Cambridge Wireless Radio Technology SIG Event

A Distinguished Lecture on Wi-Fi 7

Hosted by The Department of Computer Science and Technology, University of Cambridge

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Welcome

Delivered by:

Michaela Eschbach

Chief Executive Officer

Cambridge Wireless

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Who we are

Cambridge Wireless (CW) is a global not-for-profit membership organisation at the forefront of innovation in connectivity and digital technology.

Since 2000, CW has united industry leaders across connected devices, networks, software, data analytics, telecoms, satellites, and more.

We help our members...

COLLABORATE
LEARN
SHAPE THE FUTURE

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How we do this

We bring together industry leaders, innovators, and experts through a range of initiatives designed to foster collaboration, drive innovation, and support professional growth.

From flagship conferences and networking events to strategic innovation projects and skills development, our programmes create valuable opportunities for members:

- Events and Conferences
- Special Interest Groups (SIGs)
- Innovation Projects
- Academy and Training Courses
- Executive Meetings
- Knowledge Bank
- Partnership Programmes

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Founder's Dinners

Expand connections with industry leaders, innovators, and the wider tech ecosystem.

Engage in thought-provoking discussions in a historic Cambridge setting.

- Free for Founder Members
- 5 tickets per event
- Three dinners per calendar year
- Networking drinks reception
- Dinner in a university college hall
- Post-dinner keynote address

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Special Interest Groups (SIGs)

SIGs are at the heart of CW's mission to help our members to Collaborate, Learn and Shape the Future.

Built by and for our membership, with content shaped and delivered by the SIG.

Purpose:

- Focus on specific technology and market sectors
- Keep members up to date with industry developments
- Create opportunities for influencing developments
- Explore new business opportunities

- Academic & Industry
- Artificial Intelligence
- Connected & Intelligent Places
- Connected Thinking
- Content Production & Delivery
- Future Devices & Technologies
- HealthTech
- Location
- Mobile Networks
- Non-Terrestrial Networks
- Radio Technology
- Security, Privacy, Identity & Trust
- Wireless Heritage

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CPD Accredited Events

CW is a fully certified Continuing Professional Development (CPD) accreditation provider.

This means that delegates will be able to claim CPD points for a selection of CW events.

WEEK AT A GLANCE EVENT STRUCTURE*

15 -18 SEPTEMBER 2025

CAM TECH WEEK

MONDAY 15

SHOWCASE CAMBRIDGE

- Cambridge Tech Ecosystem Overview
- Inward Investment Partnerships and R&D
- Site Visits

TUESDAY 16

INNOVATION LANDSCAPE

- Investment and Innovation
- Innovation Alley Exhibition
- Roundtable discussions (Invite only)
- Leadership Dinner

WEDNESDAY 17

START-UP TO SCALE UP

- Innovation Alley Exhibition
- Start-up Workshops
- Scale up Pitching Event

THURSDAY 18

TECH DEEP DIVES

- Med Tech / Health Tech
- Climate Tech
- Agri-Tech
- Quantum
- Semiconductors
- Big Tech Debate
- Gala Reception

TECH FUTURES • PARTNERING LOUNGE • EVENT APP • FRINGE EVENTS

* Draft programme

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CWTEC:
6G Anarchy in the UK

How does the UK get what it needs in the 6G era?

9 July 2025 | Cambridge

Register now

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CW membership gives you further access to:

UK Telecoms Innovation Network (UKTIN)

- Specialist Supplier Guidance Service
- UKTN Small Business Support programme
- UKTIN Talent Group

Black Talent and Leadership in STEM Programme (BTLS)

- Access to tools, resources, our database of Black talent with STEM related degrees and case studies
- Events for Technology Companies and Partners

UK TELECOMS INNOVATION NETWORK

Black Talent & Leadership in *STEM*

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Thank you to our host.

The Department of Computer Science and Technology

University of Cambridge

www.cst.cam.ac.uk

Our Host

Dr Ian Wassell

Senior Lecturer,

The Department of Computer Science & Technology, University of Cambridge

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Introduction from our Chair

Peter Topham,

Qualcomm Technologies International

& CW SIG Champion

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Housekeeping

- No planned fire drill.
- Please switch your phones onto silent whilst in session
- A PDF of the presentations will be available upon request with permissions of the speakers

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The Radio Technology Group

The Radio Technology SIG will aim to increase the awareness of the scientific and engineering limits on radio communications; and the opportunities that could be exploited to improve the state-of-the-art.

Mark Beach

University of Bristol

Brian Collins

BSC Associates

Dr Paul Harris

VIAVI Solutions

Peter Kibutu

TTP Group

Peter Topham

Qualcomm

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A Distinguished lecture on Wi-Fi 7

14:40 Tony Lavender, Senior Advisor, Plum Consulting

'Wi-Fi – Navigating a complex spectrum and regulatory environment'

15:15 Refreshment break

15:45 Richard van Nee, Senior Director, Qualcomm International Technologies

'Wi-Fi-7'

16:20 Jonathan Borrill, CTO, Anritsu

'Key technology enhancements and real-world performance measurements in the evolution to Wi-Fi 7'

16:55 Closing remarks and event ends

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Wi-Fi – Navigating a complex spectrum and regulatory environment

Tony Lavender

Senior Advisor

Plum Consulting

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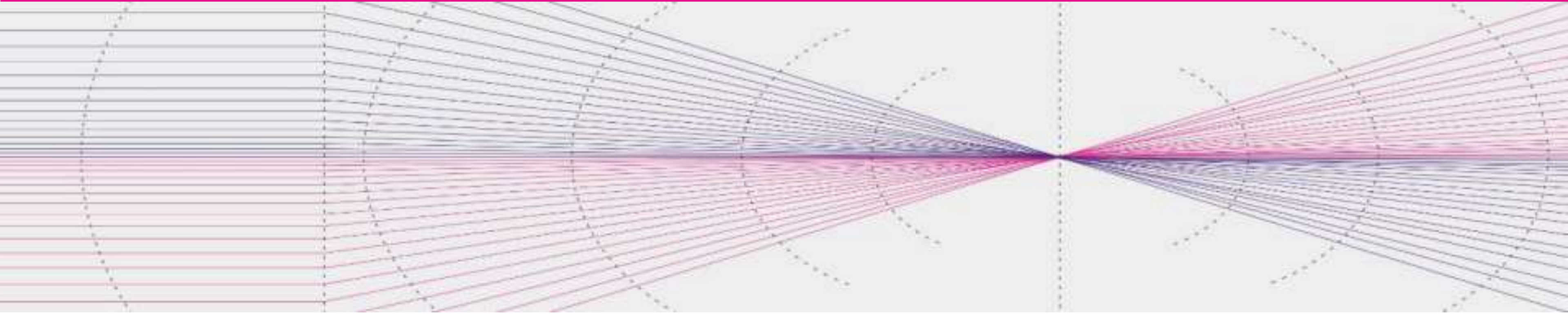
CW: Distinguished Lecture – Wi-Fi 7

A complex spectrum and regulatory environment

7 April 2025

Tony Lavender



Agenda

- Wi-Fi – background
- Demand for spectrum
- 2.4 GHz and 5 GHz bands
- 6 GHz band
- Concluding remarks

WiFi is a key connectivity solution

- Wi-Fi is a key part of global internet infrastructure – almost every home/office/industrial environment will use WiFi for connectivity, as will many indoor and outdoor public venues – it is a key access technology
- Wi-Fi has an easy and flexible deployment model and is readily scalable
- Use of mesh networks and other networking techniques have allowed deployment of effective, multi-node networks, including remote management of enterprise installations
- Standards and high volumes have enabled manufacture and distribution at reasonable cost points
- Wi-Fi benefits from a relatively light touch regulatory environment (although not fully harmonised globally)

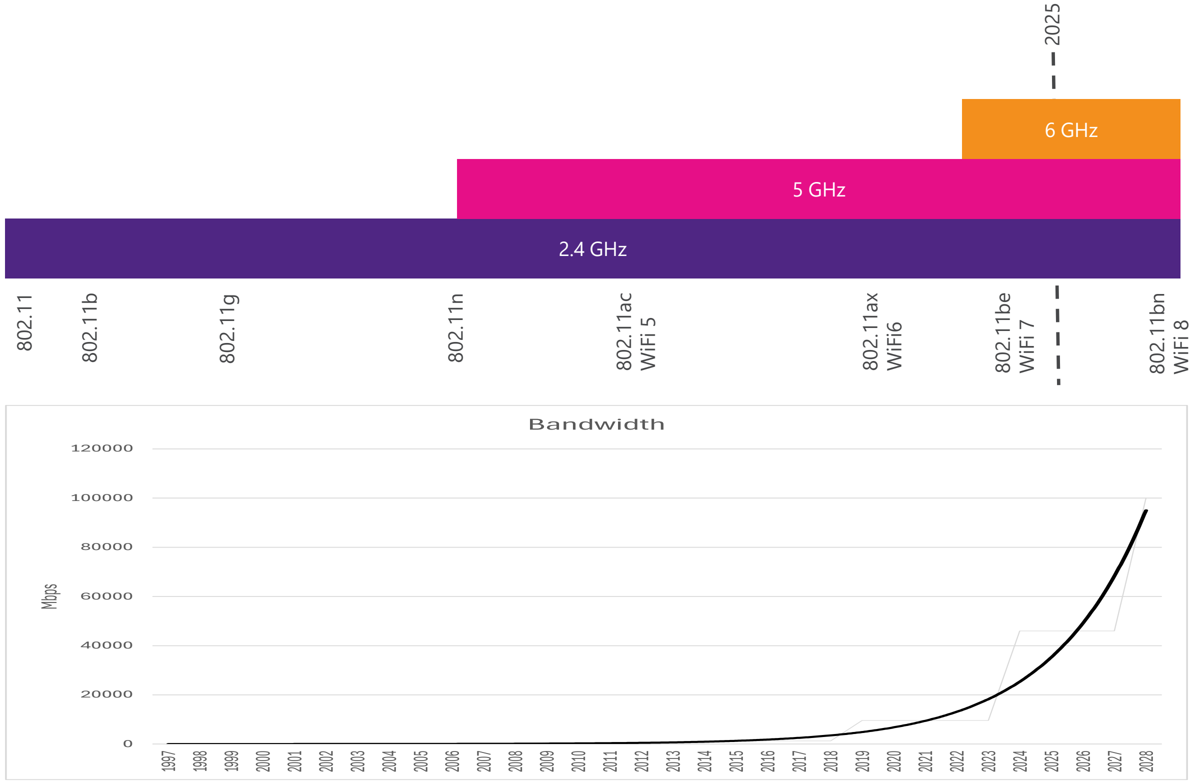
Use of unlicensed / licence exempt spectrum

- Key to the success of WiFi are standards and the use of unlicenced or licence exempt spectrum
- This spectrum promotes sharing with lower barriers to entry – there are no individual rights of use but also no requirement to carry out individual frequency planning / coordination, no registration or notification, no fee for use
- Unlicensed / licence exempt operates on the principle that transmissions are not likely to create undue interference to other spectrum users (using either the same or different technologies)
- Regulatory / spectrum authorities impose technical conditions for unlicensed / licence exempt use (e.g. specific frequency, channel size, power level, duty cycle, etc)
- There are regional variations on frequencies permitted and regional variations in technical conditions

Demand for spectrum

- More people and more devices are connecting through Wi-Fi networks – the vast majority of internet traffic (c90%) is connected to end users via Wi-Fi – in enterprise settings Wi-Fi is essential for handling the large amounts of data and simultaneously connecting a large number devices with improved reliability, higher data throughput and lower latencies
- The range of high bandwidth applications is expanding (e.g. 4K video streaming, automation, remote work, AR/VR)
- The latest generations of Wi-Fi offer features that significantly improve Wi-Fi spectral efficiency and ability to work at high density
- Ultimately there will still be bandwidth constraints to end-to-end connectivity if there are spectrum constraints
- There are increasing spectrum demands from mobile, satellite and licence exempt services (e.g. WRC 27 AI 1.7, 1.13)

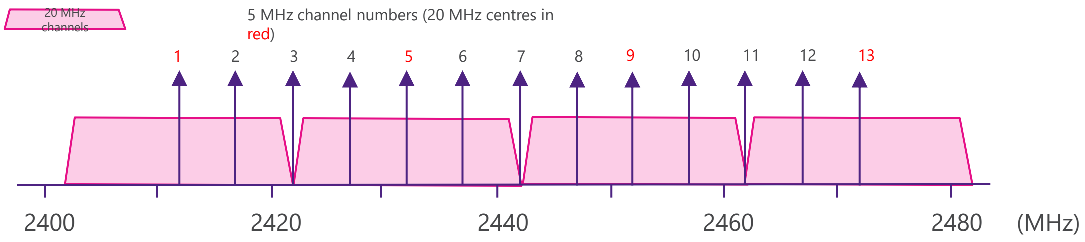
Wi-Fi timeline



Wi-Fi technical characteristics

Date	Standard	Branding	Technology	Highest modulation order	MIMO		Maximum bandwidth	Spectrum (GHz band)			Max speed Raw PHY (typ user)
					Type	Streams		2.4	5	6	
1997	802.11	-	FH	GFSK	-	-	1 MHz	✓			2 Mbit/s
1999	802.11b	(Wi-Fi 1)	DSSS	QPSK	-	-		✓			11 Mbit/s
1999	802.11a	(Wi-Fi 2)	OFDM	64QAM	-	-	20 MHz		✓		54 Mbit/s (~25 Mbit/s)
2003	802.11g	(Wi-Fi 3)	OFDM	64QAM	-	-	20 MHz	✓			54 Mbit/s
2008	802.11n	(Wi-Fi 4)	OFDM	64QAM	SU	4	40 MHz	✓	✓		600 Mbit/s
2014	802.11ac	(Wi-Fi 5)	OFDM	256QAM	MU(d)	8	160 MHz		✓		6.9 Gbit/s
2019	802.11ax	Wi-Fi 6/6E	OFDM OFDMA[1]	1024QAM	MU(du)	8	160 MHz	✓	✓	'6E'	9.6 Gbit/s (~1 Gbit/s)
2024	802.11be	Wi-Fi 7	OFDMA	4096QAM	MU(du)	8	320 MHz	✓	✓	✓	46 Gbit/s

Band plans (2.4 GHz)

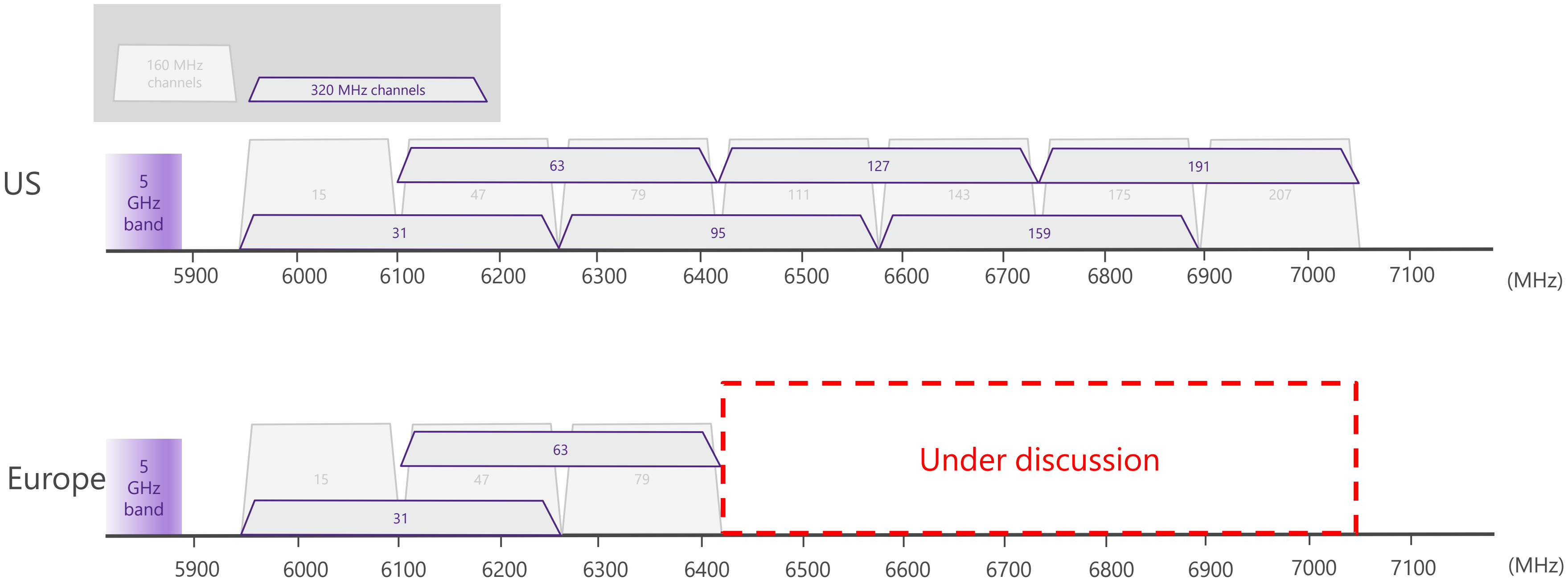


- Initial allocation in Industrial, Scientific and Medical (ISM) spectrum at 2.4 GHz
- Four non-overlapping 20 MHz channels
- Shares with other technologies including Bluetooth, Zigbee, various AV devices, microwave ovens

