FIELD TESTS DEMONSTRATE THAT WI-FI® MESH IN THE HOME STILL REQUIRES A WIRE

MoCA recently concluded field tests that compared three different Wi-Fi mesh-based products in a home networking environment, vs. a Wi-Fi network that used MoCA as the backhaul. The results showed a dramatic improvement in Wi-Fi performance when using MoCA 2.0 as the backhaul, compared to a Wi-Fi-based backhaul only.

Wi-Fi mesh has been getting a lot of attention lately as an alternative for whole-home coverage. The Alliance conducted these tests to determine if Wi-Fi mesh-based products could sustain performance throughout a typical U.S. home with multiple streams of traffic running concurrently.

All devices tested included 802.11ac fronthaul. Netgear's Orbi, Plume and Eero, which integrate 802.11ac backhaul, were compared to Actiontec Wi-Fi extenders that integrate MoCA 2.0 Bonded backhaul. All devices used are currently available via retail channels so as to test products that consumers can purchase today.

Per the graph below showing cumulative distribution results for TCP traffic type, MoCA 2.0 Bonded extenders delivered 800 Mbps or better downlink Wi-Fi performance in all homes. Orbi was able to achieve 300 Mbps or better in 50% of homes though some homes were capable of only 170 Mbps. Eero and Plume were unable to reach 200 Mbps at all. See TCP Traffic (A).

Uplink traffic with Wi-Fi was also significantly greater when using MoCA technology as the backbone compared to using Orbi, Eero or Plume.

Testing of UDP traffic showed similar improvements in performance when using MoCA technology as the wired backbone. See UDP Traffic (B).

"Whole home coverage and sustained performance in the home go hand-in-hand but can be difficult to achieve without a wired backhaul. The beauty in this is, MoCA leverages the already existing coax as its backhaul," said Charles Cerino, MoCA President. "These tests demonstrate that while Wi-Fi mesh may offer some improvement in whole home coverage, it is not consistent and a wire is still critical for the highest performance and lowest latency in every room."

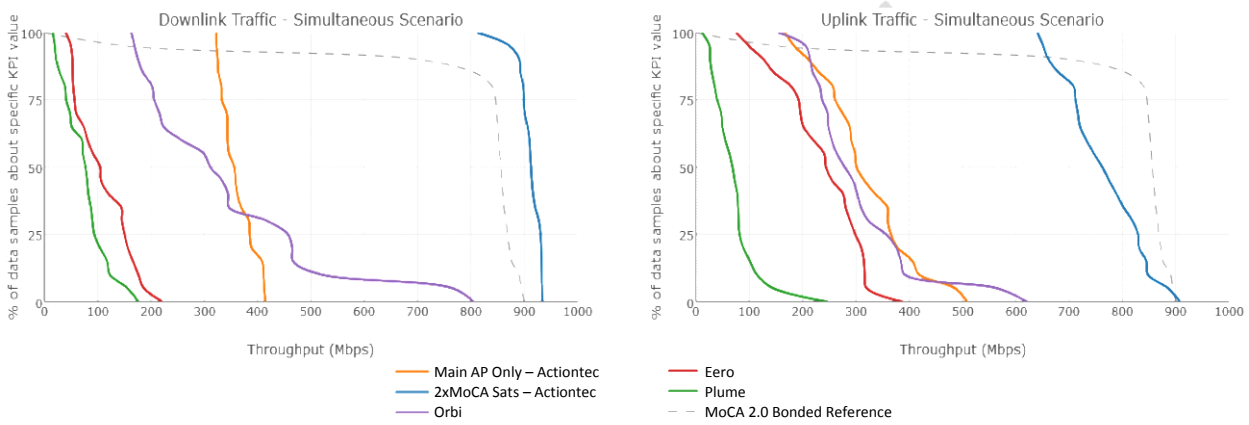
Test methodology

Dekra (formerly AT4Wireless) performed the tests and recorded the results from 11 homes around the country including Georgia, New Jersey, Virginia, Pennsylvania, Colorado and California.

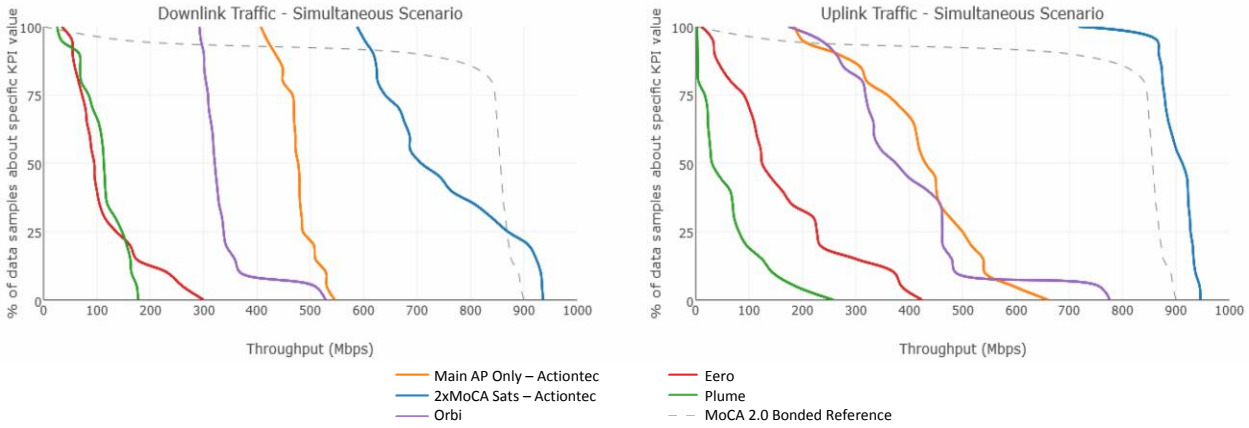
Nine Wi-Fi clients were deployed throughout each test house. Client location remained the same for all five system tests. For each system, Dekra turned off all clients, setup and enabled new APs, and then turned on all clients. Clients were not manually connected to a particular AP.

Traffic types were TCP and UDP, downlink and uplink. Traffic was sent to all clients individually in 60-second intervals in one test. In another test, traffic was sent to all nine endpoints simultaneously – most closely representing real world usage.

TCP Traffic (A)



UDP Traffic (B)



Wi-Fi MoCA Field Testing

Test Report (Public Edition)

Date: 10 May 2017

Table of Contents

1. Executive Summary

1.1 Overview

- This Public Edition of the report contains selected sections of the Full Report available to MoCA Alliance members.
- Wi-Fi mesh has been getting a lot attention lately as an attempt to improve Wi-Fi whole-home coverage. MoCA conducted these tests to determine if Wi-Fi mesh-based products could sustain performance throughout a typical U.S. home with multiple streams of traffic running concurrently.
- Field tests in 11 homes around the country were conducted measuring performance using three, off-the-shelf, Wi-Fi mesh products as the backbone and a MoCA 2.0 Bonded Wi-Fi extender
- A third party, Dekra (formerly AT4 wireless), collected and parsed data for throughput, jitter, latency and RSSI performance for individual and simultaneous test scenarios.
- All devices tested included 802.11ac fronthaul. Netgear's Orbi, Plume and Eero, which integrate 802.11ac backhaul were compared to Actiontec Wi-Fi extenders that integrate MoCA 2.0 Bonded backhaul. All devices used are currently available via retail channels so as to test products that consumers can actually purchase today.

1.2 Conclusions

- MoCA 2.0 Bonded extenders delivered 800 Mbps or better downlink Wi-Fi performance in all homes using TCP traffic. Orbi was able to achieve 300 Mbps or better in 50% of homes though some homes were capable of only 170 Mbps. Eero and Plume were unable to reach 200 Mbps at all.
- Uplink traffic with Wi-Fi was also significantly greater when using MoCA technology as the backbone compared to using Orbi, Eero or Plume.
- Testing of UDP traffic showed similar improvements in performance when using MoCA technology as the wired backbone.

1.3 Version Control

Version	Date	Change Log
V1.0	17-Apr-2017	Initial Version
V1.1	10-May-2017	Applied color to cells in ranking tables.

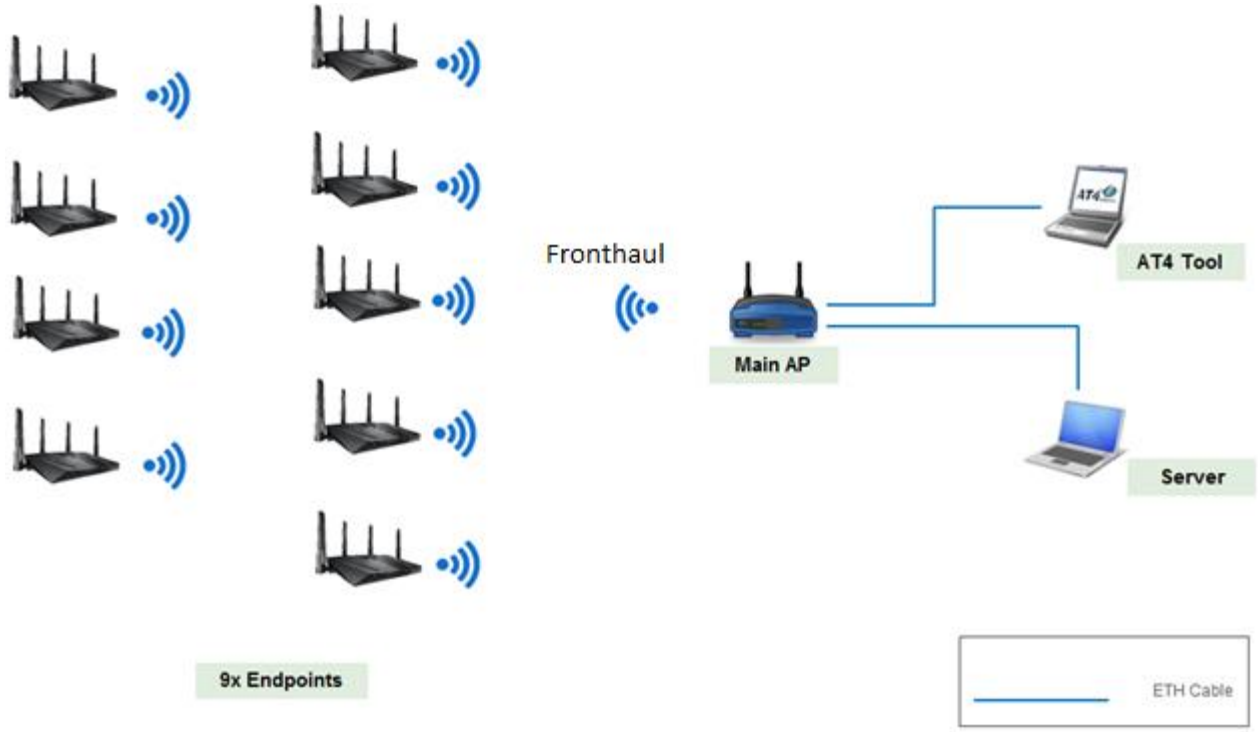
2. Test Environment

2.1 Overview

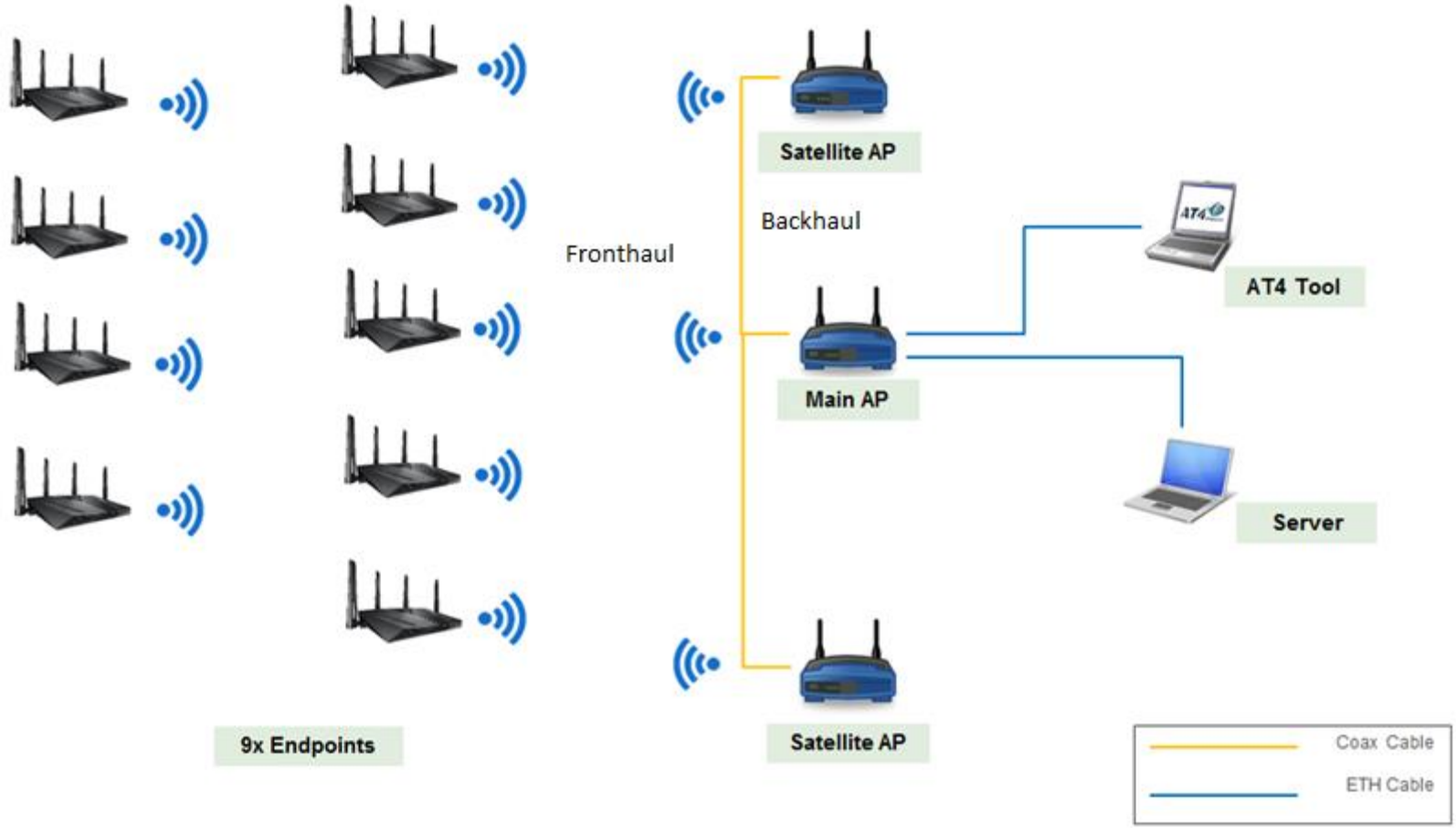
As a part of this activity, 5 different test systems were defined as for the guidelines from MoCA. Test systems include Eero, Plume, Orbi, and Main AP only and two Satellite APs connected with MoCA backhaul. End points installed at different locations in a test house are used to connect to the test system that records KPIs on each test system.

Test installation is characterized in to 3 different installations

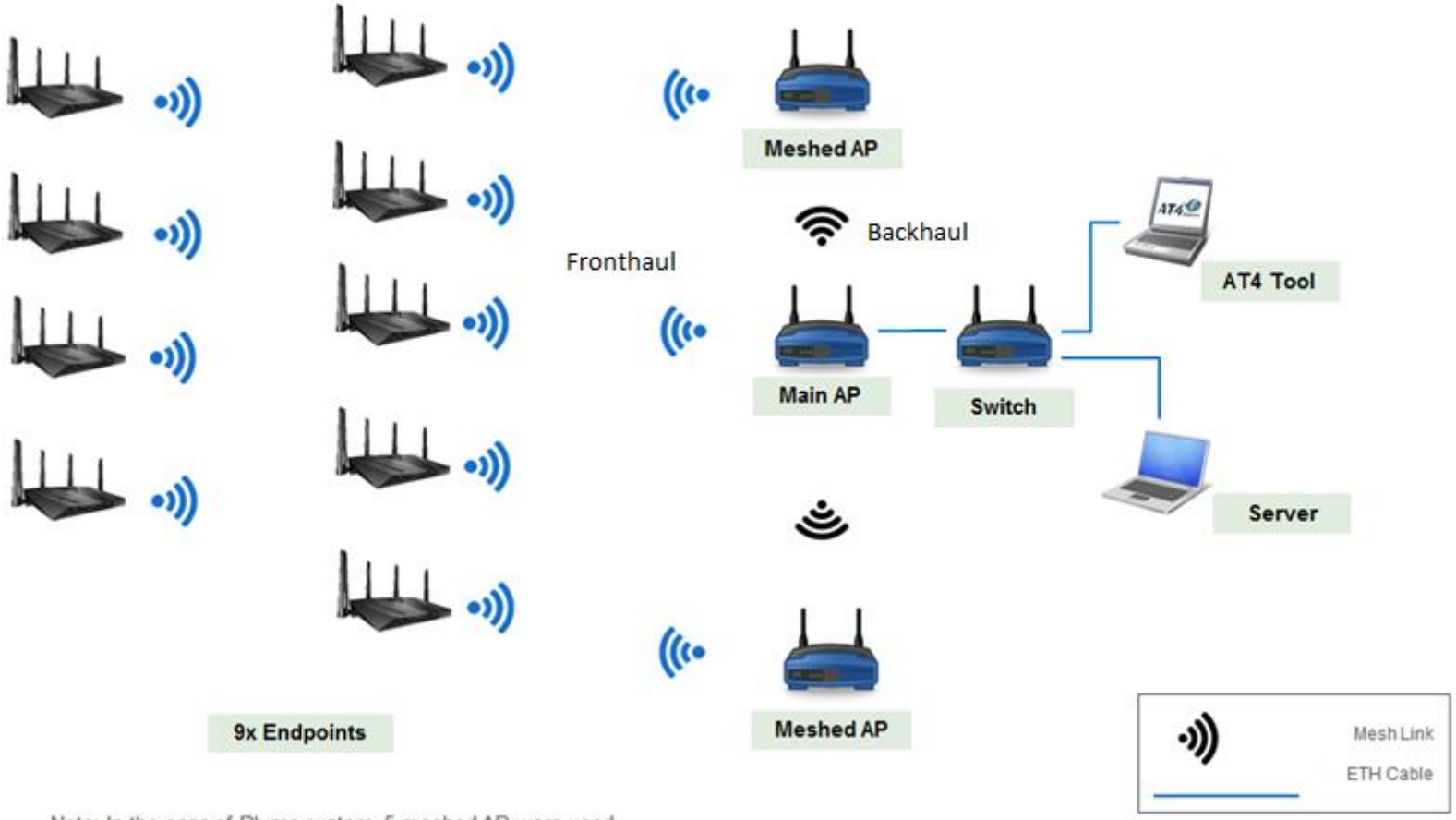
2.1.1 Main AP Only (baseline)



2.1.2 MoCA: 1xMain + 2x Satellite APs



2.1.3 Wi-Fi Mesh System



Note: In the case of Plume system, 5 meshed AP were used.

