airheads TECH TALK LIVE

aruba
a Hewlett Packard Enterprise company

What is 802.11ax and Why do I need it?

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September 24, 2019

#ArubaAirheads

Introduction

A bit of history and background
Current expectations

Introduction
The IEEE standardization effort

The IEEE 802.11ax taskgroup for High Efficiency (HE) wireless was kicked off in **May of 2014**

- Focus on *efficiency* and the average performance of client devices in dense deployments, with realistic traffic
- Enhance operation on *both* 2.4GHz and 5GHz, indoor and outdoor deployments
- Maintain or improve power efficiency
- Fully backwards compatible with 802.11b/g/n (2.4GHz) and 802.11a/n/ac (5GHz)

First draft for the 802.11ax amendment of the 802.11 standard was released in **December of 2016**

- Followed by lots of discussions, arguments, politics, etc.

Current (third) draft was released in **May of 2018**, and is considered a solid basis for the first generation of compliant products

- Remaining details are not expected to require any hardware changes and/or are not mandatory or optional for Wi-Fi Alliance certification (wave 1)

Current expectation for ratification of the 802.11ax amendment is **January of 2020**

- So this has been a 5-year journey

Fun fact: IEEE has already started a study group for the next phase: **Extreme High Throughput (802.11be)**

Introduction
Wi-Fi Alliance (WFA)

The Wi-Fi Alliance (WFA) promotes Wi-Fi Technology, and certifies Wi-Fi products

- They do quite a bit of marketing as part of that, including the recent launch of “Wi-Fi 1, 2, 3, 4, 5 and 6”

Being “Wi-Fi certified” is an important (but voluntary) stamp of approval, ensuring compliance to a minimum set of common features, and interoperability between certified devices.

The WFA kicked of the development of an 802.11ax certification program in April of 2016

As we’ve seen with 802.11ac, there will likely be multiple “waves” again

802.11ax wave 1 (R1) certification was publicly kicked off on **September 16, 2019**

Prerequisites for 802.11ax R1 certification: 11ac in 5GHz and 11n in 2.4GHz, MBO and **WPA3**

In addition, WFA defines a number of **mandatory and optional features** for certification

Many features and details from the standard are not covered; WFA focuses on a practical and critical subset

Introduction

What about 802.11ax Products?

Chipsets are available (from multiple vendors), for both access points and client devices

- But be aware: not all chipsets support the minimum featureset required for WFA certification
- And lots of variation in terms of features, performance, etc.
- First generation parts, with limited integration, are targeting mid-range and up

Product announcements and introductions

- Some very early announcements (2017), with still no products in sight
- Some more recent announcements, with products that have "issues"
- Multiple Enterprise AP products are now shipping, many more to come

Where are the clients?

- Samsung announced the Galaxy S10 products on February 20, 2019
- Intel has been shipping client chipsets for laptops since earlier this year, multiple PC makers announced laptops using Intel's 802.11ax chipsets
- Apple just launched the iPhone 11 with 11ax support

2019 will be the year for 802.11ax to mature and become established in the market. Get ready!

802.11ax Key Features

Some exciting technical stuff
With a lot of real-world potential

802.11ax Key Features

1024-QAM Modulation

QAM: Quadrature Amplitude Modulation

Amplitude of both the in-phase and quadrature component of each of the **subcarriers is modulated**

1024-QAM allows for **10 bits** (1024 combinations or constellation points) to be encoded/modulated onto each subcarrier

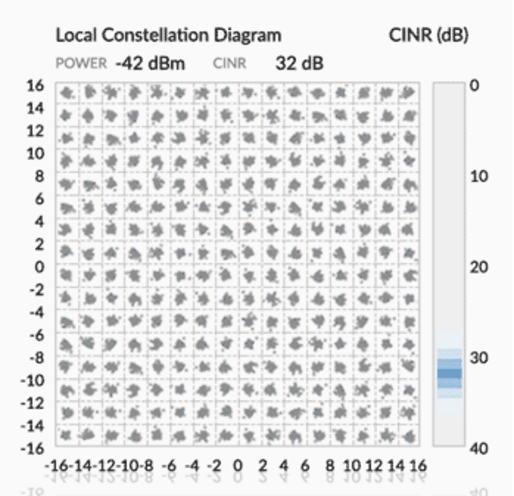
That's two more bits compared to 256-QAM, which was introduced in 802.11ac

- That in itself delivers a **25% boost** in the peak datarate for 802.11ax
- 256-QAM gave 802.11ac a 33% boost over the 802.11n peak with 64-QAM (6 bits)

However the modulation is more sensitive to noise. So:

- Need to transmit a cleaner signal (better PA)
- Need a **cleaner, stronger signal** at the receiver (+7-8dB)

Support for 1024-QAM (MCS 10-11) and 256-QAM (MCS 8-9) is optional for WFA 802.11ax R1 certification. But most devices will support it.



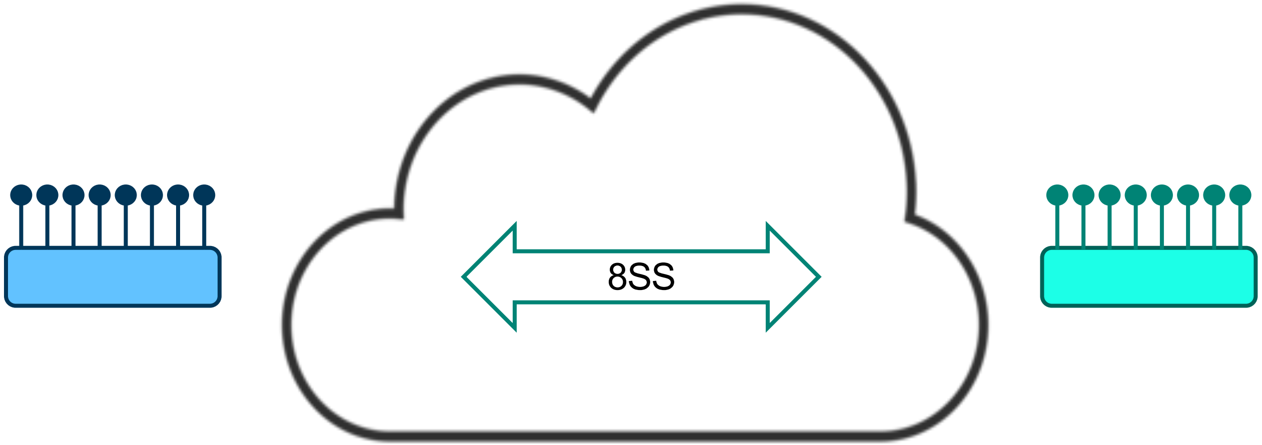
256-QAM

802.11ax Key Features

Lots of Spatial Streams, more MU-MIMO clients

Support for 8x8 MIMO with up to 8 spatial streams and up to 8 simultaneous MU-MIMO clients

Combine that with the new 1024-QAM modulation and some of the efficiency improvements in the standard, and that allows us to claim **peak datarates of up to 9.6Gbps**!



