# Latency's Contribution to Quality of Experience

Problem: Average Latency > ~ 100 ms

- Video conference conversation cross-talk
- Slow response to begin loading a video or website
- Consistent lag in security camera video and audio
- Realtime online gaming problems (> 50 ms)
- **Cause:** <u>Average latency too high</u> - causing a constant delay in arrival of packets

Problem: Excessive Jitter (Variance of Latency) > 30 ms

- Skips in video or audio during conferencing and Wi-Fi voice calls
- Inconsistent response to actions during online gaming
- **Cause:** <u>Spikes in latency causing high jitter</u> - applications drop useless, delayed packets
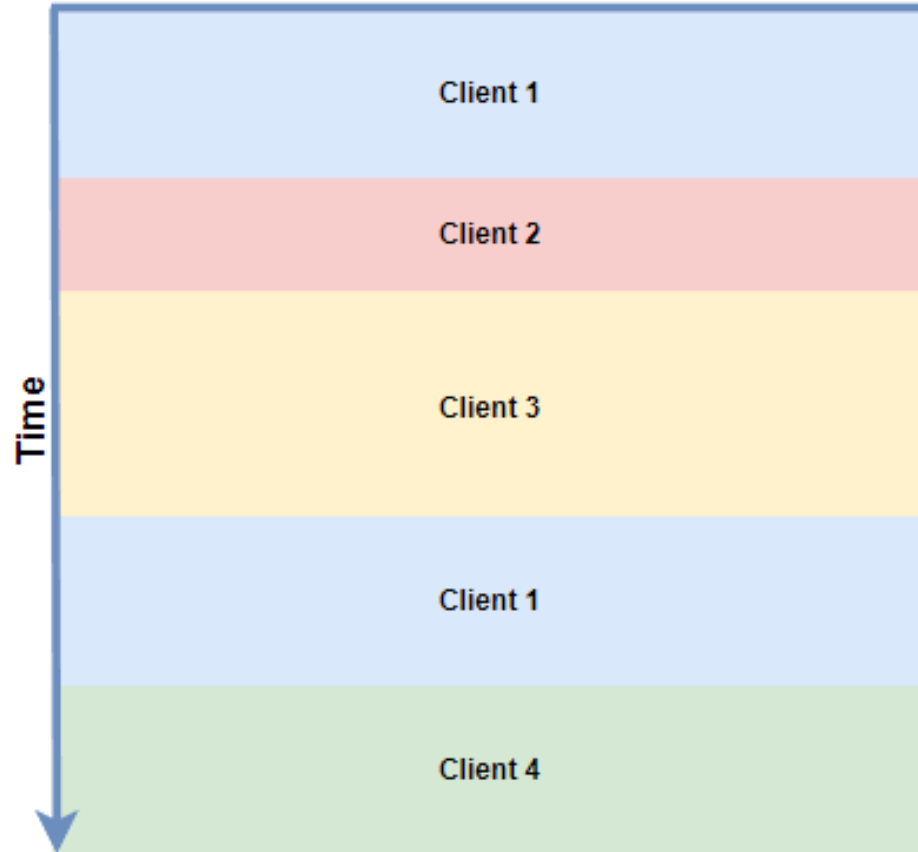
How to improve this layer?