2.2 Test Bed

2.2.1 Wi-Fi Mesh Equipment

2.2.1.1 Eero

ID	AT4 Control #	Vendor	Model	SW Version	S/N	BSSID	Role
Eero1	1762.56	Eero	A010001	v2.2.0-2478	E6CA-0612-KPQH-VKEN	14:22:DB:96:DF:C5	Main
Eero2	1762.54	Eero	A010001	v2.2.0-2478	E6CA-1141-5PZ0-ND8V	14:22:DB:97:0A:85	Satellite
Eero3	1762.52	Eero	A010001	v2.2.0-2478	E6C9-1254-QVZ2-T7BN	14:22:DB:97:27:C5	Satellite

2.2.1.2 Orbi

ID	AT4 Control #	Vendor	Model	SW Version	S/N	BSSID	Role
Orbi1	1762.86	Netgear	Orbi RBR50	V1.4.0.34	4PM56C5E07941	B0:B9:8A:5F:73:6D	Main
Orbi2	1762.87	Netgear	Orbi RBR50	V1.4.0.34	4PN56C5H07B8C	B0:B9:8A:62:07:E8	Satellite
Orbi3	1762.83	Netgear	Orbi RBR50	V1.4.0.34	4PN56C5G07B8B	B0:B9:8A:62:33:F6	Satellite

2.2.1.3 Plume

ID	AT4 Control #	Vendor	Model	SW Version	S/N	BSSID	Role
Plume1	1762.59	Plume	A1A	1.2.1-7d65e051-14	P1K651572500	E2:B4:F7:02:28:6A/69	Main
Plume2	1762.61	Plume	A1A	1.2.1-7d65e051-14	P1K651652800	E2:B4:F7:02:34:F6/F5	Satellite
Plume3	1762.63	Plume	A1A	1.2.1-7d65e051-14	P1K651263200	E2:B4:F7:02:F8:16/15	Satellite
Plume4	1762.58	Plume	A1A	1.2.1-7d65e051-14	P1K651369600	E2:B4:F7:02:08:B6/B5	Satellite
Plume5	1762.60	Plume	A1A	1.2.1-7d65e051-14	P1K651373800	E2:B4:F7:02:09:5E:5D	Satellite
Plume6	1762.62	Plume	A1A	1.2.1-7d65e051-14	P1K651373200	E2:B4:F7:02:09:46:45	Satellite

2.2.2 MoCA Equipment

ID	AT4 Control #	Vendor	Model	SW Version	S/N	BSSID	Role
MoCA1	1762.66	Actiontec	T3200M	91.164L.08-2.2.1	GTBA6240100889	70:F1:96:70:B2:66	Main
MoCA2	1762.91	Actiontec	WCB6200Q	9.1.02.51p-2.2.2	GWXA6380703192	10:78:5B:22:35:B6	Satellite
MoCA3	1762.89	Actiontec	WCB6200Q	9.1.02.51p-2.2.2	GWXA6160200412	10:78:5B:0E:19:76	Satellite

Note: MoCA1 unit was used standalone for the Only Main AP configuration.

2.3 Test Equipment

2.3.1 Traffic Generator Performance Analysis Tool

2.3.1.1 Software

Software used	Description	Purpose	Version
AT4 Performance Tool	Traffic Generator	Traffic Generation: TCP/UDP DL and UL	5.1.1
AT4-Agent	Data Performance Tool	KPI Capture	5.1
Ekahau	Site Survey	Wi-Fi Site Survey	8.7.1

2.3.1.2 Hardware

Equipment	Vendor	Model	Version	CPU/RAM	MAC Address / S/N
WLAN Monitor1	Powerspec	Raspberry	ubuntu MATE 16.04		b8:27:eb:87:1b:40
WLAN Monitor2	Powerspec	Raspberry	ubuntu MATE 16.04		b8:27:eb:1b:7d:ea
WLAN Monitor3	Powerspec	Raspberry	ubuntu MATE 16.04		b8:27:eb:d9:05:1b
Linux Server	Lenovo	E530	ubuntu 16.04LTS	Intel i5 @2.5GHz*4/7.4GB	CTC-6266-E
AT4 Controller Laptop	Dell	E6520	Windows 7 64-bit	Intel i5 @2.5GHz/8GB	8GL8FS1

2.3.2 Wi-Fi Endpoints

ID	AT4 Control #	Vendor	Model	SW Version	S/N	WLAN MAC Address	LAN IP Address
Endpoint1	1762.01	Asus	RT-AC3100	asuswrt-merlin v380.65	G7IBHA003387	70:8B:CD:CD:C4:54	192.168.7.101
Endpoint2	1762.09	Asus	RT-AC3100	asuswrt-merlin v380.65	G7IBHA003386	F8:32:E4:F5:4E:A4	192.168.7.102
Endpoint3	1762.05	Asus	RT-AC3100	asuswrt-merlin v380.65	G6IBHA010633	70:8B:CD:31:8F:FC	192.168.7.103
Endpoint4	1762.07	Asus	RT-AC3100	asuswrt-merlin v380.65	G7IBHA003305	70:8B:CD:CD:D0:0C	192.168.7.104
Endpoint5	1762.13	Asus	RT-AC3100	asuswrt-merlin v380.65	G7IBHAIR00BU	F8:32:E4:F5:CA:74	192.168.7.105
Endpoint6	1762.11	Asus	RT-AC3100	asuswrt-merlin v380.65	G2IBHAIR00DX	F8:32:E4:54:36:B4	192.168.7.106
Endpoint7	1762.03	Asus	RT-AC3100	asuswrt-merlin v380.65	G7IBHAIR00LD	70:8B:CD:31:E5:B4	192.168.7.107
Endpoint8	1762.15	Asus	RT-AC3100	asuswrt-merlin v380.65	G7IBHA003388	70:8B:CD:CD:CA:9C	192.168.7.108
Endpoint9	1762.73	Asus	RT-AC3100	asuswrt-merlin v380.65	G2IBHAIR00D4	F8:32:E4:52:E4:E4	192.168.7.109

2.3.3 Traffic Profiles

The traffic was generated by sending TCP or UDP packets directly to the transport layer from application layer. Table below provides additional information on the traffic flow characteristics used. In the case of TCP flows, packets are transmitted continuously based on TCP protocol functionally.

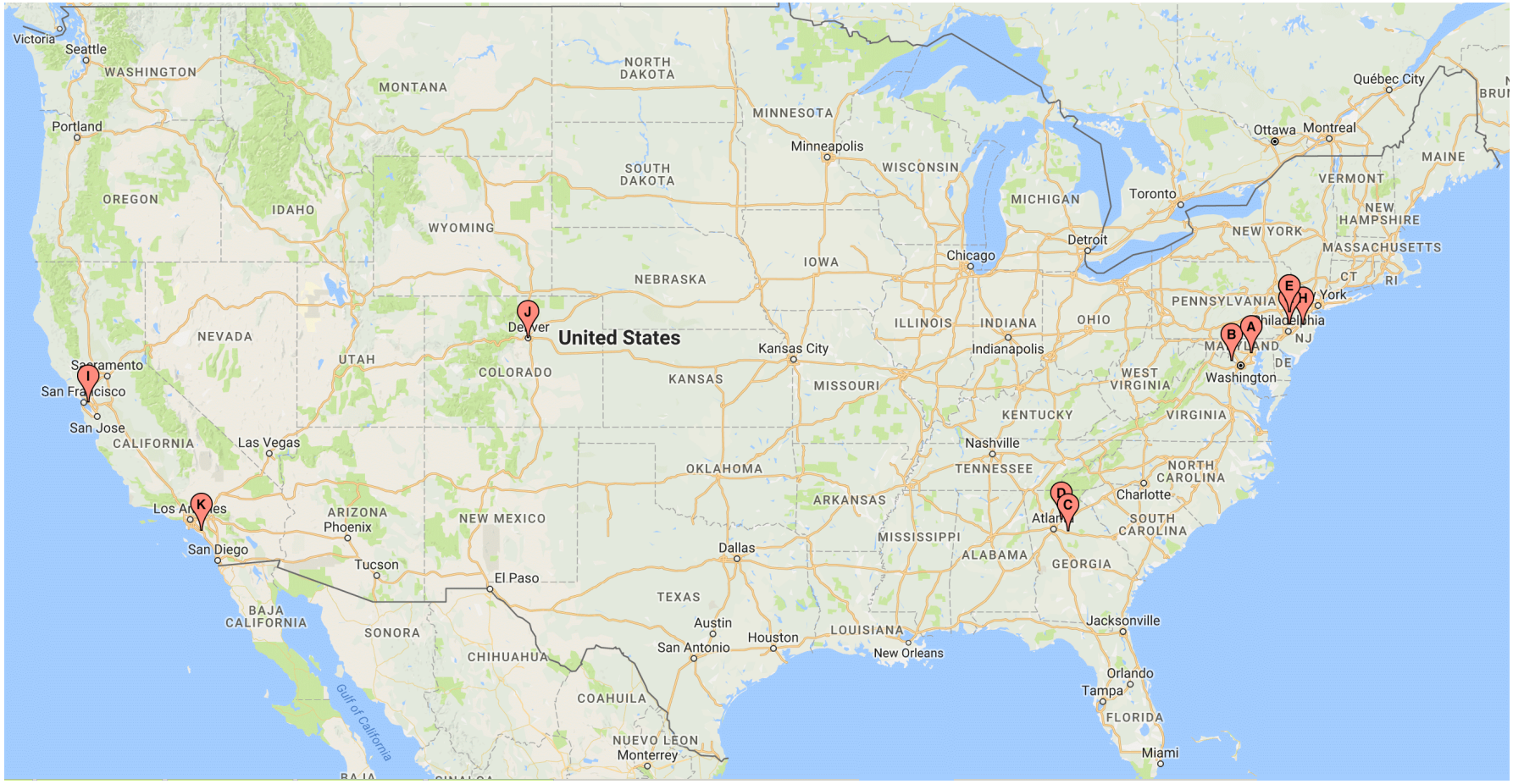
During this activity, the following traffic flows have been used:

Scenario	Transport Type	Direction	Number of parallel Data Streams	Tx / Rx Bufer	Traffic Load per Data Stream	Application SDU Rate	Application SDU Size (Bytes)	IP Fragmentation	Max MTU
Individual	TCP	DL	4	OS Default	Full Buffer	-	128 kB	-	-
		UL	4	OS Default	Full Buffer	-	128 kB	-	-
	UDP	DL	1	256 kB	Full Buffer	-	1450 B	Disabled	1500 B
		UL	2	256 kB	Full Buffer	-	1450 B	Disabled	1500 B
Simultaneous	TCP	DL	2	OS Default	Full Buffer	-	128 kB	-	-
		UL	2	OS Default	Full Buffer	-	128 kB	-	-
	UDP	DL	2	256 kB	200 Mbps	17241 SDU/s	1450 B	Disabled	1500 B
		UL	2	256 kB	200 Mbps	17241 SDU/s	1450 B	Disabled	1500 B

- Note:
  - Individual scenario was executed one time while Simultaneous scenario is executed two times.
  - In Full Buffer mode, the application sends data as soon as the transport protocol buffer is cleared.

2.4 Test Location

2.4.1 Testing Location and period



3. Test Procedure

3.1 Data Collection

The same Dekra employee/individual performed all setup and testing for all homes. Data was collected following the below steps:

1. Deploy clients throughout the test house.
    - Client Location remained the same for all the system tested.
2. Deploy APs throughout the test house.
    - Same locations were used for all the systems tested
3. For each system:
    - Turn off all clients
    - Setup and enable new APs.
    - Turn on all clients
        - Note: Clients were not manually connected to a particular AP.
    - For Type of traffic in [TCP, UDP]
        - For direction in [DL, UL]
            1. Send traffic to each Client individually during 60 seconds
    - For Type of traffic in [TCP, UDP]
        - For direction in [DL, UL]
            1. Send traffic to ALL clients Simultaneously during 60 seconds
    - Repeat #Step 4

3.2 Results Calculation Methodology

3.2.1 Nomenclature

1. TTj: Namely the four traffic types where j = 1..4 (TCP-DL, TCP-UL, UDP-DL and UDP-UL)
2. Si: Namely the five systems under test where i = 1..5 (Main AP only, 2xMoCA Sats., Eero, Orbi and Plume)
3. KPI (n): Namely the value of the KPI under calculation for each iteration where n= 1 for individual scenario and n= 2 for simultaneous scenario
4. THm: Namely the twelve test house locations where m = 1..12
5. EPp: Namely the nine Endpoints in the test bed where p = 1..9
6. Ff: namely single data stream flow where f depends on the scenario and type of traffic flow as defined in table in section 2.2.3

3.2.2 KPI calculation methodology

3.2.2.1 Data KPIs (Throughput, Jitter and Delay):

1. Calculate median value of each KPI for each single data stream:
    a. For each run, AT4 Tool saves a vector of 60 KPI samples considering a traffic flow duration of 60 seconds (t). Seven initial samples and two last samples are discarded.

$$Flow\_Tput_{TTj,Si,EPp,Ff} = Median\{Instant\_Tput_{TTj,Si,EPp,Ff,}(t)\} \ \forall\, j,i,p,f \ where \ t = 8..58$$

$$Flow\_Delay_{TTj,Si,EPp,Ff} = Median\{Instant\_Delay_{TTj,Si,EPp,Ff}(t)\} \ \forall\, j,i,p,f \ where \ t = 8..58$$

$$Flow\_Jitter_{TTj,Si,EPp,Ff} = Median\{Instant\_Jitter_{TTj,Si,EPp,Ff}(t)\} \ \forall\, j,i,p,f \ where \ t = 8..58$$

2. For each Endpoint (aka client) the single flow KPIs obtained are combined as follow

$$EP\_Tput_{TTj,Si,EPp} = \sum_{1}^{f} Flow\_Tput_{TTj,Si,EPp,Ff}(f) \ \forall\, j,i,p$$

$$EP\_Delay_{TTj,Si,EPp} = Median\left\{Flow\_Delay_{TTj,Si,EPp,Ff}\ (f)\right\} \forall\ j,i,p\ where\ f = 1,1..2\ or\ 1..4$$

$$EP\_Jitter_{TTj,Si,EPp} = Median\left\{Flow\_Jitter_{TTj,Si,EPp,Ff}\ (f)\right\} \forall\ j,i,p\ where\ f = 1,1..2\ or\ 1..4$$

3. In the simultaneous scenario, the aggregated KPIs for each group of Endpoints are calculated as follows:

$$Group\_Tput_{TTj,Si} = \sum_{1}^{p} EP\_Tput_{TTj,Si,EPp}(p)\ \forall\ j,i\ where\ p = 1..9$$

$$Group\_Delay_{TTj,Si} = Median\left\{EP\_Delay_{TTj,Si,EPp}\ (p)\right\} \forall\ j,i\ where\ p = 1..9$$

$$Group\_Jitter_{TTj,Si} = Median\left\{EP\_Jitter_{TTj,Si,EPp}\ (p)\right\} \forall\ j,i\ where\ p = 1..9$$

   a. Group of Endpoints are composed by the data KPIs collected for each Endpoint where data was being sent to them simultaneously.

3.2.2.2 Data KPIs percentile

Throughput data is reported in cumulative density function (CDF) format. CDF data is based on percentile values of the data KPIs calculated as:

$$Per\ test\ House\ CDF = P\left(KPI_{TTj,SiTHm,} \leq x\right)\ \ \forall\ j,i,m\ where\ m = 1..11$$

$$Per\ System\ CDF = P\left(KPI_{TTj,SiTHm,} \leq x\right)\ \ \forall\ j,m\ where\ i = 1..5$$

3.2.2.3 WLAN KPIs:

1. For each Endpoint:
   a. Report median value of WLAN KPI over time for each Iteration.
2. For each Group of Endpoints:
   a. Calculate the median of WLAN KPI values from each Endpoint obtained in step #1.a above.

