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Wi-Fi 8 Will Break Surveys

The changes in Wi-Fi 8 and iOS 27: What design and survey tools miss

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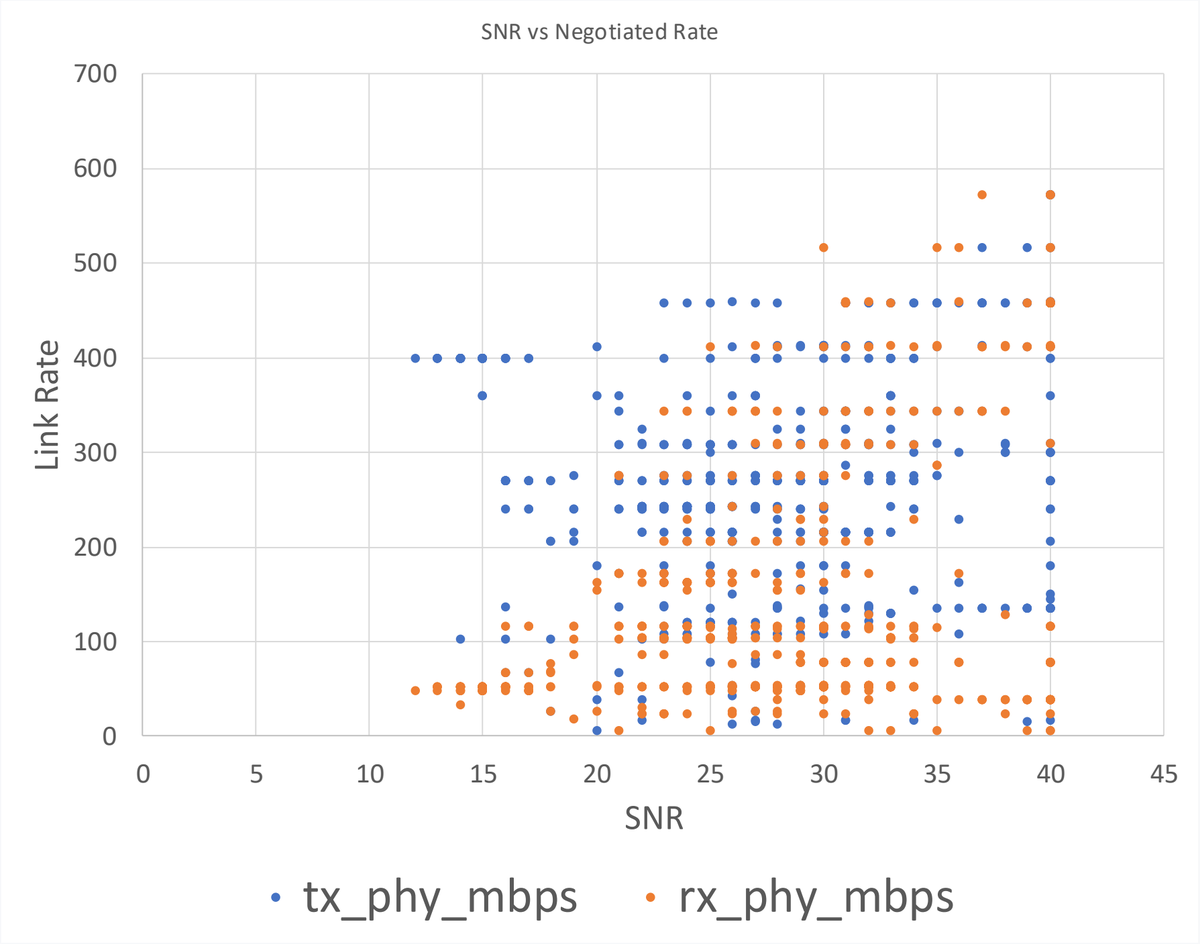
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A survey is a snapshot

Modelled designs and typical surveys are snapshots based on a statistical point through the data

A heatmap gives one value per location. Although not reality, it works as a good assumption

- The statistical nature of your Wi-Fi signal is not clearly separated between time and location



Real Data from nOversight captures shows how Link Rate can vary for the same SNR

- 61 walk tests in real environments
- 18,000 samples – 5 Hours of walking

A SURVEY IS A SNAPSHOT

How do you understand your Wi-Fi devices?

Device Ecosystem

- Best Practices
- Rules: Wi-Fi Roaming Support in Apple Devices

AP Ecosystem

- Reporting dashboards
- Best Practices

Design tools estimating device performance

- SNR and Link Rates
- Capacity involves assumptions

Technology	Roam trigger threshold	Gaining BSS relative signal strength when transmitting data	Gaining BSS relative signal strength when idle
Mac with Apple silicon	–75 dBm	12 dB stronger	12 dB stronger
Intel-based Mac	–75 dBm	12 dB stronger	12 dB stronger
iPhone 5s or later	–70 dBm	8 dB stronger	12 dB stronger
iPad Pro 13-inch (M4)	–70 dBm	8 dB stronger	12 dB stronger
iPad Pro 9.7-inch or later	–70 dBm	8 dB stronger	12 dB stronger
iPad Air (1st generation) or later	–70 dBm	8 dB stronger	12 dB stronger
iPad (5th generation) or later	–70 dBm	8 dB stronger	12 dB stronger
iPad mini (A17 Pro)	–70 dBm	8 dB stronger	12 dB stronger
iPad mini 2 or later	–70 dBm	8 dB stronger	12 dB stronger
Apple Vision Pro	–70 dBm	8 dB stronger	12 dB stronger

- Wi-Fi 7 (802.11be) is preferred over Wi-Fi 6 (802.11ax)
- Wi-Fi 6 (802.11ax) is preferred over Wi-Fi 5 (802.11ac)
- Wi-Fi 5 (802.11ac) is preferred over Wi-Fi 4 (802.11n) or 802.11a
- Wi-Fi 4 (802.11n) is preferred over 802.11a
- 160 MHz channel width is preferred over 80 MHz, 40 MHz or 20 MHz
- 80 MHz channel width is preferred over 40 MHz or 20 MHz
- 40 MHz channel width is preferred over 20 MHz

Understanding how clients roam — as well as your knowing the required signal strength of a candidate BSS — can help you design a wireless network that supports real-time services, like voice and video.

Let's look beyond the published information

Any single device has more than one roam rule.

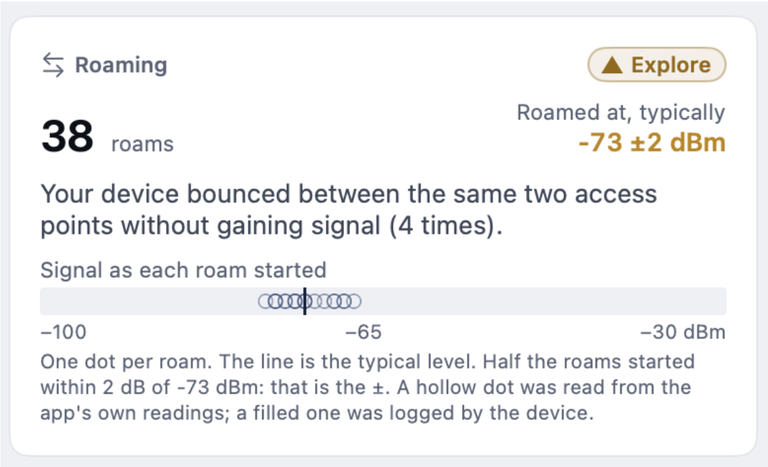
- Devices are using more than the simple published metrics
- Association and roaming is based on real-time variables such as rate, width, streams and free airtime – all things we measure independently today
- **Wi-Fi 8 Seamless Mobility Domain (SMD) will make the move faster but also puts more focus on design tools acknowledging and introducing enhancements to roaming**

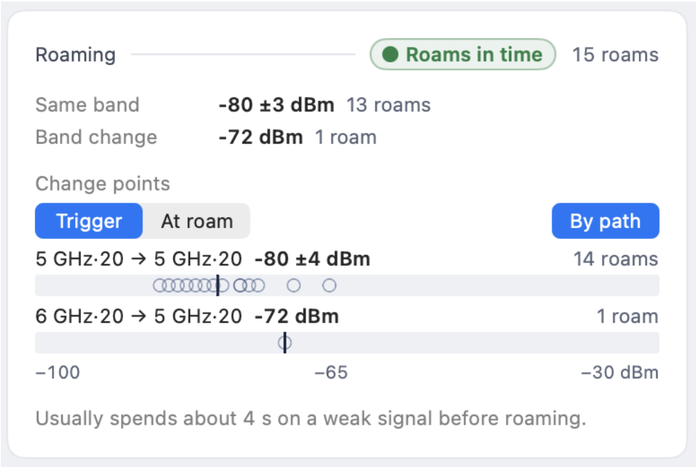
```
LQM-WiFi-Roam: roamReason=1  roamType=2 home(bssid=f8bbbf3086c8 chanSpec=<private>, rssi=-73) prof[0](flags=0x1808 trigger=-70 delta=30) userOverride=0
LQM-WiFi-Roam: roamReason=1  roamType=2 home(bssid=acec850f1aa5 chanSpec=<private>, rssi=-73) prof[0](flags=0x1808 trigger=-70 delta=30) userOverride=0
LQM-WiFi-Roam: roamReason=1  roamType=0 home(bssid=74b6b683d426 chanSpec=<private>, rssi=-85) prof[1](flags=0x1808 trigger=-75 delta=12) userOverride=0
LQM-WiFi-Roam: roamReason=19 roamType=0 home(bssid=74b6b683d425 chanSpec=<private>, rssi=-50) prof[0](flags=0x1b0b trigger=-10 delta=20) userOverride=0
LQM-WiFi-Roam: roamReason=1  roamType=0 home(bssid=74b6b683d426 chanSpec=<private>, rssi=-64) prof[0](flags=0x1808 trigger=-70 delta=30) userOverride=0
LQM-WiFi-Roam: roamReason=19 roamType=1 home(bssid=74b6b683d426 chanSpec=<private>, rssi=-87) prof[0](flags=0x1808 trigger=-70 delta=30) userOverride=0
```

