Executive Summary with Visual Evidence
Wi-Fi Performance at 5 GHz (20/40 MHz)

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1) Essentials — at a glance

Device / SSID	Standard / Link	Width	NSS	Useful ceiling (Mb/s)	Speedtest (Mb/s) & coherence
Mac — Student (VLAN 511)	**802.11ax (Wi-Fi 6)**	**40 MHz / 20 MHz effective**	**2**	**380–420** (40 MHz) / **180–220** (20 MHz)	320–360 with segments at 250–300; OFDMA temporarily reduces effective width.
Mac — IoT (VLAN 510)	**802.11ax (Wi-Fi 6)**	**40 MHz / 20 MHz effective**	**2**	**380–420** (40 MHz) / **180–220** (20 MHz)	256/323 ; same location and **same AP** (channel 48); DL lower due to more frequent 20 MHz RU; UL within range.
Promethean	**802.11ac (Wi-Fi 5)**	**40 MHz**	**2**	**270–320**	180–250 ; ac 2x2 SoC with more retries and possible 20 MHz effective.
Wired VM	1 GbE copper	N/A	N/A	**950** (LAN local)	340–370 (Internet); path/ISP and hypervisor limit.

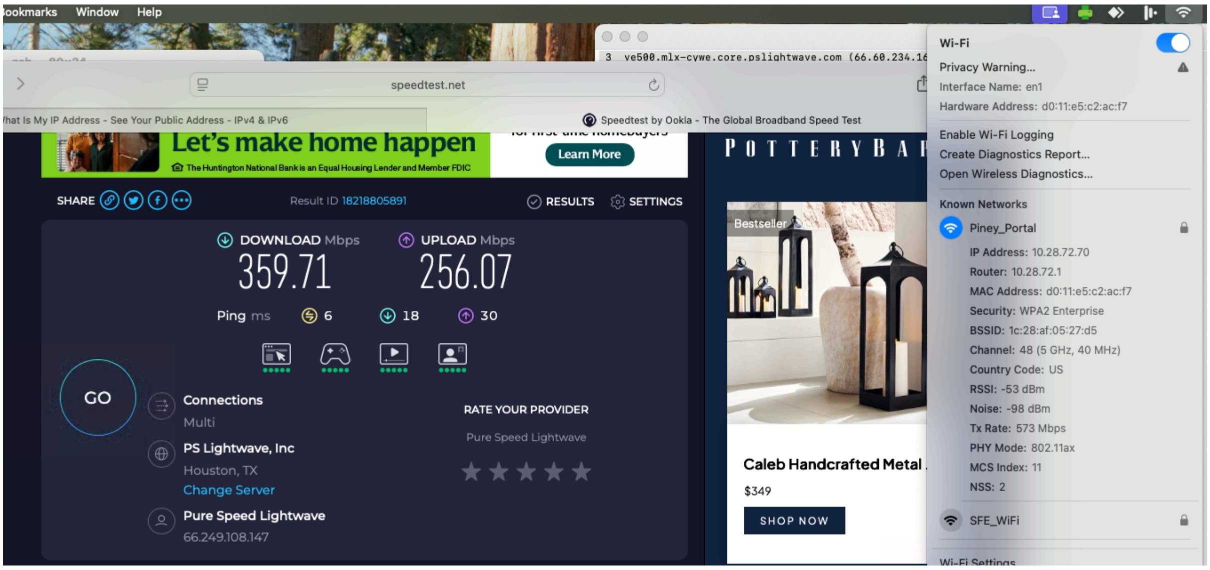

Figure 1: Mac on student SSID (VLAN 511): Speedtest ~360/256 Mb/s with idle 6 ms; Wi-Fi panel shows ax PHY, **NSS 2** and **Tx Rate 573 Mb/s** (channel 48, 40 MHz).