3.2.3 Ranking Indicators calculation methodology

Comparison of system under test is done with for types of traffic and two scenarios across several test houses. Some of these have very different performance so the results so five different indicators are calculated to rank the performance of the units under test:

1. Relative Median KPI:
   a. Indicator based on overall KPI performance relative to the performance for all the systems for each traffic type

   b. Systems under test are ranked based on the ability to deliver higher throughput consistently.

2. Relative Peak KPI:
   a. Indicator based on overall peak KPI performance relative to the peak performance for all the systems for each traffic type
   b. Systems under test are ranked based on the ability to deliver higher peak throughput.
3. Overall Variability
   a. Indicator based on the dispersion of the results of each system for the different test conditions.
   b. Systems under test are ranked based on overall performance consistency
4. Inter-Endpoint Variability
   a. Indicator based on the consistency of performance among endpoint performance within each test iteration
   b. Systems under test are ranked based on the ability to provide a similar performance for the different endpoints.
5. Inter-House Variability
   a. Indicator based on the dispersion of the results of each system for the different test conditions across the different test houses.
   b. Systems under test are ranked based on overall performance consistency across test houses.

3.2.3.1 Relative Median Throughput Calculation methodology:

Relative Median KPI (Rel. Median KPI.) is calculated as:

1. Calculate Median KPI for each system (S) and for each traffic type (TT) considering all test iterations:

$$Median\ KPI_{TTj,Si,} = Median\{KPI_{TTj,Si,}(n)\}\ \forall\ n,j,i$$

2. Calculate Overall Median KPI for each traffic type (TT) considering all test iterations:

$$Median\ KPI_{TTj} = Median\{KPI_{TTj}(n)\}\ \forall\ n,j$$

3. Calculate Relative Median KPI for each system (S) for each traffic type (TT):

$$Rel.Median\ KPI_{TTj,Si,} = \frac{Median\ KPI_{TTj,Si,}}{Median\ KPI_{TTj}}\ \forall\ j,i$$

4. Calculate Relative Median KPI for each system (S):

$$Rel.Median\ KPI_{Si} = Median\{Rel.Median\ KPI_{TTj,Si}(j)\}\ \forall\ j,i$$

3.2.3.2 Relative Peak KPI Calculation methodology:

Relative Peak KPI (Rel. Peak KPI.) is calculated as:

1. Calculate Peak Throughput for each system (S) for each traffic type (TT) considering all test iterations:

$$Peak\ KPI_{TTj,Si,} = 95th\ percentile\ \{KPI_{TTj,Si,}(n)\}\ \forall\ n,j,i$$

2. Calculate Overall 95th percentile KPI for each traffic type (TT) considering all test iterations:

$$Peak\ KPI_{TTj} = 95th\ percentile\ \{KPI_{TTj}(n)\}\ \forall\ n,j$$

3. Calculate Relative Peak KPI for each system (S) for each traffic type (TT):

$$Rel.Peak\ KPI_{TTj,Si,} = \frac{Peak\ KPI_{TTj,Si,}}{Peak\ KPI_{TTj}}\ \forall\ j,i$$

4. Calculate Relative Peak KPI for each system (S):

$$Rel.Peak\ KPI_{Si} = Median\{Rel.Peak\ KPI_{TTj,Si}(j)\}\ \forall\ j,i$$

3.2.3.3 Overall Variability:

Overall Variability (Variability) is calculated as:

1. Calculate Relative Standard Deviation of the results for each system (S) for each traffic type (TT) considering all test iterations:

$$Rel.SD\ KPI_{TTj,Si,} = \frac{Standard\ Deviation\{KPI_{TTj,Si,}(n)\}}{Median\{KPI_{TTj,Si,}(n)\}}\ \forall\ n,j,i$$

2. Calculate Median of Relative Median Throughput for each system (S):

$$Overall\ Variability\ KPI_{Si} = Median\{Rel.SD\ KPI_{TTj,Si}(j)\}\ \forall\ j,i$$

3.2.3.4 Inter-Endpoint Variability:

Inter-Endpoint Variability (Inter-EP) is calculated as:

1. Calculate Standard Deviation of single Endpoints KPI for each system (S) for each traffic type (TT) for each iteration considering all test iterations

$$SD\ KPI_{TTj,Si,} = Standard\ Deviation\{KPI_{TTj,Si,EPp}(n,p)\}\ \forall\ n,j,i,p$$

2. Calculate Median of single Endpoints KPI for each system (S) for each traffic type (TT) for each iteration considering all test iterations

$$Median\ KPI_{TTj,Si,} = Median\{KPI_{TTj,Si,EPp}(n,p)\}\ \forall\ n,j,i,p$$

3. Calculate Relative Standard Deviation of single Endpoints KPI for each system (S) for each traffic type (TT)

$$Rel.SD\ KPI_{TTj,Si,} = \frac{SD\ KPI_{TTj,Si,}}{Median\ KPI_{TTj,Si,}}\ \forall\ j,i$$

4. Calculate Median of Relative Standard Deviation of single Endpoints KPI for each system (S):

$$Inter-EP\ KPI_{Si} = Median\{Rel.SD\ KPI_{TTj,Si}(j)\}\ \forall\ j,i$$

3.2.3.5 Inter-House Variability:

Inter-House Variability (Inter-House) is calculated as:

1. Calculate Median KPI for each system (S) (for each traffic type (TT) for each test house (TH) considering all test iterations:

$$Median\ KPI_{TTj,Si,THm} = Median\{KPI_{TTj,Si,THm}(n)\}\ \forall\ n,j,i,m$$

2. Calculate Standard Deviation KPI for each system (S) for each traffic type (TT) considering all test houses:

$$SD\ KPI_{TTj,Si} = Standard\ Deviation\ \{Median\ KPI_{TTj,Si,THm}\ (m)\}\ \forall\ n,j,i,m$$

3. Calculate Median KPI for each system (S) for each traffic type (TT) considering all test houses:

$$Median\ KPI_{TTj,Si} = Median\ \{Median\ KPI_{TTj,Si,THm}\ (m)\}\ \forall\ n,j,i,m$$

4. Calculate Relative Standard Deviation KPI for each system (S) for each traffic type (TT):

$$Rel.SD\ KPI_{TTj,Si,} = \frac{SD\ KPI_{TTj,Si}}{Median\ KPI_{TTj,Si}}\ \forall\ j,i$$

5. Calculate Median of Relative Standard Deviation KPI for each system (S) considering all traffic types:

$$Inter - House\ Variability\ KPI_{Si} = Median\{Rel.SD\ KPI_{TTj,Si,}(j)\}\ \forall\ j, i$$

3.2.3.6 Ranking Calculation

Systems evaluated are ranked in each of the five categories identified in above section for both scenarios: Individual and simultaneous for each one of the twelve test locations and all test locations combined for four different KPIs: Throughput, Latency, Jitter and RSSI

Lower absolute indicator KPI value indicates better performance except for Rel. Median KPI and Rel. Peak KPI for Throughput where a higher value indicates better performance.

The ranking process is:

For *KPI* in [Throughput, Latency, Jitter, RSSI]

For *test house* in [All, 1..12]

For *scenario* in [Ind., Sim.]

For each indicator identified

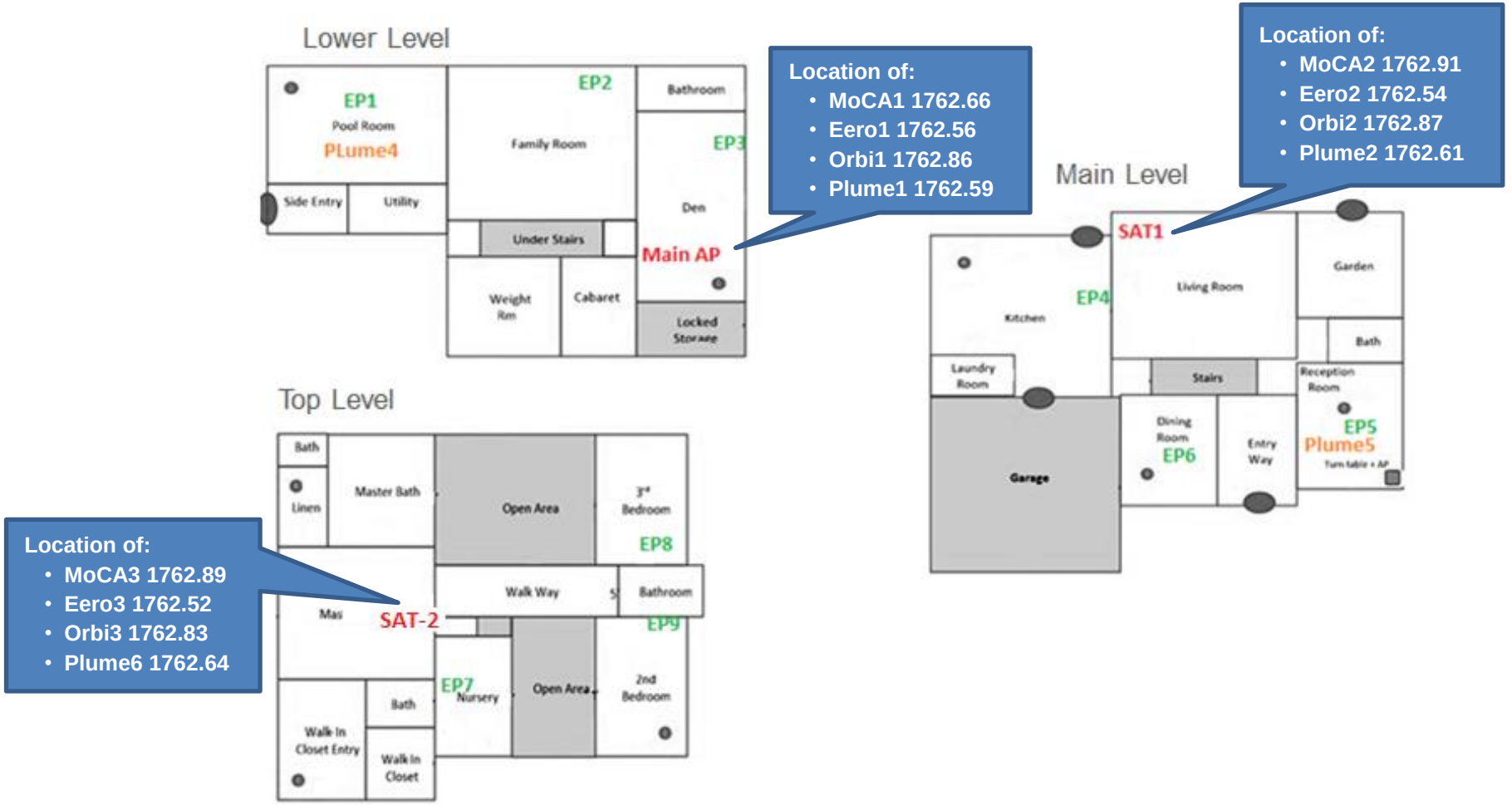
Calculate indicator value for each system

Rank Systems based on indicator values.

4. Test House Floor Plans

The devices were deployed following Test house host recommendations. This section provides the approximate location of the devices in Suwanee, GA.

Note: Location of the devices is approximate. [Public Edition only contains one example floorplan.]



5. Overall Test Results

5.1 System Performance Ranking

5.1.1 Throughput

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	1	2	5	4	3
	Rel. Peak KPI	1	2	5	4	2
	Variability	2	3	4	5	1
	Inter-EP Variability	1	3	5	4	2
	Inter-House Variability	1	3	5	4	2
Sim	Rel. Median KPI	1	2	5	4	3
	Rel. Peak KPI	1	3	5	4	2
	Variability	3	2	1	4	5
	Inter-EP Variability	2	1	4	5	3
	Inter-House Variability	1	2	5	4	3

Overall Throughput ranking

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	1.32	1.09	0.26	0.37	1
	Rel. Peak KPI	1.09	1	0.79	0.85	1
	Variability	88.51	107.07	122.88	155.16	73.05
	Inter-EP Variability	11.93	18.78	94.32	93.73	12.34
	Inter-House Variability	6.44	7.44	75.78	34	6.64
Sim	Rel. Median KPI	2.58	1.15	0.25	0.33	1
	Rel. Peak KPI	1.83	1	0.29	0.58	1.22
	Variability	61.27	61.07	45.07	75.05	127.46
	Inter-EP Variability	0.65	0.44	0.9	0.96	0.8
	Inter-House Variability	6.44	26.5	121.94	45.44	36.87

Overall throughput ranking values

5.1.2 Latency

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	2	1	5	4	3
	Rel. Peak KPI	2	1	5	4	3
	Variability	3	1	5	4	2
	Inter-EP Variability	1	4	5	3	2
	Inter-House Variability	2	1	3	4	5
Sim	Rel. Median KPI	1	2	5	4	3
	Rel. Peak KPI	1	2	5	3	4
	Variability	2	1	5	3	4
	Inter-EP Variability	3	1	2	4	4
	Inter-House Variability	2	5	3	1	4

Overall Latency Ranking

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	0.9	0.68	4.21	1.5	0.95
	Rel. Peak KPI	0.9	0.49	2.27	1.63	0.97
	Variability	935.82	370.78	1174.67	956.98	430.66
	Inter-EP Variability	60.1	101.18	121.52	100.93	88.26
	Inter-House Variability	39.05	32.34	69.37	87.62	107.61
Sim	Rel. Median KPI	0.31	0.79	2.35	1.15	1.07
	Rel. Peak KPI	0.31	0.59	4.63	1	1.08
	Variability	206.78	188.18	4273.56	770.33	827.16
	Inter-EP Variability	1.1	0.81	1	1.47	1.47
	Inter-House Variability	167.34	543.1	204.37	135.13	510.5

Overall Latency Ranking Values

5.1.3 Jitter

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	1	2	5	4	3
	Rel. Peak KPI	3	1	5	4	2
	Variability	2	2	4	5	1
	Inter-EP Variability	3	2	5	4	1
	Inter-House Variability	3	2	4	5	1
Sim	Rel. Median KPI	1	2	5	4	3
	Rel. Peak KPI	1	2	5	4	3
	Variability	1	2	5	4	3
	Inter-EP Variability	3	1	2	5	4
	Inter-House Variability	3	1	5	2	4

Overall Jitter Ranking

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	0.83	0.85	2.83	1.86	1
	Rel. Peak KPI	0.95	0.8	8.19	5.15	0.87
	Variability	0.28	0.28	2.41	2.44	0.16
	Inter-EP Variability	11.46	10.72	56.35	43.88	8.82
	Inter-House Variability	13.69	12.17	40.89	94.68	11.76
Sim	Rel. Median KPI	0.38	0.64	1.88	1.35	1
	Rel. Peak KPI	0.41	0.57	3.14	1.2	1
	Variability	0.68	0.87	13.47	8.04	6.25
	Inter-EP Variability	0.54	0.34	0.5	0.76	0.67
	Inter-House Variability	83.34	53.13	124.53	82.68	90.38

Overall Jitter Ranking Values

5.1.4 RSSI

Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	1	5	2	4	3
	Rel. Peak KPI	1	5	3	4	2
	Variability	4	5	2	1	3
	Inter-EP Variability	4	5	2	1	3
	Inter-House Variability	5	3	1	4	2
Sim	Rel. Median KPI	1	5	2	3	4
	Rel. Peak KPI	1	5	3	2	4
	Variability	4	5	1	3	2
	Inter-EP Variability	4	5	2	1	3
	Inter-House Variability	5	4	2	3	1

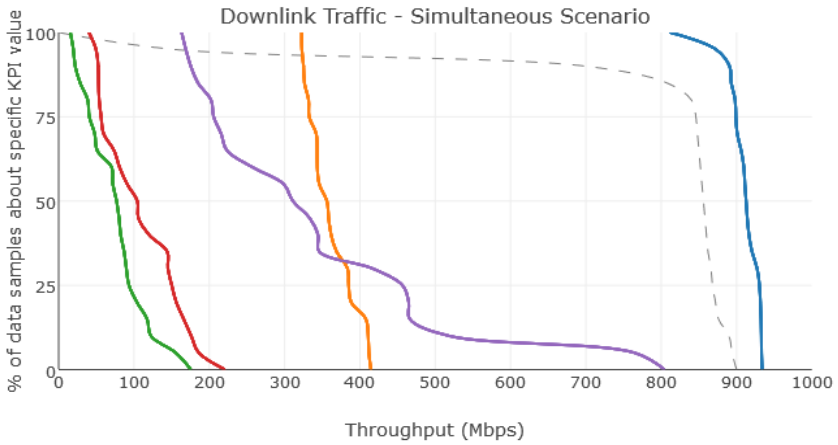
Overall RSSI Ranking

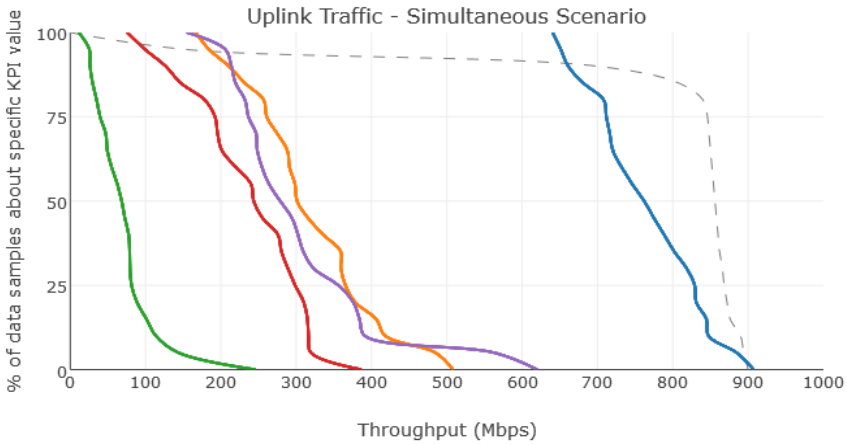
Scenario	KPI Indicator	2xMoCA Sats	Main AP Only	Plume	eero	orbi
Ind	Rel. Median KPI	0.95	1.24	0.99	1.07	1
	Rel. Peak KPI	0.86	1.07	1	1.03	0.92
	Variability	9.05	11.51	8.43	7.54	8.53
	Inter-EP Variability	-18.33	-18.97	-13.65	-10.88	-15.65
	Inter-House Variability	-13.96	-12.36	-10.98	-12.68	-11.22
Sim	Rel. Median KPI	0.9	1.13	0.93	1	1.03
	Rel. Peak KPI	0.91	1.09	1	0.97	1.01
	Variability	6.2	6.96	5.09	6.15	5.54
	Inter-EP Variability	-0.17	-0.18	-0.14	-0.13	-0.15
	Inter-House Variability	-14.92	-13.24	-11.75	-13.17	-11.65

