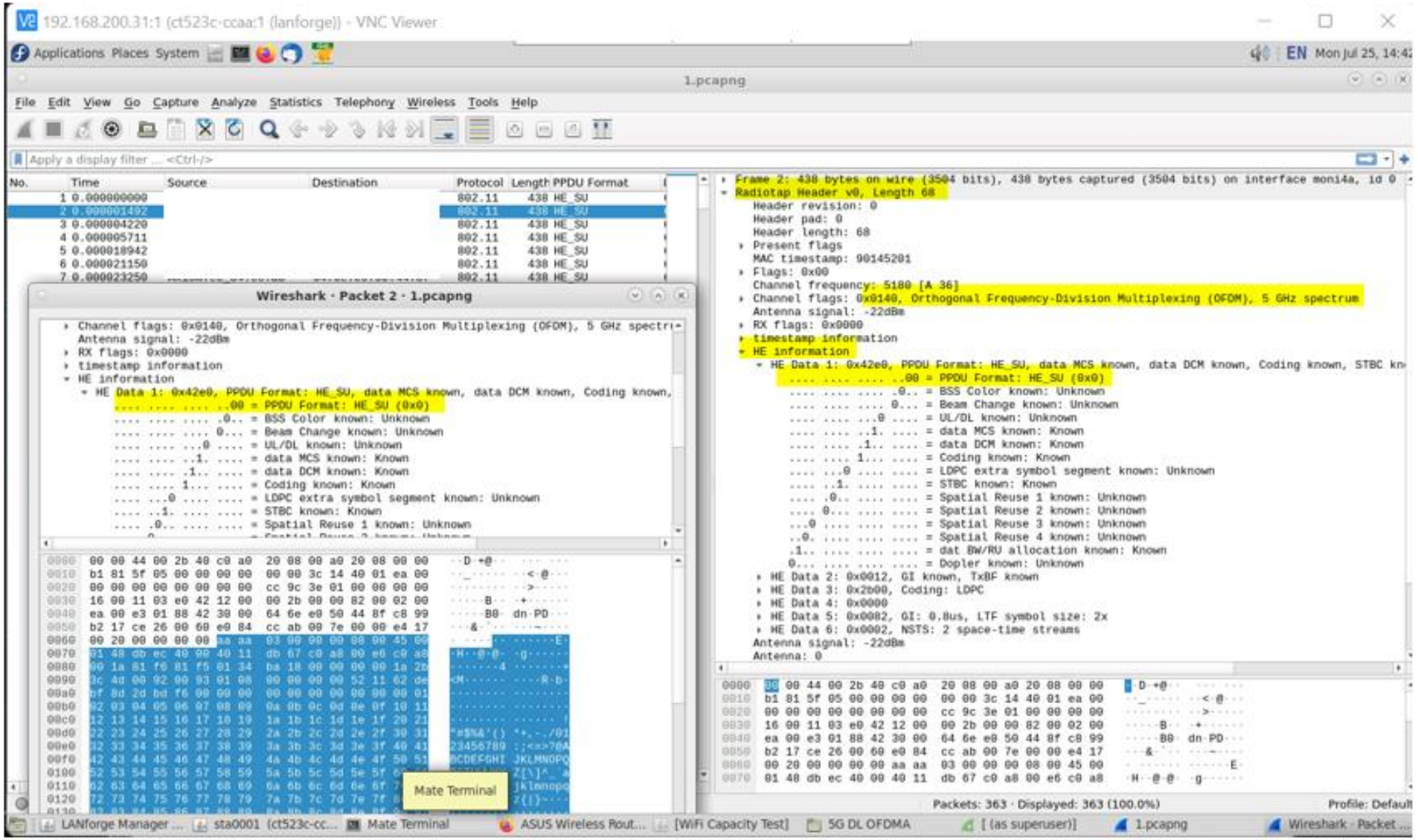
TEST PROCEDURE for OFDMA(Orthogonal Frequency Division Multiple Access):

- It works only for 802.11ax clients.
- We have fixed the packet size to 64 bytes, and the upstream traffic to 100mbps, such that we can create the perfect scenario and observe the wire-shark captures.
- The objective of the testcase is to check the captures and ensure we are getting HE_MU packets in data frames while we enable OFDMA, and HE_SU packets in data frames while we disable OFDMA, and observe the throughput variations.

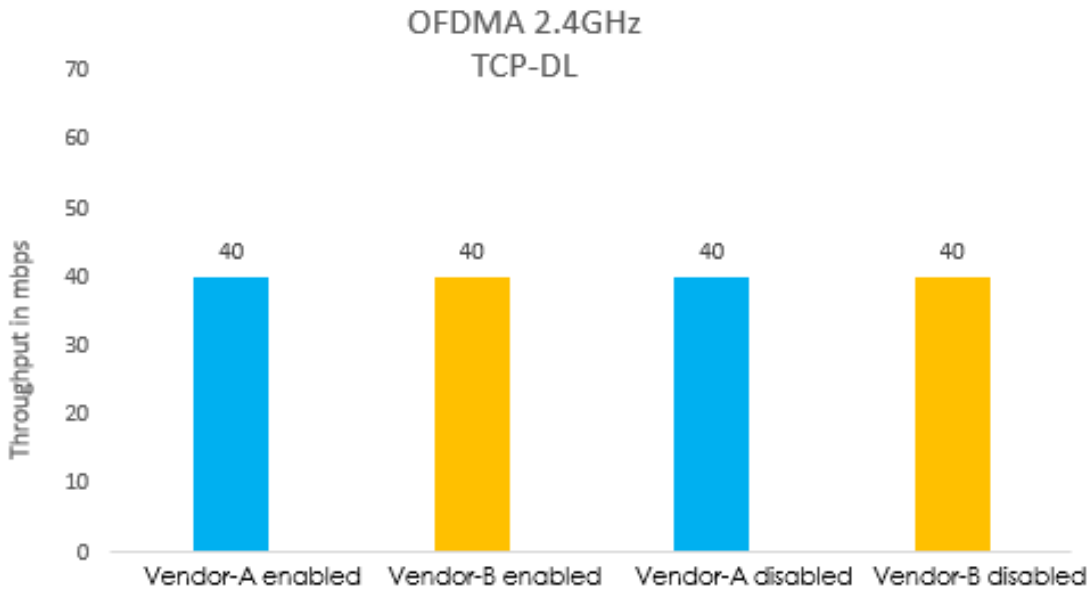
Wire-shark captures-OFDMA[Enabled].



Wire-shark captures-OFDMA[Disabled].



OFDMA: TCP-UL[2.4GHz]



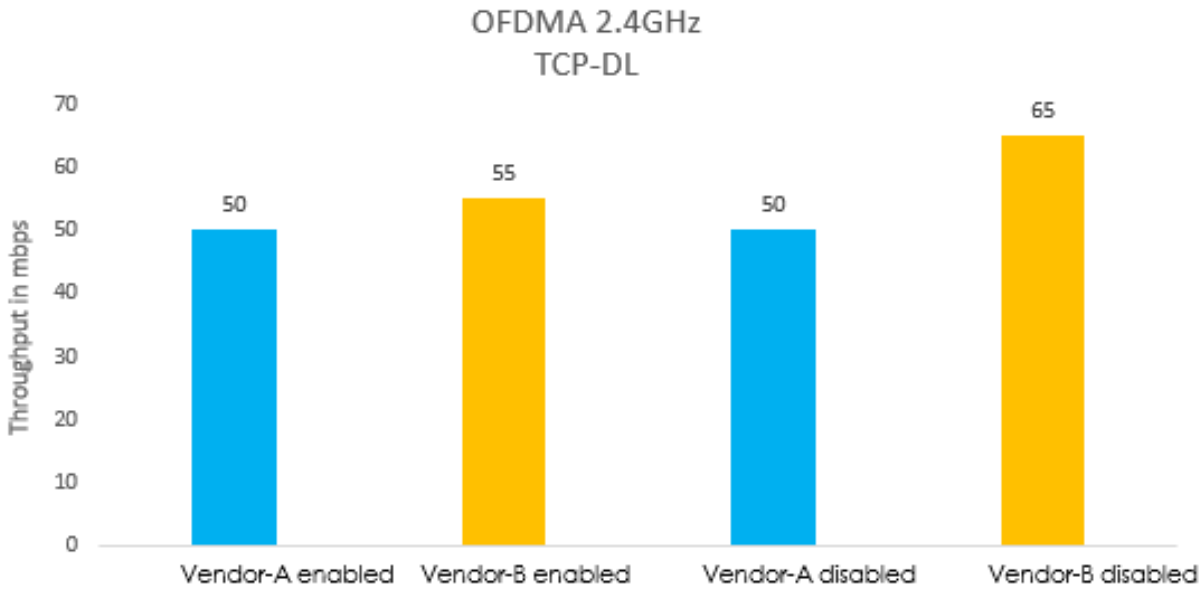
Test description:

- The OFDMA is by default enabled for SKY-CPE , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The Asus is also having no variation in the throughput at both the scenarios.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- Both are showing similar outputs.

OFDMA: TCP-DL[2.4GHz]



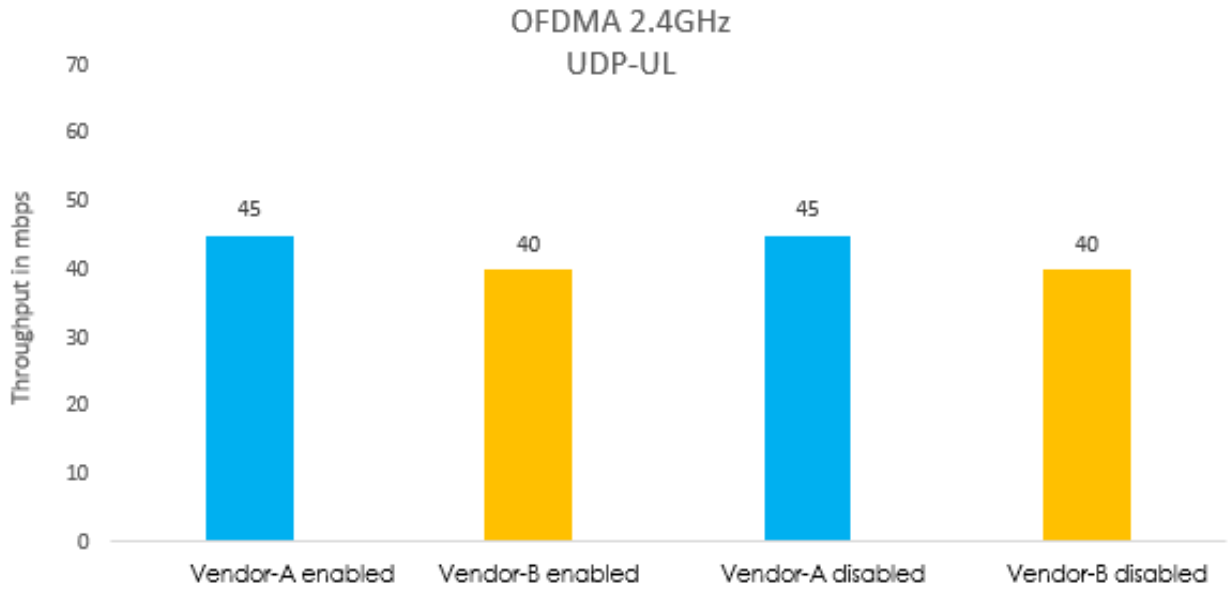
Test description:

- The OFDMA is by default enabled for Vendor-A , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The Vendor-B AP has OFDMA option and the throughput varies by enabling and disabling OFDMA

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- But Vendor-B is showing higher throughput.

OFDMA: UDP-UL[2.4GHz]



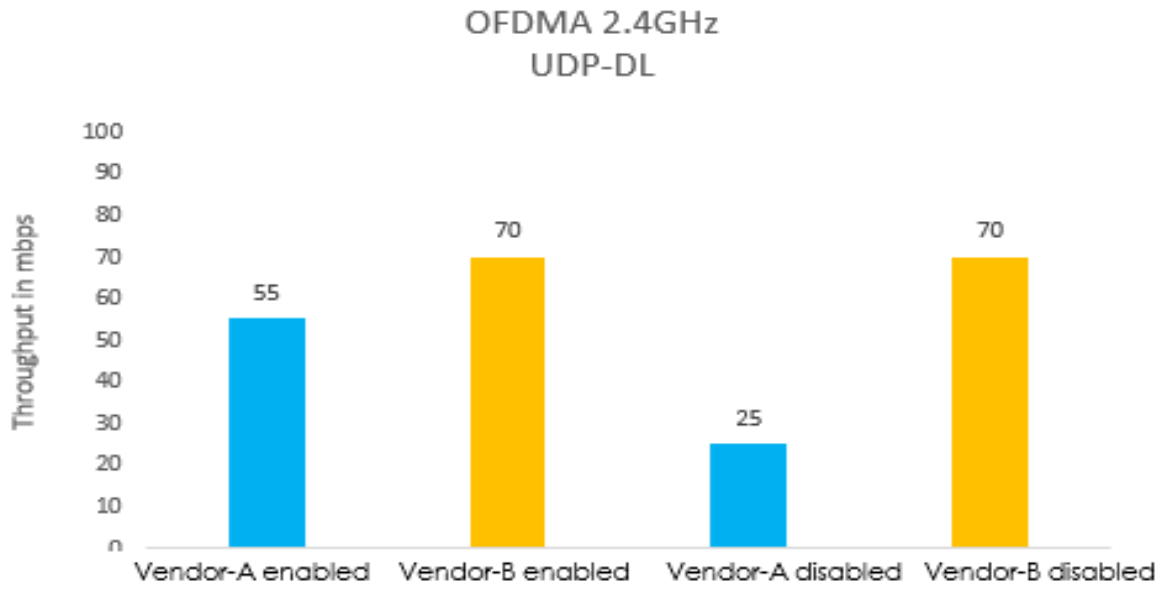
Test description:

- The OFDMA is by default enabled for Vendor-A, and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The Vendor-B has OFDMA option and the throughput varies by enabling and disabling OFDMA.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- Vendor-A is working better in this scenario.

OFDMA: UDP-DL[2.4GHz]



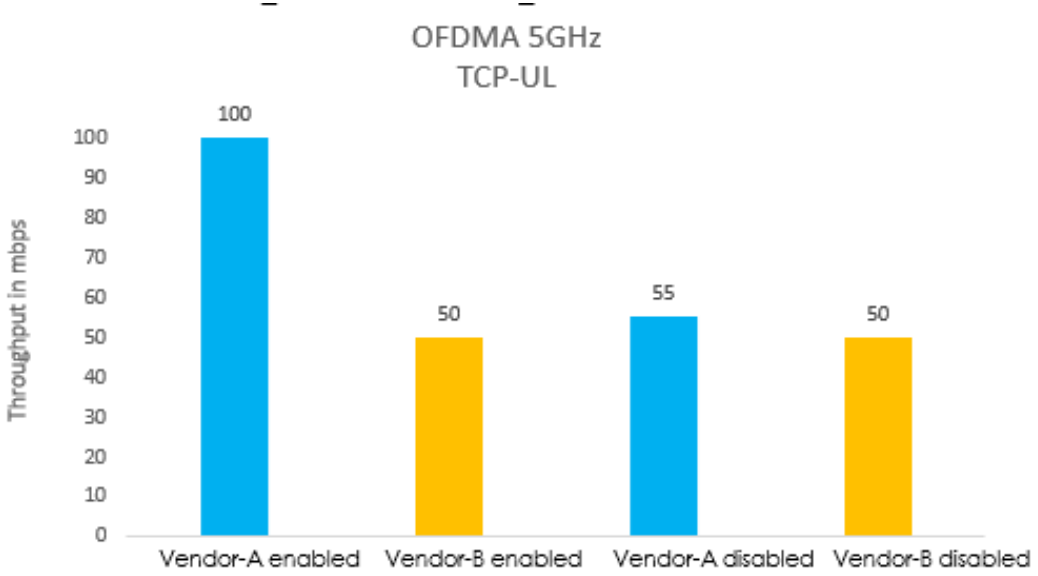
Test description:

- The OFDMA is by default enabled for Vendor-A , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The Vendor-B has OFDMA option and the throughput varies by enabling and disabling OFDMA.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- But Vendor-B is showing higher throughput.

OFDMA: TCP-UL[5GHz]



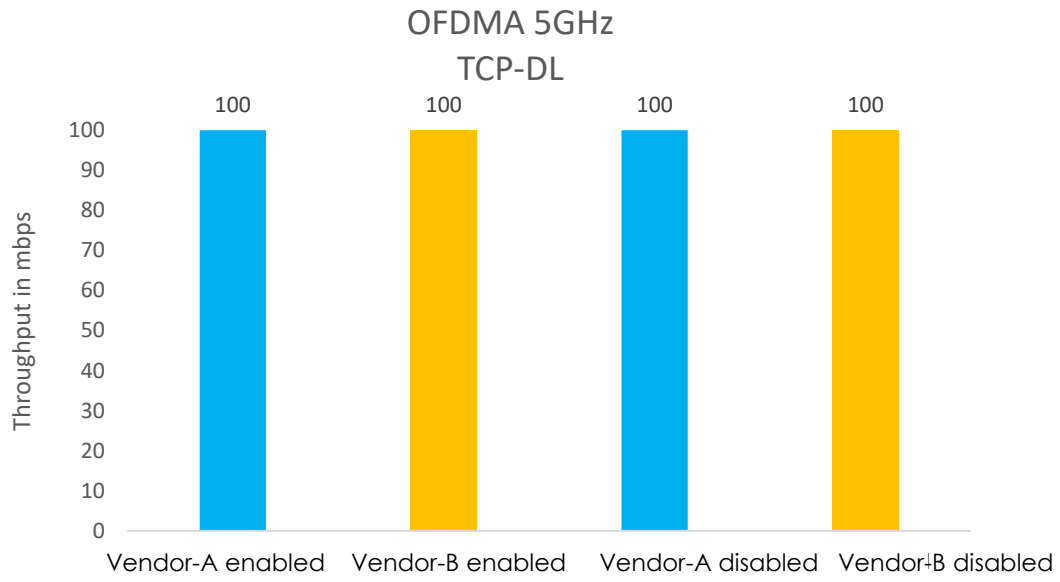
Test description:

- The OFDMA is by default enabled for Vendor-A , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The maximum throughput is around 70mbps as we have set the upstream traffic is 100mbps.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- Vendor-A is showing higher throughput.

OFDMA: TCP-DL[5GHz]



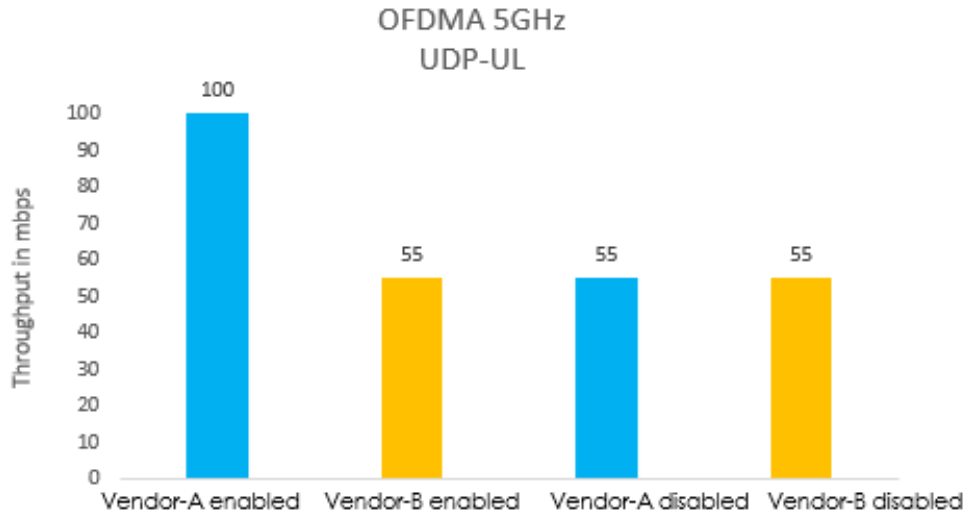
Test description:

- The OFDMA is by default enabled for Vendor-A , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The maximum throughput is around 70mbps as we have set the upstream traffic is 100mbps.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- Both are showing similar higher throughput.

OFDMA: UDP-UL[5GHz]



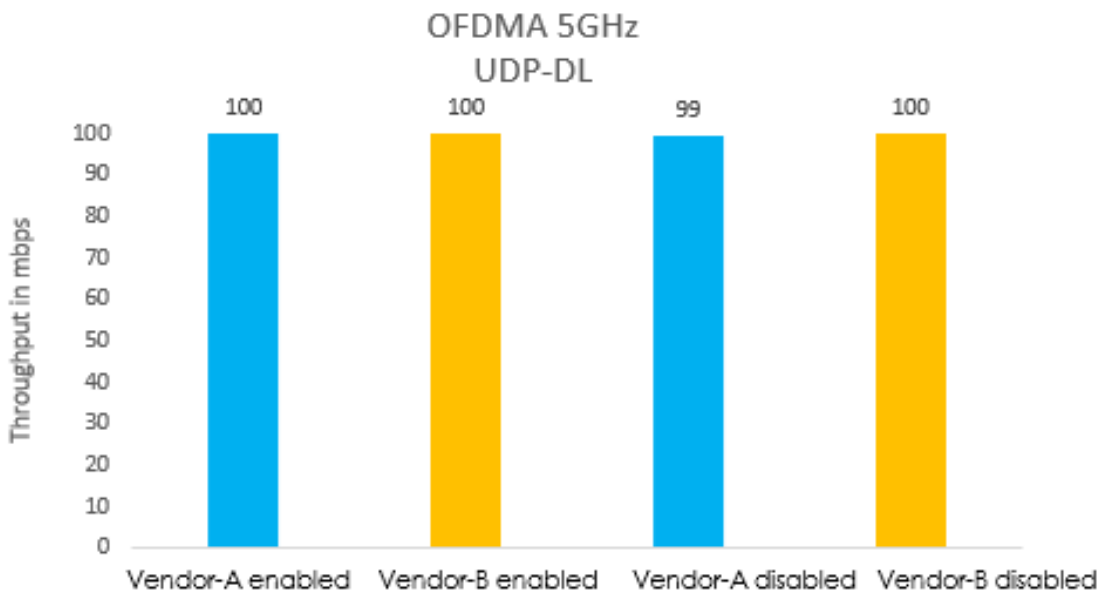
Test description:

- The OFDMA is by default enabled for Vendor-A , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The maximum throughput is around 70mbps as we have set the upstream traffic is 100mbps.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- Vendor-A is showing higher throughput.

OFDMA: UDP-DL[5GHz]



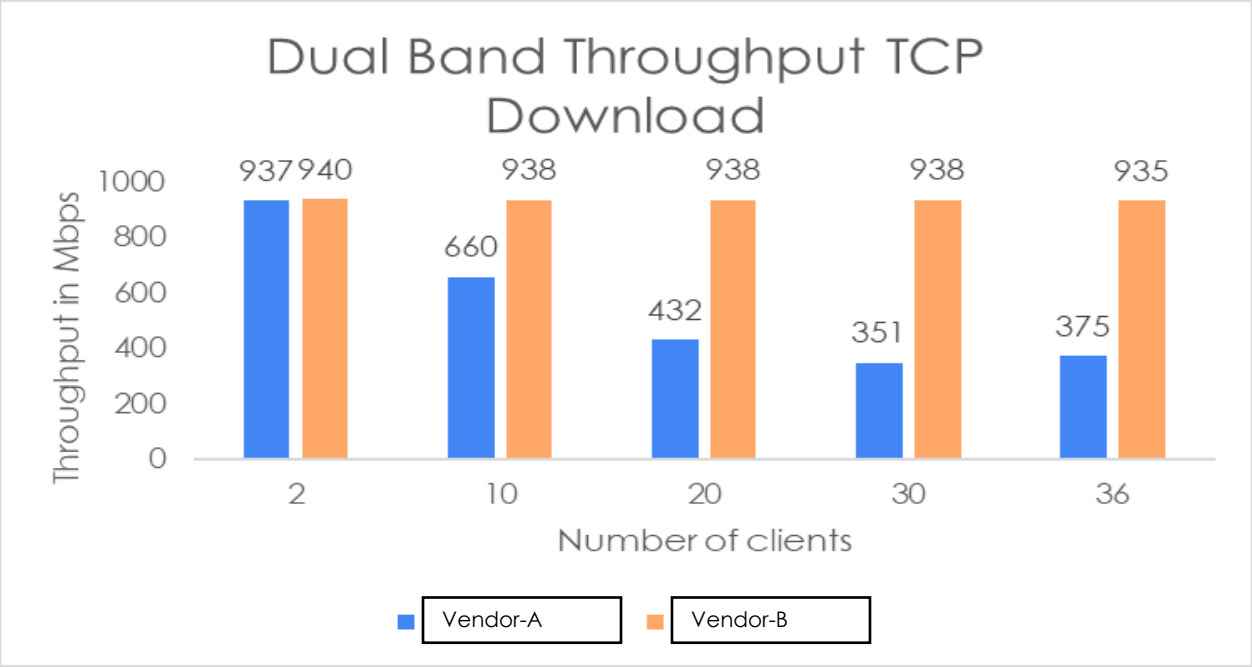
Test description:

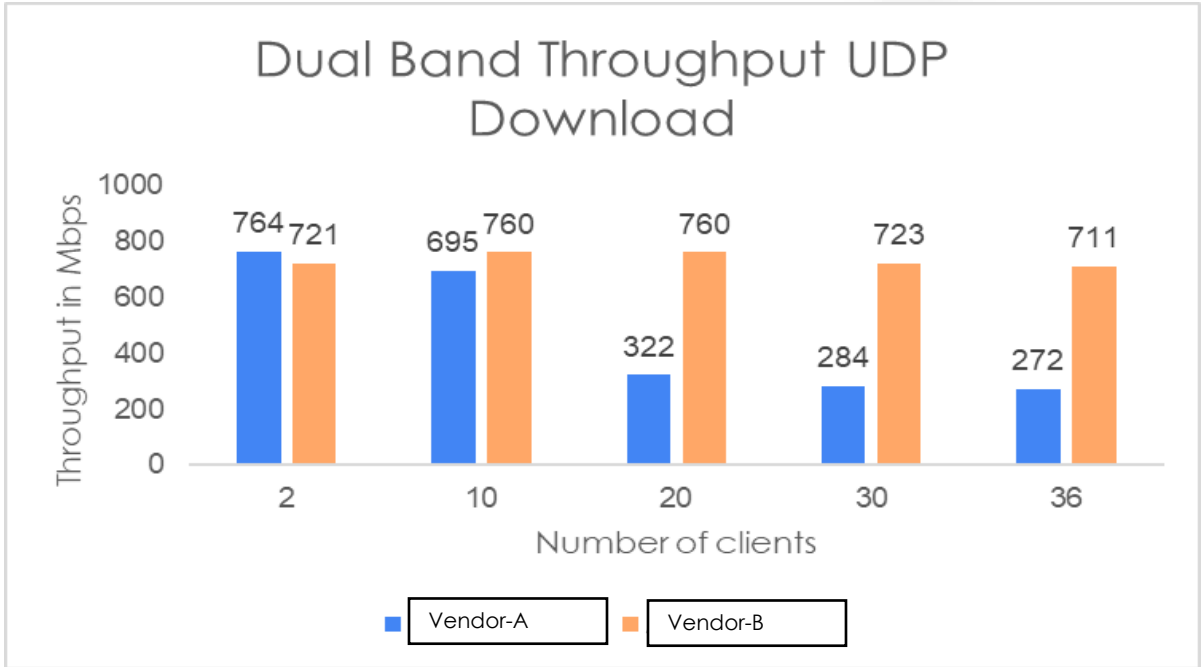
- The OFDMA is by default enabled for Vendor-A , and we use the CLI commands to disable the OFDMA.
- The throughput has no variation in both the cases.
- The maximum throughput is around 70mbps as we have set the upstream traffic is 100mbps.

Result observations:

- Both the CPE's are showing HE_MU packets when OFDMA is enabled .
- Both are showing similar throughput.

Dual Band Performance Test





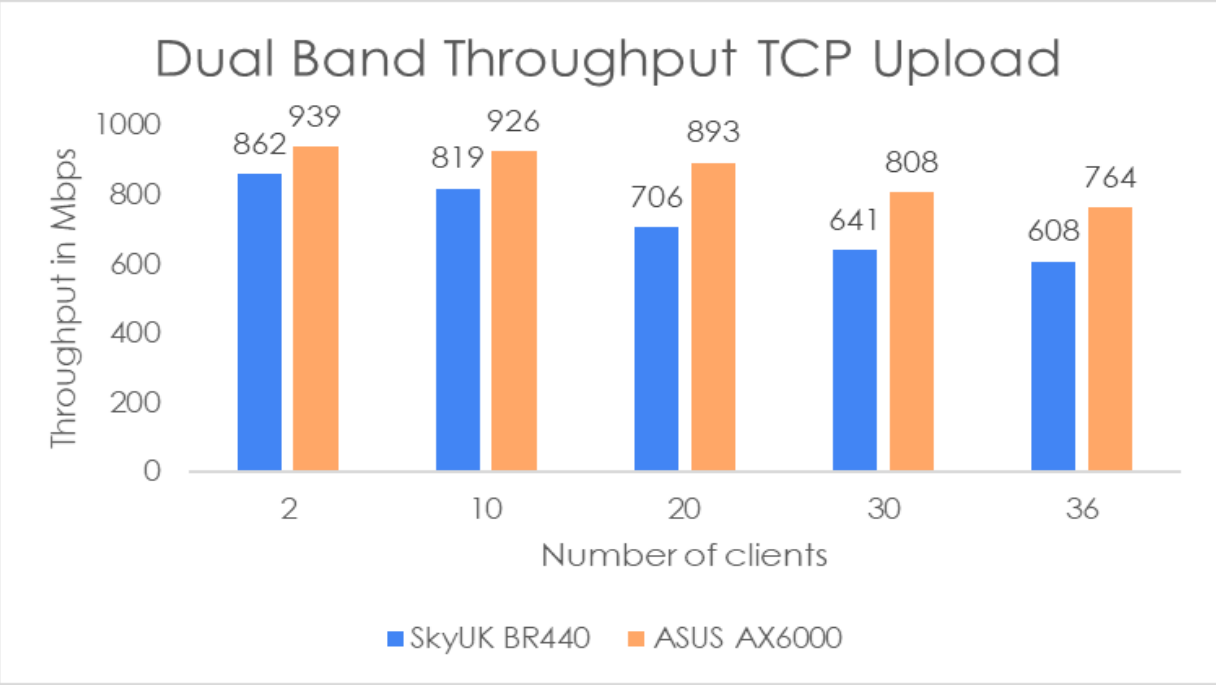
Test Description:

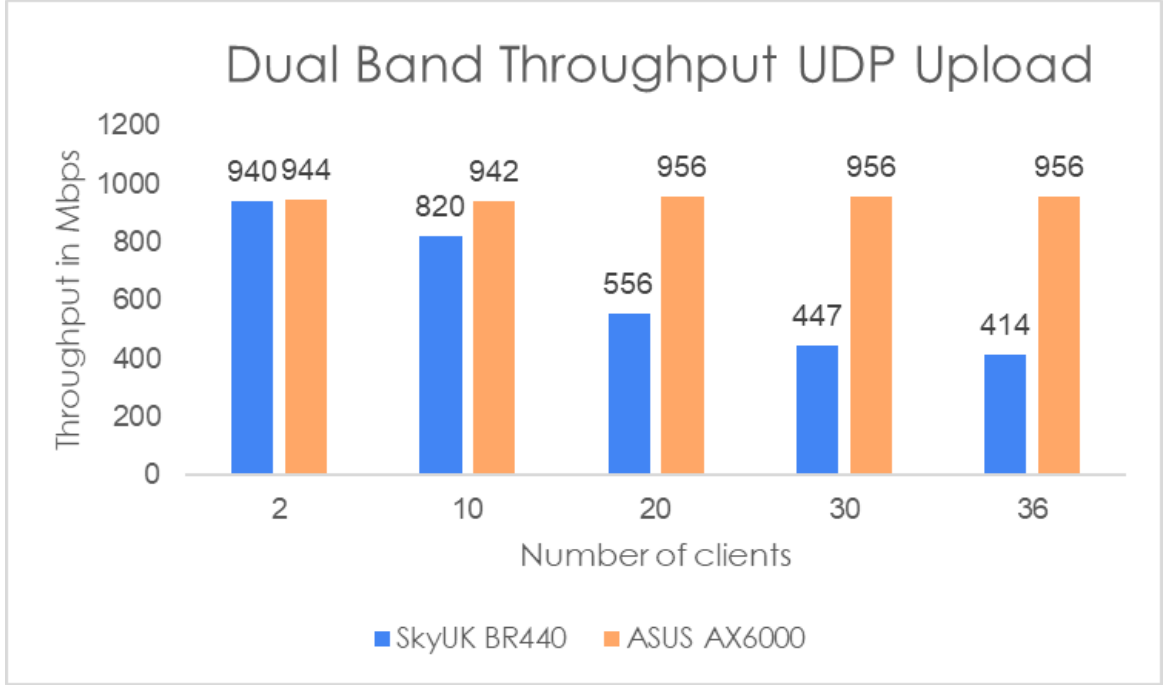
- All 2.4 GHz clients are connected in 3*3 with ax mode. All the 5 GHz clients are connected in 4*4 with ax mode.
- Traffic is running parallelly on both bands.

Results Observations:

- With Vendor-B is giving better throughput.

Dual Band Performance Test





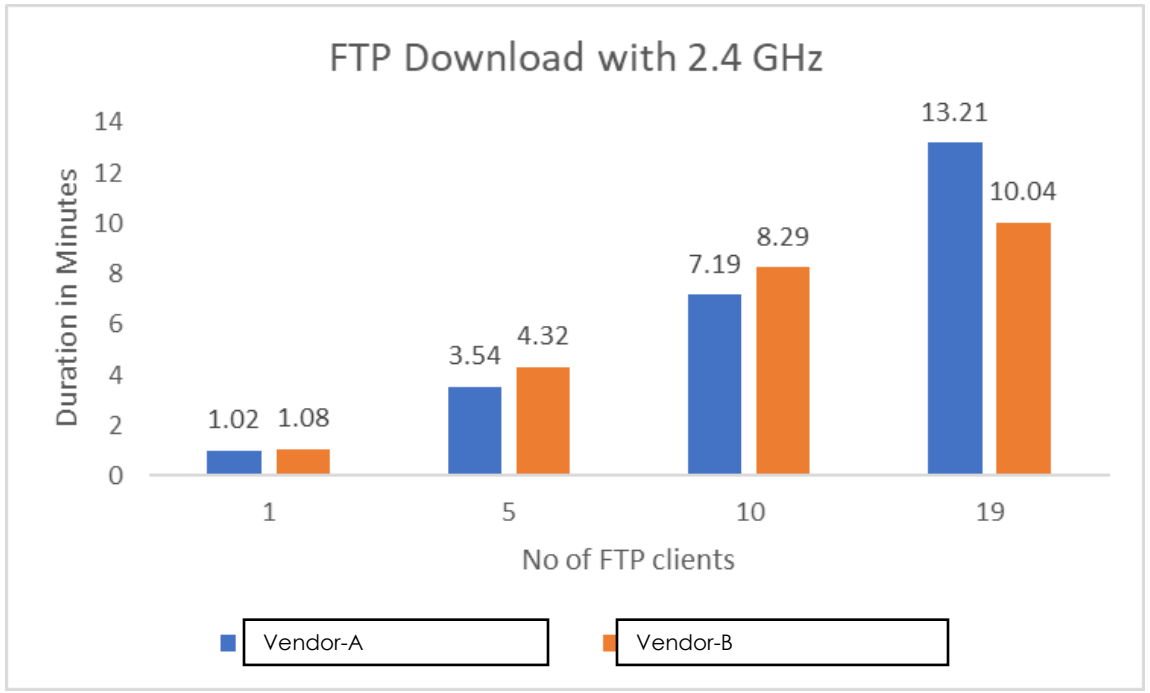
Test Description:

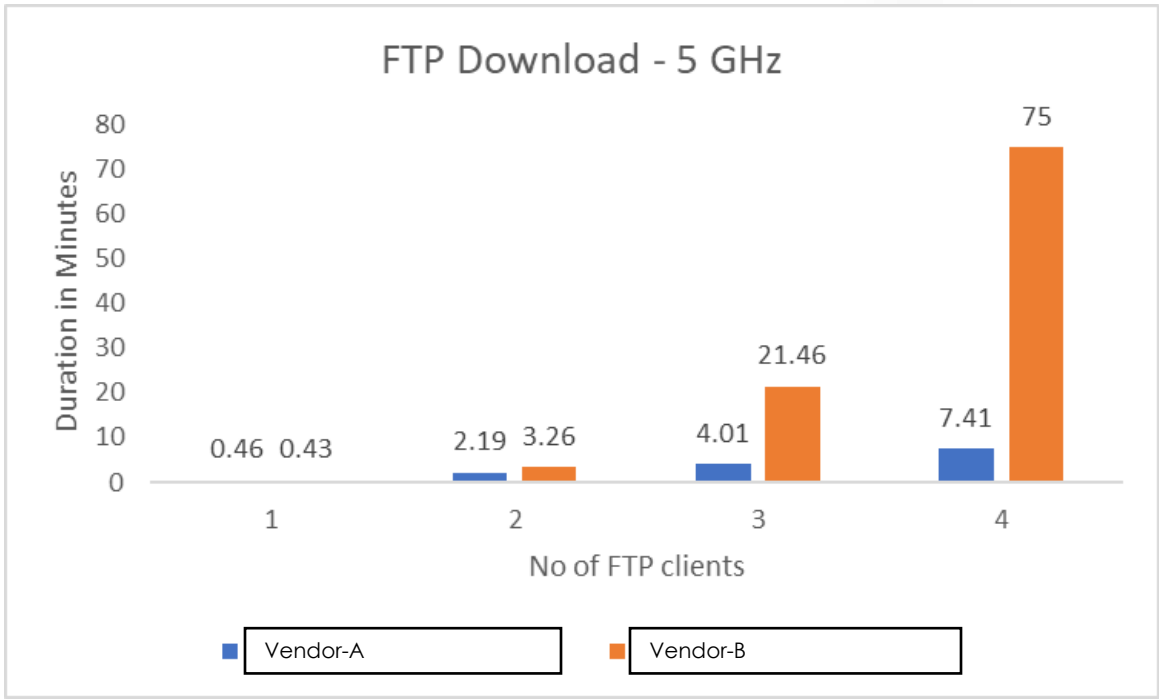
- All 2.4 GHz clients are connected in 3*3 with ax mode. All the 5 GHz clients are connected in 4*4 with ax mode.
- Traffic is running parallelly on both bands.

Results Observations:

- With Vendor-B is giving better throughput.

File Transfer Protocol Testing





Test Description:

- All 2.4 GHz clients are connected in 3*3 with ax mode. All the 5 GHz clients are connected in 4*4 with ax mode.
- FTP file (1GB) is transferred from server to wireless client

Results Observations:

- With Vendor-B is performing better with respect of transferring files in 5 GHz mode

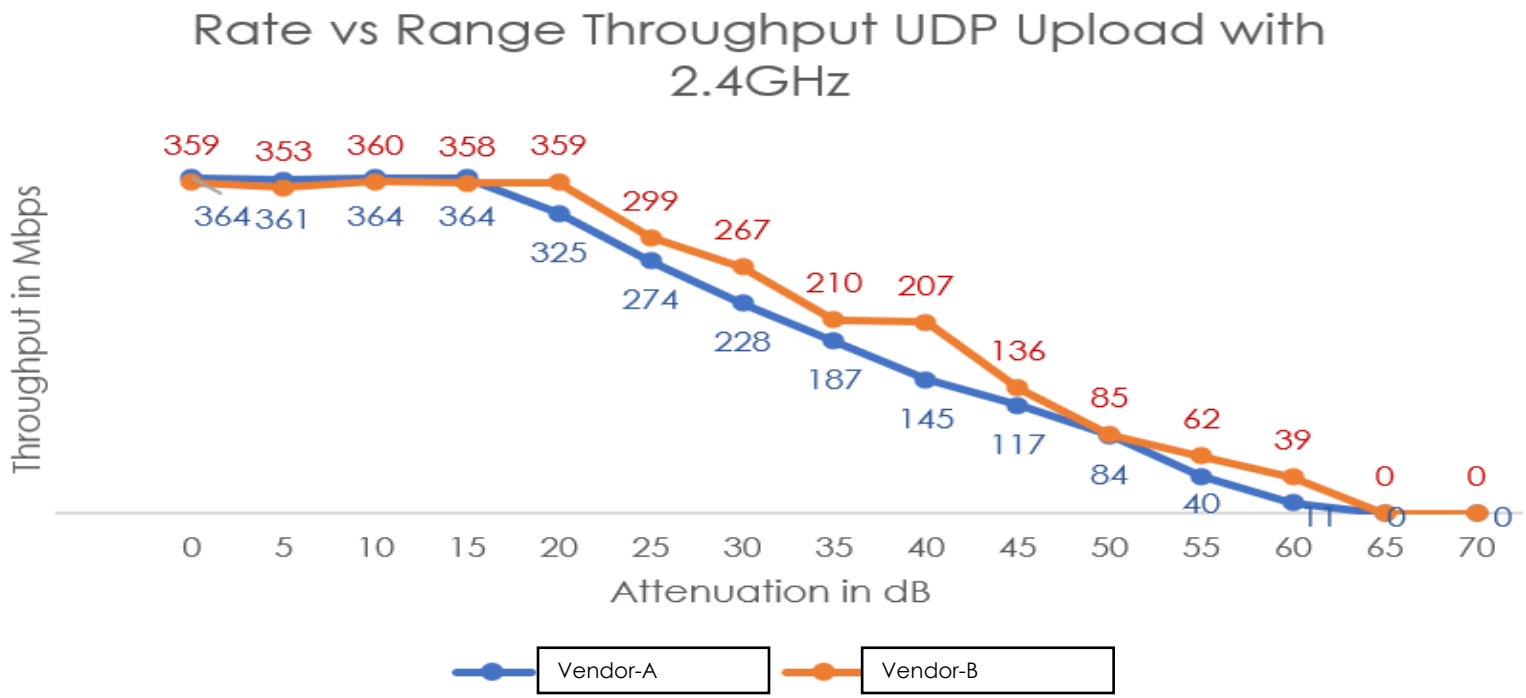
Dynamic Frequency Selection

DFS Channels	52	56	60	64	100	104	108	112	116	120	124	128	132	136	140
Radar Detected	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Channel Shifted	48	40	157	157	157	140	140	144	56	48	36	36	144	144	44

Test Description:

- Clients connected in 5 GHz with 20 MHz band with radar type used here is FCC0

Rate Vs Range – 2.4GHz UDP Upload



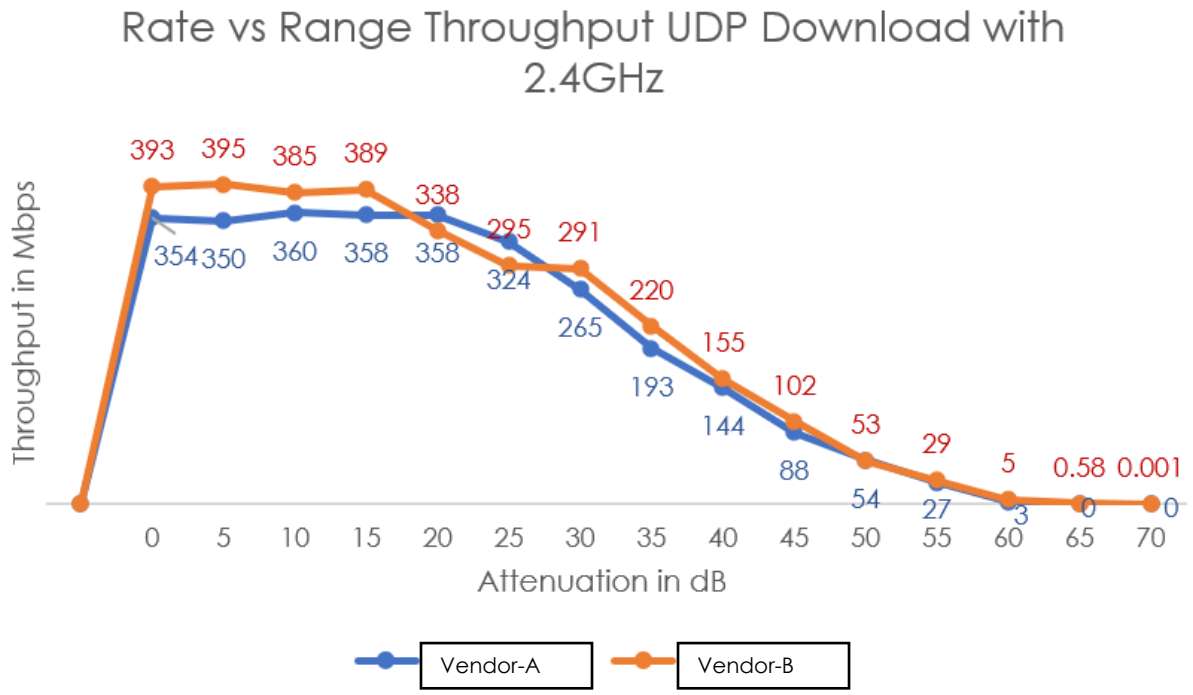
Test Description:

- In this scenario, Station associated and start running traffic when attenuation is 0 dB and gradually increase attenuation 5 dB steps.
- Intended load is set to 1 Gbps with UDP upload traffic with client3NSS, 20Mhz BW in AX mode.
- Traffic from Client to AP and throughput test run in 2.4GHz on channel 1.

Results Observations:

- Vendor-B has more RSSI at zero attenuation compared to Vendor-A.
- Vendor-B is getting more throughput with the increase in attenuation than Vendor-A.
- Vendor-A, Vendor-B have disconnected after 60dB.