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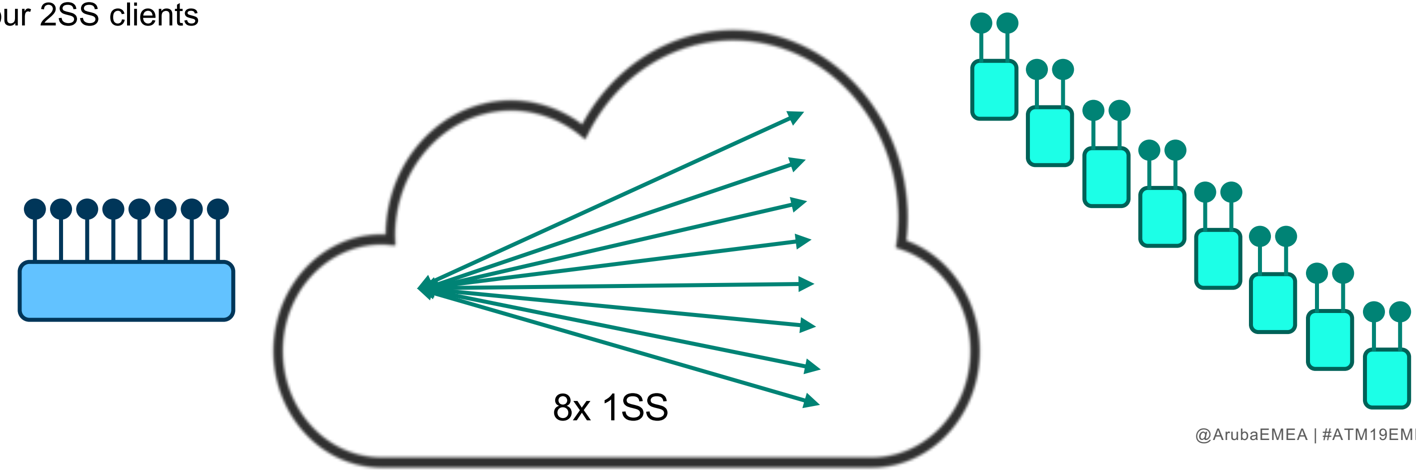
Caveats:

- This requires the use of 160MHz channels, which is generally not possible or just not a good idea
- Your client devices are unlikely to support more than 2 spatial streams and 2x2 MIMO, so you'll need MU-MIMO
- MU-MIMO is not perfect. You'll be very lucky to get to 90% aggregate performance with eight 1SS client devices, or 75% with four 2SS clients



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And do not forget:

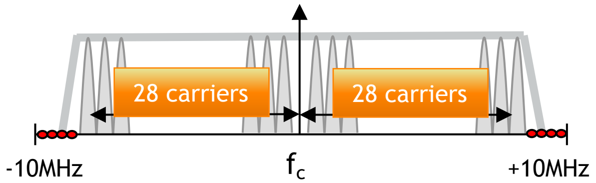
- All Wi-Fi traffic and performance is half-duplex. Ethernet is full-duplex
- Typical best case performance for TCP is ~70% of the over-the-air (OTA) datarate. Packet size is critical.
- Maintaining the peak OTA rates is a challenge, even in the lab..

Mandatory for WFA 802.11ax R1 certification: at least 2x2, DL-MU-MIMO and TxBF if AP supports >= 4SS, client to support DL-MU-MIMO sounding for up to 4SS (only!).
UL-MU-MIMO is not in scope for R1.

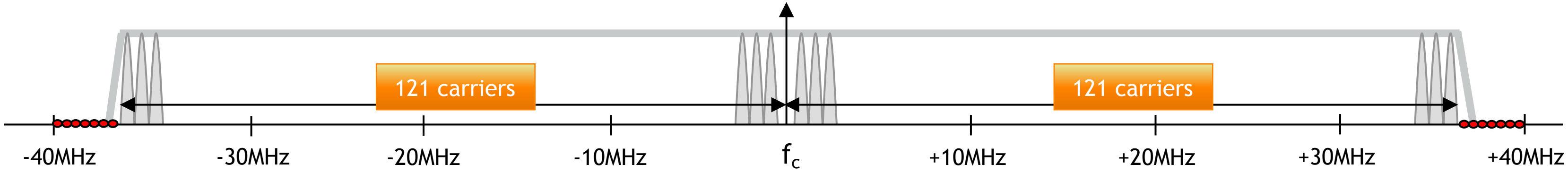
802.11ax Key Features
Orthogonal Frequency Division Multiple Access (OFDMA)

A **“traditional” (802.11a/g/n/ac) OFDM** signal consists of a number of *subcarriers* (or *tones*) in the frequency domain, spaced 312.5kHz apart (implying a symbol duration of 3.2us)

- In an 80MHz channel, there are 256 such subcarriers
- Some are not used (guard), some are *pilot tones*. 234 can be used to carry data
- Within each symbol, all tones are used to exchange data between the **same pair of devices (AP <> client)**