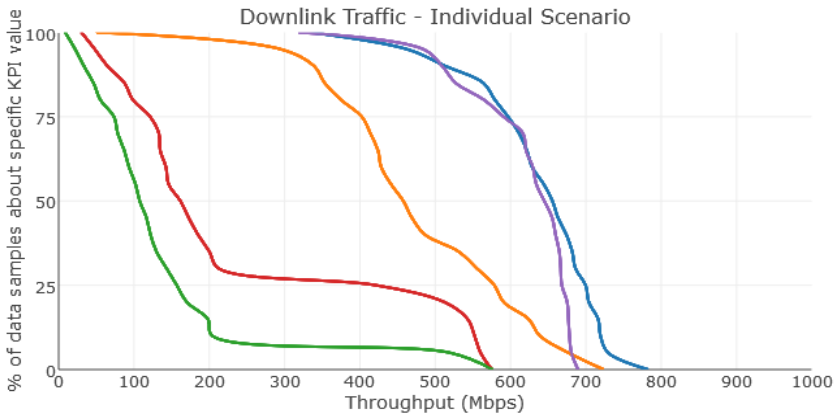
Overall RSSI Ranking Values

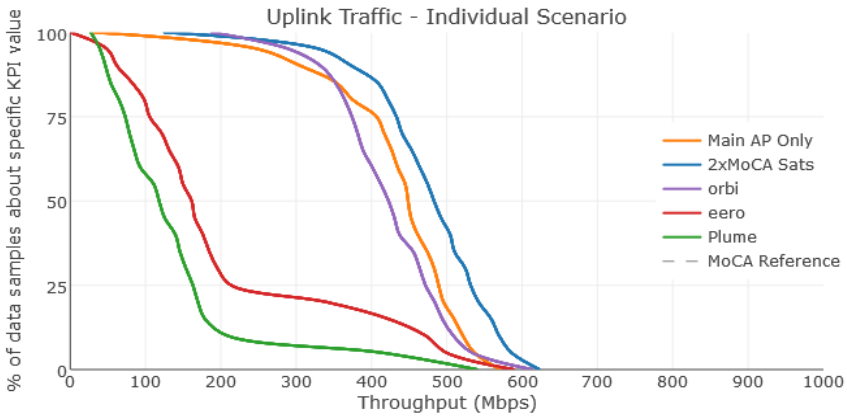
5.2 System Performance Comparison

5.2.1 Throughput

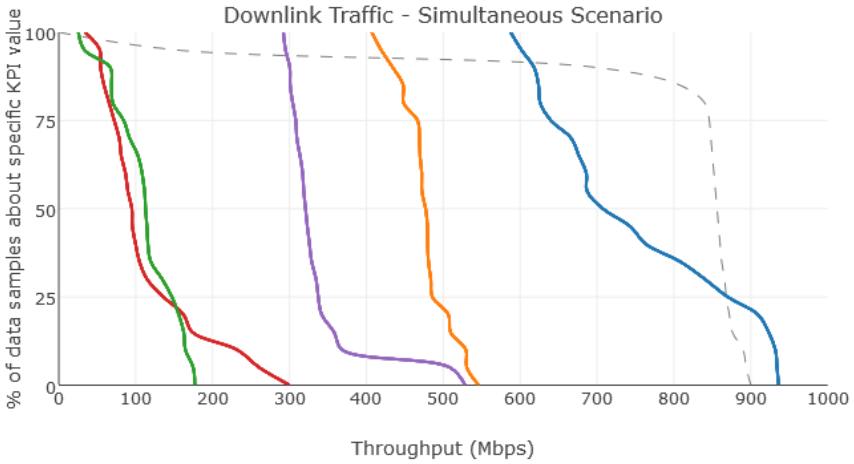


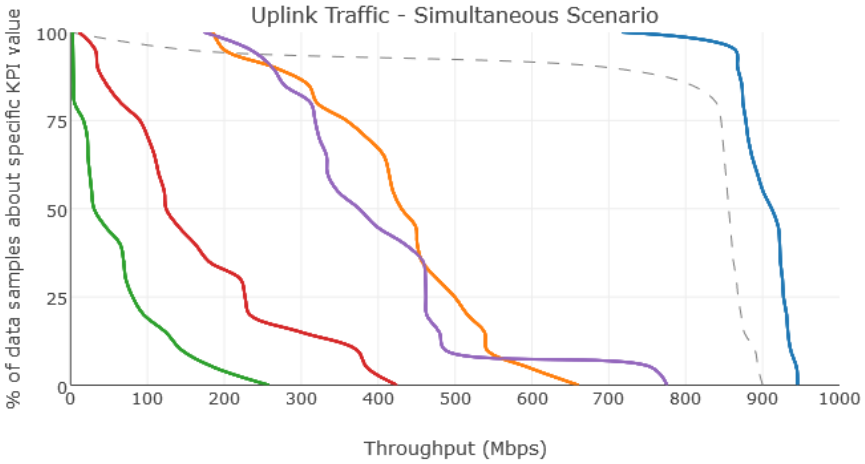


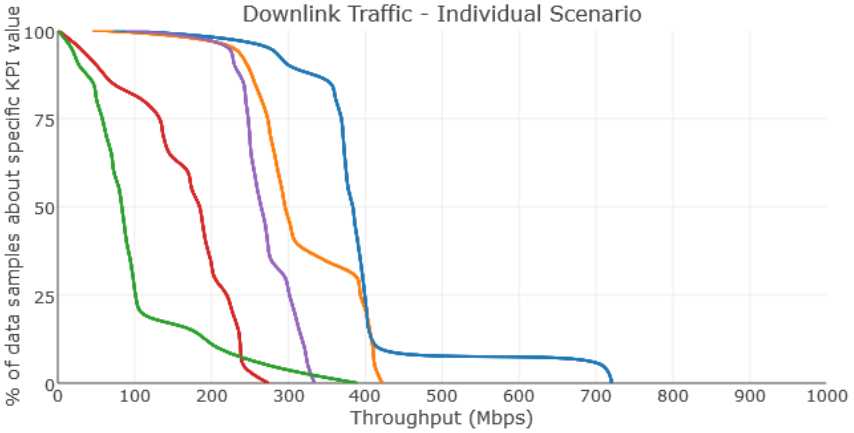


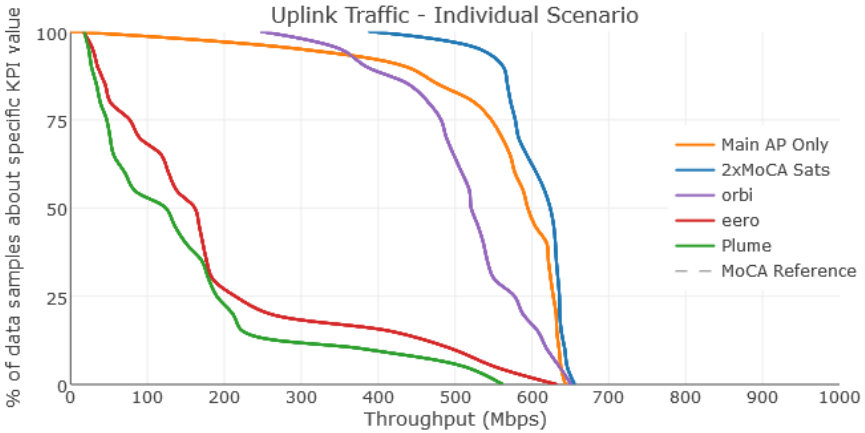


Overall Throughput TCP Results – All houses



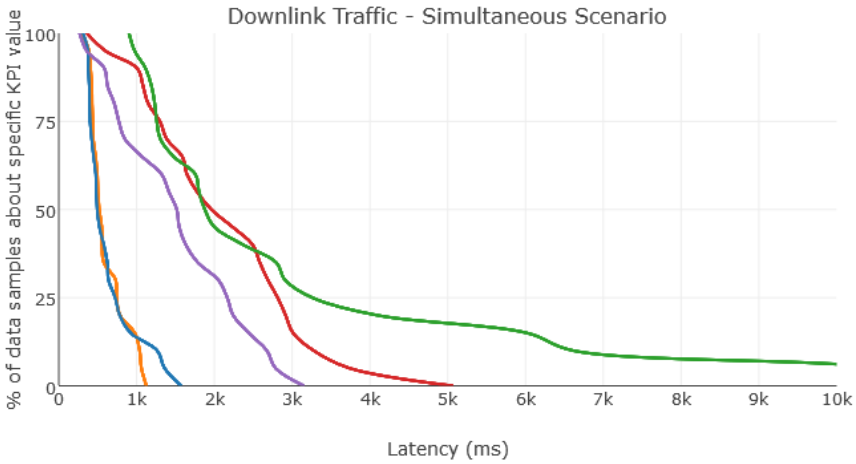


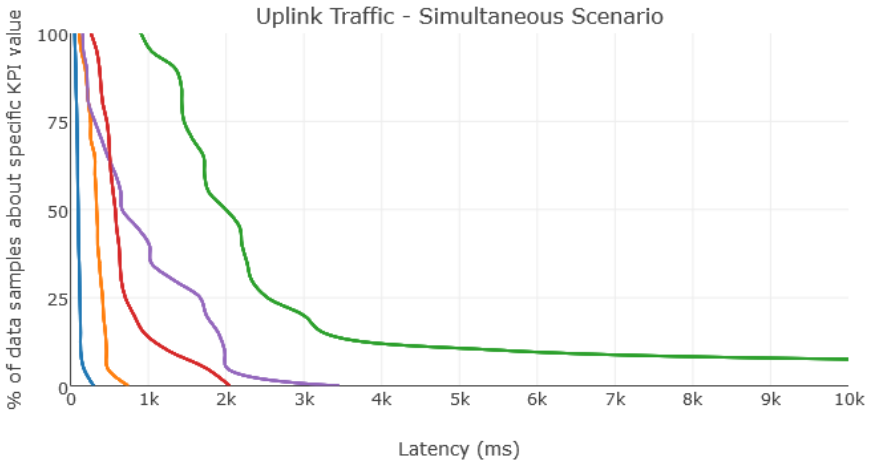


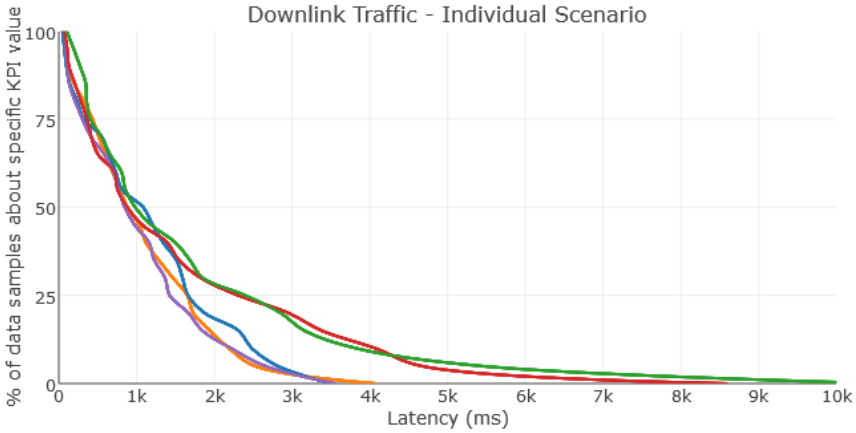


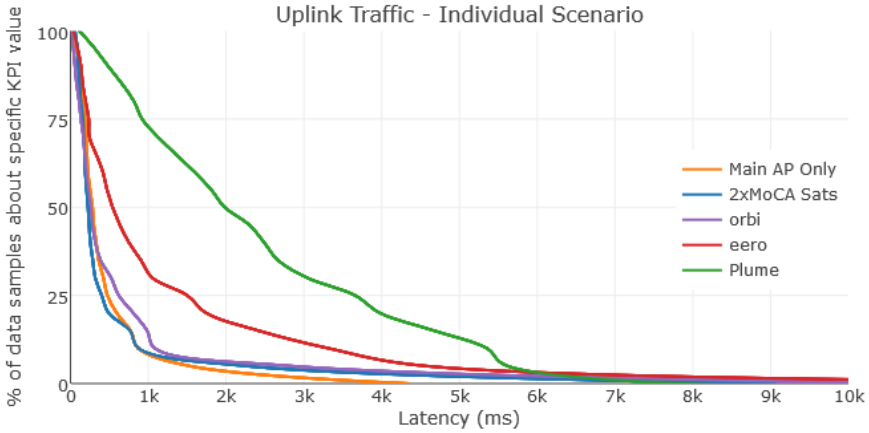
Overall Throughput UDP Results – All houses