2) Latency and "jitter" under load (ELC)

Device / SSID	Standard	NSS	Idle	DL lat	UL lat	ELC_DL / ELC_UL
Wired VM	1 GbE	N/A	27 ms	30 ms	31 ms	3 ms / 4 ms
Mac — Student	802.11ax	**2**	9 ms	21 ms	28 ms	12 ms / 19 ms
Mac — IoT	802.11ax	**2**	**8 ms**	**15 ms**	**28 ms**	**7 ms** / **20 ms**
Promethean	802.11ac	**2**	12–20 ms	40 ms	50 ms	20–28 ms / 30–38 ms

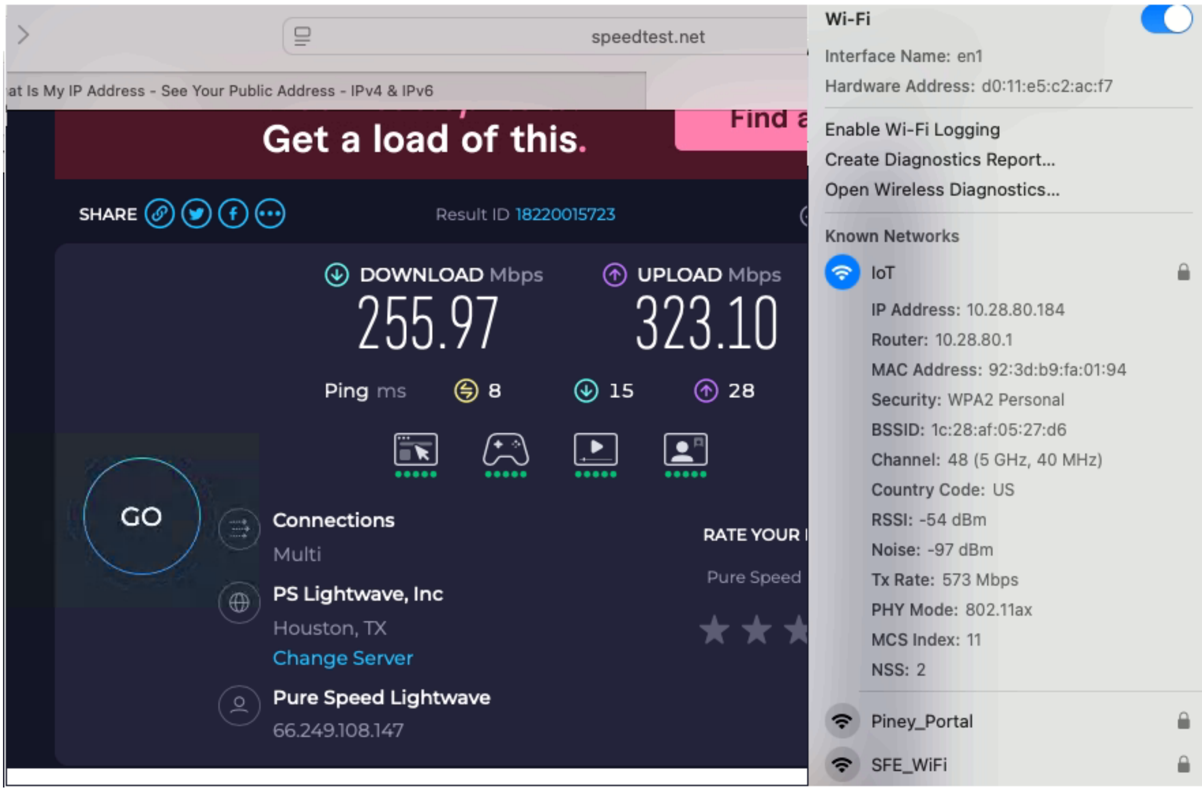

Figure 2: Mac on **IoT** SSID (VLAN 510) and **same AP** (BSSID 1c:28:af:05:27:d*), **channel 48** at 40 MHz, **NSS 2**, MCS 11: Speedtest **255.97/323.10 Mb/s**, idle **8 ms**. Consistent with ax 2x2 when the scheduler more often uses 20 MHz RU in downlink.

How to read the results. The *Idle* column is the latency reference without transfer; it is the round-trip time at rest. On the **wired VM** that value appears higher than over Wi-Fi (27 ms), but the key point is that when the link is loaded, latency barely increases (ELC_DL ≈ 3 ms and ELC_UL ≈ 4 ms). This shows that even with sustained traffic, no significant queuing forms on the wired leg; the higher *Idle* is due to the path or virtualization, not load-induced congestion.

On the **Mac — Student** we see a typical modern Wi-Fi pattern: low *Idle* and, once download/upload begins, latency rises moderately to 21/28 ms (ELC_DL ≈ 12 ms and ELC_UL ≈ 19 ms). In a shared medium this is normal: contention, retries and the AP sharing airtime across clients. Upload is usually penalized slightly more than download because the client competes to transmit, hence higher ELC in UL.

