WIFI 6 - MORE THAN JUST SPEEDS
IT'S ABOUT EFFICIENCY AND DENSITY

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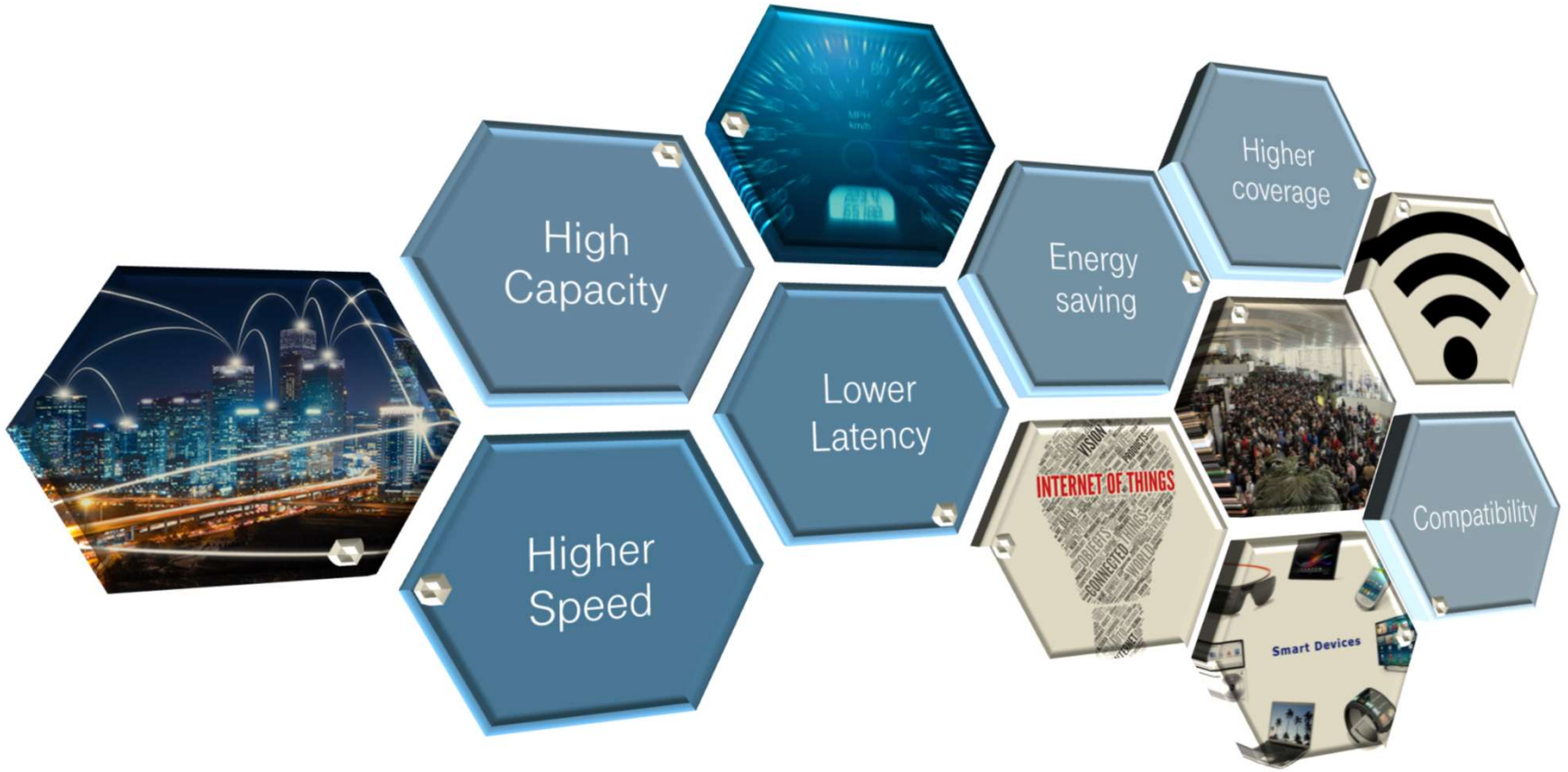
Budapest 2021. március 29