Band plans (5 GHz) US and Europe

- Expanded over time to a range of 5150-5900 MHz
- Use of upper parts of the band is constrained by need to protect radar and other incumbent systems
- Requirement to implement Dynamic Frequency Selection (DFS)
- Europe more constrained than the US
  - Many countries permit only SRD indoors at <25mW in range 5710-5875 MHz (ITS coexistence issues)

Band plans (6 GHz)



6 GHz band US and Europe

- 802.11ax (Wi-Fi 6) included ability to use spectrum at 6 GHz for Wi-Fi 6E
- US
  - FCC Report and Order FCC 20-51 – 1200 MHz of spectrum available in frequency range 5925-7125 MHz
  - All channels are available for indoor use at EIRP up to 30dBm (Low Power Indoor – LPI) (U-NII-5-8)
  - Four channels may be used outdoors at up to 36dBm (U-NII-5&7)
  - Automated Frequency Coordination (AFC) to be used to protect fixed services in U-NII-5&7 bands
- Europe
  - Commission Implementing Decision (EU) 2021/1067 - harmonised use of radio spectrum in the 5945-6425 MHz frequency band for the implementation of wireless access systems including radio local area networks (WAS/RLANs) – two modes LPI (23dBm EIRP) and VLP (very low power 14dBm) indoor and outdoor use
  - Upper 6 GHz still under discussion

Upper 6 GHz UK and European Union

UK – current proposal

- Lower 6 GHz band (5925-6425 MHz) has been available for Wi-Fi (LPI) since 2020
- Ofcom is now proposing to:
  - Enable up to 4 watts indoor and outdoors in lower 6 GHz provided AFC is used subject to expression of demand from industry
  - Make upper 6 GHz available in 2 phases:
    - LPI Wi-Fi across the whole band
    - Add a sharing mechanism for mobile when European position on harmonisation is clear – envisaging a minimum of 300 MHz being available for high-power mobile operation – may apply a low/high density use concept for mobile

EU

- European Commission has mandated CEPT to develop proposals for least restrictive harmonised technical shared conditions for potential shared use of 6425-7125 MHz (issued December 2024 and aiming for output by July 2027)
- Radio Spectrum Policy Group (RSPG) aiming for Opinion in June 2025 – also considering options for use including MFCN and WAS/RLAN

Brief summary of Asia Pacific developments (data from Wi-Fi Alliance)

Country	5945-6425 MHz	6425-7125 MHz
Australia	Adopted	Considering
Hong Kong	Adopted	Considering
Indonesia	Adopted	
Japan	Adopted	Considering
Malaysia	Adopted	
New Zealand	Adopted	
Philippines	Adopted	
Singapore	Adopted	
South Korea	Adopted	
Thailand	Adopted	

Conclusions

- Wi-Fi has been around for a considerable time and has evolved to be a key access / connectivity technology and is a large-scale market
- Standards have played an important role but full global spectrum and regulatory harmonisation has not been possible for either spectrum bands or technical conditions – however, there is a workable alignment
- This spectrum and regulatory environment increases the complexity of the design and cost of Wi-Fi equipment – it can also require user education
- Current debate is around use of 6 GHz spectrum – still work to do in many places
- Ultimately there will still be bandwidth constraints to end-to-end connectivity if there is not enough spectrum capacity

Refreshment break

Please return at 15:50

Wi-Fi

Richard van Nee

Senior Director,

Qualcomm International Technologies

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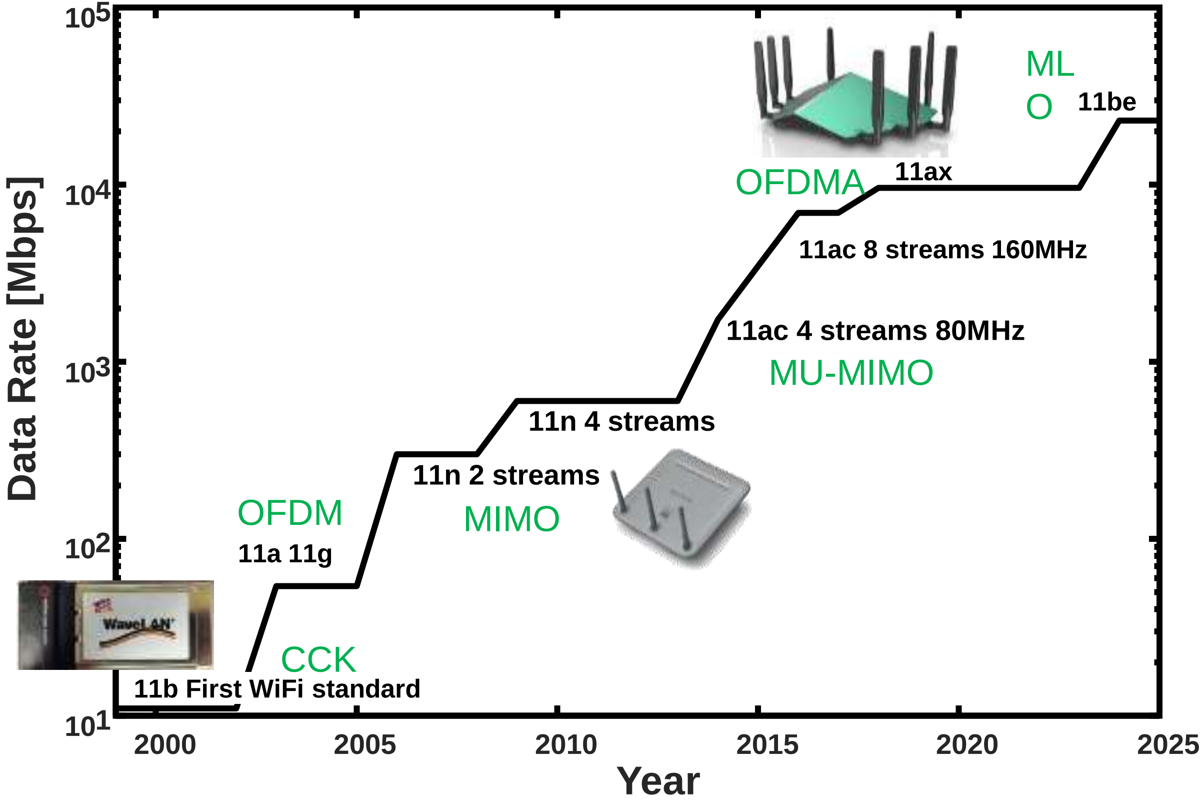
Richard van Nee
Qualcomm
Utrecht, The Netherlands
rvannee@qualcomm.com

Wi-Fi and IEEE 802.11

- IEEE 802.11
  - Defines new Standards
- Wi-Fi Alliance
  - Selects which parts from 802.11 standards are mandatory for a certain device class
  - Defines Interoperability Tests
  - Wi-Fi certification
    - WiFi logos for various device classes
  - Since Wi-Fi 6, changed from letters to generation number
    - 11ax == Wi-Fi 6
    - 11be == Wi-Fi 7

802.11 PHY Data Rate Growth

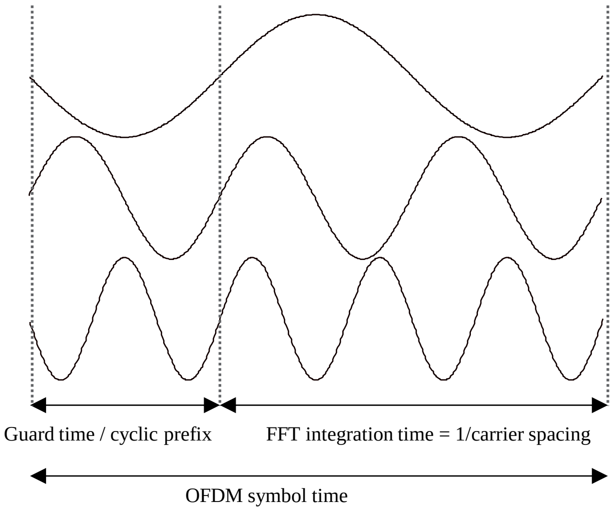


802.11be (==Wi-Fi 7) Key Features

- 320Mhz channels
- 4096-QAM
- MIMO up to 8 spatial streams
- OFDMA and MU-MIMO mandatory for both uplink and downlink
- MRU (Multi Resource Unit)
- Multilink operation
- Puncturing
- 23 Gbps peak PHY rate for 8 spatial streams in 320MHz
- 46 Gbps peak rate for MLO
  - 8 streams in 320 (6GHz) + 160 (upper 5GHz) + 160 (lower 5GHz)

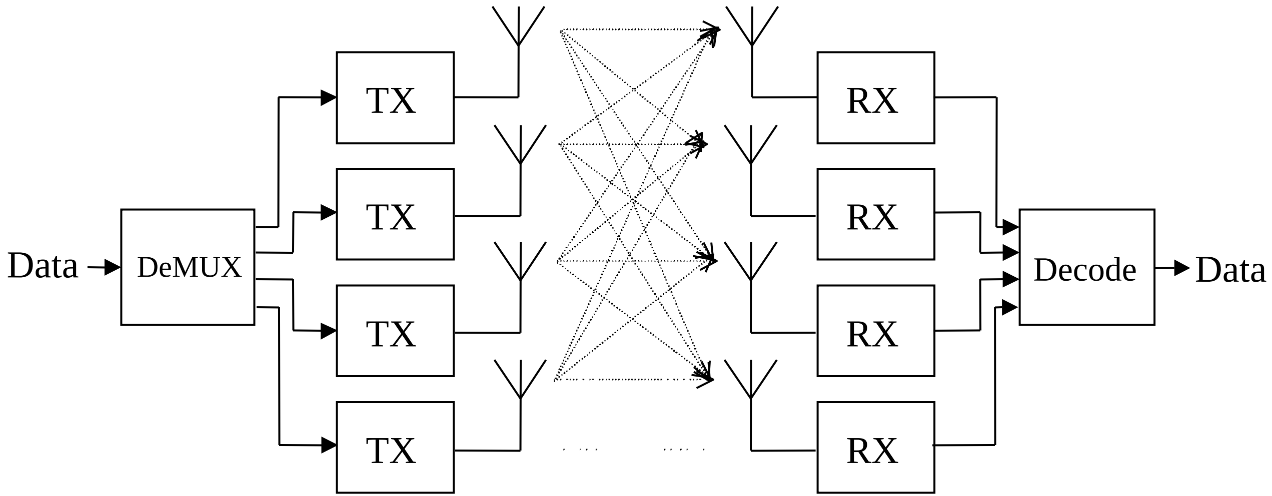
OFDM (Orthogonal Frequency Division Multiplexing)

- Use N orthogonal subcarriers to make symbol duration N times longer
- Add guard interval to deal with ICI/ISI



- 802.11a started with 52 subcarriers with 3.2us FFT interval
- 802.11be (Wi-Fi 7) goes up to 4 x 996 subcarriers with 12.8us FFT interval (4x symbols for better delay spread robustness)

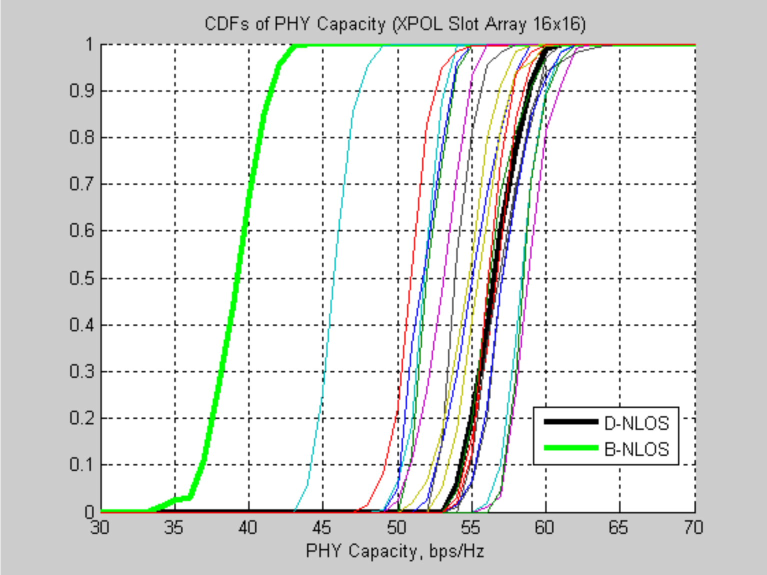
Multiple Input Multiple Output (MIMO)



- Increase data rate without increasing bandwidth by transmitting multiple simultaneous data streams from different antennas

Measured MIMO Capacity

- Channel measurements using a 16 antenna array at both sides of a link shows capacity around 50 bps/Hz
  - For comparison: 11a peak capacity is 2.7 bps/Hz (54Mbps in 20MHz), 11n 4 streams peak capacity is 15 bps/Hz (600Mbps in a 40MHz channel)



Note: Green and Black curve are capacities derived from channel models, all other curves are based on measurements

Each CDF curve reflects a different test location

Downlink Multi-User MIMO

- Access Point transmits packets to multiple clients ***simultaneously***
- Network throughput is increased rather than increasing the maximum throughput for a single link

Uplink Multi-User MIMO

- Multiple clients transmit packets to Access Point ***simultaneously***
- Network throughput is increased rather than increasing the maximum throughput for a single link
- Uplink packets need to use power control and synchronization to AP in time and frequency to minimize inter-carrier interference
  - Uplink MU-MIMO packets are sent only in response to a Trigger Frame from AP

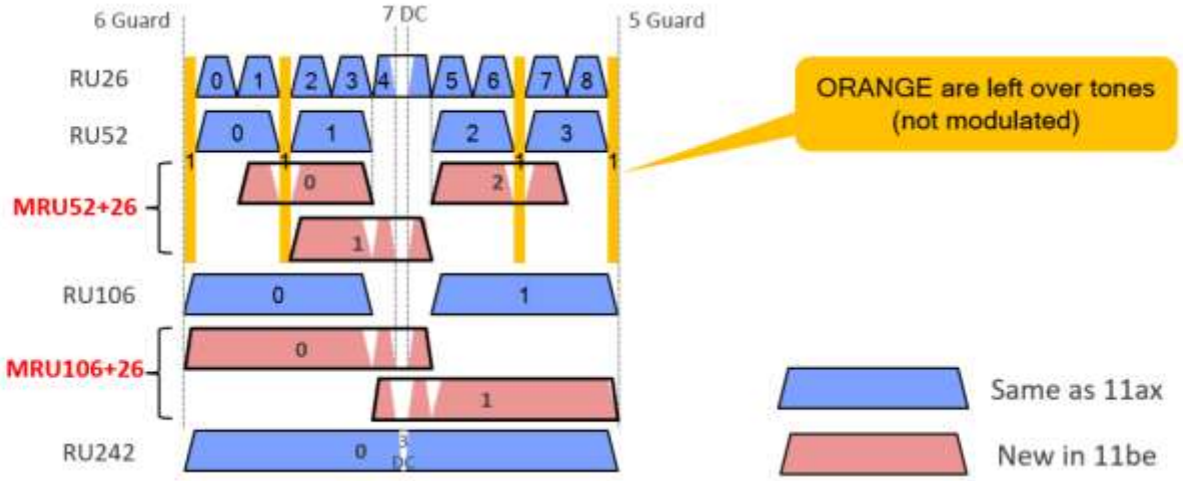
OFDMA (Orthogonal Frequency Division Multiple Access)

- Use subsets of tones (Resource Units) for different clients simultaneously

- Minimize overhead of PHY preambles and MAC backoff by aggregating packets from many clients in one OFDMA packet
  - Preamble + MAC backoff is in the order of 100μs ⇒ Ideally want packet to be > 1ms to minimize overhead ⇒ more than 1MB of data at 10Gbps
  - This requires a lot of aggregation and latency for a single client
  - Easier to achieve by aggregation of multiple clients