Rate Vs Range – 2.4GHz UDP Download



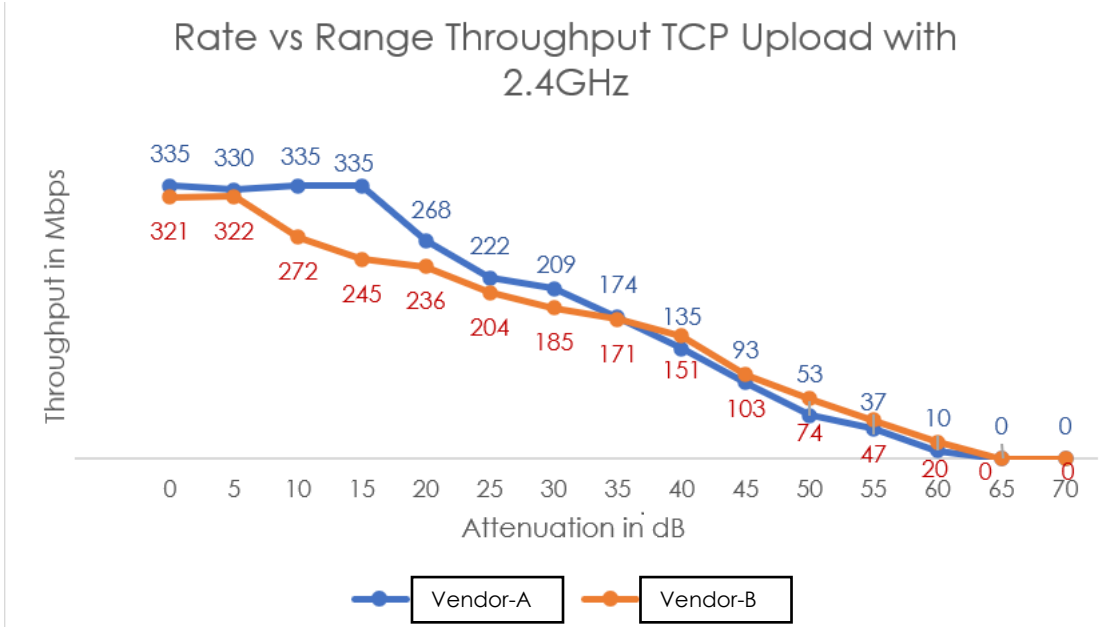
Test Description:

- In this scenario, Station associated and start running traffic when attenuation is 0 dB and gradually increase attenuation 5 dB steps.
- Intended load is set to 1 Gbps with UDP download traffic with client3NSS, 20Mhz BW in AX mode.
- Traffic from AP to client and throughput test run in 2.4GHz on channel 1.

Results Observations:

- Vendor-B has good RSSI at zero attenuation compared to Vendor-A
  Vendor-B is getting more throughput with zero attenuation than Vendor-A.
- Vendor-A, Vendor-B have disconnected after 60dB.

Rate Vs Range – 2.4GHz TCP Upload



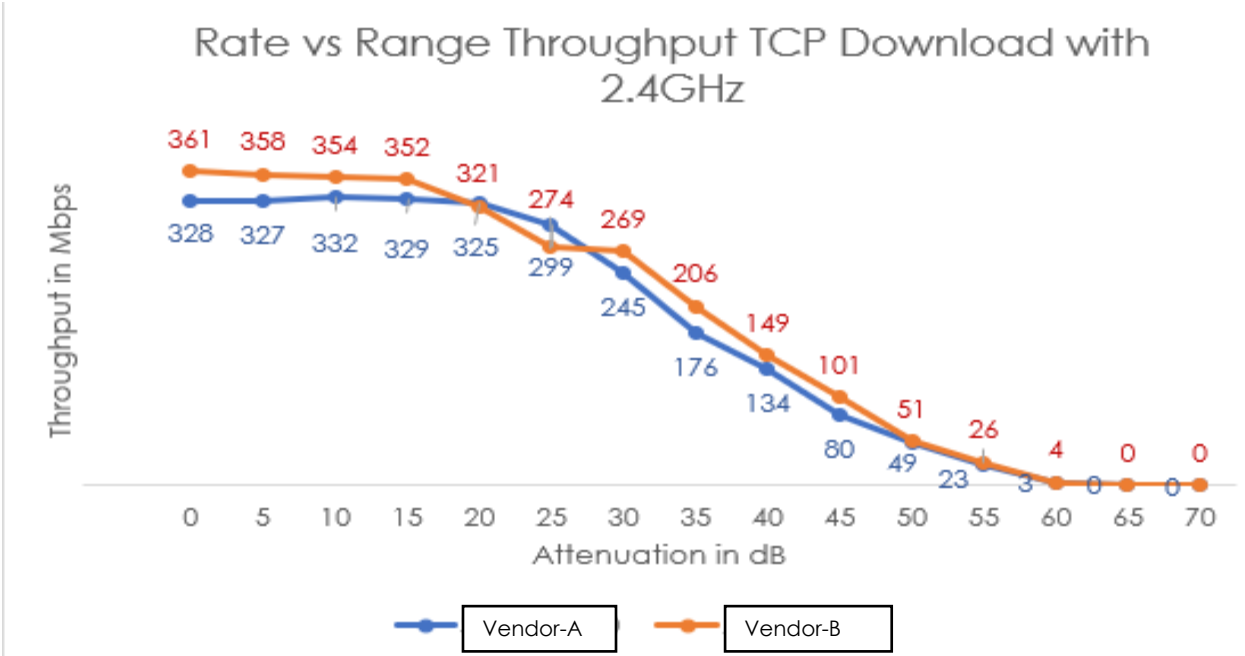
Test Description:

- In this scenario, Station associated and start running traffic when attenuation is 0 dB and gradually increase attenuation 5 dB steps.
- Intended load is set to 1 Gbps with TCP upload traffic with client3NSS, 20Mhz BW in AX mode.
- Traffic from client to AP and throughput test run in 2.4GHz on channel 1.

Results Observations:

- Vendor-B has more RSSI at zero attenuation compared to Vendor-A.
- Vendor-A is getting more throughput with zero attenuation than Vendor-B.
- Vendor-A, Vendor-B have disconnected after 60dB.

Rate Vs Range – 2.4GHz TCP Download



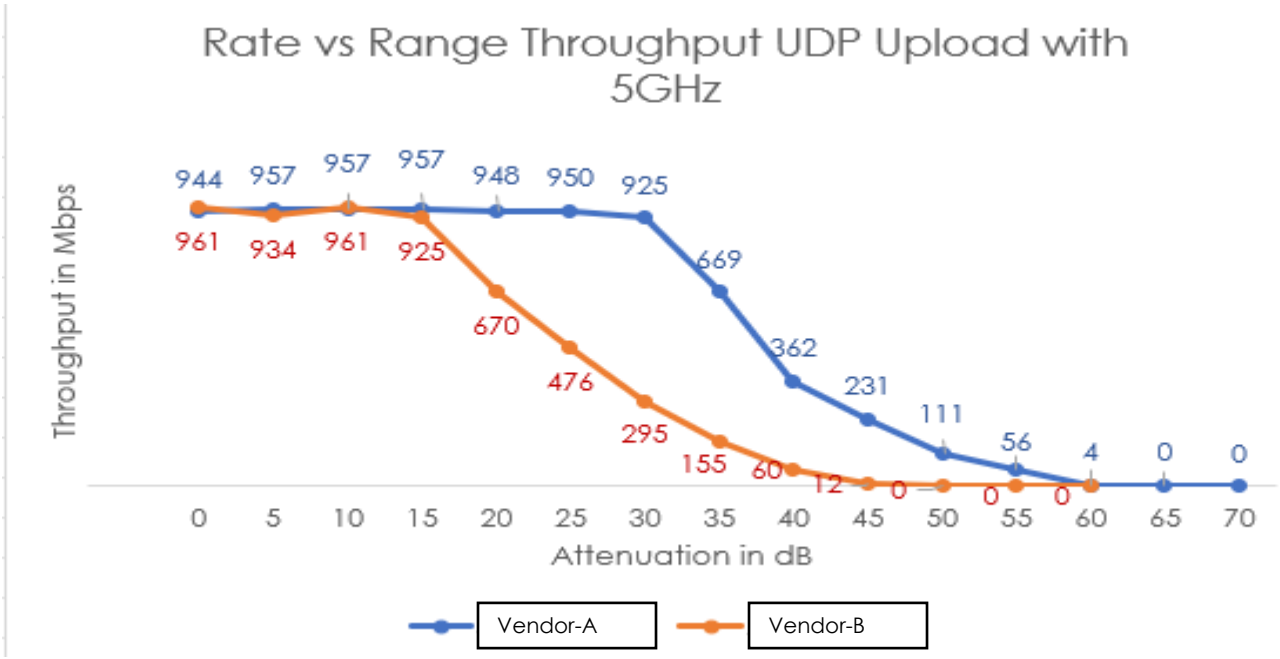
Test Description:

- In this scenario, Station associated and start running traffic when attenuation is 0 dB and gradually increase attenuation 5 dB steps.
- Intended load is set to 1 Gbps with TCP download traffic with client3NSS, 20Mhz BW in AX mode.
- Traffic from AP to client and throughput test run in 2.4GHz on channel 1.

Results Observations:

- Vendor-B is getting more throughput with increase in attenuation than Vendor-A.
- Vendor-A, Vendor-B have disconnected after 60dB.

Rate Vs Range – 5GHz UDP Upload



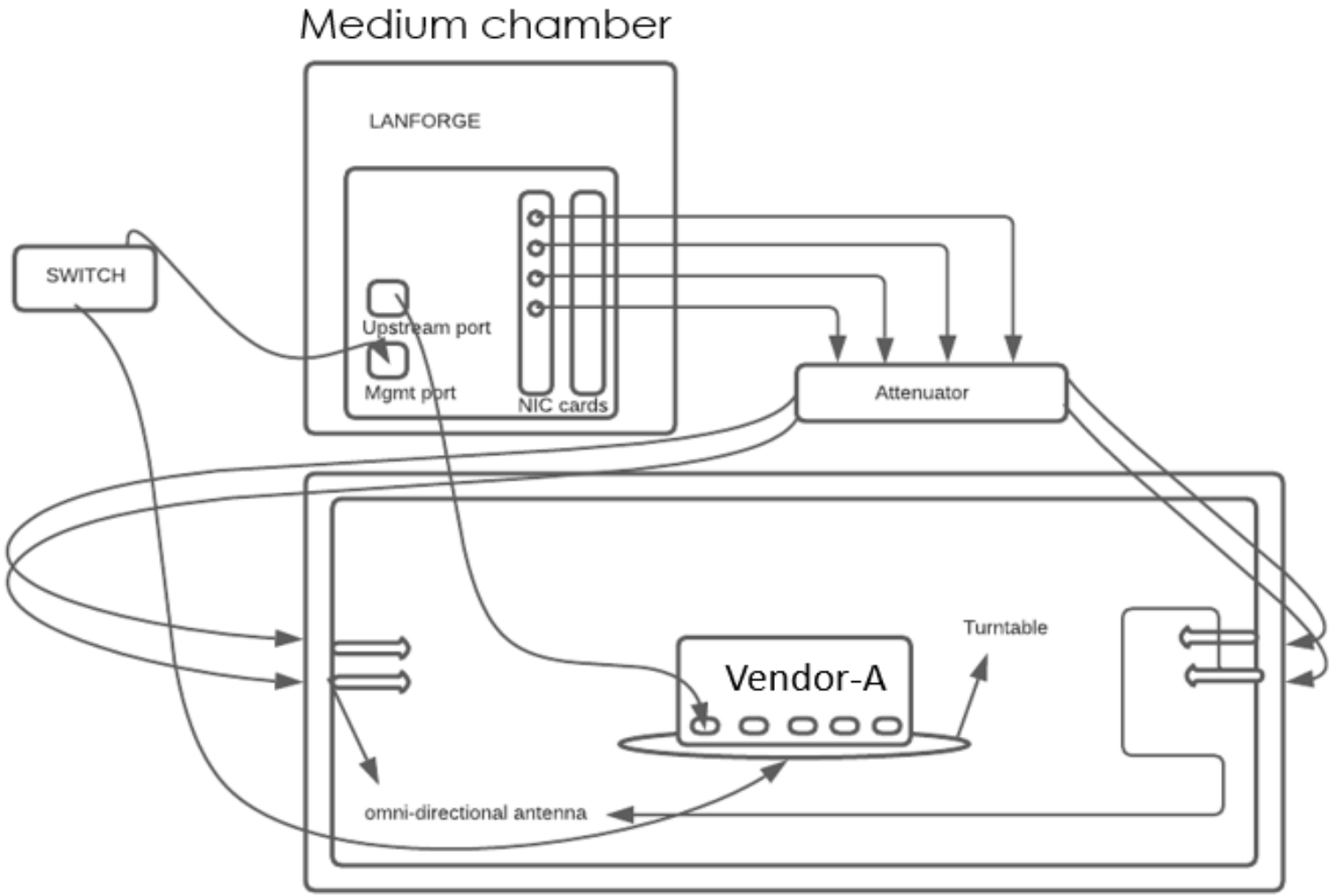
Test Description:

- In this scenario, Station associated and start running traffic when attenuation is 0 dB and gradually increase attenuation 5 dB steps.
- Intended load is set to 1 Gbps with UDP Upload traffic with client 4NSS, 80Mhz BW in AX mode.
- Traffic from client to AP and throughput test run in 5GHz on channel .

Results Observations:

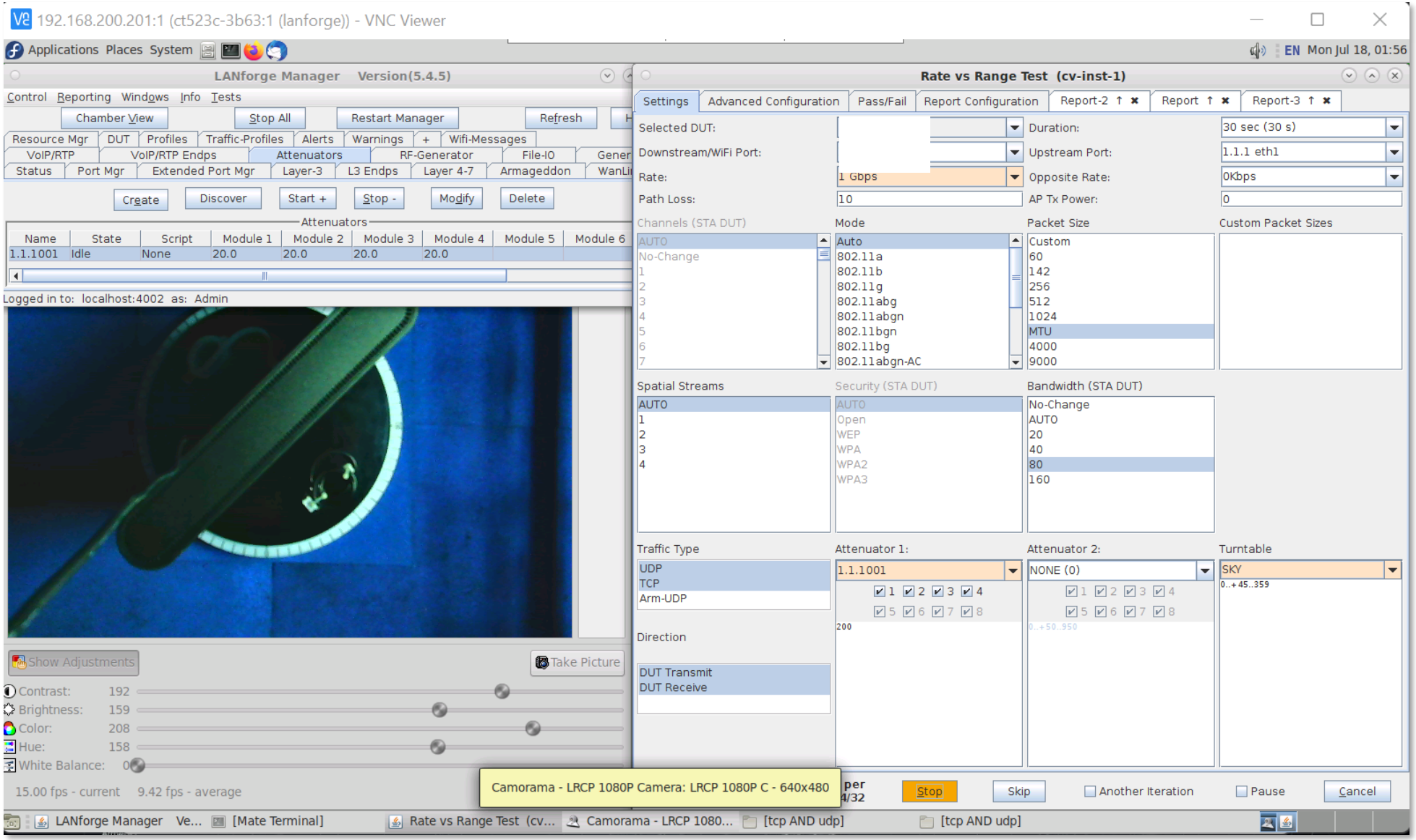
- Vendor-B is getting more throughput with increase in attenuation than Vendor-A.
- Vendor-A, Vendor-B have disconnected after 60dB.

Testbed Setup for Rate vs Orientation:

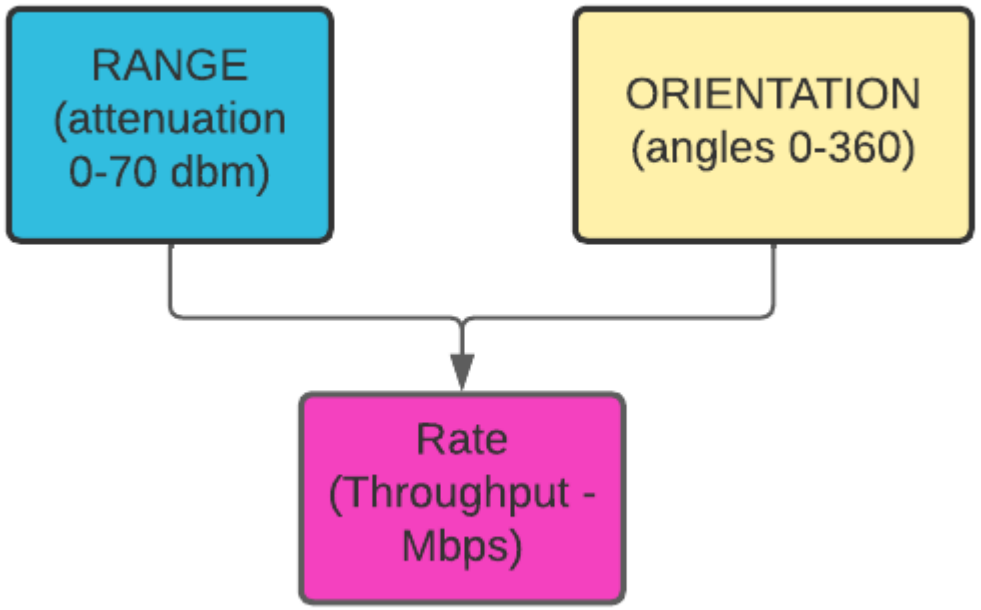


- We used MTK 4*4 Radios for this test.
- The attenuator which is used can provide maximum 95dbm.
- The turntable provides 0-359 degrees rotation.

Testing images:



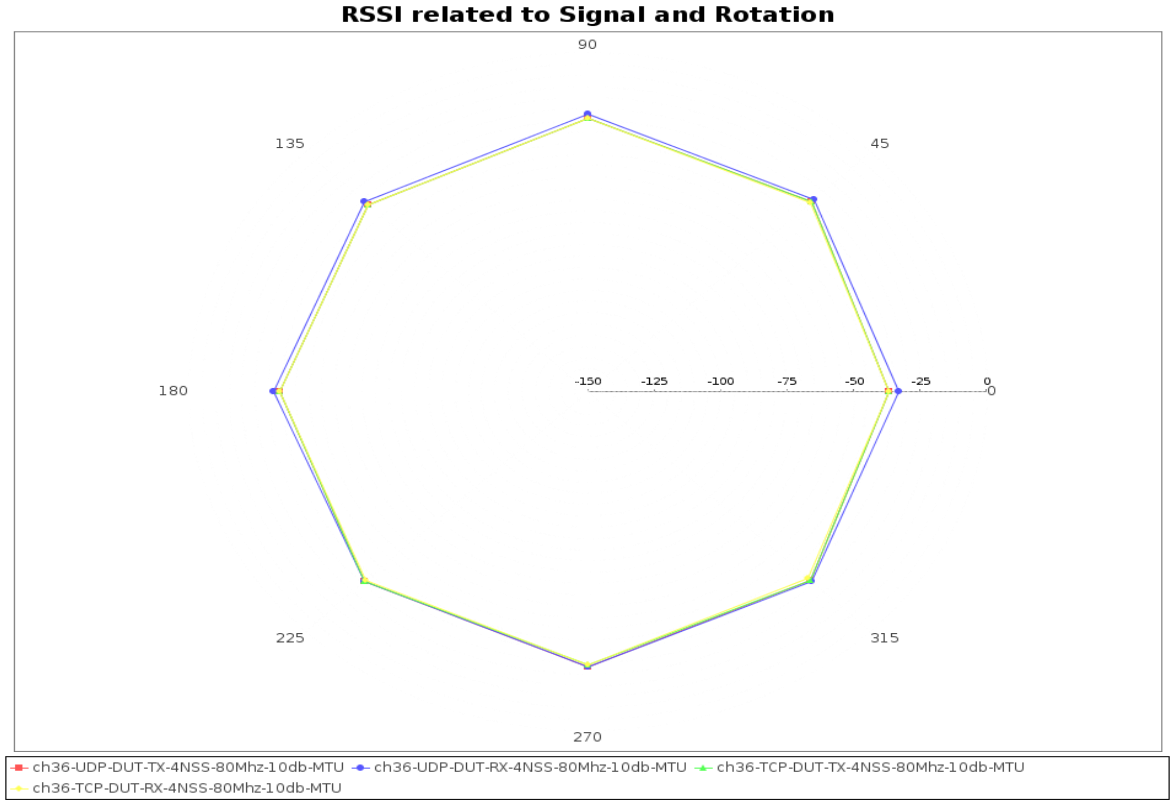
Rate vs Orientation test:



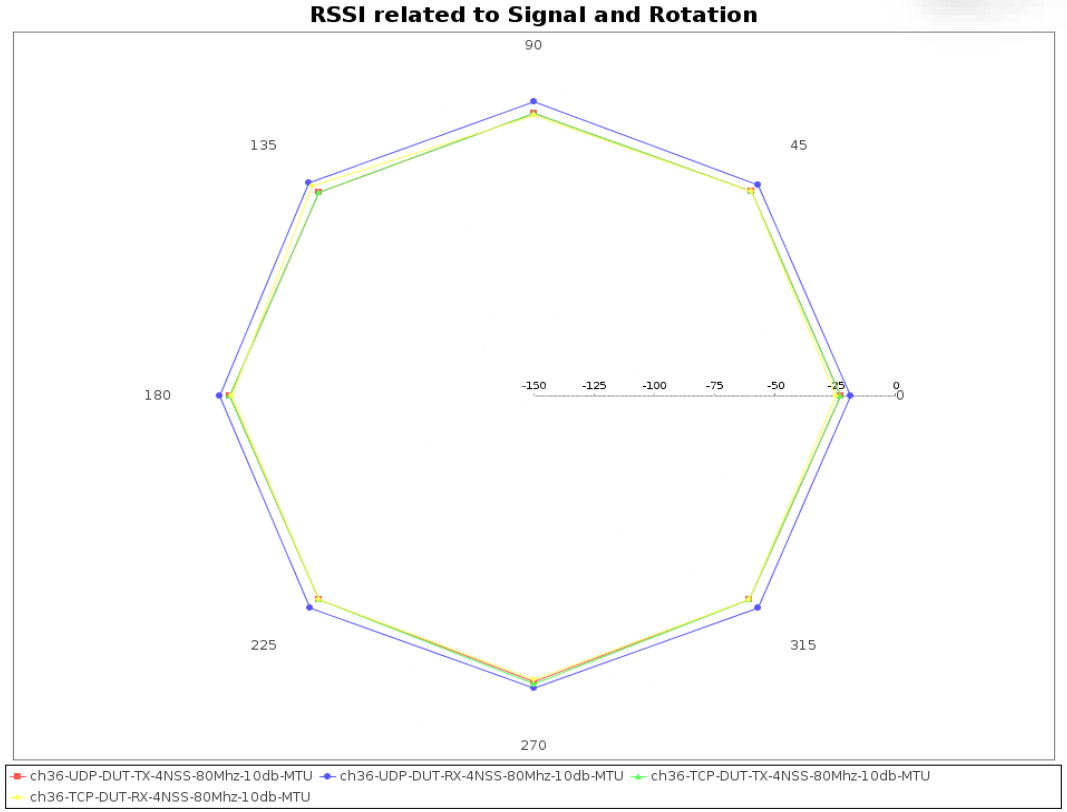
- Here we change both the distance and the angular position of the CPE and calculate the throughput.
- Changing the distance means in terms of increasing the attenuation.
- The maximum attenuation at which the client can connect to the CPE IS 60dbm.
- Changing the orientation means in terms of changing the angle of the turntable.
- The turntable can rotate from 0 to 360 degrees.
- We can run both the TCP and UDP traffics.

Rate vs Orientation test at 0db (5GHz):

Vendor-A



Vendor-B



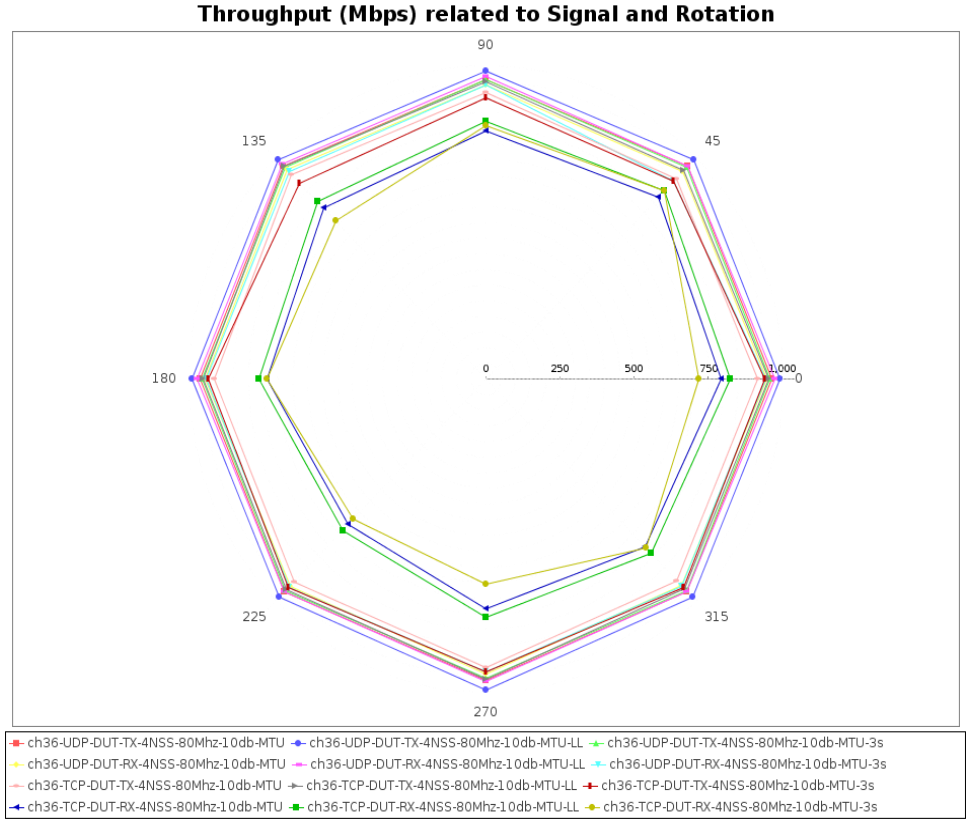
Test Analysis:

- Attenuation=0db, orientation= 0-360 degrees with an increment of 45degrees.
- Here the RSSI values are between 25dbm to 50dbm for SKY-CPE.
- The RSSI values are at 25dbm constantly for Vendor-B.

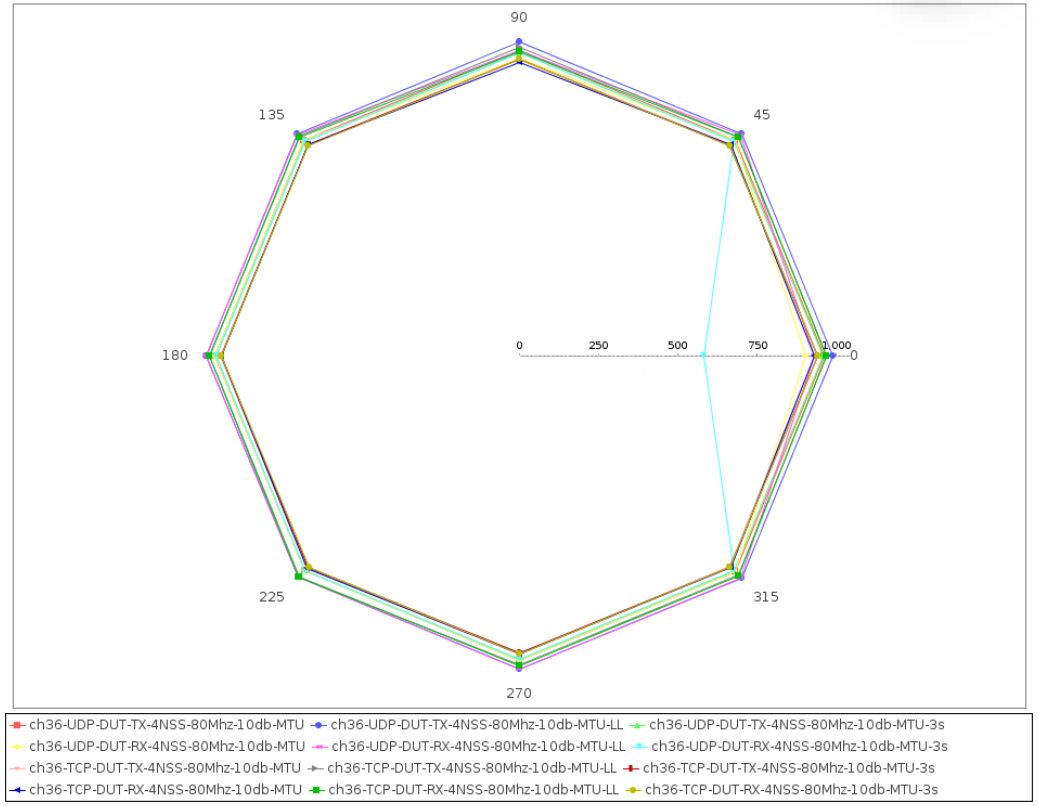
Result:
Vendor-B is showing good RSSI values.

Throughput at 0db (5GHz):

Vendor-A



VENDOR-B



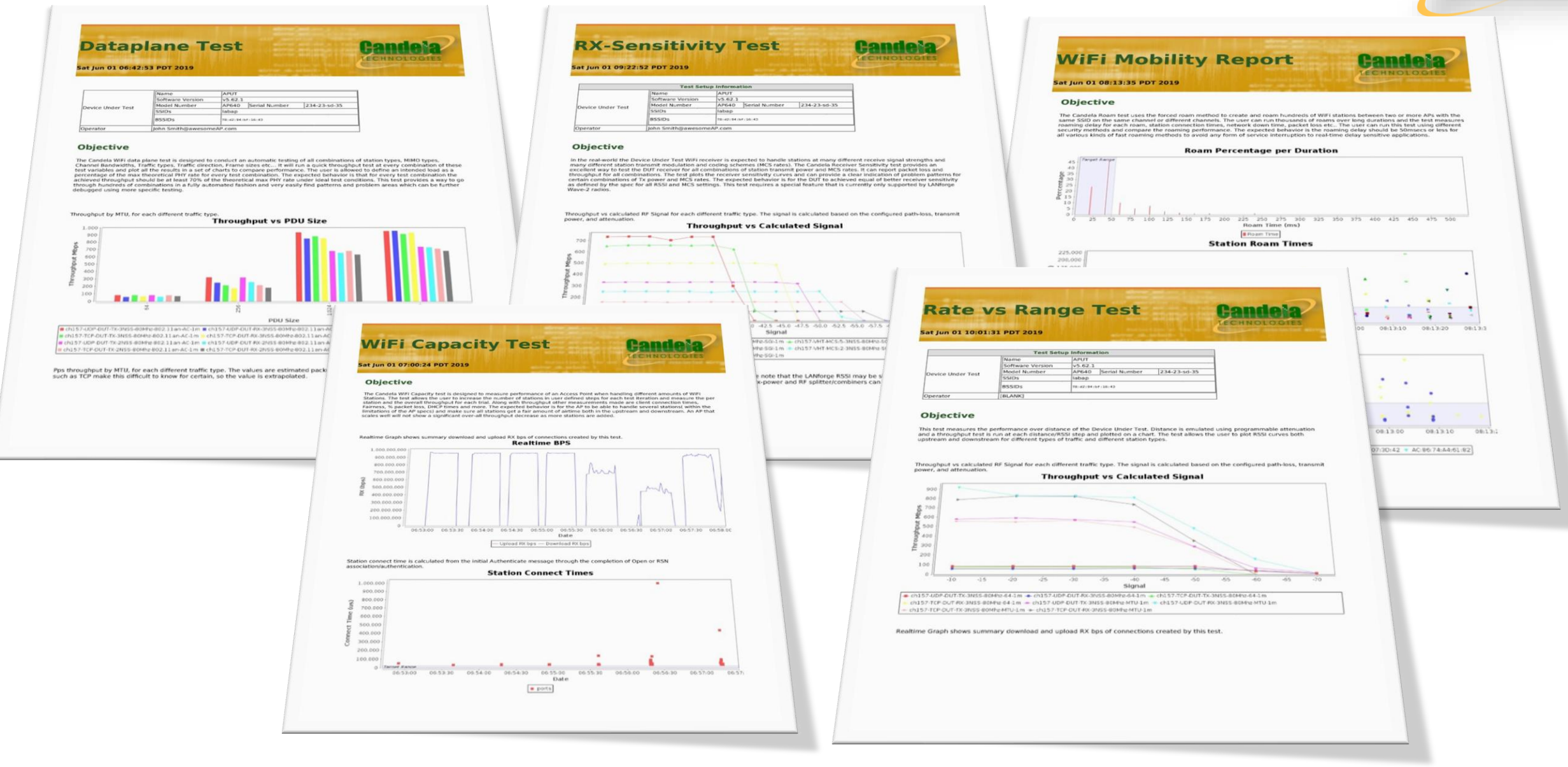
Test analysis:

- Attenuation=0db, orientation= 0-360 degrees with an increment of 45degrees.
- Here the Throughput values are between 730mbps to 950mbps for SKY-CPE from 0-360 degrees.
- Here the Throughput 900mbps to 950mbps above for Vendor-B from 0-360 degrees.

Result:
Vendor-B is showing a consistent performance in throughput compared to Vendor-A.

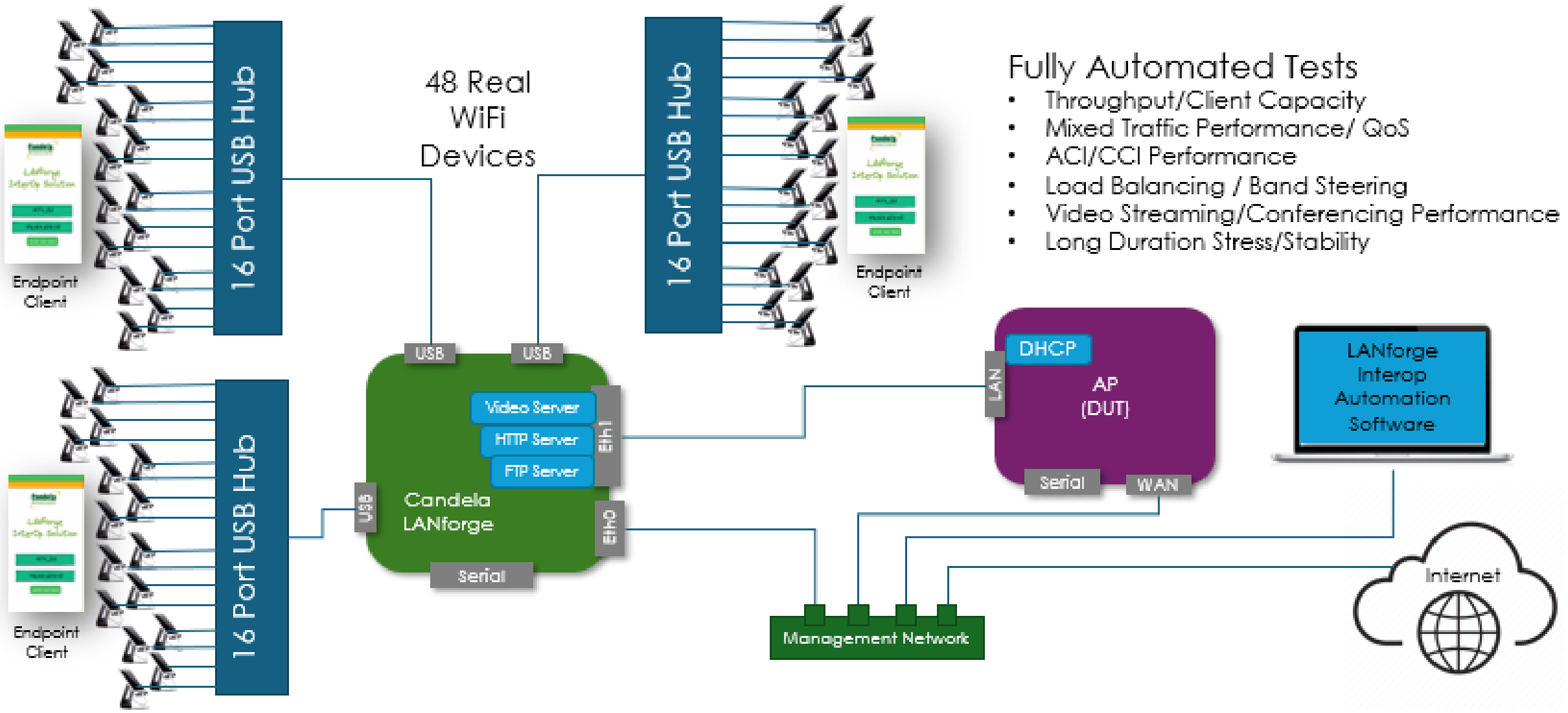
Report link: https://www.dropbox.com/s/p925d4qdz8ma996/o-att.pdf?dl=0

Lots of Tests Run.....



Real Device Testing - LANforge Interop Testbed

Interop Scale Testbed Topology



Fully Automated Tests

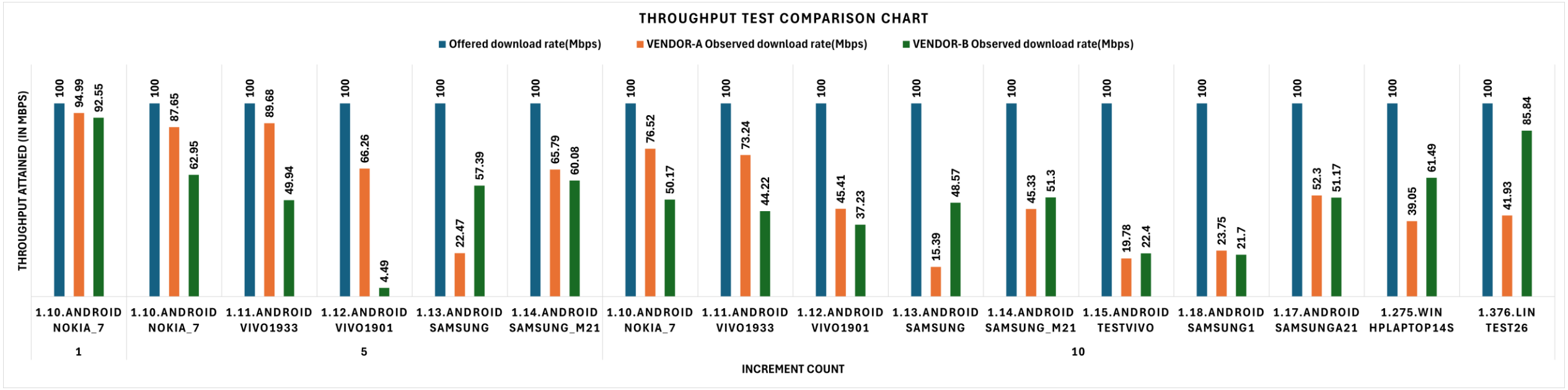
- Throughput/Client Capacity
- Mixed Traffic Performance/ QoS
- ACI/CCI Performance
- Load Balancing / Band Steering
- Video Streaming/Conferencing Performance
- Long Duration Stress/Stability

Test Coverage

- ✓ Throughput test
- ✓ Interoperability Test
- ✓ QOS Test
- ✓ Multicast Test
- ✓ Ping Plotter Test
- ✓ Port Reset Test
- ✓ FTP Test
- ✓ HTTP Test
- ✓ Video Streaming
- ✓ Real Browser Test
- ✓ YouTube Streaming Test
- ✓ Zoom Call Test
- ✓ Mixed Traffic Test

Throughput Test

- The **Candela Throughput test** assesses Access Point performance with real clients, including Android, Linux, and Windows, measuring per-client and overall throughput as client count increases. The test evaluates scalability, airtime fairness, and performance consistency under load.
- Vendor-A demonstrated stable and consistent throughput across multiple client increments. It performed well with Android devices like Nokia and Vivo, maintaining higher throughput as the number of clients increased. Even under load, Vendor-A sustained relatively stable performance without significant drops.

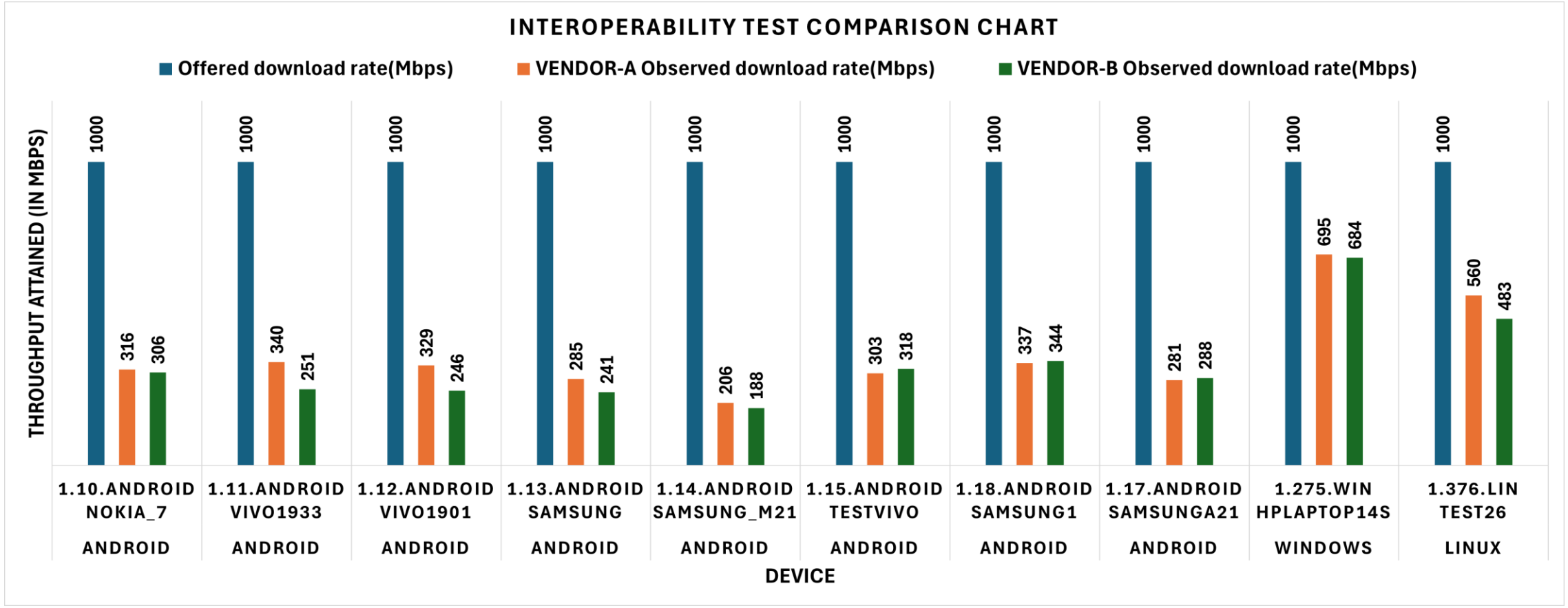


Throughput Test

- Vendor-B showed noticeable throughput fluctuations, particularly with increasing client numbers. While it struggled with consistency, it outperformed Vendor-A on select devices, such as Samsung and Windows laptops. However, certain devices, like Vivo1901, experienced a drastic performance drop with Vendor-B.
- As client load increased, Vendor-A maintained better overall performance, while Vendor-B struggled with throughput stability. Windows and Linux devices performed better on Vendor-B, whereas Android devices showed stronger performance on Vendor-A.
- In summary, Vendor-A provided more reliable and scalable performance, handling load increases effectively. Vendor-B showed higher peak throughput in some cases but lacked overall consistency, making it less reliable under varying conditions.

Interoperability Test

- The **Candela Interoperability test** is designed to measure an Access Point's performance when handling single real clients using different OS, such as Android, Linux, Windows, and iOS. The test evaluates the per-client performance over a given duration, measuring the throughput for each client. Additionally, it ensures that all clients receive a fair share of airtime for both upstream and downstream traffic based on the client specifications.