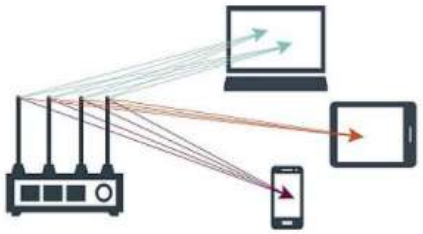

Main drivers of Wi-Fi6
Key Technologies
WiFi6 & 5G
Market overview

WIFI EVOLUTION – INITIALLY THE SPEED WAS IN THE FOCUS
NOW THE EFFICIENCY AND OPERATION IN DENSE ENVIRONMENT



Wi-Fi CERTIFIED 6™ key features

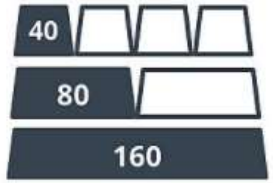
Multi-User MIMO



OFDMA

Beamforming

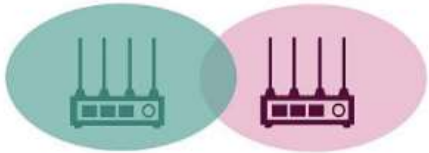
160 MHz Channel Bandwidth



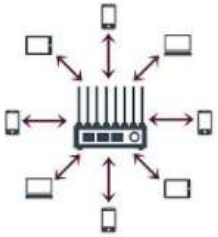
Wi Fi 6™ CERTIFIED

Target Wake Time

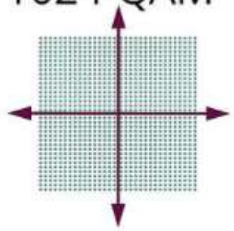
BSS Coloring