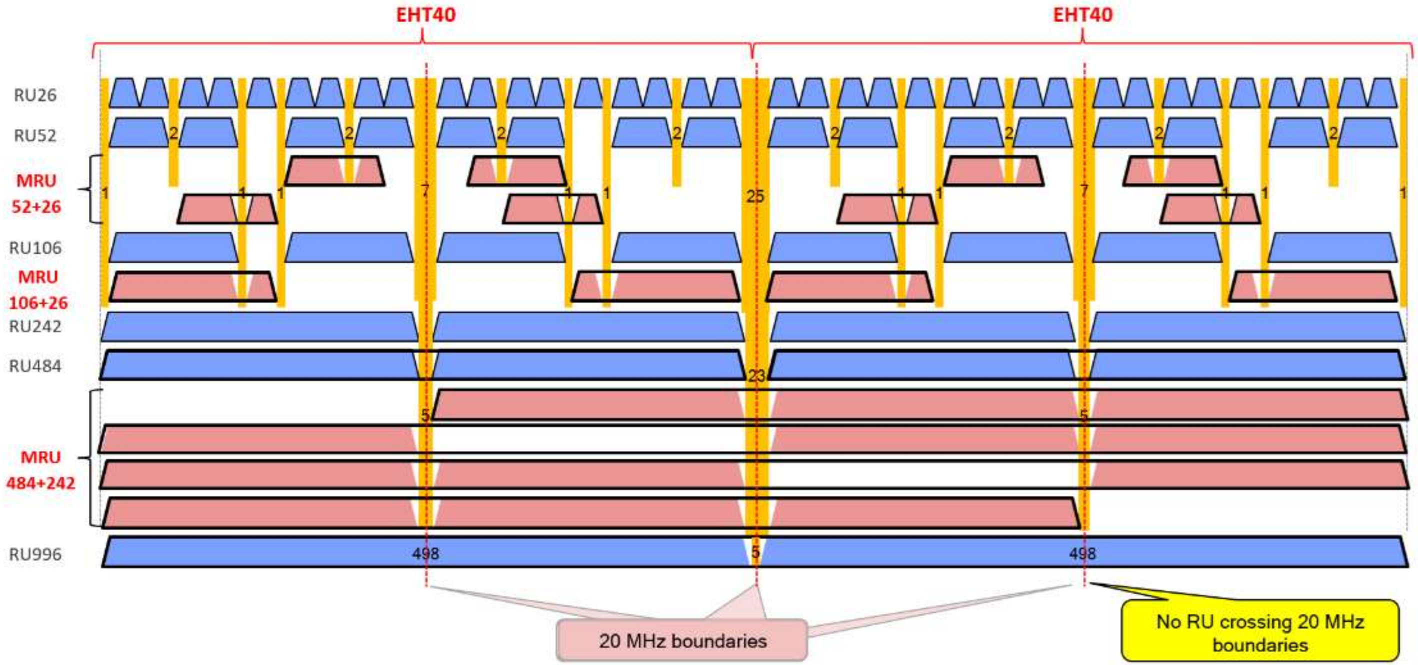
- OFDMA in 80MHz allows 2 to 37 clients simultaneously
- Allocations with specific RU sizes are defined for 20 to 320 MHz channels

Wi-Fi 7 Multiple Resource Unit (MRU) For OFDMA



- MRU allows using 2 different RUs to gain efficiency
  - easier to fill more of available spectrum

Wi-Fi 7 OFDMA Tone Plan 80MHz



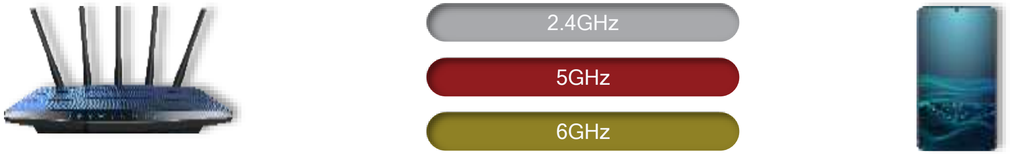
Uplink OFDMA

- Same aggregation benefit as downlink OFDMA
- Power aggregation benefit
  - N uplink clients transmitting at maximum power give a 10logN SNR gain in uplink
  - Alternative explanation: uplink client gets SNR gain by transmitting same maximum power in a smaller OFDMA bandwidth
    - Depending on PSD regulations, may not achieve this with 6GHz LPI rules
  - Because of SNR gain, client can transmit higher MCS or get more range at same MCS relative to non-OFDMA
- Note that power aggregation benefit also applies to uplink MU-MIMO

Multi Link Operation (MLO)

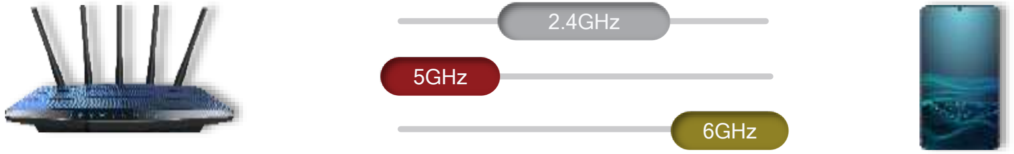
- Wi-Fi 7 enables devices to associate using multiple links
- Simultaneous MLO: Allow a flow to distribute over 2 or more links
  - Can use 3 channels in 2.4, 5, 6 GHz but also lower 5, upper 5, 6 GHz
- Nonsimultaneous MLO: Radios observe channel conditions and decide on which link to send the flow

MLO using Simultaneous Transmit and Receive (STR)



Higher throughput

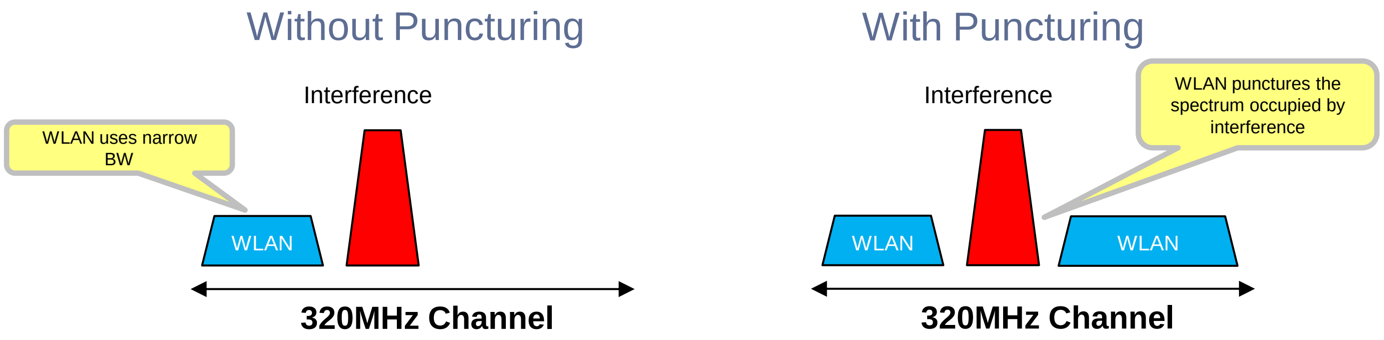
MLO using Nonsimultaneous Transmit and Receive (NSTR)



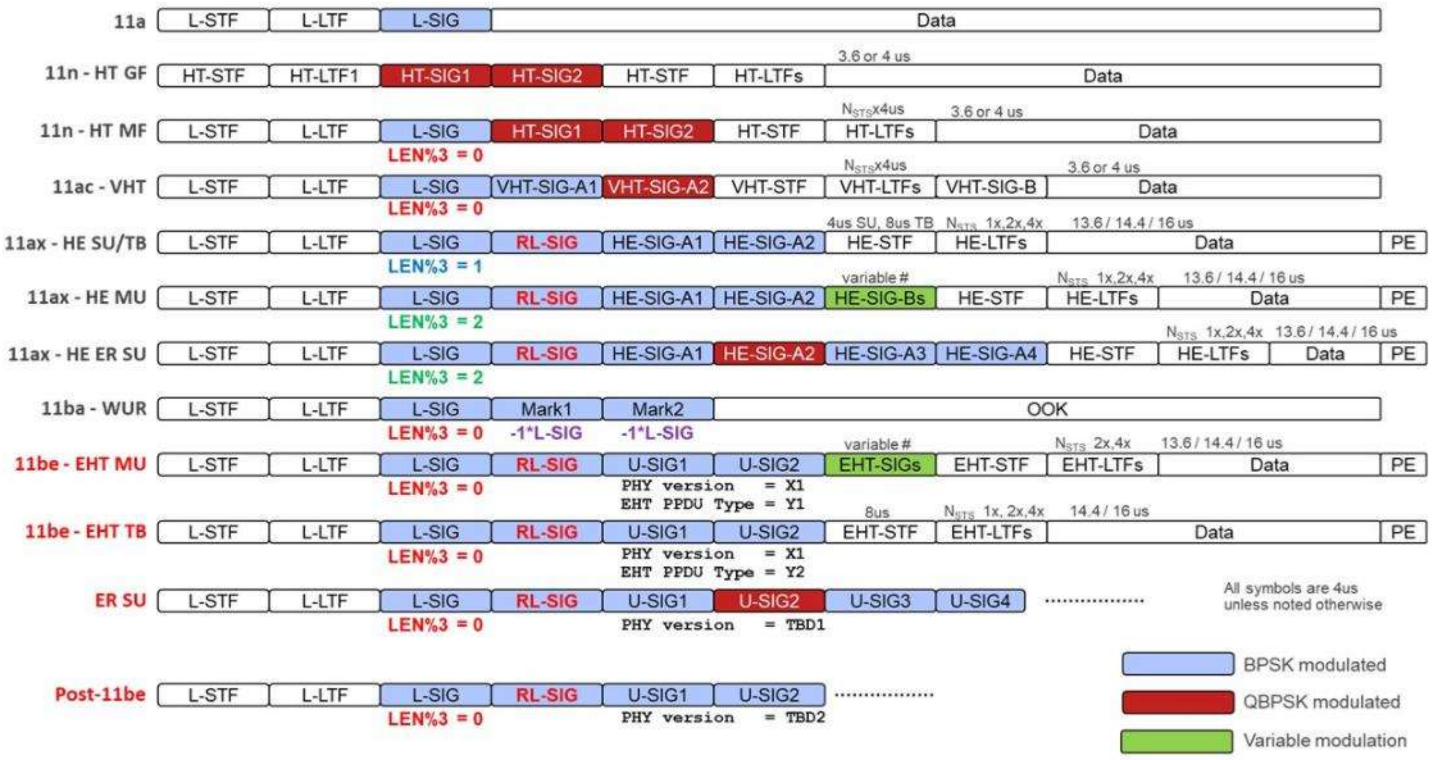
Lower latency
Better link robustness

Puncturing

- Existing WLAN systems have to give up a large portion of spectrum when there is interference
- Interference could be from various sources
  - Incumbent wireless systems in 6 GHz
  - Radars in 5 GHz
  - OBSS WLAN interference
- Puncturing in Wi-Fi 7 reclaims much of spectrum in presence of interference



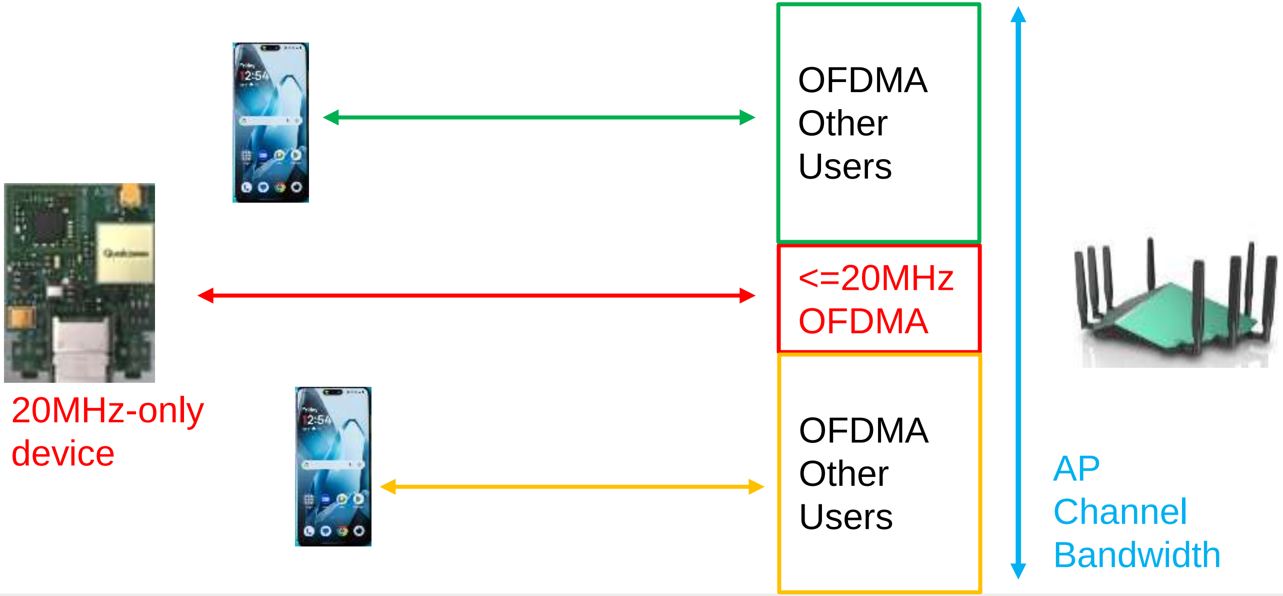
Wi-Fi Preambles



Wi-Fi 7 device needs to be able to detect and distinguish between all of these preambles

Low Power 20MHz-Only Device

- Low power devices prefer not to implement power-hungry modes like 320MHz Multi Gbps rates
- To still benefit from at least some Wi-Fi 7 features, a special category is introduced since Wi-Fi 6: 20MHz-only non-AP station
- Benefit for instance from OFDMA in 20MHz and 4x symbols

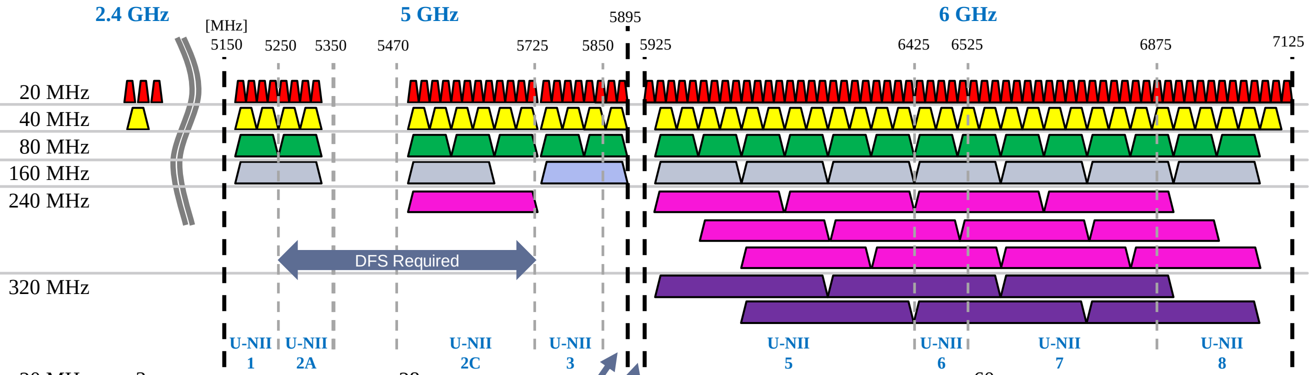


Smart Badminton Racket

Victor badminton racket

with Qualcomm module inside handle

Channelization (US FCC)



# of Non-overlapping Channels	2.4 GHz	5 GHz	6 GHz
20 MHz	3	28	60
40 MHz	1	14	29
80 MHz		7	14
160 MHz		3	7
240 MHz		1	4
320 MHz			3

FCC Allowed TX Power In 6 GHz

- Standard Power
  - Up to 36dBm EIRP
  - Requires AFC (Automatic Frequency Coordination)

- Low Power Indoor (LPI)
  - 5dBm/MHz for indoor AP and Mesh nodes, max EIRP = 30dBm (320MHz only)
  - -1dBm/MHz for clients, max EIRP = 24dBm