56 subcarriers (52 usable) for a **20MHz HT** mode (802.11n) channel



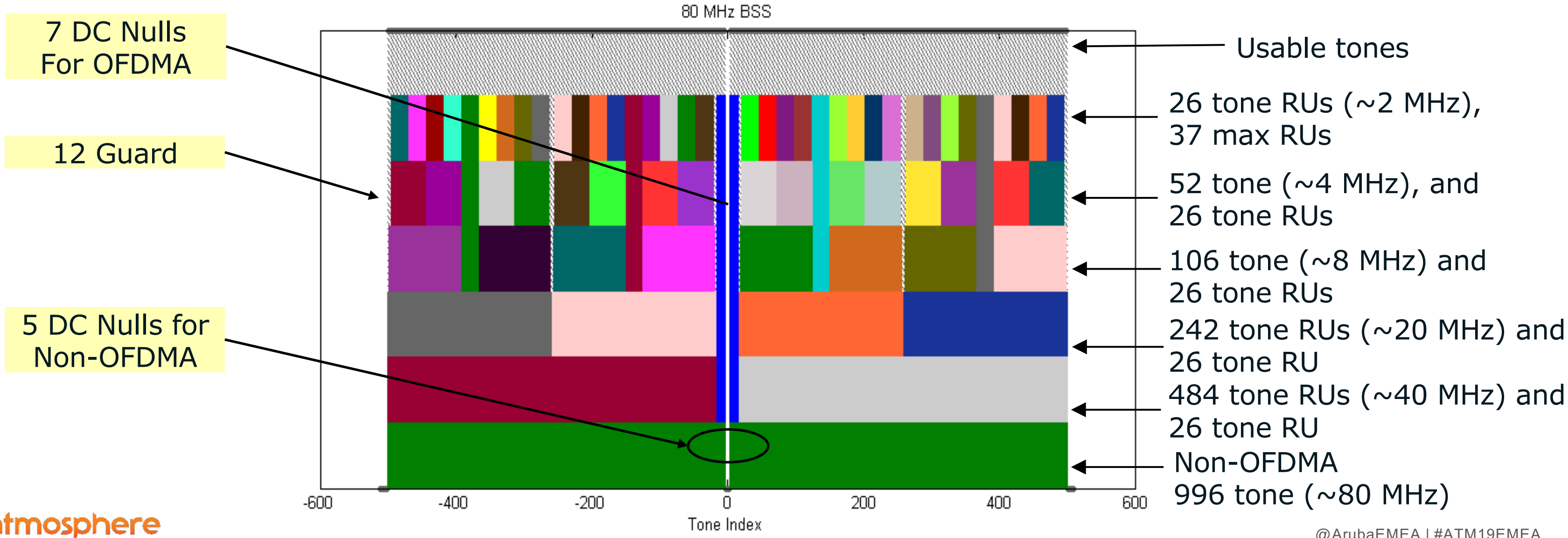
242 subcarriers (234 usable) for a **80MHz VHT** mode (802.11ac) channel
An 80+80MHz or 160MHz channel is exactly two 80MHz channels, for 484 subcarriers (468 usable)

802.11ax Key Features

Orthogonal Frequency Division Multiple Access (OFDMA)

With **OFDMA**, variable numbers of subcarriers can be grouped and allocated for multiple individual AP-client pairs

These groups are called ***Resources Units (RU)*** and can be (roughly) 2MHz, 4MHz, 8MHz, 20MHz, 40MHz or 80MHz wide in varying mixes.



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The maximum number of RUs in an 80MHz channel is 37, 18 in 40MHz, and 9 in 20MHz

OFDMA support in both *downlink and uplink* direction is mandatory for WFA 802.11ax R1 certification. No requirement on the minimum number of supported RUs

802.11ax Key Features

More Subcarriers

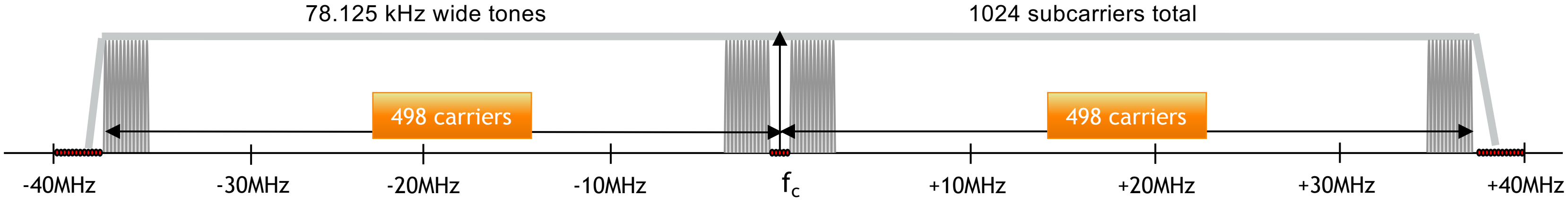
Without change, the smallest 2MHz resource unit would have just 6 subcarriers. That will not work very well

The **subcarrier spacing** was therefore reduced for OFDMA by a factor of four in 802.11ax: **78.125kHz**

- That allows for 26 subcarriers in the 2MHz RU (24 usable, 2 pilot)

Number of subcarriers (usable) in each RU size (2 / 4 / 8 / 20 / 40 / 80):

- 26 (24) tones, 52 (48) tones, 106 (102) tones, 242 (234) tones, 484 (468) tones, 996 (980) tones



996 subcarriers (980 usable) for a **80MHz HE** mode (802.11ax) channel
An 80+80MHz or 160MHz channel is exactly two 80MHz channels, for 1992 subcarriers (1960 usable)

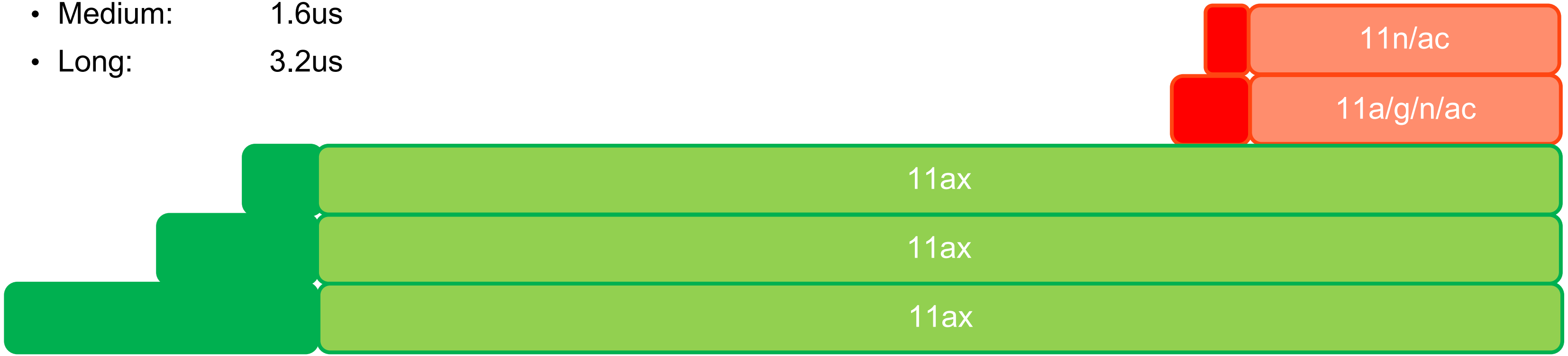
802.11ax Key Features

Increased Symbol Length

The shorter subcarrier spacing implies that the **symbol duration** for 802.11ax is 4x longer: **12.8us**

Traditional guard space options (0.4us or 0.8us) has been replaced with **three guard space options**:

- Short: 0.8us
- Medium: 1.6us
- Long: 3.2us



Support for the new subcarrier spacing (and symbol duration) is mandatory for WFA 802.11ax R1 certification. Same applies to all guard space options.

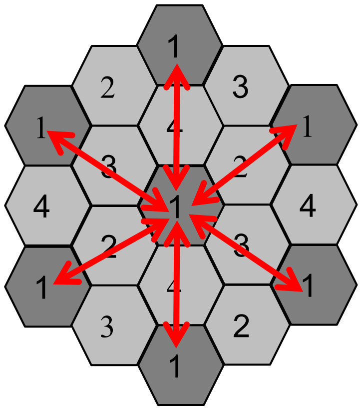
802.11ax Key Features

Spatial Reuse or BSS Coloring

Traditional Wi-Fi devices will back-off transmissions when detecting energy above -82dBm on the same channel.