8 Spatial Streams



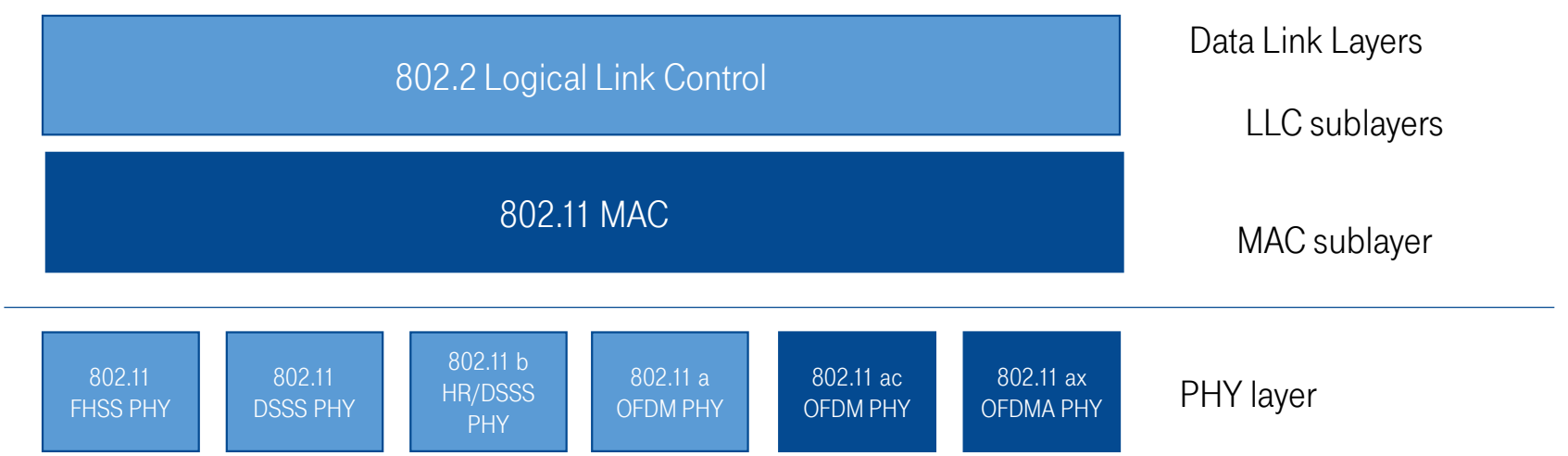
1024-QAM




TECHNOLOGY

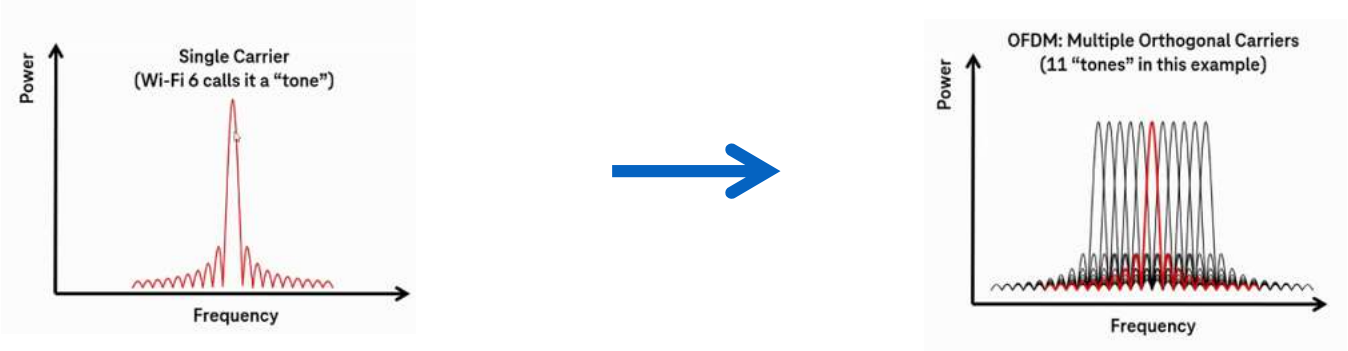
IEEE 802.11 STANDARDS AND OSI MODEL

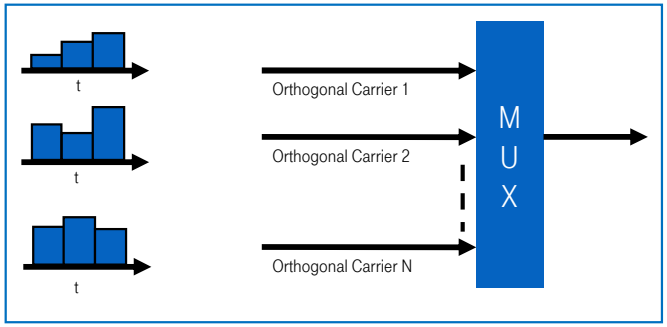
MAC layer is common to all 802.11 Physical layer (PHY) standards



OFDM (ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING)

With OFDM, data is transmitted over multiple orthogonal carriers. The carriers are orthogonal (they are spaced such that their sideband are aligned and do not interfere with the carriers' center frequencies)