Full RTT Latency

Wi-Fi
2 – 2000 ms

WAN / ISP
10 – 40 ms

Cloud
> 1 ms
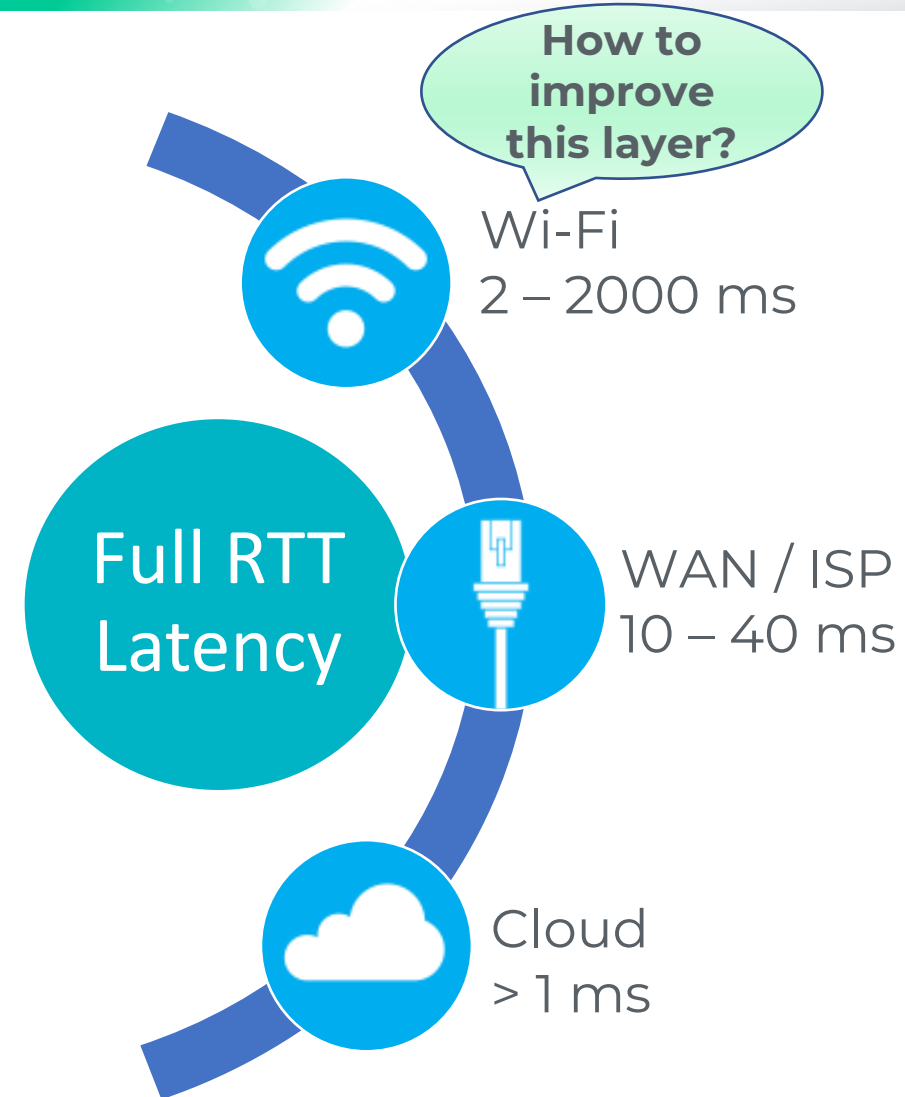
Wi-Fi 6/6E HE SU
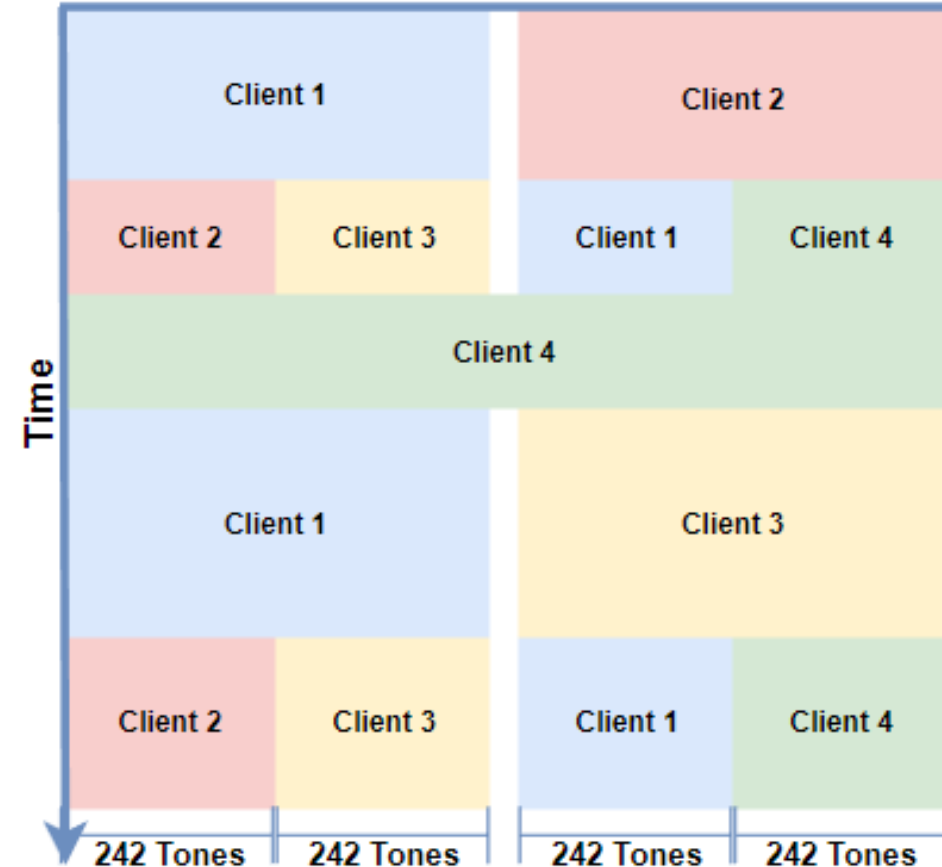Each transmit opportunity is for a single client on an entire channel
* With MU-MIMO Disabled

Wi-Fi 6/6E HE OFDMA
Each transmit opportunity is for one or more clients on different tones/subcarriers

Goal: Determine which scenarios achieve better latency in a real house with real clients using today's AP solutions.

House: 4500 sqft - 3 story - Clean Airtime

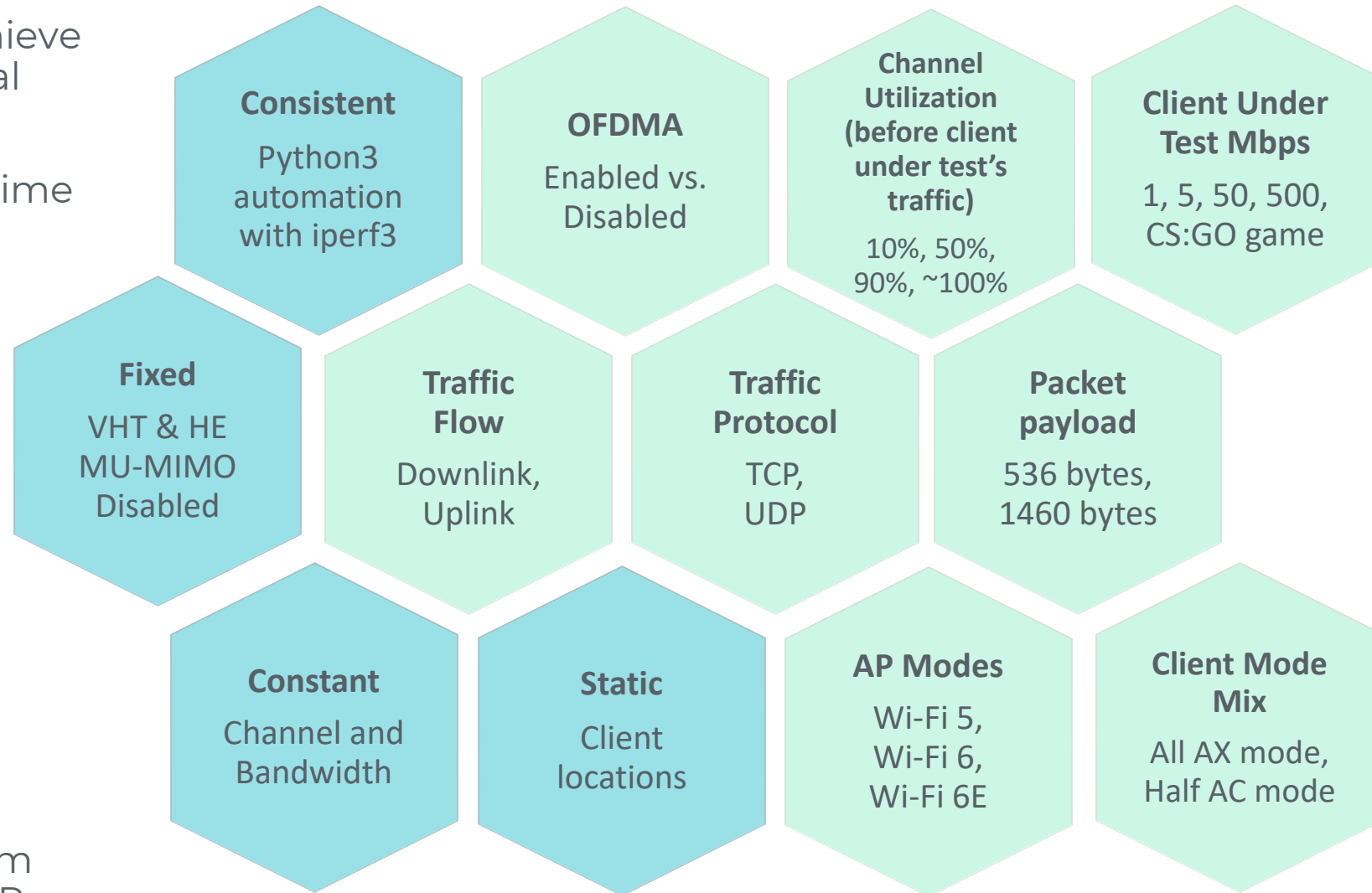**AP:** Front corner – main floor (4x4:4)