- Very Low Power (VLP)
  - -5dBm/MHz
  - 14dBm max EIRP

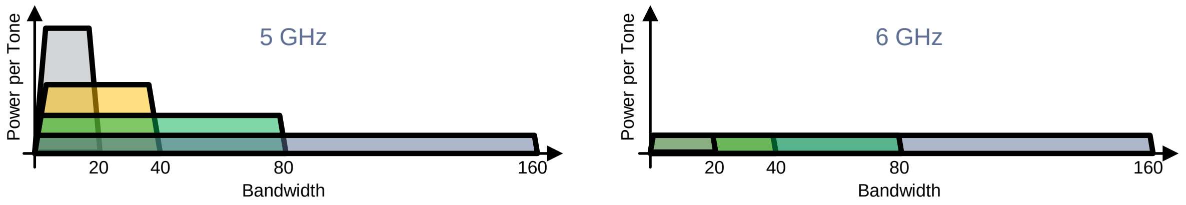
Automated Frequency Coordination

- AFC required for 6GHz Standard Power
- Requires AP to have positioning capability
  - GPS / GNSS
  - Qualcomm Aware™ Positioning
    - Uses database of Wi-Fi APs to get position based on what APs you see
    - May also use cellular data and GPS if available
- Access AFC database
  - To check what channels are available at a certain EIRP

Example of AFC database contours for various EIRP levels

Rate Control And LPI

- In 5 GHz, packet bandwidth is reduced at far range to get more TX power on fewer tones
  - Increase range at cost of rate

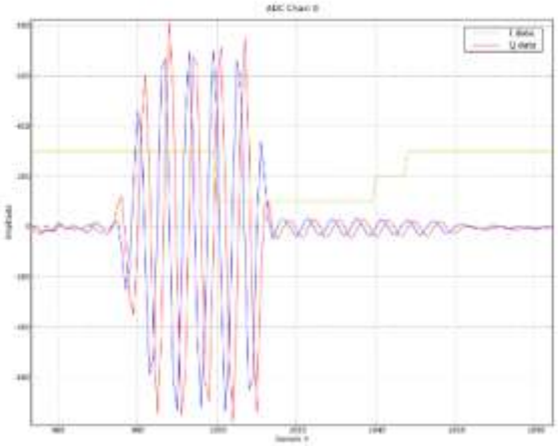


- 6GHz LPI (Low Power Indoor) devices cannot increase power per tone
  - Because of 5dBm/MHz restriction
- This means LPI devices cannot get a better range in 20MHz vs 320MHz
  - Lowest data rate in 6 GHz 320 MHz channel is about 72 Mbps
  - No range gain by going back to 6Mbps in 20MHz
- To get more power and range, need AFC or move to another band

Some Other Wi-Fi Topics

Radar Detection

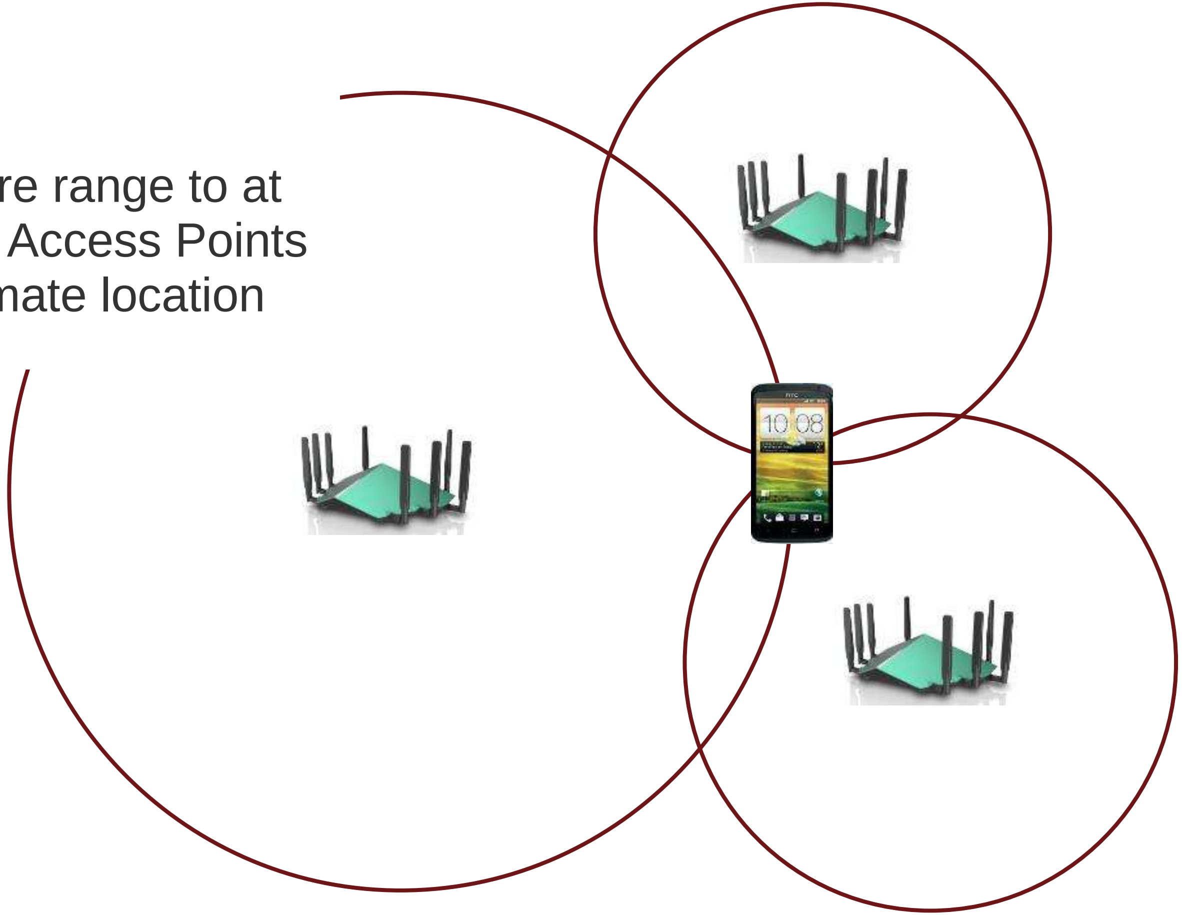
- Radar detection and Dynamic Frequency Selection is required in 5.25 to 5.725 GHz
  - AP is not allowed to use a channel where radar is



- Measured radar pulse from KNMI weather radar
- Pulse detected inside Qualcomm office at 14km distance

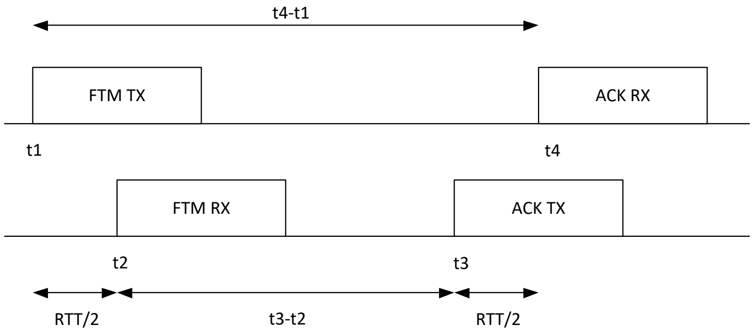
WiFi Ranging (802.11mc)

- Measure range to at least 3 Access Points to estimate location

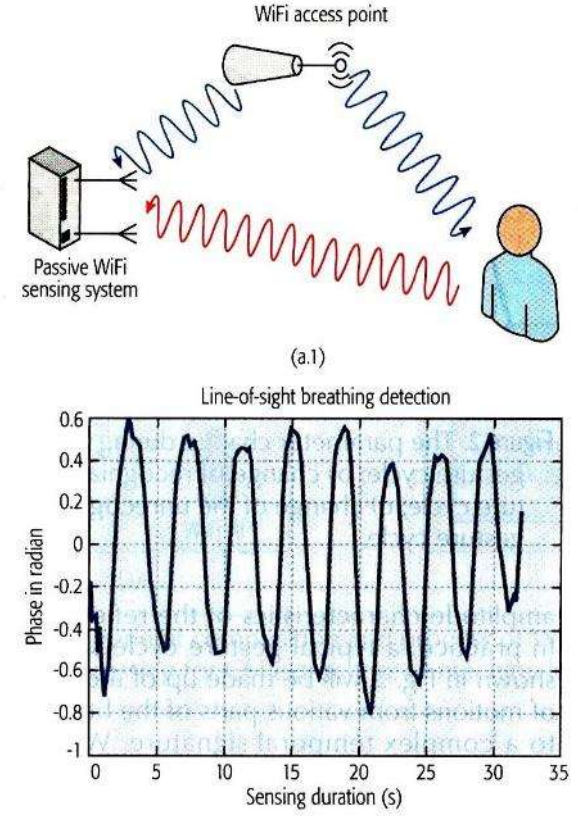


Round Trip Time Estimation

- RTT is estimated as difference of 2 time intervals (t4-t1)-(t3-t2) in FTM-ACK exchange
  - Starts with FTM (Fine Time Measurement) request, not shown in figure below
  - FTM ACK contains measured time of arrival t2 and transmit time t3
  - RTT estimate = (t4-t1) – (t3-t2)



Wi-Fi Sensing (802.11bf)



- Detect people, movement, breathing rate, heart rate, gestures
- Based on detecting changes in WiFi CSI (Channel State Information)

Tan et al., Behavior recognition based on WiFi CSI, IEEE Communications Magazine, May 2018

Key technology enhancements and real-world performance measurements in the evolution to Wi-Fi 7

Jonathan Borrill

CTO

Anritsu

CAMBRIDGE WIRELESS

Evolution towards latest Wi-Fi standard 802.11be and RF measurement challenges.

Jonathan Borrill

CTO, Test & Measurement Company.

2025

Contents.

1. New features for Wi-Fi 7 (802.11be)
2. How we measure Wi-Fi
3. Wi-Fi Measurement examples
4. Conclusions

IEEE802.11 Standards

Anritsu
Advancing beyond

IEEE802.11	11b	11a	11g	11n Wi-Fi 4	11ac Wi-Fi 5	11ax Wi-Fi 6, 6E	11be Wi-Fi 7	11bn Wi-Fi 8
Transmission Vector Format	Non-HT (Non-High Throughput)	Non-HT (Non-High Throughput)	Non-HT (Non-High Throughput)	HT (High Throughput)	VHT (Very High Throughput)	HE (High Efficiency)	EHT (Extreme High Throughput)	UHR Ultra High Reliability
Definition	1999	1999	2003	2009	2014	2021	2024	2028?
Freq. 2.4G Hz	✓		✓	✓		✓	✓	✓
Freq. 5GHz		✓		✓	✓	✓	✓	✓
Freq. 6GHz						✓	✓	✓
Bandwidth [MHz]	20	20	20	20/40	20/40/80/160/80+80	20/40/80/160/80+80	20/40/80/160/320	20/40/80/160/320
Maximum throughput rate [bps]	11M	54M	54M	540M	6.9G	9.6G	30G～	100G～ ?? mmWave
Modulation scheme	DBPSK DQPSK	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM 256QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM 4096QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM 4096QAM
Stream	-	-	-	4 Stream	8 Stream	8 Stream	16 Stream	?? Stream

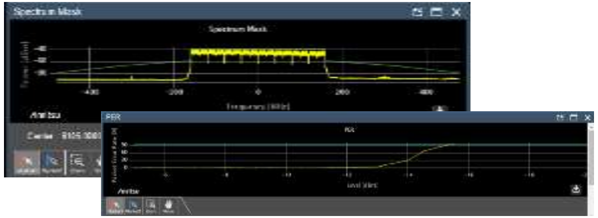
IEEE 802.11be (Wi-Fi 7)

IEEE 802.11be (Wi-Fi 7) Advanced Technology and Evaluation Issues

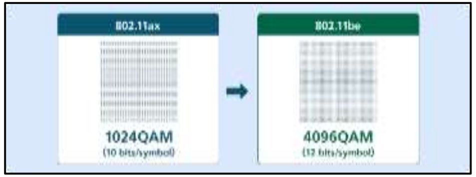
IEEE 802.11be (Wi-Fi 7) radio adopts the following **three advanced technologies**, significantly increasing the theoretical IP throughput from the conventional 9.6Gbps to over 30Gbps. **To achieve such high-speed communication, products must meet high quality targets**.

The MT8862A contributes to device evaluation by efficiently wireless characteristics evaluation using network mode.

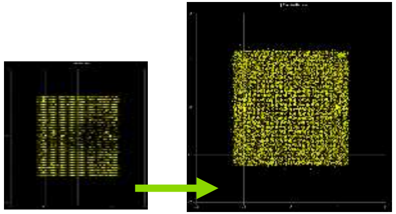
320MHz bandwidth in
the wide 6GHz Frequency band,



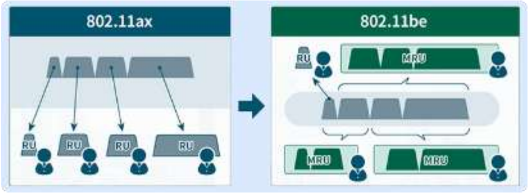
6GHz band 320MHzBW TX/RX test



High speed with 4096QAM modulation



802.11be MCS13 4096QAM Test

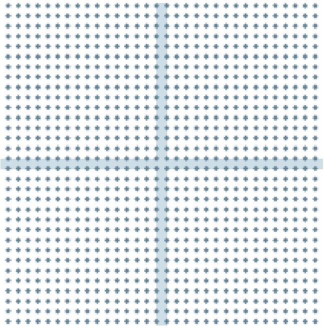


Advanced OFDMA, multi-user

OFDMA Multi-User Test

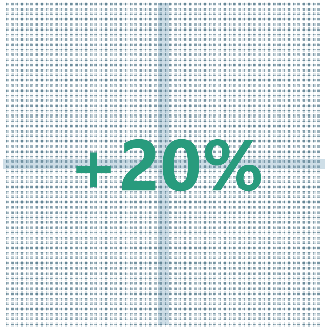
Subcarrier modulation

802.11ax



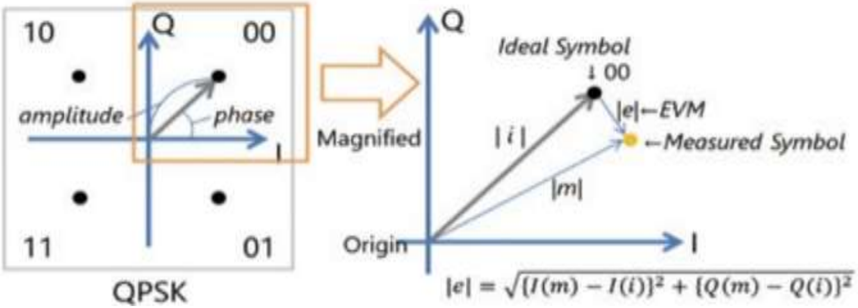
1024QAM
(10 bits/symbol)

802.11be



4096QAM
(12 bits/symbol)

EVM:≤ 1.78%

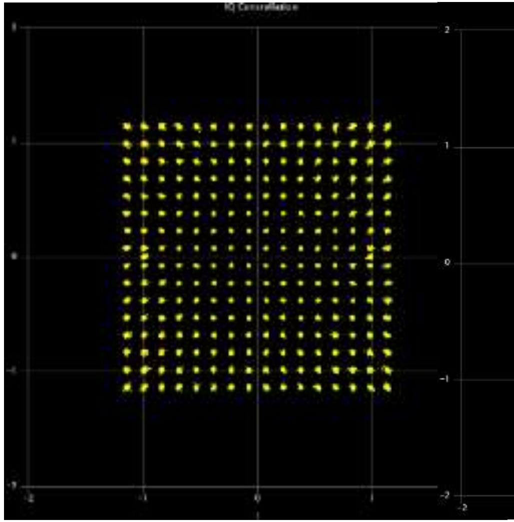


EVM:≤ 1.26%

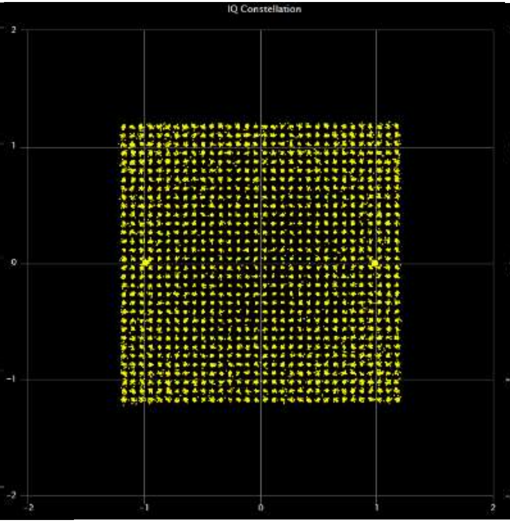
New Features -11be 4096QAM

IEEE802.11be supports up to 4096QAM (MCS13) as modulation method. Ether 4096QAM is available on 2.4GHz band , 5GHz band and 6GHz band. 4096QAM requires strict EVM performance (≦-38dB).