That threshold was defined in a time when deployments were less dense, frequency reuse not as high, and overall RF power levels much lower.

In today's dense Wi-Fi deployments, this threshold is often too conservative, and devices are unnecessarily deferring transmit opportunities that would likely still be successfully received



The AP in the center BSS will defer transmissions when there's any data being exchanged between clients and APs in the other BSS's that operate on the same channel.

Compare this to multiple conversations happening in the same room, but nobody talking at the same time. Very organized, but not the most effective way to exchange data/words

802.11ax Key Features
Spatial Reuse or BSS Coloring

BSS Coloring was a mechanism introduced in 802.11ah to assign a different “color” per BSS, which will be extended to 802.11ax

Client “learns” color from its AP/BSS

The traditional -82dBm threshold will be used when the colors match

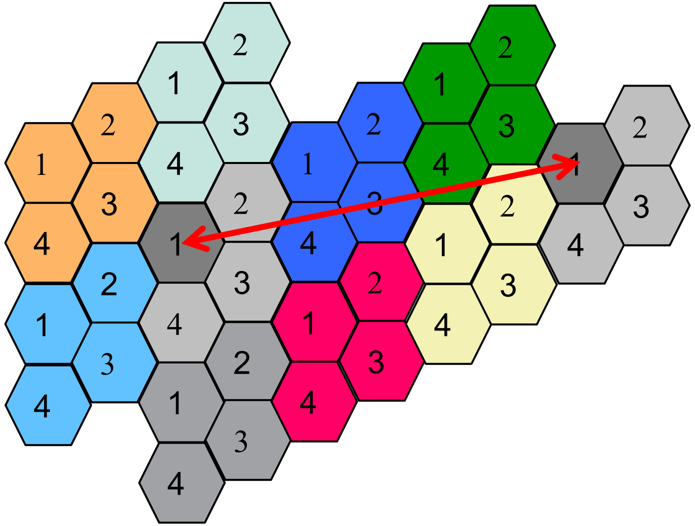
When the colors don’t match, a higher threshold can be used

- Other devices are known to be close, so it’s not surprising to “hear” them. No need to be overly quiet

Actual threshold is dynamic, and could be as high as -62dBm

Transmit power of the device factors into the threshold level

- If a device lowers its power, it can transmit more aggressively



Only setting, detecting and propagating of the BSS color are mandatory for WFA 802.11ax R1 certification. Actual Spatial Reuse operation is not in the R1 scope (but may be supported)

802.11ax Key Features

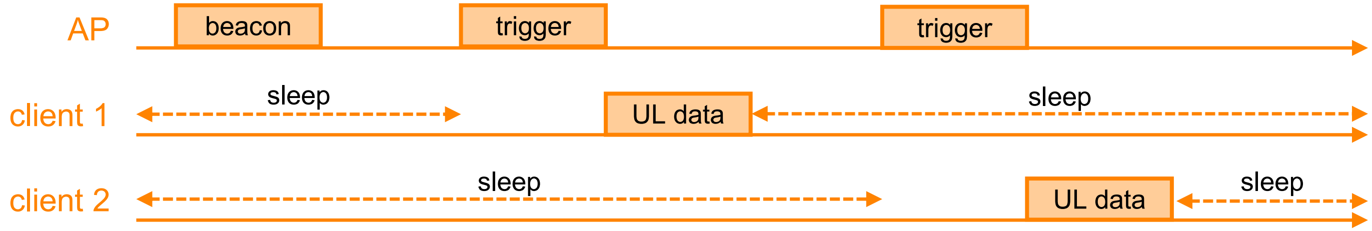
Schedule Sleep and Wake Times

With the Target Wake Time (TWT) feature, an 802.11ax AP can schedule devices to sleep for long times, depending on anticipated traffic load

Devices can be scheduled to wake up individually or as a group (taking advantage of MU technologies) to quickly and efficiently exchange data before going back to sleep again

The primary goal is to reduce power consumption for battery-powered devices like smartphones and IOT sensors. In addition, OTA efficiency will improve

The AP can send data to the client device(s) at the scheduled wake-up time, or it will send out a trigger frame prior to the scheduled wake-up time to clear the channel for data from the client device



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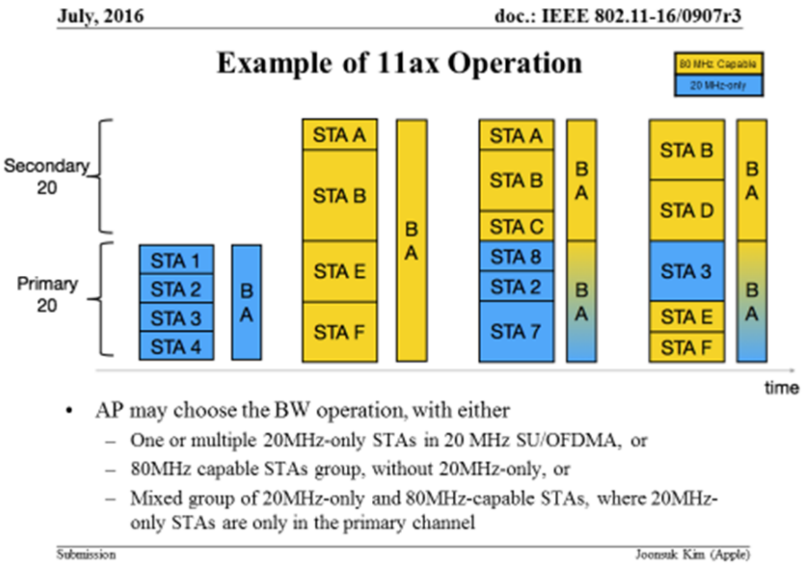
Individual TWT is mandatory for WFA 802.11ax R1 certification of access points. It's optional for client devices. Broadcast TWT is not in scope for WFA R1 certification

802.11ax Key Features

20MHz only Client Devices

To allow for lower-cost, simpler devices with lower power-consumption, 802.11ax supports client devices whose operation is limited to a 20MHz channel even when the AP is operating in 40, 80 or 160MHz mode with OFDMA.

- For “normal 802.11ax clients”, support for 40MHz and 80MHz is mandatory (160MHz is optional)
- The 20MHz-only clients are served in the primary 20MHz channel, possibly in combination with (RUs from) regular clients throughout the full channel


July, 2016 doc.: IEEE 802.11-16/0907r3

Example of 11ax Operation

- AP may choose the BW operation, with either
  - One or multiple 20MHz-only STAs in 20 MHz SU/OFDMA, or
  - 80MHz capable STAs group, without 20MHz-only, or
  - Mixed group of 20MHz-only and 80MHz-capable STAs, where 20MHz-only STAs are only in the primary channel

Submission Joonsuk Kim (Apple)

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Support for 20MHz client operation in wideband OFDMA is mandatory for WFA 802.11ax R1 certification of access points. It’s an optional feature for client devices.