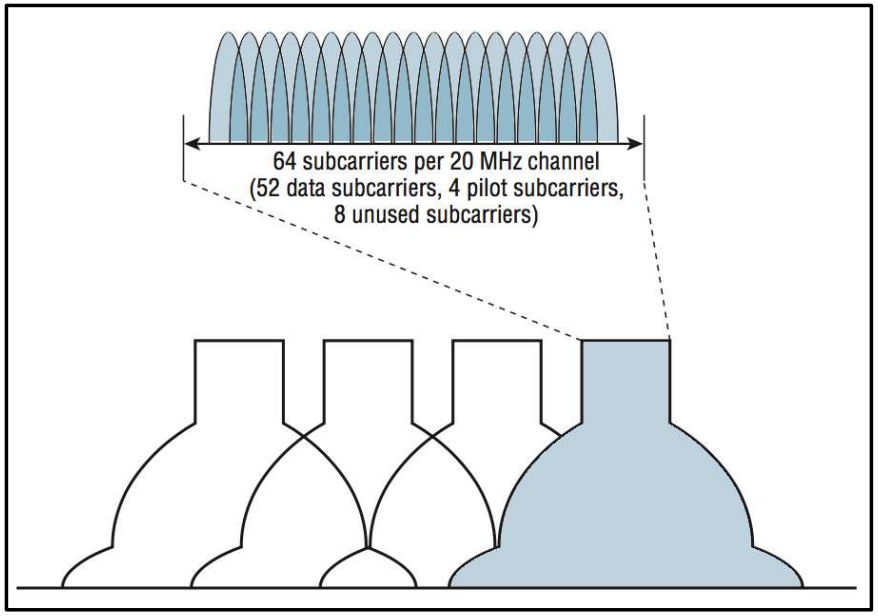




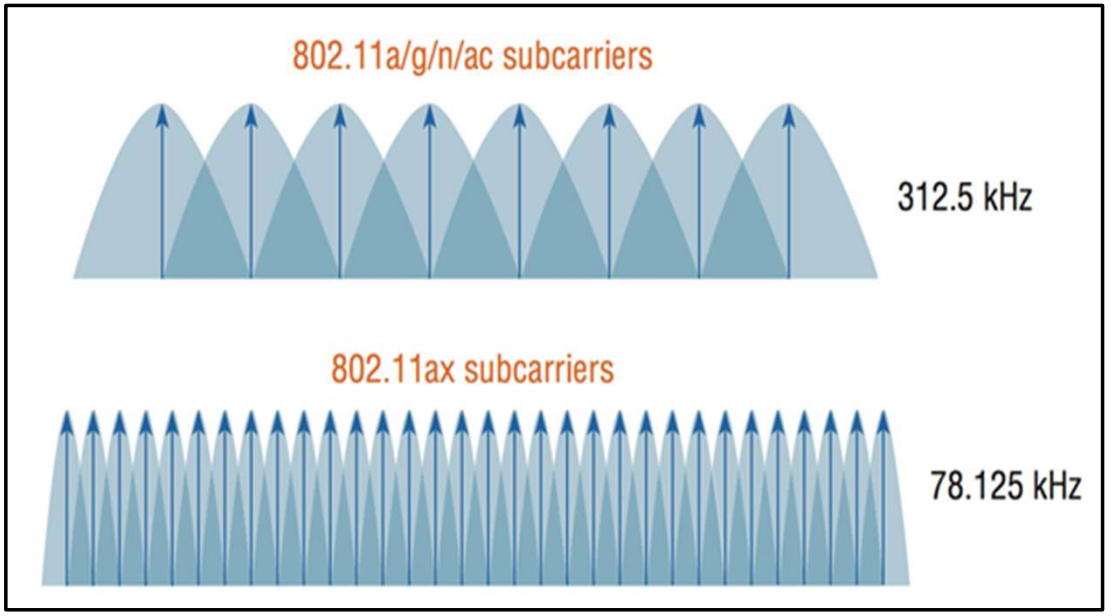
OFDM/OFDMA SUBCARRIERS

The narrow subcarrier spacing allows better equalization and therefore enhanced channel robustness.