- Ch. 100/80 MHz (5 GHz) and Ch. 37/80 MHz (6 GHz)

1 client under test: Wi-Fi 6/6E (2x2:2)

- Located on same floor in next room away from AP

3 control clients: Wi-Fi 6/6E (2x2:2)

- To create predetermined percentages of channel utilization

- Located in room above, room below, and same room as AP

Consistent

Python3 automation with iperf3

OFDMA

Enabled vs. Disabled

Channel Utilization (before client under test's traffic)

10%, 50%, 90%, ~100%

Client Under Test Mbps

1, 5, 50, 500, CS:GO game

Fixed

VHT & HE MU-MIMO Disabled

Traffic Flow

Downlink, Uplink

Traffic Protocol

TCP, UDP

Packet payload

536 bytes, 1460 bytes

Constant

Channel and Bandwidth

Static

Client locations

AP Modes

Wi-Fi 5, Wi-Fi 6, Wi-Fi 6E

Client Mode Mix

All AX mode, Half AC mode

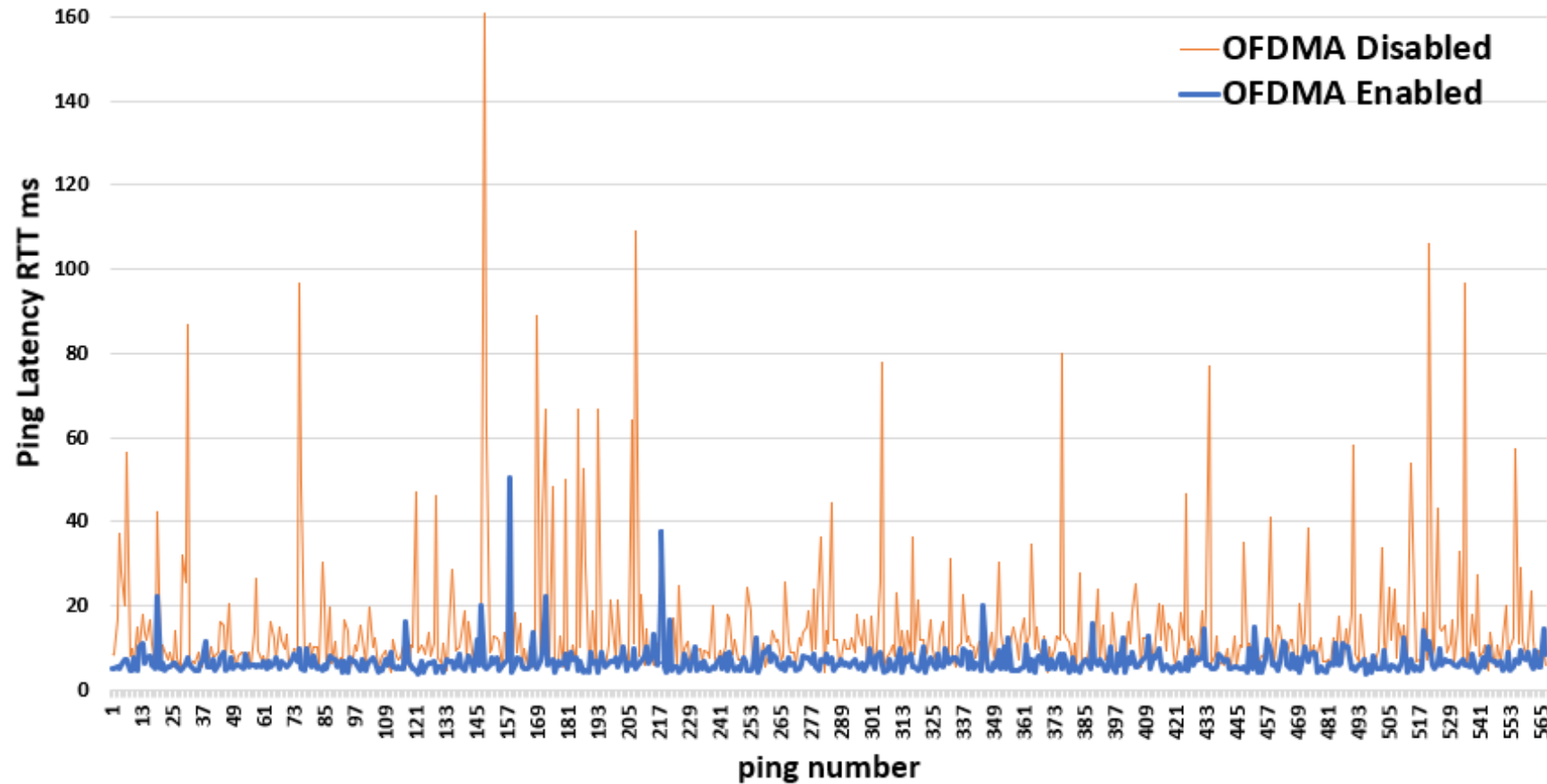**UDP Uplink** 1460 byte packet 60 seconds traffic