5.2.2 Latency

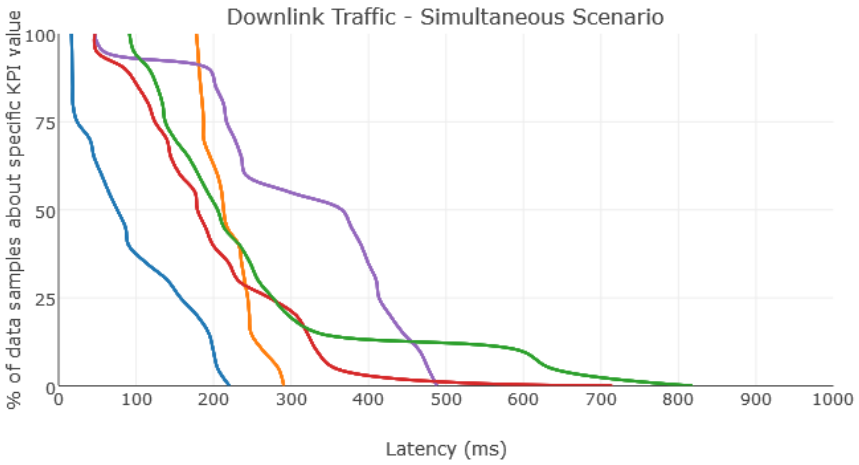


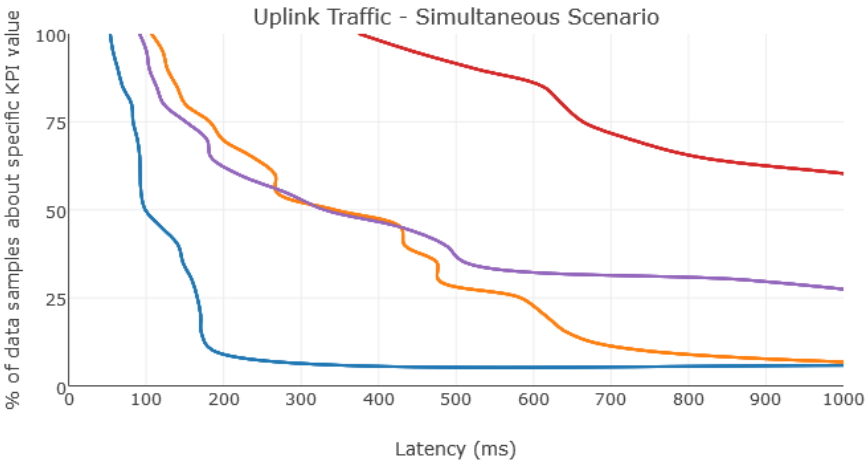


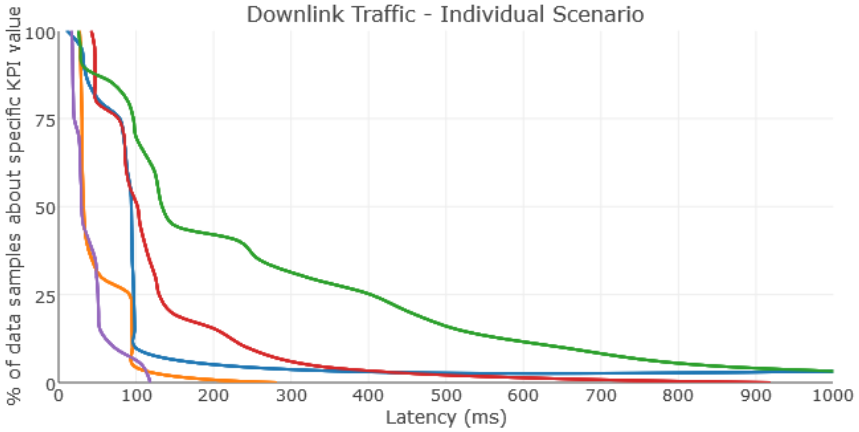


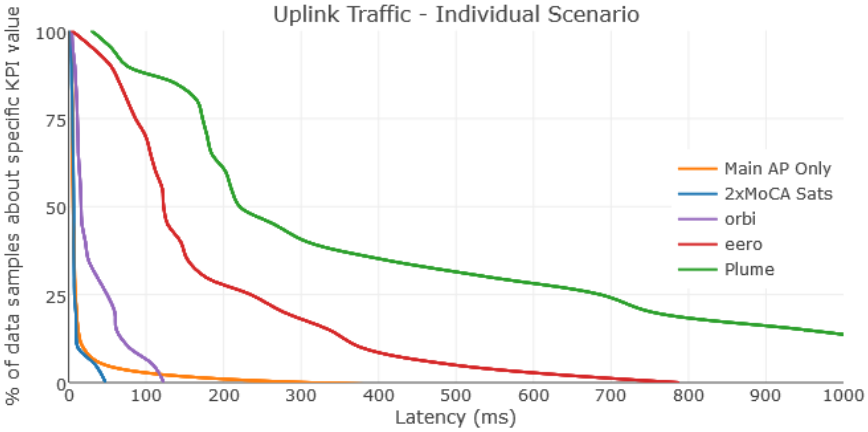


Overall Latency TCP – All houses



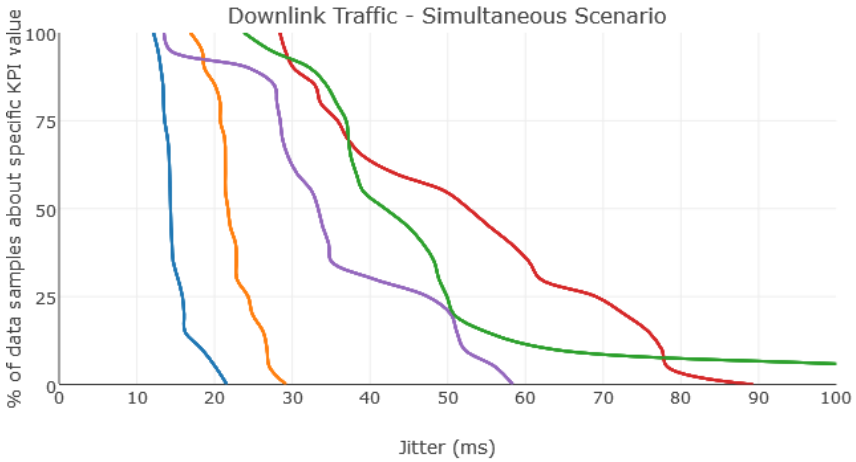


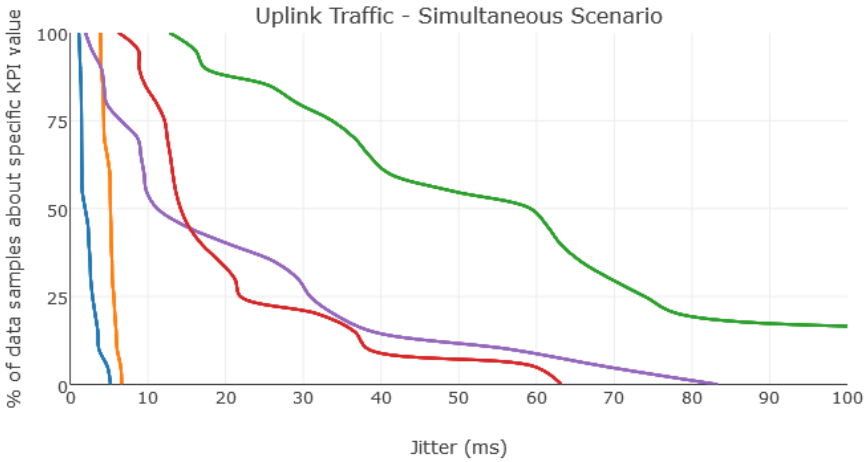


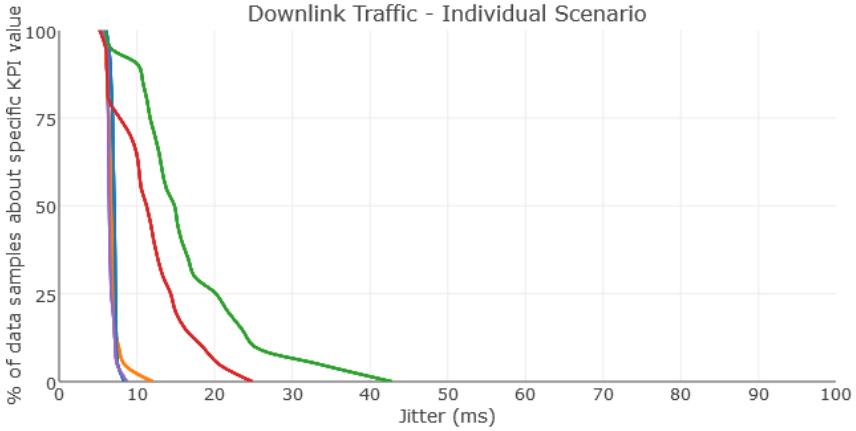


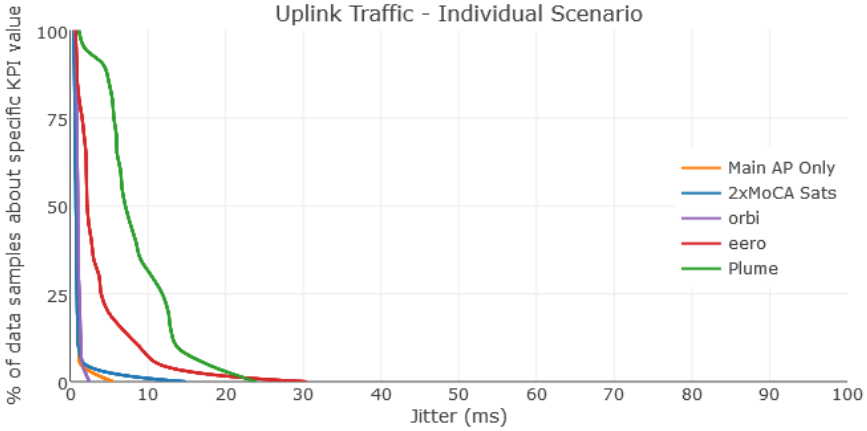
Overall Latency UDP – All houses

5.2.3 Jitter

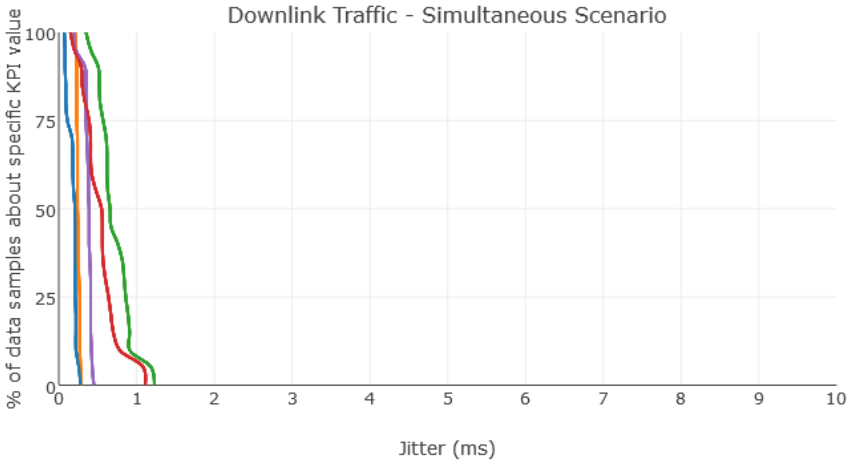


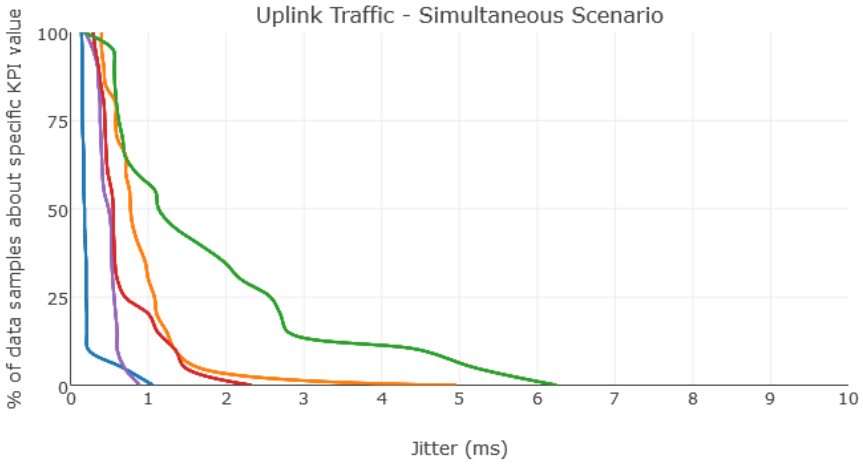


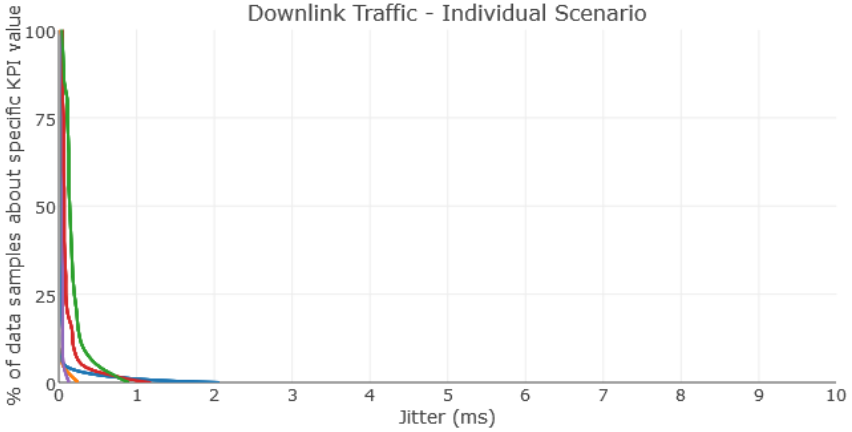


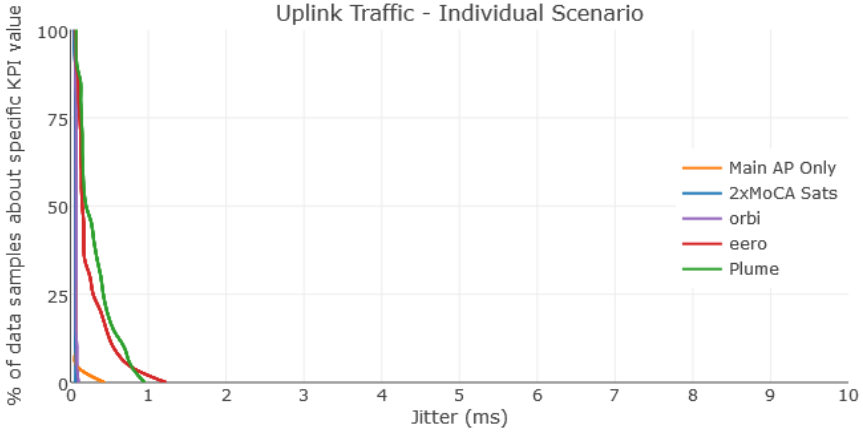


Overall Jitter TCP – All houses



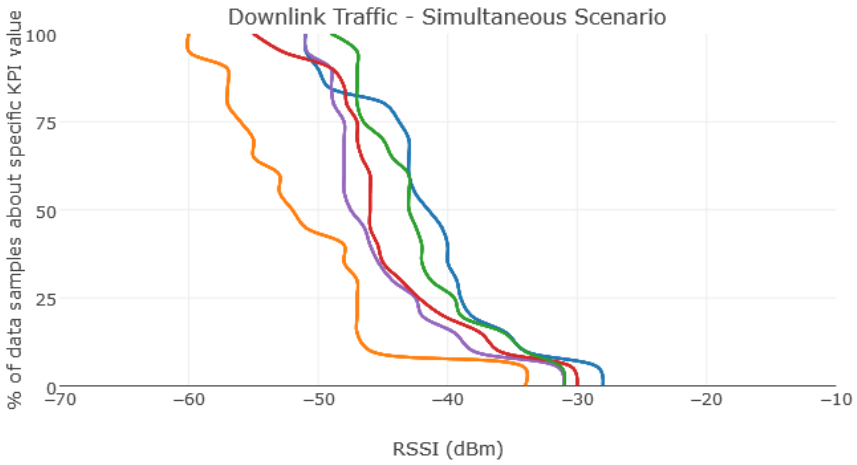


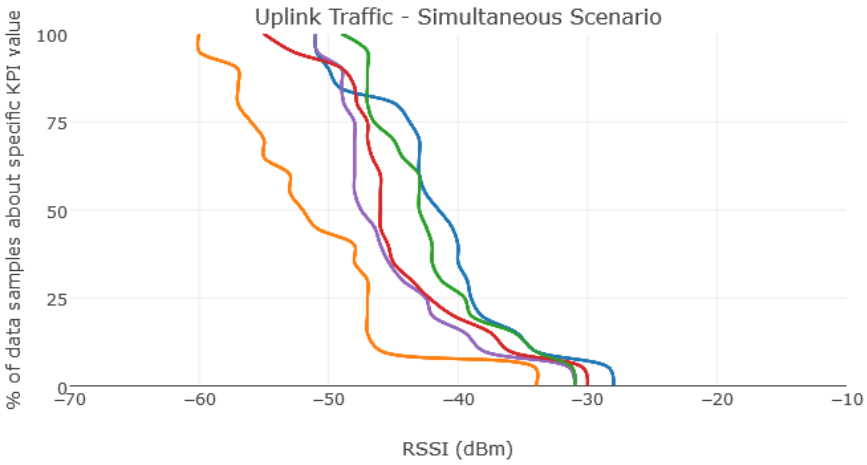


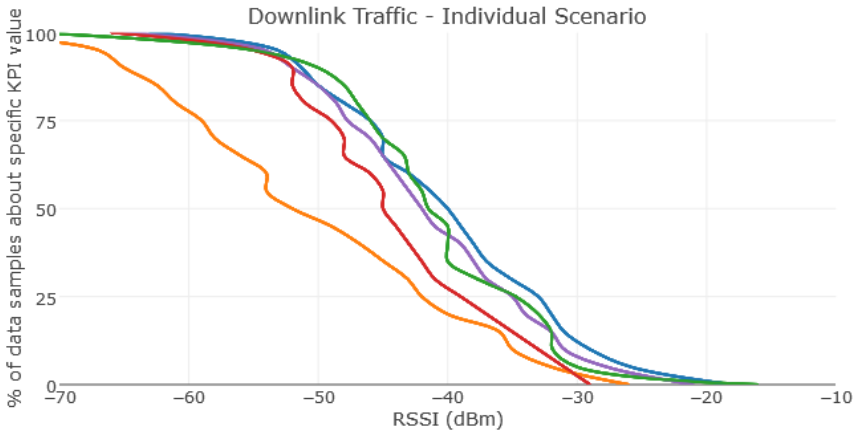


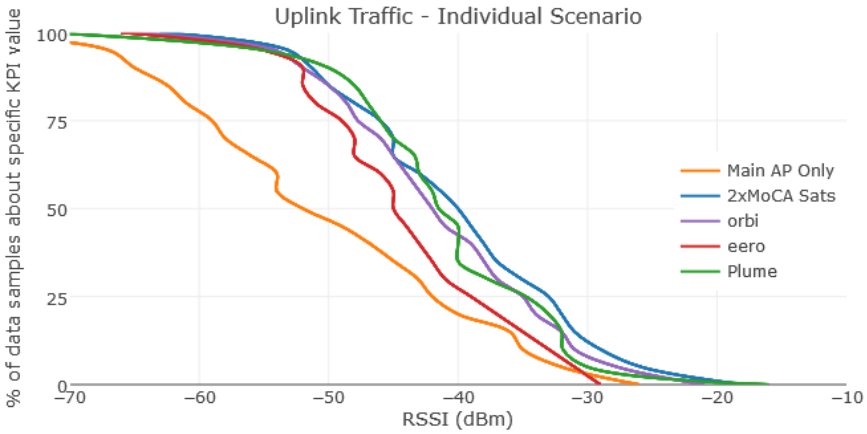