802.11n/ac/ax 20 MHz channel—OFDM subcarriers

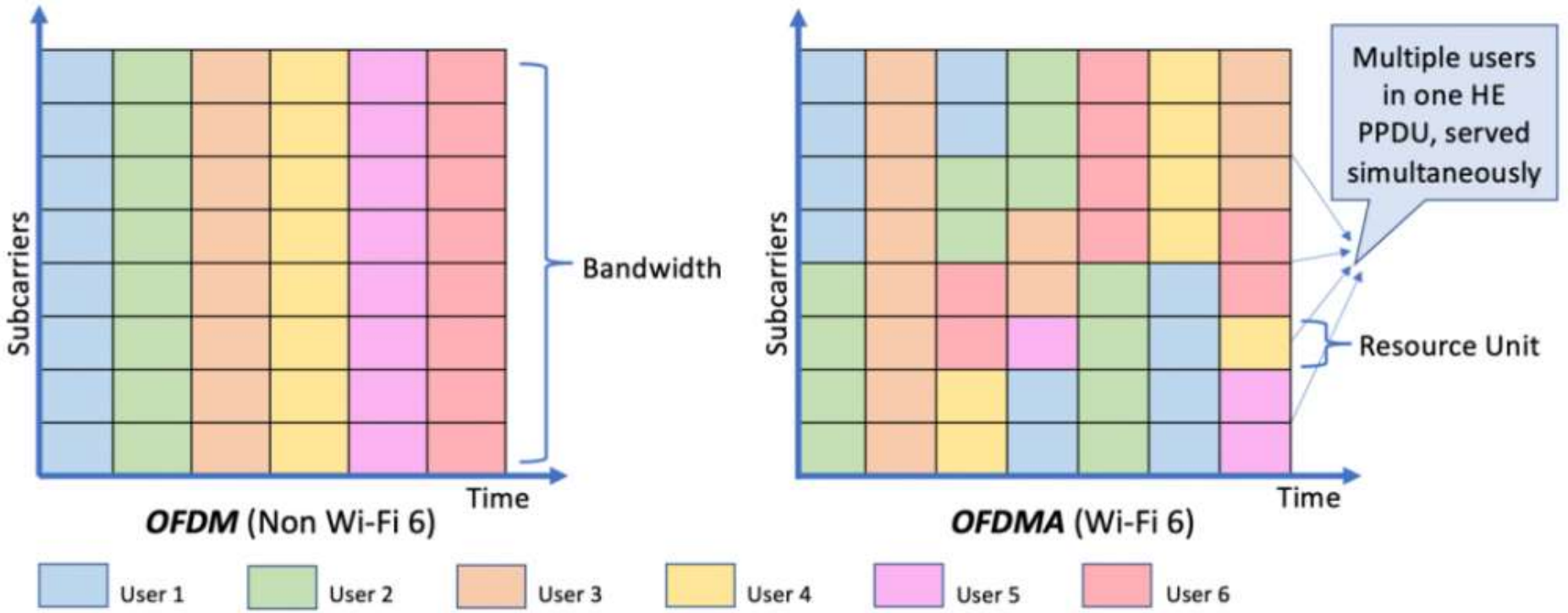


OFDM/OFDMA subcarriers spacing



OFDMA symbol time : 12.8 µs
OFDM symbol time: 3.2 µs

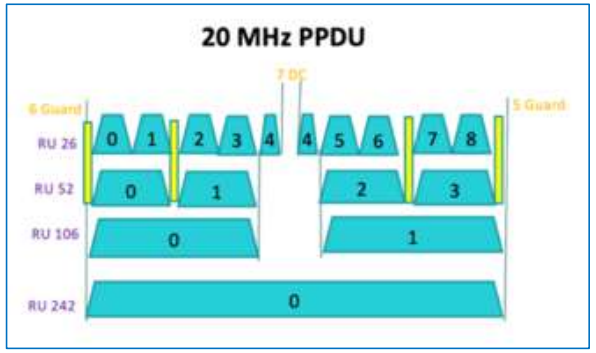
OFDM ALLOWS SINGLE USER TRANSMISSION WHILE OFDMA USES RUs THAT CAN BE INDIVIDUALLY ASSIGNED TO STA (CLIENT)



Source: https://blogs.cisco.com/networking/wi-fi-6-ofdma-resource-unit-ru-allocations-and-mappings