No Rate Limits on all clients 100% utilization

4 Clients

Pings 10/sec to one of the Wi-Fi 6 Clients Under Test with traffic

Wi-Fi 6 Client Under Test Latency	Wi-Fi 6 OFDMA Disabled (ms)	Wi-Fi 6 OFDMA Enabled (ms)
Avg	14	7
Max	161	51
Jitter	15	3

Wi-Fi 6 OFDMA Disabled vs. Enabled

OFDMA enabled reduces latency in fully utilized channels in the uplink direction.
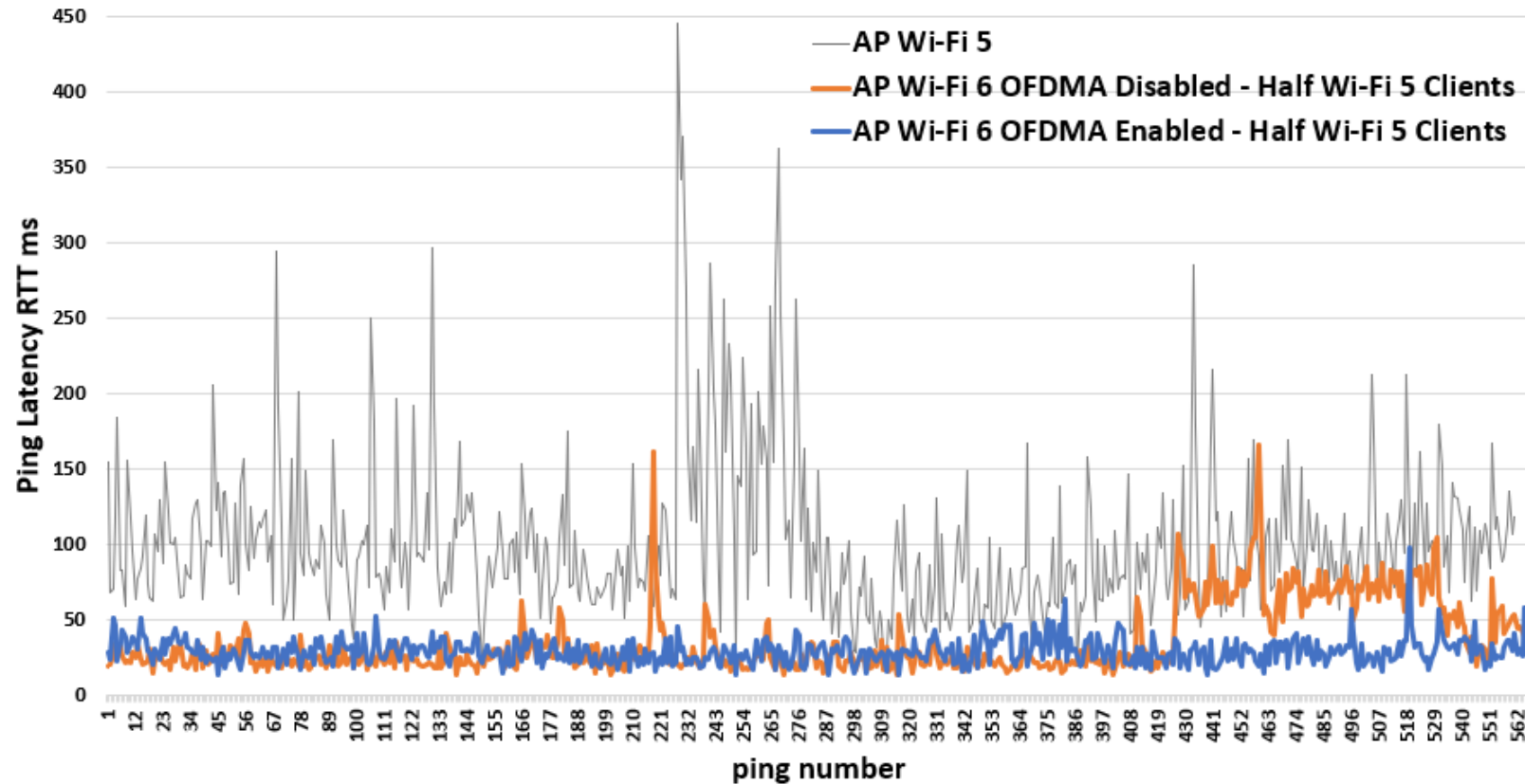
TCP Downlink 1460 byte MSS 60 seconds traffic

No Rate Limits on all clients 100% utilization

4 Clients half Wi-Fi 5 mode, half Wi-Fi 6 mode

Pings 10/sec to one of the Wi-Fi 6 Clients Under Test with traffic

Wi-Fi 5 vs. Wi-Fi 6 OFDMA Disabled vs. Enabled – Half Wi-Fi 5 Clients

Wi-Fi 6 Client Under Test Latency	Wi-Fi 5 (ms)	Wi-Fi 6 OFDMA OFF – half AC Clients (ms)	Wi-Fi 6 OFDMA ON – half AC Clients (ms)
Avg	100	36	29
Max	445	166	98
Jitter	51	22	8