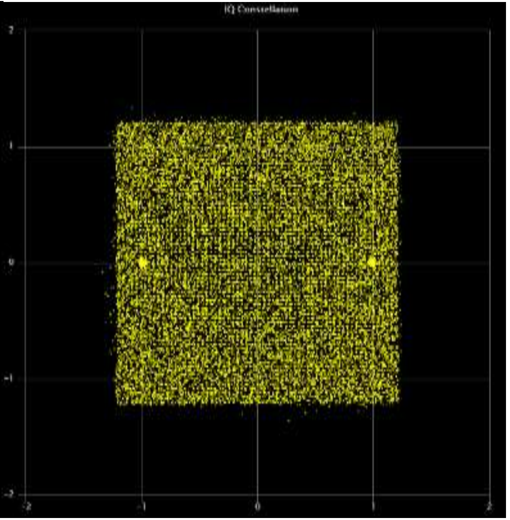
MT8862A supports data rate control to measure RF performance on the fixed MCS.



11be 256QAM

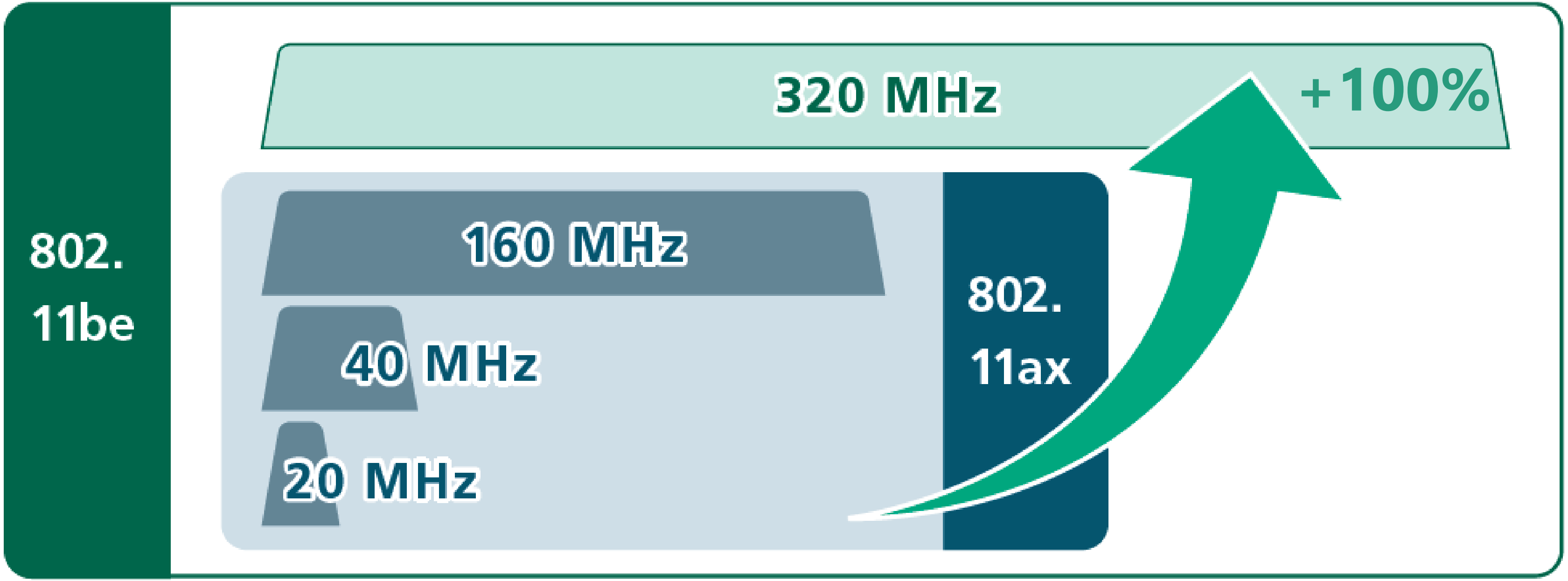


11be 1024QAM

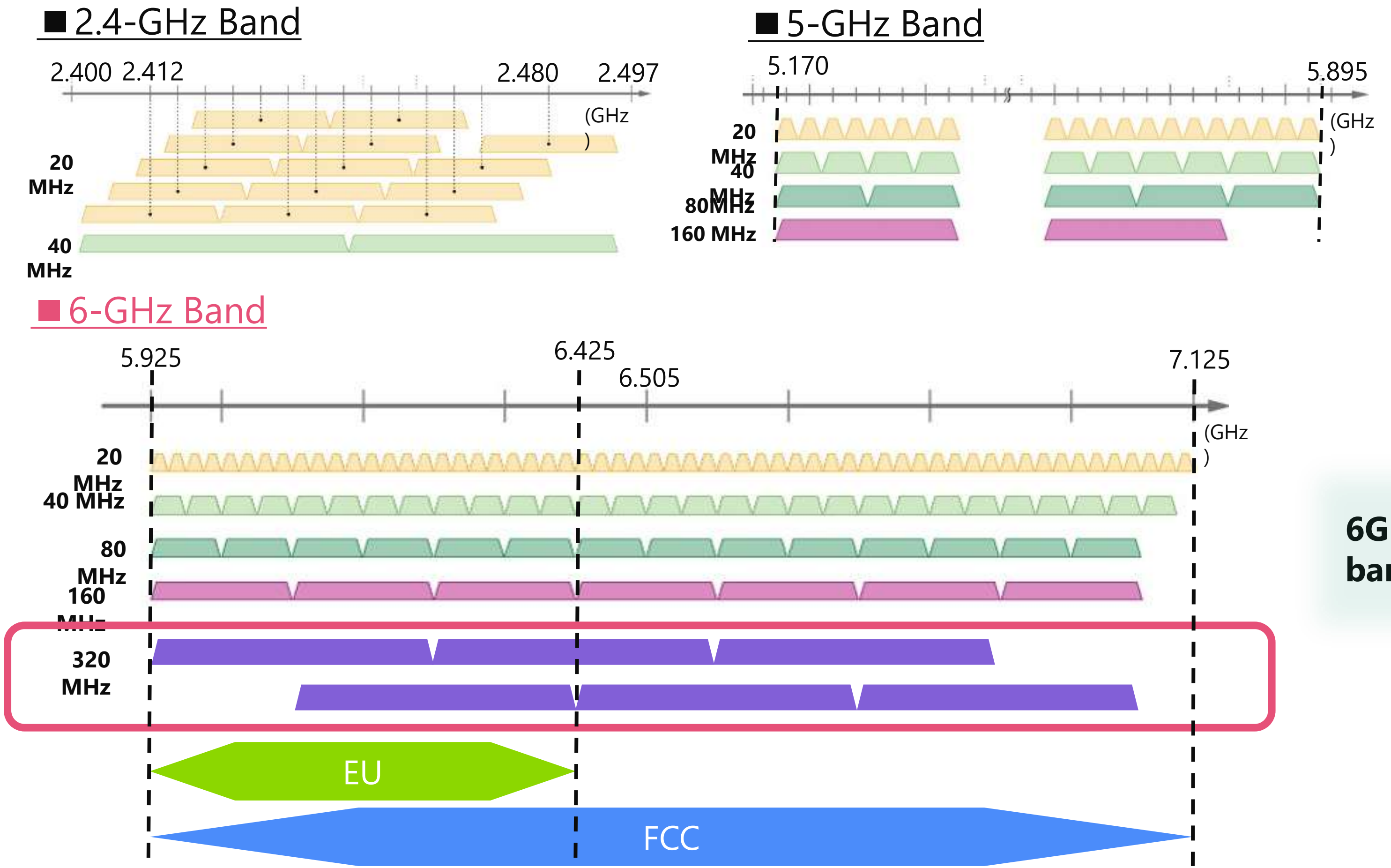


11be 4096QAM

Maximum Channel Bandwidth



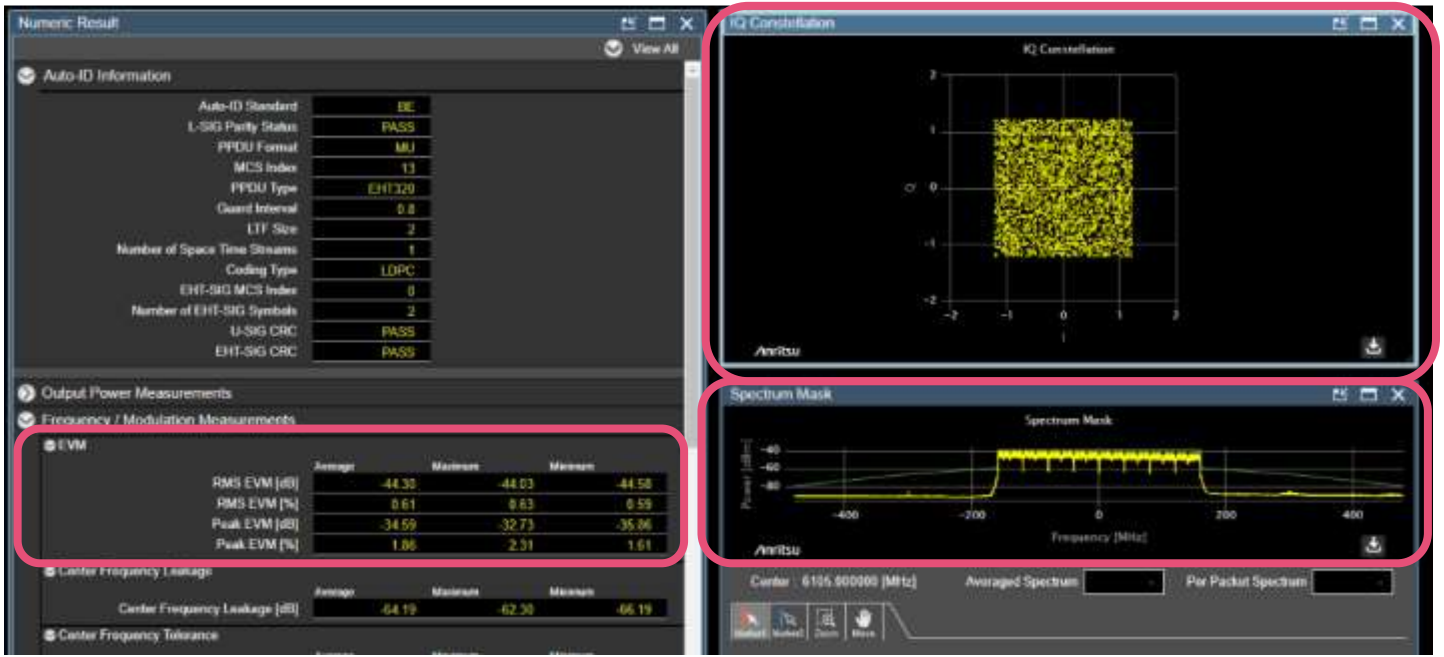
Spectrum allocation



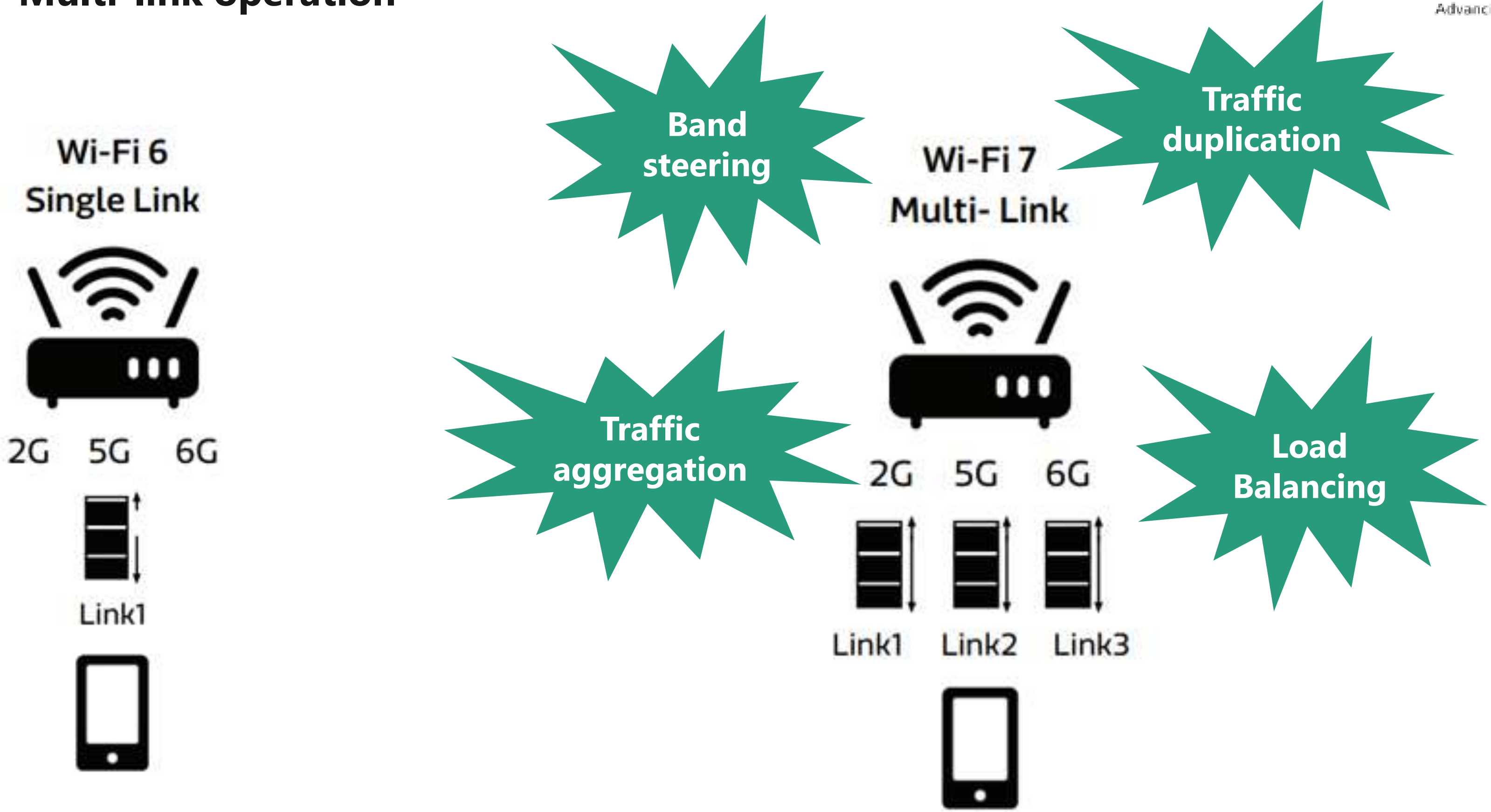
6GHz-Band 1200MHz band-width spectrum

New Features -11be 320MHz bandwidth

In IEEE802.11be, full 6GHz band has six 320MHz bandwidth channels and the max three channels can be used at the same time.
MT8862A will support Tx/Rx RF measurement for 320MHz bandwidth channel in one box with direct mode/network mode.