RESOURCE UNIT MAP
A STA CAN ONLY BE ASSIGNED TO ONE RU AT A TIME

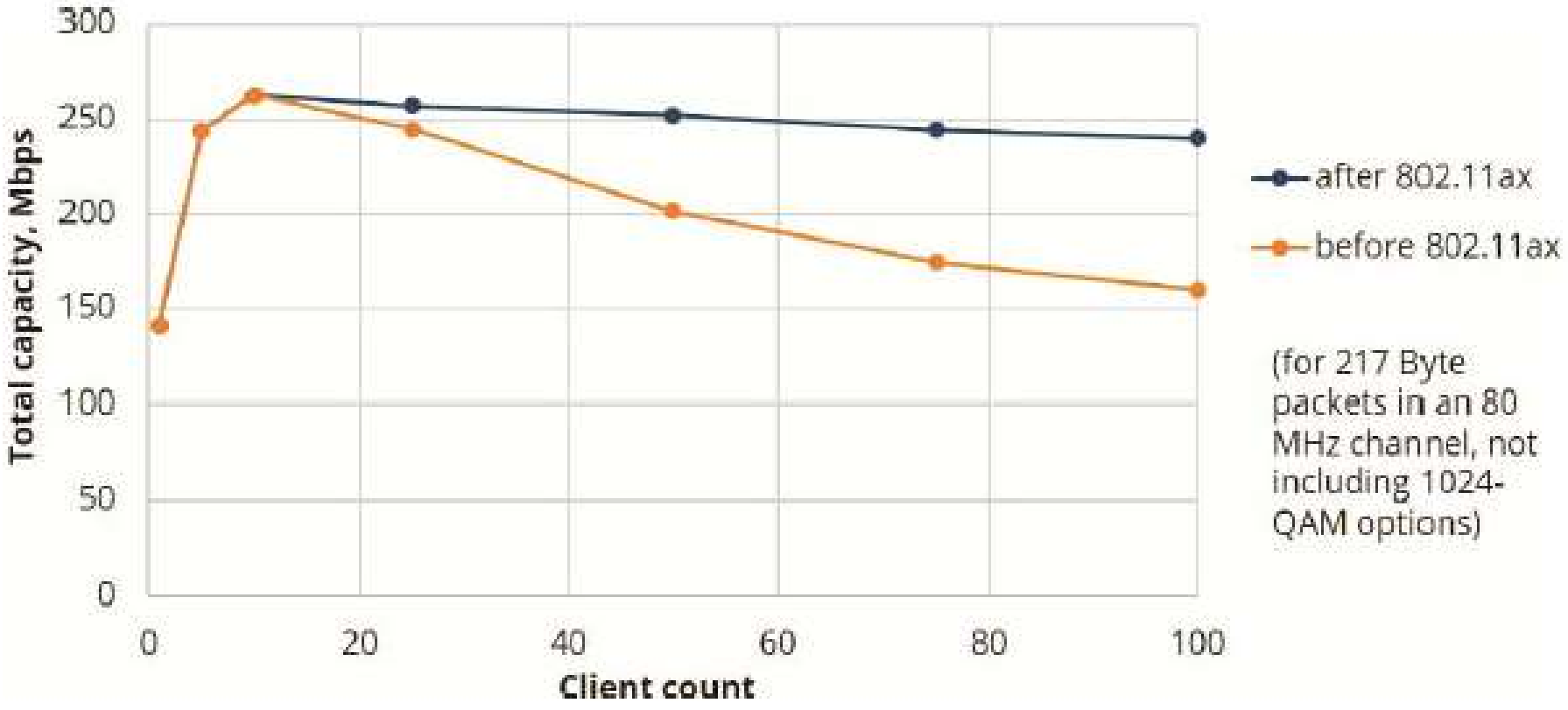
Bandwidth	Tones WiFi6	Tones WiFi5
20MHz	256	64
40MHz	512	128
80MHz	1024	256
160MHz	2048	512



RU type	20MHz	40MHz	80MHz	80+80/160MHz
26-tone RU	9	18	37	74
52-tone RU	4	8	16	32
106-tone RU	2	4	8	16
242-tone RU	1	2	4	8
48-toneRU	N/A	1	2	4
996-tone RU	N/A	N/A	1	2
2x996-tone RU	N/A	N/A	N/A	1

Some Tones are used for DC (direct conversion), Guard and unused (Null Sub carriers) tones.