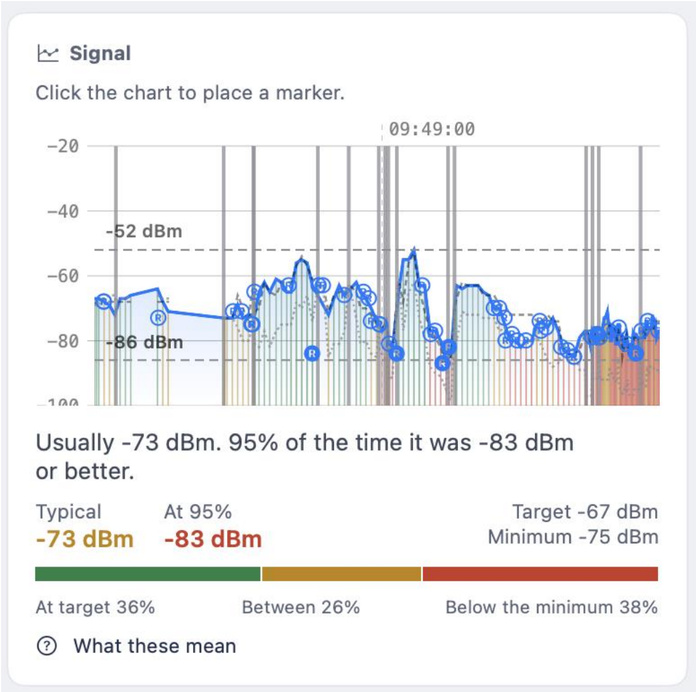
Example: Roaming is not just a threshold but a range

If we observe roaming triggers, they vary.

This real world device made decisions based on real-world, changing conditions.







A SURVEY IS A SNAPSHOT

Designing for devices to deliver reliable performance

It is becoming common to design networks that constrain device choices

- This is in favour of the way design tools work today, and validation can easily match the design
- BUT - It shrinks the device’s choices.
  - This is probably not the Wi-Fi 8 way where performance enhancements rely on AP overlap and more device choices

LCMI

Least capable, most important

Build the whole network around the weakest device you cannot afford to lose. Everything else fits inside its margin.

PRA

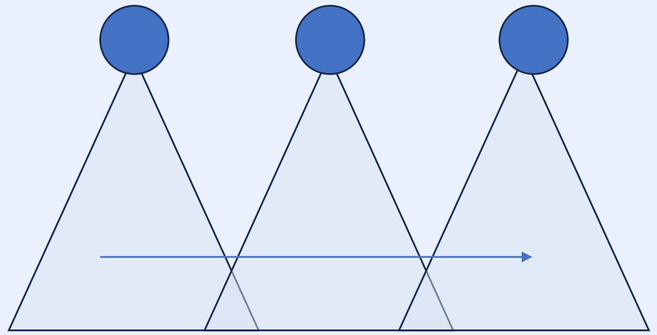
Parallel reality architecture

One RF layer per device cohort, each tuned on its own: legacy on 2.4 GHz, fragile on 5 GHz non-DFS, fast movers on DFS, modern on 6 GHz. *Troy Martin*

Constrained Devices

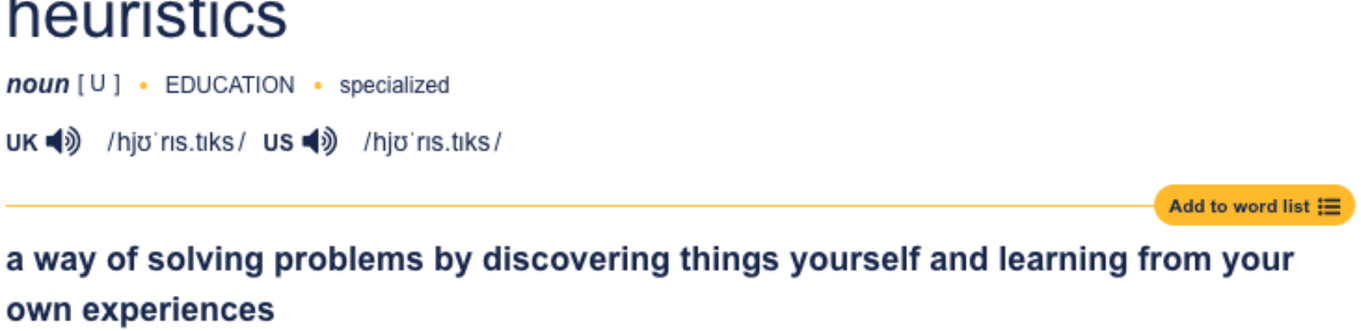
Minimise the device's choices

Many directional cells so that at any point the device has one sensible candidate. Roaming happens where you drew the line because nothing else is on offer.



What might be the future of design and survey

- Design and survey heatmaps describe the environment.
- Heuristics decide what the device does with it.
- Wi-Fi 8 adds significant new uplink gains, and some will need to be incorporated into your designs.
    - Snapshots and constrained designs may limit the benefits here



Designs and surveys will need to incorporate more knowledge on the variability of Wi-Fi performance and dynamic decisions around that

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Wi-Fi 8 adds reliability and new design considerations

The aim is reliability, particularly in the uplink.

Most of these are not native to the way we design and cannot appear in a survey

Coordinated Spatial Reuse
Two APs transmit together

How could this affect cell sizes?

Coordinated Beamforming
Improved steering with nulls

Could affect SNR estimations

Non-primary Channel Access
Better sharing of busy channels

The meaning of co-channel contention heatmaps

Unequal Modulation
Different MCS per stream

One path value no longer describes the link

Distributed Resource Units
More uplink power

Models and surveys aligned to resource unit allocations

Enhanced Long Range
More processing gain

Different uplink cell sizes for IoT devices

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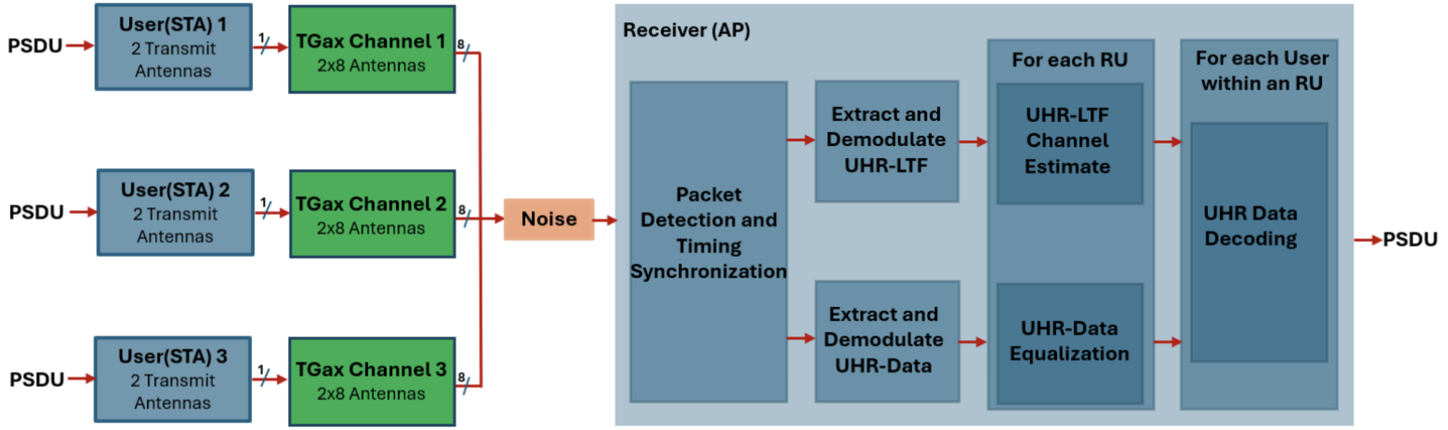
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Using simulation tools to investigate Wi-Fi 8