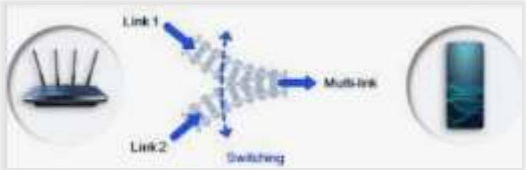


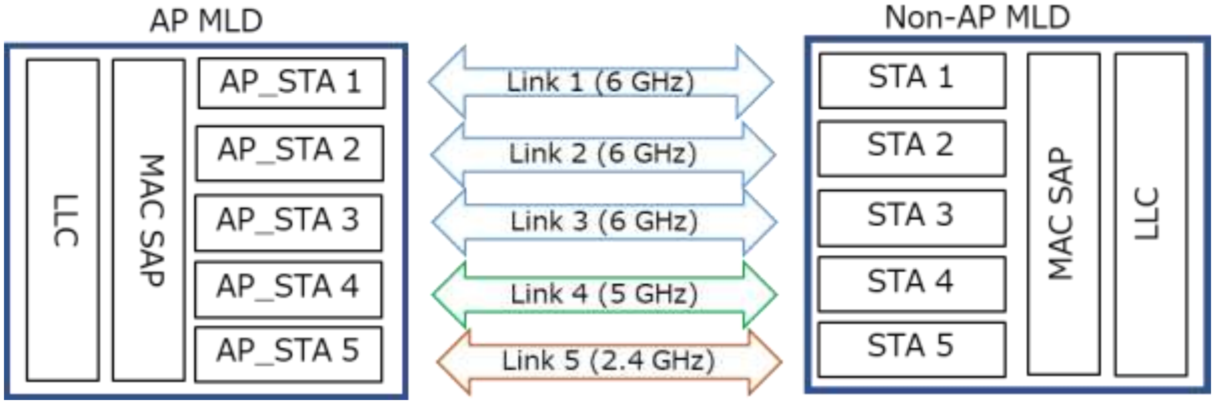
MLO - Multi-link operation



Anritsu
Advancing beyond

Multi-Link Technology





No. of Links	Configuration (Modulation: 4096 QAM, SS: 16 Streams)		Max. Data Rate
	Band [GHz]	Channel Bandwidth Configuration	
2	6	320 MHz x 2 links	92 Gbps
3	6	320 MHz x 3 links	138 Gbps
4	5 / 6	80 MHz x 1 link + 320 MHz x 3 links	149 Gbps
11	2.4/5/6	40 MHz x 2 link + 80 MHz x 2 link +160 MHz x 7 links	194 Gbps

New Features -11be Multi RU

IEEE802.11 newly supports multi-RU function that one user can use multiple RU. MT8862A also supports multi-RU and evaluate multi-RU by selecting predetermined combination of RU by IEEE on GUI.

MT8862A Product Summary

320MHz Bandwidth measurement option – Available from November 2023 !

Connection

- Standards
  - IEEE 802.11a/b/g (20MHz BW)
  - IEEE 802.11n (20/40MHz BW)
  - IEEE 802.11ac (20/40/80/160MHz BW)
  - IEEE 802.11ax (20/40/80/160MHz BW), HESU/HETB
  - **IEEE 802.11be (20/40/80/160/320MHz BW), EHTMU/EHTTB** *1)
  - IEEE 802.11n/ac 2x2 MIMO (up to 80MHz BW)
- Network mode/ Direct mode
- WEP, WPA/WPA2-Personal/**WPA3-Personal(incl.GCMP)** [AP/STA]

RF

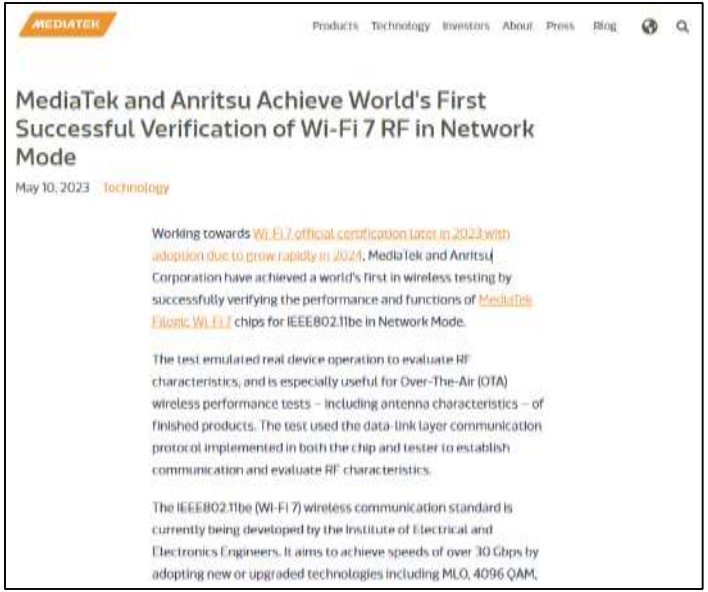
- Frequency 2.4G/5G/6GHz-band (up to 7.125GHz)
- Bandwidth 20MHz/40MHz/80MHz/160MHz/**320MHz**
- Power Output:
  - Aux : -120 to 0dBm
  - Main 1,2 : -120 to 0dBm for 2.4/5GHz
    -120 to -5dBm for 6GHz-band
- Power Input: -65dBm to +25dBm

Tools

- Simple GUI control with web browser
- Frame capture (signaling messages logging)
- Internet connection of DUT from IP data interface *2)

Press release for Wi-Fi 7 with Mediatek

We release joint PR with Mediatek to successed Wi-Fi7 evaluation in network mode. This is the world first successful.



MEDIATEK Products Technology Investors About Press Blog

MediaTek and Anritsu Achieve World's First Successful Verification of Wi-Fi 7 RF in Network Mode

May 10, 2023 Technology

Working towards Wi-Fi 7 official certification later in 2023 with adoption due to grow rapidly in 2024, MediaTek and Anritsu Corporation have achieved a world's first in wireless testing by successfully verifying the performance and functions of MediaTek Filogic Wi-Fi 7 chips for IEEE802.11be in Network Mode.

The test emulated real device operation to evaluate RF characteristics, and is especially useful for Over-The-Air (OTA) wireless performance tests – including antenna characteristics – of finished products. The test used the data-link layer communication protocol implemented in both the chip and tester to establish communication and evaluate RF characteristics.

The IEEE802.11be (Wi-Fi 7) wireless communication standard is currently being developed by the Institute of Electrical and Electronics Engineers. It aims to achieve speeds of over 30 Gbps by adopting new or upgraded technologies including MLO, 4096 QAM,

[MediaTek and Anritsu Achieve World's First Successful Verification of Wi-Fi 7 RF in Network Mode | MediaTek (en)]

Anritsu Advancing beyond

PRODUCTS TECHNOLOGIES INDUSTRIES BUY SUPPORT

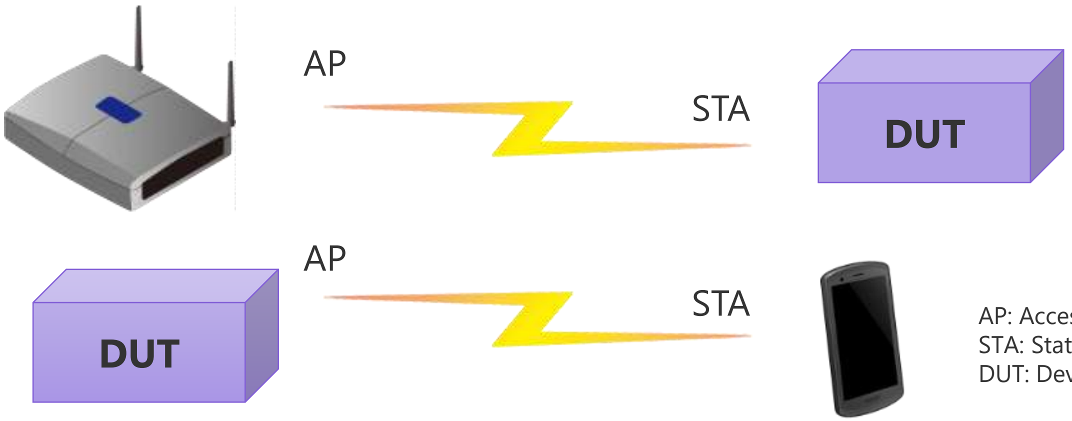
Anritsu–MediaTek Collaboration Successfully Verified Wi-Fi 7 Chip Connection with Network Mode

Vienna – May 3, 2023 –

[Anritsu–MediaTek Collaboration Successfully Verified Wi-Fi 7 Chip Connection with Network Mode | Anritsu Europe]

Anritsu
Advancing beyond

Evaluation under actual operating conditions:
Issues when testing commercial WLAN equipment



AP: Access Point
STA: Station
DUT: Device Under Test

Common complaints when evaluating commercial WLAN equipment include inability to conduct stable, quantitative, or reproducible evaluation.

Using a commercial WLAN reference device instead?

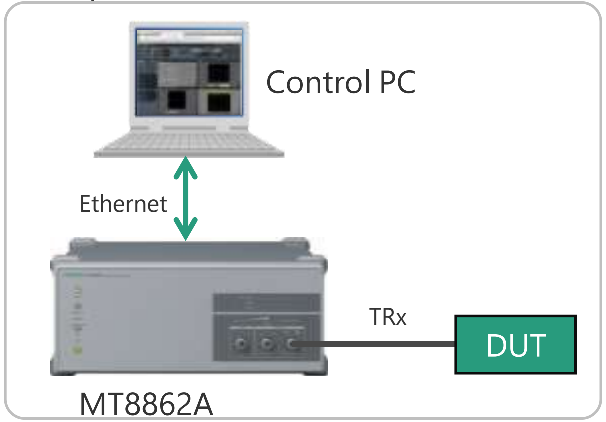
Cannot specify/fix standard and modulation (data rate)

- Cannot control output power at Rx sensitivity evaluation
- Cannot identify whether problem due to DUT or communicating partner device

Evaluation under actual operating conditions:
MT8862A Network Mode solution

- MT8862A simulates an access point (AP) or station (STA) and uses standard WLAN protocol messaging to establish DUT connection and measure RF TRx characteristics under realistic operation conditions
- MT8862A supports operation from Web browser to easily configure test setup.
- MT8862A can control DUT communication state to support quantitative and repeatable evaluation.
  - ✓ Standard (11a/b/g/n/ac/ax)
  - ✓ Data rate (54 Mbps, etc.)
  - ✓ Channel (Frequency)*1

Setup



Test items
- Tx characteristics
  Power, modulation accuracy (EVM*2)
- Rx characteristics
  Receiver sensitivity (PER*3), etc.

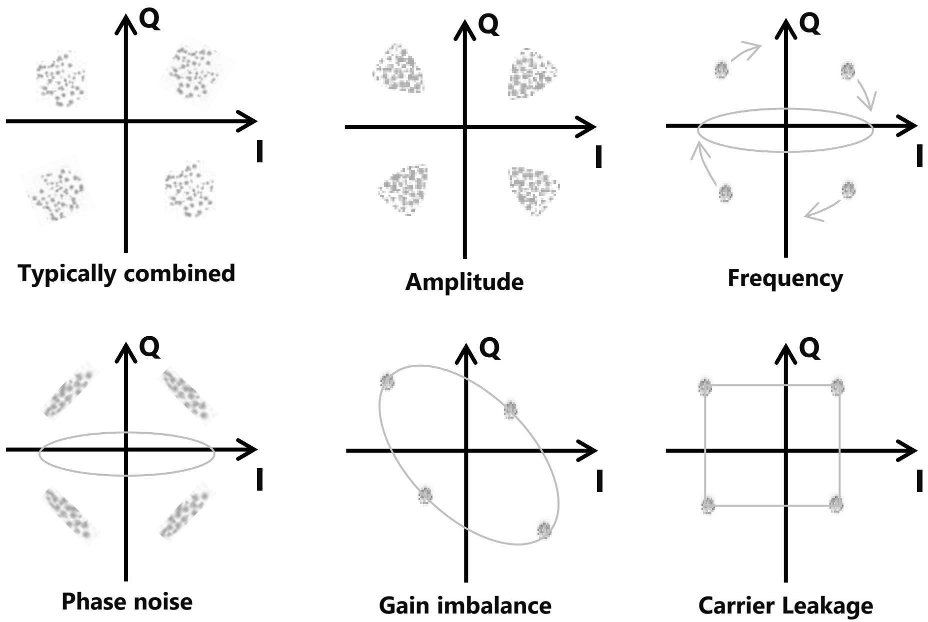
*1: When MT8862A in Access Point mode
*2: EVM = Error Vector Magnitude
*3: PER = Packet Error Rate

2. How we measure WLAN Tx signal quality?

Specified Tx requirements

What is Error Vector Magnitude (EVM)?

Drift phenomena allows inference about factors contributing to degraded characteristics



Specified Rx requirements

Receiver minimum input level sensitivity

Example: 17.3.10.2 Table 17-18
Receiver performance requirements

Data Rate (20 MHz Ch BW)	Modulation	Code Rate	Minimum Sensitivity [dBm]		
			20 MHz ch	10 MHz ch	5 MHz ch
6 Mbps	BPSK	1/2	−82	−85	−88
9 Mbps	BPSK	3/4	−81	−84	−87
12 Mbps	QPSK	1/2	−79	−82	−85
18 Mbps	QPSK	3/4	−77	−80	−83
24 Mbps	16QAM	1/2	−74	−77	−80
36 Mbps	16QAM	3/4	−70	−73	−76
48 Mbps	64QAM	2/3	−66	−69	−72
54 Mbps	64QAM	3/4	−65	−68	−71

The packet error ratio (PER) shall be 10% or less when the PSDU length is 1000 octets.

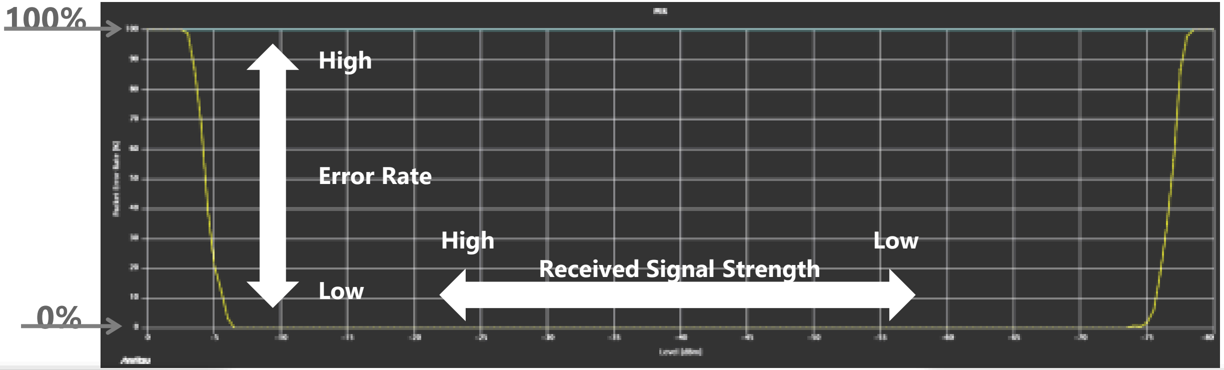
Source: IEEE Std 802.11-2020

Specified Rx requirements

What is Packet Error Rate (PER)?

Signal level at which PER meets permissible value while varying signal level received by DUT

Example of MT8862A test result



Fewer errors = Normal communications

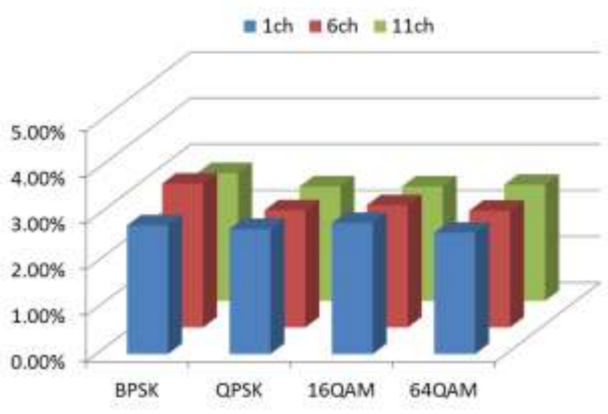
Example of normal receiver sensitivity Bathtub Curve

Low signal and low error = Wide communication coverage area

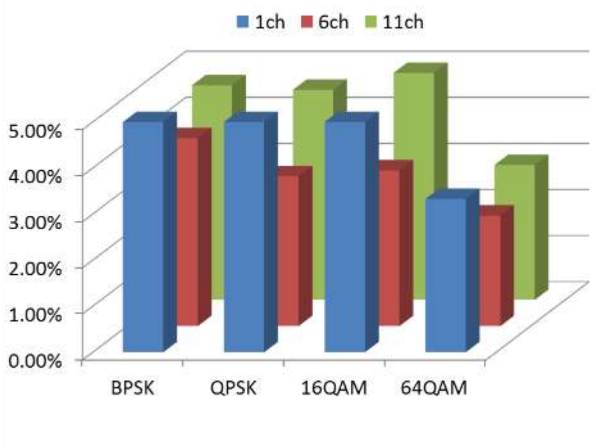
Evaluation of transmitter characteristics – Example:
(11g, 2.4 GHz band)

Modulation accuracy (EVM) per channel (frequency) and data rate (modulation) [%]

DUT_A



DUT_B

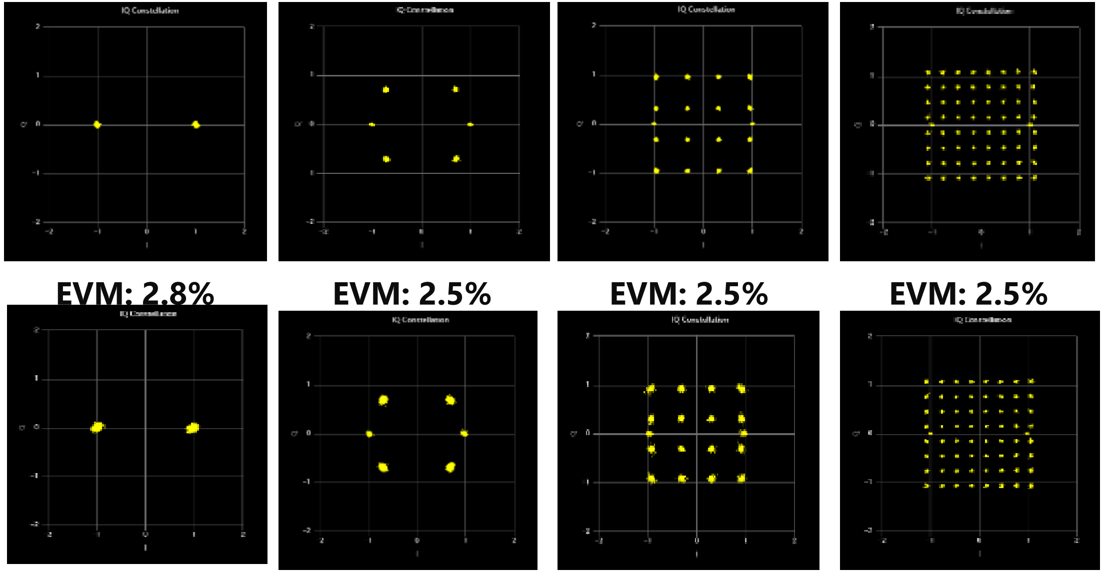


Although the DUT_B modulation accuracy deteriorates when using BPSK/QPSK/16QAM, each modulation still satisfies the required specification.