OFDMA enabled improves latency on Wi-Fi 6 clients even with mixed traffic from Wi-Fi 5 clients.
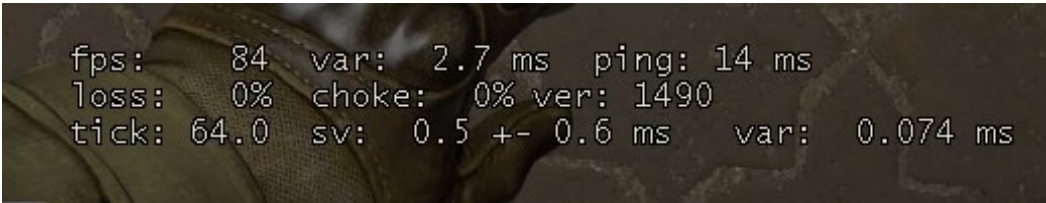
Playing LAN Hosted Game
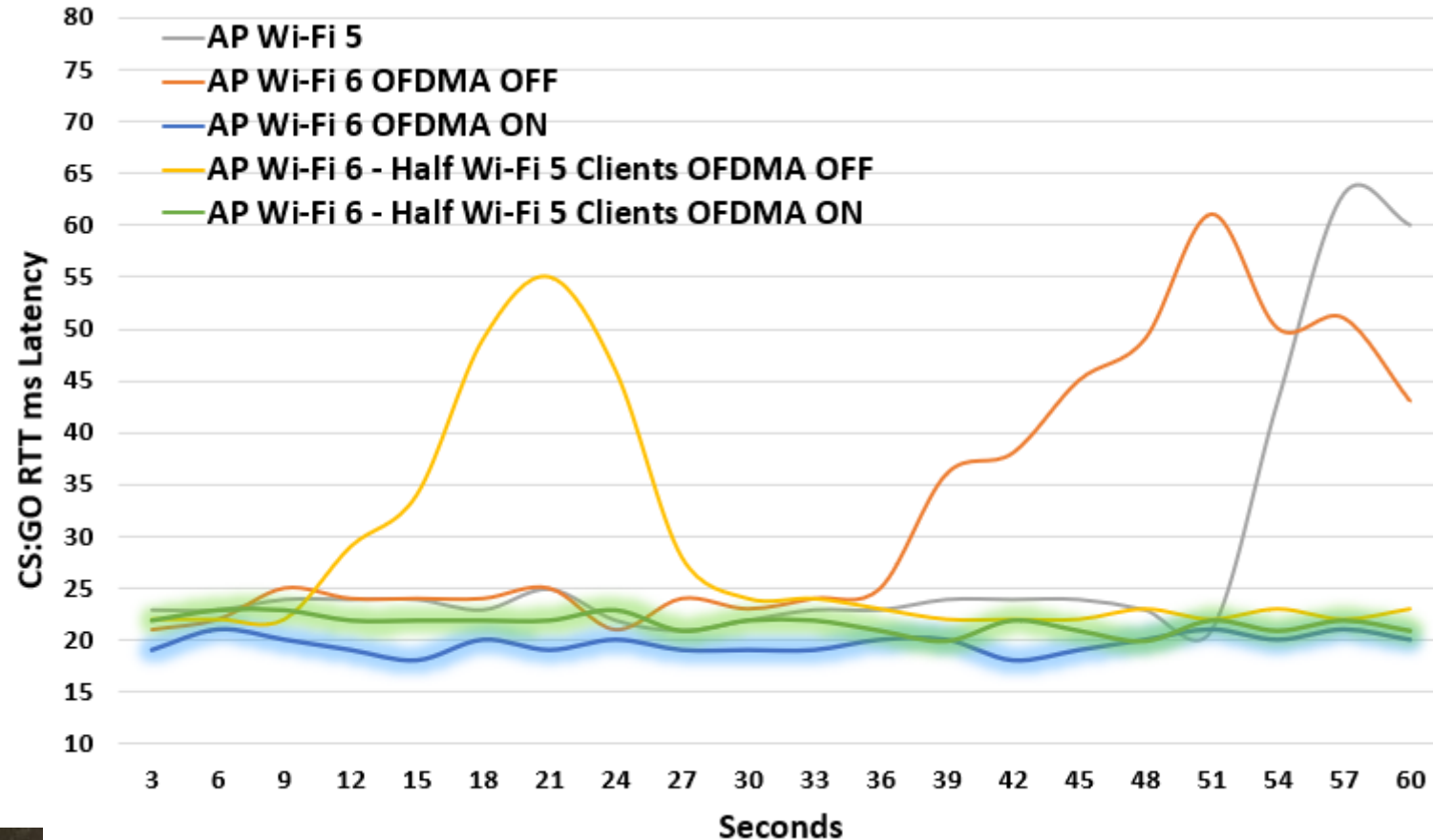
TCP Uplink 1460 byte MSS
60 seconds traffic

3 control clients - **90% utilization**

1 Wi-Fi 6 Client Under Test at 1 Mbps iperf3 rate limit while **playing CS:GO LAN hosted game** and pings 10/sec during traffic

Game Server for **Counter Strike: Global Offensive** was hosted on LAN Ethernet – without any WAN dependency – screen overlay shows game RTT latency in real-time.

Game Reported Latency During Play

Legend:
- AP Wi-Fi 5
- AP Wi-Fi 6 OFDMA OFF
- AP Wi-Fi 6 OFDMA ON
- AP Wi-Fi 6 - Half Wi-Fi 5 Clients OFDMA OFF
- AP Wi-Fi 6 - Half Wi-Fi 5 Clients OFDMA ON

OFDMA enabled test cases (blue and green) show smooth latency during game play.

```
fps:    84   var:  2.7 ms    ping: 14 ms
loss:   0%   choke:  0% ver: 1490
tick:  64.0   sv:  0.5 +- 0.6 ms    var:   0.074 ms
```