802.11ax Key Features

Other Stuff related to WFA certification

Devices can be 2.4GHz only, 5GHz only, or dual-band. 11ax needs to be supported on all radios/modes

Support for 160MHz channel operation in 5GHz is **optional**

- Contiguous. 80 + 80 is not in scope

Support for 40MHz channel operation in 2.4GHz is no in scope

OFDMA + MU-MIMO in the same PPDU is not in scope

DL-OFDMA + TxBF is not in scope

Some range improvements for outdoor deployments are not in scope

- Extended range packet format
- Dual Carrier Modulation

Power save features

6GHz support is not in scope

Plenty of opportunities for WFA to define a second wave (R2) ;-)

802.11ax Key Features

So why do I need 802.11ax?

1. **Significantly improved network efficiency, resulting in better average and aggregate performance experienced by users in dense wireless networks with realistic traffic patterns**

2. **Support for higher peak performance and increased client density per radio**

3. **Improved latency and QOS (voice, video)**

4. **Support for devices ranging from extreme high-performance laptops to low-bandwidth & low-power IOT sensors**

5. **Improved interoperability/coexistence with other IOT technologies like Bluetooth and Zigbee**

6. **Last but not least: your users will want to see that Wi-Fi 6 icon on their mobile device!**

The Aruba 802.11ax Products

Are they cool?
Are they better?
Will you notice a difference?

The Aruba 802.11ax Products

So why do I need the Aruba products?

We believe **Wi-Fi 6 offers great value** to the typical Aruba wireless customer

- Very high density deployments, delivering a great experience to large numbers of wireless users and devices
- Optimized support for a broad range of devices, applications and needs
- Setting a new bar for peak performance, while also effectively supporting (large numbers of) low-bandwidth devices (IOT)
- Delivering optimized connectivity with security, power-efficiency and control

As always, we're early to market with new technology. It's in **our DNA**!

Delivering **standards-compliant** and **differentiated** products, that deliver the **full value** of Wi-Fi 6:

- No shortcuts or compromises, no false announcements or half-baked products just for bragging rights
- We're not bolting 802.11ax radios onto existing AP platforms, but designing the new products from the ground up
- Exploiting the baseline capabilities of the standard to optimize Wi-Fi for the enterprise environment

Aruba is building a broad portfolio

- **Launched the 510 Series last November, added 530 and 550 Series in April, and introducing the 500 Series now**

Wireless Update, Fall 2019

Aruba's Current Wi-Fi 6 Portfolio – Campus

- **500 Series (AP-504 and AP-505): Entry-level 802.11ax (256/75)**
  - 2x2 + 2x2 radios, 1x 1Gbps Ethernet
  - BLE, 802.15.4, USB, unrestricted* from 802.3af POE (class 3)
  - IPM, deep-sleep mode

- **510 Series (AP-514 and AP-515): Mid-range 802.11ax (512/100)**
  - 4x4 + 2x2 radios, 1x 2.5Gbps + 1x 1Gbps Ethernet
  - BLE, 802.15.4, USB, unrestricted from 802.3at POE (class 4)
  - IPM, deep-sleep mode

- **530 Series (AP-534 and AP-535): High-end 802.11ax (1024/150)**
  - 4x4 + 4x4 radios, 2x 5Gbps Ethernet
  - BLE, 802.15.4, USB, unrestricted* from 802.3at POE (class 4)
  - IPM, deep-sleep mode, hitless failover (Smart POE)

- **550 Series (AP-555): Flagship 802.11ax (1024/150)**
  - 8x8 + 4x4 radios or 4x4 + 4x4 +4x4 tri-radio, 2x 5Gbps Ethernet
  - BLE, 802.15.4, USB, 802.3bt (class 5) or 2x 802.3at POE, reduced from 1x 802.3at
  - IPM, deep-sleep mode, hitless failover (Smart POE)

The Proof of the Pudding

Some actual test results

The Proof of the Pudding

Introduction

First and foremost, any 802.11ax access point is also (and for now mostly) an 802.11ac / 802.11n AP

- The standard is fully backwards compatible, and 802.11ax clients are rare for now
- Our 802.11ax access points are WFA certified for compliance with 802.11ac and 802.11n
- The increased number of radio chains, better radio specs (EVM, sensitivity), and increased platform performance (CPU, memory) will benefit all client devices

Some of the 802.11ax-specific functionality is not yet (fully) available in current chipset drivers

- Multiple driver and firmware iterations needed as things mature towards the WFA certification target

A lot of the current test data focuses on the generic platform capabilities

- Which are quite impressive!

So: not a lot of 11ax pudding to eat yet, but what we've seen so far tastes good and like more

The Proof of the Pudding

Checking Peak Platform Performance

Testing the peak performance numbers of the AP-535 and AP-555 platforms

- Using the AP-345 as the 802.11ac baseline

Using the same AP platform with special firmware as a simulated client device

- Ruling out client issues and limitations
- AP-555 as an 8x8 client device ;-)