Overall Jitter UDP – All houses

5.2.3.1 RSSI

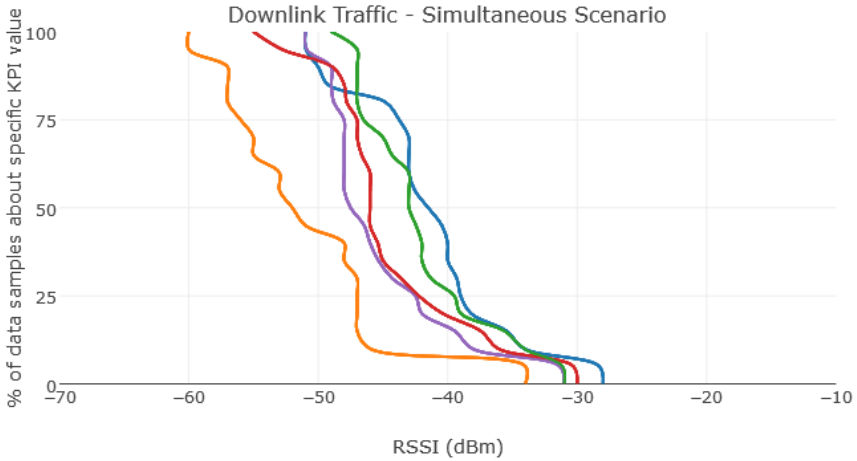


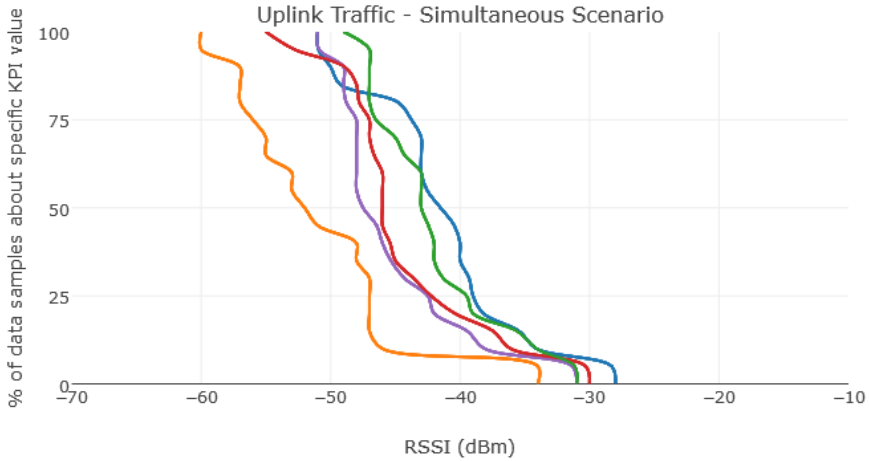


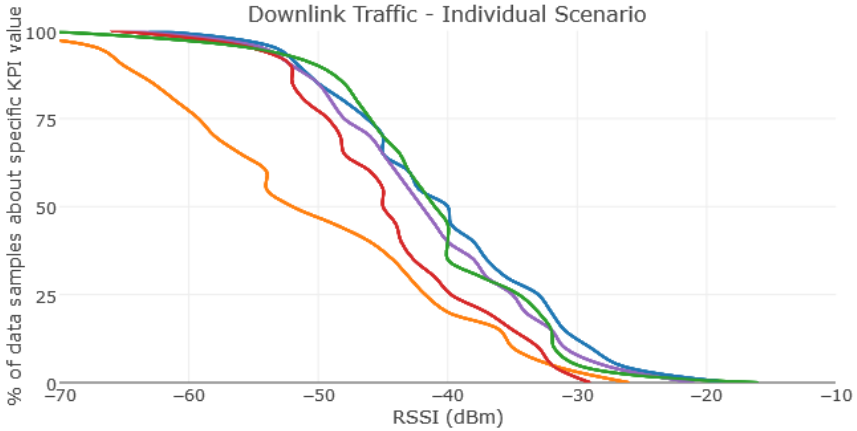


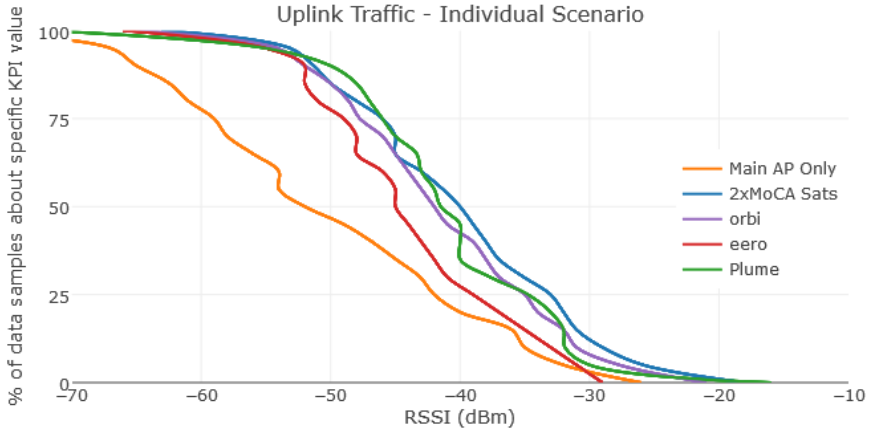


Overall RSSI TCP – All houses









Overall RSSI UDP – All houses

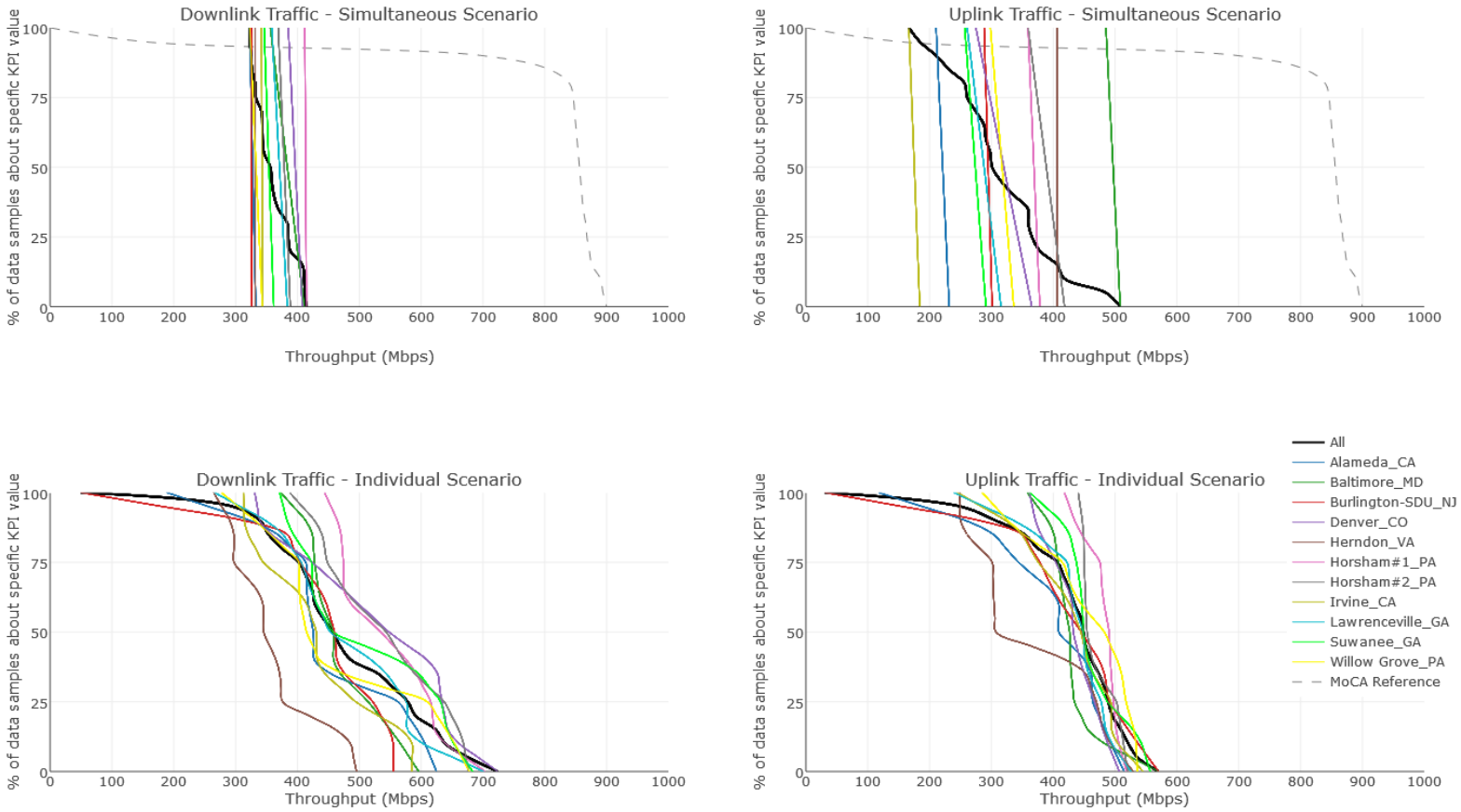
6. Test Results by Test House

[Not included in the Public Edition]

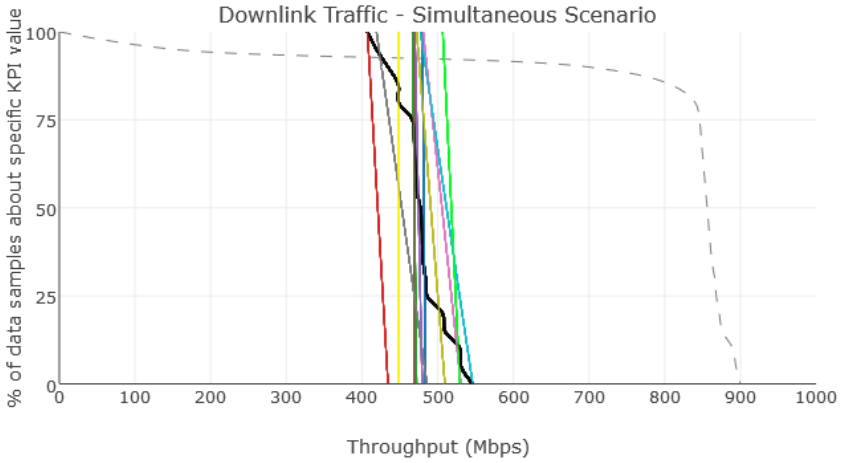
7. System Performance Comparative by System

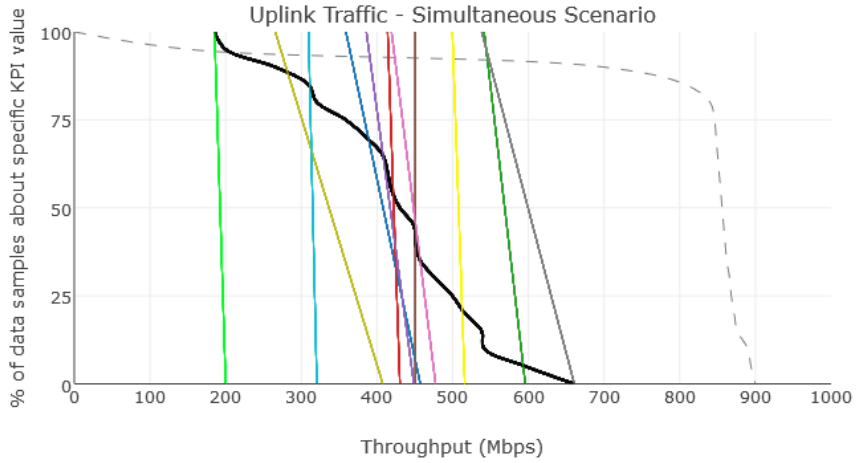
7.1 Main AP Only

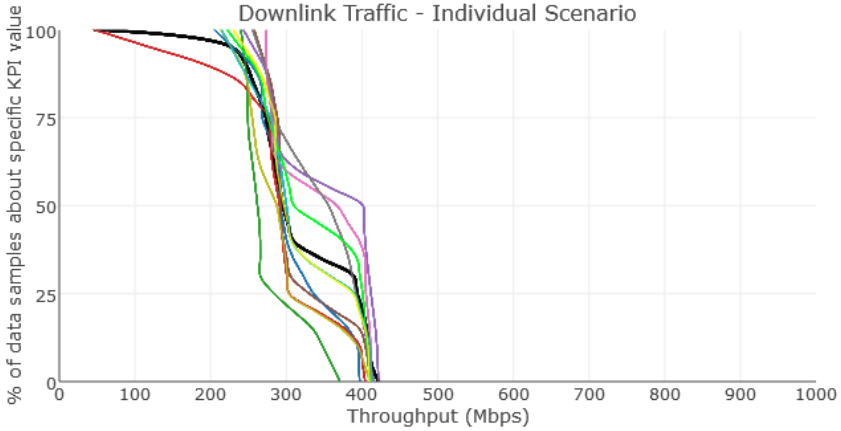
7.1.1 Throughput

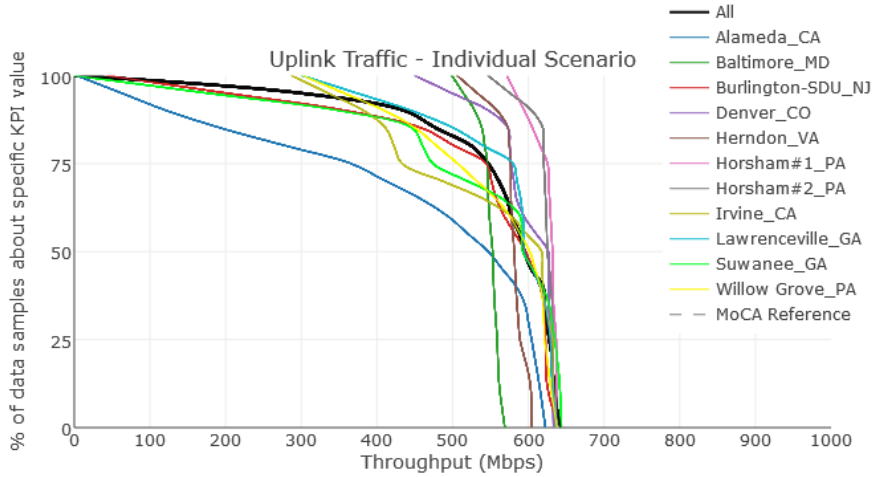


Overall Throughput TCP Results – Main AP only





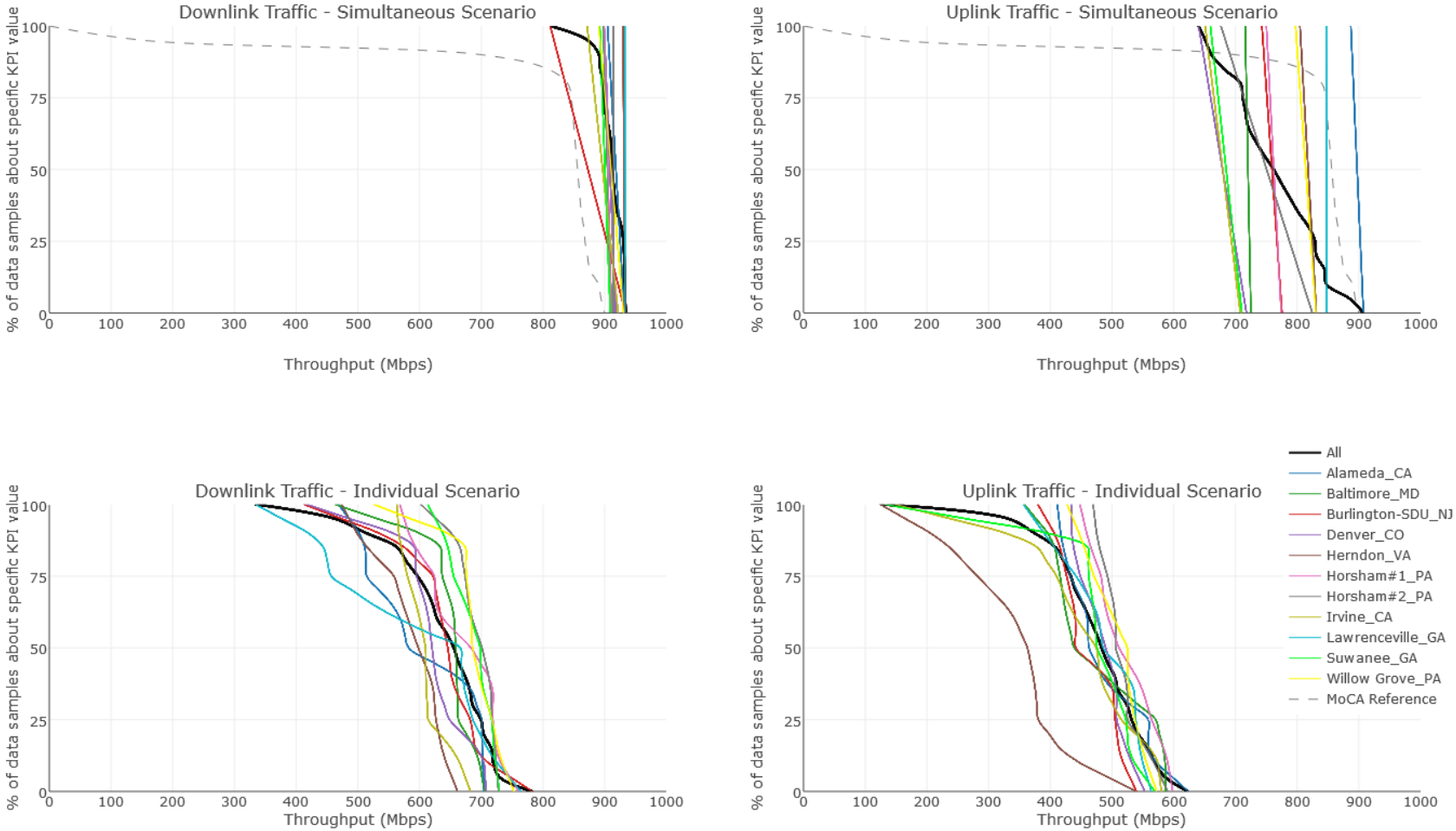




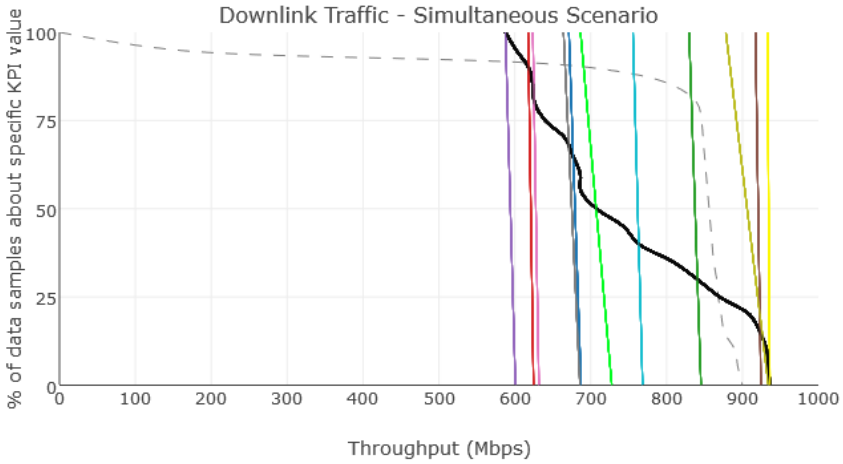
Overall Throughput UDP Results – Main AP only