Matlab is a popular academic tool for telecommunications simulation

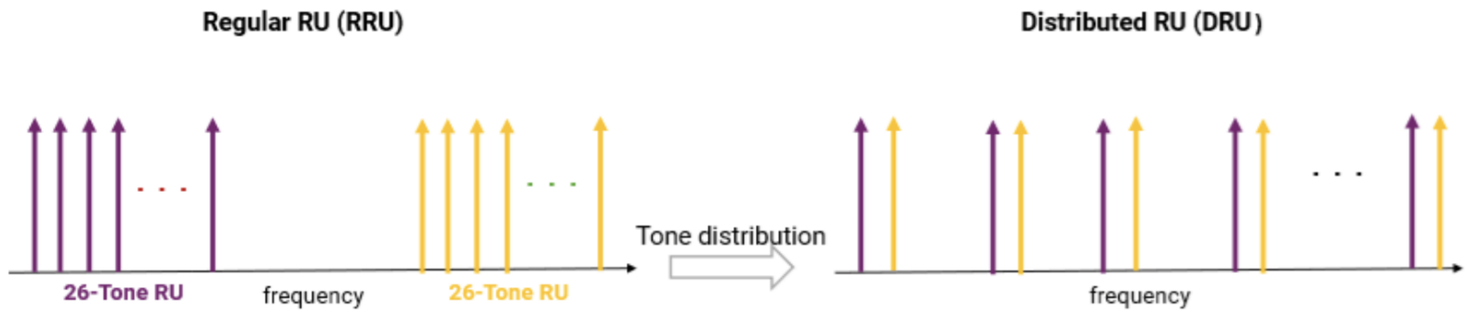
- The Wi-Fi 8 toolbox already can build UHR (Wi-Fi 8) frames
- It allows us to simulate CSMA
- We can create environments and channel conditions to explore how real-world Wi-Fi 8 might behave

MathWorks®



Distributed Resource Units

This example uses distributed resource units (DRUs), which are new to Wi-Fi 8. In a DRU, the tones that make up the RU are evenly spread across the whole bandwidth.



Coordinated TDMA
take turns, by agreement

How it works

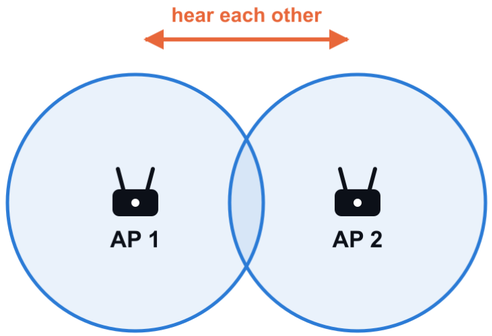
APs on the same channel agree to coordinate. The AP that wins the channel shares its transmit opportunity with a neighbour AP, and they transmit one after the other, each at full power on the full channel. No backoff and no collisions between them.

What it means for design and survey

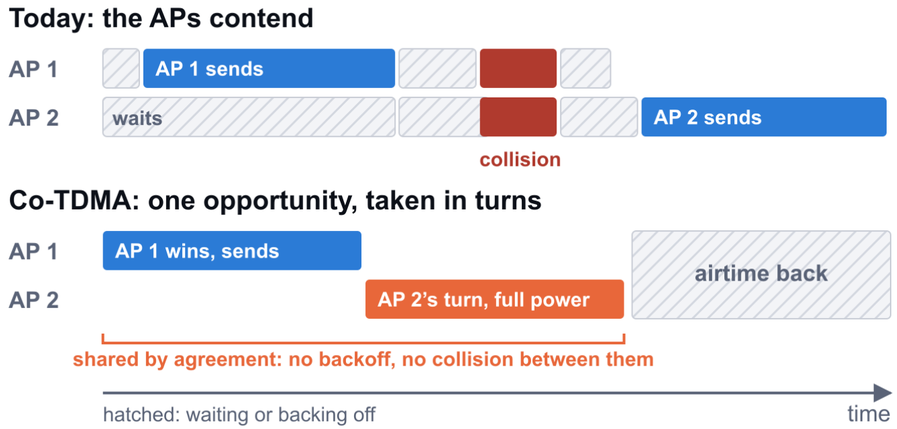
- The coverage map is unchanged for AP -> Client
- The AP -> AP link predictions are needed
- Co-channel overlap heatmap will be pessimistic

Optional in the draft standard.

If it happens, expect it later than the first Wi-Fi 8 products.



Both at full power, same channel:
the coverage map does not change



WI-FI 8 CHANGES THE LOGIC UNDER THE HOOD

Coordinated spatial reuse two APs, one transmit opportunity

How it works

The AP that wins the channel can share its transmit opportunity with a same-channel neighbour AP. The neighbour transmits at reduced power, so both can send at once with interference kept low.

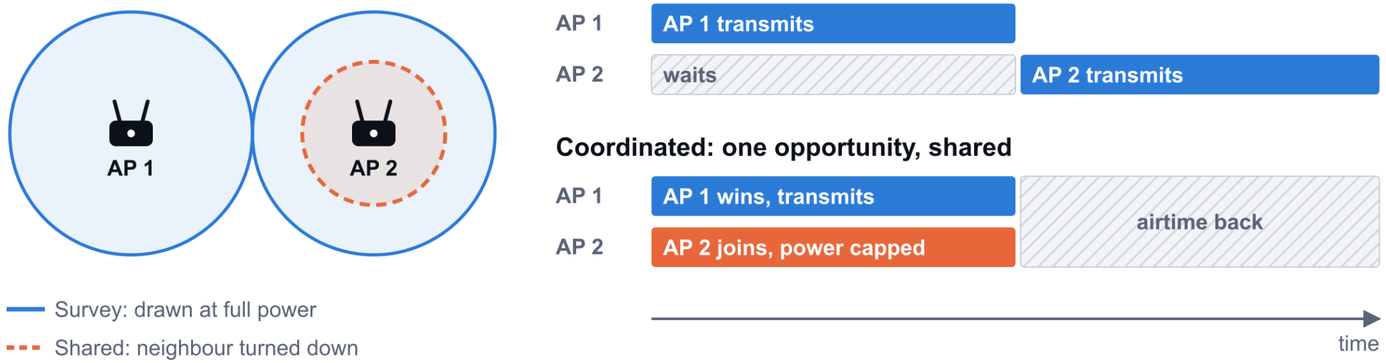
What it means for design and survey

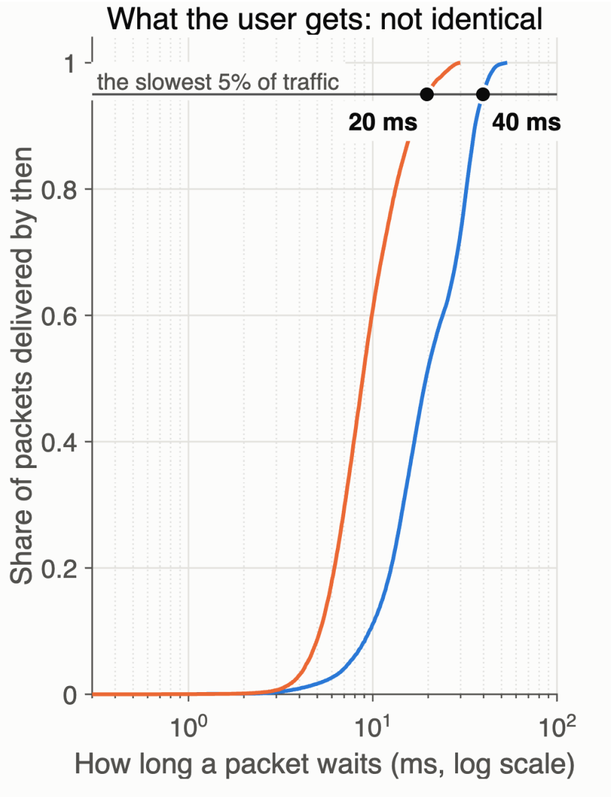
- The design is drawn at a single full power, but the real cell could shrink during shared transmissions.
- Not in a beacon.

Optional in the draft standard.

If it happens, expect it later than the first Wi-Fi 8 products.

Needs APs that hear each other well enough to coordinate





SIMULATION Four APs, 45 m apart. The slowest 5% of traffic waits 40 ms when APs defer to each other (blue) and 20 ms when they transmit together (orange).