Anritsu
Advancing beyond

Evaluation of transmitter characteristics – Example:
(11g, 2.4 GHz band)

Constellation for each data rate (modulation) of 11ch



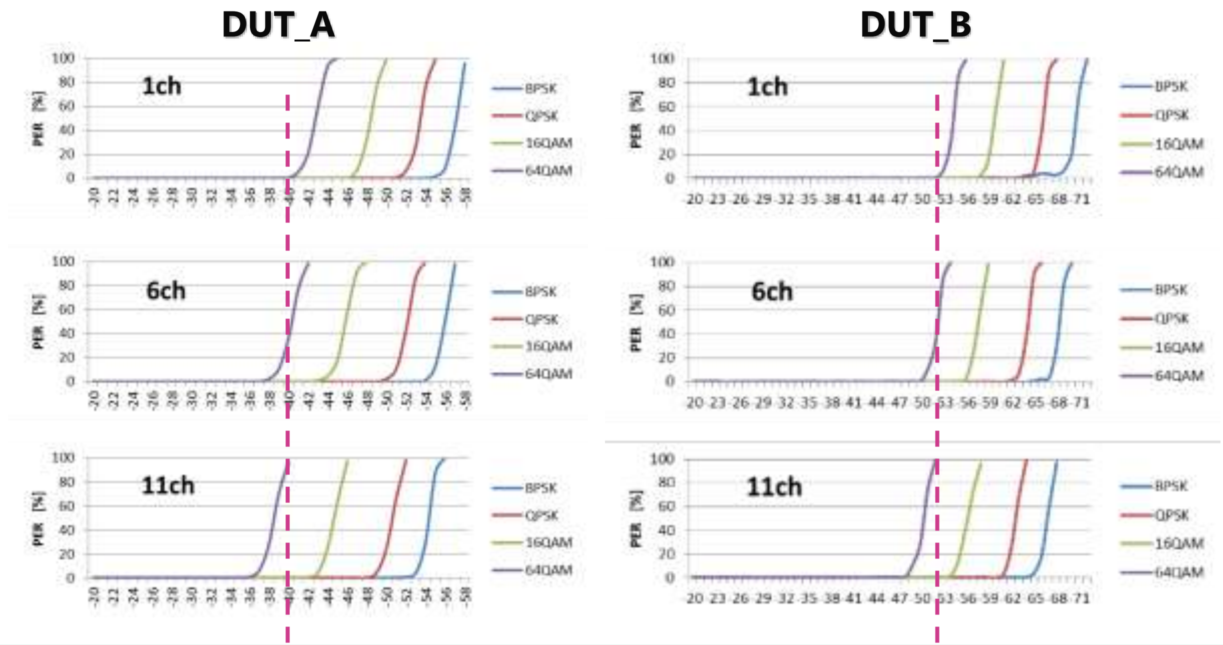
DUT_A 11ch	**EVM: 2.8%**	**EVM: 2.5%**	**EVM: 2.5%**	**EVM: 2.5%**
DUT_B 11ch	**EVM: 4.7%**	**EVM: 4.6%**	**EVM: 4.9%**	**EVM: 2.9%**

By checking the constellation, you can also confirm that each symbol in the cluster is identified correctly.

Anritsu
Advancing beyond

Evaluation of receiver characteristics – Example:
(11g, 2.4 GHz band)

Receiver sensitivity for each channel (frequency) and data rate (modulation)



DUT_B can be received at lower levels than DUT_A

3. WLAN measurement examples

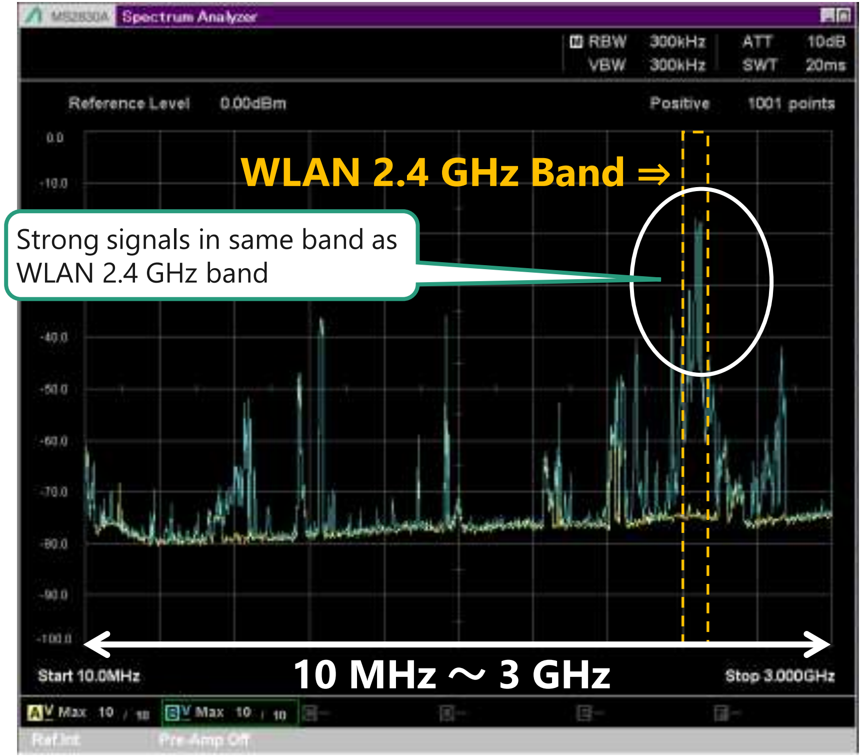
Evaluation of external radio interference:

2. Interference from other WLAN devices, microwave ovens, etc.

Evaluation assumes an actual WLAN operating environment to evaluate transmitter/receiver characteristics when exposed to radio waves from nearby devices.

*1 Electronic Toll Collection

Evaluation of external radio interference:
Microwave oven



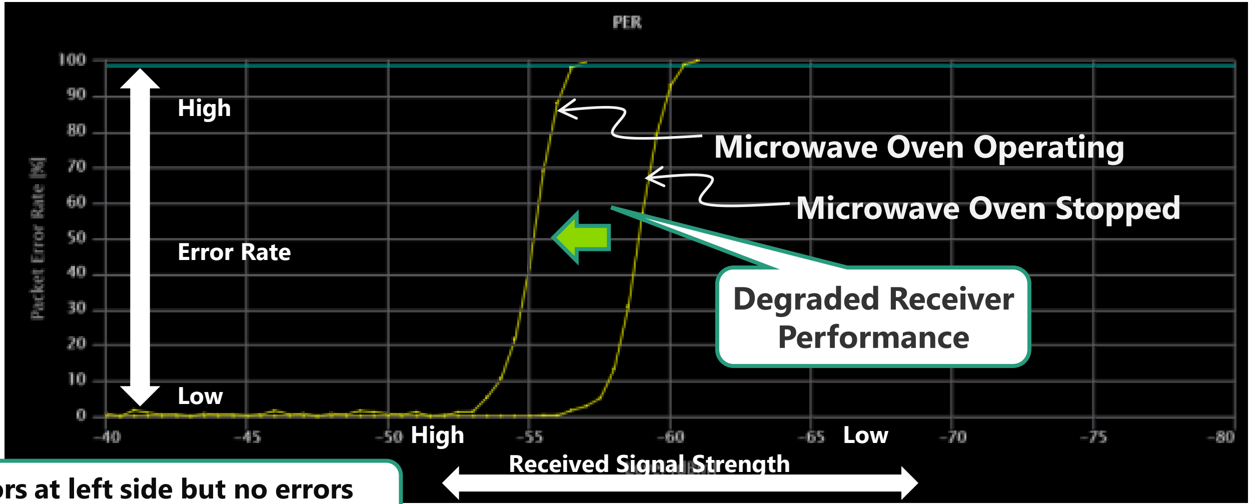
A microwave oven heats food by using a magnetron vacuum tube to emit microwaves.

The emitted frequency is 2.45 GHz, which interferes with the WLAN 2.4 GHz band.

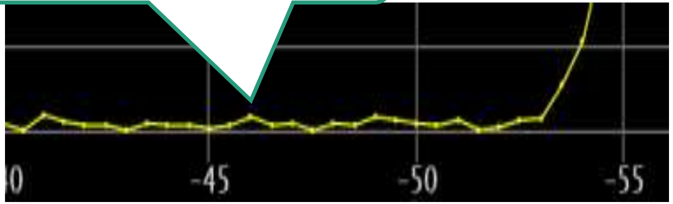
Yellow: Steady state
Blue: Microwave operating

Evaluation of external radio interference:
Microwave oven

MT8862A: Packet Error Rate (PER) graph



Small errors at left side but no errors when microwave oven stopped



Anritsu Advancing beyond

Evaluation of internal radio interference (self-poisoning):

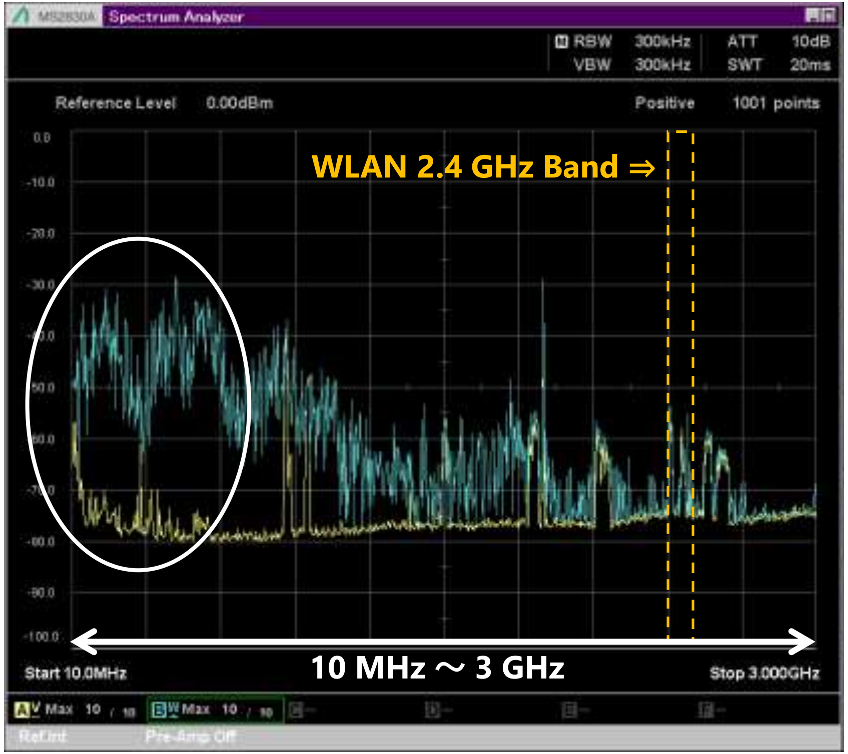
3. Product internal noise from own power supply circuit, CPU board, LCD, etc.

The finished product with all components mounted is placed under load and subjected to interference (self-poisoning) from various internal noise sources to evaluate the transmitter and receiver characteristics.

What is internal radio interference?

As equipment becomes smaller and lighter, conventional countermeasures, such as separating the physical distance between the wireless board and other boards or installing shielding, are becoming more difficult. In contrast, the speeds of CPUs, power converters, fans and other motors, and noise sources that adversely affect WLAN communications are increasing. **This phenomenon of internal noise from sources within the equipment interfering with WLAN communications is called "self-poisoning" or "intra-system EMC".**

Product internal interference:
Motor



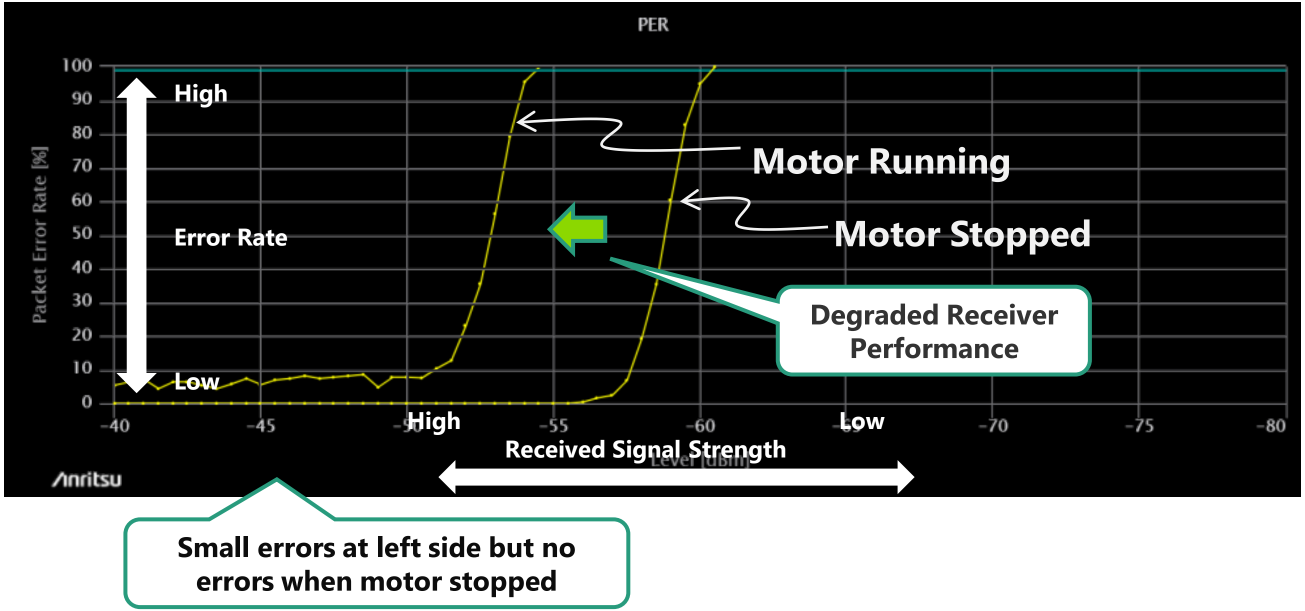
End products, such as home appliances, cars, and industrial equipment have built-in power circuits and motors.

Motor noise has a lower frequency than WLAN but is generated over a wide range (left figure).