THROUGHPUT VS STA NUMBER WITH SMALL PACKETS
NO SIGNIFICANT PERFORMANCE DEGRADATION



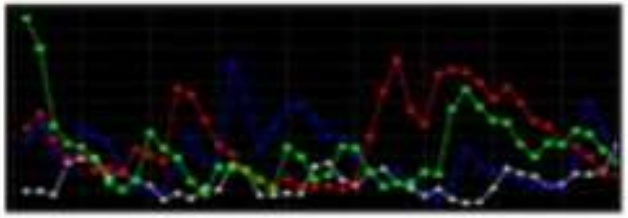
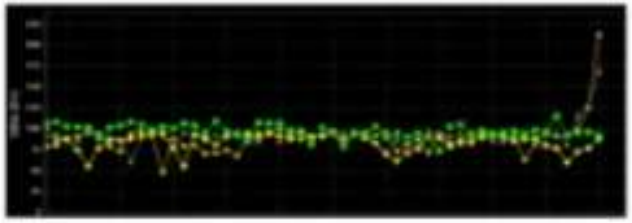
STABLE TCP THROUGHPUT WITH LOW LATENCY (<5 ms) USING OFDMA

- Test environment

- 4 Smartphones (Wi-Fi6)

- Performance Results

- Latency is reduced by about 80%
- Throughput fluctuation per user is reduced
- Througput about 1G (2SS, 80MHz, 1024QAM)

	Latency	Throughput Variation per user
w/o OFDMA	21 ms	
w/ OFDMA	4 ms	

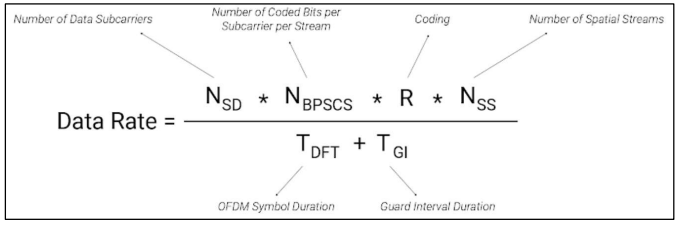
Source: SK telekom

MCS INDEX – WHY SO DIFFICULT TO DETERMINE THE WI-FI SPEED

The Modulation Coding Scheme (MCS) index is a metric based on several parameters of a WiFi connection between two stations.