Coordinated beamforming a null aimed at the neighbour

How it works

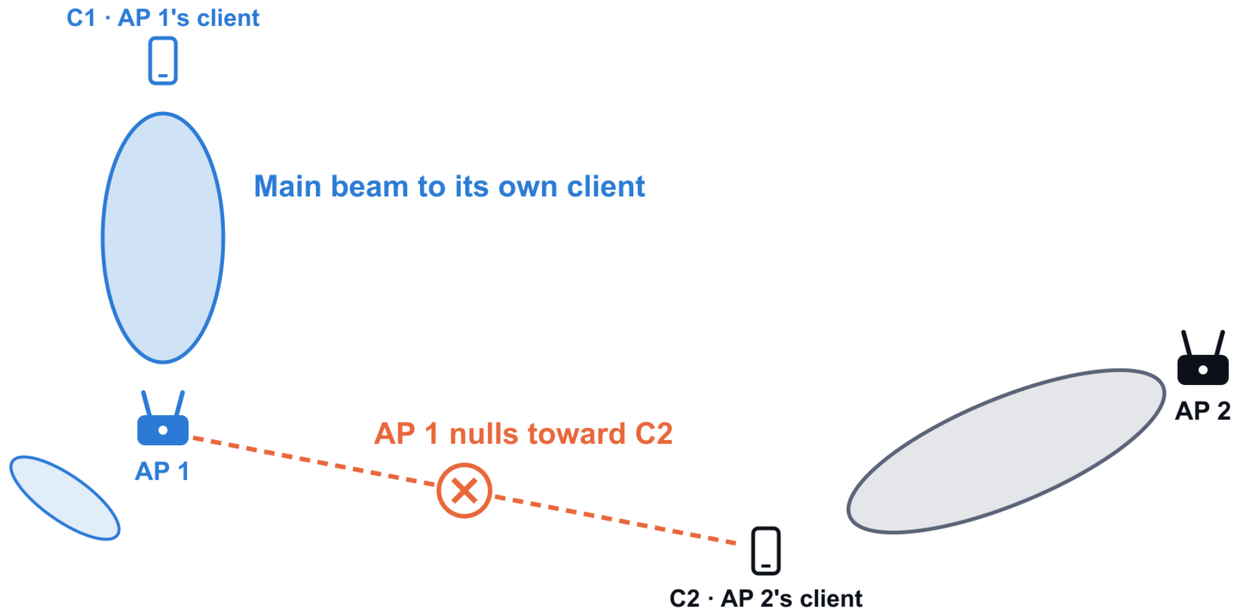
An AP steers nulls toward a same-channel neighbour's clients while it serves its own. To do that it first has to sound those clients, so the two APs must cooperate.

What it means for design and survey

- Spectrum measurements will be affected by steering
- The SINR benefit while coordination is active is not evident in beacon captures (typical survey)
- Tools need to model AP groups and how APs will hear each other – this will be important for Seamless Mobility Domain (SMD) too

Optional in the draft standard.

Needs APs that hear each other well enough to coordinate.



C2's signal quality (SINR)

AP 1 not coordinating	lower: AP 1 interferes
AP 1 nulling toward C2	higher, only while coordination is active

A survey records one of these states and cannot tell which.

WI-FI 8 CHANGES THE LOGIC UNDER THE HOOD

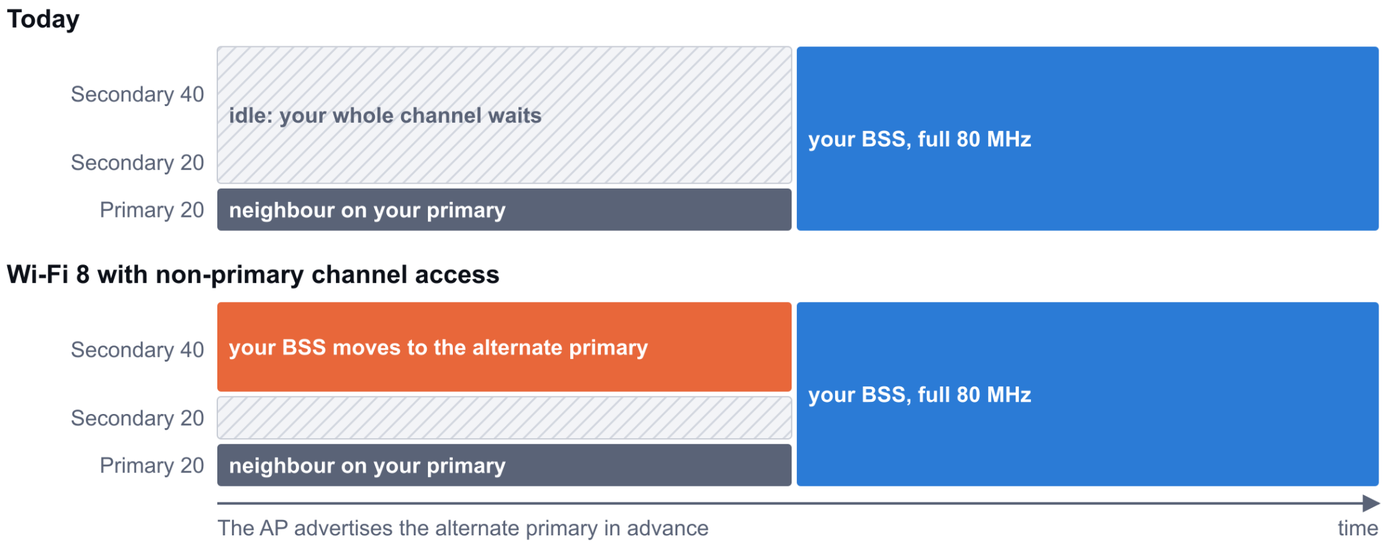
Non-primary channel access step aside, keep sending

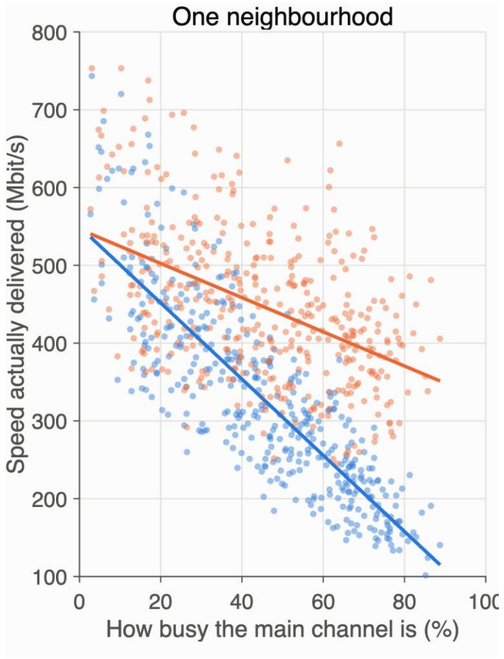
How it works

If a neighbour occupies your primary 20 MHz, the BSS moves to a pre-agreed secondary channel for the rest of the neighbour's transmission, then moves back. The AP advertises the alternate primary in advance.

What it means for design and survey

- Designs will assume co-channel contention and plan around it
- Surveys will record a worst case co-channel contention, but they can see if alternate primary is advertised so this can make its way into future surveys
- Estimated data rates will need to support some way to add in a fraction of NPCA capable APs & Clients



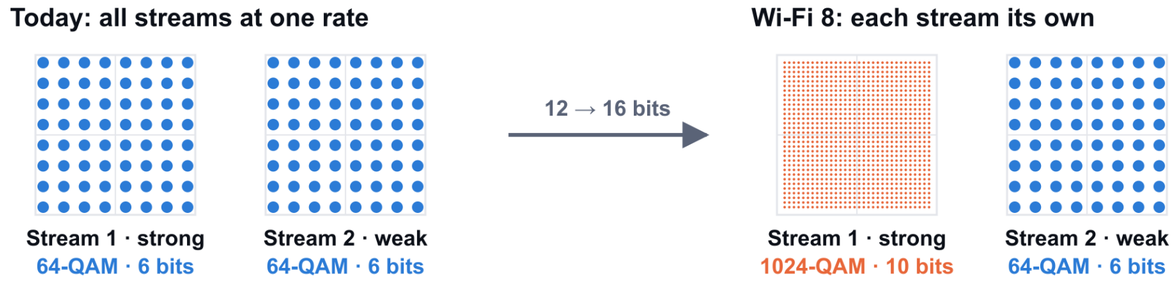


MODEL Speed delivered against how busy the main channel is, 80 MHz.

Blue – today's contention, as the channel gets busy, the data rate available to others on the channel drops

Orange - Wi-Fi 8: the same busy number gives very different speeds. At 80% busy, roughly 150 → 380 Mbit/s.