Yellow: Steady state
Blue: Motor running

Product internal interference:
Motor

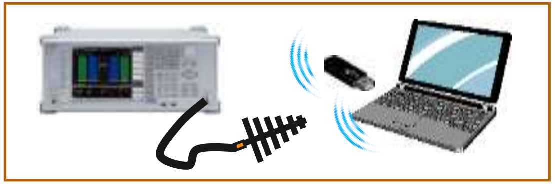
MT8862A: Packet Error Rate (PER)



Product internal interference:

USB 3.0

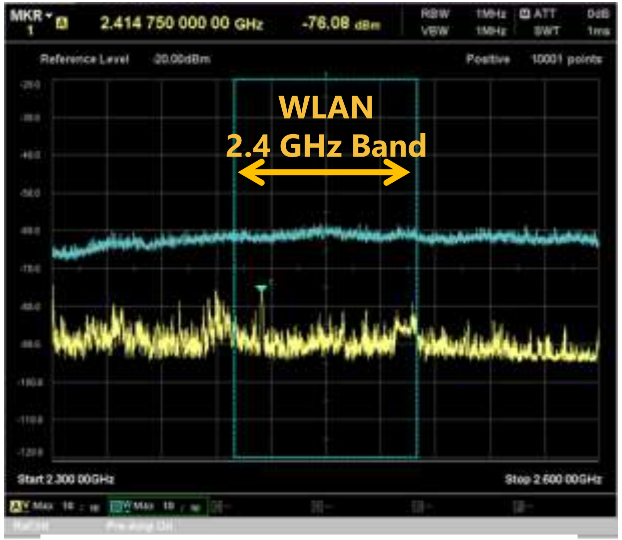
Theoretically, USB3.0 can transmit data at up to 5 Gbps, but its base frequency is 2.5 GHz, so radiated noise may interfere with the WLAN 2.4 GHz band.



PC ① USB 2.0

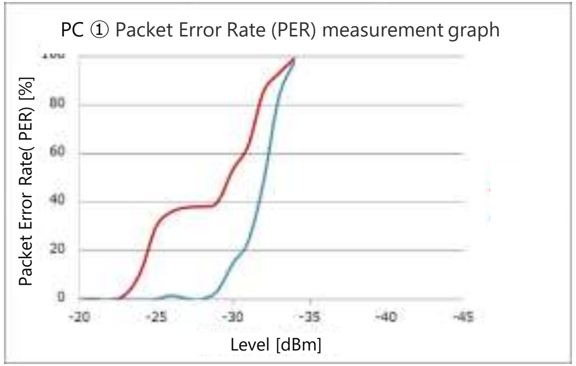
- ✓ Yellow: Steady state (no communication)
- ✓ Blue: Operating (communicating)

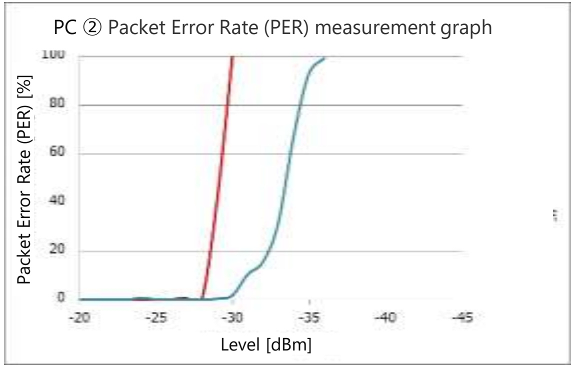
PC ① USB 3.0

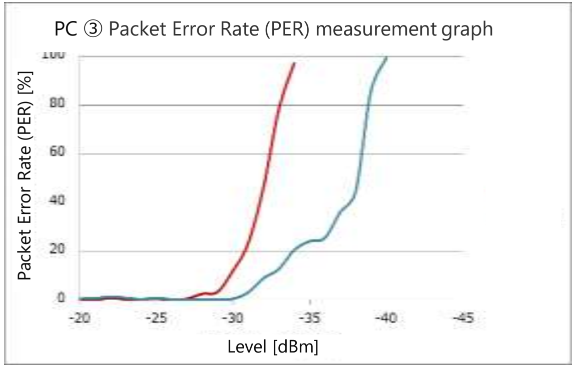


- ✓ Yellow: Steady state (no communication)
- ✓ Blue: Operating (communicating)

Evaluation of internal radio interference:
USB 3.0





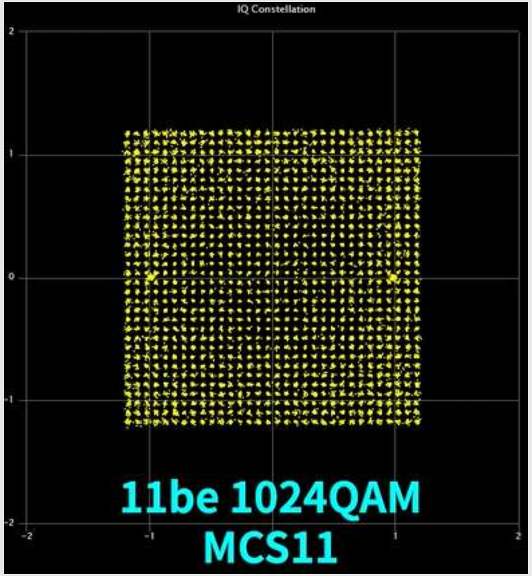


- ✓ Blue: Steady state (no communication)
- ✓ Red: Operating (communicating)

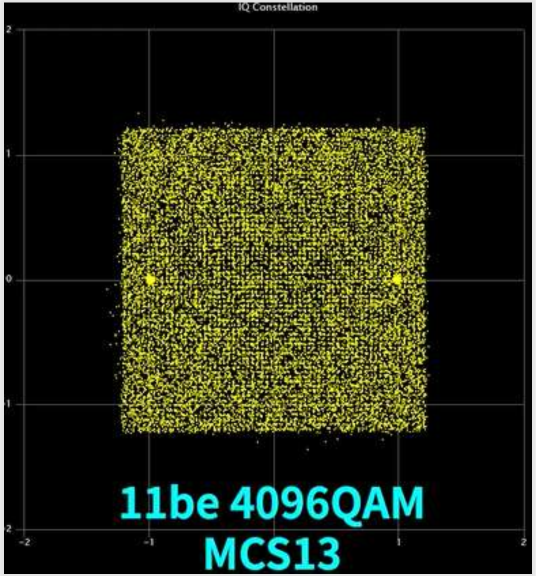
Data transmission over USB 3.0 on three PCs degrades WLAN reception sensitivity.

It is important to take countermeasures to both external radiation of internal noise and to noise leaking internally, and to verify the countermeasures' effectiveness.

3. Wi-Fi 7: Modulation examples



10 bits/symbol

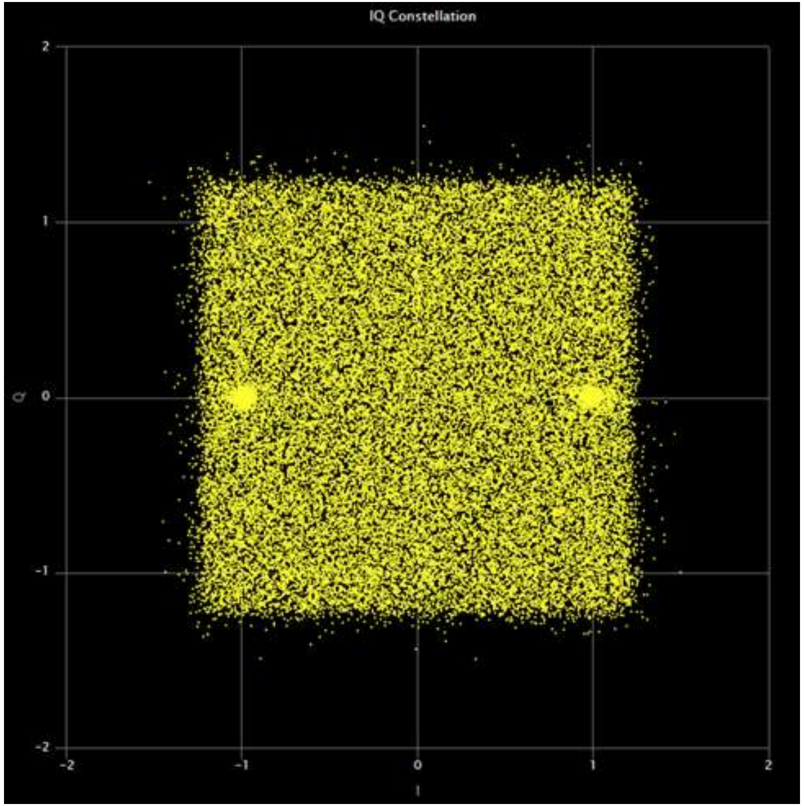


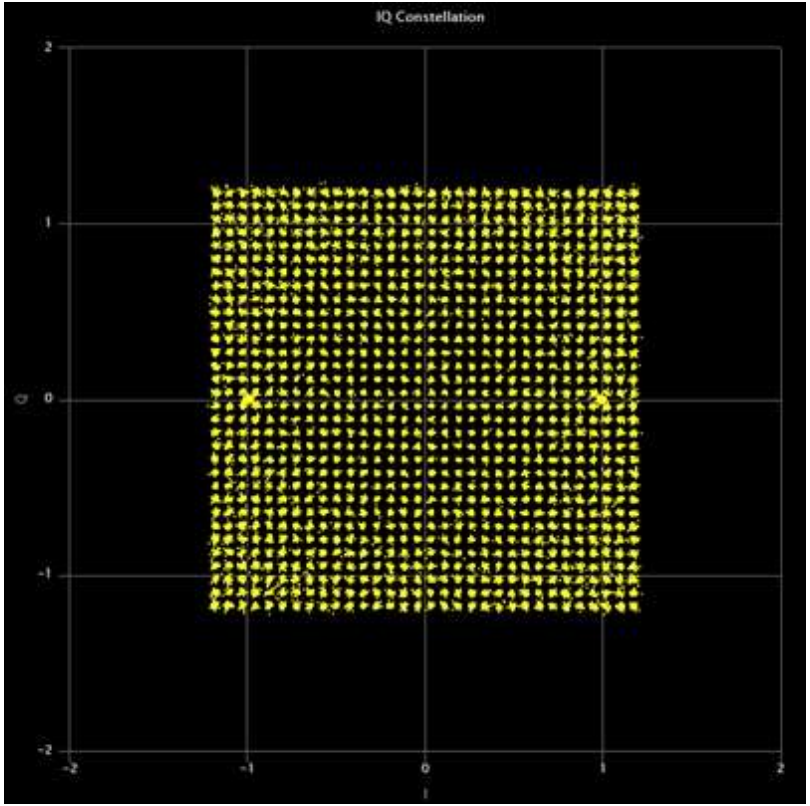
12 bits/symbol

Theoretically Wi-Fi 7 can support up to >30 Gbps.

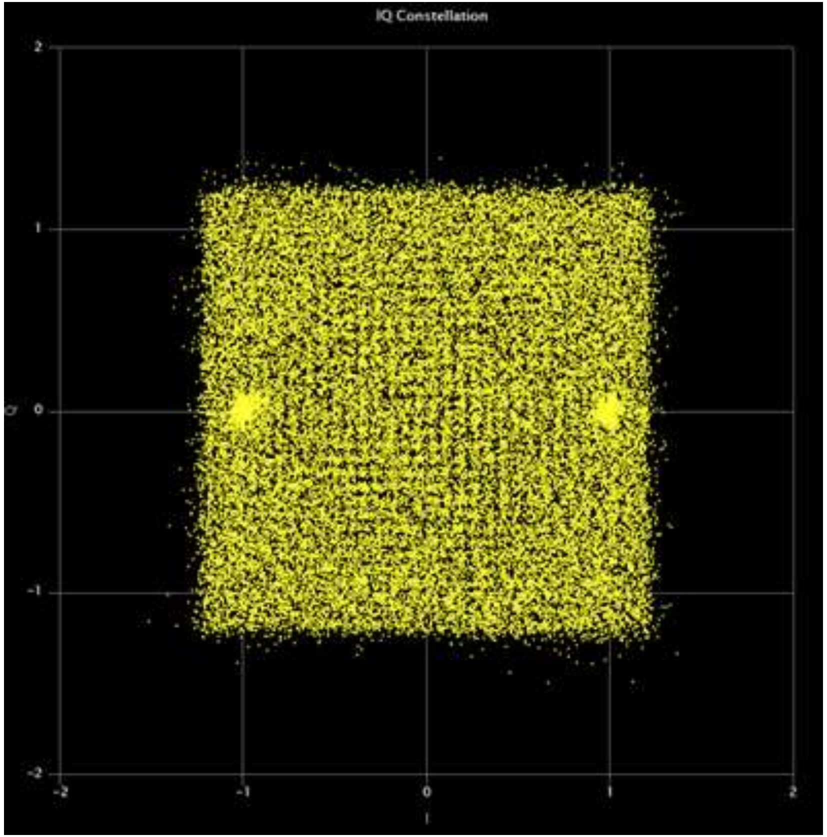
Practically, a device implementing 2 Antenna, allocated 2x 160 MHz, at 4096 QAM, data rate ~ 2.8 Gbps

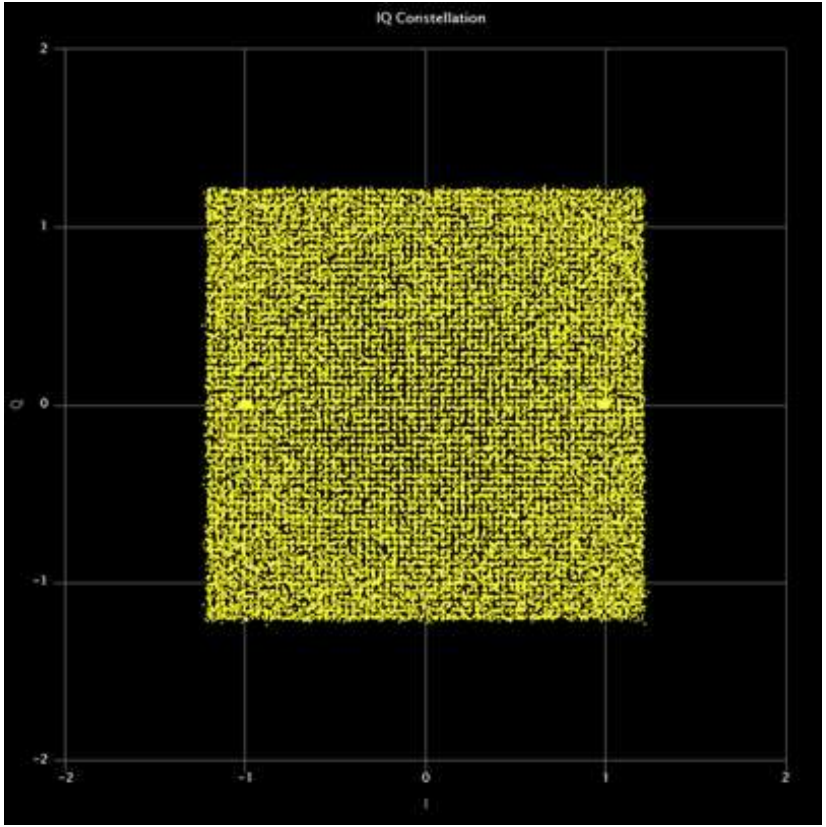
3. Comparison of 2 Wi-Fi7 smartphones – 1024 QAM, MCS 11





3. Comparison of 2 Wi-Fi7 smartphones – 4096 QAM, MCS 13





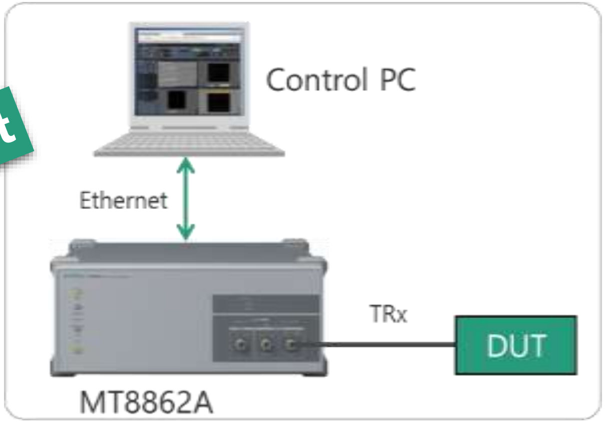
4. Conclusions

- 802-11be brings in some new RF capabilities and corresponding measurement challenges.
- New requirements on testing for higher data rates, on both Tx and Rx side.
- Fundamentals of Wi-Fi RF testing remain the same....but now pushed to greater extremes.
- New testing features are required for advanced access modes.
- MT8862A has the required features, and network mode capabilities, to support validation of latest generation chipsets and devices.

Quality improvement

Risk avoidance

Brand value improvement



Anritsu

Advancing beyond

And finally

Thank you again to the Department of Computer Science and Technology for kindly hosting this event

- A PDF of the speaker presentations will be available upon request - The CW Team will email you with further details.
- Evaluation Forms - Please can you complete our online event feedback form. This information helps us to improve our events and has been sent via email.

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