On the **Mac — IoT** download is somewhat more favorable (15 ms DL, ELC_DL ≈ 7 ms), while upload is similar to Student (28 ms UL, ELC_UL ≈ 20 ms). This matches moments where the AP assigns a larger chunk of channel to DL or simply faces less competition at that instant. In any case, these figures are expected in a real environment with several clients.

The **Promethean (802.11ac)** shows higher latencies under load (40/50 ms) and wider ELC. Not necessarily a problem: it often reflects older 11ac radios, older drivers, or slightly worse signal. For browsing and streaming it is fine; in very latency-sensitive apps (interactive whiteboard, live uplink video) it can feel less fluid than the ax Mac.

Bottom line. Overall the values are coherent: the wired path stays stable with little increase under load, and over Wi-Fi the rise is moderate and larger in UL than DL. As long as *extra latency under load* stays in the tens of milliseconds and doesn't grow persistently, the state is healthy for general use. If latency under load spikes persistently, check signal, channel contention, and on the Internet side, the 100-Mb/s cap effect.

3) Mac: why I see 574 and 287 (two paths in ax)

Situation (interface)	Standard	NSS	What happens on RF and what I see in tests
574 Mb/s	802.11ax	2	40 MHz width with high MCS (good SNR). User: peaks 380–420 Mb/s.
287 Mb/s	802.11ax	2	OFDMA assigns 20 MHz effective (or SMPS favors one wide RU). User: segments 180–220 Mb/s and averages 250–350.

3.1) Percentages: why I don't reach the negotiated speed with the AP

Component	Brief description	Typical impact
802.11 headers and control	MAC, QoS/WMM, security (AES), BlockAck, preambles, IFS	15–25%
IP/TCP/UDP/VLAN overhead	L3/L4 encapsulation and VLAN	3–6%
Contention and backoff	Shared airtime (CSMA/CA), collisions, retries	5–15%
Rate adaptation	MCS adjustments due to SNR variation	0–10%
OFDMA (RU < 40 MHz)	**20 MHz** RU or smaller for part of the traffic	**up to 50%** drop in effective width

Examples using the figures.

Case	Estimated PHY	Throughput	Efficiency	Reading
Student (DL)	573 Mb/s	~360 Mb/s	**~63%**	Within the 60–70% range typical of ax 40 MHz.
Student (UL)	573 Mb/s	~256 Mb/s	~45%	UL is more sensitive to contention and RU size.
IoT (DL)	573 Mb/s	~256 Mb/s	~45%	Higher proportion of 20 MHz RU in download.
IoT (UL)	573 Mb/s	~323 Mb/s	~56%	Consistent with ax and mixed RU.

Efficiency reference (ax 2×2)		
Condition	**Reference PHY**	**Typical efficiency $\eta = \frac{\text{throughput}}{\text{PHY}}$ ⇒ expected throughput**
40 MHz (RU 484)	573–574 Mb/s	**60–70%** ⇒ **380–420 Mb/s**
20 MHz (RU 242)	286–287 Mb/s	**60–75%** ⇒ **180–220 Mb/s**

OFDMA and RU (Resource Units) In Wi-Fi 6 (802.11ax) the access point can split the channel into **RU** (*Resource Units*) and serve several clients in the same transmission. Each RU is a set of subcarriers, and its size defines the client's *effective width* at that instant. Typical sizes: 26, 52, 106, **242** ($\approx$ 20 MHz), **484** ($\approx$ 40 MHz), **996** ($\approx$ 80 MHz) and 2×996 ($\approx$ 160 MHz).

- If the scheduler assigns **RU 484** ($\approx$ 40 MHz) to a 2×2 client with a high MCS, the **PHY** is typically $\sim$ 573 Mb/s.
- If, due to load or fairness, the AP temporarily reduces to **RU 242** ($\approx$ 20 MHz), the **PHY** drops to $\sim$ 286 Mb/s for that client, even though the physical channel is 40 MHz.