Unequal modulation
each stream at its own rate

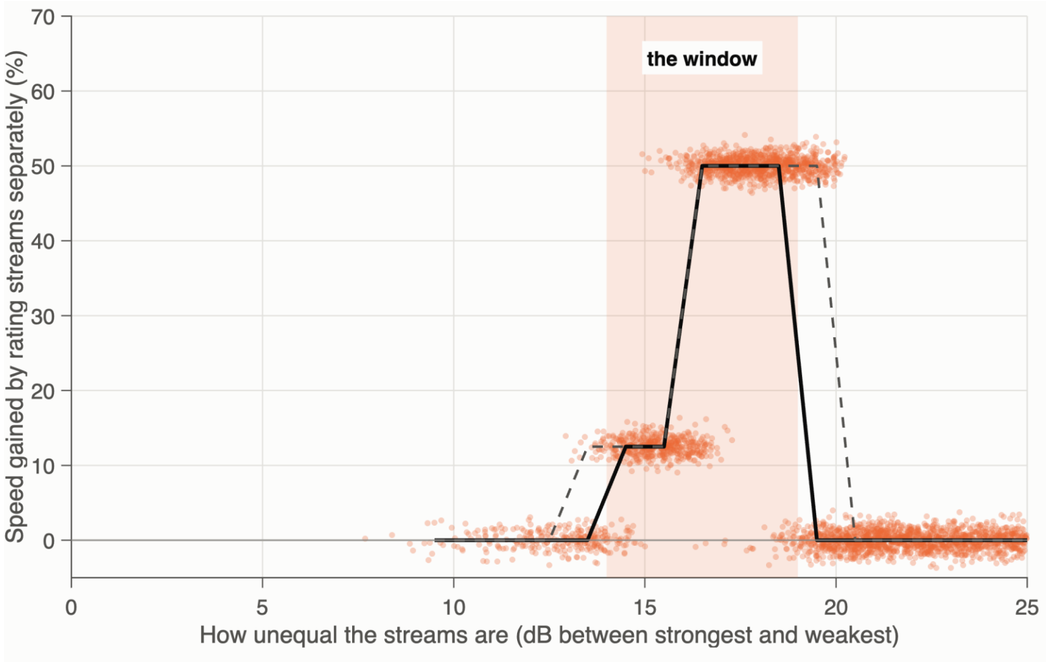


How it works

Each spatial stream gets its own MCS. Today every stream aligns to the lowest MCS. With Wi-Fi 8, when the streams arrive at very different strengths, the strong one can step up.

What it means for design and survey

- A survey reports one signal value per point.
- The design would need the signal per stream, which means modelling multipath and the device's antennas, and how that changes as the user moves.
- Perhaps designs include a factor to account for some UEQM
- It will need controller data to determine how it is working



SIMULATION 4,000 channels, 80 MHz, four streams. A gain in 35% of channels, up to 50%, but only when the streams are about 14–19 dB apart. Outside that window nothing changes.

Distributed resource units spread the tones, raise the power

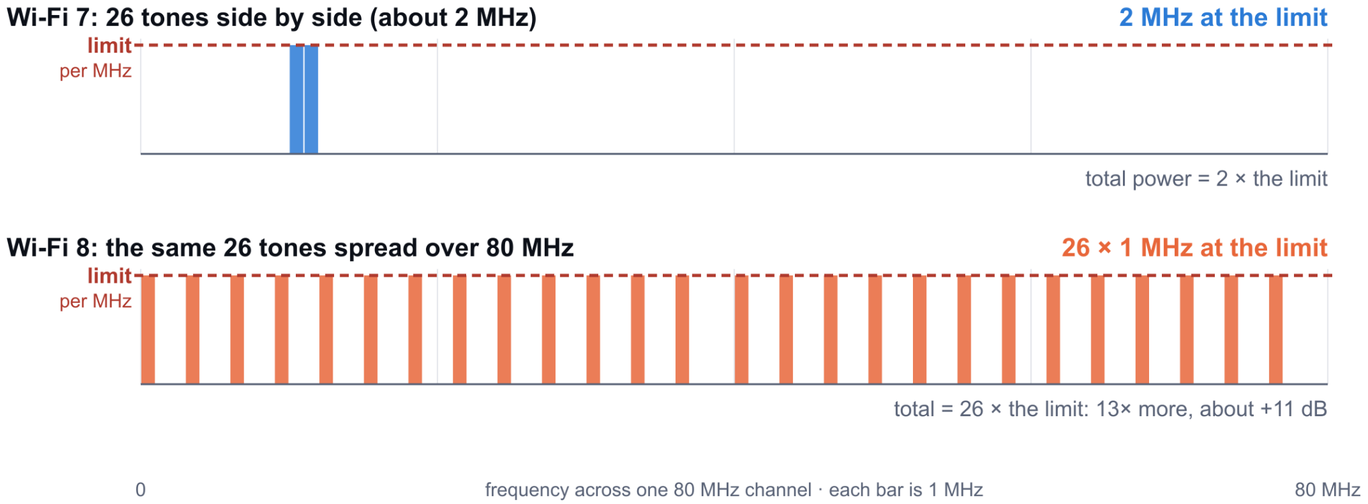
How it works

A small uplink resource unit has its tones spread across 20–80 MHz. Under a 6 GHz low-power indoor PSD (per-MHz power limit) the client can then transmit more total power.

What it means for design and survey

- Uplink coverage changes when the AP schedules the client this way
- The design would need to show coverage with and without it.

Only for scheduled (trigger-based) uplink, where the channel is PSD limited



+5 dB

UK and EU indoor. The phone's own maximum power is reached first.

+11 dB

US low-power indoor, where the per-MHz limit is tighter.

0 dB

Standard Power has no benefit because it is EIRP limited (The PSD is no longer the limit)

MODEL Link-budget arithmetic at the regulatory ceilings.

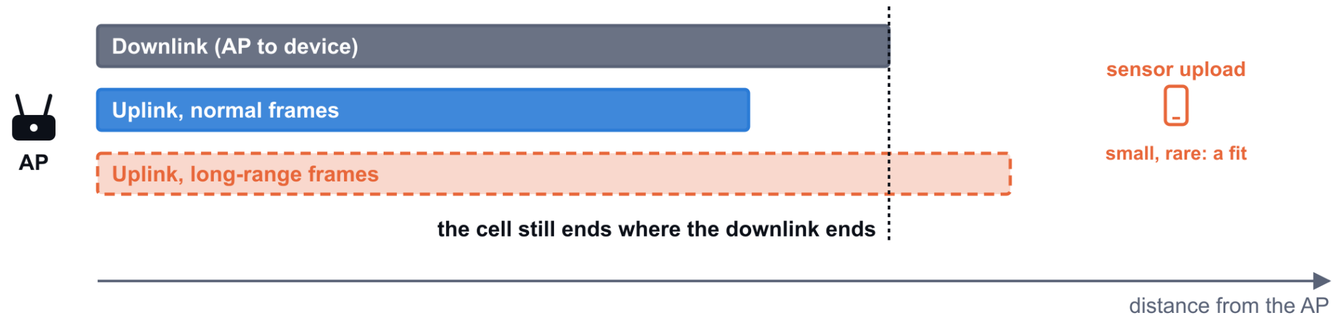
Enhanced long range a few dB more, for some frames

How it works

A more robust, low-rate frame format gives a few dB more reach, only for those frames.

What it means for design and survey

- Uplink coverage plots need to show an ELR/IOT boost
- The cell still ends where the downlink ends, but setting Tx/Rx power levels becomes a new design thought (at least for IOT)





MEASURED 46 s real walk, Apple N1 iPhone.

Wi-Fi 8 uplink modelled: long-range frames +6 dB,

distributed RUs +4.9 dB on 6 GHz.

Green works, orange marginal, red dead.

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Device logic needs to adapt and already is

iOS 27 is already introducing new approaches to evaluating Wi-Fi

- Something for Design and Survey tools to pay attention to
- Or is it part of the same development direction?



Link Throughput Estimate regularly scores the Wi-Fi Link

The link is assessed every 5 seconds

- Advisory Score
- Anticipated **max-tput-Mbps**
- Link Recommendation (for changes)

- How will designs and surveys know how to show such internal measure?
- What will this look like in Wi-Fi 8 (As Uplink/Downlink diverge)

[wcl] **computeAdvisoryScores**@1024:LQM-WiFi: lqa=4 thput=2117 lat=0 rssi=-45

L2 Assessment on en0, quality: 6, RSSI: -49, **max-tput-Mbps: 1080**

WiFiLQAMgrLinkRecommendationNotify: channel score: lqa=4, chq=5, sig-str=4, tx-rate=5, rx-rate=5, tx-lat=5, rx-lat=5, tx-loss=5, rx-loss=5 txPer=0.0%, p50-lat=0, p95-lat=0, RT=0x0, link-recommendation=0x0

Leave Wi-Fi Voting is more internal, proprietary logic

Apple's new TD (Trigger-Disconnect) logic

- Check and Assess User Impact
- TD Evaluation

- The device may give up on Wi-Fi where the survey says coverage is fine.
- It may stay on an AP where the survey suggests it should not.