No MU-MIMO, no OFDMA

- Just pushing the platform to its limits

Over-the-air measurements in a clean (shielded) environment

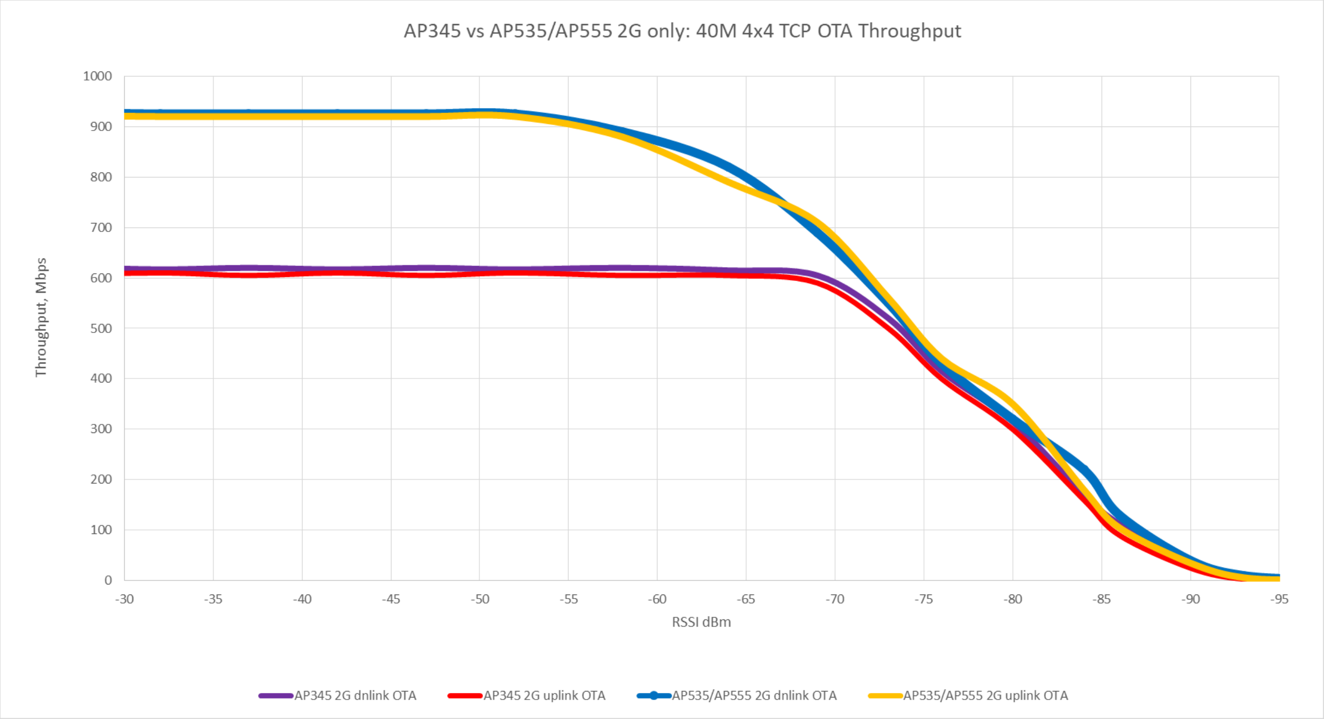
Channel is optimized for MIMO performance

Using test software (not production AOS or Instant)

Testing throughput with iPerf, focusing on downlink and uplink TCP traffic

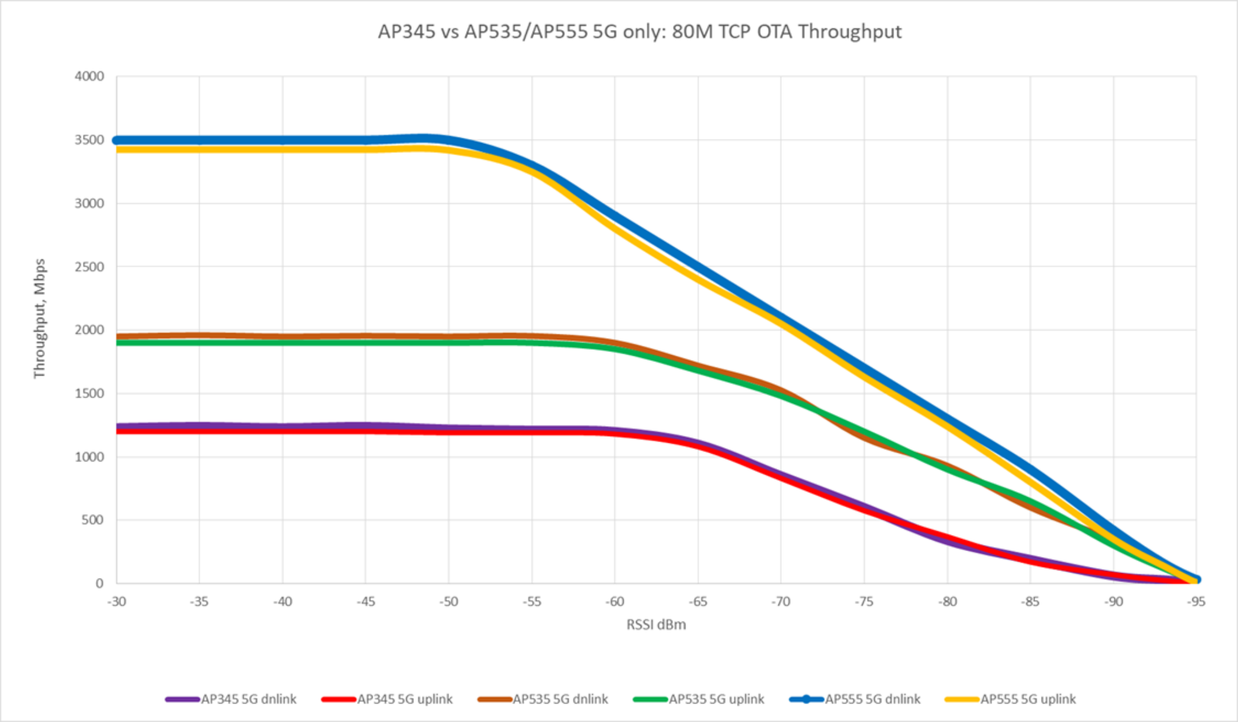
The Proof of the Pudding

Checking Peak Platform Performance – 2.4GHz 4x4 40MHz



The Proof of the Pudding

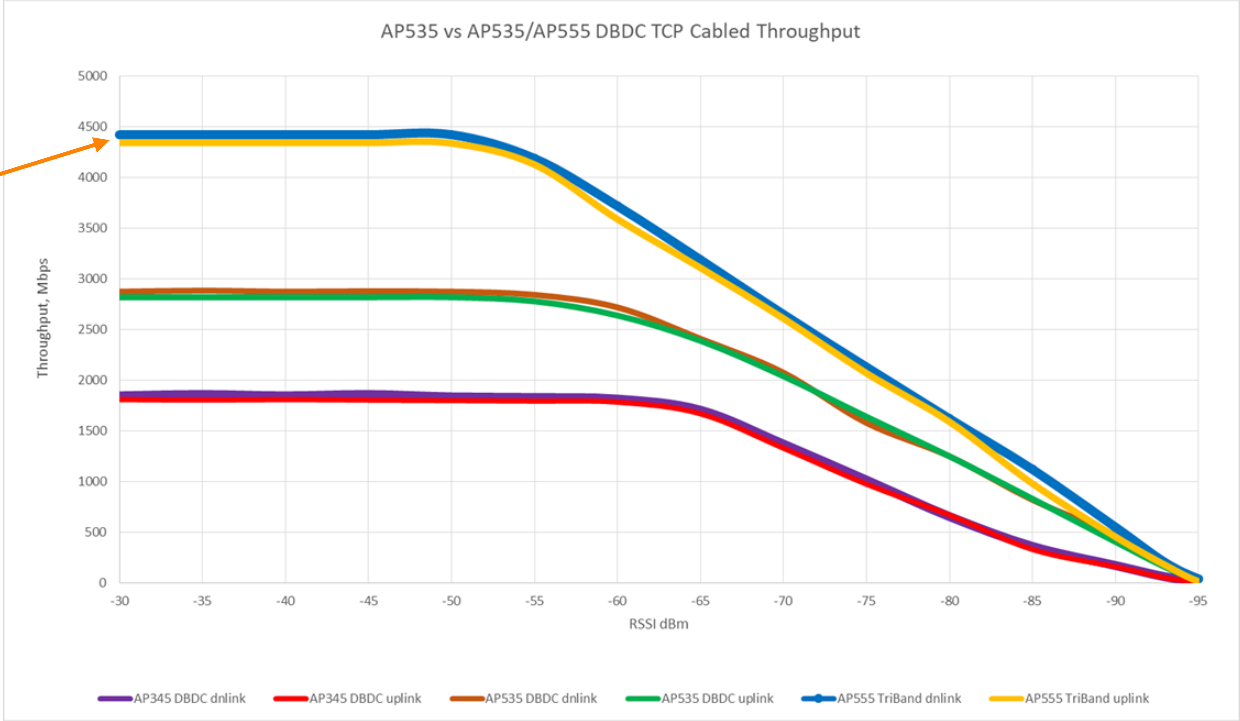
Checking Peak Platform Performance – 5GHz 4x4/8x8 80MHz