Playing LAN Hosted Game

Wi-Fi 6 OFDMA Disabled vs. Enabled
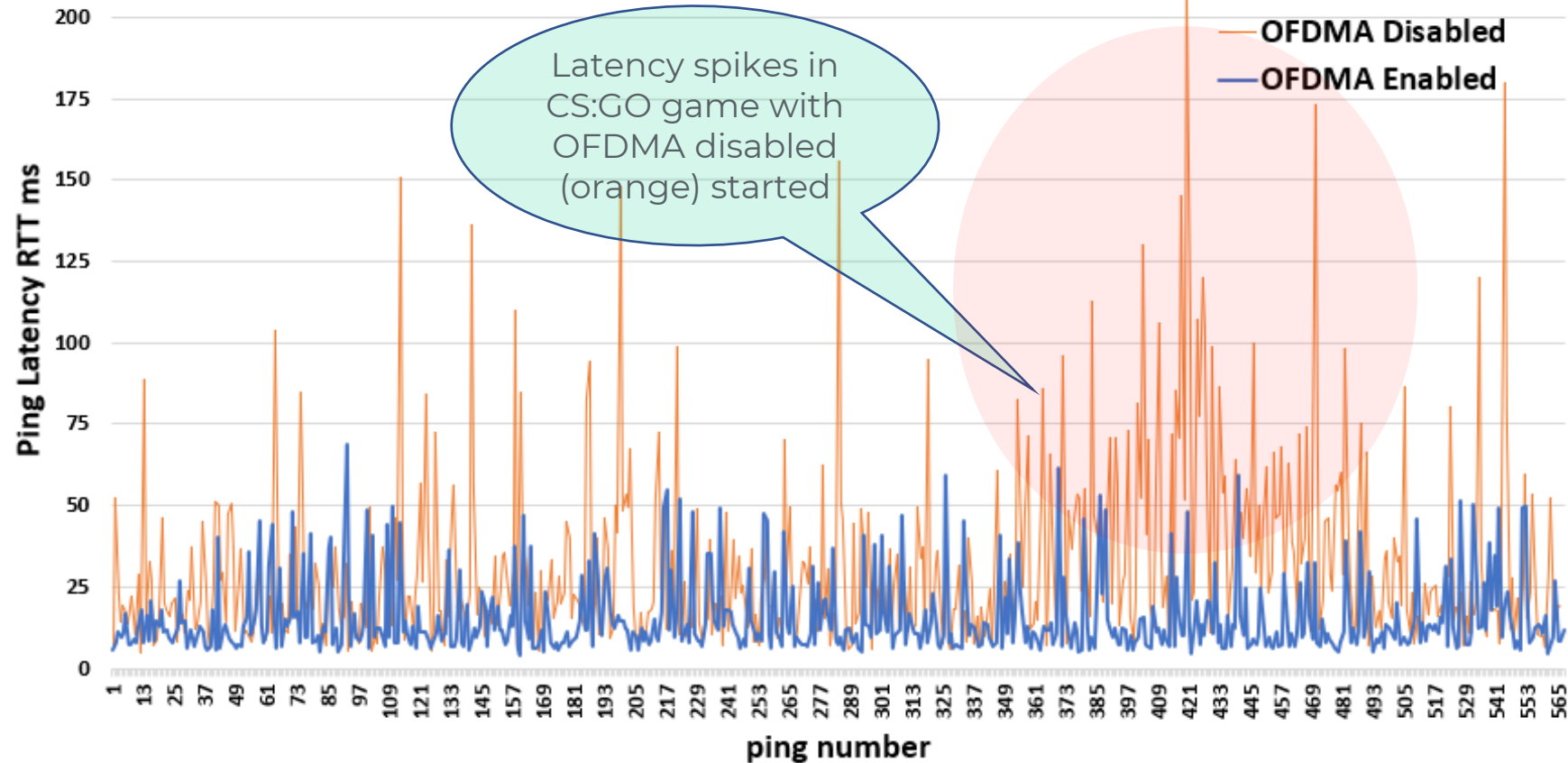
OFDMA disabled shows ping **RTT latency spiking more often** at t=36 seconds into run.

This correlates with game play RTT latency rising at same time shown on previous slide.

Wi-Fi 6 Client Under Test Latency	Wi-Fi 6 OFDMA Disabled (ms)	Wi-Fi 6 OFDMA Enabled (ms)
Avg	32	15
Max	212	69
Jitter	28	12

Latency spikes in CS:GO game with OFDMA disabled (orange) started

OFDMA enabled improved latency when channel 90% utilized with upstream traffic.
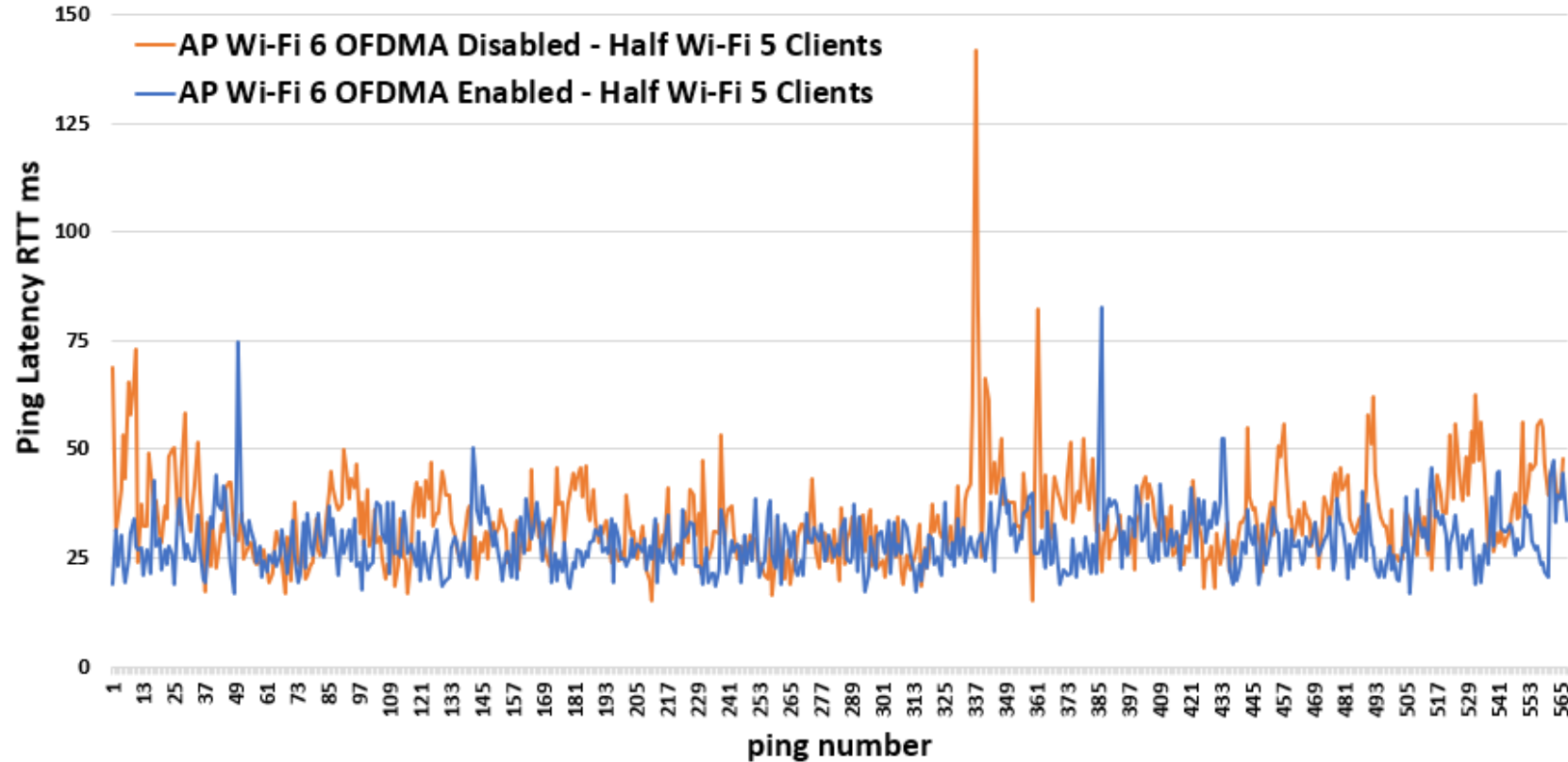
TCP Downlink 1460 byte MSS
60 seconds traffic