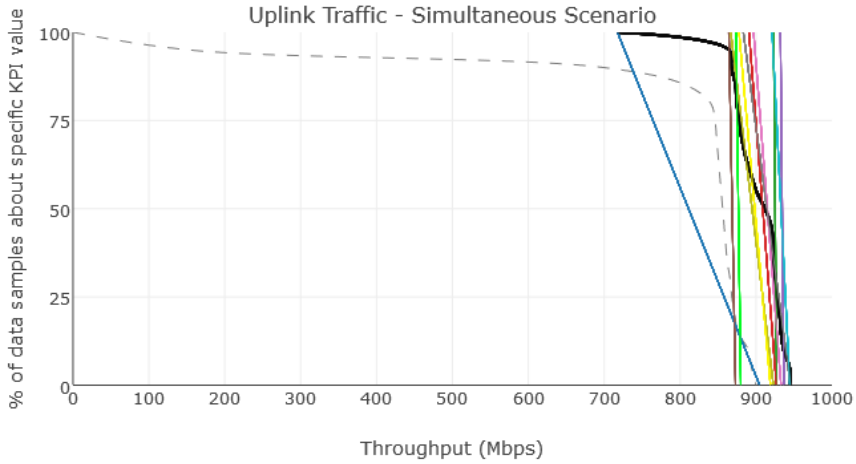
7.2 2xMoCA Satellite APs

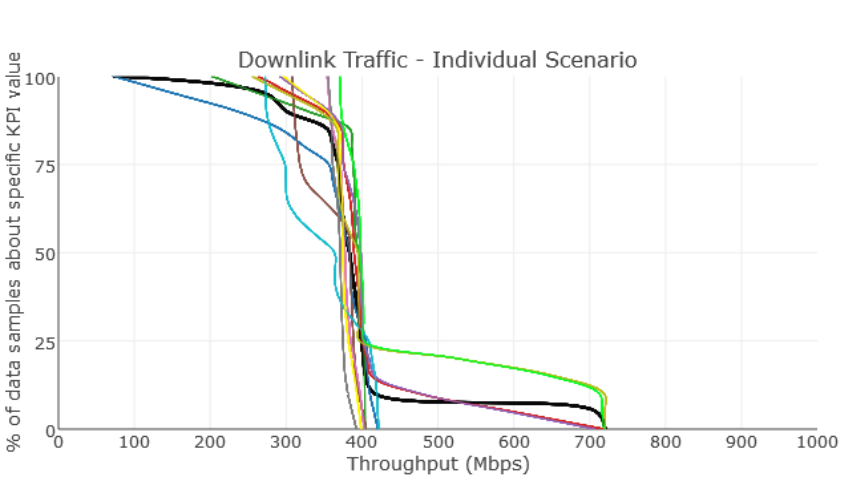
7.2.1 Throughput

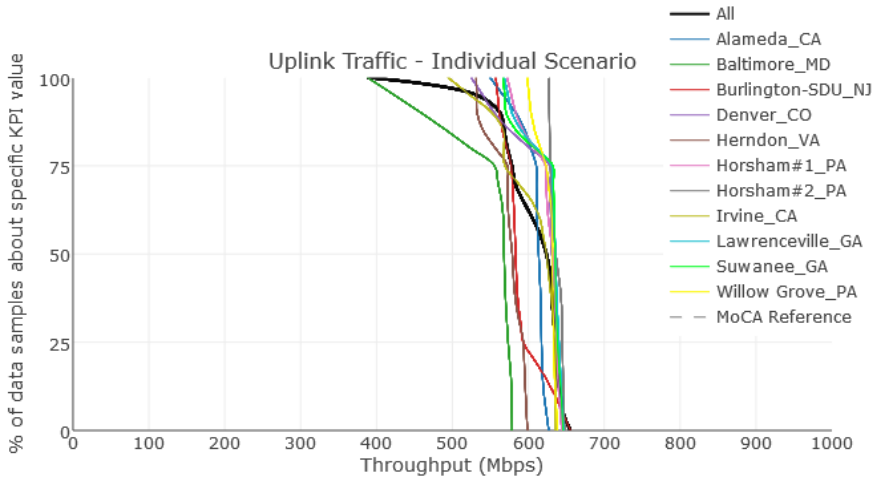


Overall Throughput TCP Results – 2xMoCA Satellite APs





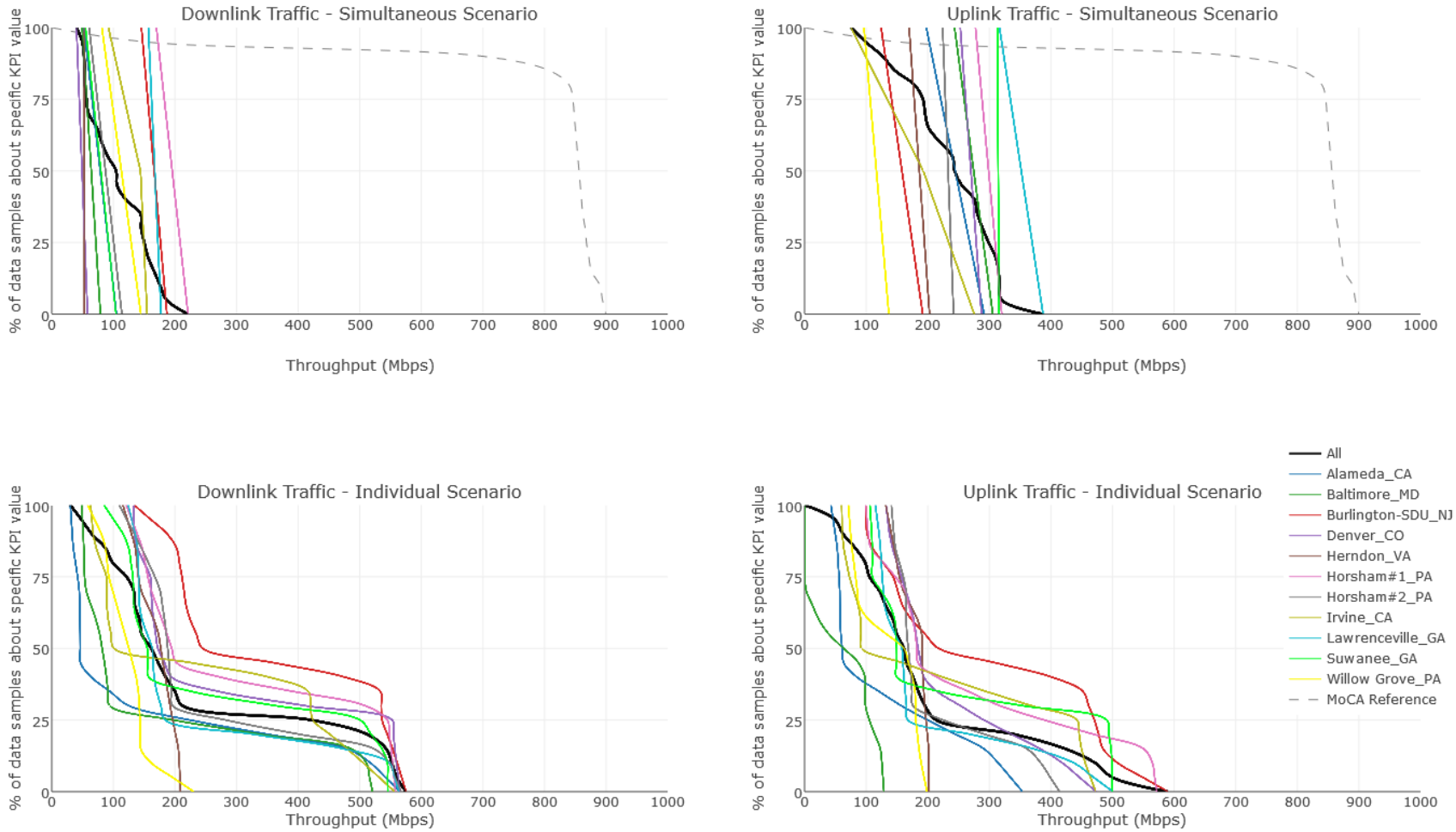




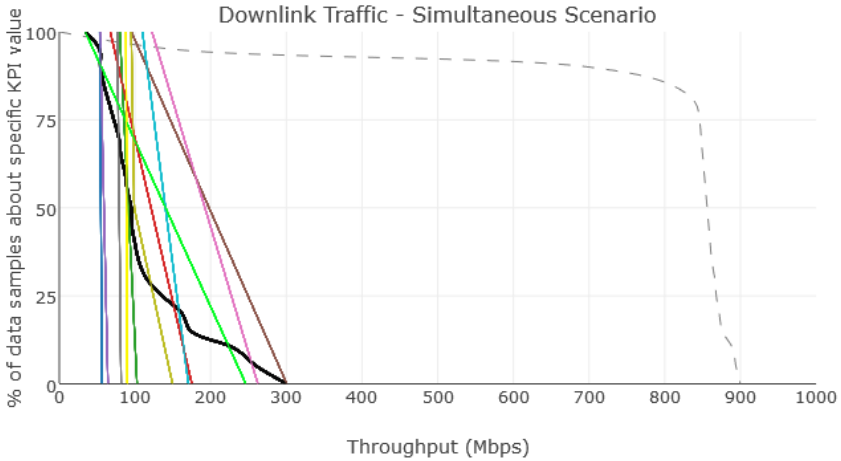
Overall Throughput UDP Results – 2xMoCA Satellite APs