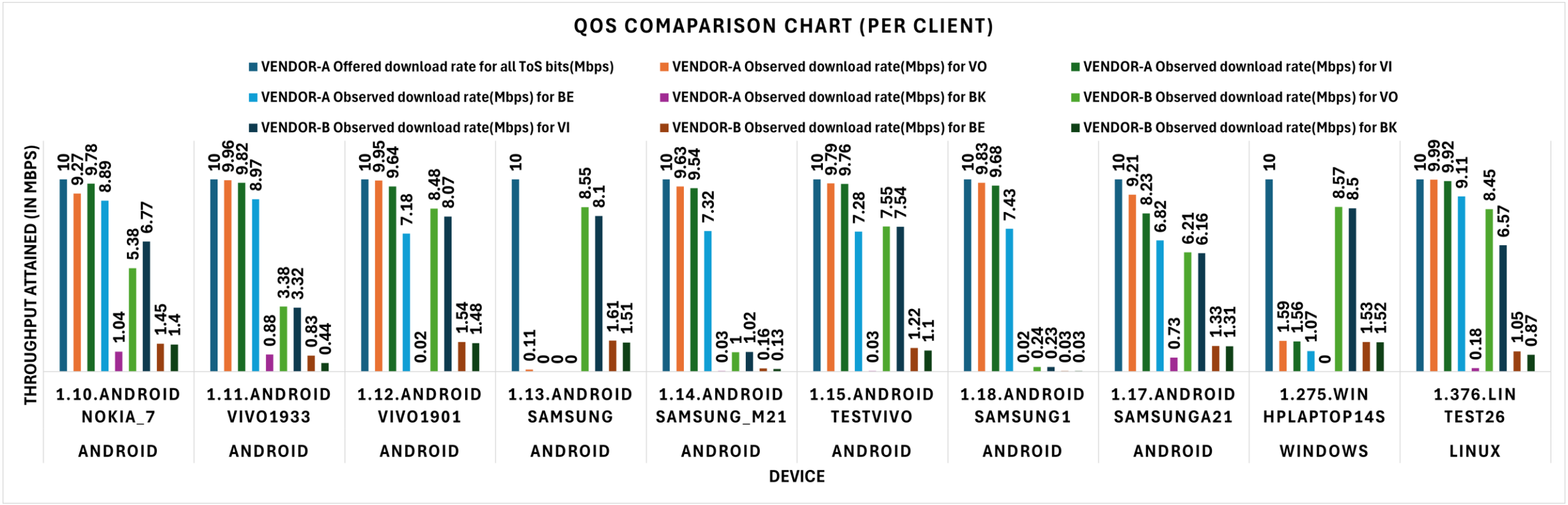


Interoperability Test

- Vendor-A demonstrated strong and stable throughput across most Android devices, consistently outperforming Vendor-B on key models, including Nokia_7, vivo1933, Vivo1901, and Samsung.
- Vendor-B exhibited more variability in performance. While it generally lagged behind Vendor-A, it outperformed in select cases, such as testvivo and Samsung1.
- For Windows and Linux, both vendors showed high performance, with Win HPLaptop14s and Lin test26 performing better on Vendor-A.
- In summary, Vendor-A provided more consistent and stable throughput, particularly excelling with Nokia_7, vivo1933, and Vivo1901. Vendor-B demonstrated competitive performance on select devices like testvivo and Samsung1 but showed more variability overall, making it less predictable under high-load conditions.

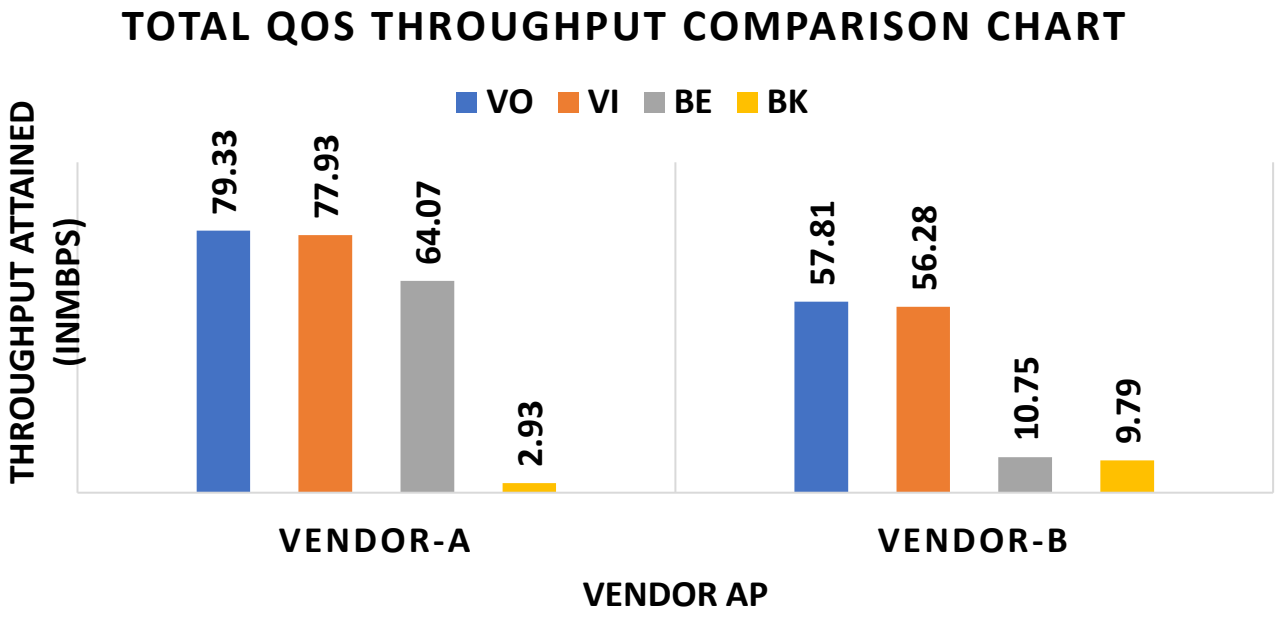
QoS Test

- The **Candela QoS (Quality of Service) traffic test** measures the network's ability to handle high traffic volumes while maintaining performance across different ToS (Type of Service) categories—**Voice (VO)**, **Video (VI)**, **Best Effort (BE)**, **and Background (BK)**. This ensures that the network meets QoS standards and can support real-world usage demands.



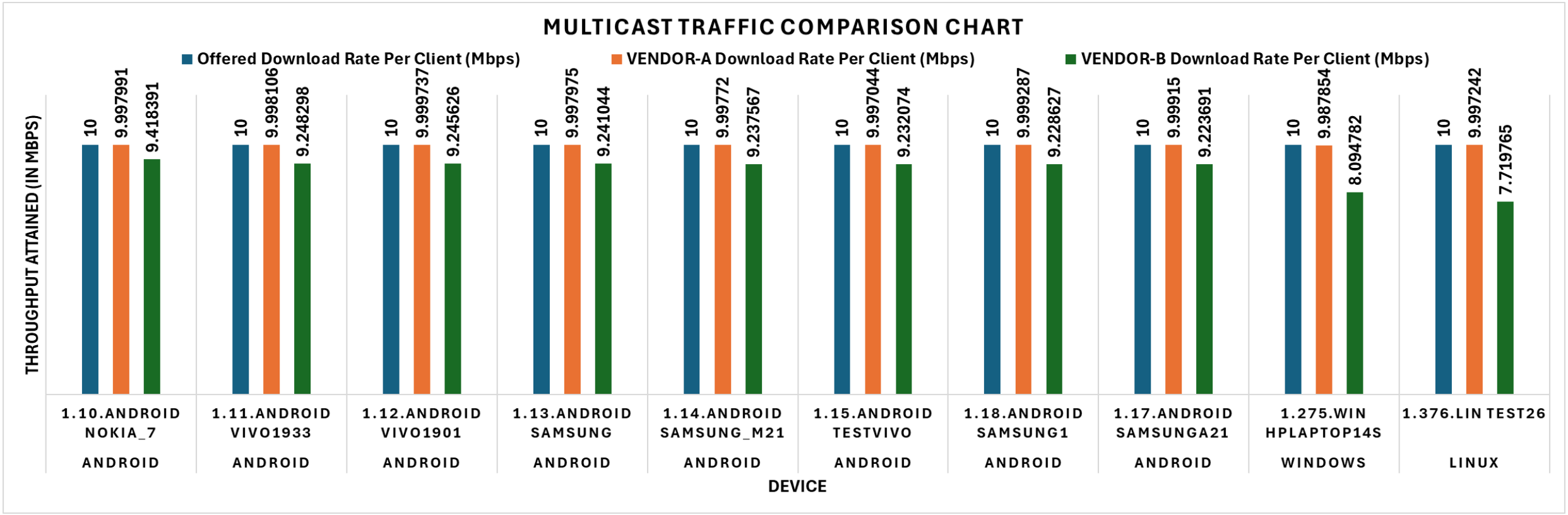
QoS Test

- Vendor-A demonstrated strong prioritization of high-priority traffic (VO, VI), achieving near-max throughput across multiple Android devices, including Nokia_7, vivo1933, and Vivo1901.
- Vendor-B struggled with maintaining consistent QoS, particularly in the Best Effort (BE) and Background (BK) categories, where throughput dropped significantly on several devices.
- Windows (HPLaptop14s) and Linux (Lin test26) performed better on Vendor-B in high-priority categories, while Vendor-A showed inconsistencies.
- In Summary Vendor-A delivered more reliable QoS handling, prioritizing real-time traffic efficiently, while Vendor-B displayed significant variations, particularly in lower-priority traffic categories.



Multicast Test

- The **Candela Multicast Traffic Test** is designed to evaluate the efficiency, reliability, and scalability of multicast communication across various real-world client devices, including Android, Linux, and Windows. By simulating multicast traffic, this test provides insights into how well the network handles multicast distribution under different conditions, identifying potential performance issues related to latency, throughput consistency, and packet delivery.

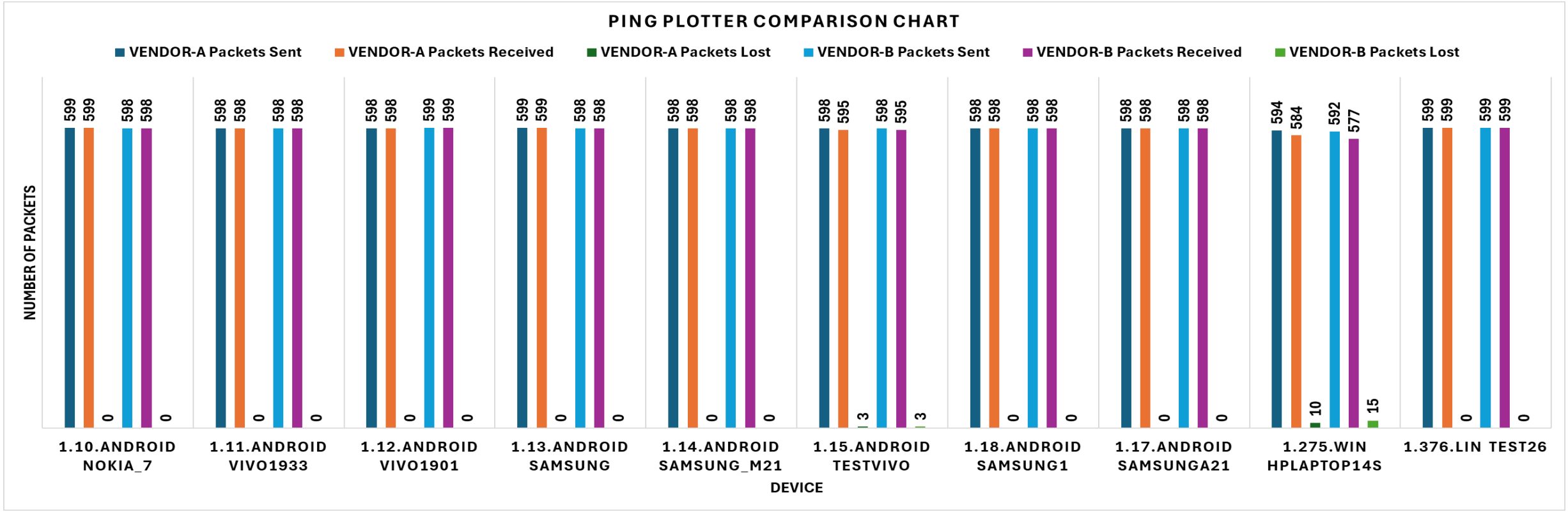


Multicast Test

- Vendor-A maintained near-perfect multicast throughput across all devices, consistently achieving ~9.99 Mbps per client with zero packet drops, demonstrating excellent multicast efficiency.
- Vendor-B showed variations in multicast throughput, with most Android devices performing similarly to Vendor-A, but Windows and Linux devices experienced noticeable performance drops.
- The Windows (HPLaptop14s) client exhibited a 13.88% drop in throughput under Vendor-B, indicating potential inefficiencies in handling multicast traffic for Windows devices.
- The Linux (test26) client suffered the highest drop at 15.67% under Vendor-B, suggesting multicast packet loss or suboptimal handling on Linux platforms.
- Android devices maintained stable throughput under both vendors, but Vendor-A's multicast handling was more consistent across all operating systems.
- In Summary Vendor-A demonstrated superior multicast efficiency with stable throughput and zero packet loss across all tested devices. Vendor-B performed well for Android clients but struggled with multicast distribution on Windows and Linux, leading to noticeable throughput drops. Further optimizations may be needed in Vendor-B's multicast handling, particularly for non-Android platforms.

Ping Plotter Test

- The **Candela Ping Plotter test** is to evaluate network connectivity and measure the round-trip time taken for data packets to travel from the source to the destination and back. It helps assess the reliability and latency of the network, identifying any packet loss, delays, or variations in response times. The test aims to ensure that devices can communicate effectively over the network and pinpoint potential issues affecting connectivity.

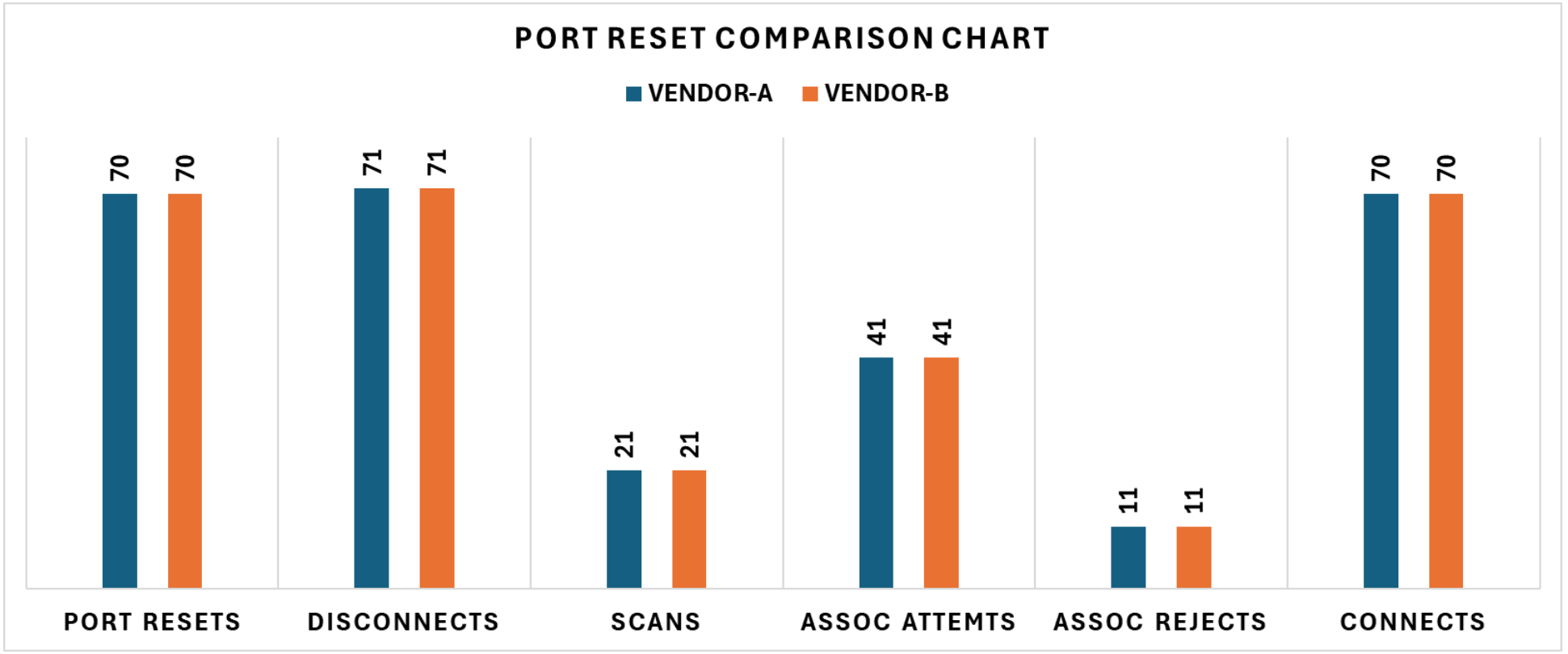


Ping Plotter Test

- Packet Loss: Minimal across devices, except for Windows (HPLaptop14s), which recorded higher loss (1.68%-2.53%).
- RTT Performance: VENDOR-A consistently showed lower RTT (19.88 ms – 40.25 ms), whereas VENDOR-B had significantly higher RTT (64.10 ms – 102.84 ms).
- Device Trends:
  - Android devices performed better on VENDOR-A, showing lower and more stable RTT.
  - Windows device had higher packet loss and RTT, impacting performance.
  - Linux device had moderate RTT, but still performed better on VENDOR-A.
- In Summary, VENDOR-A demonstrated superior network performance, ensuring better connectivity and lower delays, while VENDOR-B exhibited higher RTT and potential network inefficiencies.

Port Reset Test

- The **Candela Port Reset Test** is designed to evaluate the stability and performance of the Access Point (AP) under stress by simulating frequent disconnections and reconnections of multiple Wi-Fi stations. This test mimics the dynamic environment of a busy enterprise or public venue, where stations continuously arrive and depart. The primary objective is to assess the AP's control and management functions, ensuring reliable connectivity and effective handling of frequent connection disruptions.

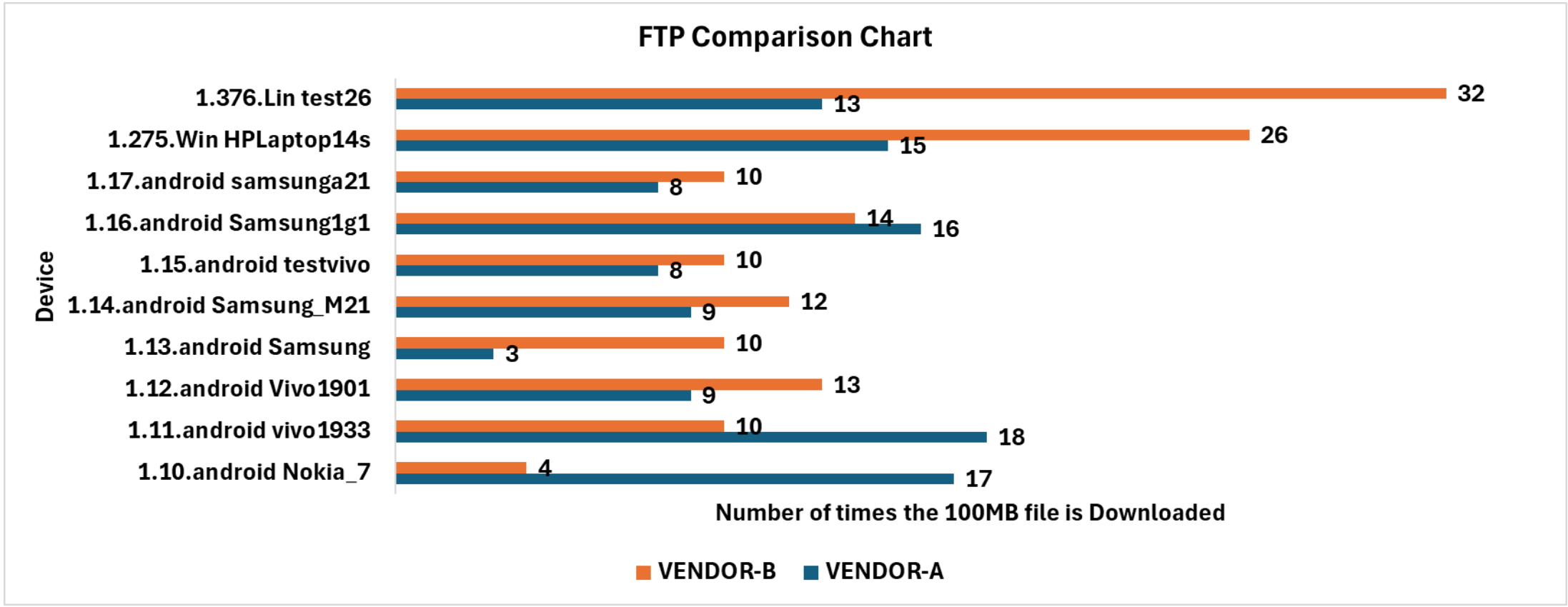


Port Reset Test

- **Port Resets**: Both Vendor-A and Vendor-B stations experienced 10 resets each, indicating consistent behavior during disconnections and reconnections.
- **Disconnects**: Minor variation in disconnects, with Vendor-A's Win HPLaptop14s showing 11 disconnects. All other devices in both vendors had 10 disconnects.
- **Association Attempts/Rejects**: Vendor-A's Nokia_7 had 20 attempts and 10 rejects, indicating potential compatibility issues. Vendor-B showed stable association attempts with fewer rejects.
- **Connects**: Both vendors achieved 10 successful connections, demonstrating stable reconnection performance.
- In Summary, Vendor-A and Vendor-B performed similarly, but Vendor-A's Nokia_7 device showed higher reject rates.

FTP Test

- The **Candela FTP Test** is designed to verify that multiple clients, connected on a specified band, can simultaneously download a specified file size from an FTP server. The test measures the time taken by each client to download the file, providing insights into the network performance and efficiency under load conditions.

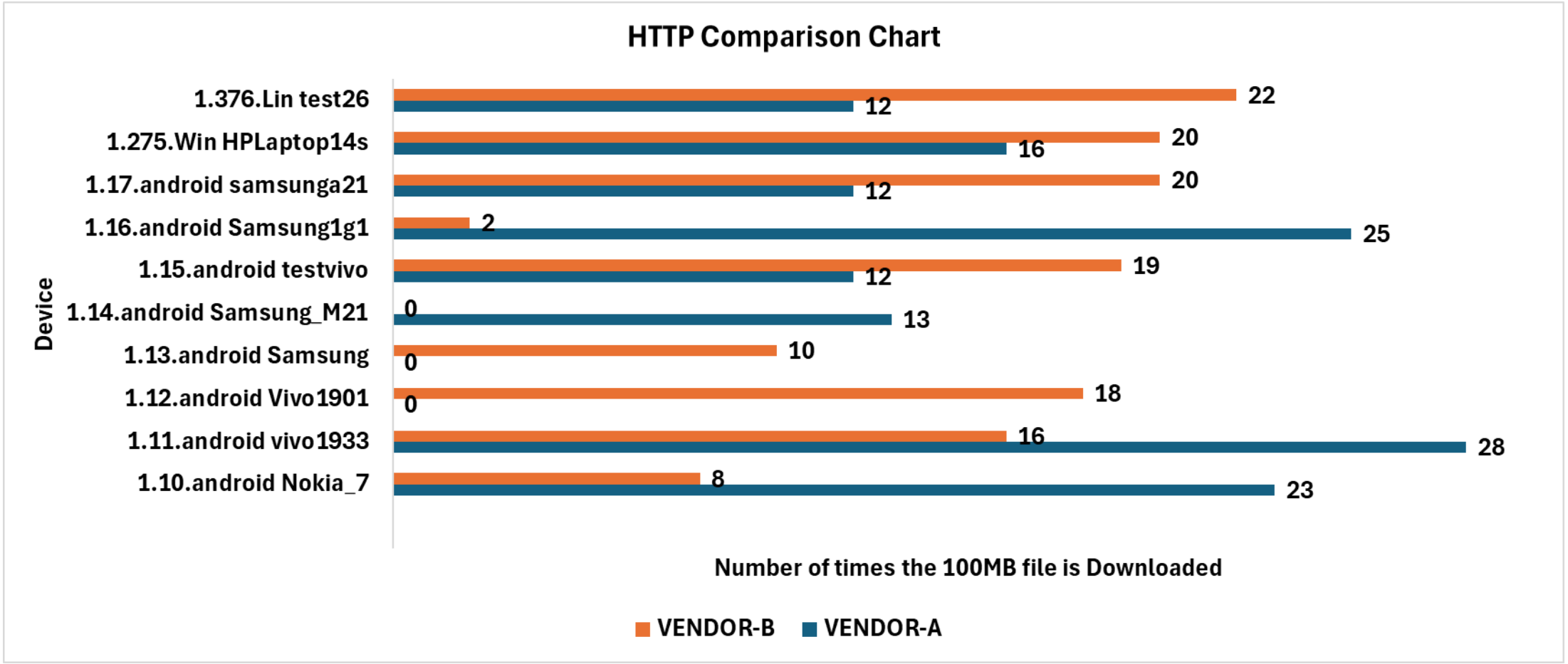


FTP Test

- Vendor-A devices (e.g., Nokia_7, vivo1933, Samsung) generally show varied download rates, with values ranging from 8 Mbps to 18 Mbps.
- Vendor-B devices (e.g., vivo1933, Samsung, testvivo) show better throughput with values ranging from 10 Mbps to 32 Mbps, especially in higher-end devices like HPLaptop14s (26 Mbps).
- Rx-Rate (download rate) measurements highlight that Vendor-B outperforms Vendor-A in most cases, especially in devices like vivo1933 and HPLaptop14s, showing better handling of FTP file transfers.
- Bytes-RD values represent the total number of bytes received, showing that Vendor-B devices consistently download larger files, further proving better throughput.
- In summary, Vendor-B consistently outperforms Vendor-A in terms of FTP download rates across various devices.

HTTP Test

- The **Candela HTTP Test** is designed to verify that multiple clients, connected on a specified band, can simultaneously download a specified file size from an HTTP server. The test measures the time taken by each client to download the file, providing insights into the network performance and efficiency under load conditions.

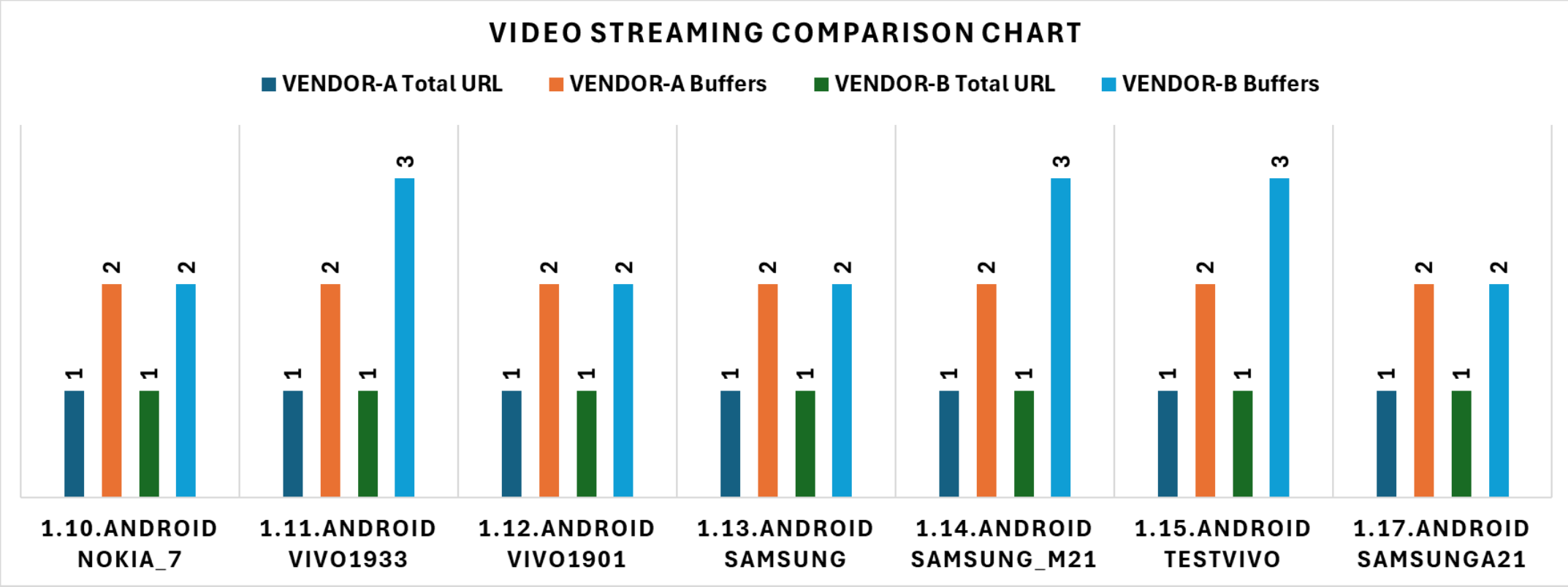


HTTP Test

- Vendor-A devices (e.g., Nokia_7, vivo1933, Samsung) show a wide range of performance, with download rates ranging from 8 Mbps to 28 Mbps.
- Vendor-B devices (e.g., vivo1933, Samsung, testvivo) consistently demonstrate better download speeds, ranging from 2 Mbps to 20 Mbps, with peak performance seen in testvivo and HPLaptop14s.
- The Bytes-RD values indicate that Vendor-B devices download significantly larger file sizes in comparison to Vendor-A devices, suggesting that Vendor-B devices have better throughput.
- The RX-Rate (download rate) measurements show that Vendor-B devices, particularly testvivo, vivo1933, and HPLaptop14s, outperform Vendor-A devices like Nokia_7 and Samsung in terms of download speeds.
- In summary, Vendor-B outperforms Vendor-A in the HTTP download test across multiple devices, particularly for devices like HPLaptop14s and testvivo.

Video Streaming Test

- The **Candela Video Streaming Test** is designed to measure the access point performance and stability by streaming the videos from the local browser or from over the Internet in real clients like android which are connected to the access point, this test allows the user to choose the options like video link, type of media source, media quality, number of playbacks. Along with the performance other measurements like No of Buffers, Wait-Time, per client Video Bitrate, Video Quality, and more.

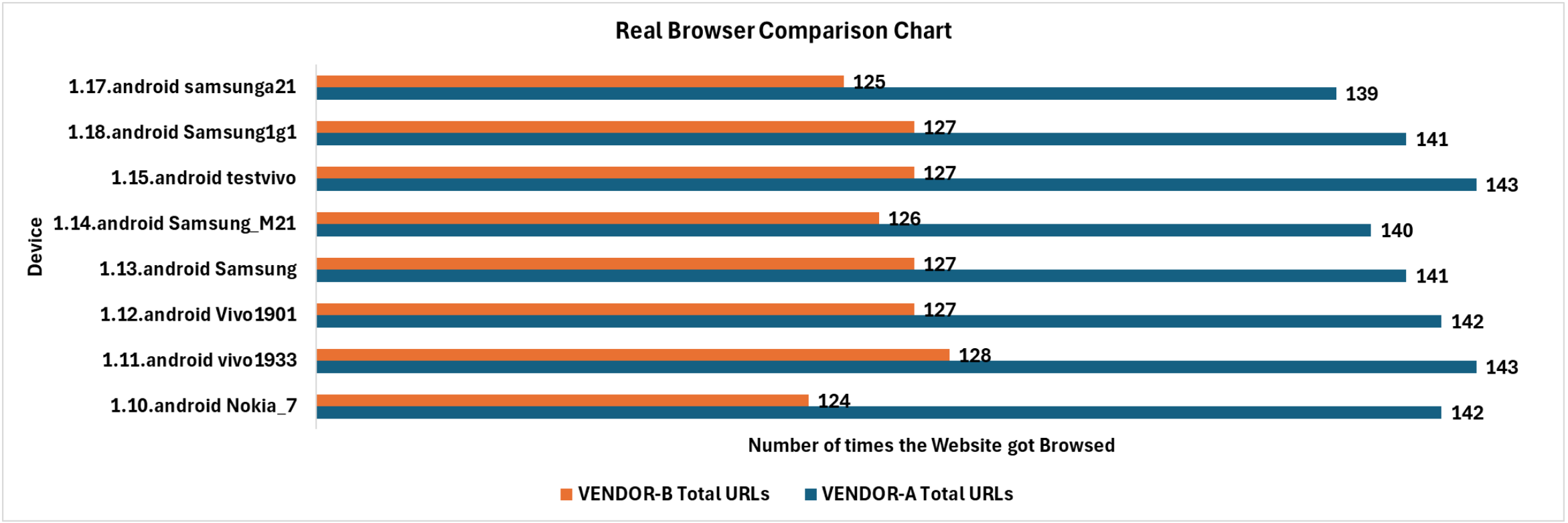


Video Streaming Test

- Vendor-A devices (e.g., Nokia_7, vivo1933, Samsung) show higher Bytes-RD values, indicating better throughput compared to Vendor-B.
- Vendor-B devices (e.g., vivo1933, Samsung_M21, testvivo) experience more buffering events (2-3 times), leading to possible playback interruptions.
- RX-Rate (download speed) is consistently higher on Vendor-A across most devices, with Nokia_7 and vivo1933 achieving peak performance.
- Vendor-B devices show lower RX-Rates, especially Samsung_A21 (709 kbps), which could lead to video lag and buffering issues.
- In summary, Vendor-A demonstrates superior video streaming performance, offering higher throughput and fewer interruptions compared to Vendor-B.

Real Browser Test

- The **Candela Real Browser Test** is designed to measure the performance and stability of an access point by simulating real-world browsing activities across devices such as Android, Linux, Windows, and iOS. This test allows users to configure parameters like website links, the number of times a page should be browsed, and the time taken to complete the browsing task. In addition to performance metrics, it also collects data on failed URL attempts and other relevant measurements.

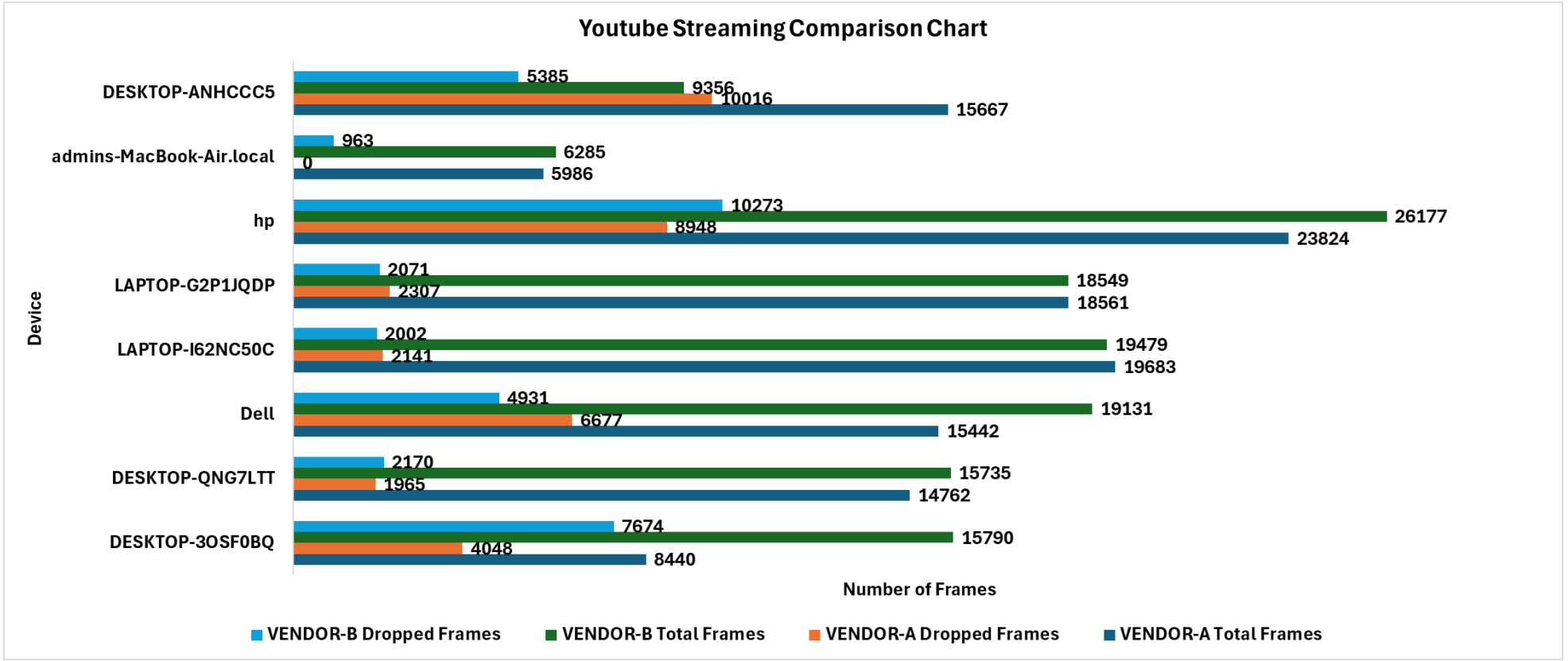


Real Browser Test

- Vendor-A devices consistently completed more URLs (140-143) compared to Vendor-B (124-128), indicating better handling of web requests.
- Vendor-A showed faster page load times, completing 50 URLs in 311-320 seconds, whereas Vendor-B took longer (346-360 seconds).
- Nokia_7 and vivo1933 in Vendor-A were the top performers, with the fastest completion times.
- Samsung_A21 in Vendor-B had the slowest performance, taking 360 seconds to complete 50 URLs.
- Overall, Vendor-A demonstrates superior web browsing efficiency, achieving higher URL completion rates and faster browsing speeds than Vendor-B.

YouTube Streaming Test

- The **Candela YouTube Streaming Test** is designed to evaluate the performance of video streaming across multiple laptops by collecting key statistics such as video resolution, buffer health, total frames, and dropped frames. This test simulates real-world streaming scenarios to assess the stability and efficiency of video playback across different devices and operating systems.

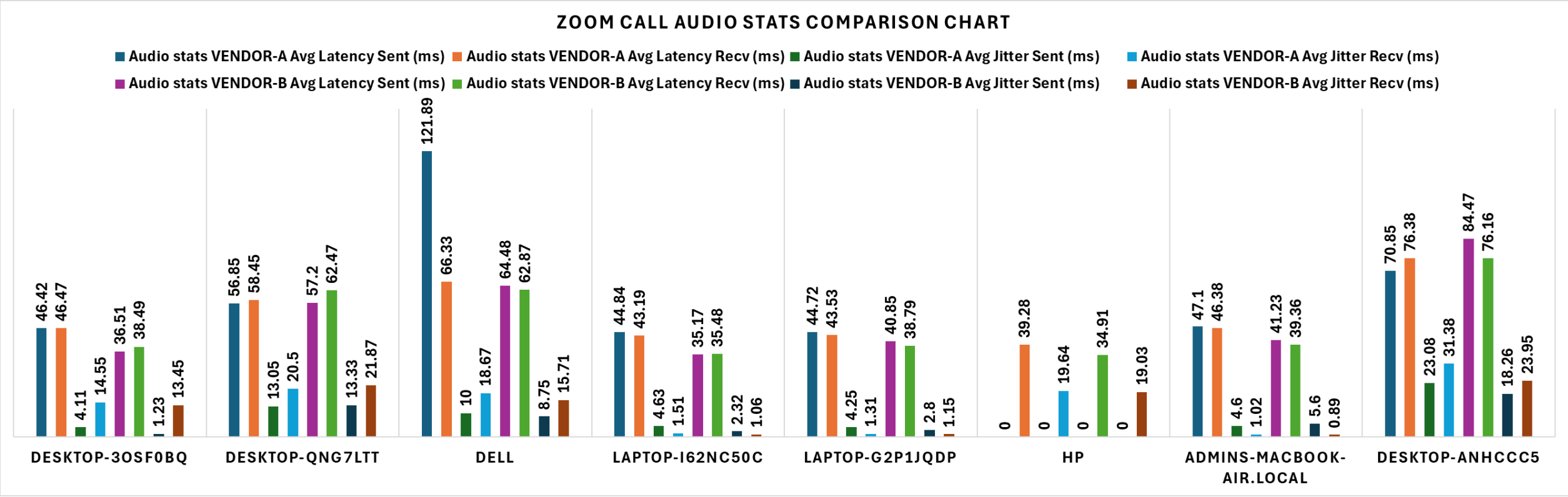


YouTube Streaming Test

- **Buffer Health**: Vendor-A showed a generally stable maximum buffer health across all devices, with a few minor variations. Vendor-B performed well, with buffer health metrics staying close to Vendor-A. However, Vendor-B devices like hp (Linux) had slightly higher buffer health, indicating a more stable stream.
- **Total Frames vs Dropped Frames:**
  - Vendor-A: Dropped frames were minimal, with large frame counts. Devices like DESKTOP-3OSF0BQ recorded 8440 total frames with 4048 dropped frames.
  - Vendor-B: Dropped frames were also low, but certain devices like DESKTOP-QNG7LTT showed slightly higher drops (2170) compared to Vendor-A.
- **Device Performance:**
  - Windows devices from both vendors showed similar performance across the board with slight variations in dropped frames and buffer health.
  - MacOS devices (Admins-MacBook-Air. Local) showed significantly higher maximum buffer health (51.34 seconds), but this could be due to the lower streaming resolution of 1280x720, which might have resulted in more stable playback.
- In Summary, Both Vendor-A and Vendor-B demonstrated solid performance during the YouTube Streaming test. Vendor-A generally had a higher number of frames dropped on certain devices, but Vendor-B devices showed small performance fluctuations.

Zoom Call Test

- The **Candela Zoom Call Test** is designed to conduct automated tests across multiple laptops to gather detailed statistics on the performance of audio and video during Zoom calls. These statistics include average latency, jitter, packet loss, and overall audio and video performance.

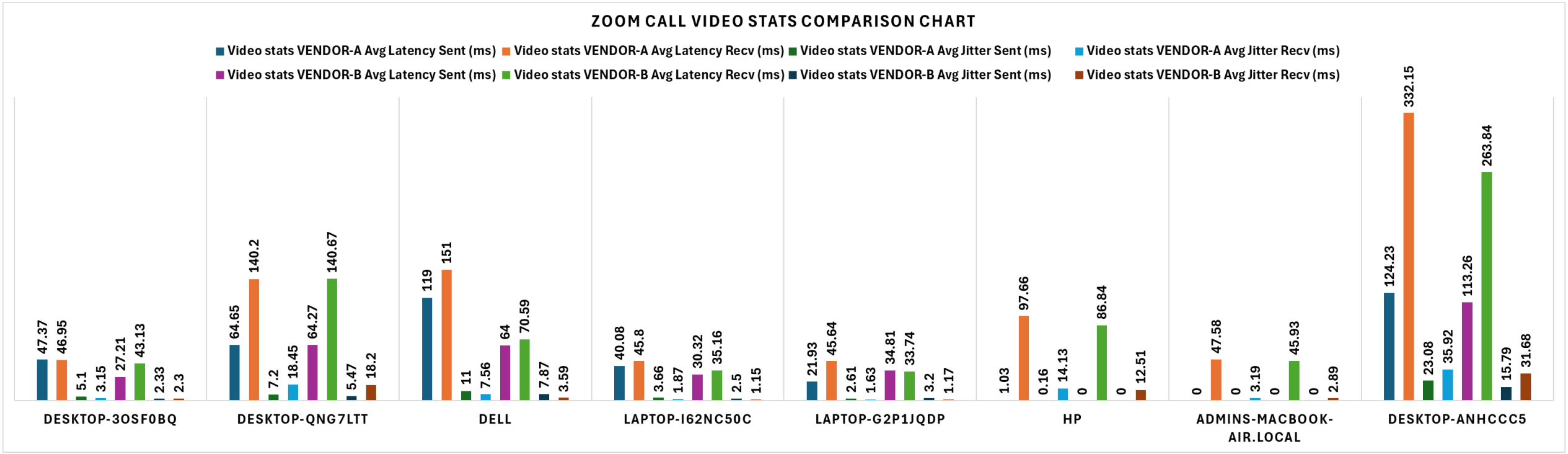


Zoom Call Test

- **Audio Stats:**
  1. Vendor-A showed lower average latency and jitter across most devices compared to Vendor-B. Devices like LAPTOP-I62NC50C and LAPTOP-G2P1JQDP demonstrated low latency and jitter, ensuring stable audio performance.
  2. Vendor-B devices like DESKTOP-ANHCCC5 experienced higher latency and jitter (e.g., 70.85 ms avg. latency recv), potentially indicating less stable connections compared to Vendor-A.
  3. Packet loss remained minimal across both vendors, with Vendor-A devices generally showing slightly better performance with respect to packet loss (close to 0%).
- **Video Stats:**
  1. Vendor-A devices like DESKTOP-3OSF0BQ demonstrated low video latency (47.37 ms avg. latency sent), ensuring smooth video transmission with minimal jitter.
  2. Vendor-B devices like DESKTOP-QNG7LTT experienced higher video latency and jitter (e.g., 140.2 ms avg. latency recv, 18.45 ms avg. jitter sent), suggesting potential delays in video rendering and transmission.
  3. Packet loss in video performance was minimal for both vendors but slightly higher for Vendor-B on devices like DESKTOP-ANHCCC5, with 0.03% packet loss received.

Zoom Call Test

- In Summary, Vendor-A generally provided better audio and video performance across all devices, with lower latencies, jitter, and packet loss compared to Vendor-B.
- Vendor-B showed occasional spikes in latency and jitter, especially in video performance, which could impact overall call quality.
- Both vendors performed well with minimal packet loss, which is crucial for maintaining call stability.