4 Clients - half Wi-Fi 5 mode,
half Wi-Fi 6 mode

control clients - **50% utilization**

1 Wi-Fi 6 Client Under Test with 500 Mbps rate limit with pings 10/sec during traffic

Wi-Fi 6 Client Under Test Latency	Wi-Fi 6 OFDMA OFF – half AC Clients (ms)	Wi-Fi 6 OFDMA ON – half AC Clients (ms)
Avg	34	29
Max	142	83
Jitter	11	8

Wi-Fi 6 OFDMA Disabled vs. Enabled Half Wi-Fi 5 Clients

OFDMA enabled does not improve latency as much in lower channel utilization scenarios.

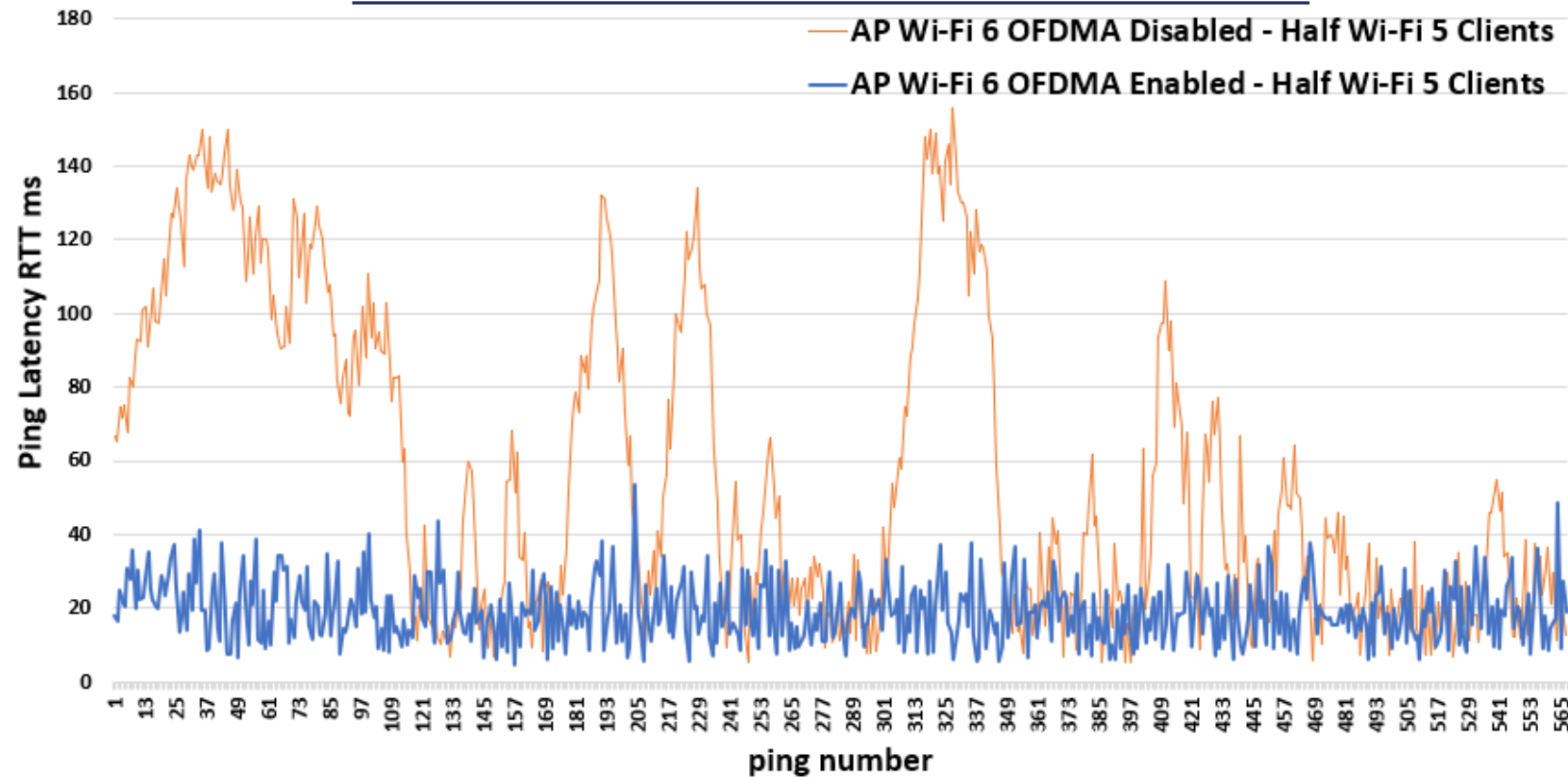**TCP Uplink** 1460 byte MSS 60 seconds traffic

4 Clients - **half Wi-Fi 5 mode**, half Wi-Fi 6 mode

control clients - **10% utilization**

1 Wi-Fi 6 Client Under Test with 500 Mbps rate limit with pings 10/sec during traffic

Wi-Fi 6 Client Under Test Latency	Wi-Fi 6 OFDMA OFF – half AC Clients (ms)	Wi-Fi 6 OFDMA ON – half AC Clients (ms)
Avg	56	19
Max	156	54
Jitter	42	8

Wi-Fi 6 OFDMA Disabled vs. Enabled Half Wi-Fi 5 Clients

— AP Wi-Fi 6 OFDMA Disabled - Half Wi-Fi 5 Clients
— AP Wi-Fi 6 OFDMA Enabled - Half Wi-Fi 5 Clients

OFDMA enabled shows more improvement with higher traffic from the client under test.