The Proof of the Pudding

Checking Peak Platform Performance – Combined 2.4GHz + 5GHz

4,300Mbps!



The Proof of the Pudding
Checking High Client Counts

Welcome to the Aruba UHD testbed!

A mix of different client devices
- And lots of them!

Currently mostly 802.11ac
- Lots of 3x3 client bridges

Starting the migration to 802.11ax

And further increase the client count

The Proof of the Pudding

Checking High Client Counts – Test specifics

512 associated clients to AP-555 5GHz radio

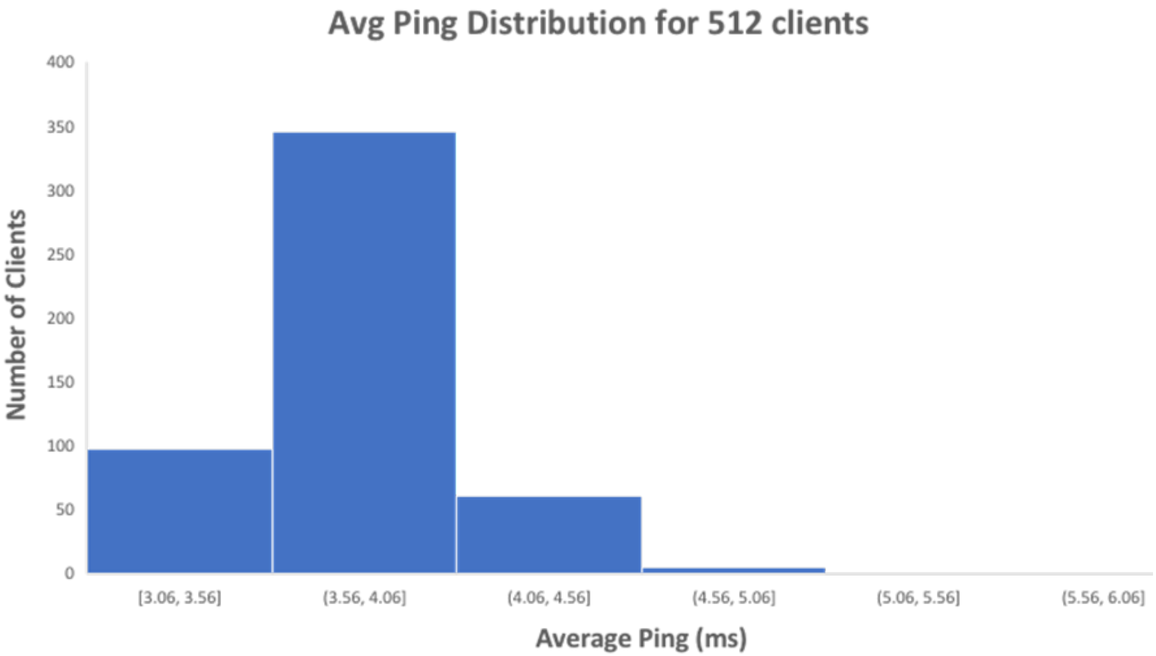
- Current chipset driver version is limited to 512; this will eventually grow to 1024

Sending 1000 pings of 1500B to each client device simultaneously

Recording the average ping time for each client device

All clients below 5ms

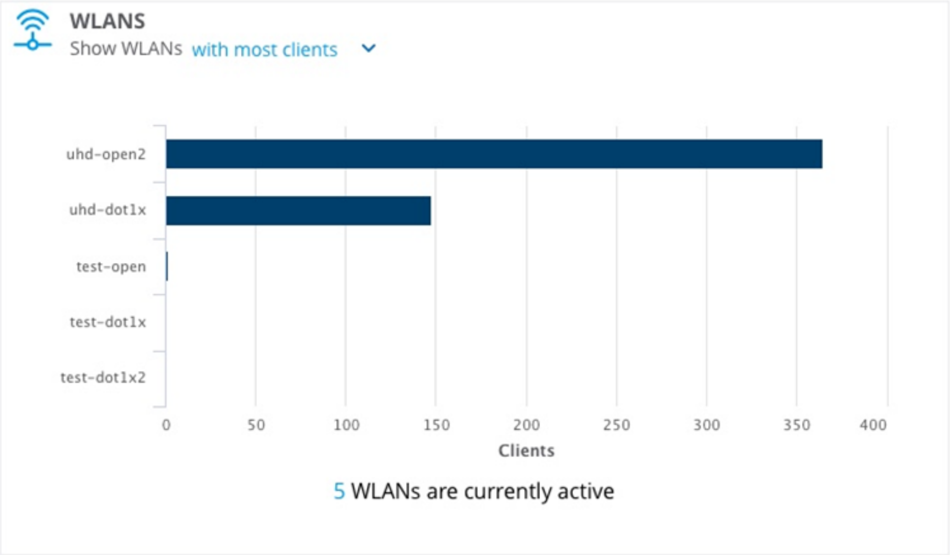
- Most below 4ms



The Proof of the Pudding

Checking High Client Counts – Test specifics

MM Dashboard showing 512 active clients associated a single AP 555 on 2 VAPs



The Proof of the Pudding

How about that OFDMA thing?