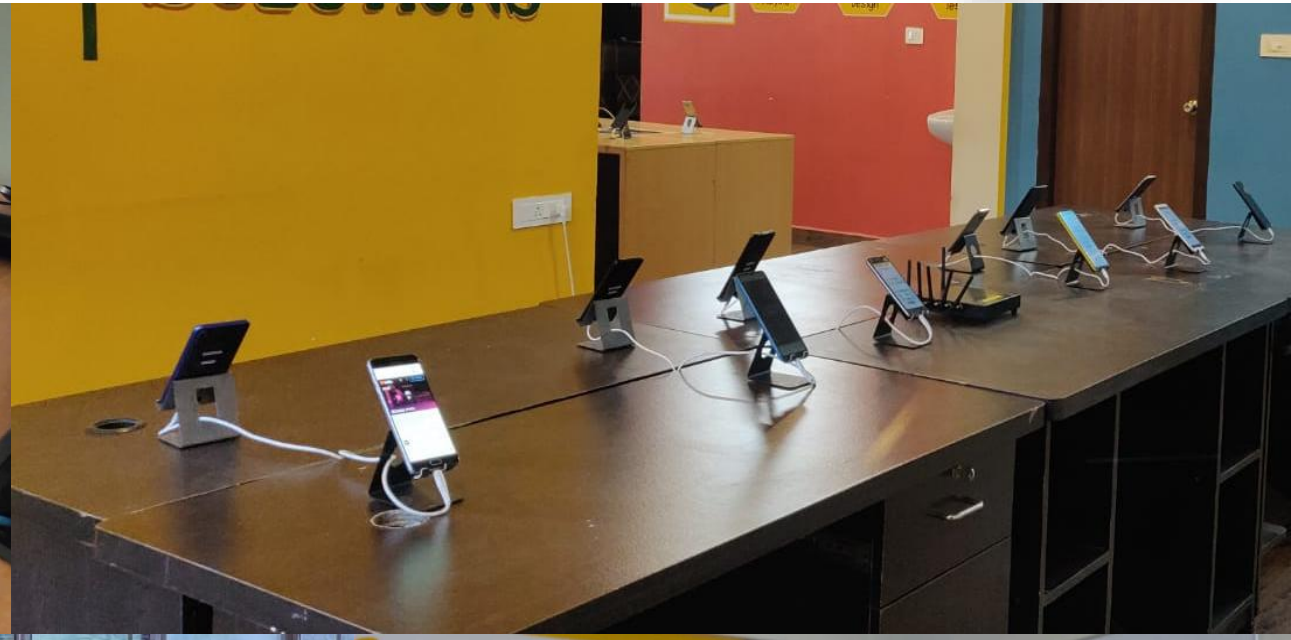
Mixed Traffic Test

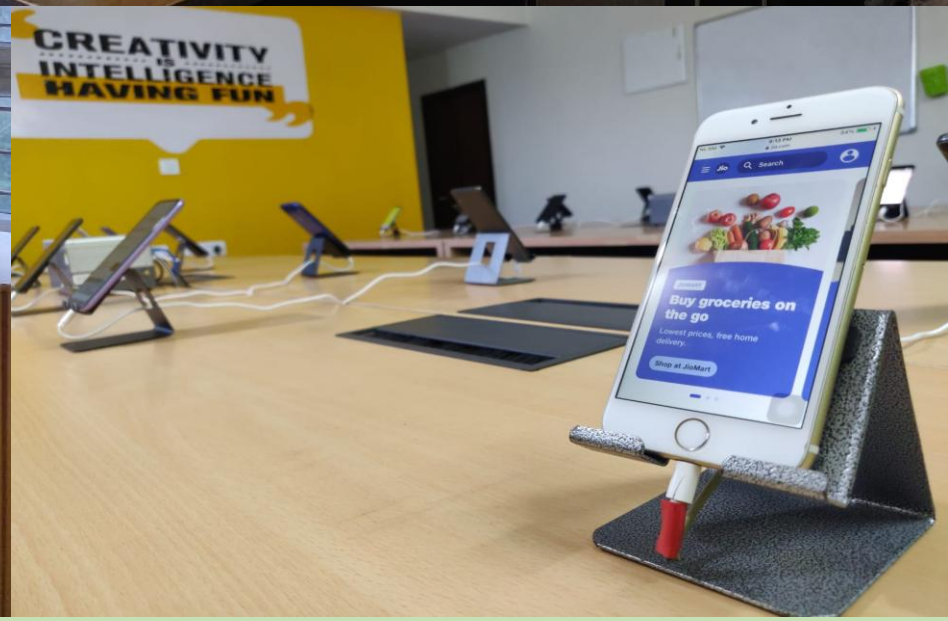
- The **Candela Mixed Traffic Test** is designed to assess the performance and stability of an access point by generating various types of traffic on real client devices, such as Android, Linux, Windows, and iOS, all connected to the AP. The test allows users to configure multiple traffic types, including QoS, FTP, HTTP, Multicast, and Ping, running either in series or parallel. The expected behavior is for the access point to handle all traffic types efficiently across several stations (within the limitations of the AP specifications), ensuring that all connected clients can support and run the selected traffic types seamlessly.

Mixed Traffic Test

- Channel Utilization: VENDOR-A has 72% channel utilization on the 5G band and 46% on the 2G band, showing a more balanced distribution. In contrast, VENDOR-B utilizes the 5G band more heavily at 83%, while the 2G band is much lower at 26%.
- Ping Test: Both vendors reported that Android devices on the 2.4GHz band experienced ping loss and higher latency during the ping test, showing a similar behavior for devices on the 2.4GHz band across both vendors.
- Multicast Test: With Both vendors we observed deauthentication of some devices during the multicast traffic test.
- FTP & HTTP Tests (10MB):
  - VENDOR-A: 43 out of 46 Android devices, as well as other OS devices (Windows, Linux, MacBook), were able to download the 10MB file successfully within 5 minutes on both 5GHz and 2.4GHz bands.
  - VENDOR-B: All 46 Android devices and other OS devices successfully downloaded the 10MB file within 5 minutes on both bands. VENDOR-B performed slightly better in handling the 10MB file download test, with all devices successfully completing the test, compared to a few devices in VENDOR-A.
- In Summary, Both vendors demonstrated similar behaviors in terms of connection stability, multicast issues, and FTP/HTTP download tests. However, VENDOR-B showed better overall performance in FTP file downloads and a 100% success rate in the small file download test (10MB), whereas VENDOR-A had a few devices that struggled with the 10MB download.

Capacity Test House





Test Environment Details - VILLA AND FLOOR PLAN

VILLA HAS 2 FLOORS WITH TOTAL AREA = 1985 SQ.FT

GROUND FLOOR AREA = 905 SQ.FT
FIRST FLOOR AREA = 1080 SQ.FT

DUT and client details

Model A
Build A

DUT
Model A- GW

Specs
Tri-band System
Radio1: 2.4 GHz 2x2
Radio2: 5 GHz 4X4
Radio3: 6GHz 4x4
Build Info: **Build A**
Chipset: Qualcomm
Channel for 6G: 37, BW: 320MHz, TX power: 18 dBm
Channel for 5G: 36, BW: 160MHz, TX power: 23 dBm
Channel for 2.4G: 6, BW: 40MHz, TX power: 27 dBm

Model A
Build B

DUT
Model A- GW

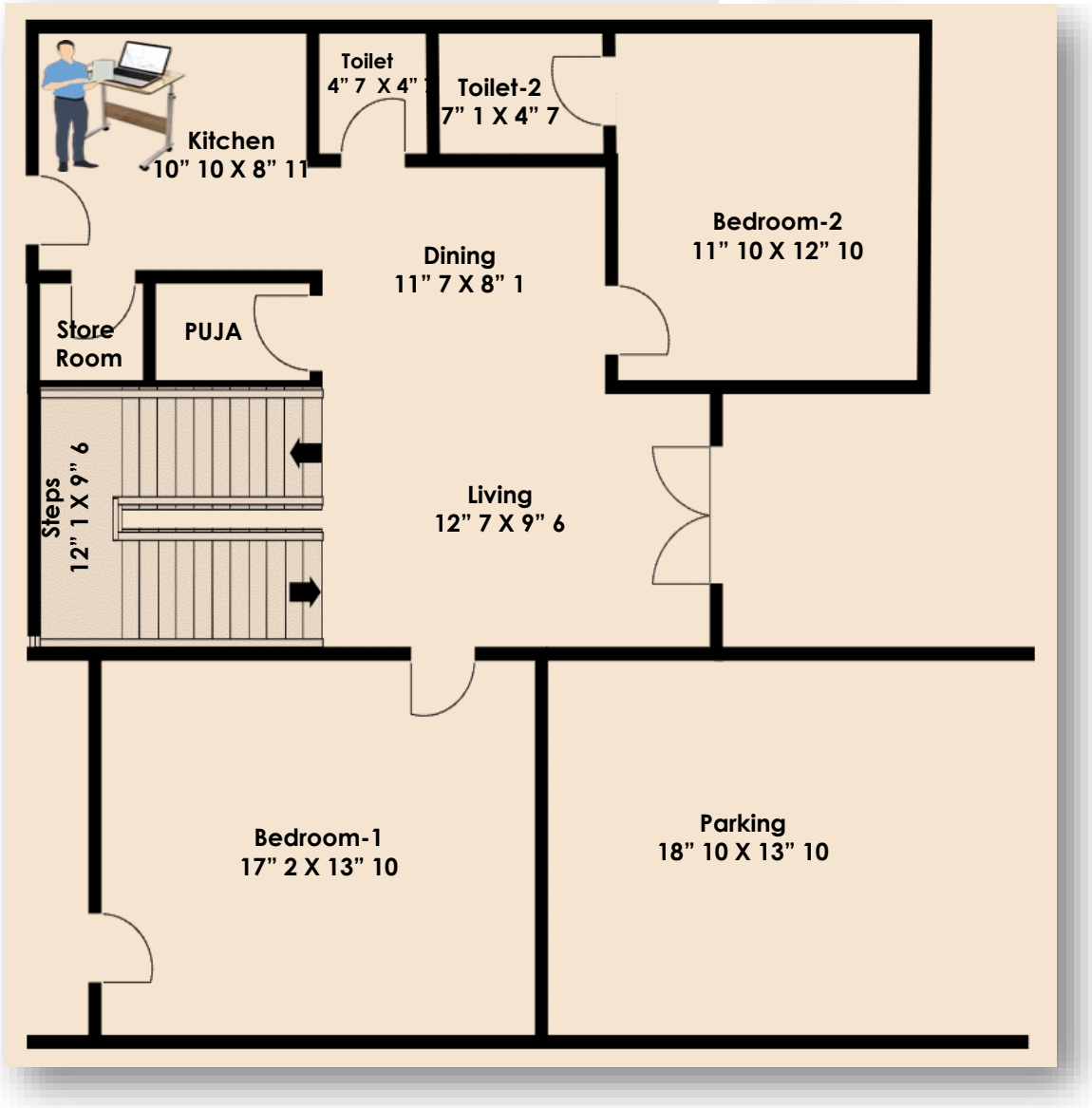
Specs
Tri-band System
Radio1: 2.4 GHz 2x2
Radio2: 5 GHz 4X4
Radio3: 6GHz 4x4
Build Info: **Build B**
Chipset: Qualcomm
Channel for 6G: 37, BW: 320MHz, TX power: 21 dBm
Channel for 5G: 36, BW: 160MHz, TX power: 23 dBm
Channel for 2.4G: 6, BW: 40MHz, TX power: 27 dBm

Test Client
One Plus 11

Specs
Android Version: 13
Chipset: Qualcomm
Dual band System
NSS: 2x2
WLAN: 802.11 a/b/g/n/ac/ax/be

Test Procedure

- The floor plan is loaded into the heatmap test software.
- The test engineer will physically take the client device to each test point without disconnecting the Wi-Fi.
- At each point, the tester will measure RSSI and run the TCP Upstream/Downstream throughput and other measurements at measurement point and push results to a database.
- The software then generates the heatmaps for coverage testing.



Ground Floor and First Floor Residential AP Coverage Comparison for Build A vs Build B

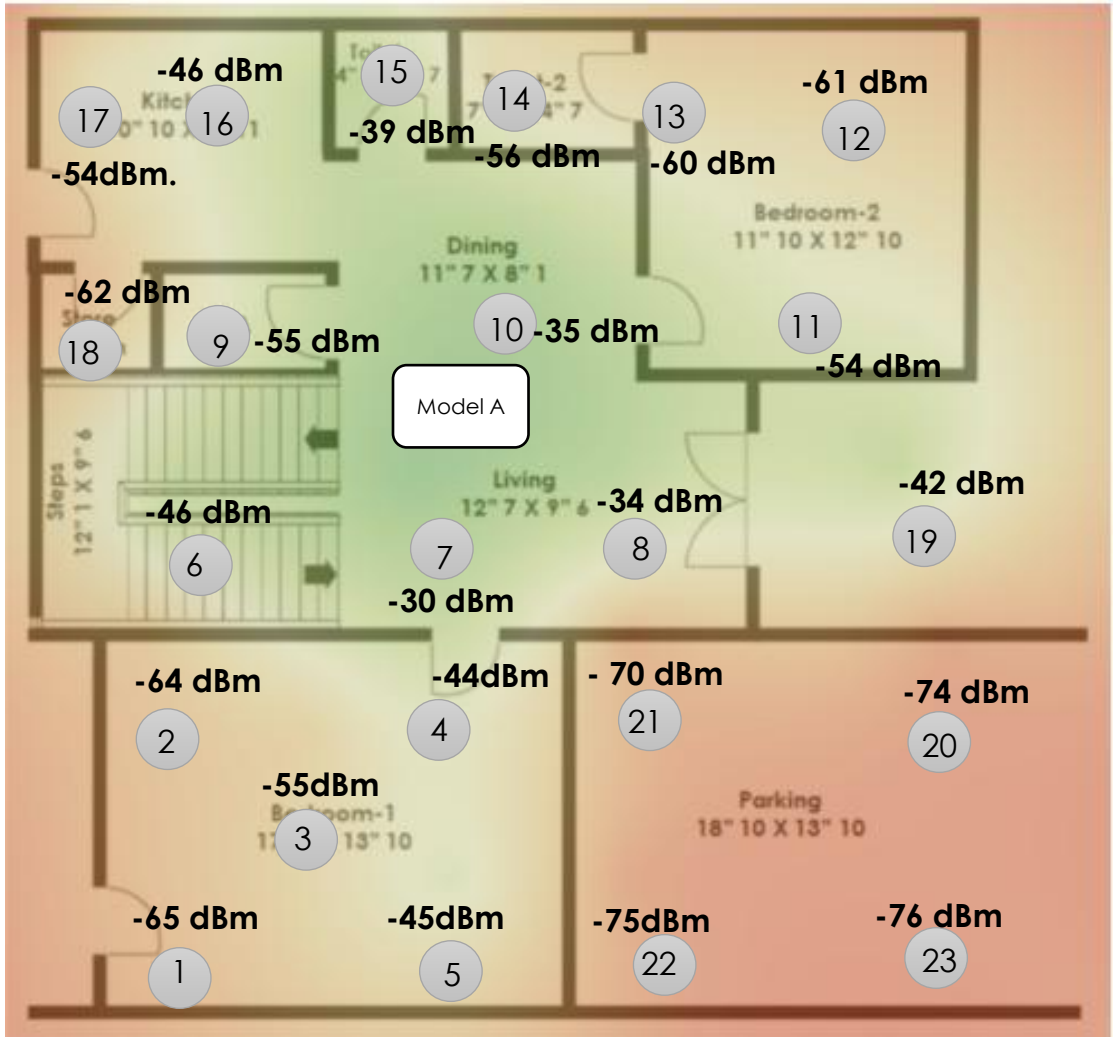
Analysis on 6GHz Band Coverage:

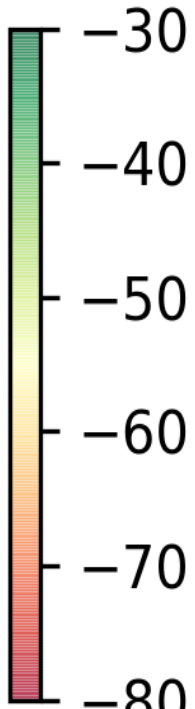
Parameters	Build B	Build A	Observations/Comments
Ground Floor - 6 GHz Coverage	Improved	Reduced	Highlights: With Build B, AP is able to provide coverage for the entire ground floor with a transmit power of 21 dB. Lowlights: With Build A, the AP is unable to provide complete coverage. There is no coverage in the parking area with a transmit power of 18 dB.
GF - 6GHz Max Throughput	Improved	Reduced	Highlights: • With Build B max DL throughput achieved is 3706 Mbps (Coordinate:- 8) whereas with Build A max throughput is 2873 Mbps (Coordinate:- 15). • With Build B max UL throughput achieved is 2954 Mbps (Coordinate:- 7) whereas with Build A max throughput is 2586Mbps (Coordinate:- 15).
GF - Overall experience	Improved	Reduced	Highlights: Build B provides complete coverage for the entire floor. The TCP download throughput values of the Build B are higher than those of the Build A. Lowlights: The Build B exhibits higher upload throughput values than the Build A, except at coordinates 10, 5, and 19.
First Floor - 6 GHz Coverage	Improved	Reduced	Highlights: With Build B, the AP is unable to provide complete coverage on First floor. There is no coverage for 13 coordinates with a transmit power of 21 dB. Lowlights: With Build A, the AP is unable to provide complete coverage. There is no coverage for 14 coordinates with a transmit power of 18 dB.
FF - 6GHz Max Throughput	Improved	Reduced	Highlights: • With Build B max DL throughput achieved is 3604 Mbps (Coordinate:- 24) whereas with Build A max throughput is 2933 Mbps (Coordinate:- 24). • With Build B max UL throughput achieved is 2845 Mbps (Coordinate:- 24) whereas with Build A max throughput is 3016 Mbps (Coordinate:- 24).
FF - Overall experience	Improved	Reduced	Highlights: The TCP download throughput values of the Build B are higher than those of the Build A. Lowlights: The Build B exhibits higher upload throughput values than the Build A, except at coordinates 9, 10, 11, 15, 19, 24 and 28.

AP RSSI in 6GHz

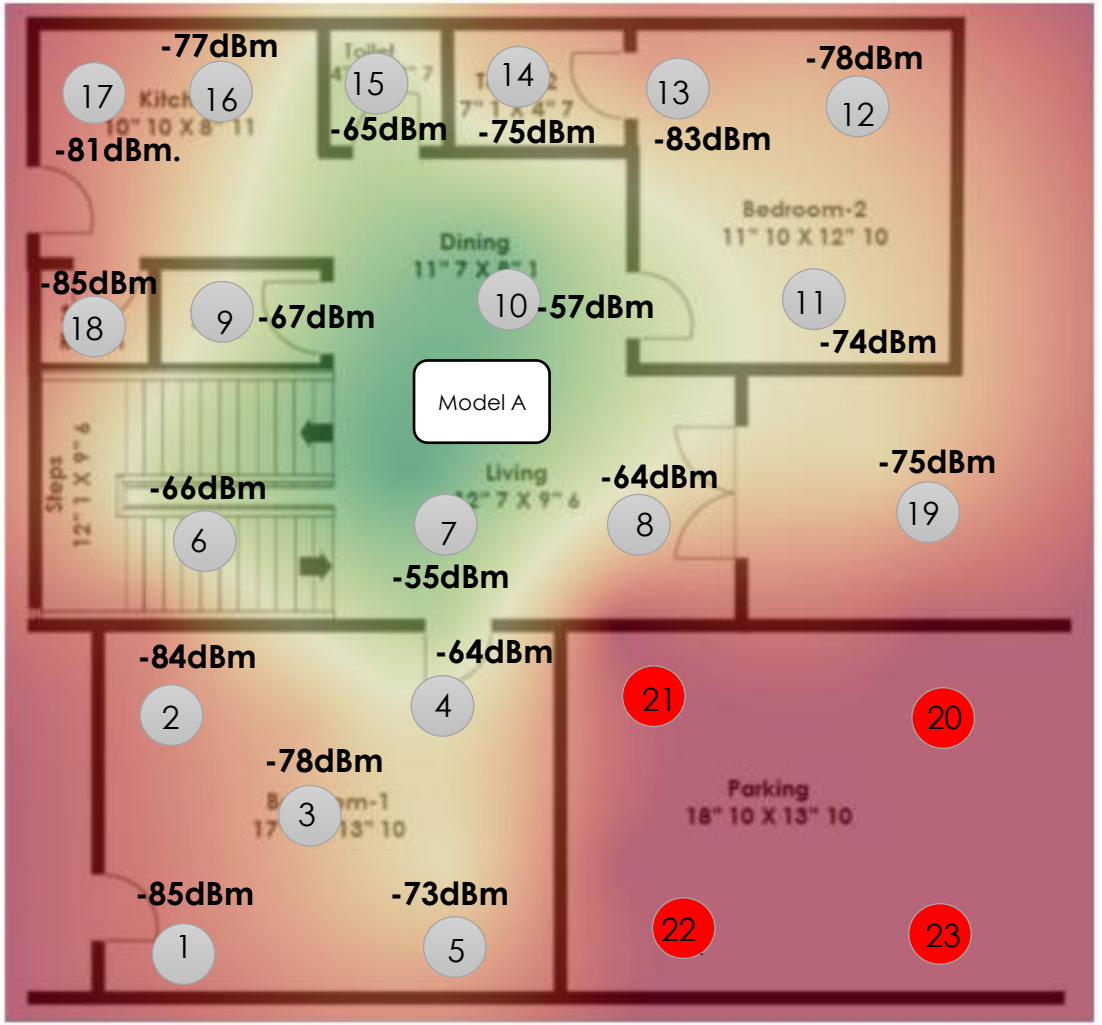
Ground Floor signal strength (dBm)

Build B





Build A



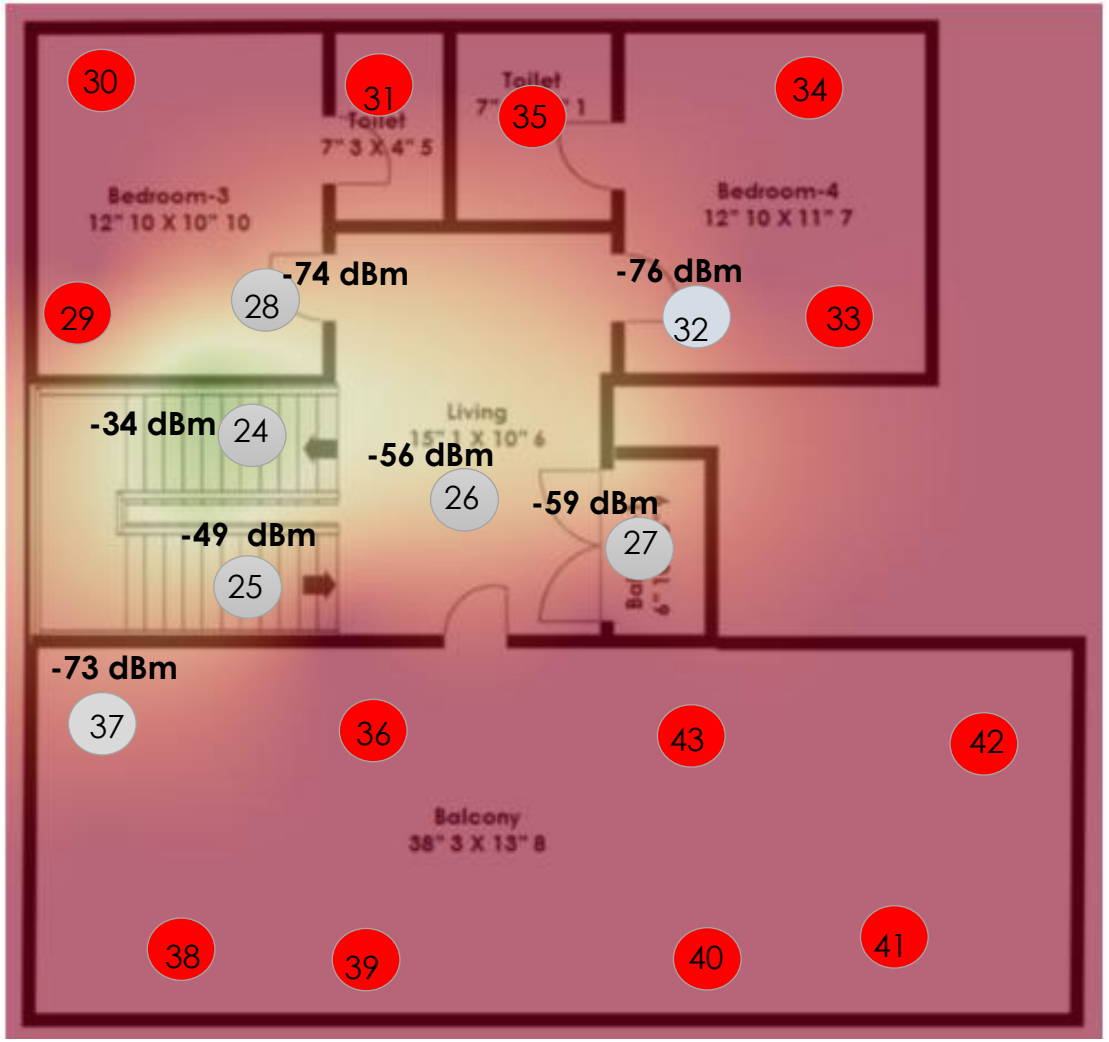
Client connected state

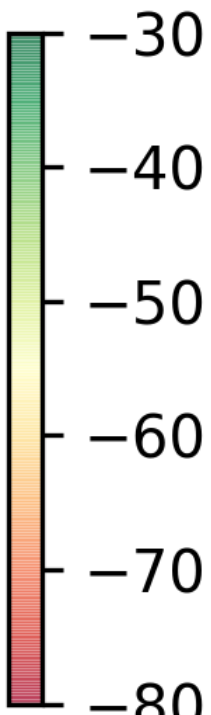
Client disconnected state

AP RSSI in 6GHz

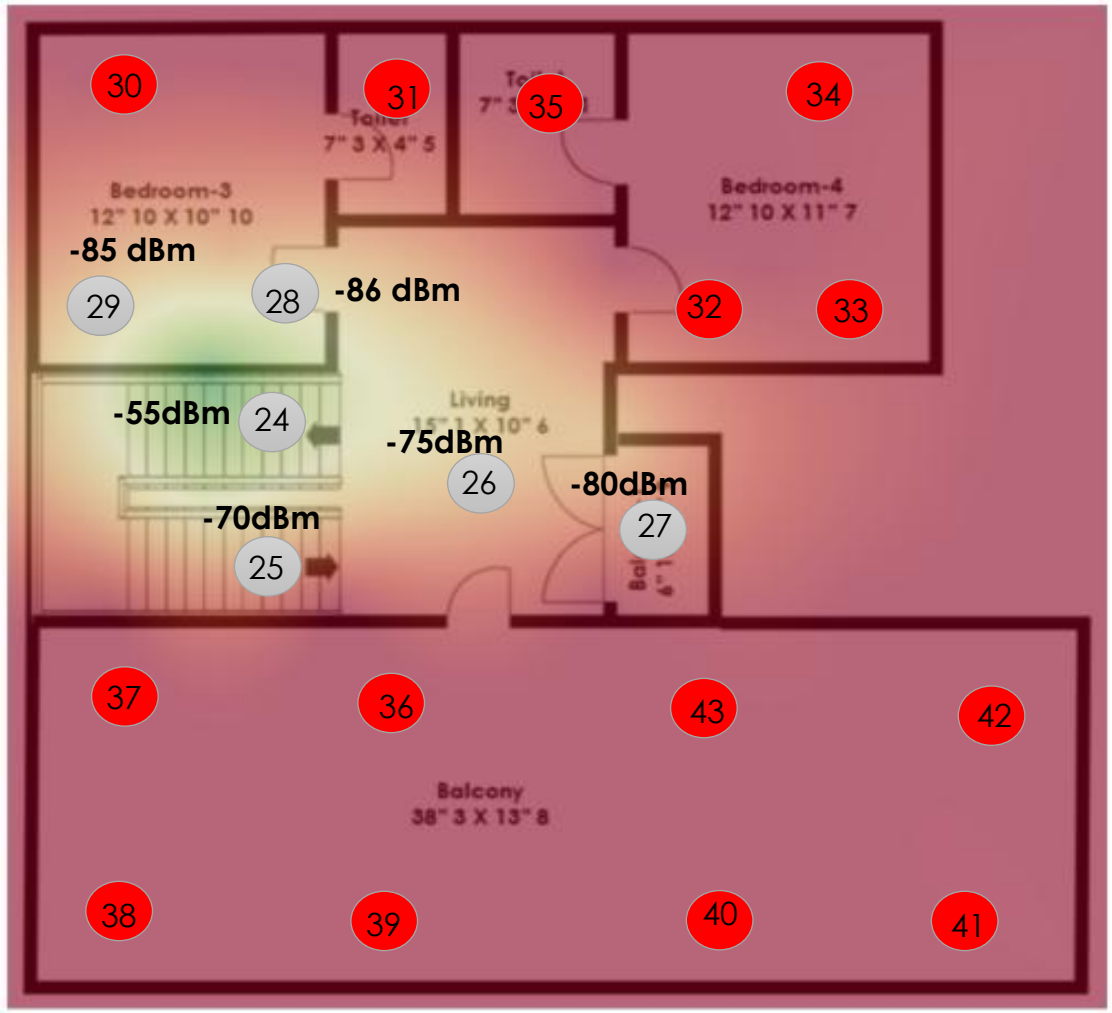
First Floor signal strength (dBm)

Build B





Build A



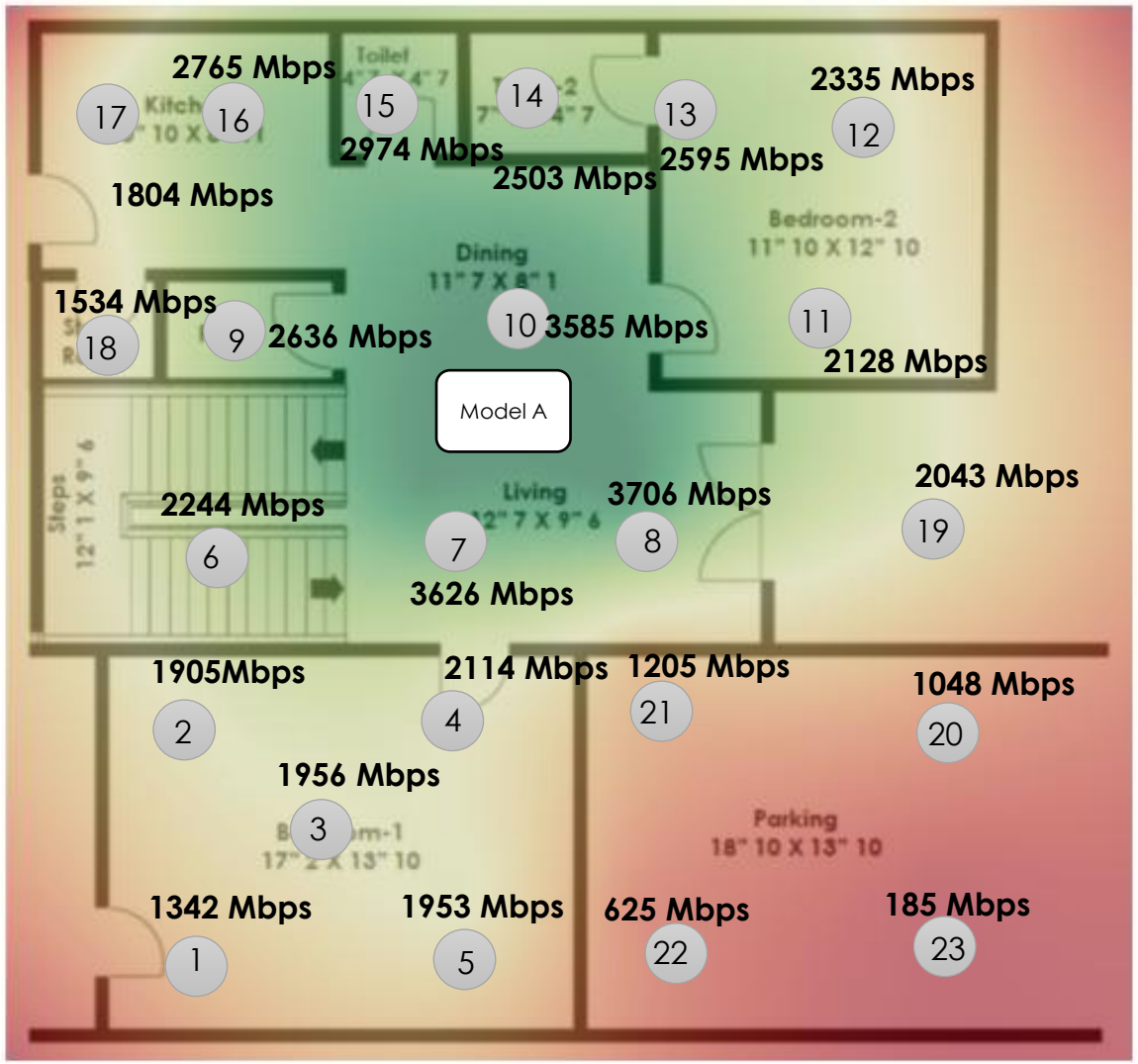
Client connected state

Client disconnected state

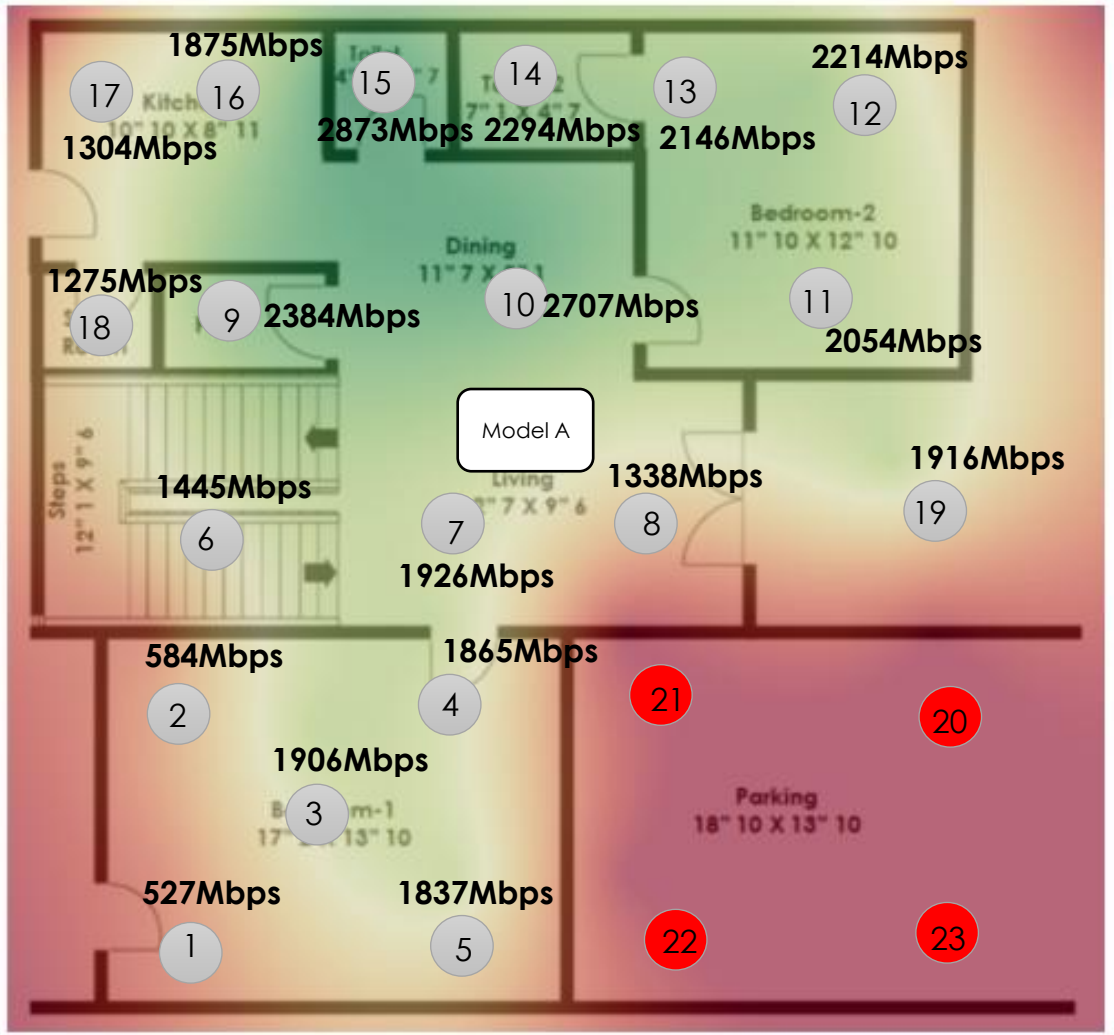
TCP_DL in 6GHz

Ground Floor Download TCP (Mbit/s)

Build B



Build A



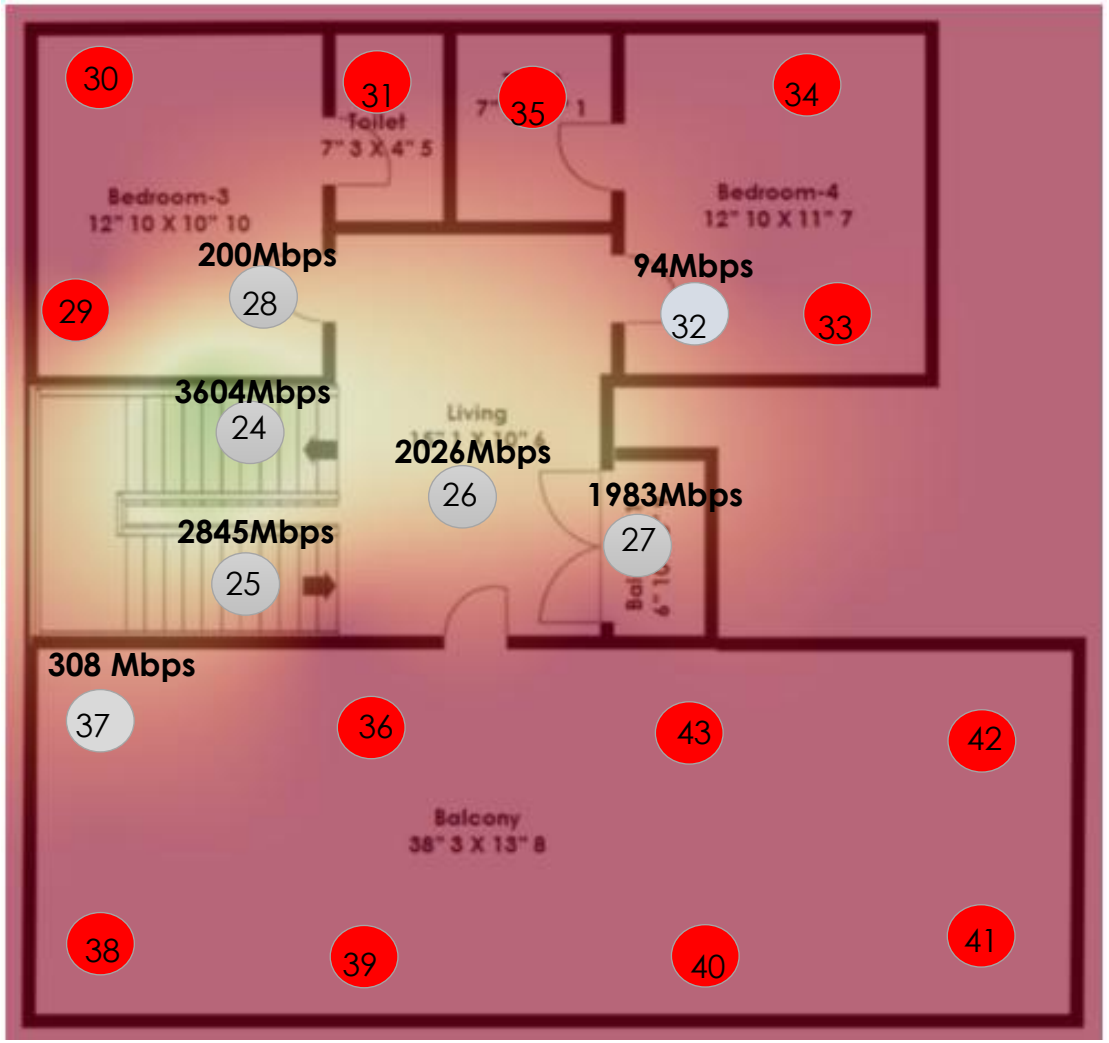
Client connected state

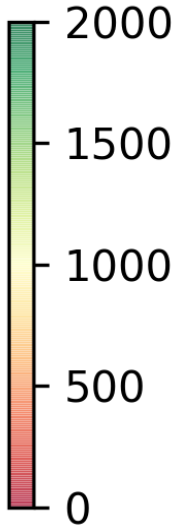
Client disconnected state

TCP_DL in 6GHz

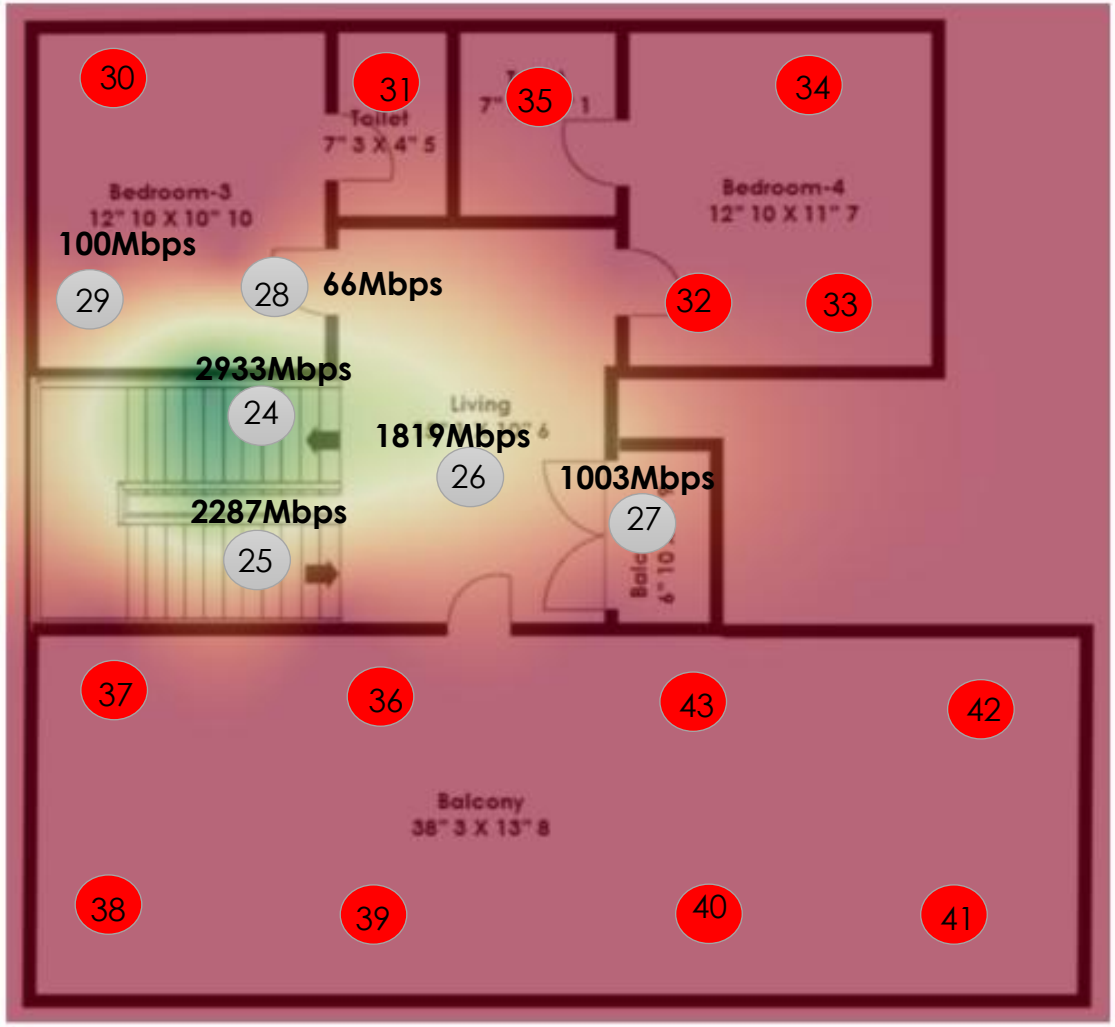
First Floor TCP Download (Mbps)