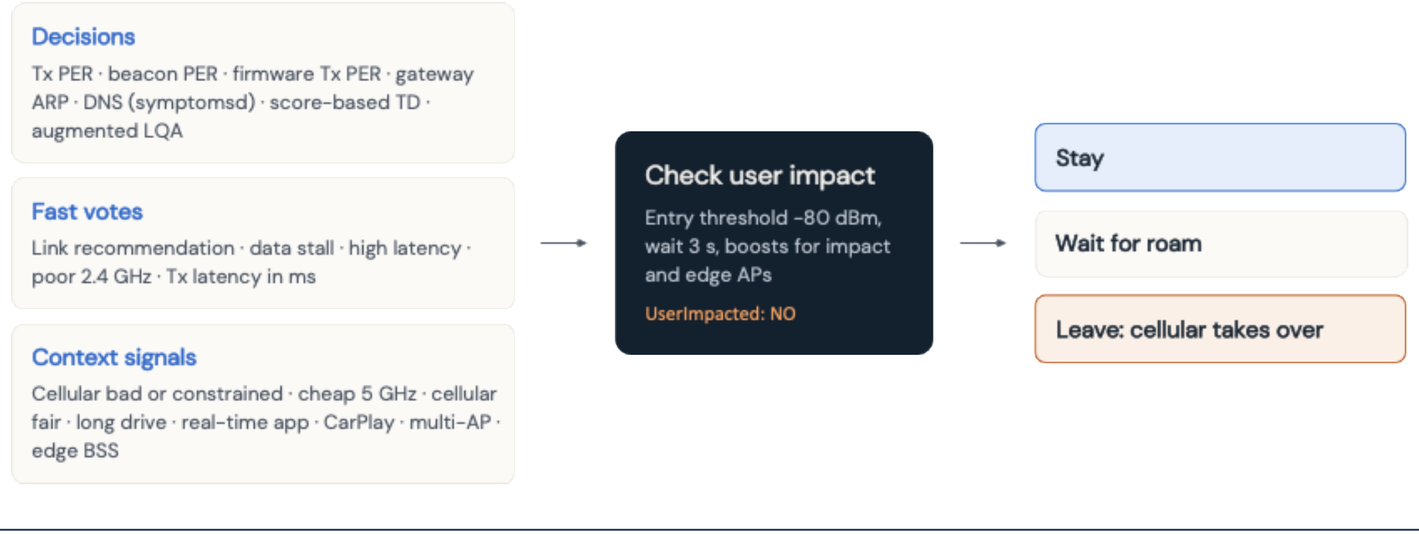
WiFiLQAMgrCheckUserImpact: LastRSSI:-68 UserImpacted:NO FastDisconnect:NO …

WiFiLQAMgrScoreBasedTDEvaluateCriteria: action=0 rssi=-82 band=2 cell=1 entryBoost=0…

[**WiFiUsageSession tdLogic**_end:evalTime:rssi:roamTime:]: TDEval ended upon GoodRSSI …

[**WiFiUsagePoorLinkSession** logUserImpactTimes] UnusableLQAImpactTime 0 UnusableLatOrLossScoreImpactTime 0

[**WiFiUsagePoorLinkSession** sessionDidEnd:] Session (started: BadRSSI, ended: GoodRssiThenLinkChange)



Individual Network Tuning with learning and weekly updates

Usage Based set of per-AP edge thresholds

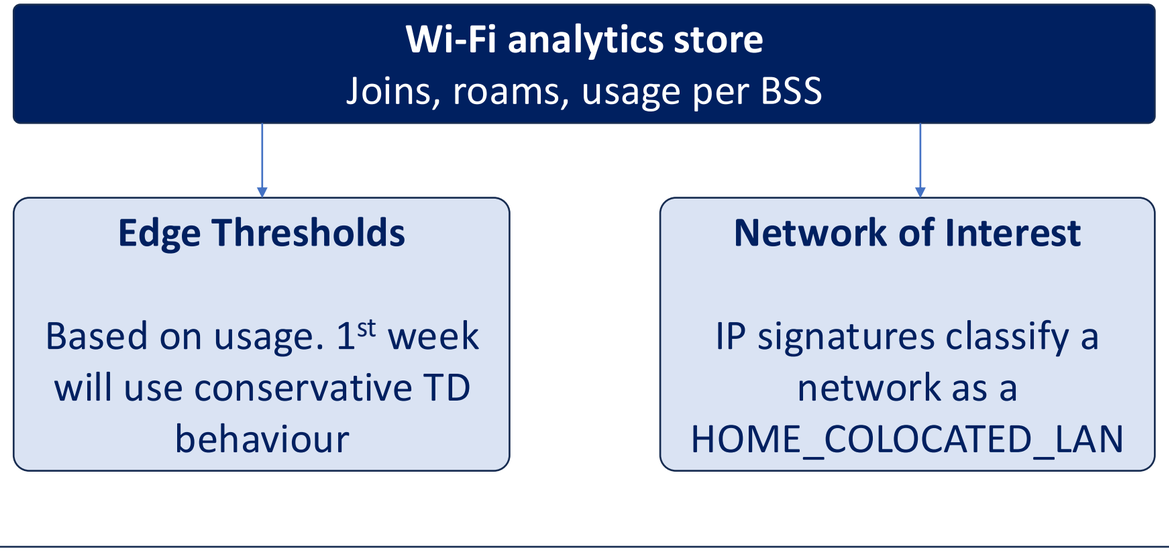
- Weekly policy (conservative in week 1)
- Networks of Interest (e.g., Home)
- Possible changes from iOS 26 adaptive roaming

- Devices are already working out their own learnt cell edge
- How will surveys indicate the user experience from devices which learn, adapt and change over time?

AnalyticsReader **edgeParametersForBSS**:]_block_invoke::107:BSS EdgeParamsVersion does not match version in db: 0 (Legacy) version required: 1 (UsageBased).

CWFNetworkOfInterestManager homeTypeForNetworkName:]_block_invoke (CWFNetworkOfInterestManager.m:413) CoreWiFi

WiFiDeviceManagerGetAdaptiveRoamParams: not enabling adaptive roaming on <SSID> (forceApply:0 deviceSupport:0 EAP:0 env:Tri Band AP networkOfInterestType:**HomeColocatedLAN**)



It's more than just coverage, but we've known that for a while

Internal logic is migrating towards something that will support better decisions for Wi-Fi 8. *(and N2 chip perhaps?)*

Network memory wifianalyticsd	New: usage-based edge thresholds, home-LAN classing, inside/outside classifier, learned roam triggers
Path symptomsd, CoreWiFi	New: Wi-Fi and cellular path monitors, partial-connectivity check, Assist override, throughput estimate
Link wifid link-quality manager	New: user-impact votes, score-based leave, 2.4 GHz traffic and airtime monitor, MLO runtime config
Radio N1 driver and firmware	Per-link MLO stats, anchor moves, WMM latency; new MLD-specific failure codes

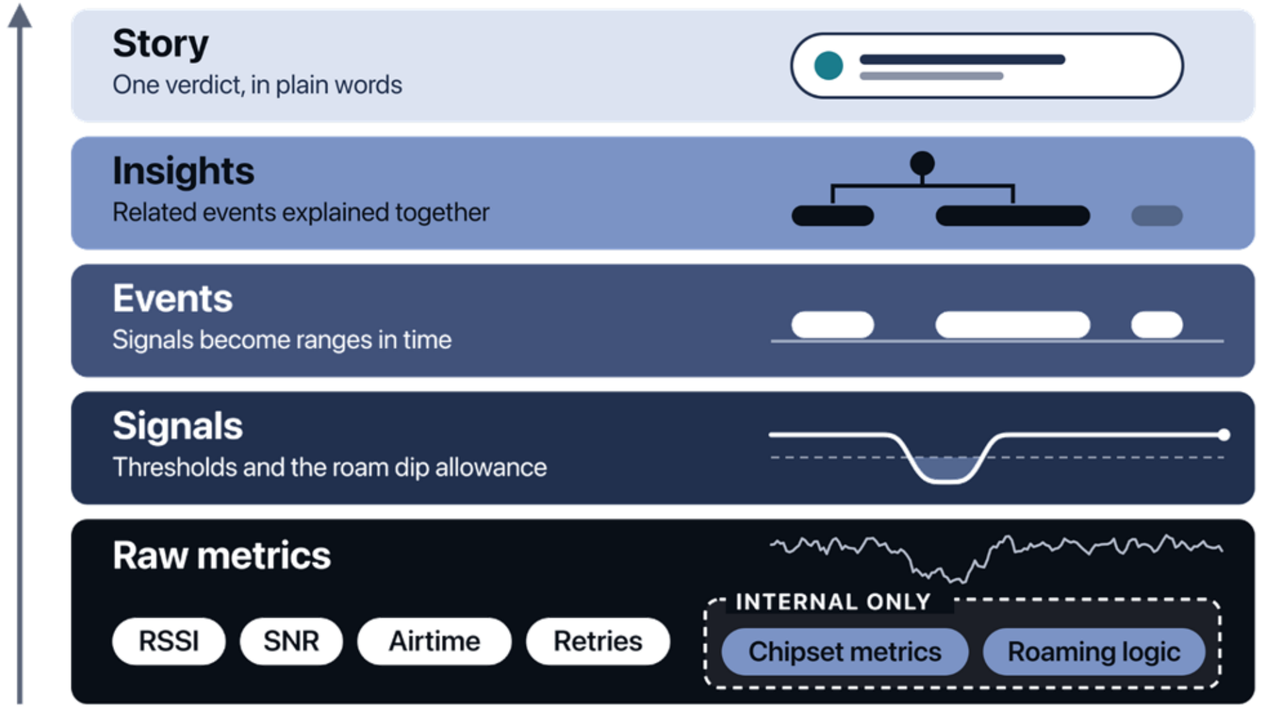
Will Wi-Fi 8
and advancing device heuristics
break designs and surveys?