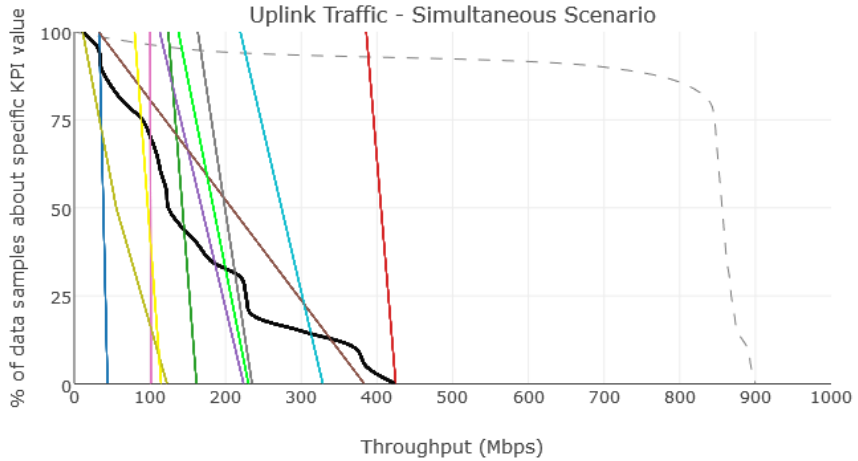
7.3 eero

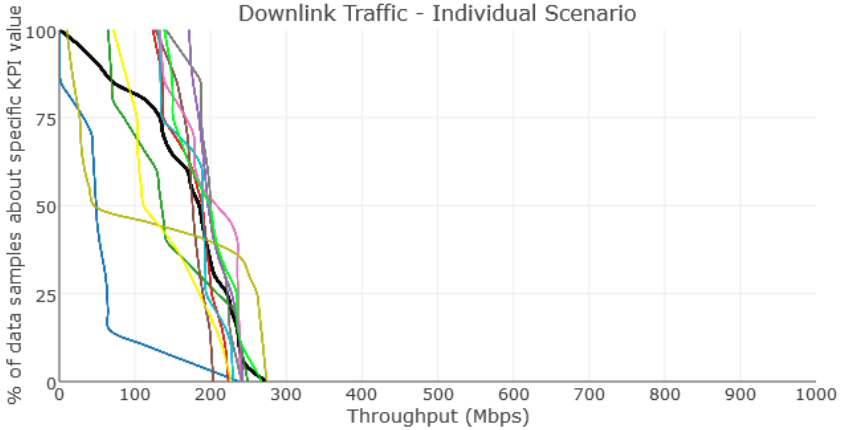
7.3.1 Throughput

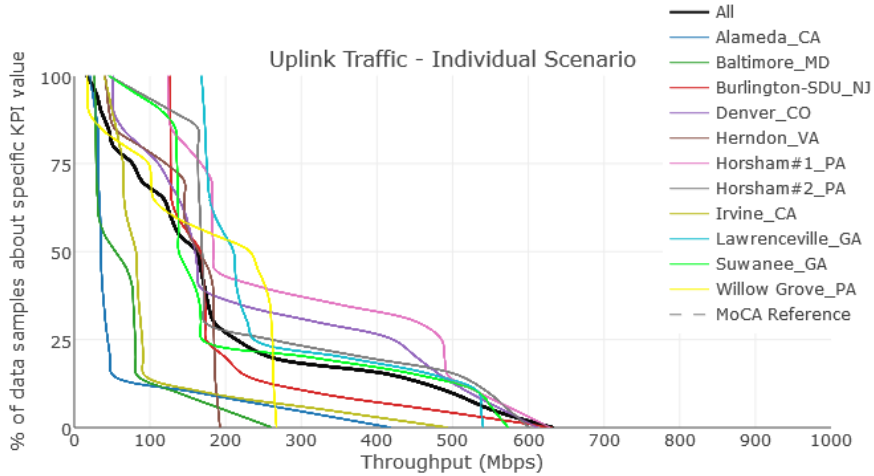


Overall Throughput TCP Results – eero





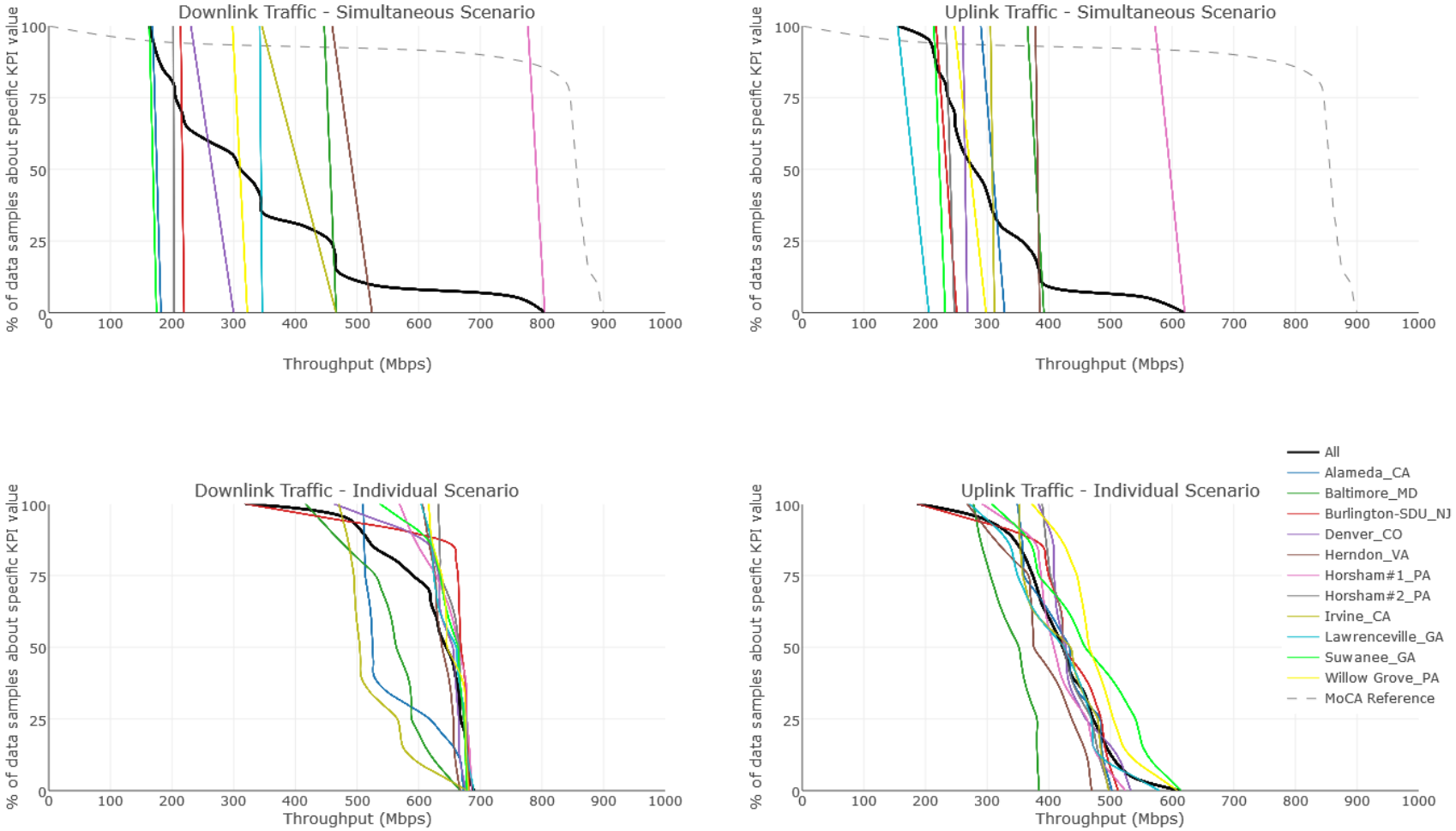




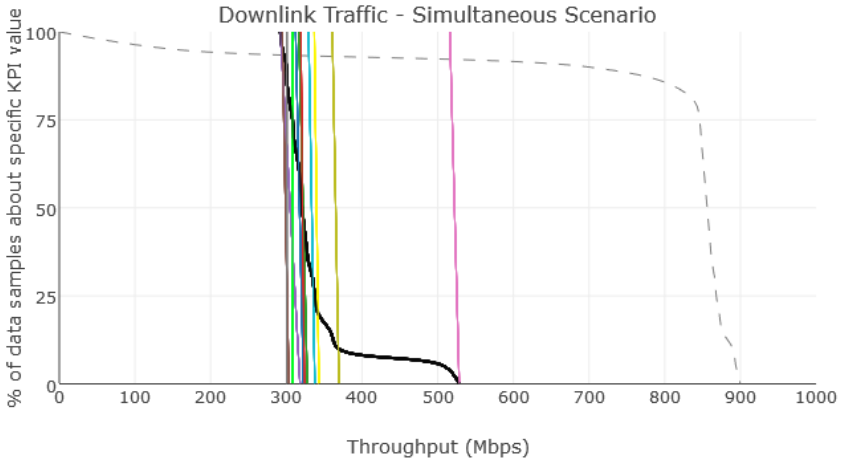
Overall Throughput UDP Results – eero

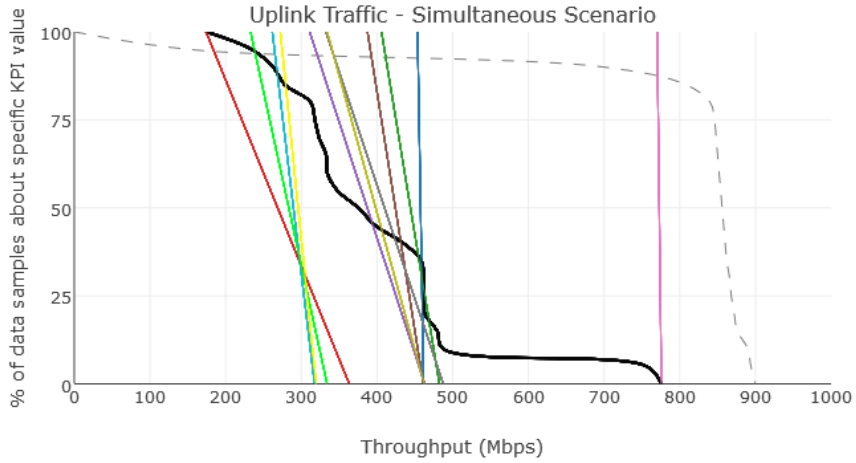
7.4 Orbi

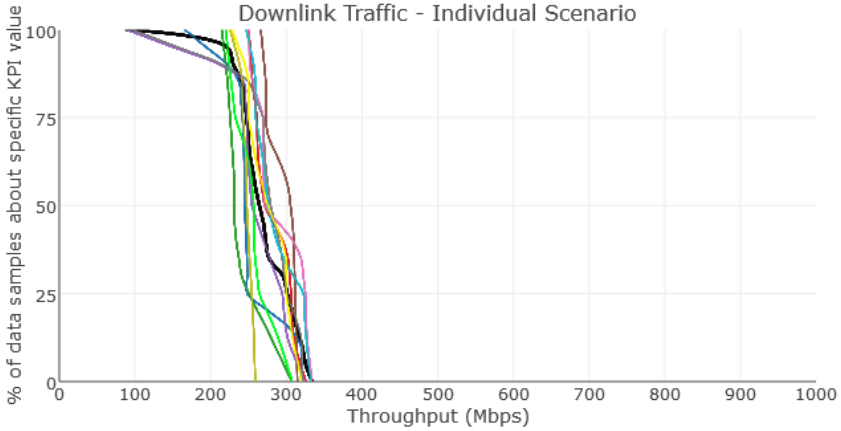
7.4.1 Throughput

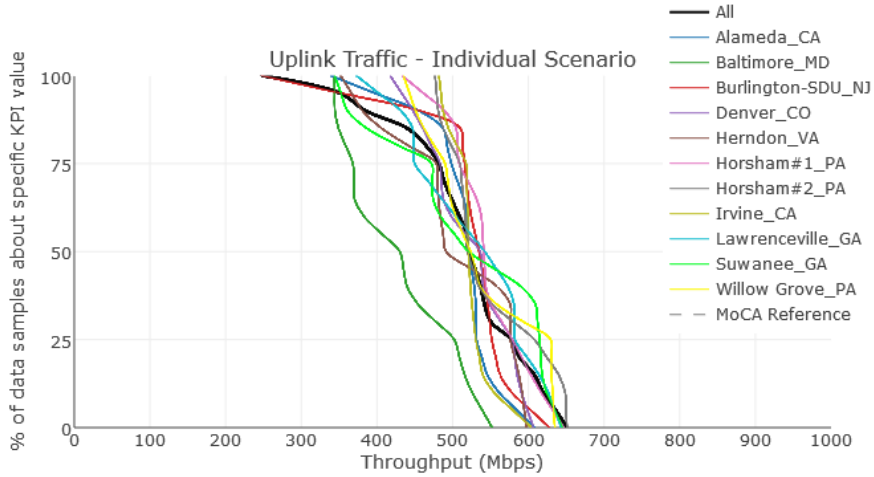


Overall Throughput TCP Results – Orbi





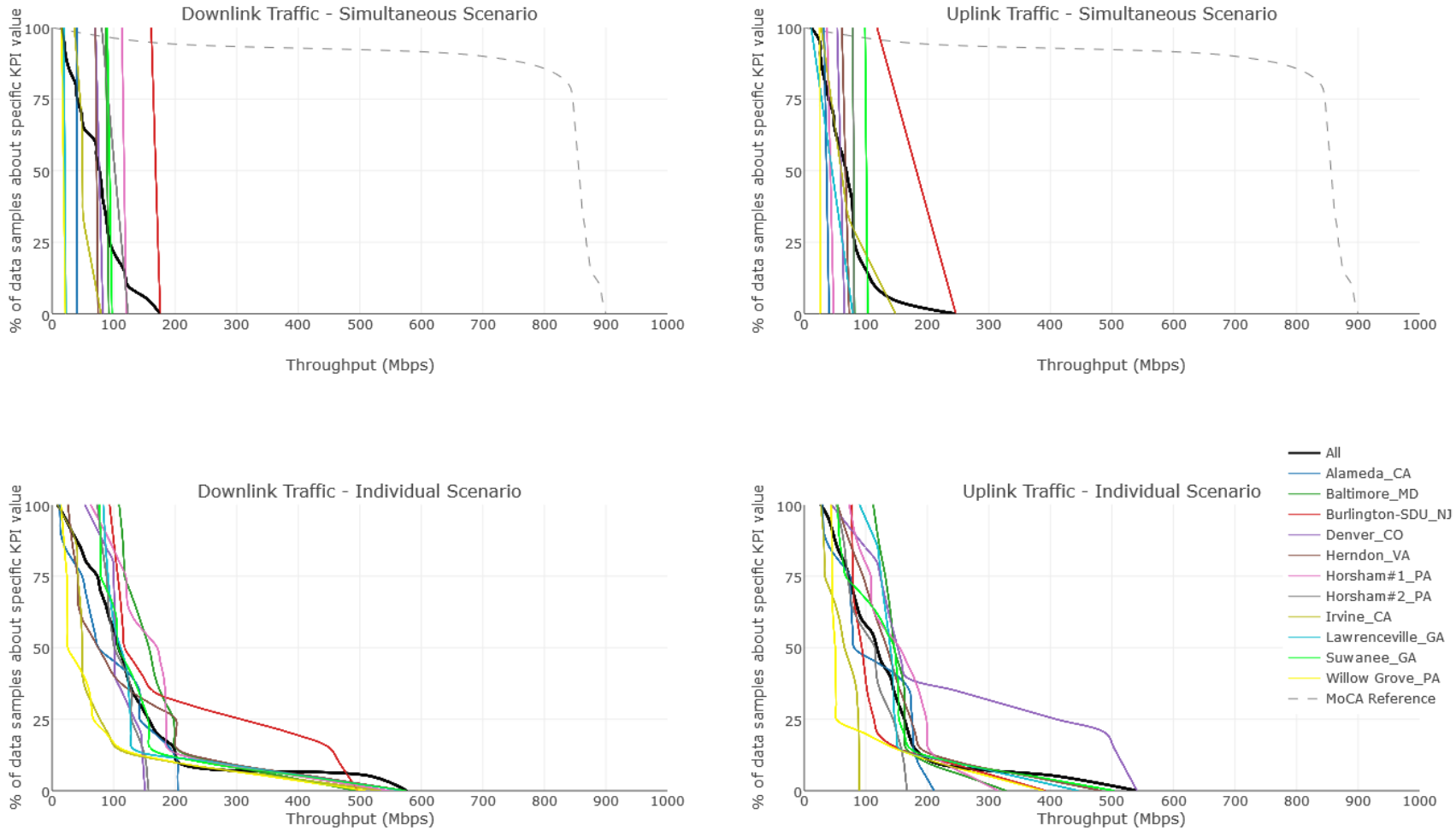




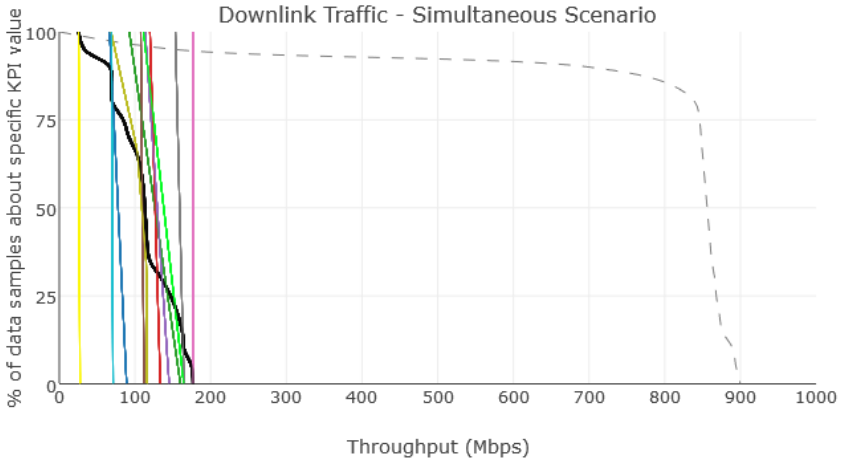
Overall Throughput UDP Results – Orbi

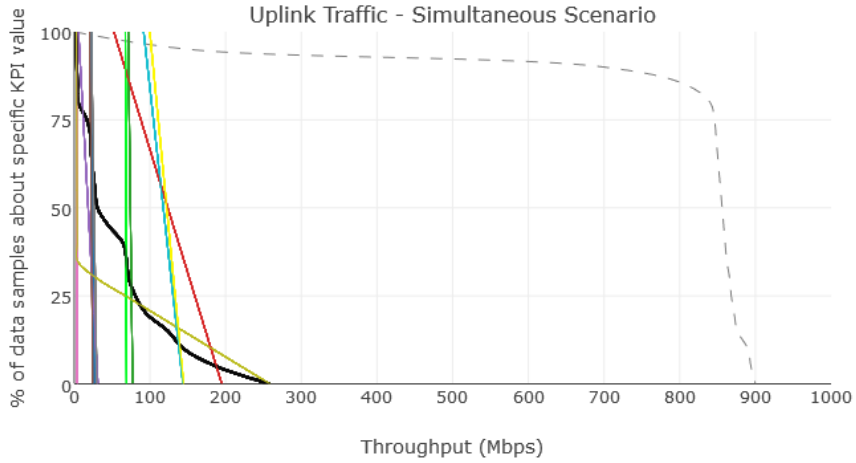
7.5 Plume

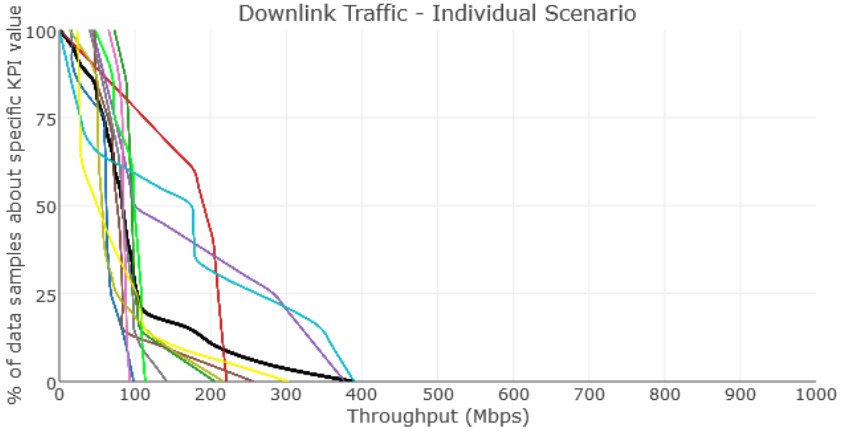
7.5.1 Throughput

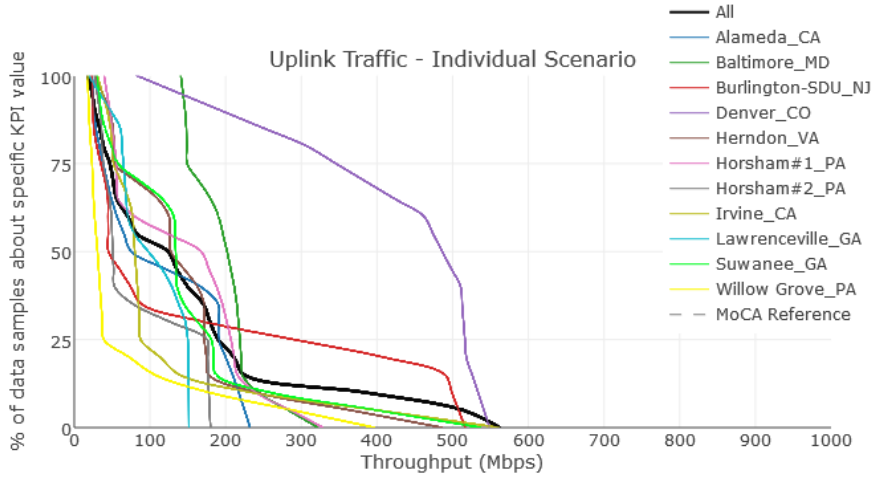


Overall Throughput TCP Results – Plume









Overall Throughput UDP Results – Plume

8. Remarks

The following deviations from test methodology have been identified during test execution:

- Tests were conducted using Layer-7 end-to-end applications with observation points at layer-7 and layer-2. In six (out of 5,940) flow instances, two orders of magnitude anomalies inexplicably existed between the layer-7 and layer-2 measurements, so the layer-2 measurements were used
- Results from the MoCA 2.0 Field Trial conducted in 2015 are included on some throughput graphs comparison purposes.

9. Appendix

9.1 Glossary

Wi-Fi:

Wi-Fi is the name of a popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections

Throughput:

Throughput – indicates the number of transactions per second an application can handle, the amount of transactions produced over time during a test.

Jitter:

Packet delay variation (PDV) also termed as jitter is the difference in end-to-end one-way delay between selected packets in a flow with any lost packets being ignored

RSSI:

RSSI (Recieved Signal Strength Indicator) is a common name for the signal strength in a wireless network environment. It is a measure of the power level that a RF client device is receiving from an access point

Latency:

Network latency is an expression of how much time it takes for a packet of data to get from one designated point to another

Backhaul:

In a hierarchical telecommunications network the backhaul portion of the network comprises the intermediate links between the core network, or backbone network and the small subnetworks at the "edge" of the entire hierarchical network.

9.2 Acronyms

Acronym	Description
Router	Wi-Fi Router
DHCP	Dynamic Host Control Protocol
DUT	Device Under Test
LAN	Local Area Network
MCS	Modulation Coding Scheme
OWD	One-way Delay
RSSI	Received Signal Strength Indication
TCP	Transport Control Protocol
UDP	User Datagram Protocol
WLAN	Wireless Local Area Network
DL	Downlink
UL	Uplink
OS	Operative System
ETH	Ethernet
TBU	To Be Updated
MoCA	Multimedia Over Coax Alliance

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