Build B





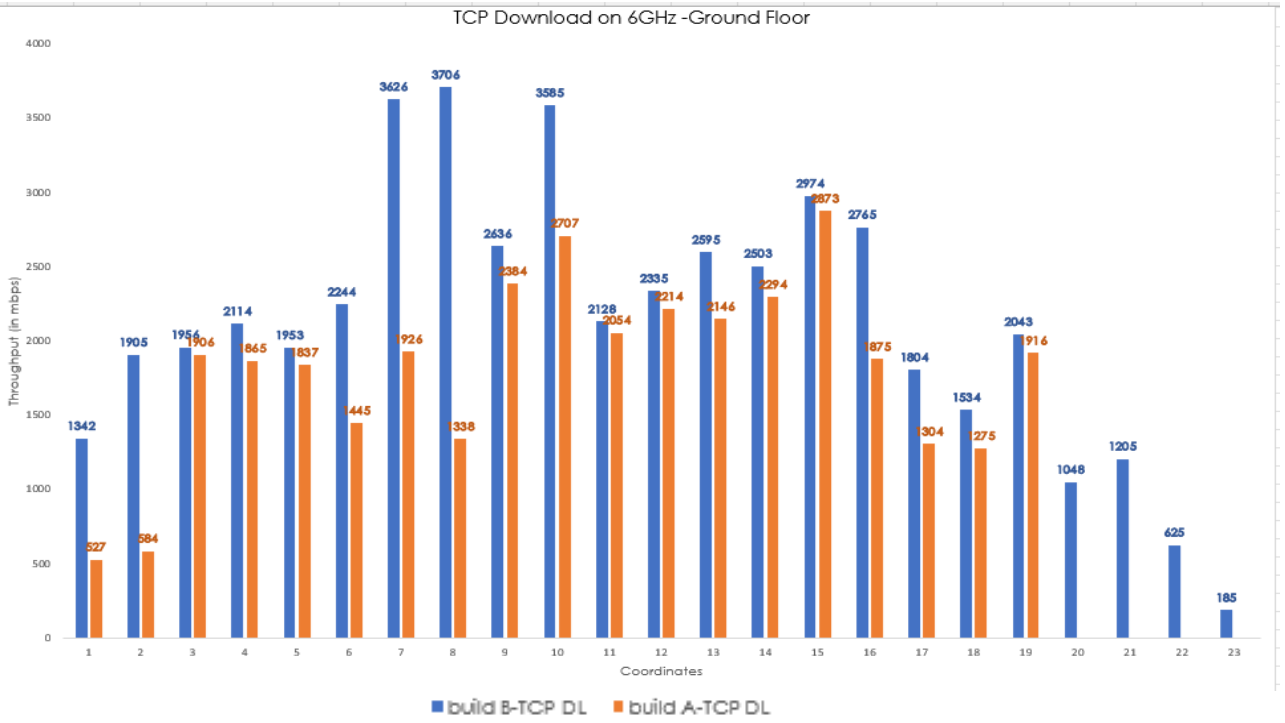
Build A

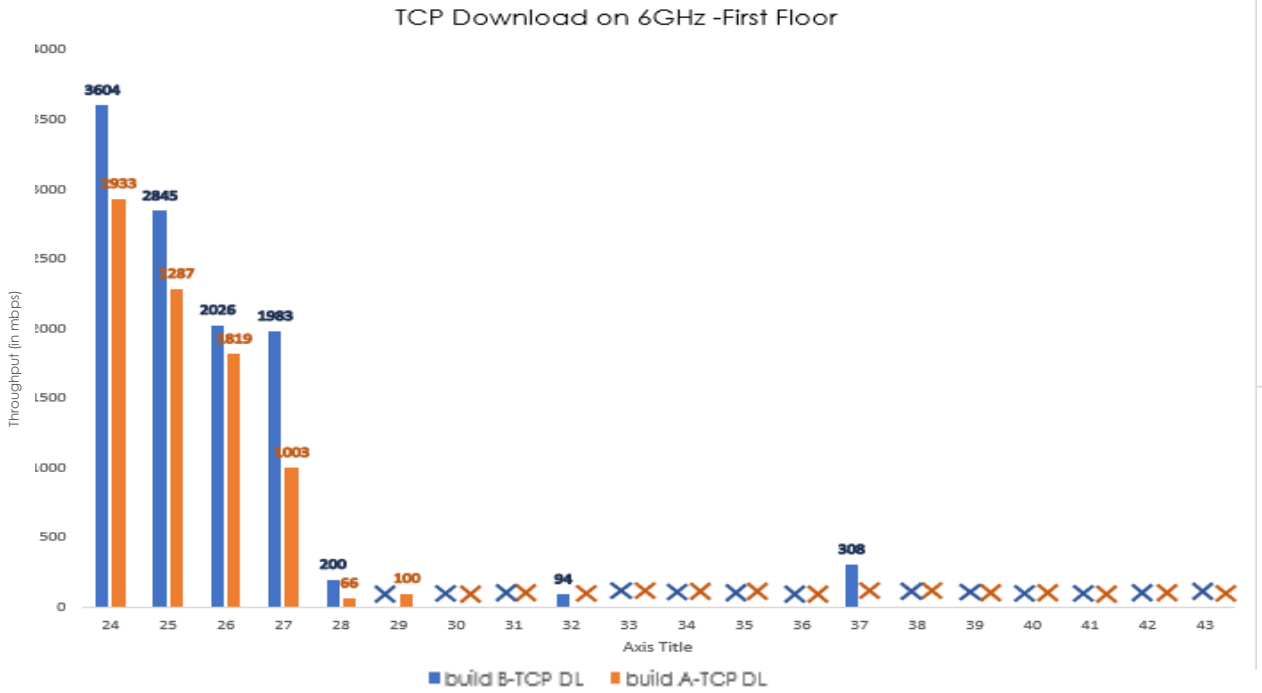


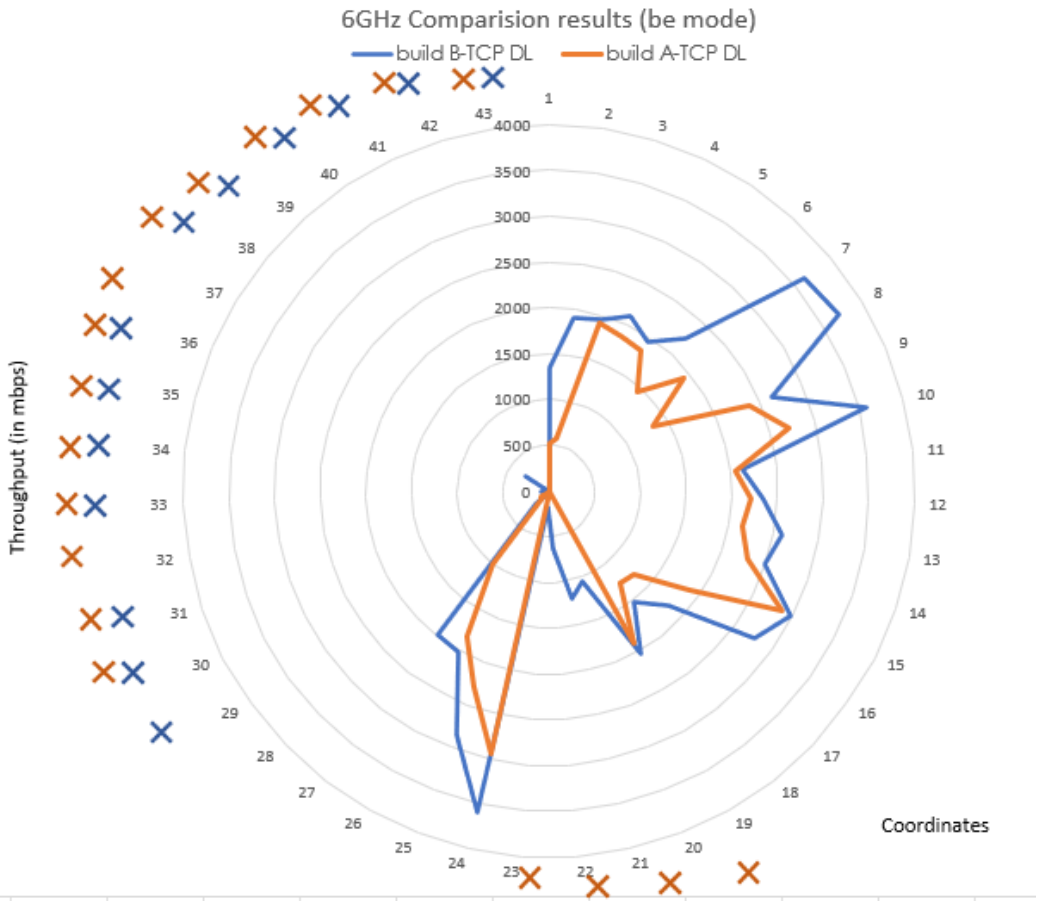
Client connected state

Client disconnected state

TCP Download on 6GHz Band







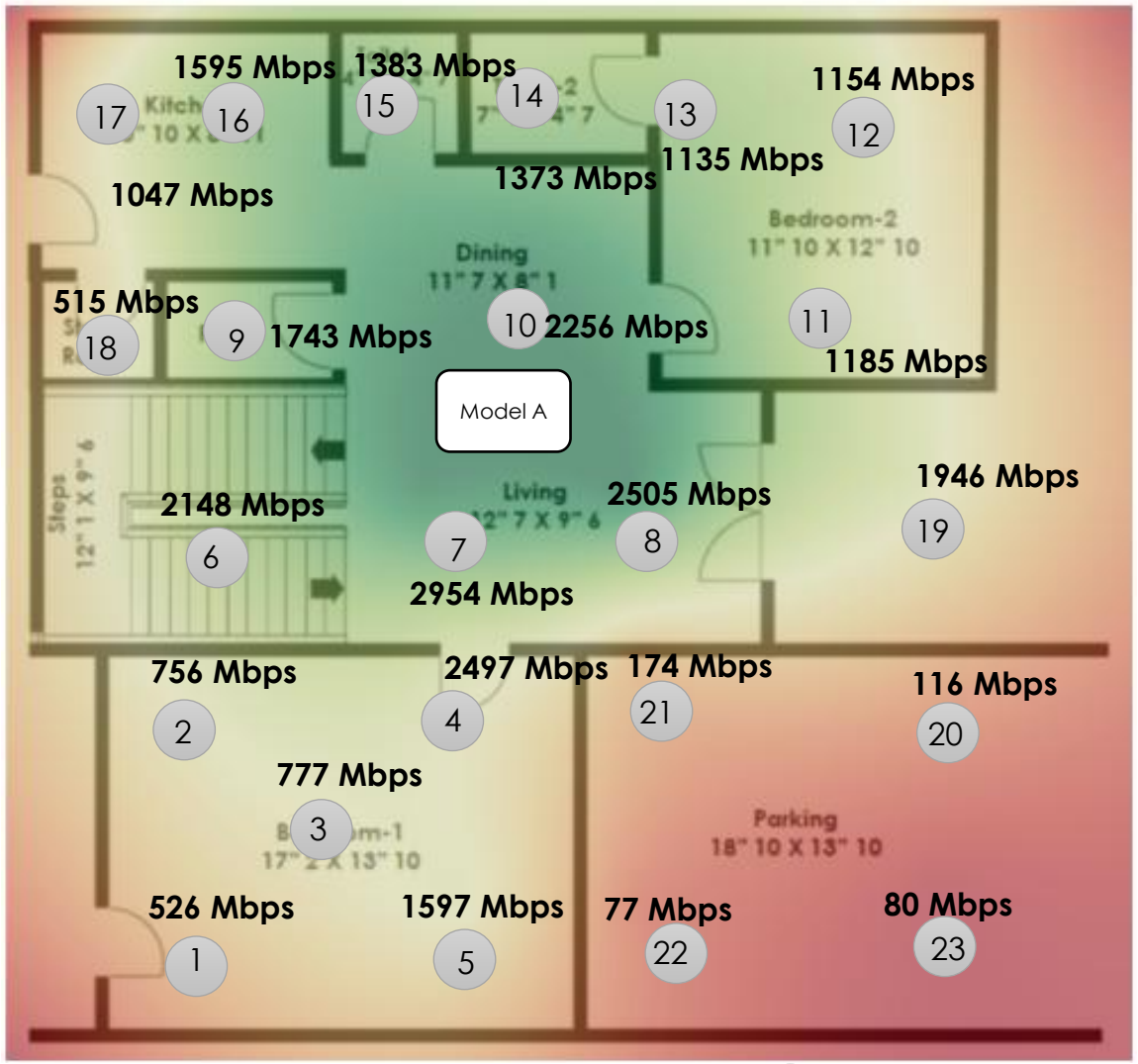
✕ Build A Wi-Fi Dead Zone

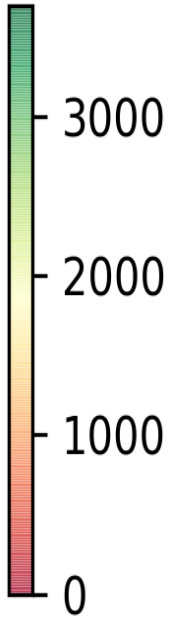
✕ Build B Wi-Fi Dead Zone

TCP_UL in 6GHz

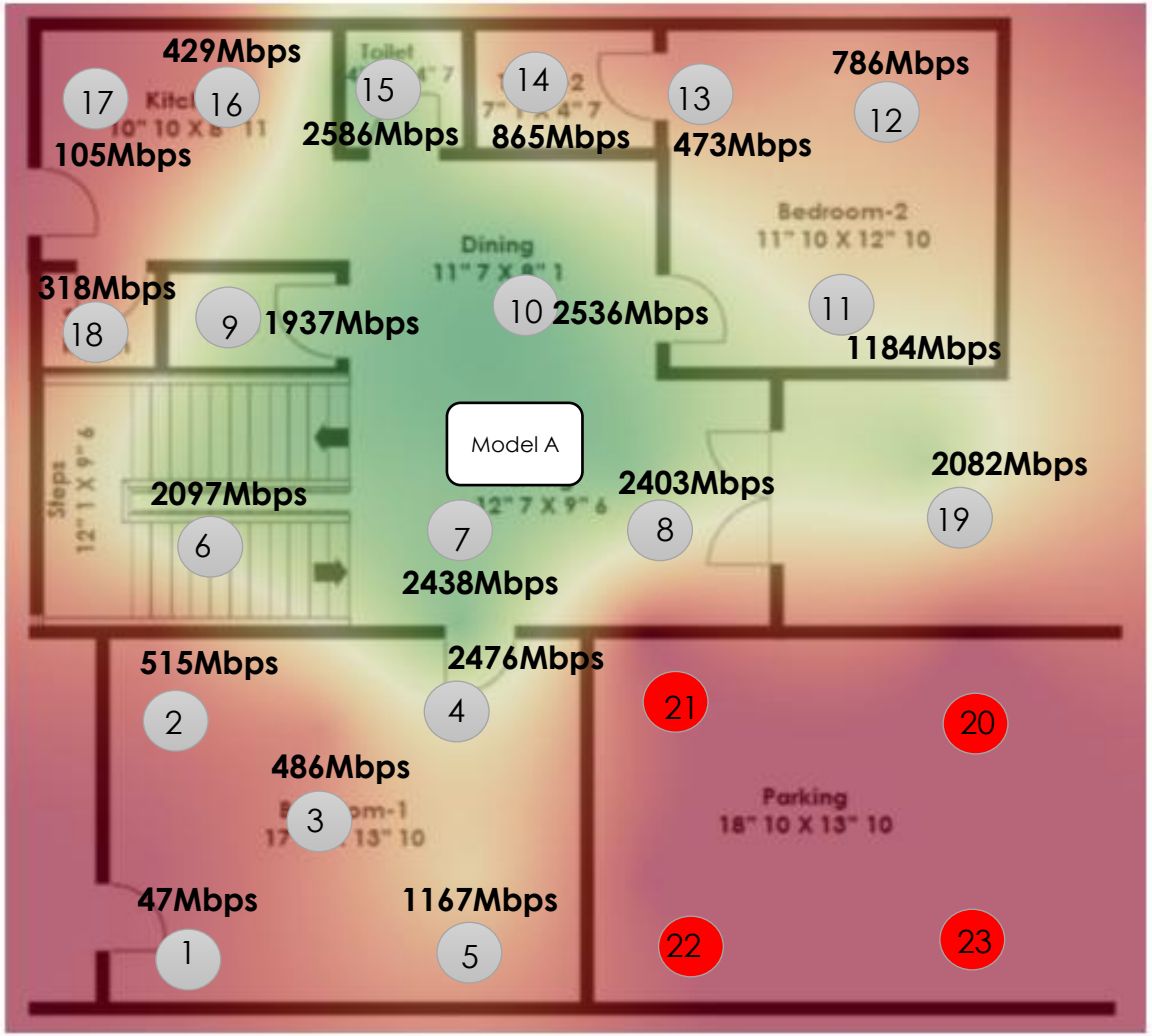
Ground Floor Upload TCP (Mbit/s)

Build B





Build A

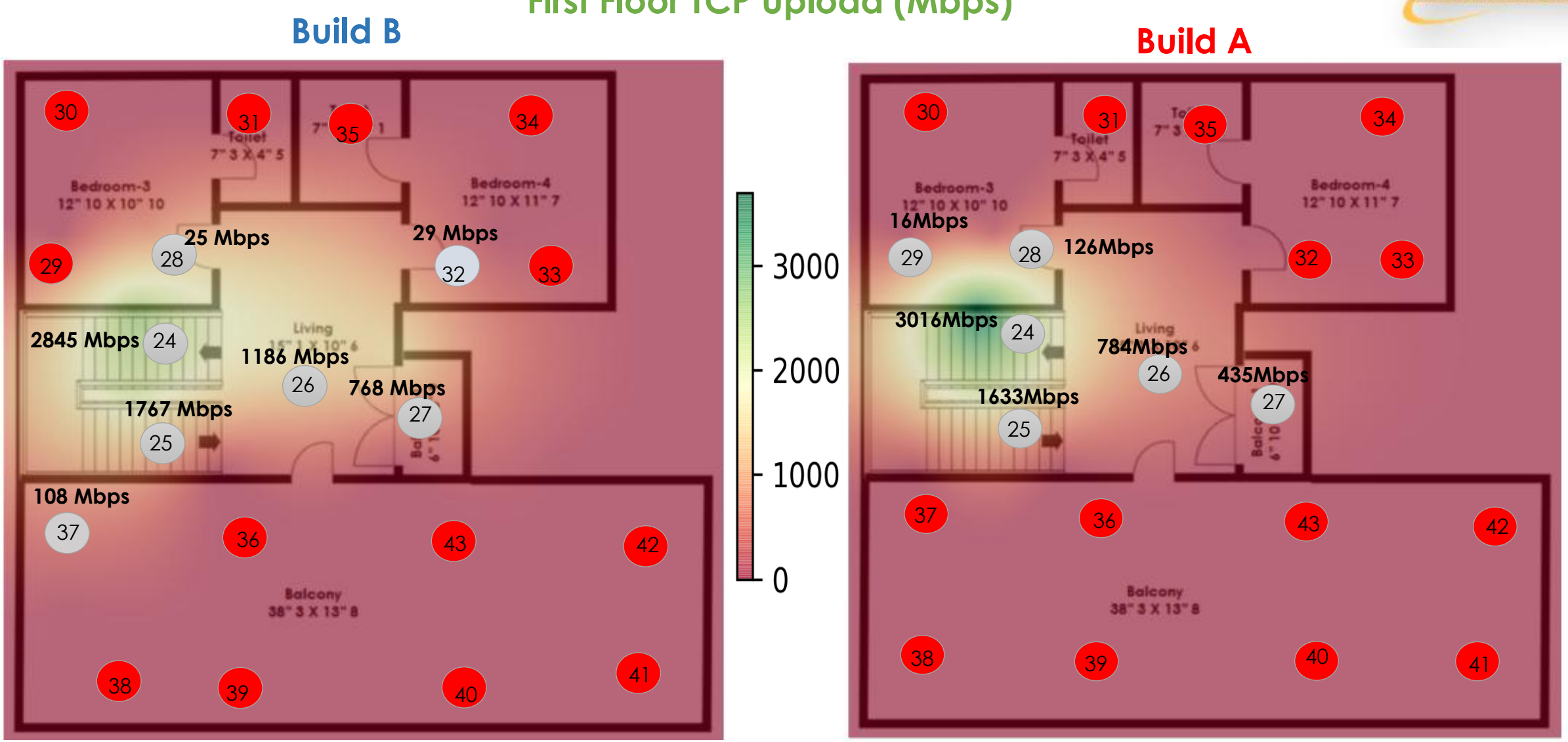


Client connected state

Client disconnected state

TCP_UL in 6GHz

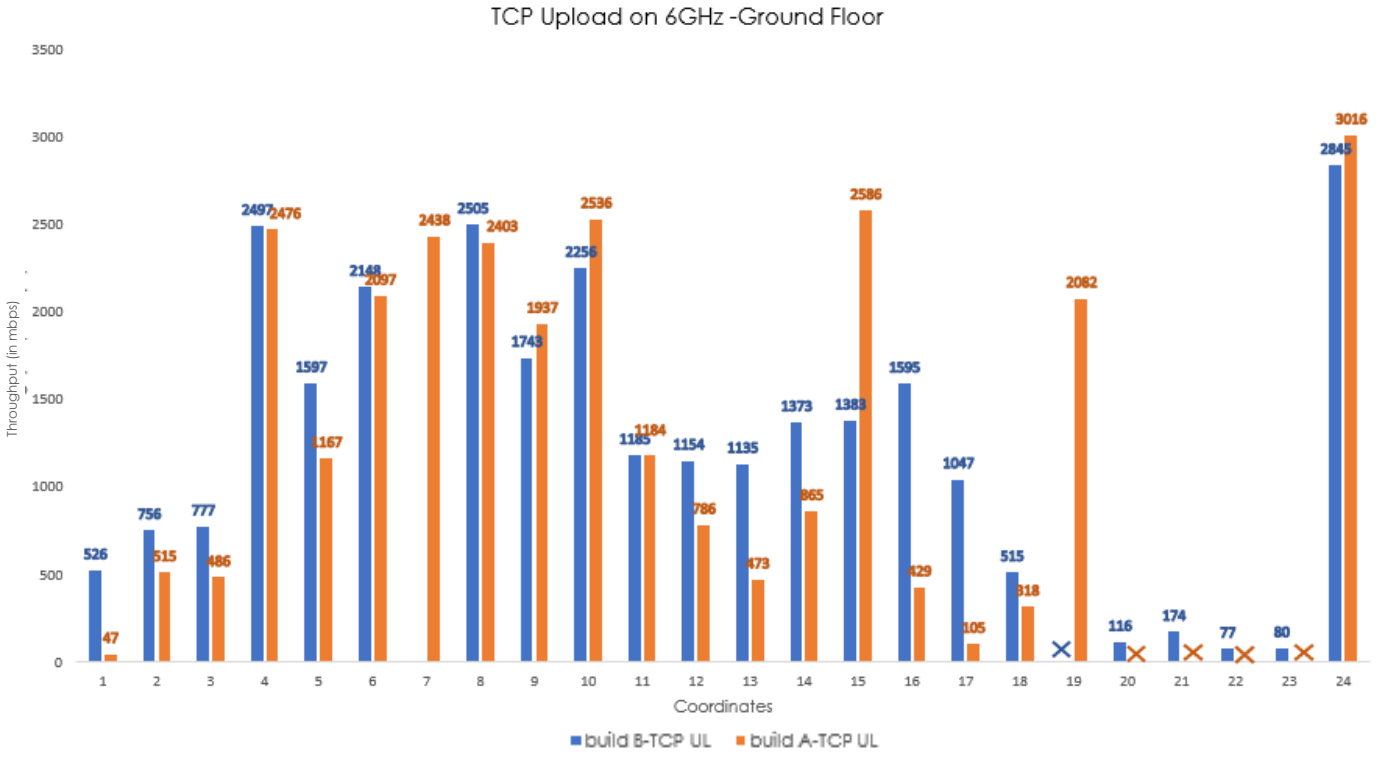
First Floor TCP Upload (Mbps)

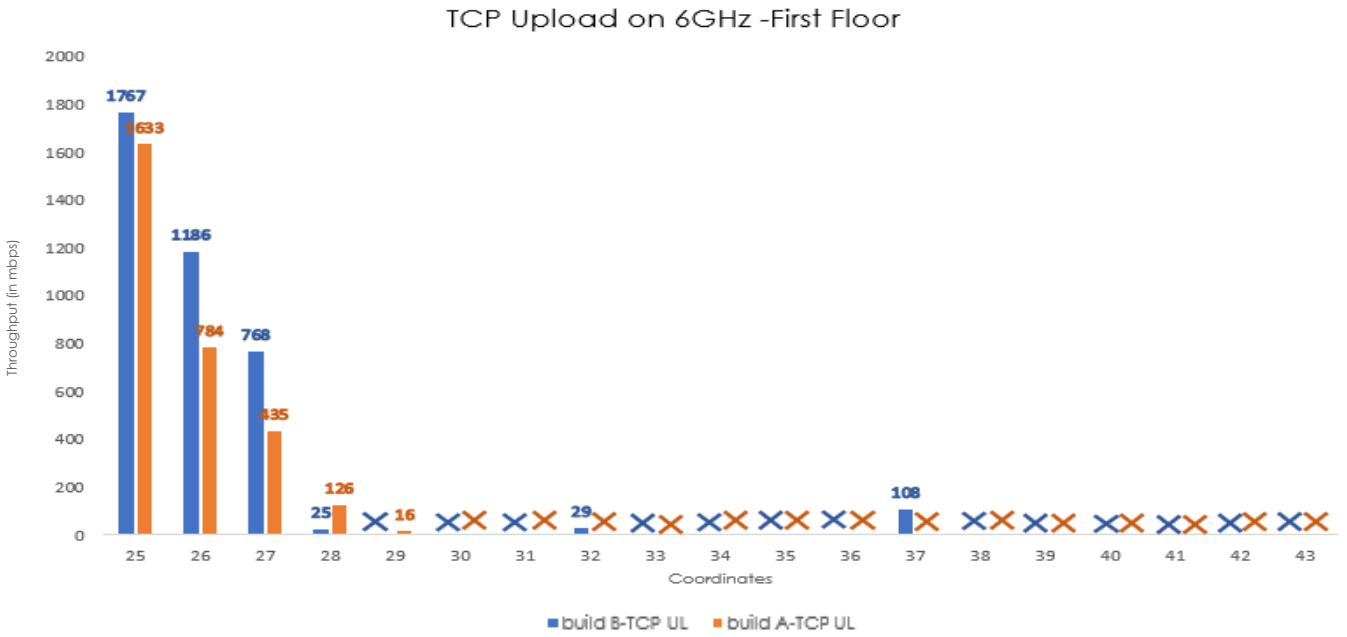


Client connected state

Client disconnected state

TCP Upload on 6GHz Band





Build A Wi-Fi Dead Zone

Build B Wi-Fi Dead Zone

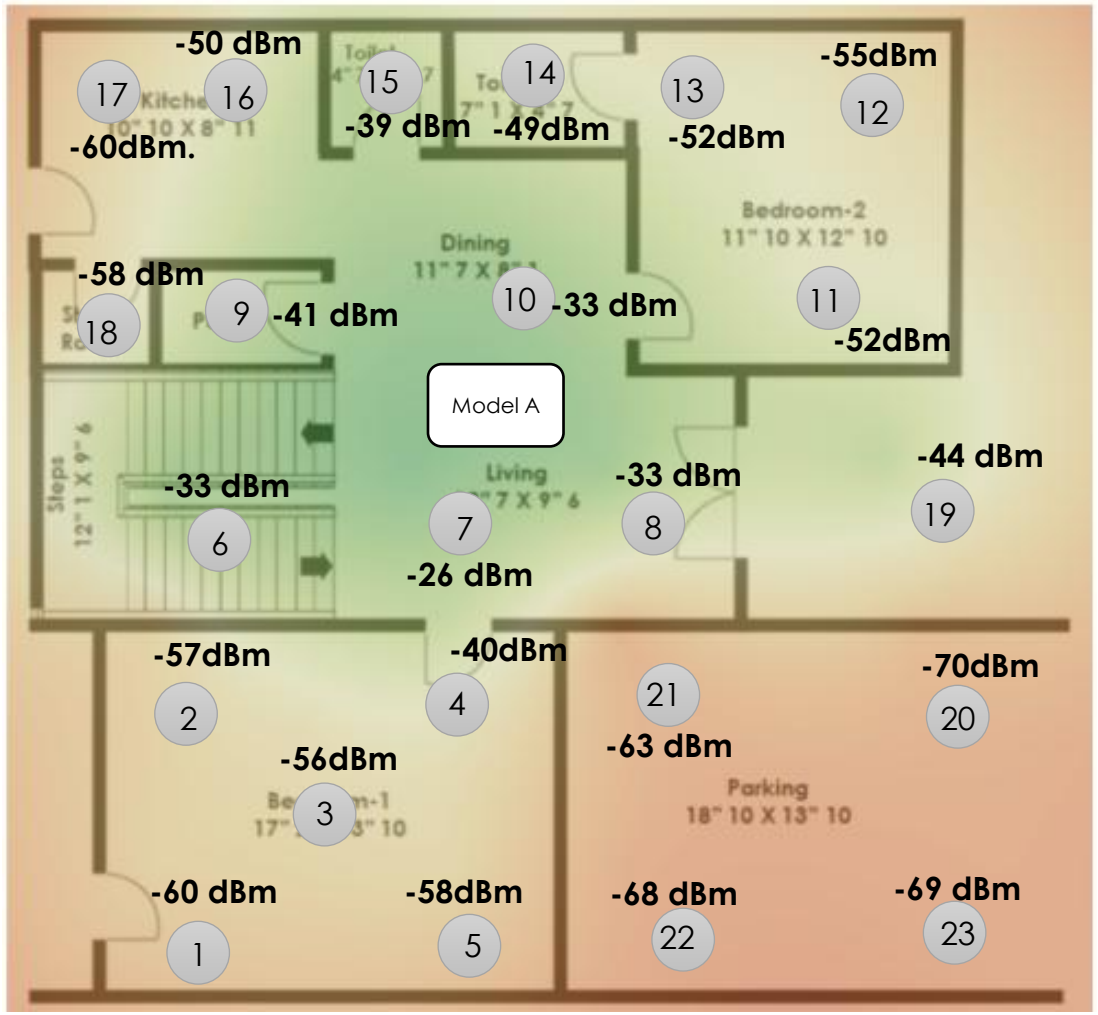
Analysis on 5GHz Band coverage:

Parameters	Build B	Build A	Observations/Comments
Ground Floor - 5 GHz Coverage	Improved	Reduced	Highlights: With both Build A & Build B, AP is able to provide coverage for the entire ground floor with a transmit power of 23 dB.
GF - 5 GHz Max Throughput	Improved	Reduced	Highlights: • With Build B max DL throughput achieved is 2012 Mbps (Coordinate:- 7) whereas with Build A max throughput is 1882 Mbps (Coordinate:- 7). • With Build B max UL throughput achieved is 1876 Mbps (Coordinate:- 6) whereas with Build A max throughput is 1924Mbps (Coordinate:- 7).
GF - Overall experience	Improved	Reduced	Highlights: • Build B provides complete coverage for the entire floor. • In both TCP DL and UL, throughput values of the Build B are higher than those of the Build A. Lowlights: • The Build B exhibits higher download throughput values than the Build A, except at coordinates 1, 3, 4, 5, 9, 11, 12, 14, 16, 19 and 23. • The Build B exhibits higher upload throughput values than the Build A, except at coordinates 4, 7, 9, 13, 14, 16, 17 and 21.
First Floor - 5 GHz Coverage	Improved	Reduced	Highlights: With both Build A & Build B, AP is able to provide coverage for the entire First floor with a transmit power of 23 dB.
FF - 5 GHz Max Throughput	Improved	Reduced	Highlights: • With Build B max DL throughput achieved is 2077 Mbps (Coordinate:- 24) whereas with Build A max throughput is 1679 Mbps (Coordinate:- 24). • With Build B max UL throughput achieved is 2103 Mbps (Coordinate:- 24) whereas with Build A max throughput is 1774 Mbps (Coordinate:- 24).
FF - Overall experience	Improved	Reduced	Highlights: • Both Build A & Build B provides complete coverage for the entire floor. • In both TCP DL and UL, throughput values of the Build B are higher than those of the Build A. Lowlights: • The Build B exhibits higher download throughput values than the Build A, except at coordinates 25, 26, 27, 29, 42 and 43. • The Build B exhibits higher upload throughput values than the Build A, except at coordinates 26, 27, 32, 35, 38, 41, 42 and 43.

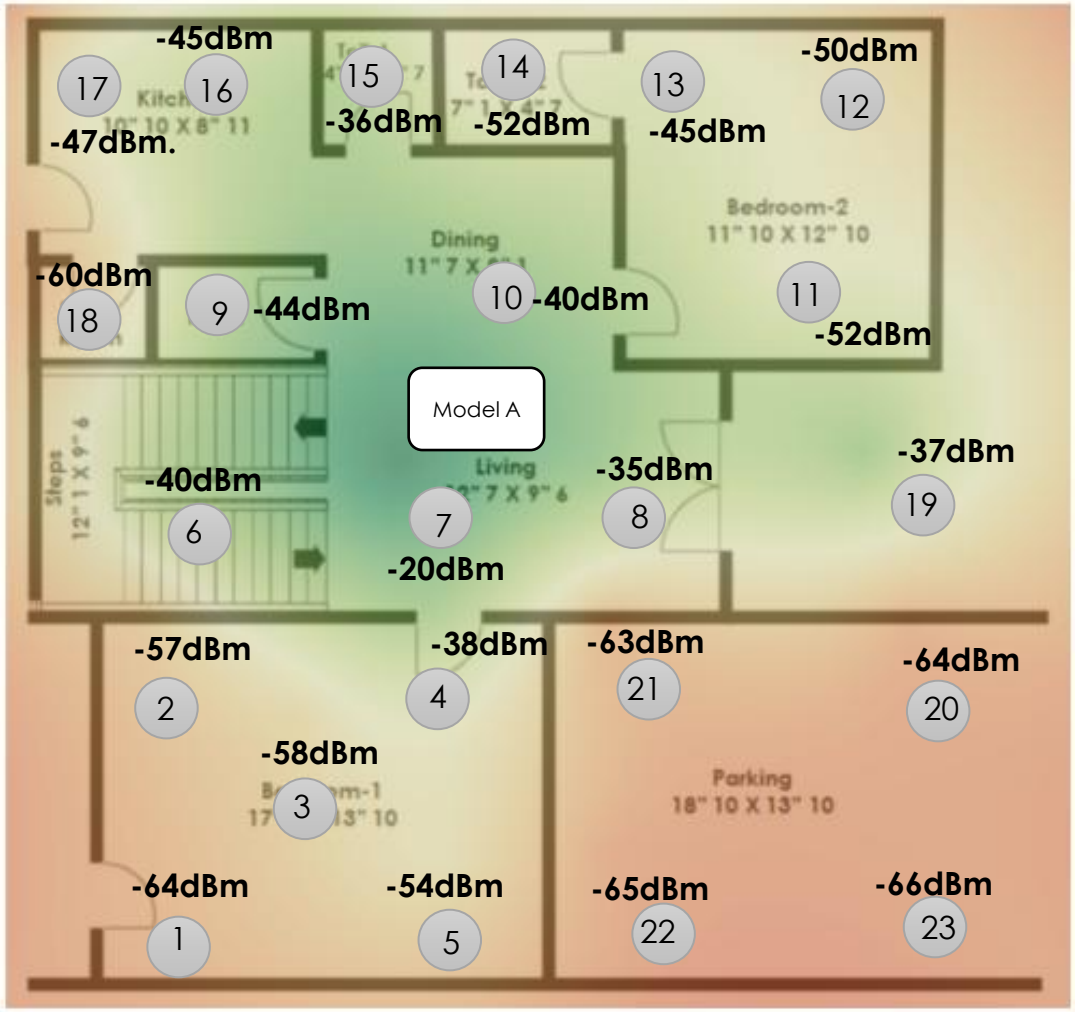
AP RSSI in 5GHz

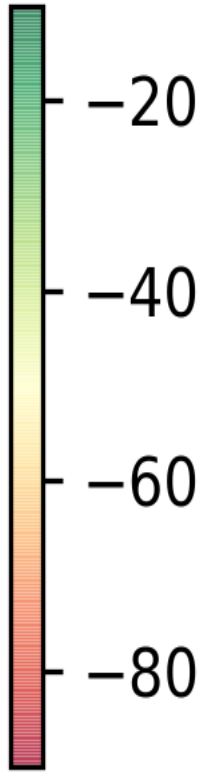
Ground Floor signal strength (dBm)

Build B



Build A





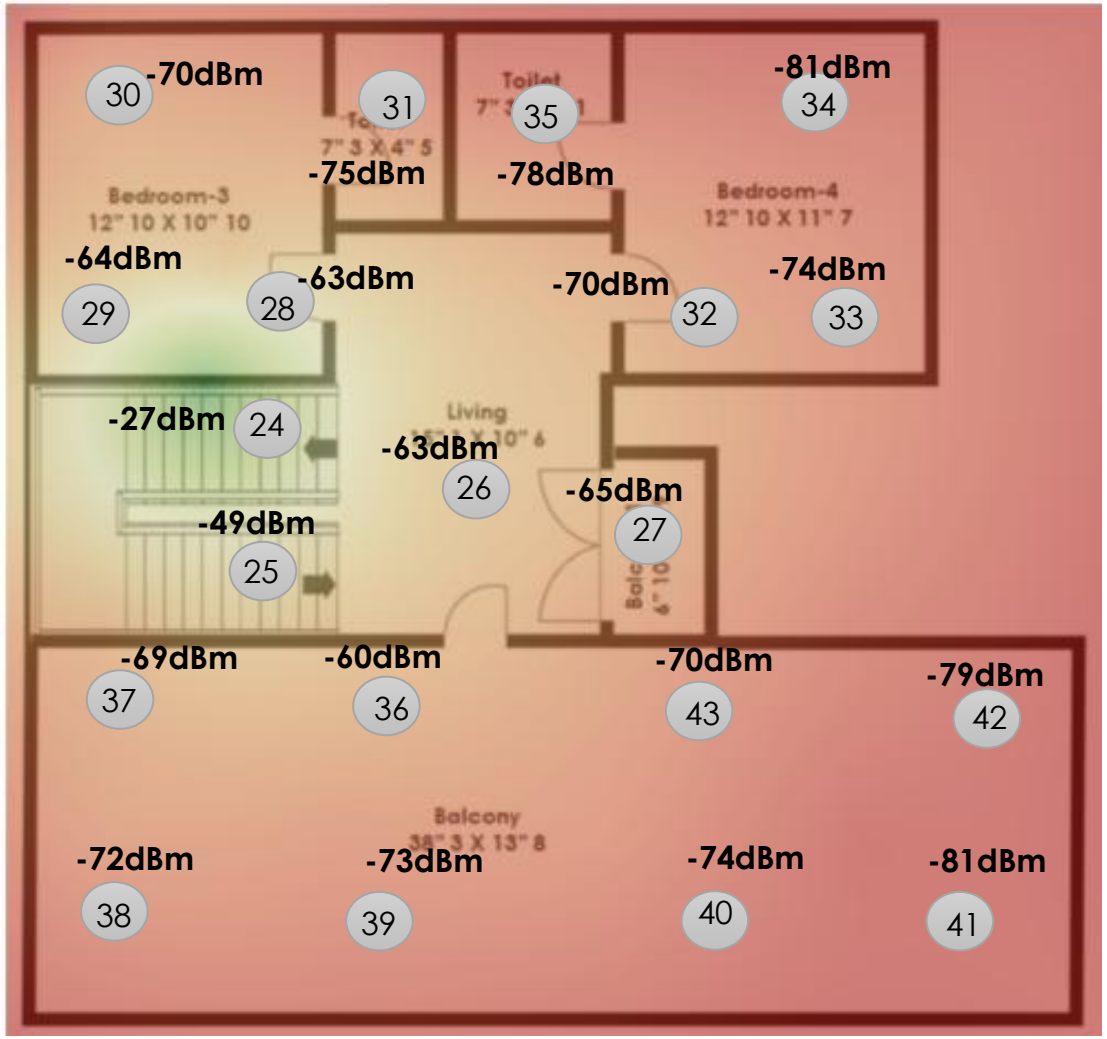
Client connected state

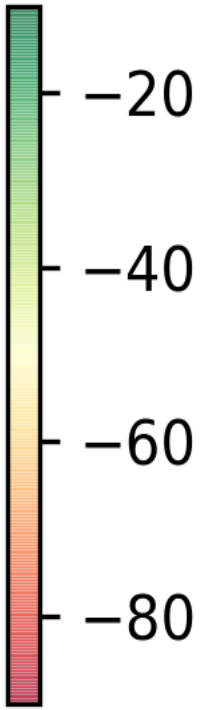
Client disconnected state

AP RSSI in 5GHz

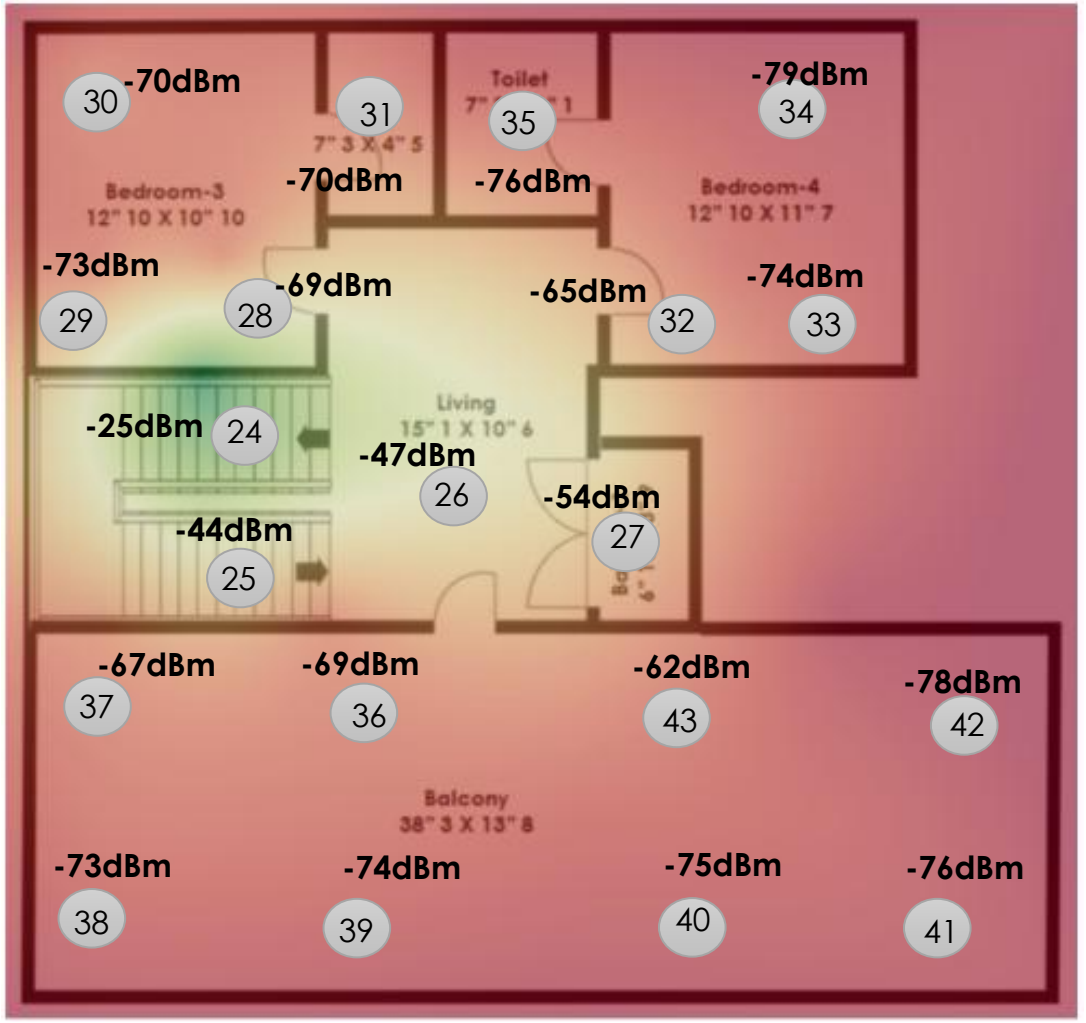
First Floor signal strength (dBm)

Build B





Build A



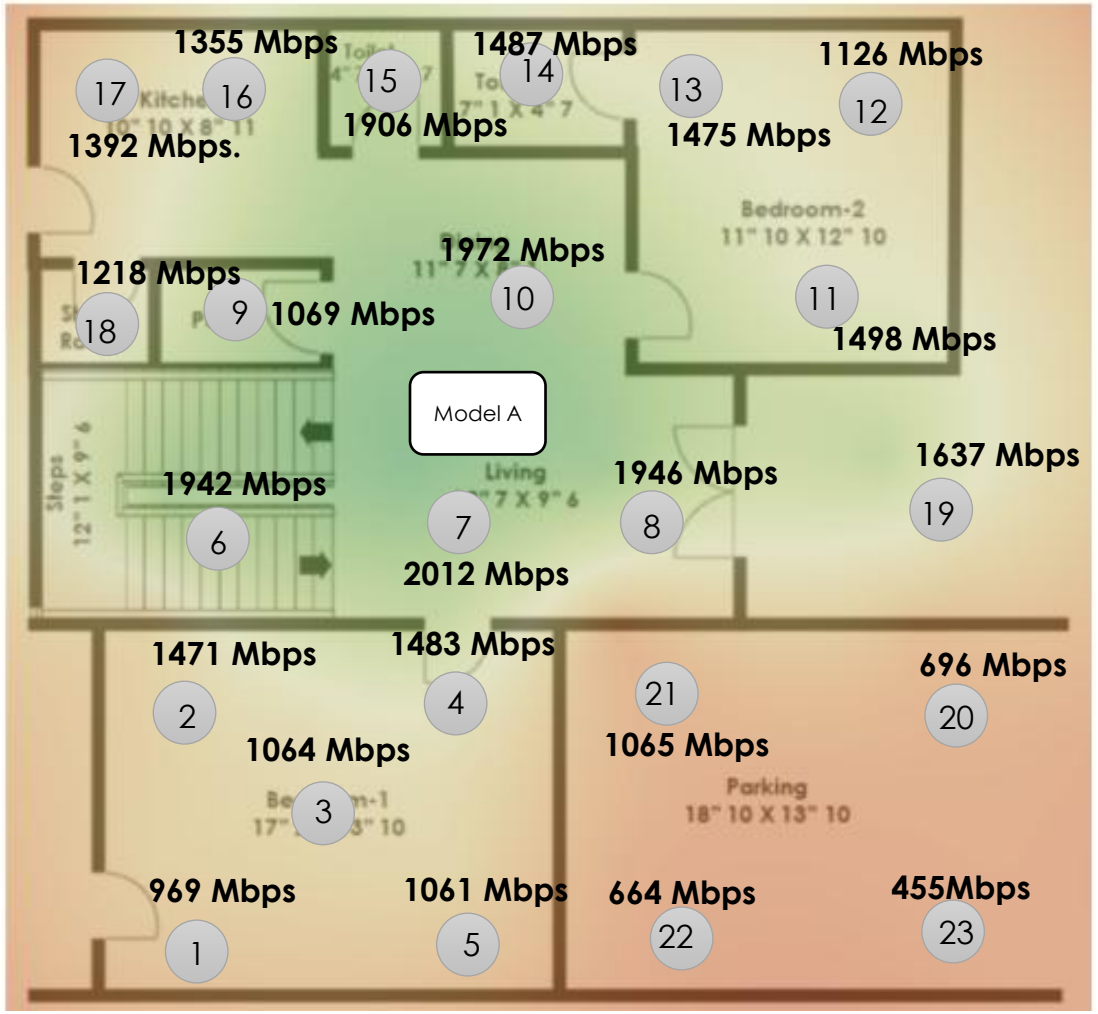
Client connected state

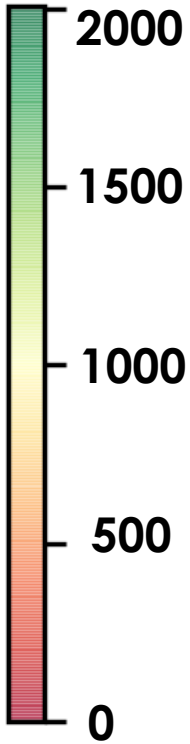
Client disconnected state

TCP_DL in 5GHz

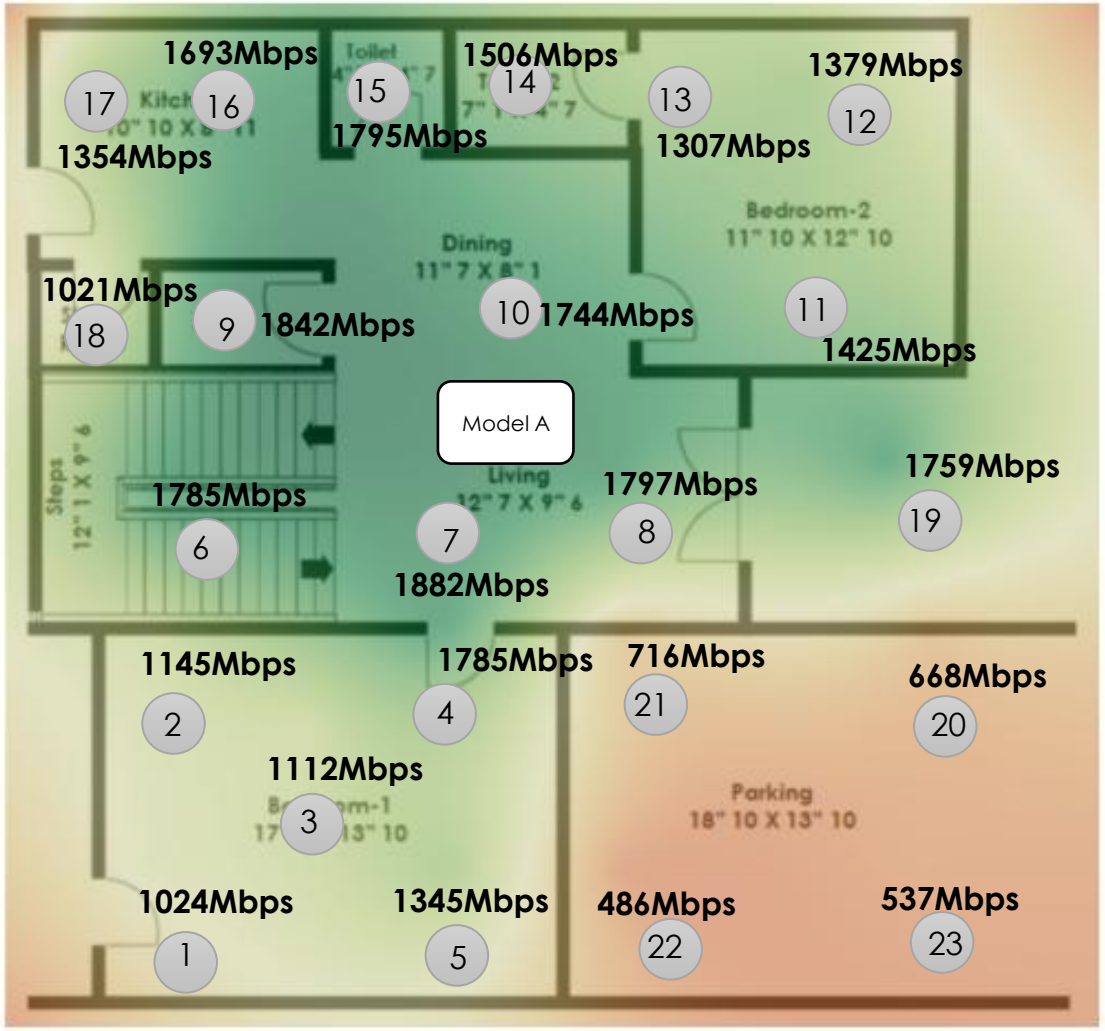
Ground Floor Download TCP (Mbit/s)