- **PHY** (*Physical layer data rate*): **physical** rate negotiated between client and AP (depends on MCS, number of spatial streams *NSS*, and width). It is not application throughput.
- **DL** / **UL**: *Downlink* (AP to client) / *Uplink* (client to AP).
- **RU**: *Resource Unit.* Slice of the OFDMA channel assigned to a client in a transmission; defines its momentary effective width.

In summary. The gap between the **negotiated rate (PHY)** and the **user throughput** comes from three main factors: (1) protocol overhead and timings in 802.11 and IP, (2) contention and retries in a shared medium, and (3) in Wi-Fi 6, **OFDMA RU assignment**, which can temporarily reduce the *effective width* to 20 MHz or other sizes. Therefore, seeing **60–70% of PHY** with a 40-MHz-equivalent RU and **60–75% of PHY** with a 20-MHz-equivalent RU is entirely **normal and healthy**.

4) Where Promethean fits (ac 2x2 at 40 MHz)

Connection/State	Standard	Width	NSS	Explanation and practical consequence
Typical current level	**802.11ac**	**40 MHz**	**2**	**PHY $\approx$ 400–433 Mb/s** (MCS8–9, short GI) in **ac 2x2 40 MHz**. Useful ceiling: **270–320 Mb/s**.
Next level down (NSS)	802.11ac	40 MHz	**1**	If it falls to 1 stream (SM Power Save/conditions): **PHY $\approx$ 200 Mb/s**. Useful: **120–150 Mb/s**.
Next level down (width)	802.11ac	**20 MHz effective**	**2**	Due to contention/RF policy: **PHY $\approx$ 173 Mb/s**. Useful: **105–130 Mb/s**.
Observed averages	802.11ac	40 MHz (variable)	2 (sometimes 1)	180–250 Mb/s; consistent with retries/contention and episodes of 1x1 or 20-MHz effective.

INCREASED DATA RATES

Wi-Fi 6 delivers significantly higher peak data rates than Wi-Fi 5 (802.11ac) in 5GHz and 802.11n in 2.4GHz. Note that support for 8SS was not widely adopted with Wi-Fi 5, but is expected to be more common with Wi-Fi 6.

CHANNEL BANDWIDTH	1 SS	2 SS	3 SS	4 SS	8 SS
20 MHz 802.11n (2.4 GHz)	*72 Mbps*	*144 Mbps*	*217 Mbps*	*289 Mbps*	*N/A*
20 MHz 802.11ac (5 GHz)	*87 Mbps*	*173 Mbps*	*289 Mbps*	*347 Mbps*	*693 Mbps*
20 MHz 802.11ax (2.4/5 GHz)	143 Mbps	287 Mbps	430 Mbps	574 Mbps	1147 Mbps
40 MHz 802.11n (2.4 GHz)	*150 Mbps*	*300 Mbps*	*450 Mbps*	*600 Mbps*	*N/A*
40 MHz 802.11ac (5 GHz)	*200 Mbps*	*400 Mbps*	*600 Mbps*	*800 Mbps*	*1600 Mbps*
40 MHz 802.11ax (2.4/5 GHz)	287 Mbps	574 Mbps	860 Mbps	1147 Mbps	2294 Mbps
80 MHz 802.11ac (5 GHz)	*433 Mbps*	*867 Mbps*	*1300 Mbps*	*1733 Mbps*	*2167 Mbps*
80 MHz 802.11ax (5 GHz)	600 Mbps	1201 Mbps	1801 Mbps	2402 Mbps	4804 Mbps
160 MHz 802.11ac (5 GHz)	*867 Mbps*	*1733 Mbps*	*2340 Mbps*	*3467 Mbps*	*6933 Mbps*
160 MHz 802.11ax (5 GHz)	1201 Mbps	2402 Mbps	3603 Mbps	4804 Mbps	9608 Mbps

** Data rate may vary depending on client availability.*

Figure 3: Peak-rate reference: **ax 2x2 40 MHz → 574 Mb/s** and **ax 2x2 20 MHz → 287 Mb/s**; useful ceilings **380–420** and **180–220 Mb/s**.

5) What is NOT the problem

Item	Evidence	Conclusion
PoE / power AP-515	LLDP **25.5 W** offered; draw ~9 W idle; 2930F 2/16 Class 4	PoE OK; the 574/287 difference is **effective width (OFDMA)**, not power.
Mac coverage/SNR	RSSI -53 dBm (Student) and -54 dBm (IoT), Noise -97/ -98 dBm ⇒ SNR **~45 dB**	High MCS sustainable; both tests on **same AP** and **same location**.