Testing the downlink transfer of UDP data in small packets (64B) to 9 client devices “simultaneously”

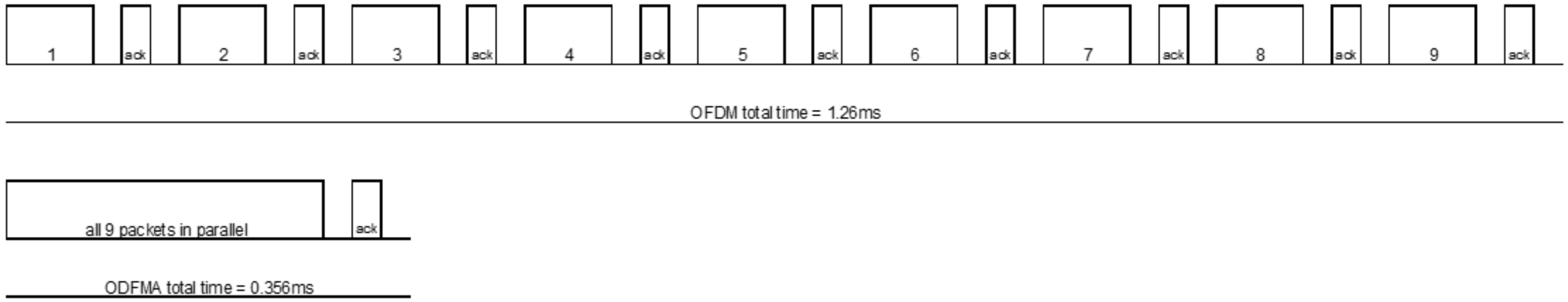
Using a 20MHz channel, comparing SU-MIMO and OFDMA

- With SU-MIMO, the packets will be serialized; with OFDMA they will truly be simultaneous

This was done using actual 2x2:2 11ax client devices from a partner company and an AP-535

Driver stability (on our side) made it difficult to do a standard iPerf performance test

Instead, we’re looking at the over-the-air transmissions in the time domain



The Proof of the Pudding

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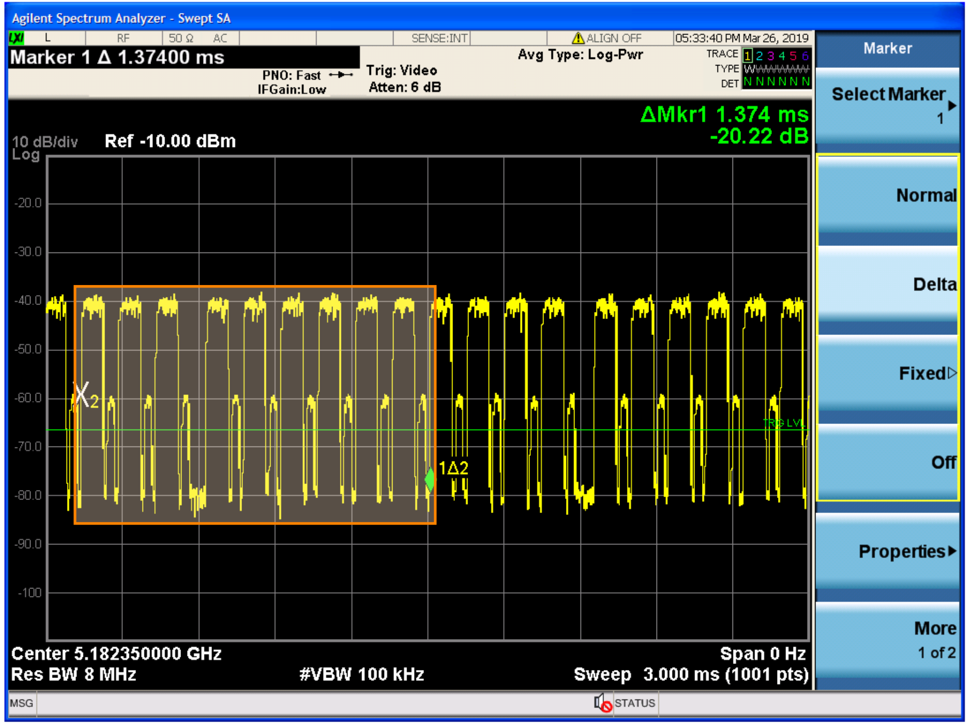
Let's look at the OFDM SU-MIMO case first

Sequences of packets from the AP, each followed by an ACK from the client

The whole thing takes about 1.374ms



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The whole thing takes about 1.374ms

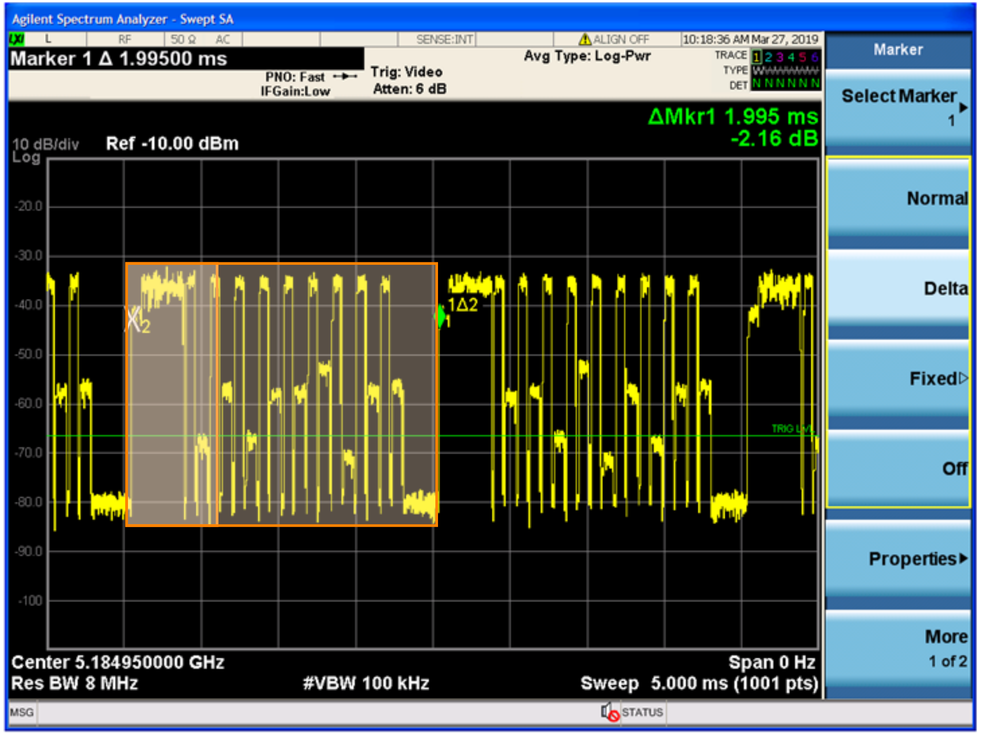
Now, let's look at the OFDMA case

New combined packet + one ACK: 550us

- **That's a 2.5x improvement**

Unfortunately our current driver does not support UL-OFDMA, so there's a sequence of (BARs and) ACKs

Another reason to make sure UL-OFDMA is supported!



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airheads TECH TALK LIVE

Thank You