Building the story is the key

Device behaviour cannot be predicted from RF alone

If we build a story, we can improve our understanding of how non-deterministic devices tend to behave and;

- Tune designs to best match ‘typical’ client behaviours
- Improve configurations
  - MBR, Client steering, Overlap, BW
- Offer better support to customers



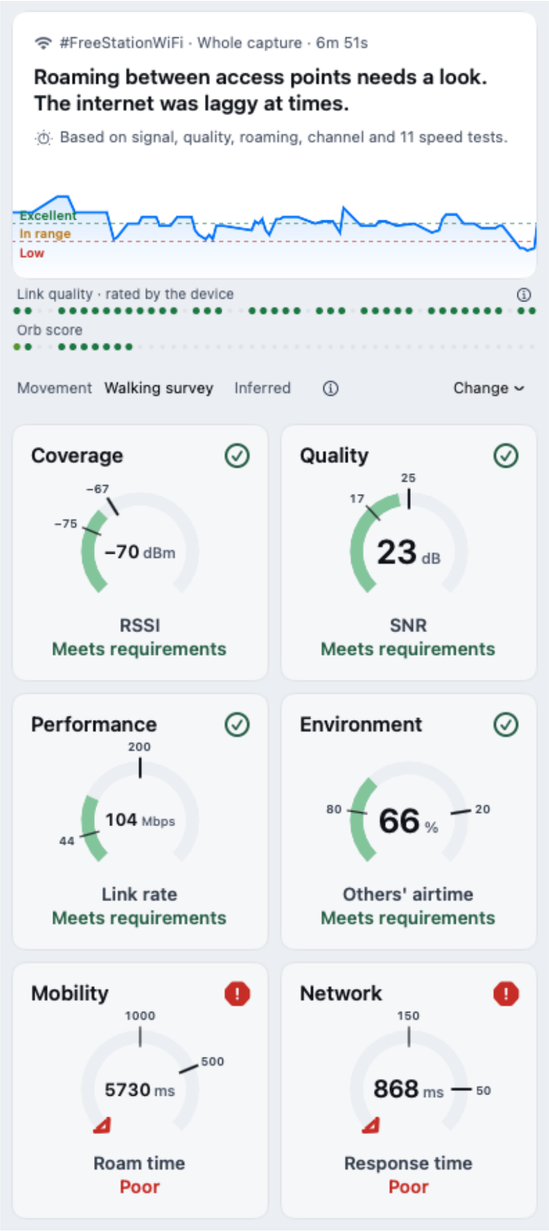
A story which can <u>only</u> be compiled from the device view

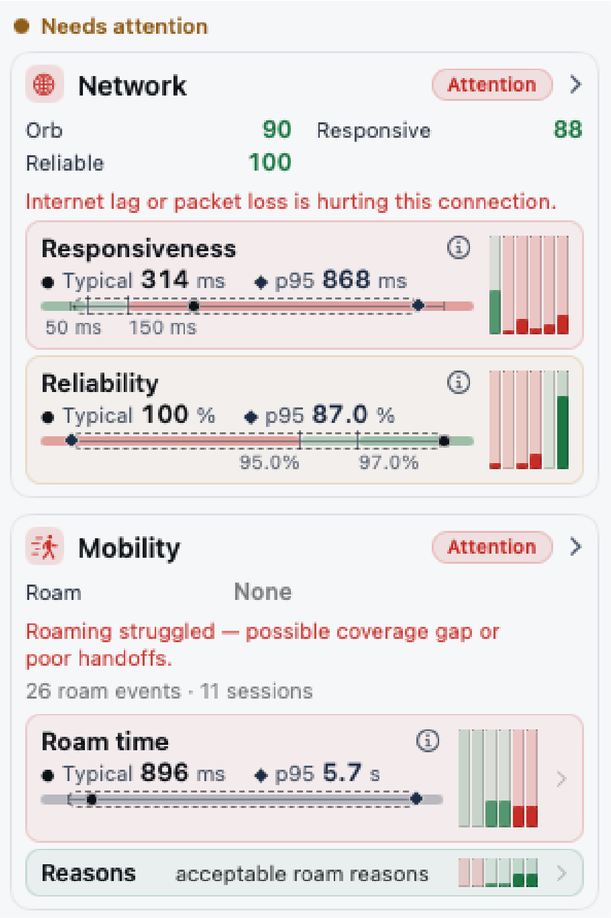
Capture Events and Build a Wi-Fi Story

Be like a device, embrace heuristics for a full picture

The story tells us whether the performance, as evaluated on the device, was able to meet the design criteria

- We can home in on the user experience impacts
- We can target an overall design approach that plays into achieving success with a Wi-Fi 8 device



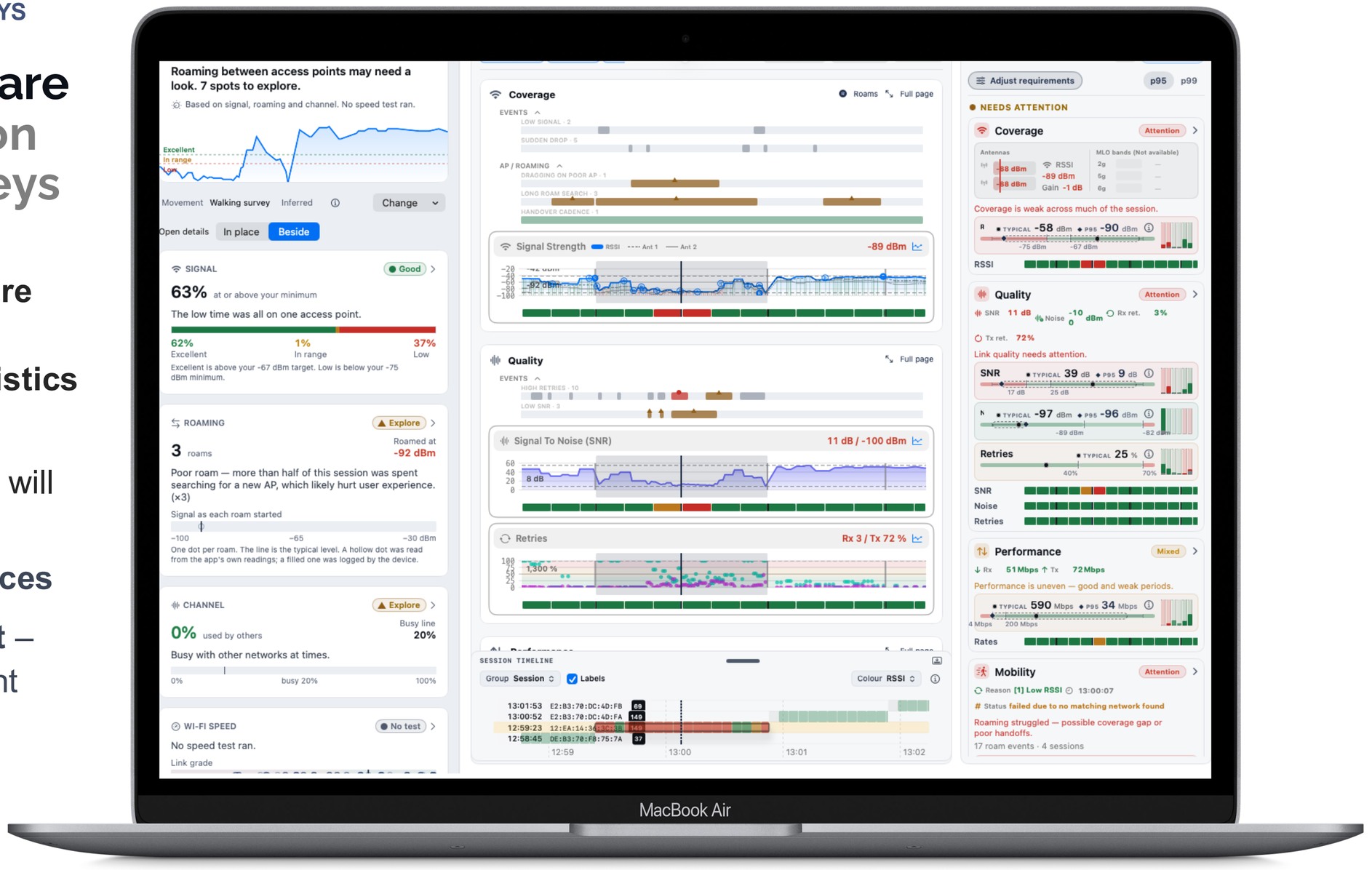


How can we prepare for next generation designs and surveys

Apple devices (at least) are already making complex decisions based on heuristics

Static designs and surveys will not tell the full story

- **Learn about your devices**
- **Capture, tweak, repeat** – create better deployment configurations



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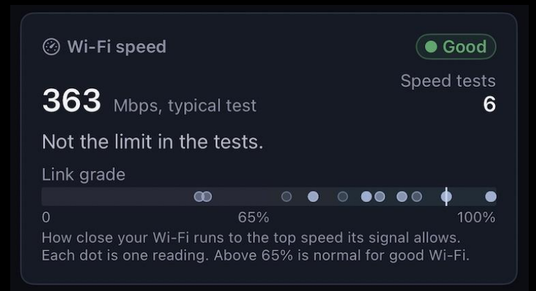
A little data goes a long way