Build B





Build A



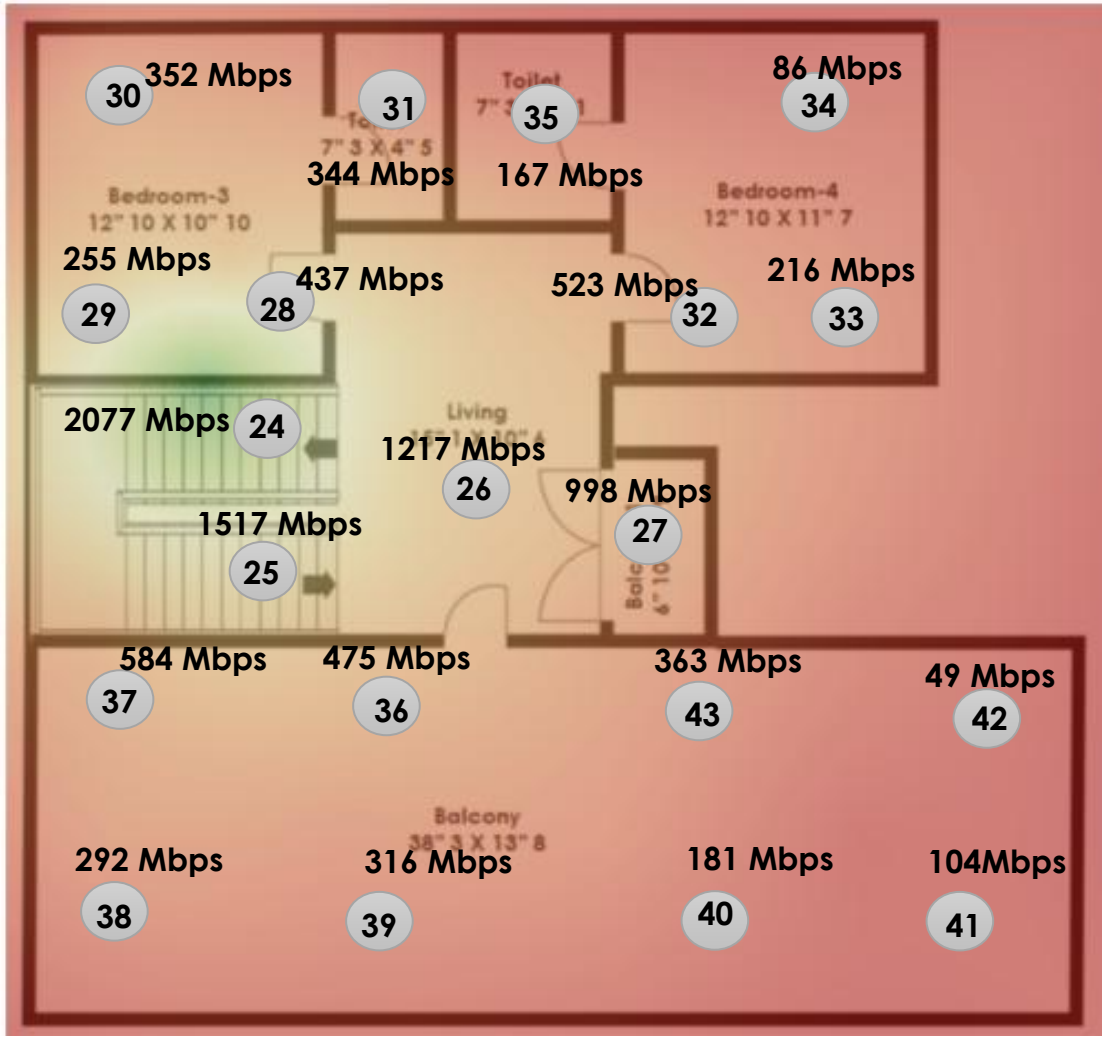
Client connected state

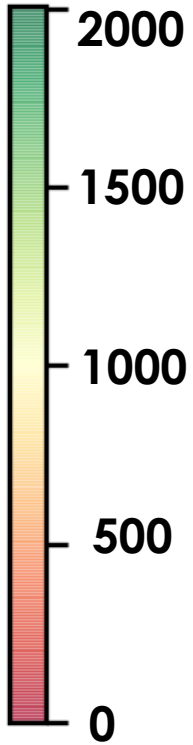
Client disconnected state

TCP_DL in 5GHz

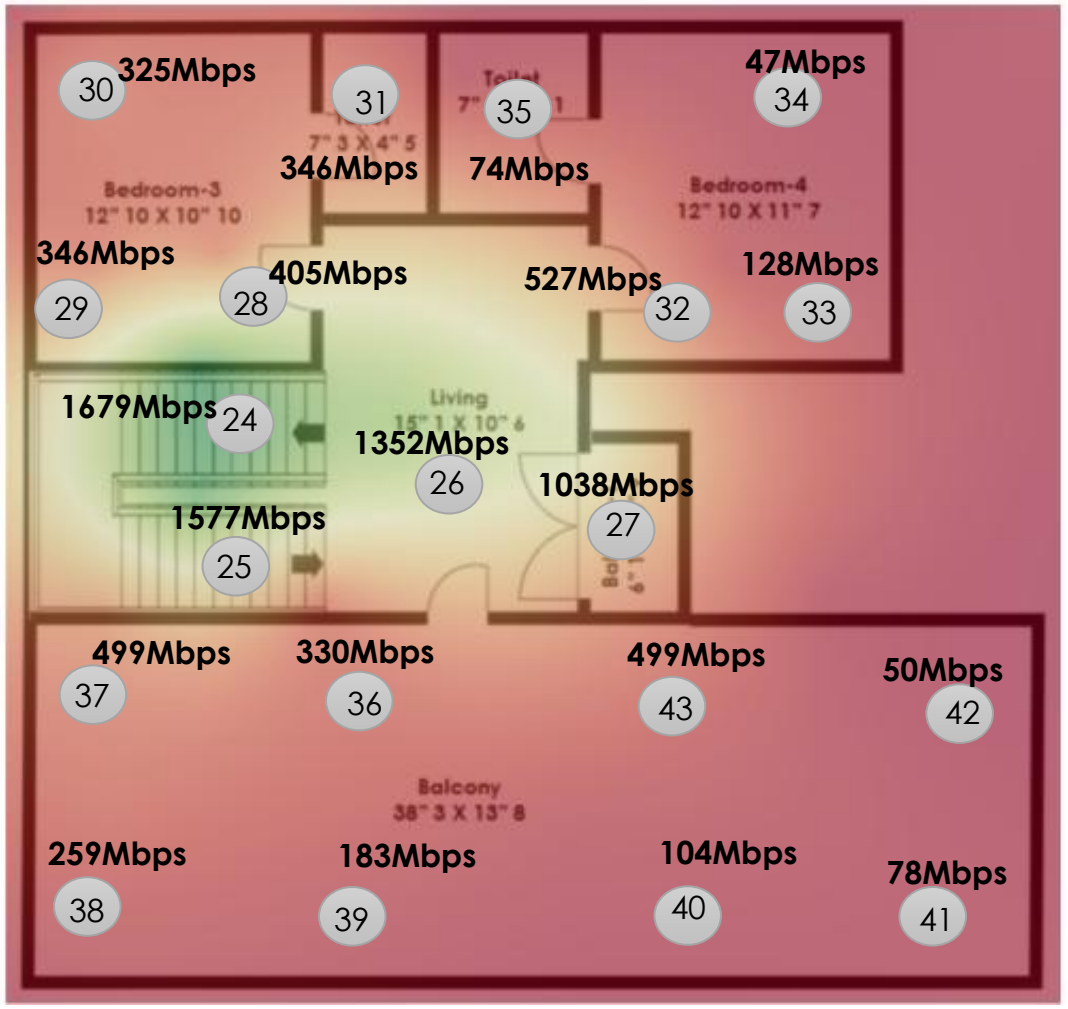
First Floor TCP Download (Mbps)

Build B





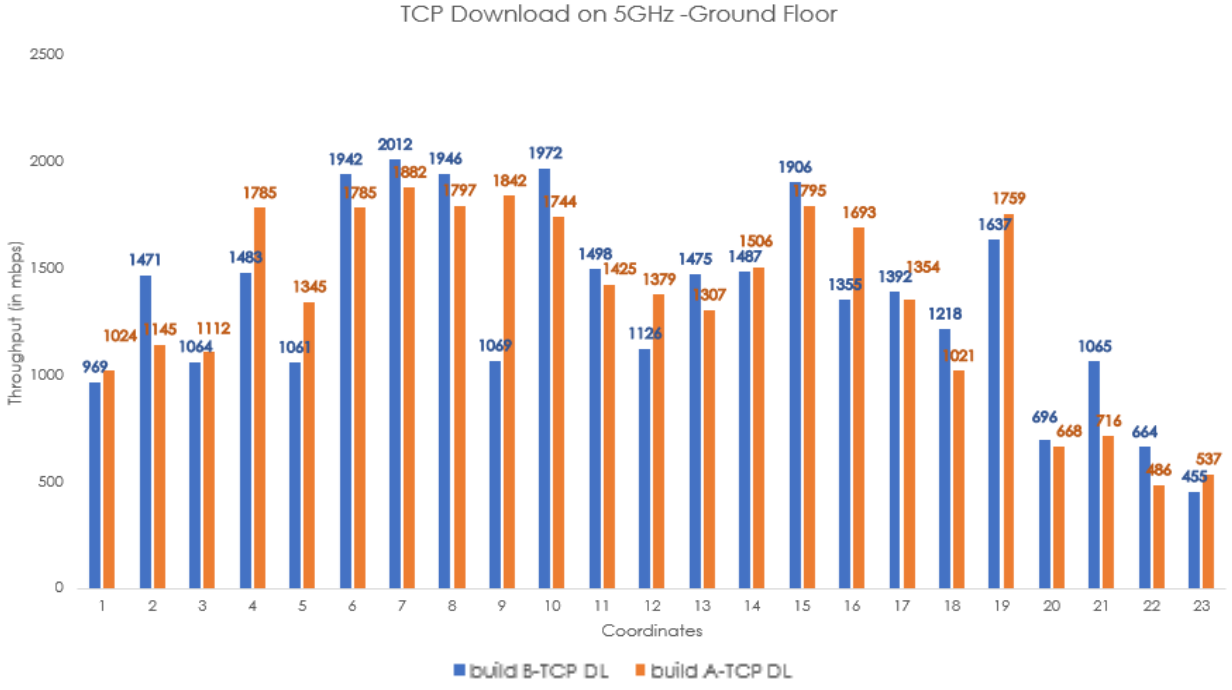
Build A

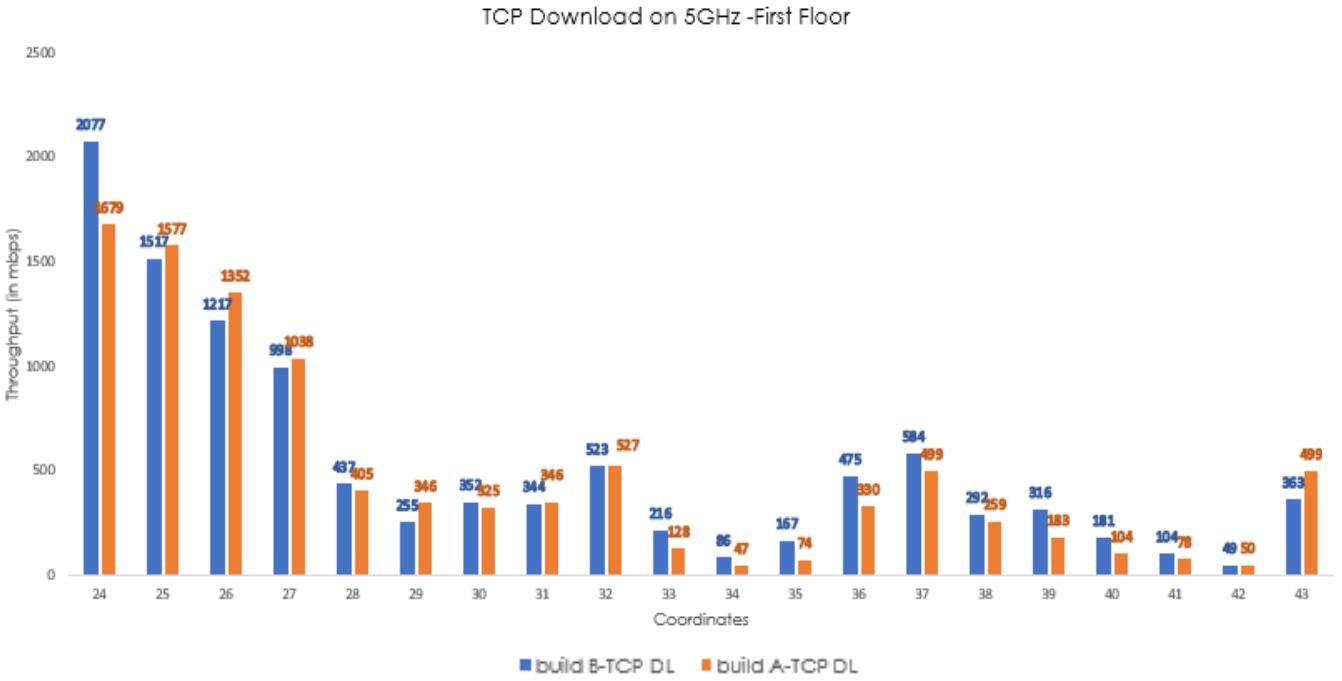


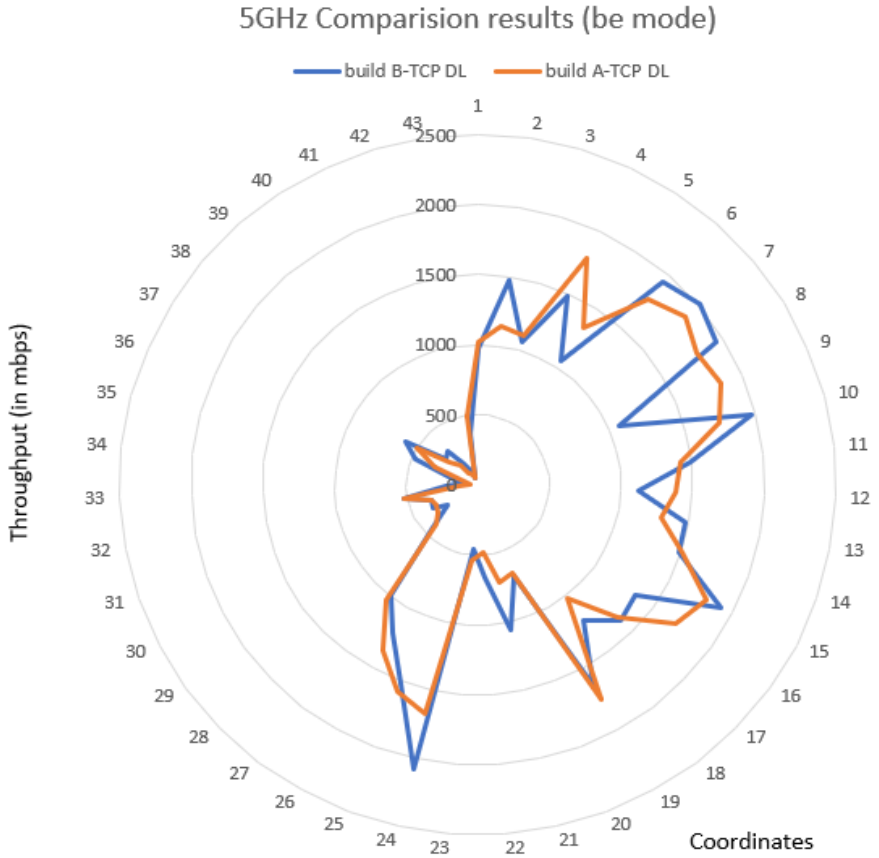
Client connected state

Client disconnected state

TCP Download on 5GHz Band





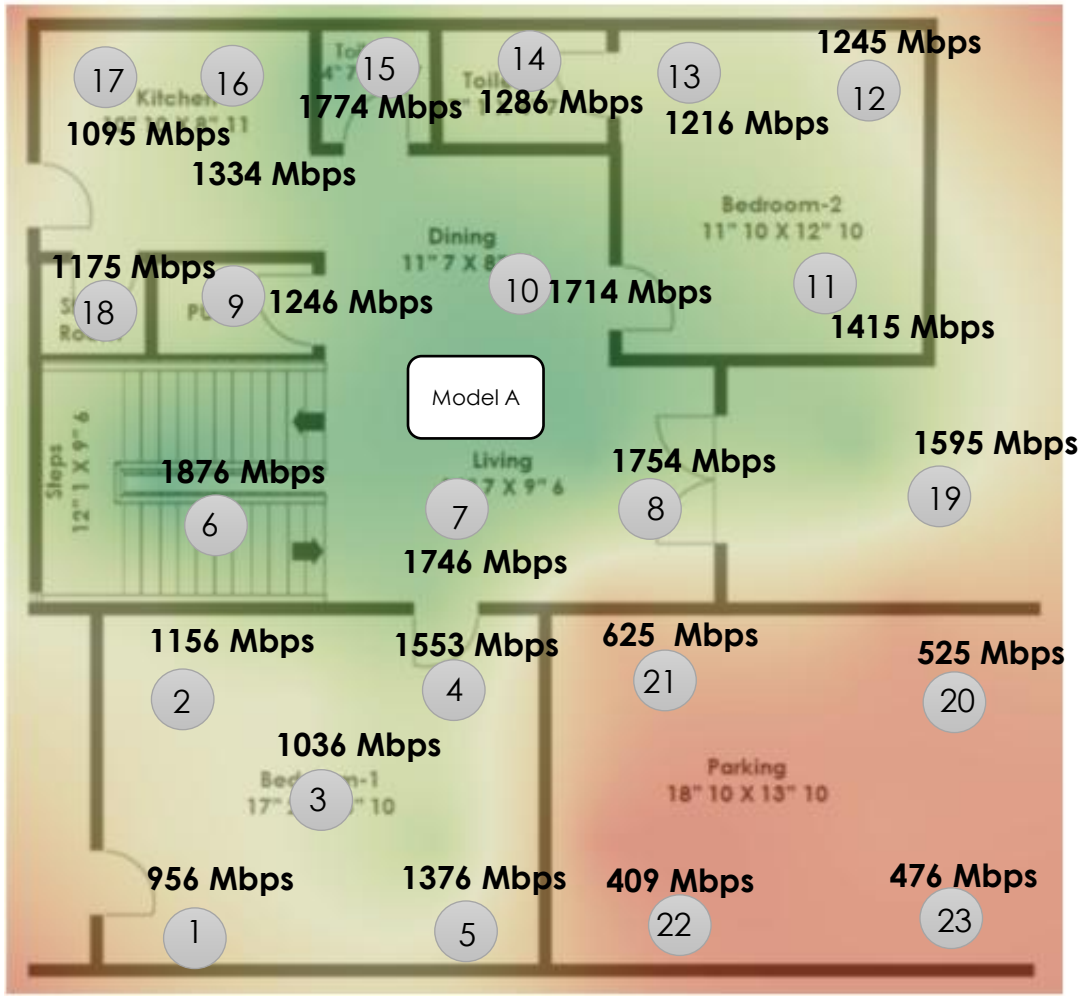


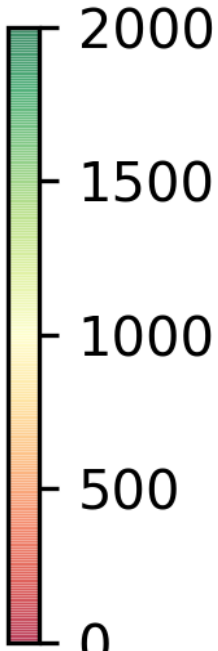
TCP_UL in 5GHz

Ground Floor Upload TCP (Mbit/s)

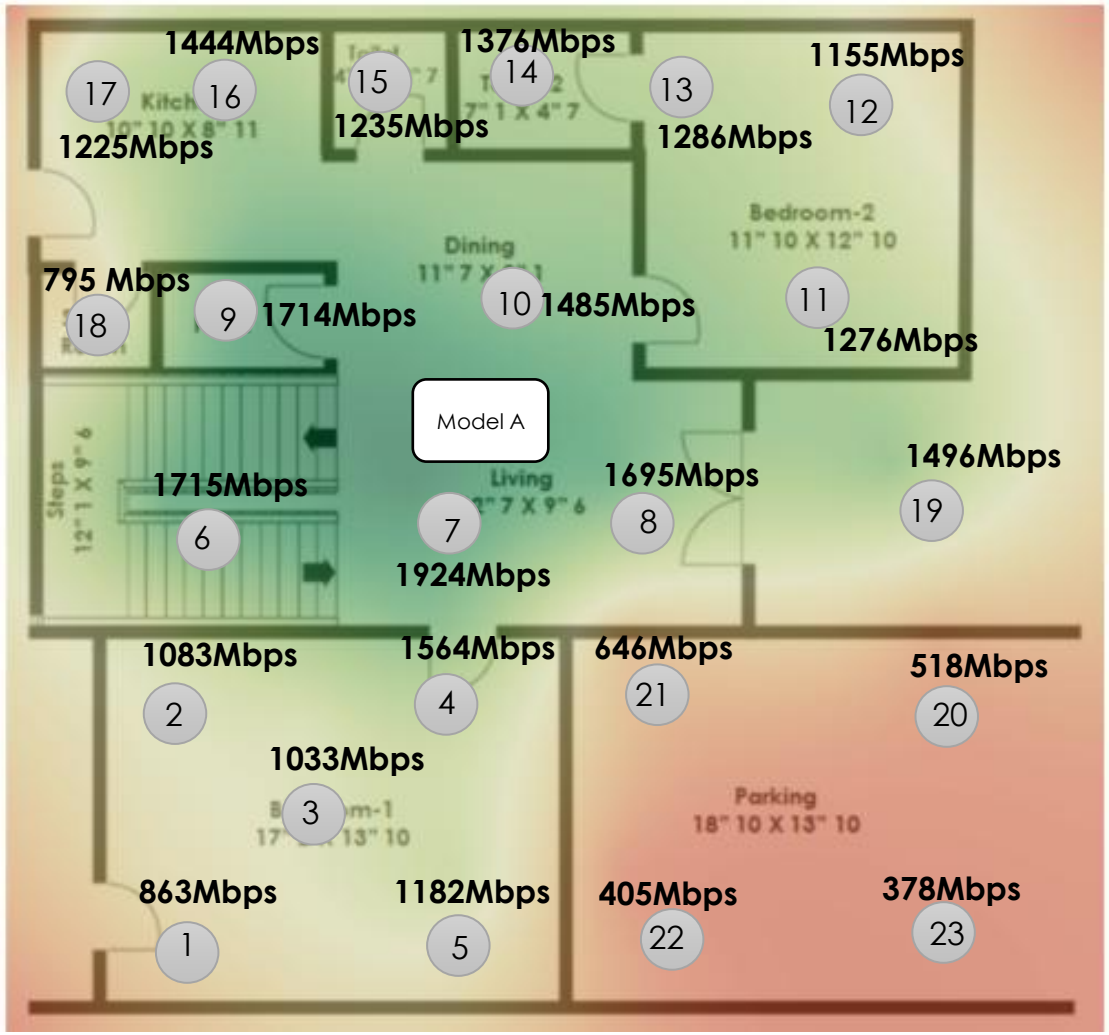
Candela TECHNOLOGIES

Build B





Build A

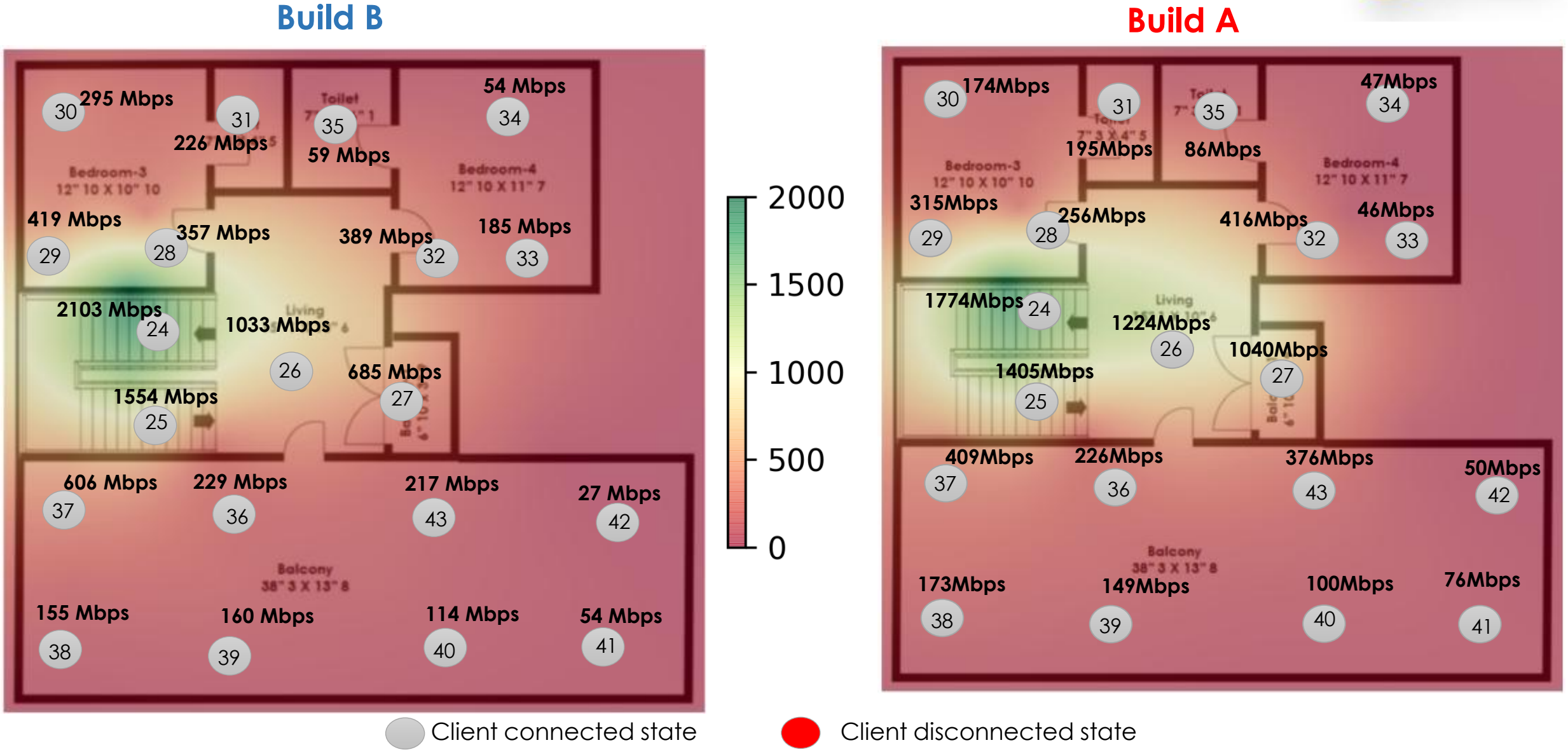


Client connected state

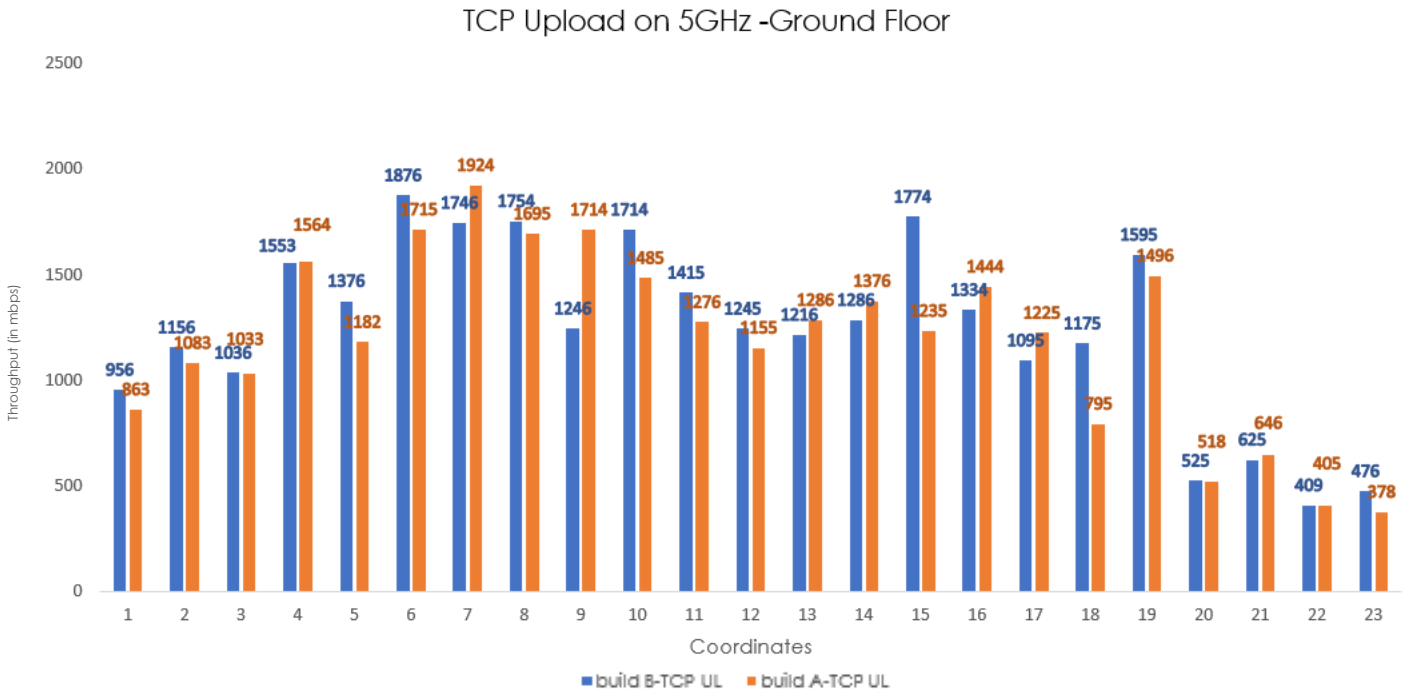
Client disconnected state

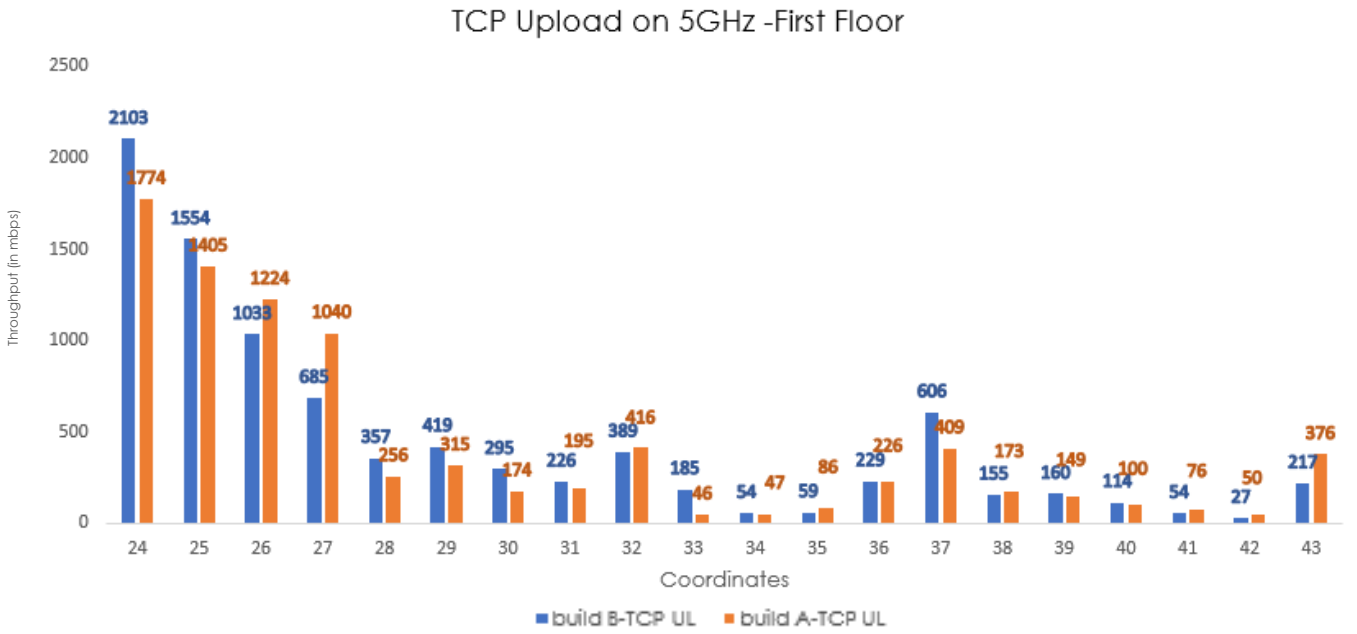
TCP_UL in 5GHz

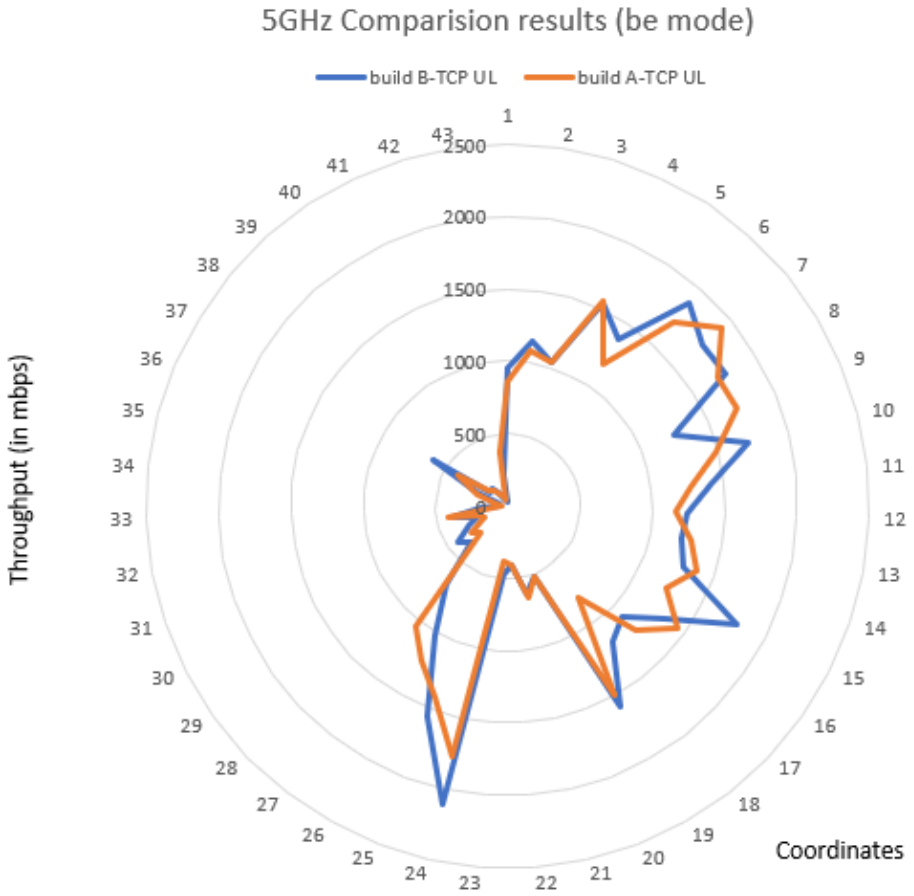
First Floor TCP Upload (Mbps)



TCP Upload on 5GHz Band







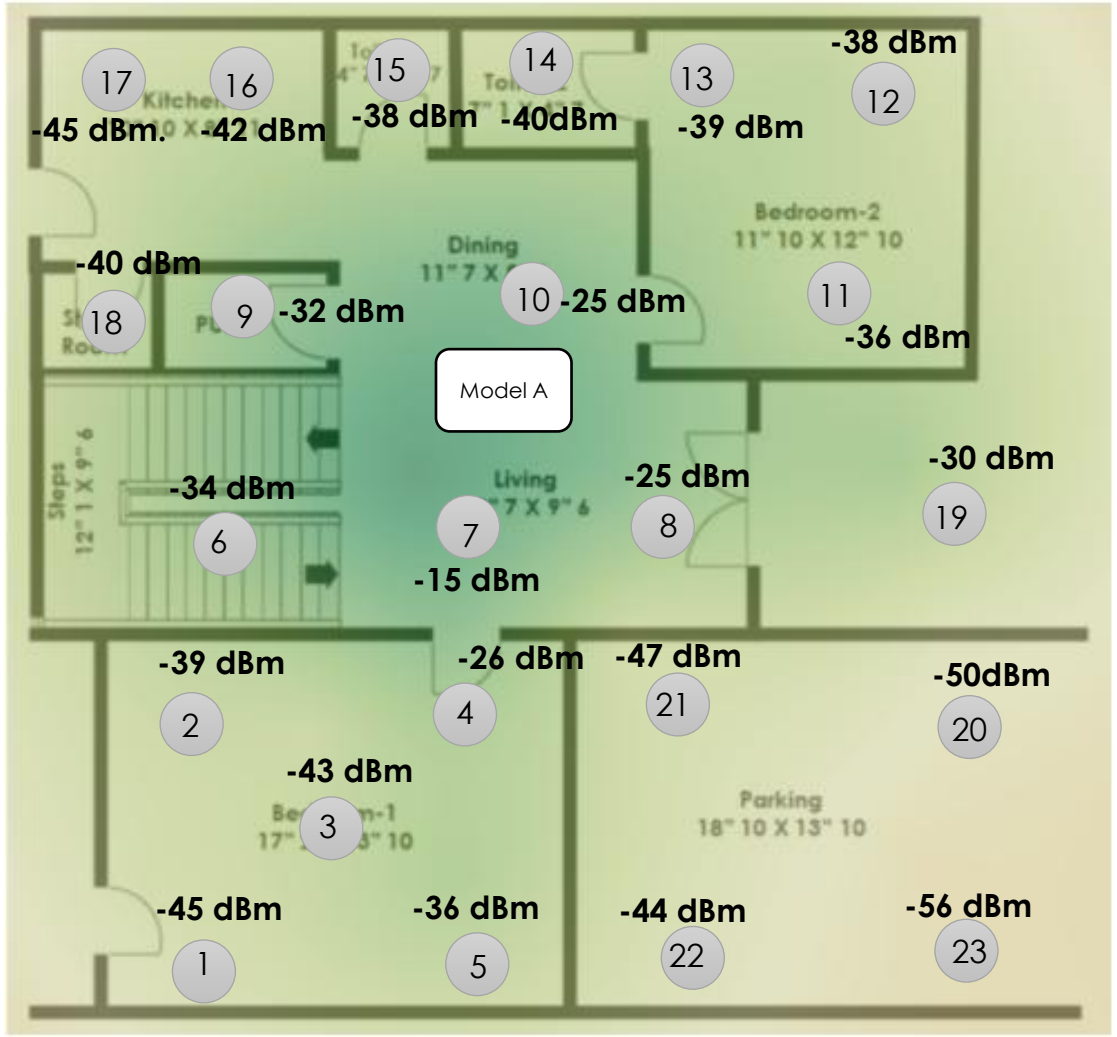
Analysis on 2.4GHz Band coverage:

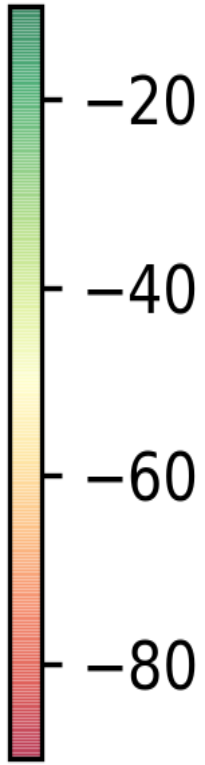
Parameters	Build B	Build A	Observations/Comments
Ground Floor - 2.4 GHz Coverage	Improved	Reduced	Highlights: With both Build A & Build B, AP is able to provide coverage for the entire ground floor with a transmit power of 27 dB.
GF - 2.4 GHz Max Throughput	Improved	Reduced	Highlights: • With Build B max DL throughput achieved is 466 Mbps (Coordinate:- 7) whereas with Build A max throughput is 437 Mbps (Coordinate:- 9). • With Build B max UL throughput achieved is 466 Mbps (Coordinate:- 4) whereas with Build A max throughput is 370Mbps (Coordinate:- 4).
GF - Overall experience	Improved	Reduced	Highlights: • Build B provides complete coverage for the entire floor. • In TCP DL and UL, throughput values of the Build Bare higher than those of the Build A. Lowlights: • The Build B exhibits higher download throughput values than the Build A, except at coordinates 9, 20, 21 and 22. • The Build B exhibits higher upload throughput values than the Build A, except at coordinate 12.
First Floor - 2.4 GHz Coverage	Improved	Reduced	Highlights: With both Build A & Build B, AP is able to provide coverage for the entire First floor with a transmit power of 27 dB.
FF - 2.4 GHz Max Throughput	Improved	Reduced	Highlights: • With Build B max DL throughput achieved is 476 Mbps (Coordinate:- 24) whereas with Build A max throughput is 345 Mbps (Coordinate:- 24). • With Build B max UL throughput achieved is 445 Mbps (Coordinate:- 24) where as with Build A max throughput is 425 Mbps (Coordinate:- 24).
FF - Overall experience	Improved	Reduced	Highlights: • Both Build A &Build B provides complete coverage for the entire floor. • In TCP DL and UL, throughput values of the Build B are higher than those of the Build A.