TCP Uplink 1460 byte MSS
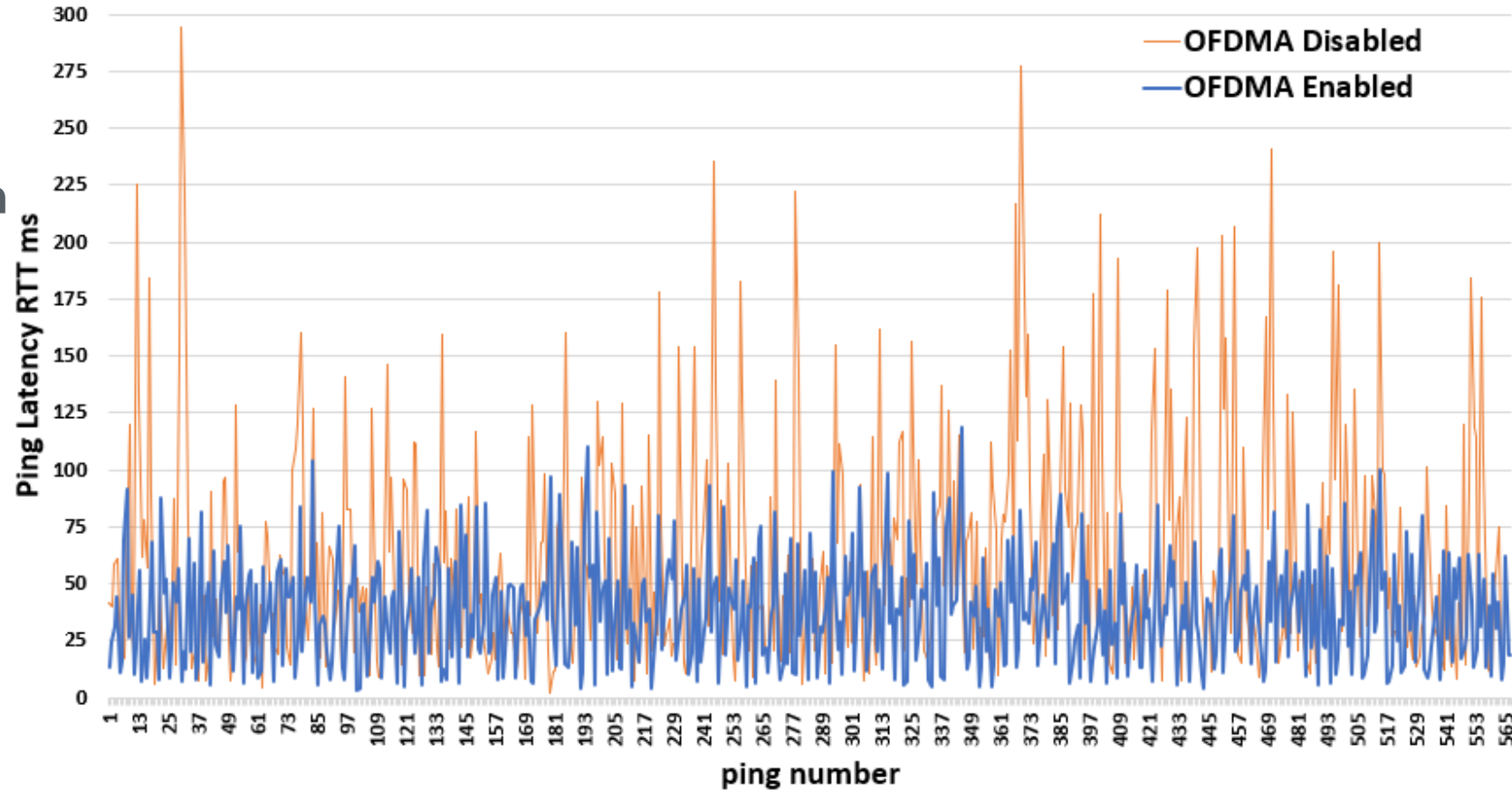60 seconds traffic

4 Clients – Wi-Fi 6E

control clients - **90% utilization**

1 Wi-Fi 6E Client Under Test with 50 Mbps rate limit with pings 10/sec during traffic

Wi-Fi 6E Client Under Test Latency	Wi-Fi 6E OFDMA OFF (ms)	Wi-Fi 6E OFDMA ON (ms)
Avg	62	38
Max	294	119
Jitter	49	23

Wi-Fi 6E OFDMA Disabled vs. Enabled

Wi-Fi 6E with OFDMA enabled shows similar results and reduces latency in highly utilized channels.

OFDMA Works!

Reduced latency seen with real scenarios in a home using today's AP solutions with OFDMA enabled.

High Airtime Utilization

Most latency improvement seen with high airtime utilization and OFDMA enabled.

Uplink Direction

Uplink traffic showed the most latency improvements with OFDMA enabled.

Wi-Fi 5 clients okay!

Tests with mixing of Wi-Fi 5 & Wi-Fi 6 clients still allow Wi-Fi 6 clients' latency to improve with OFDMA enabled.

Additional details are available in the SCTE Cable-Tec Expo 2022 White Paper:
Testing Wi-Fi Upgrades for Latency and Throughput
- In the paper there is an extensive list of additional test scenarios to consider.
- Many results would differ if VHT/HE MU-MIMO was enabled; in order to see OFDMA's individual contributions, MU-MIMO was disabled.

Creating Infinite Possibilities.

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Thank You!

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