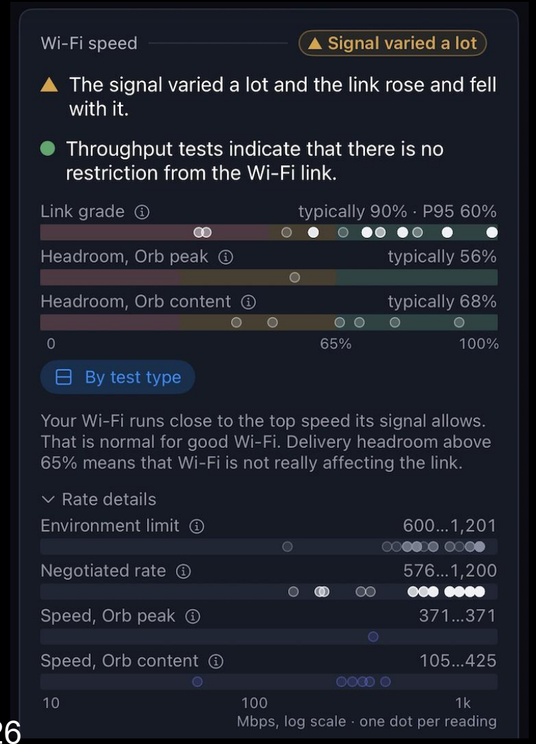
With the right analysis device data can be transformed into a story

Which will help to

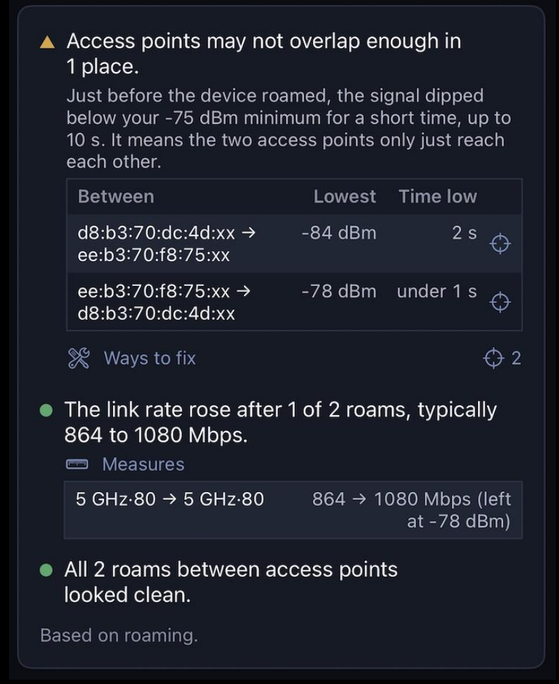
- Understand the device
- Improve our Wi-Fi 8 designs and surveys
- Support your customers

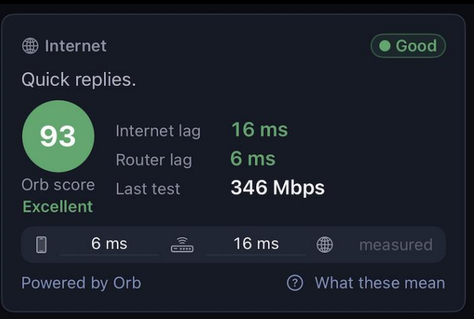
Link ➡ Mobility ➡ Performance

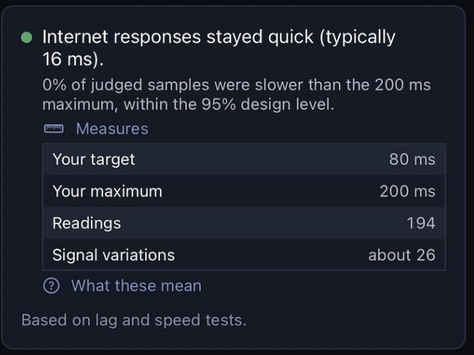


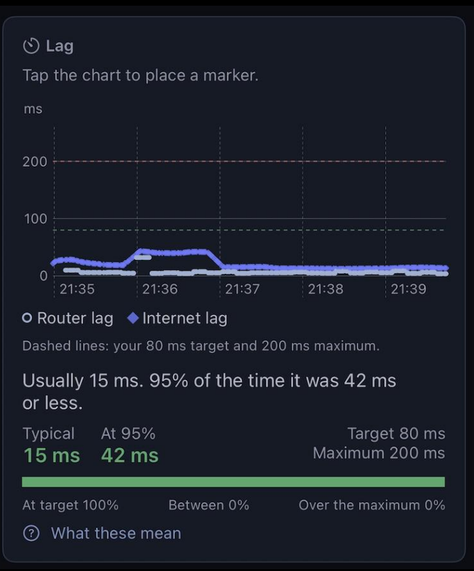












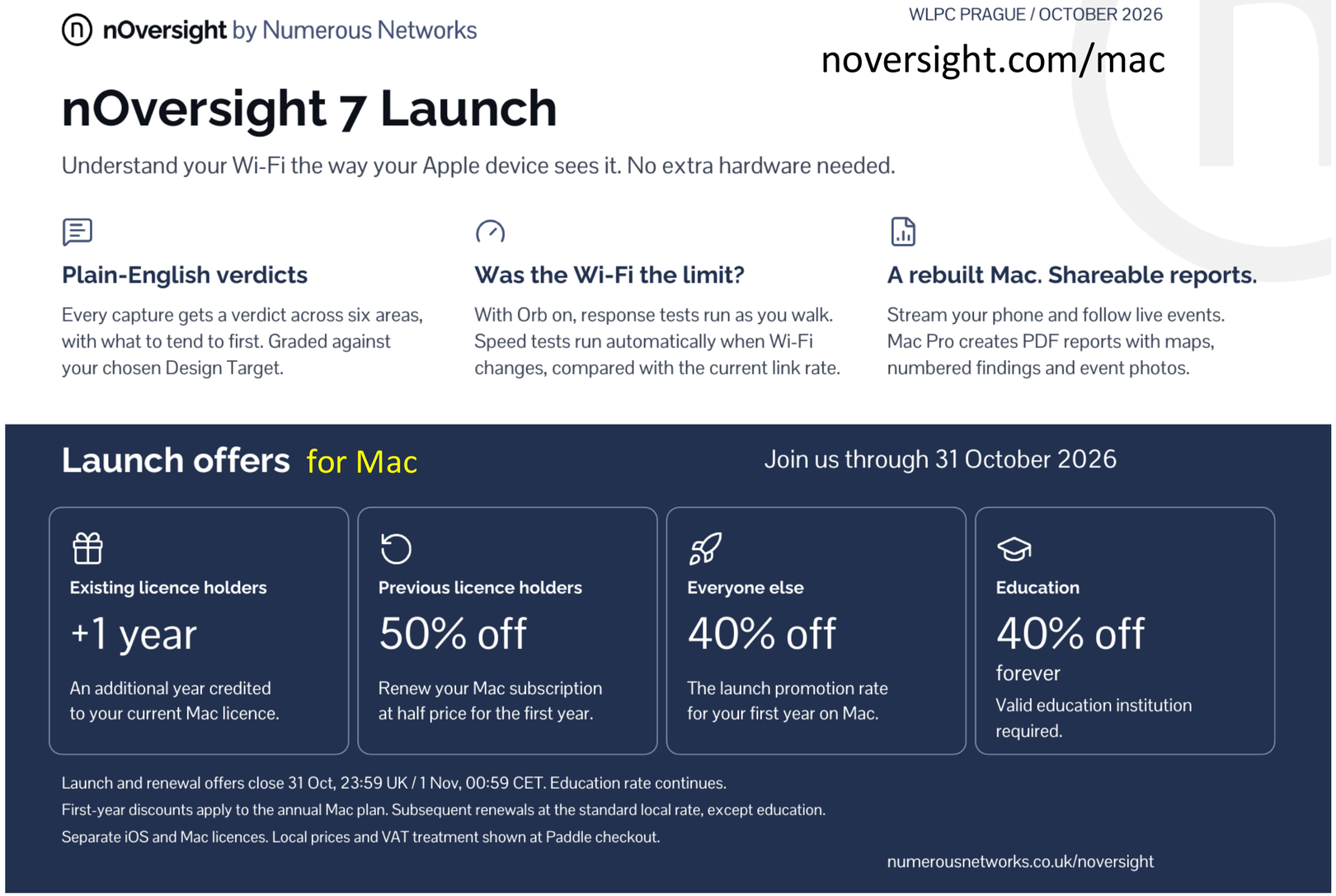
nOversight v7

Capture the device heuristics

[In Beta Now]

- Start listening to your devices
- Look beyond your survey
- Evaluate design concepts
- Validate the early installs
- Low-cost repeat measurements

- 20:45 – Walkthrough Webinar [Jupiter]



Numerous Networks
CREATOR OF nOversight

Thank You

Mac v7

iOS v7

The changes in Wi-Fi 8 and iOS 27: What design and survey tools miss