AP RSSI in 2.4GHz

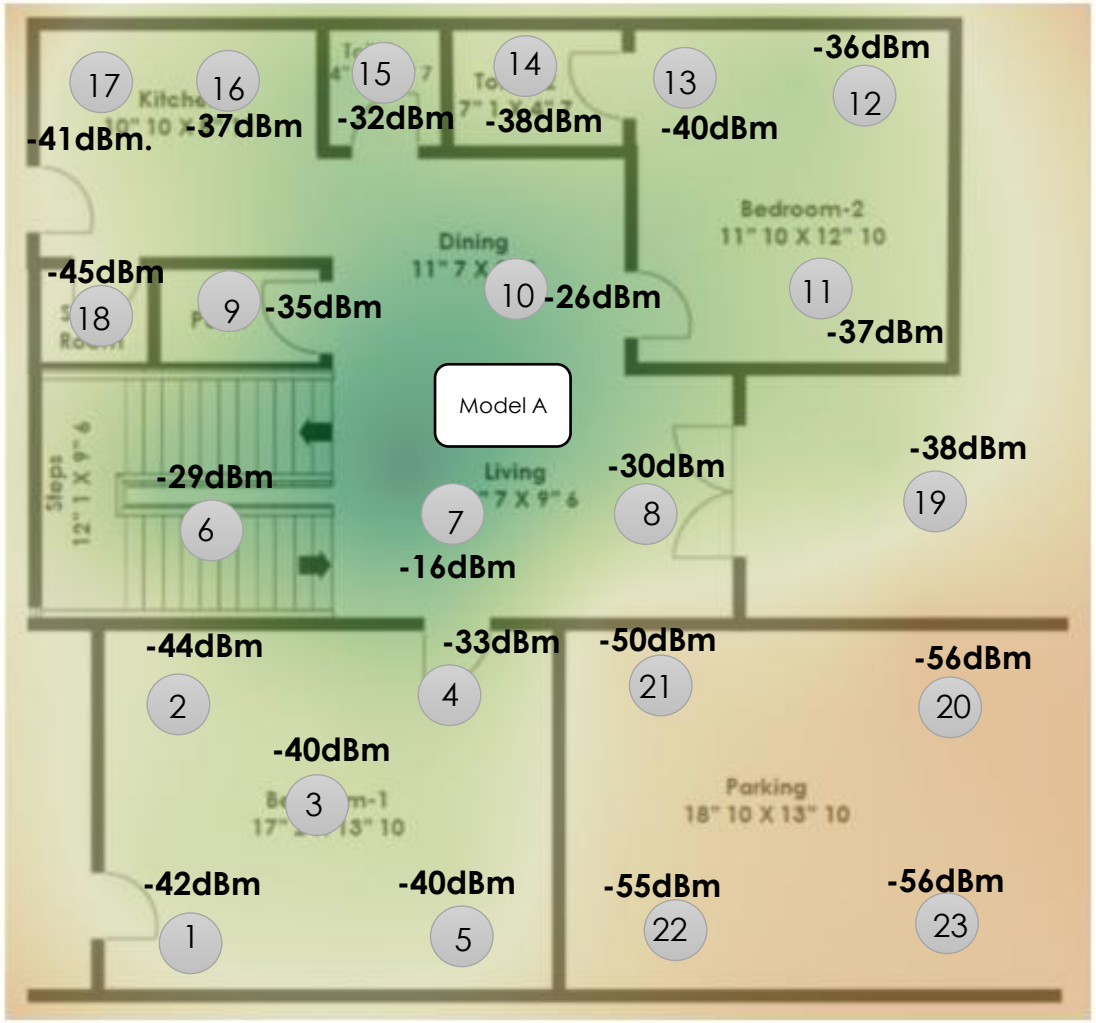
Ground Floor signal strength (dBm)

Build B





Build A



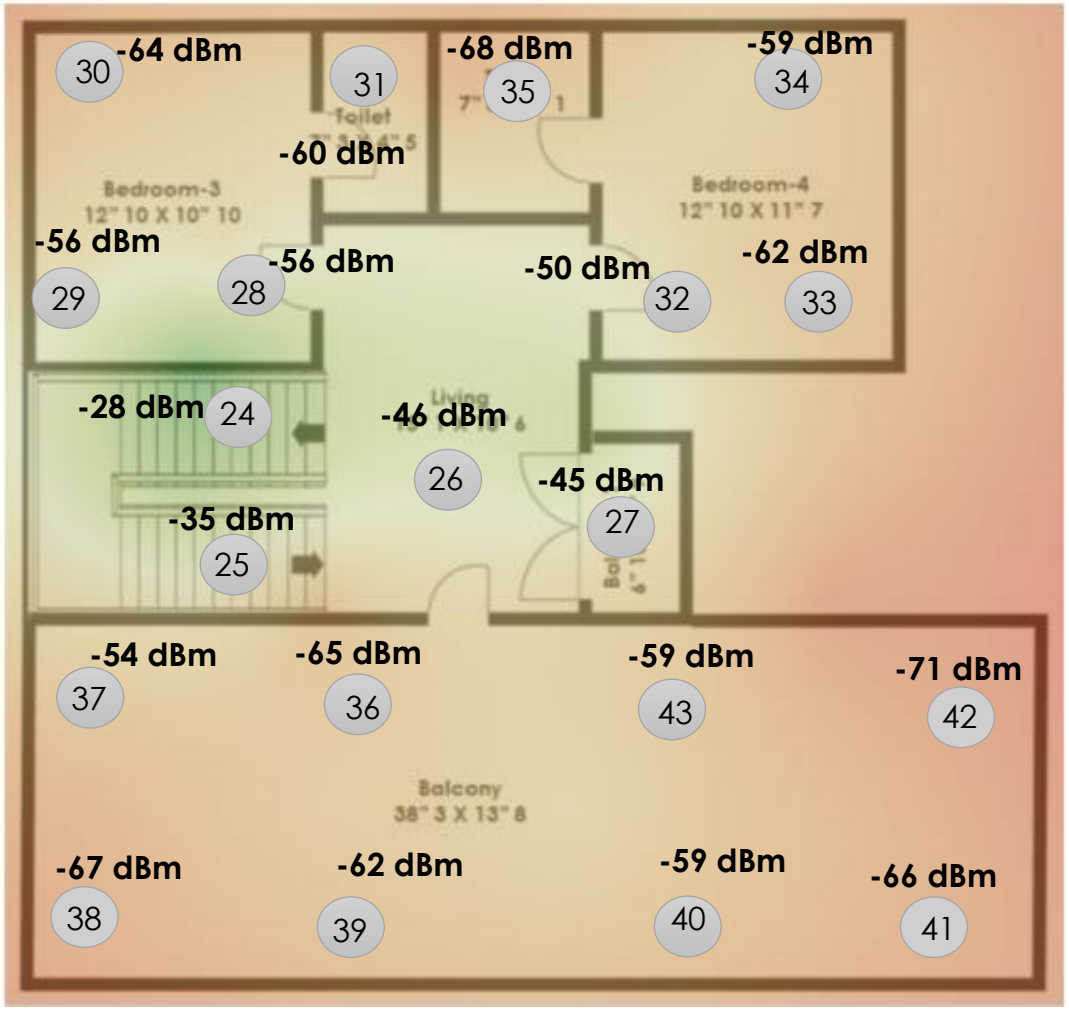
Client connected state

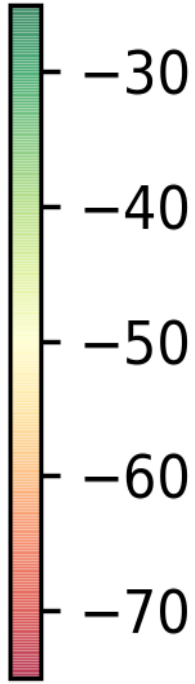
Client disconnected state

AP RSSI in 2.4GHz

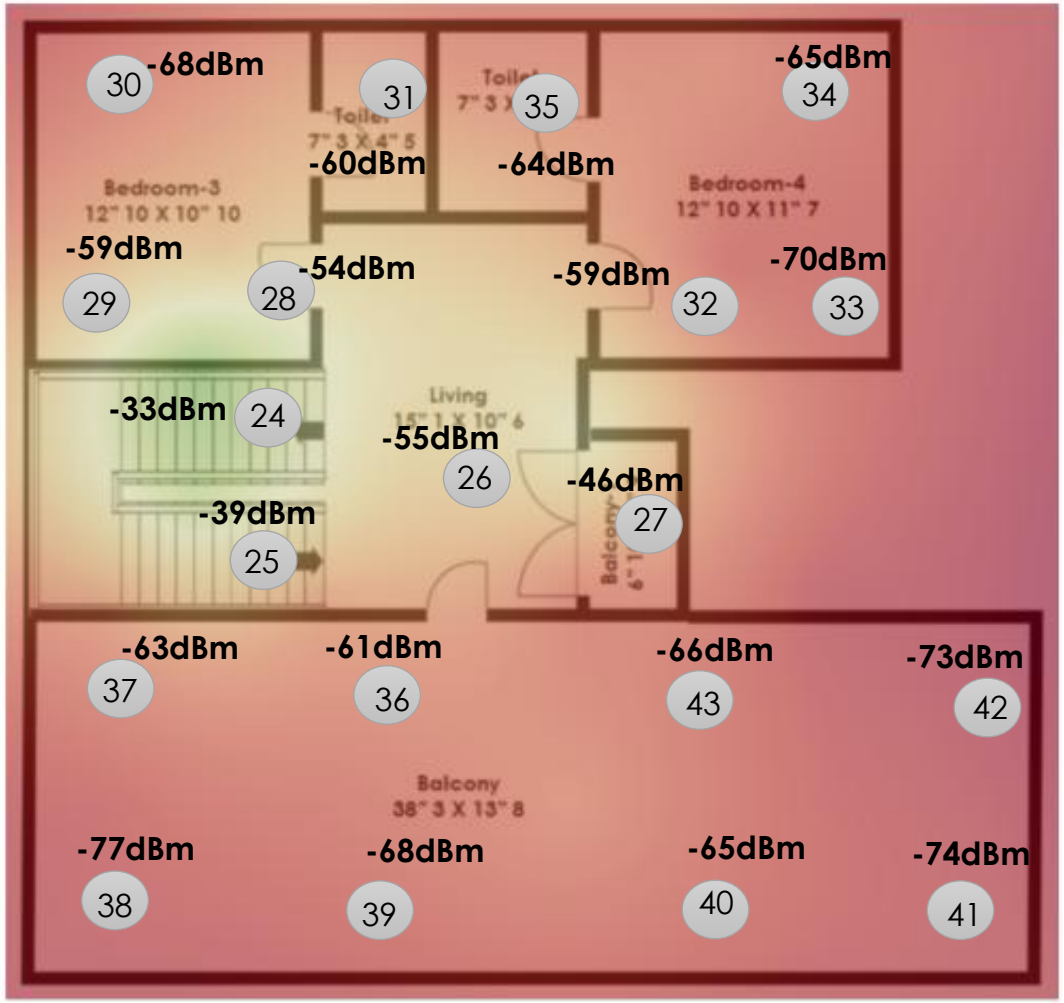
First Floor signal strength (dBm)

Build B





Build A



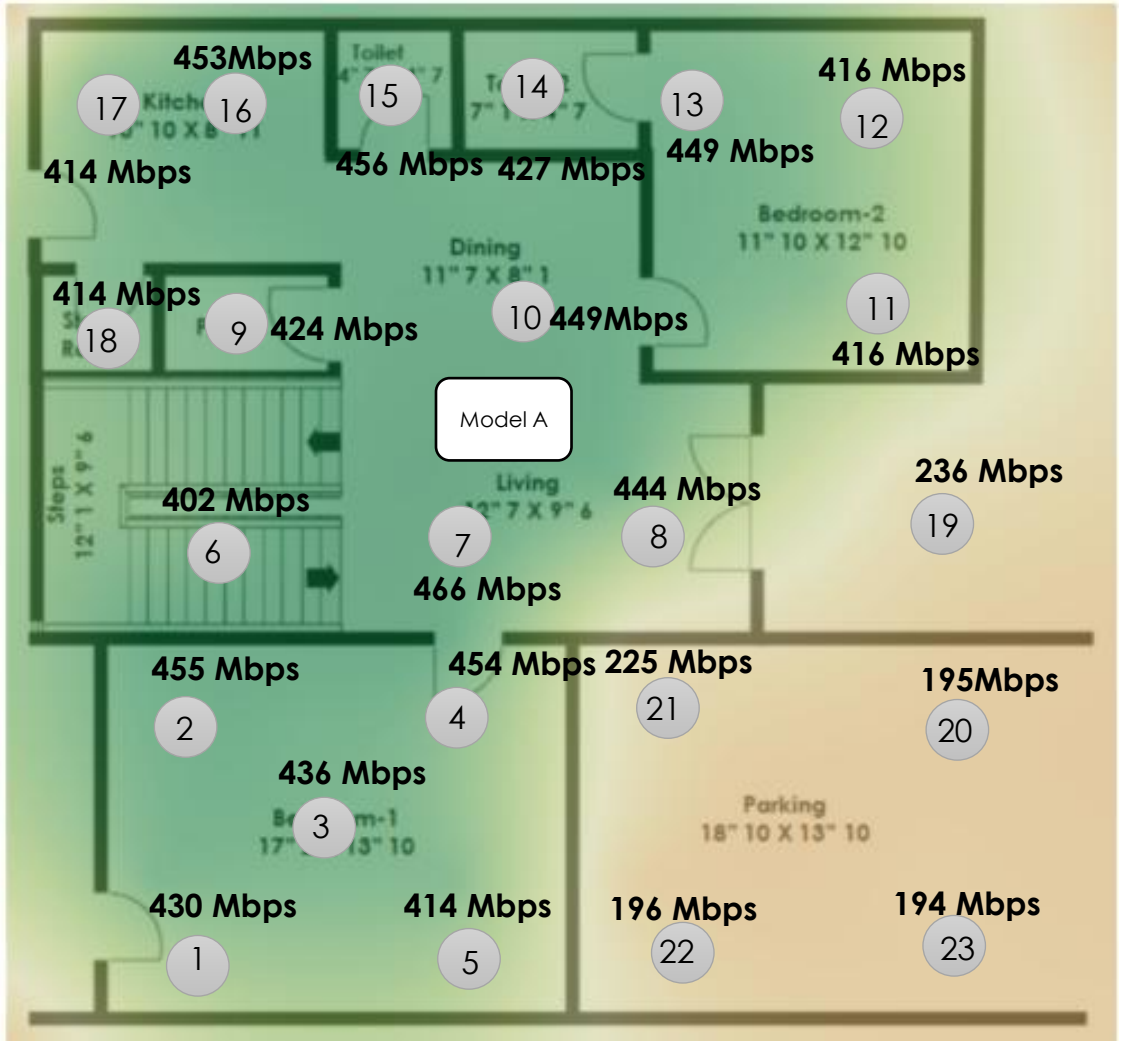
Client connected state

Client disconnected state

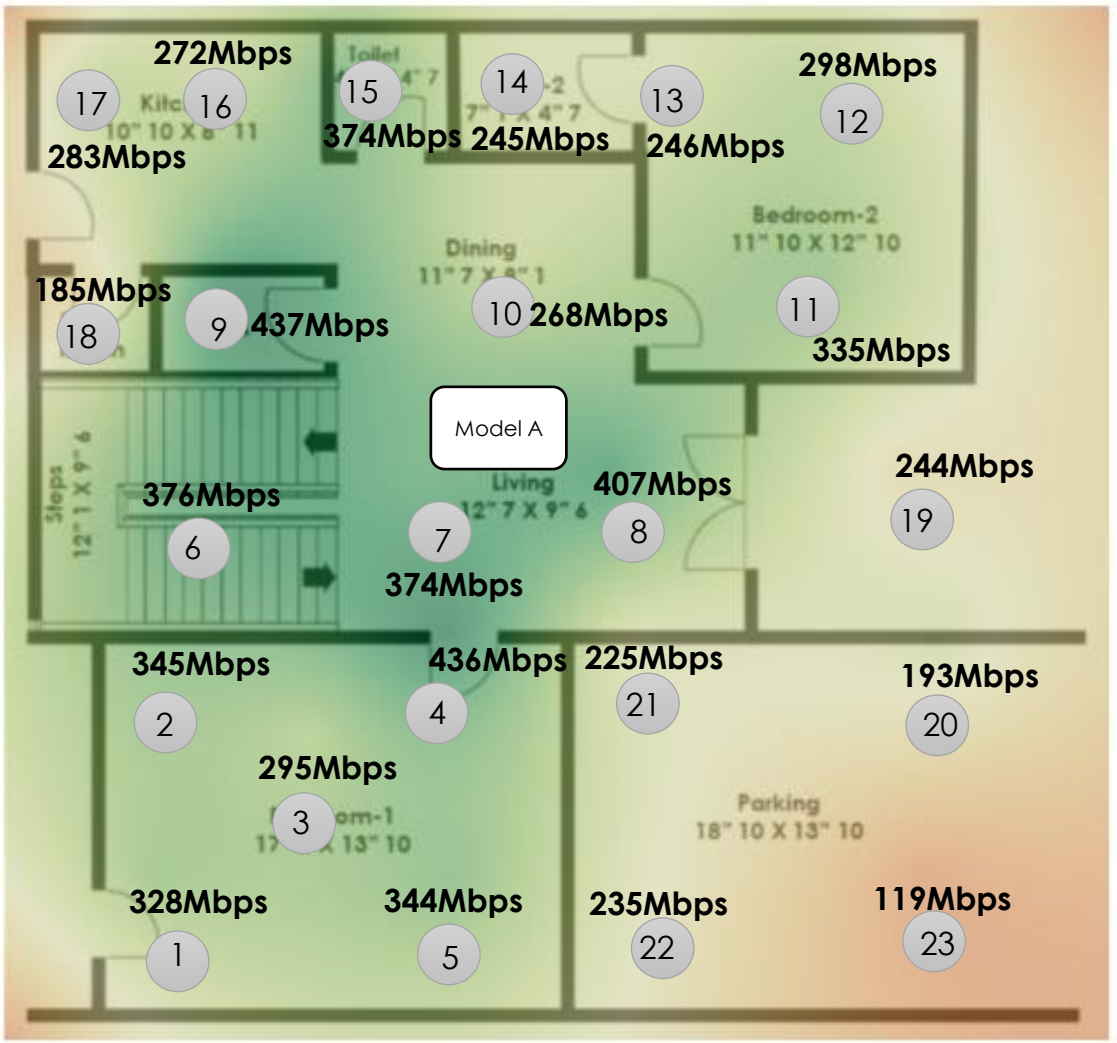
TCP_DL in 2.4GHz

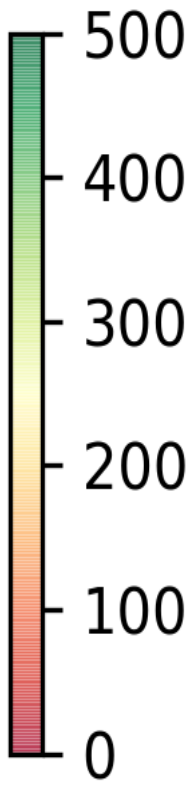
Ground Floor Download TCP (Mbit/s)

Build B



Build A





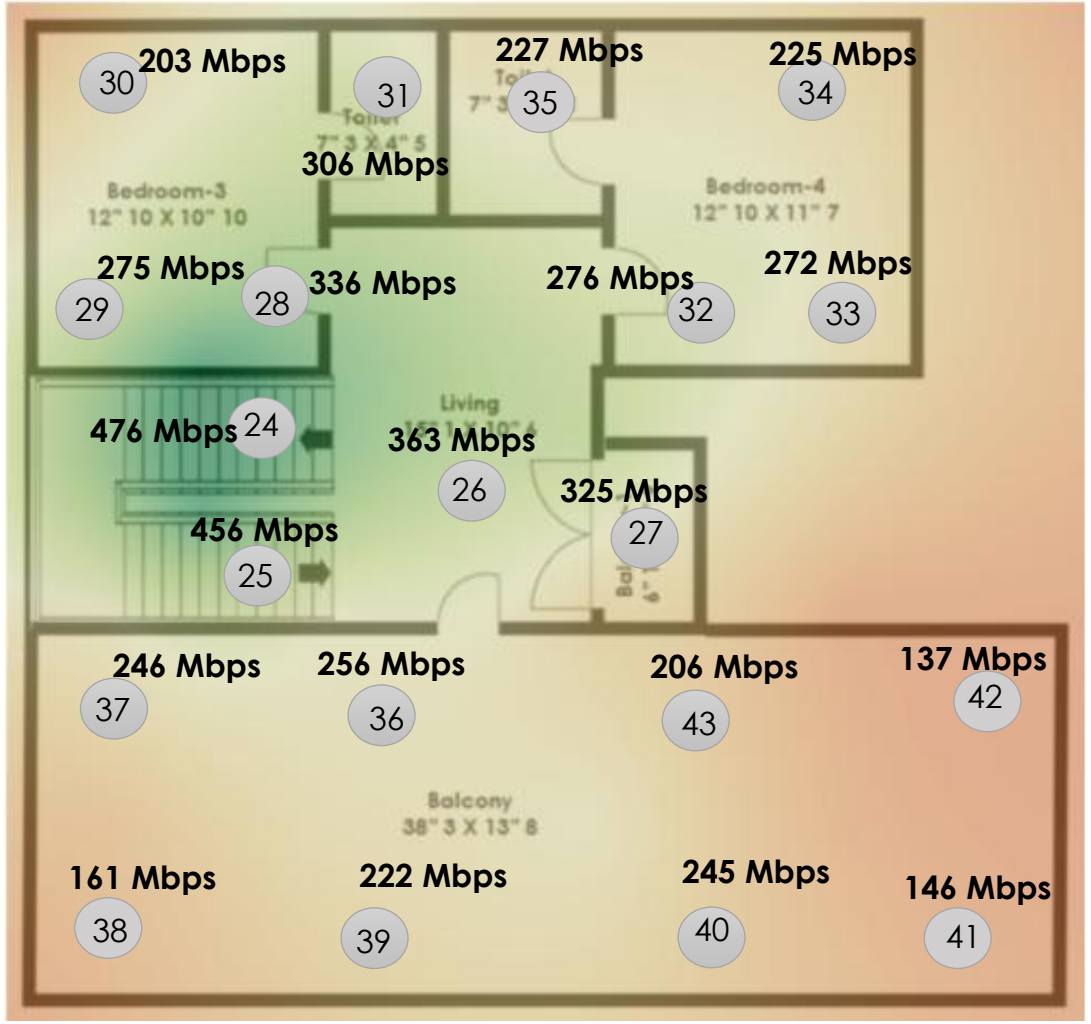
Client connected state

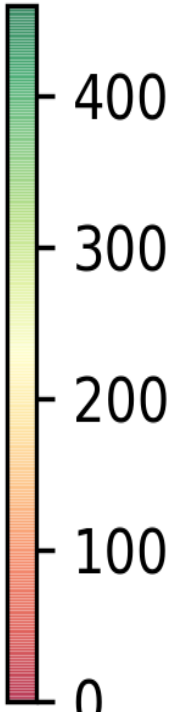
Client disconnected state

TCP_DL in 2.4GHz

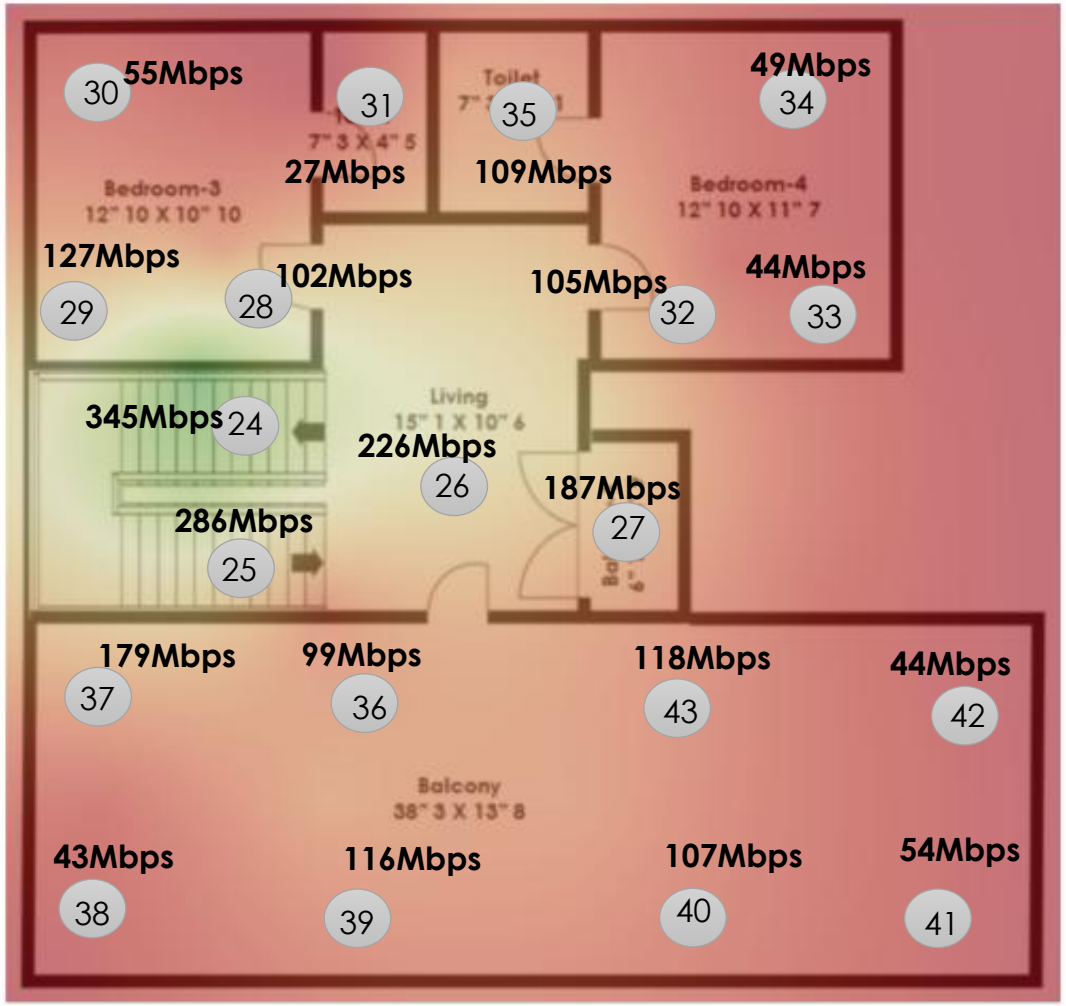
First Floor TCP Download (Mbps)

Build B





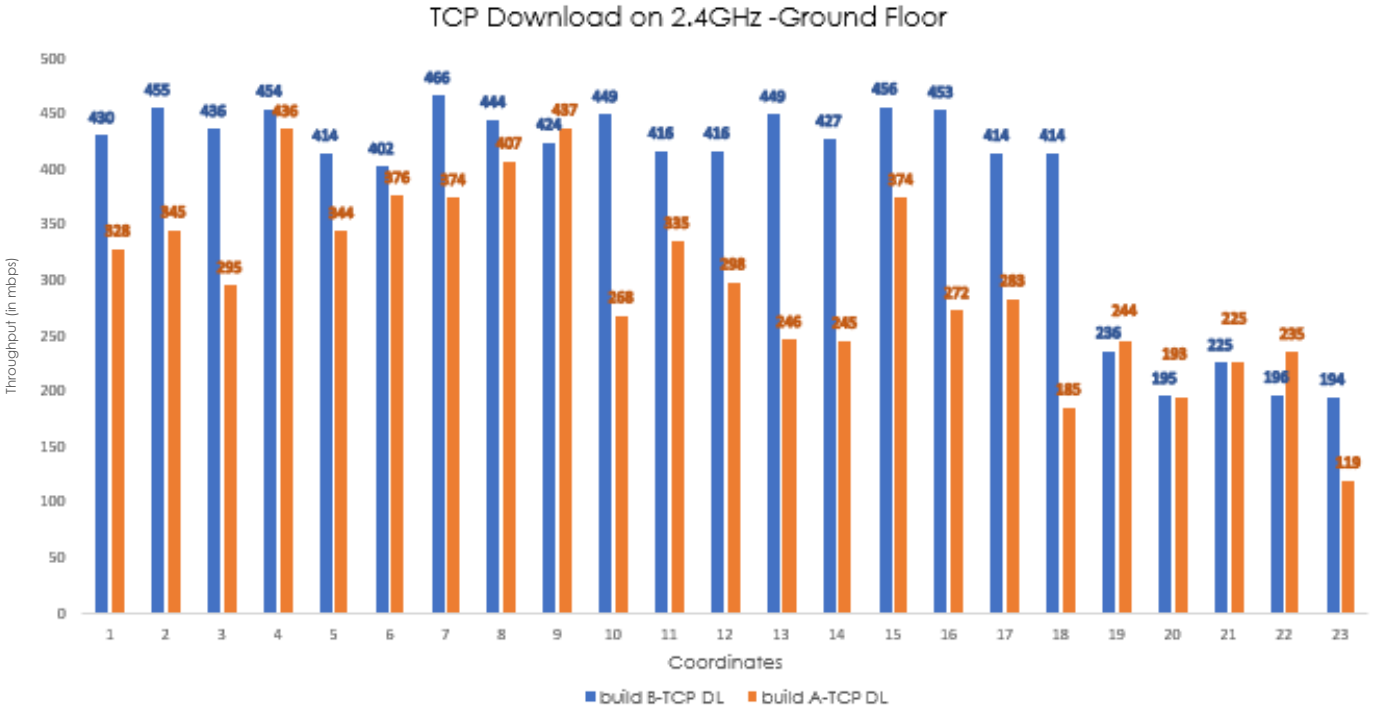
Build A

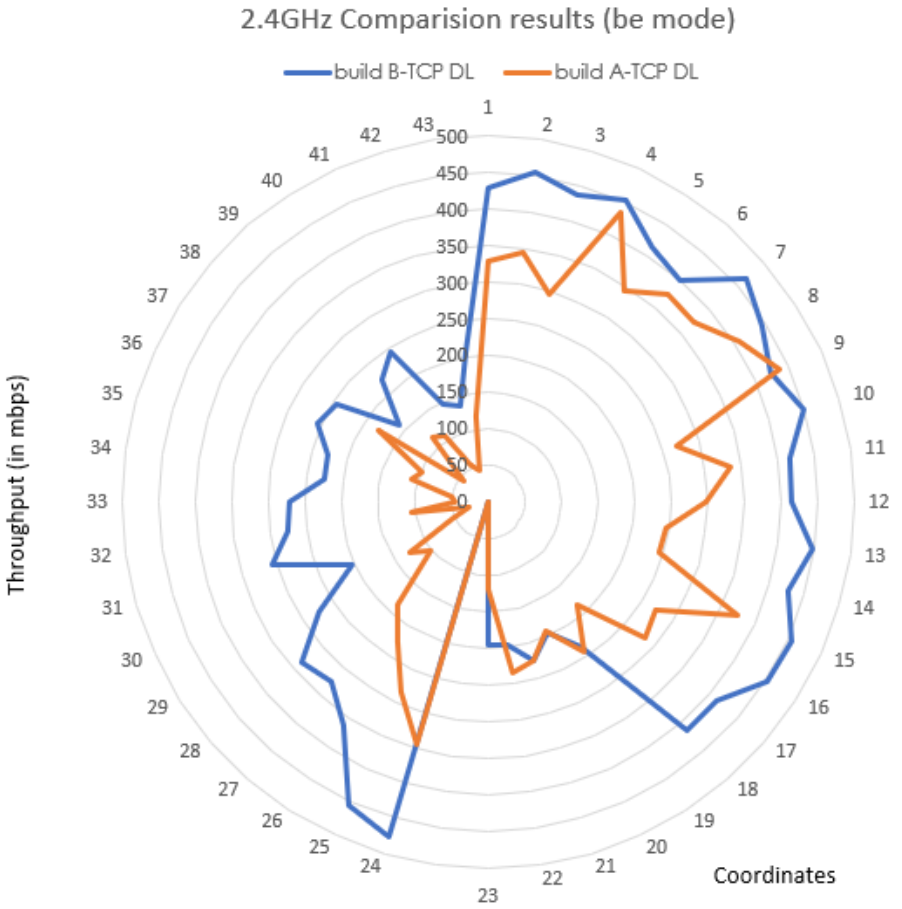


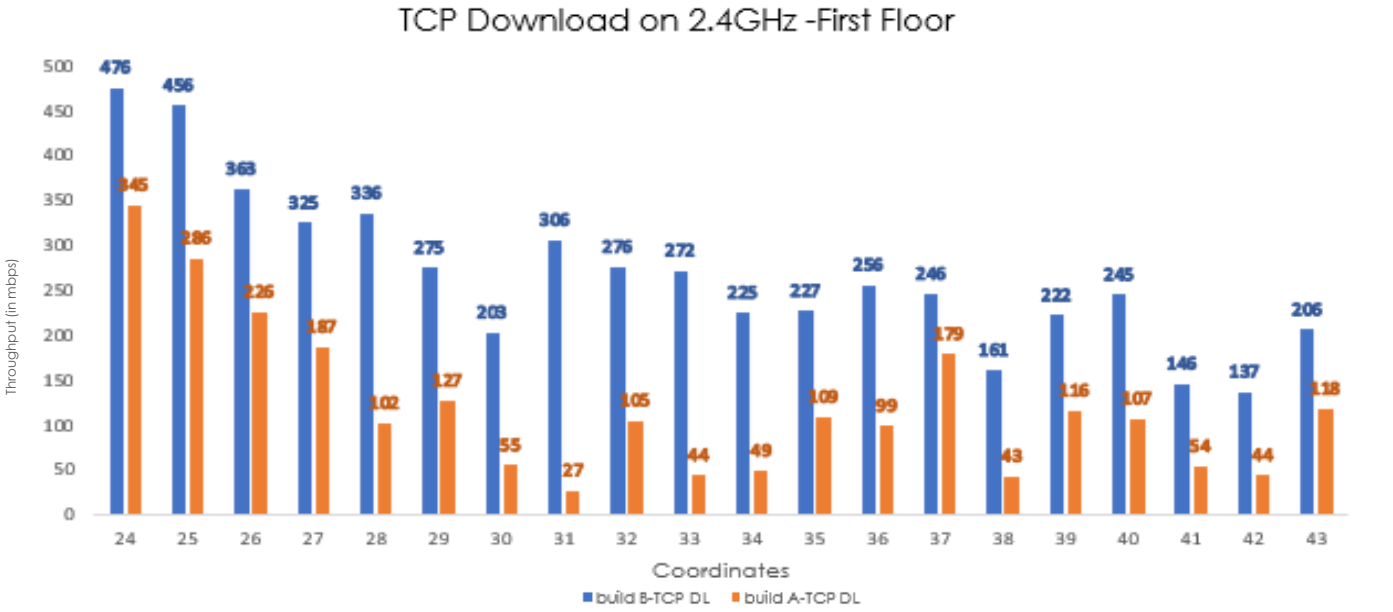
Client connected state

Client disconnected state

TCP Download on 2.4GHz Band



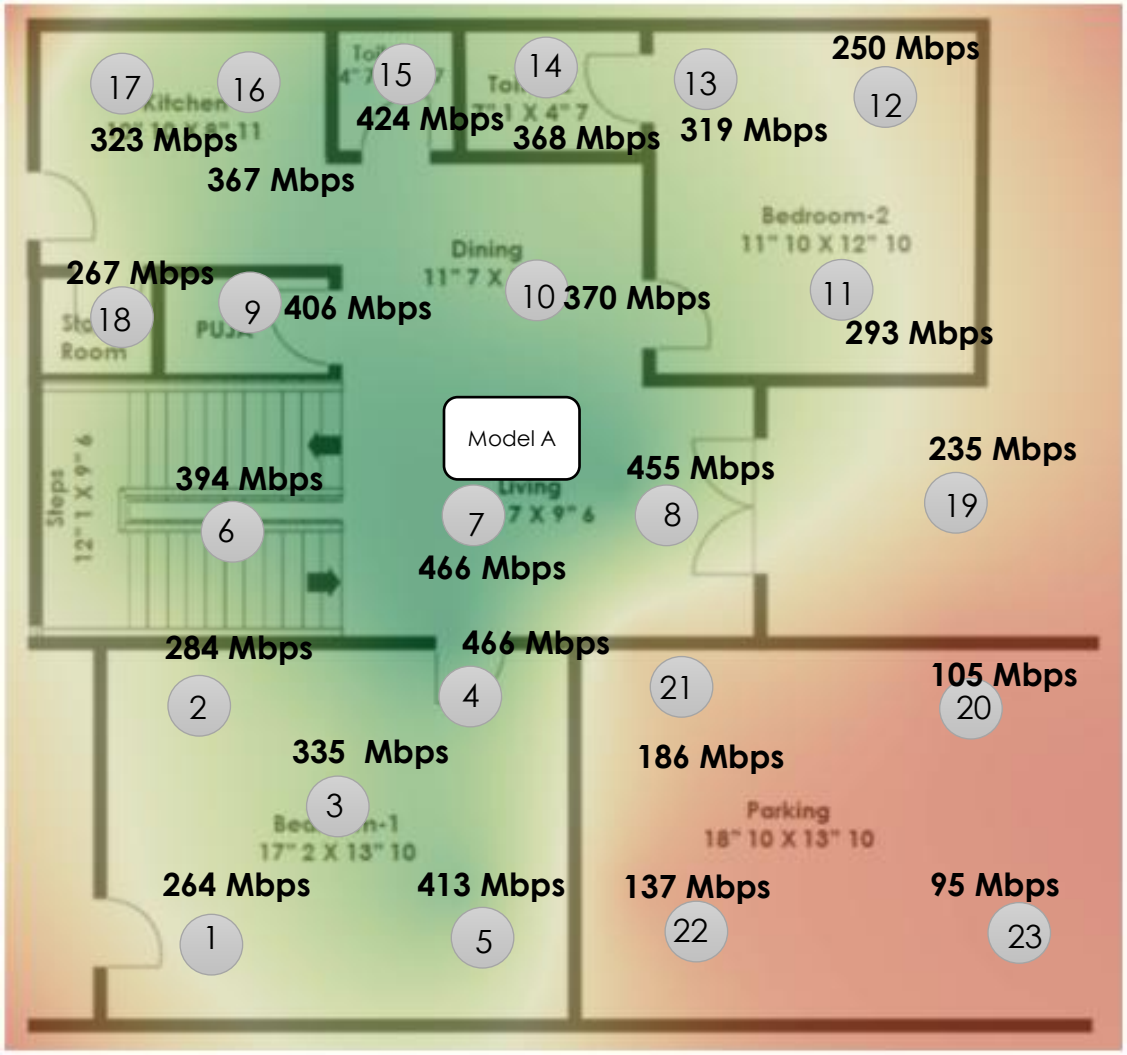


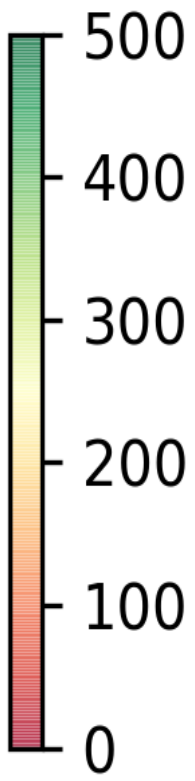


TCP_UL in 2.4GHz

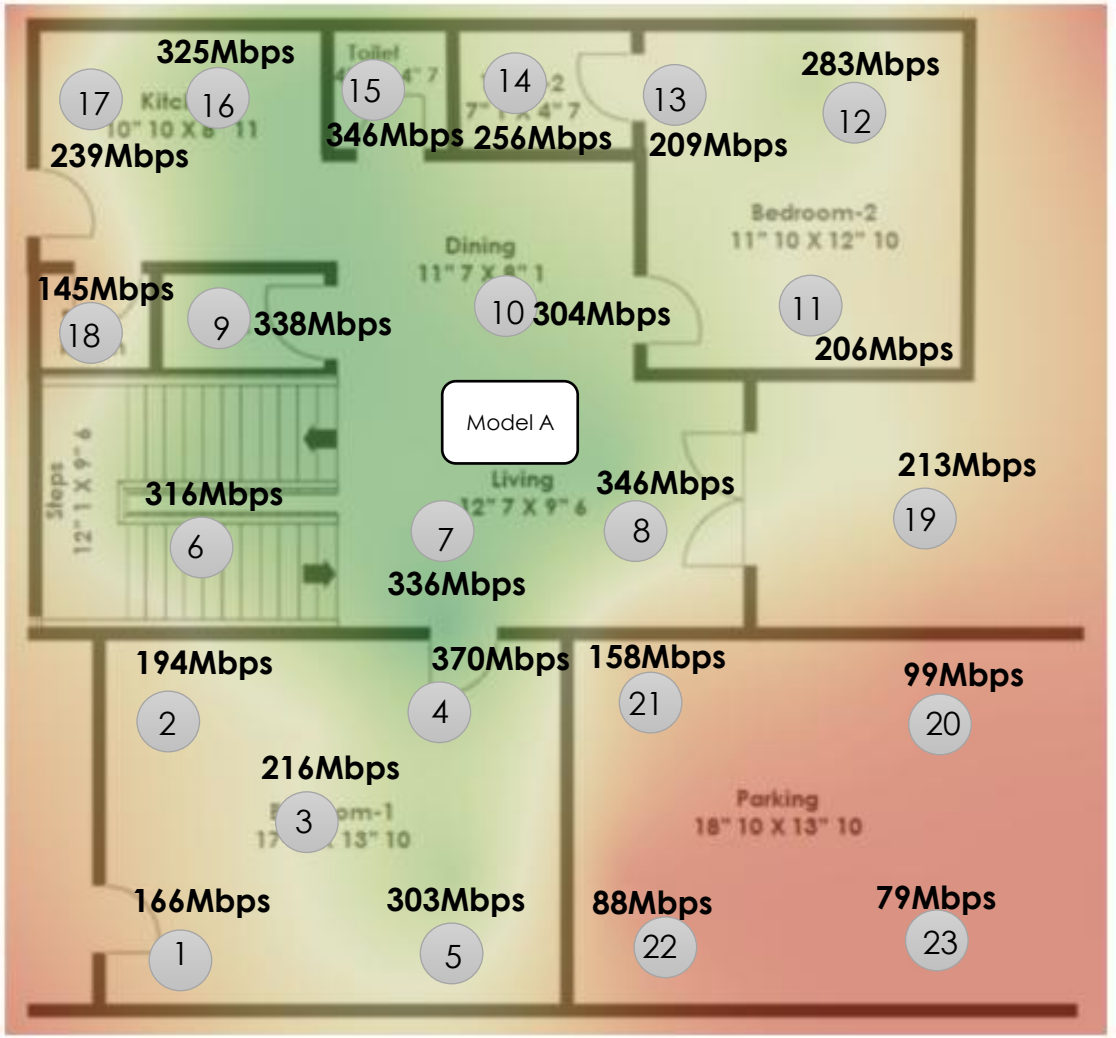
Ground Floor Upload TCP (Mbit/s)

Build B





Build A



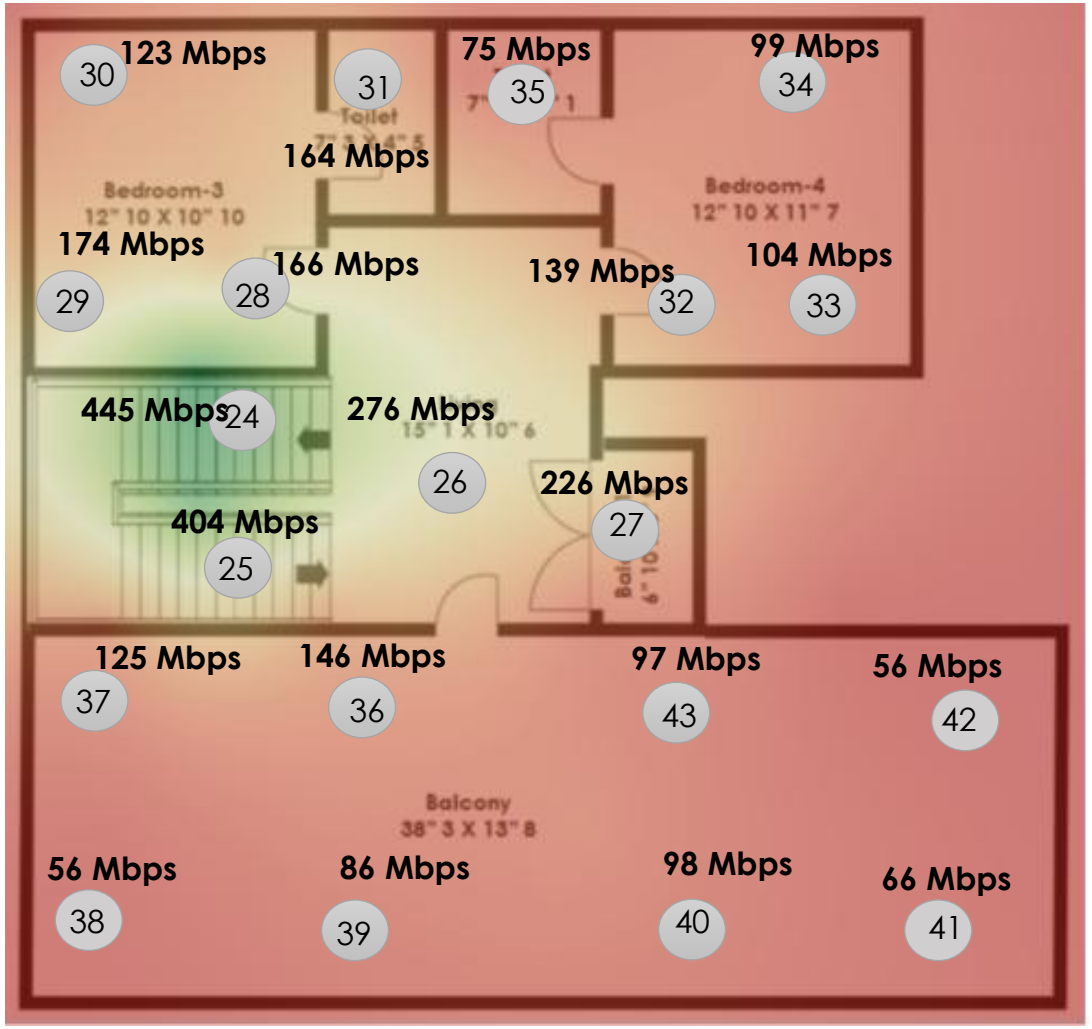
Client connected state

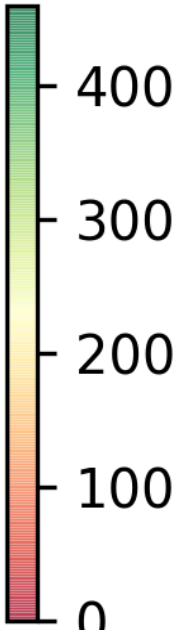
Client disconnected state

TCP_UL in 2.4GHz

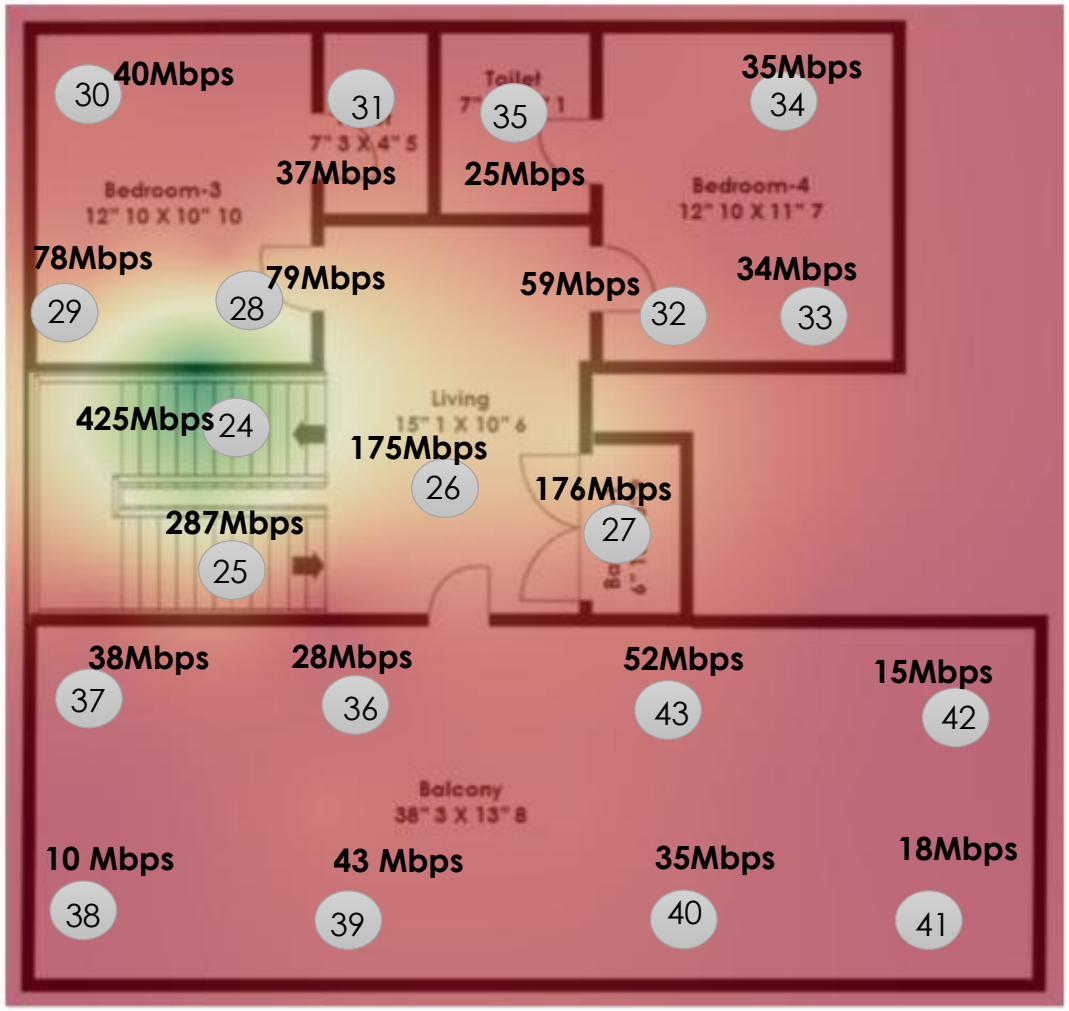
First Floor TCP Upload (Mbps)