6) Changes made

Decision	Justification (see tables)	Expected outcome
Keep 40 MHz in production	Cell balance/peaks (Tables 1, 2, 4) with **NSS=2** clients	Averages 280–350 Mb/s per 2x2 client.
Tested 80 MHz in lab	To demonstrate **>500 Mb/s** per ax 2x2 client (Tables 1 and 3)	Confirm peaks **>500 Mb/s** on a Mac near the AP.
Tune **QoS/WMM** and **DMO**	Lower ELC; improves video and responsiveness (Table 2)	Less latency under load.
Measure with Connections=Single	Avoid multi-connection/path bias (Table 1)	Homogeneous, comparable metric.

With 5 GHz at **40 MHz**, the **ax 2x2 Mac (NSS 2)** delivers 320–360 Mb/s on Student and 256/323 Mb/s on IoT, both **consistent** with ax 2x2 when the scheduler more often assigns **20 MHz** RU on download (IoT). **Promethean ac 2x2 (NSS 2)** has **PHY ≈ 400–433 Mb/s** at **40 MHz** and yields 180–250, coherent with its standard and contention. **AP-515/PoE** is fine; 4x4 adds *cell capacity*, while per-user throughput is determined by the **client's NSS** and **effective width**. The observed efficiencies (45–65% of PHY depending on the case) are within expectations for Wi-Fi 6 with OFDMA and real load.

7) Why Aruba AP 300 series looks more stable than 500

Aspect	**Series 200 (Aruba AP-205/AP-215) — 11ac Wave-1**	**Series 300 (Aruba AP-315/AP-325) — 11ac Wave-2**	**Series 500 (Aruba AP-505/AP-515/AP-535/AP-555) — 11ax Wi-Fi 6**
Physical / standard	802.11ac W1; SU-OFDM; 20/40/80 MHz.	802.11ac W2; SU-OFDM + **MU-MIMO DL**; 20/40/80 MHz.	**802.11ax**; **OFDMA DL+UL** + MU-MIMO; 20/40/80/160 MHz; BSS Coloring, TWT.
Allocation unit	*Full channel* per TXOP (no RU).	*Full channel* per TXOP (no RU).	**RU** 26/52/106/242/484/996 (and 2×996): *effective width varies per client.*
Per-client rate stability	**High** (little instantaneous variation).	**High–medium** (some variation due to MU-MIMO DL).	**Medium–low** in single-client tests: oscillation due to RU changes (e.g., 40→20 MHz).
Latency under load (ELC)	Medium/high.	Better than 200 thanks to MU-MIMO DL.	**Lower** thanks to OFDMA and fine scheduling.
DL vs UL	SU DL/UL.	**MU-MIMO DL**; UL SU.	**OFDMA DL** very active; **UL-OFDMA** depends on client support and scheduler.
Legacy client compatibility	Full (11n/ac).	Full.	Full; legacy uses SU; mixes may require more protection/overhead.
Perceived "stability"	**Very stable**.	**Stable**.	**More "oscillatory"** due to RU; better median in high density.

- **Series 300 (802.11ac)**: no OFDMA. The client uses the *full channel* (20/40/80 MHz) during its TXOP ⇒ **per-client rate is steady** (few jumps).
- **Series 500 (802.11ax)**: **OFDMA DL+UL**. The AP splits the channel into *RUs*; if it alternates *RU 484* (≈40 MHz) and *RU 242* (≈20 MHz), PHY oscillates $\sim 573 \leftrightarrow 286$ Mb/s even with a 40-MHz physical channel.
- This is **normal** in 11ax: it prioritizes **latency and total capacity** in dense environments at the cost of a less "smooth" instantaneous per-client rate.
- The apparent "*channel change*" is often **RU/Dynamic Bandwidth change**, not a real ARM/DFS channel move.
- **How to tell**: ARM/DFS leaves events. Check `show ap arm history ap-name "<AP>"` and `show log system 1` (look for ARM/DFS). If there are no changes, assume variation due to RU/DBO.
- **Mitigation for smoother demos**: keep 40 MHz; single ax client with high SNR and steady traffic; in the lab, optionally *disable UL-OFDMA* to measure a flatter curve.