Build B





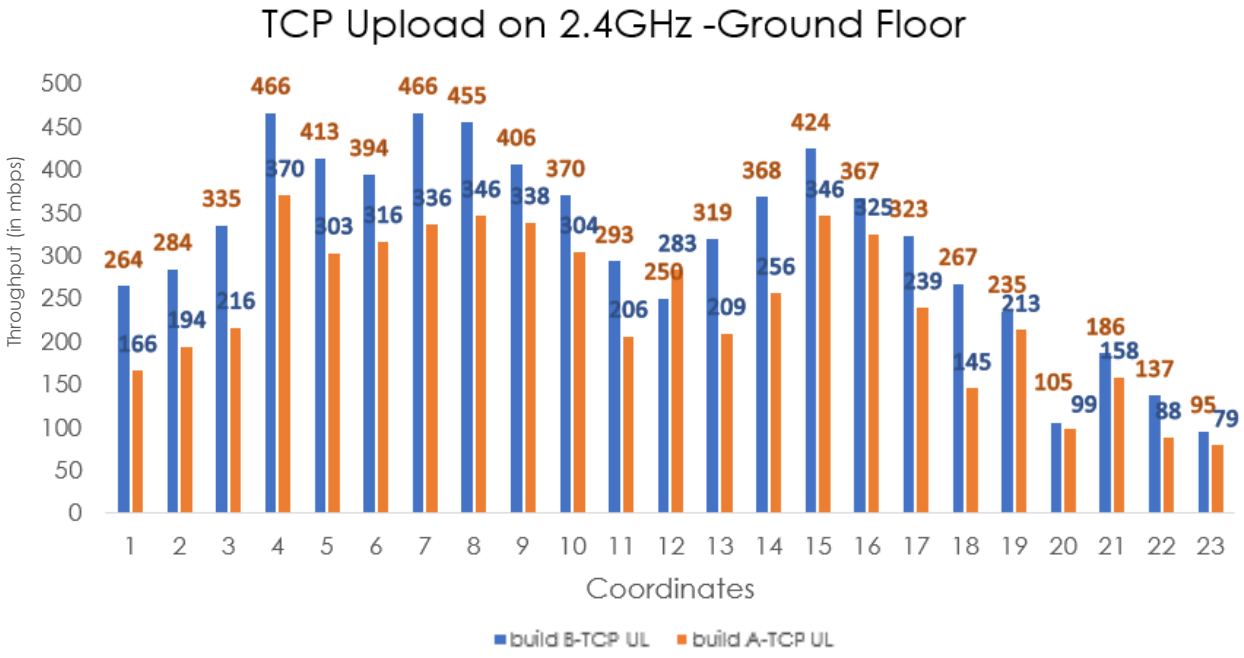
Build A

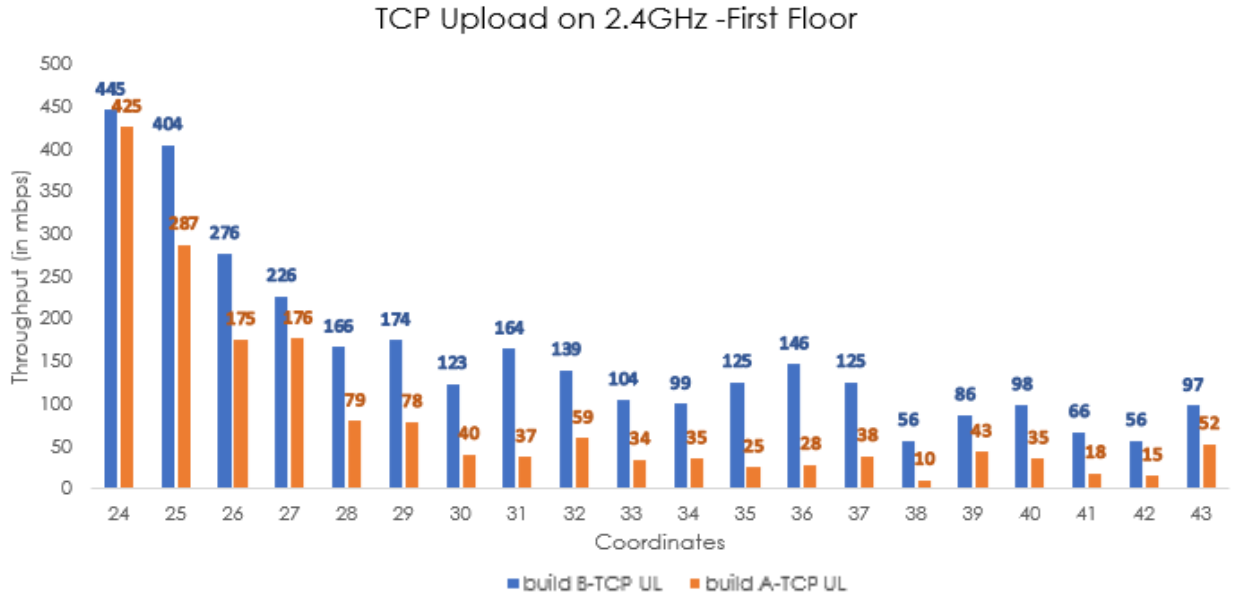


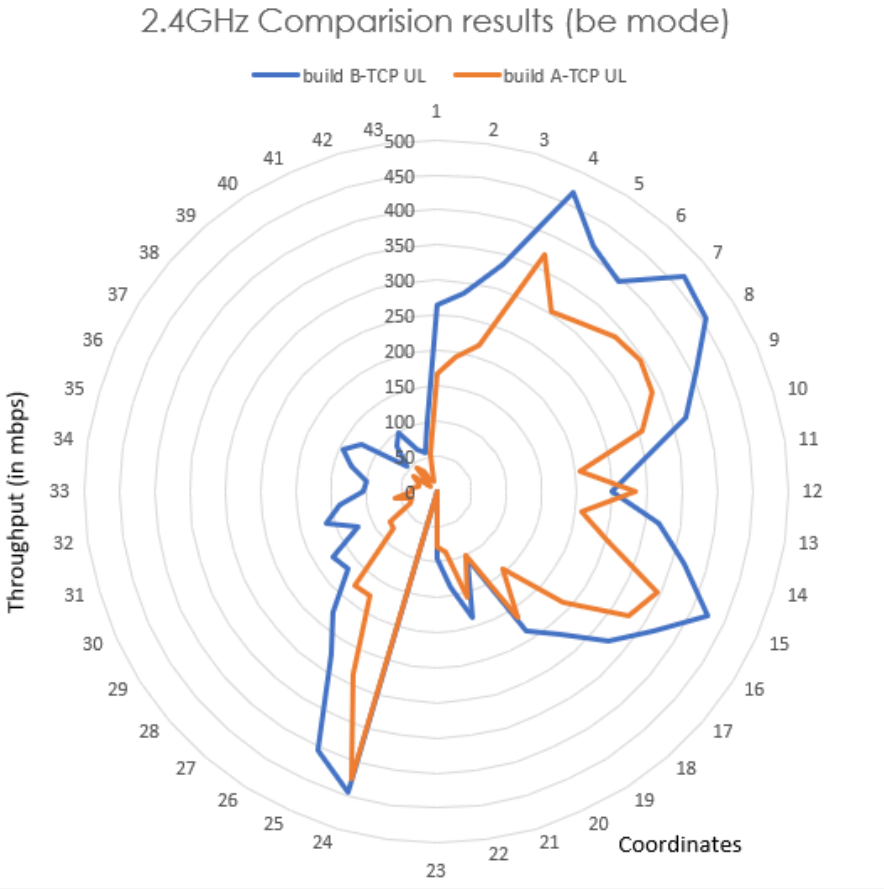
Client connected state

Client disconnected state

TCP Upload on 2.4GHz Band

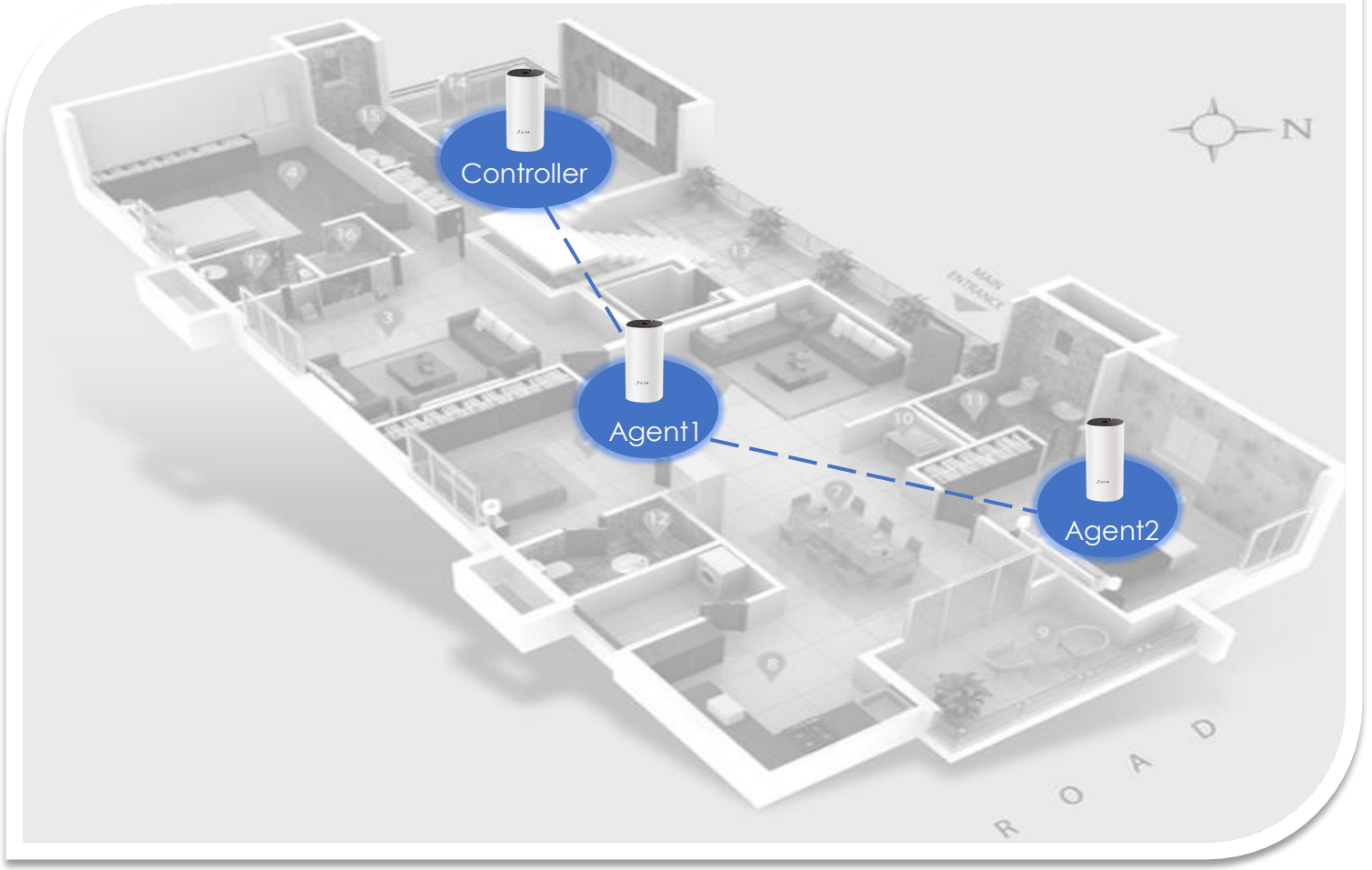






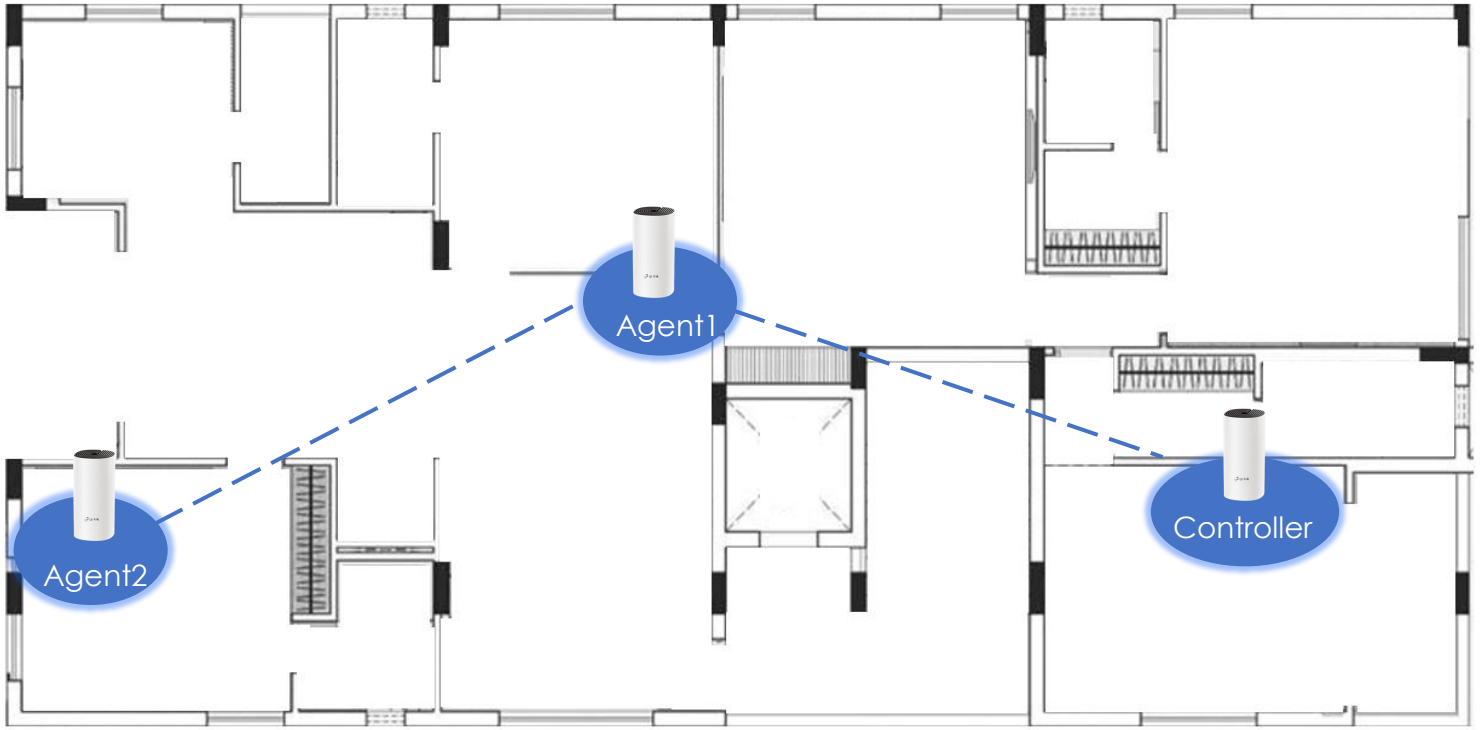
Vendor A and Vendor B

Capacity Test house (Single Floor) comparison results



Test House Details

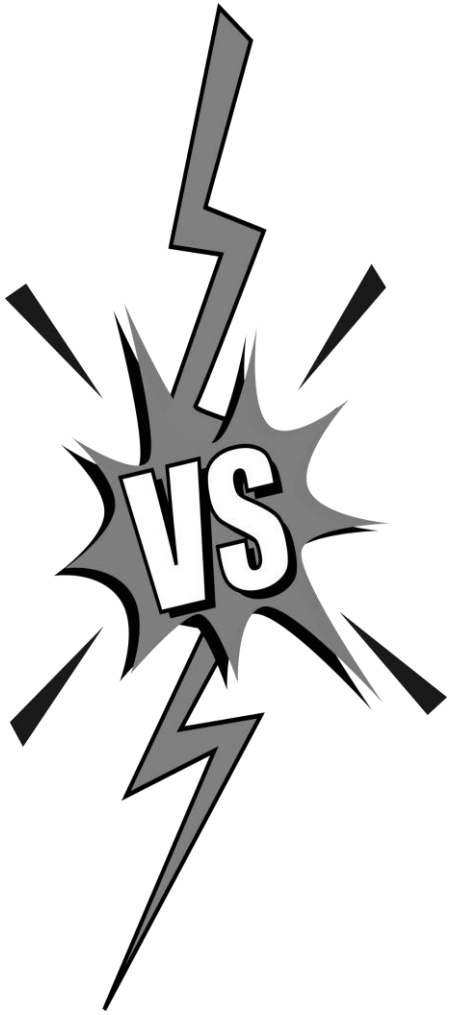
- 3,500 Sqft Single Level 4 Bedroom Apartment.
- 40+ Real WiFi devices comprising of Phones, Tablets and TVs
- Devices spread across 7 sections at fixed positions
- TCP-DL, TCP-UL tests are performed on all the clients.
- Same type of clients and test environment are used for both Vendor-A and Vendor-B APs.



DUT Details

DUT1
Vendor A Mesh System

Specs
Chipset : Broadcom
Triband System
Radio1: 2.4GHz b/g/n/ax 2x2 MIMO
Radio2: 5GHz a/n/ac/ax 2x2 MIMO
Radio3 : 5GHz a/n/ac/ax 4x4 MIMO
1GE WAN/LAN
AP Mode Only

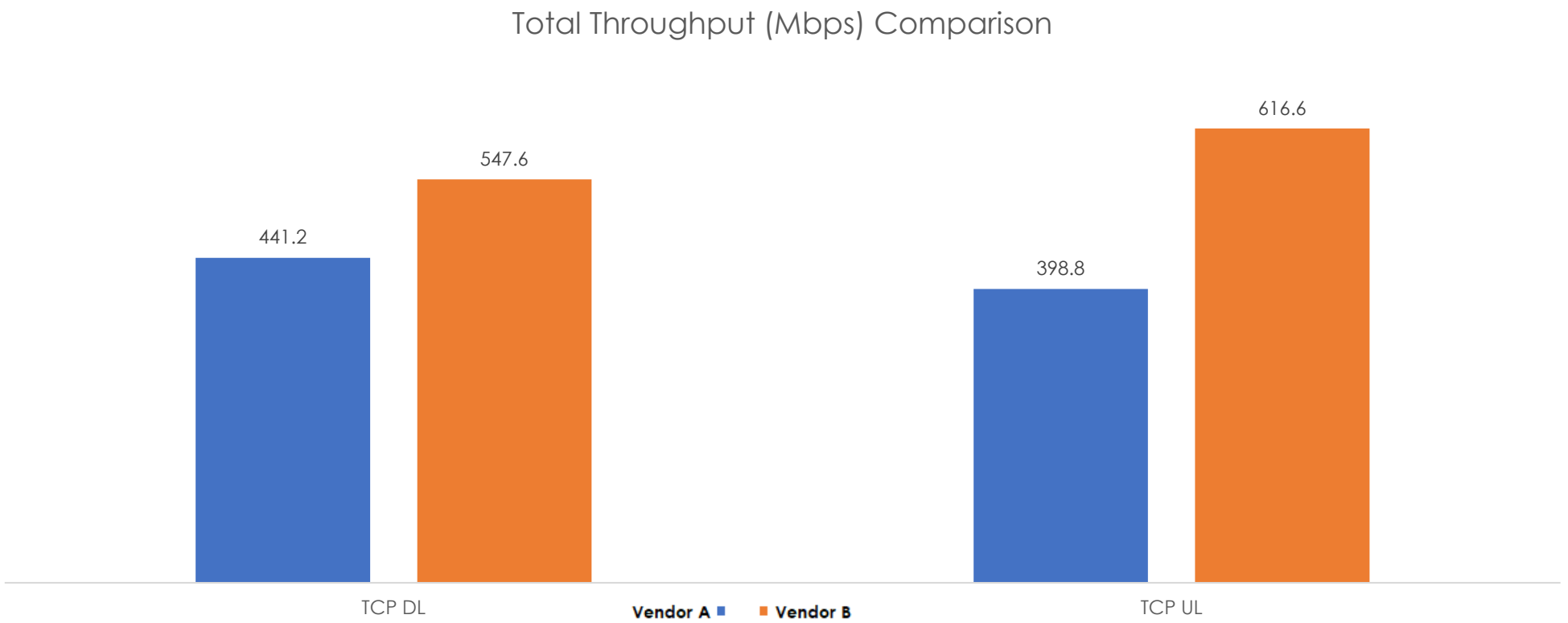


DUT2
Vendor B Mesh System

Specs
Chipset : RealTek
Triband System
Radio1: 2.4GHz b/g/n/ax 2x2 MIMO
Radio2: 5GHz a/n/ac/ax 2x2 MIMO
Radio3 : 5GHz a/n/ac/ax 4x4 MIMO
1GE WAN/LAN
Router and AP Modes

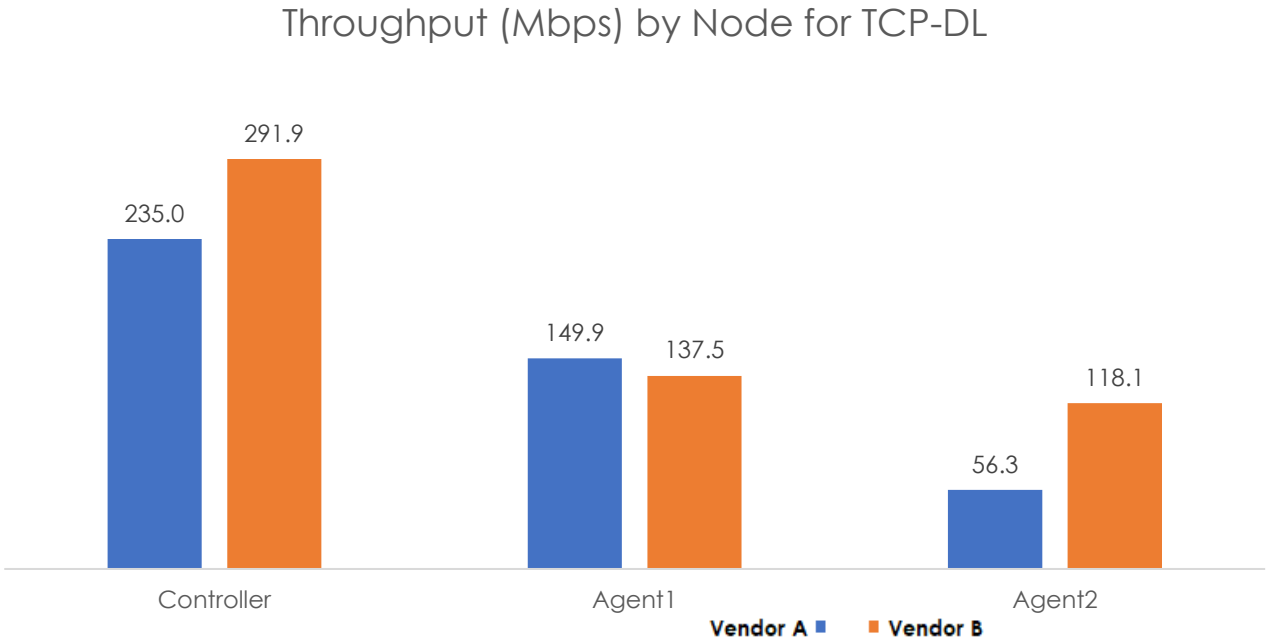
Device Placement in the Test House – 40+ Devices

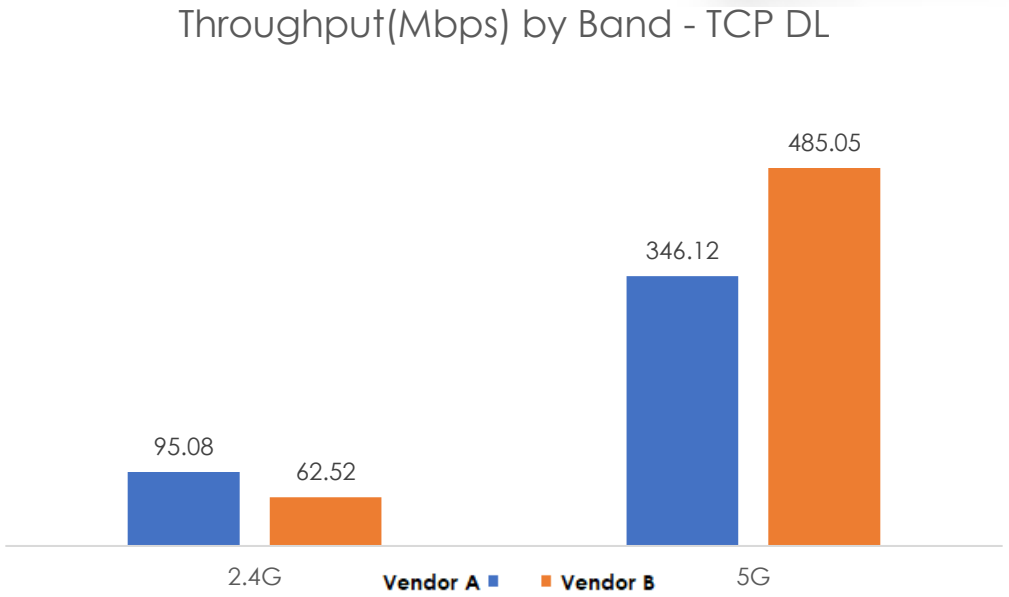
Total Mesh System Throughput Comparison

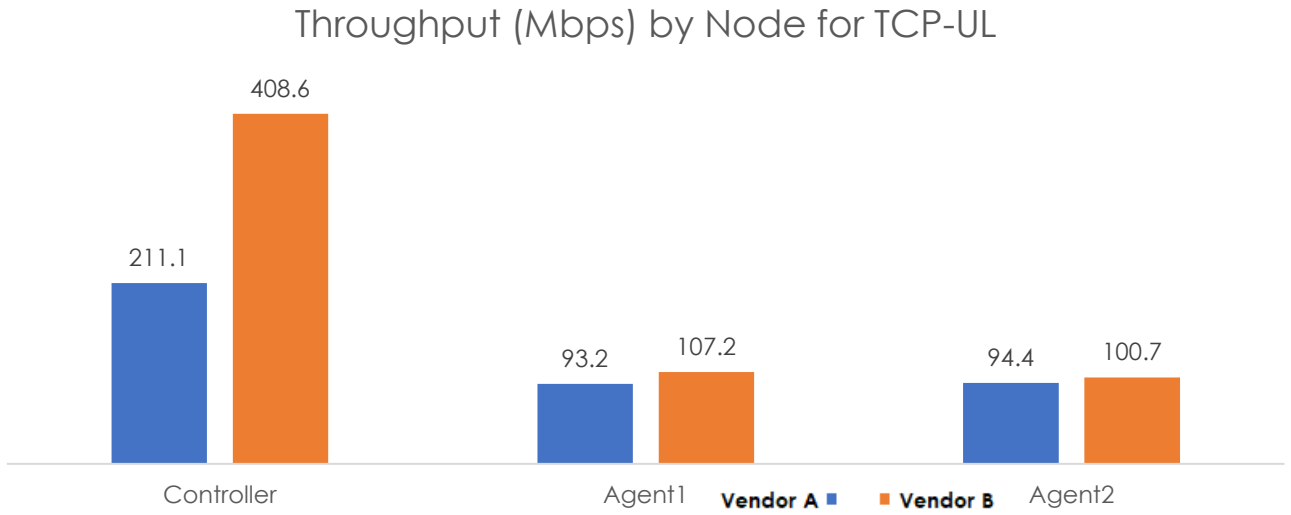


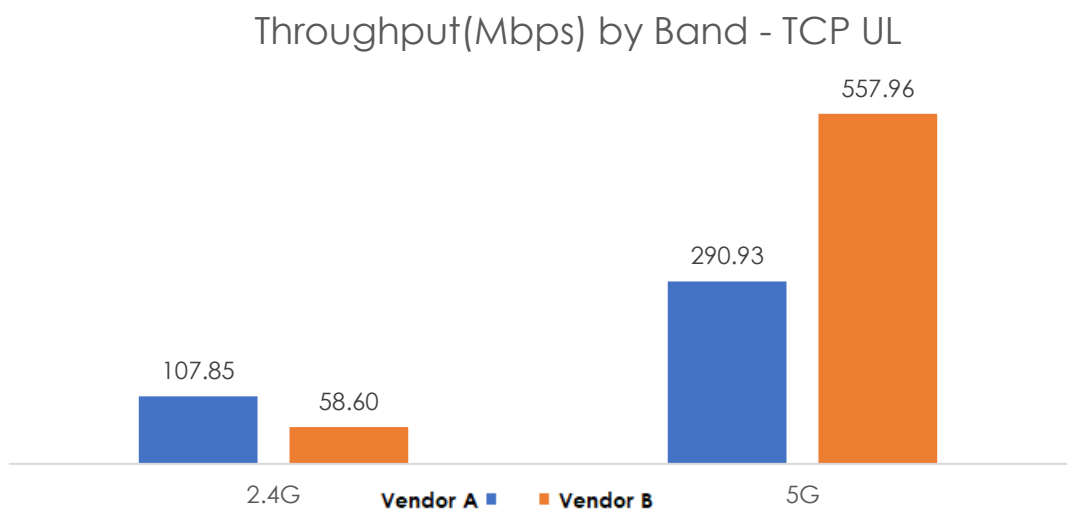
- Test run with total of 42 devices spread across 3500 sqft with devices automatically distributed across Controller and Agents and both 2.4 and 5GHz bands
- The Intended traffic load for each device was set to a Maximum of 200Mbps for both TCP Upstream and Downstream

Throughput Distribution across Nodes and Bands

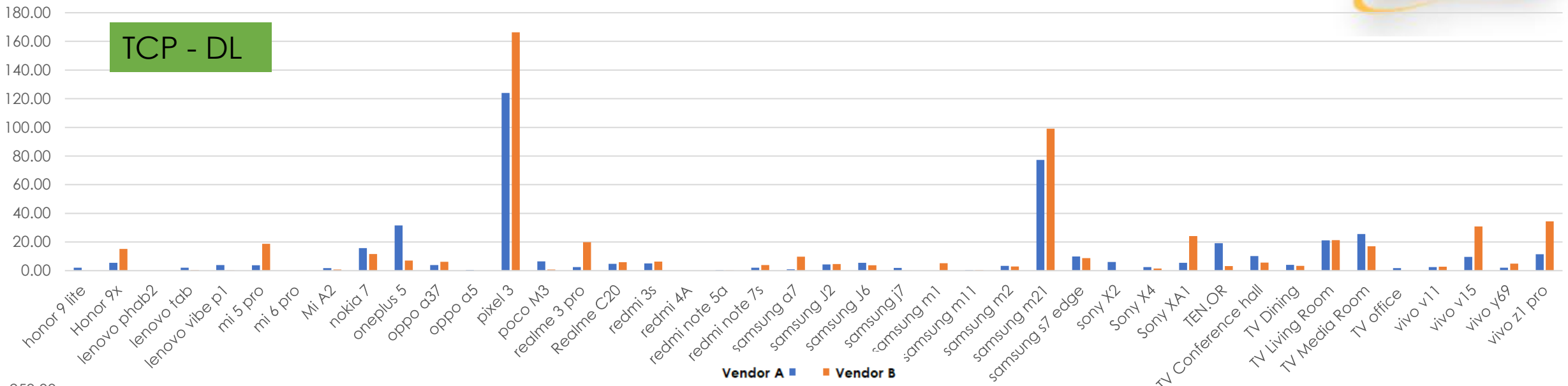


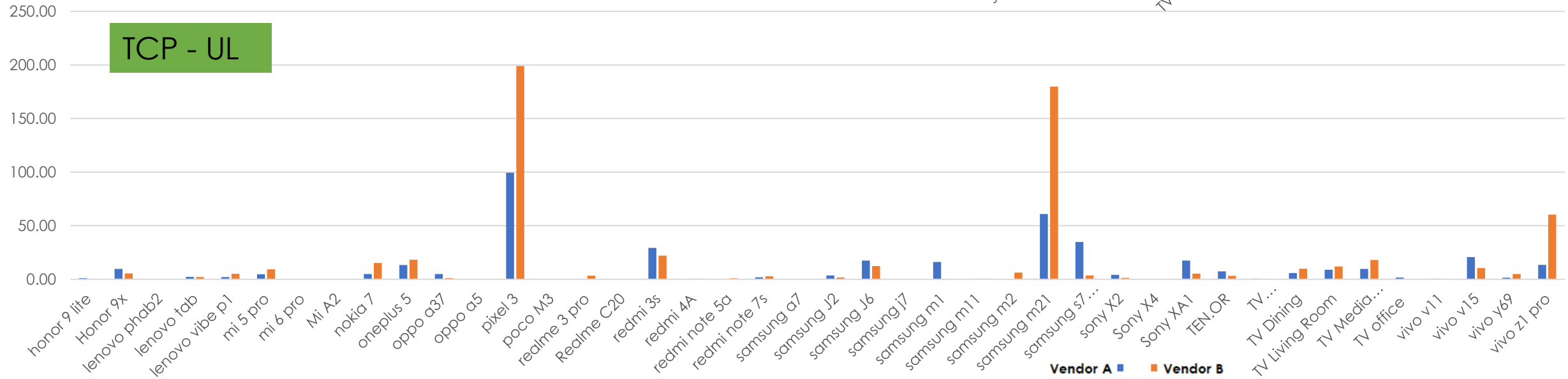




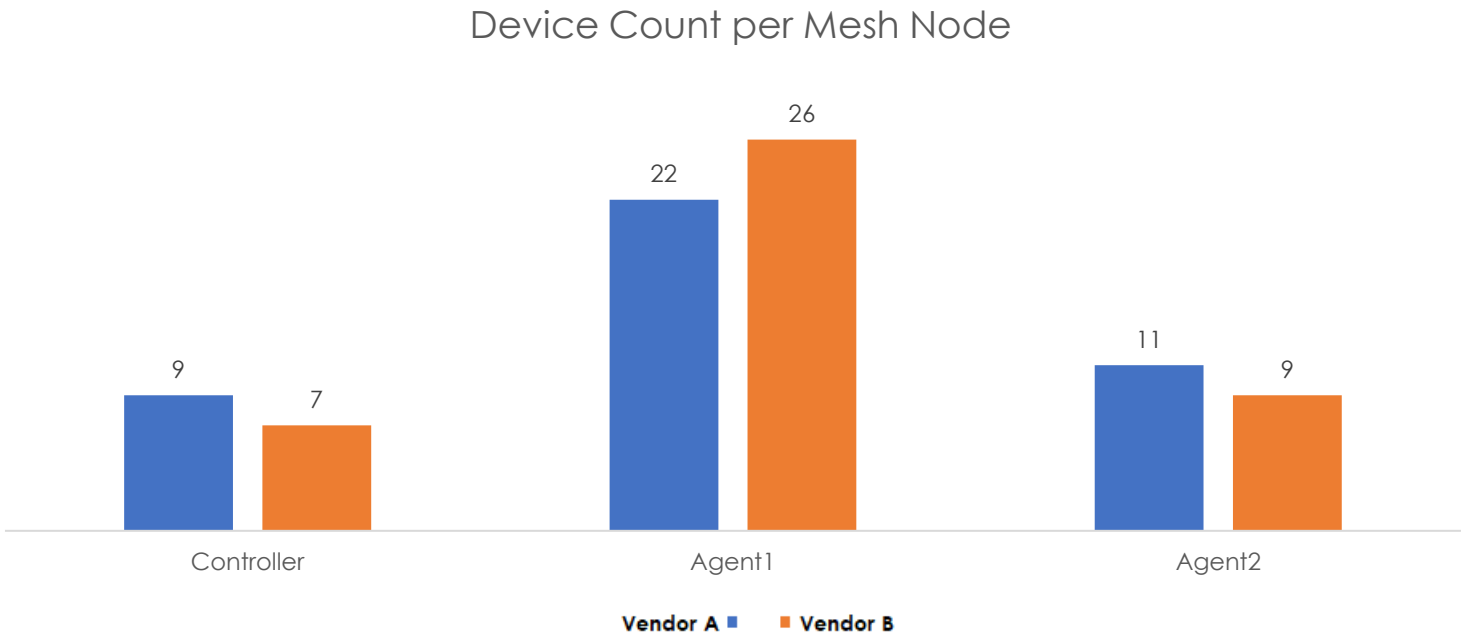


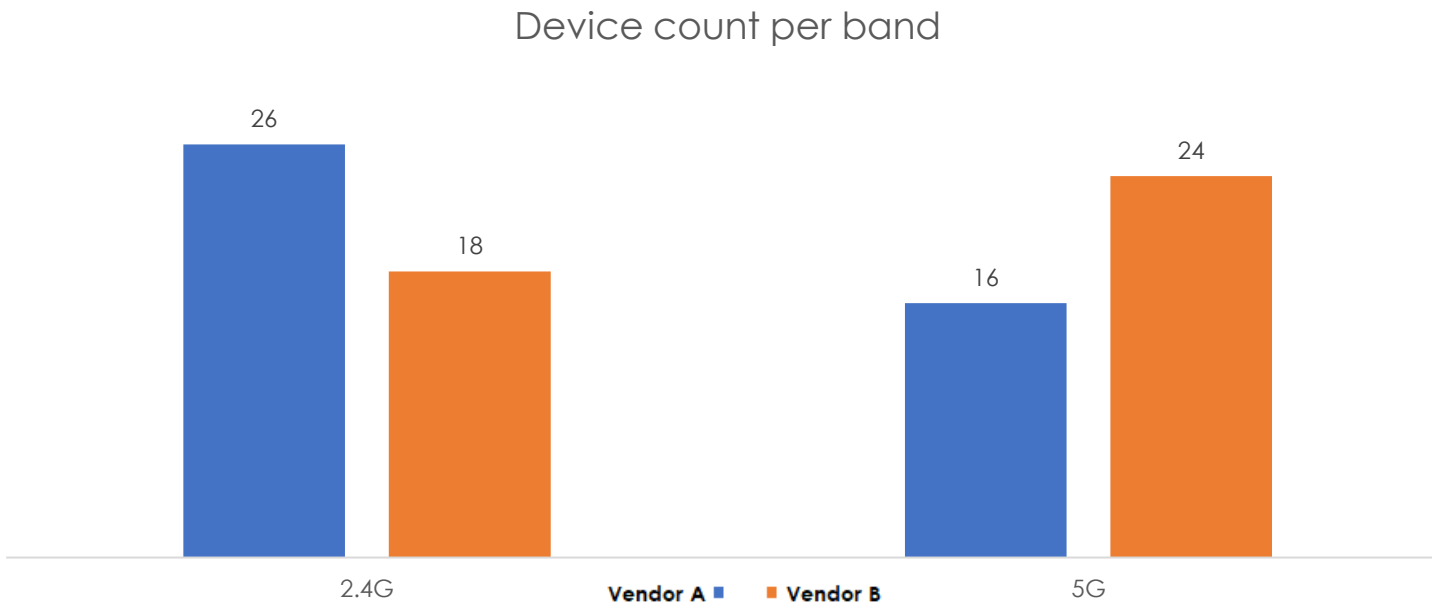
Per Device Throughput (Mbps)



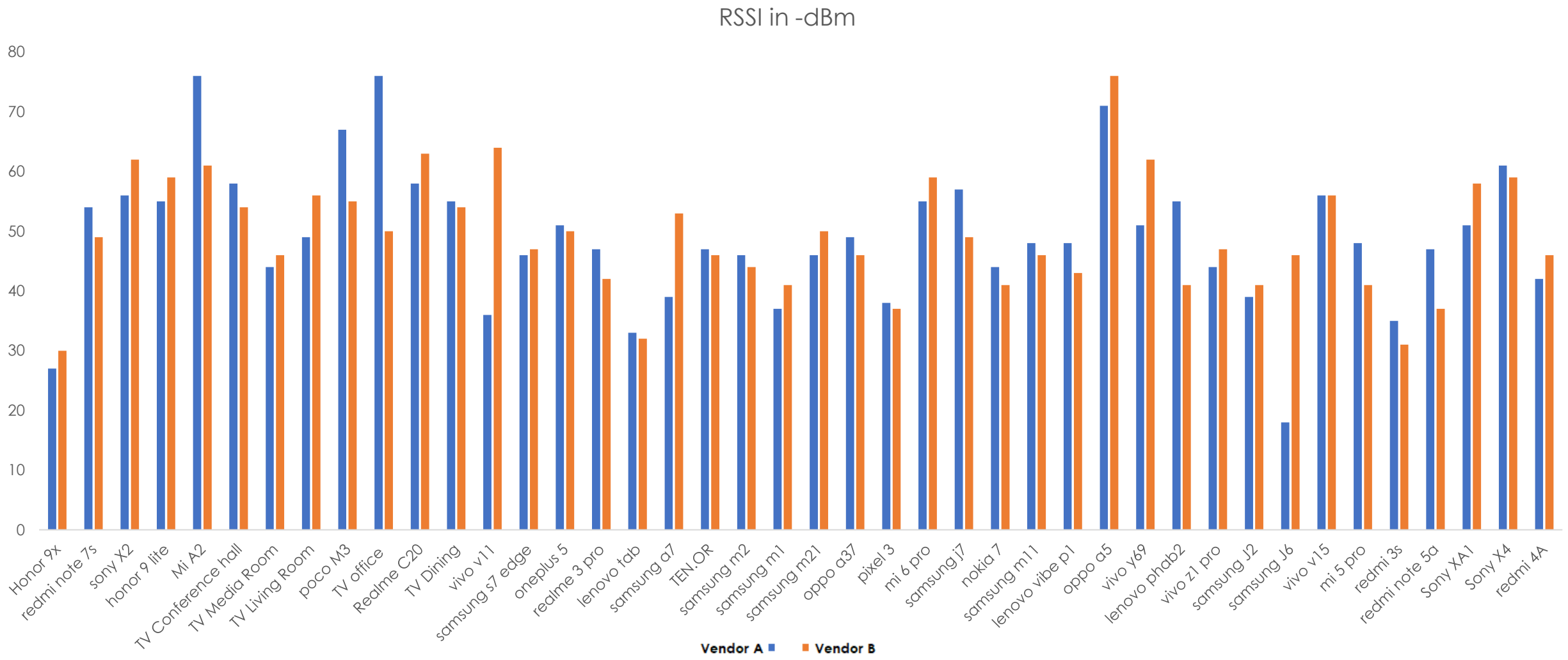


Device Connection Distribution



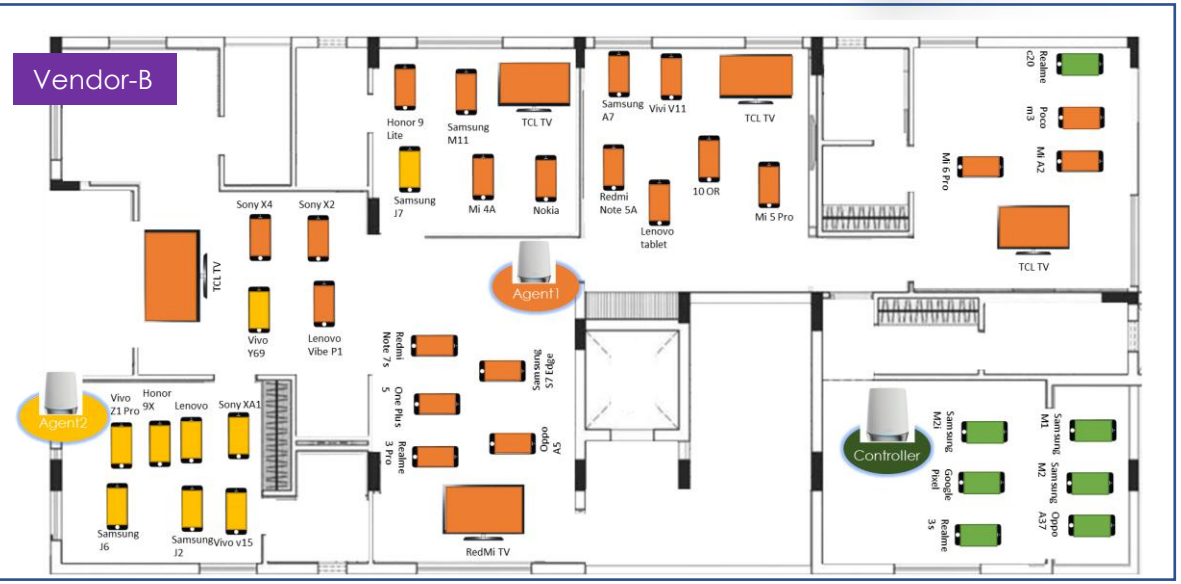


RSSI of Devices in –dBm

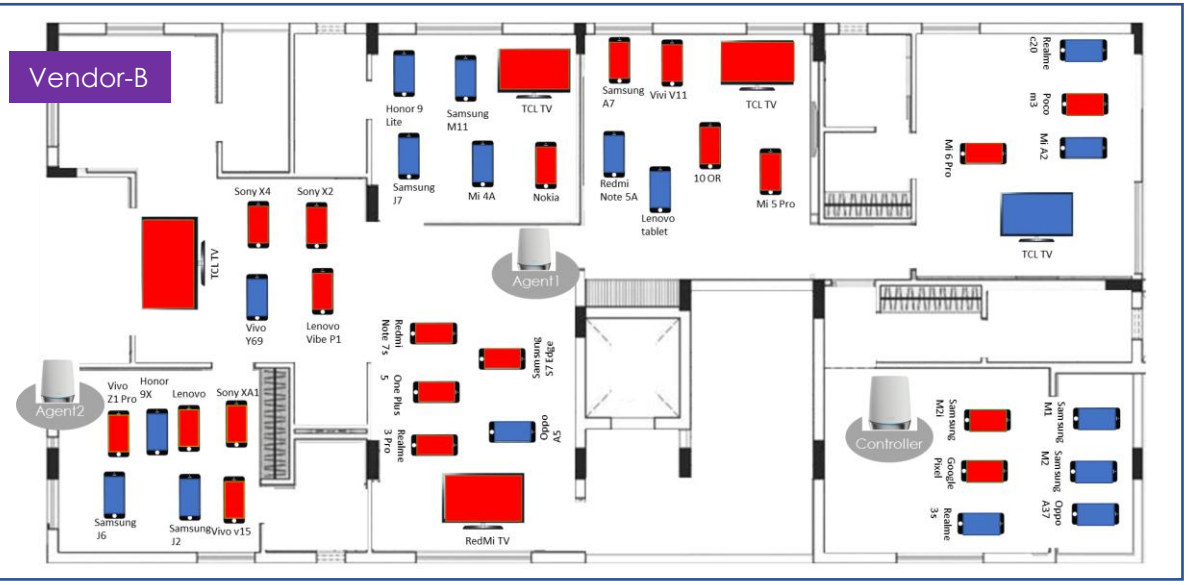


Device Distribution by Nodes and Bands

Distribution By Nodes



Distribution By Bands



2.4GHz 5GHz

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