www.mcsindex.com

Math behind it

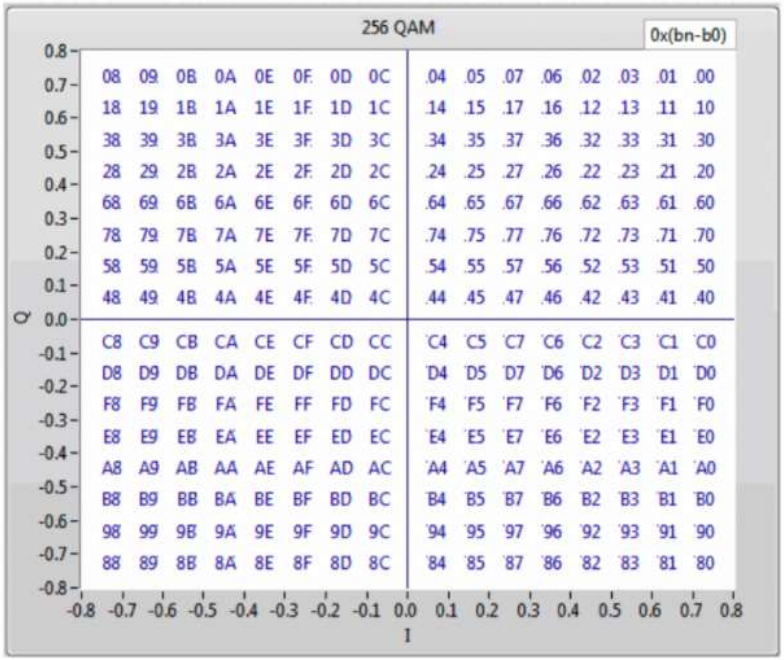


						OFDM (Prior 11ax)							
MCS Index			Spatial Stream	Modulation	Coding	20MHz		40MHz		80MHz		160MHz	
HT	VHT	HE				0.8µs GI	0.4µs GI	0.8µs GI	0.4µs GI	0.8µs GI	0.4µs GI	0.8µs GI	0.4µs GI
0	0	0	1	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	1	1	1	QPSK	1/2	13	14.4	27	30	58.5	65	117	130
2	2	2	1	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	3	3	1	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	4	4	1	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	5	5	1	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	6	6	1	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	7	7	1	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
	8	8	1	256-QAM	3/4	78	86.7	162	180	351	390	702	780
	9	9	1	256-QAM	5/6	N/A	N/A	180	200	390	433.3	780	866.7
		10	1	1024-QAM	3/4								
		11	1	1024-QAM	5/6								
8	0	0	2	BPSK	1/2	13	14.4	27	30	58.5	65	117	130
9	1	1	2	QPSK	1/2	26	28.9	54	60	117	130	234	260
10	2	2	2	QPSK	3/4	39	43.3	81	90	175.5	195	351	390
11	3	3	2	16-QAM	1/2	52	57.8	108	120	234	260	468	520
12	4	4	2	16-QAM	3/4	78	86.7	162	180	351	390	702	780
13	5	5	2	64-QAM	2/3	104	115.6	216	240	468	520	936	1040
14	6	6	2	64-QAM	3/4	117	130	243	270	526.5	585	1053	1170
15	7	7	2	64-QAM	5/6	130	144.4	270	300	585	650	1170	1300
	8	8	2	256-QAM	3/4	156	173.3	324	360	702	780	1404	1560
	9	9	2	256-QAM	5/6	N/A	N/A	360	400	780	866.7	1560	1733.3


MODULATION

25% INCREASMENT IN PHY DATA RATE USING 1024 QAM

11ac – 256 QAM
8 bits per symbol



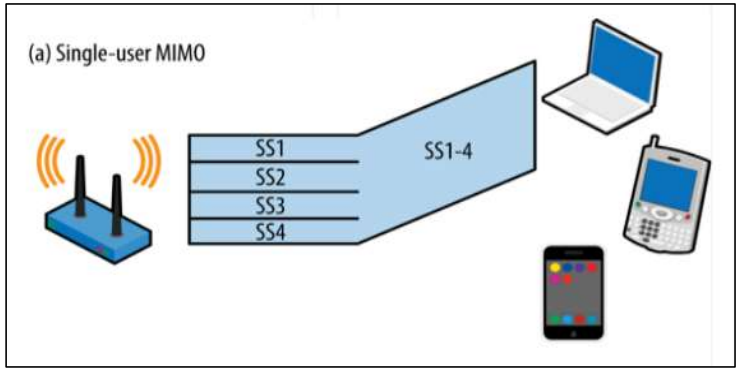
TX EVM MCS9 = -32 dB
Min Sens MCS9 (20 MHz, 80 MHz) = -57, -51 dBm

11ax – 1024 QAM
10 bits per symbol

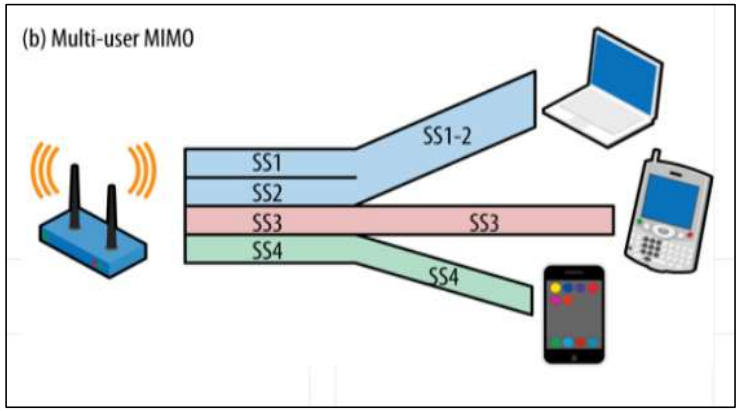
TX EVM MCS11 = -35 dB
Min Sens MCS11 (20 MHz, 80 MHz) = -52, -46 dBm


MULTIUSER MI-MO

MIMO/MU-MIMO TECHNOLOGIES



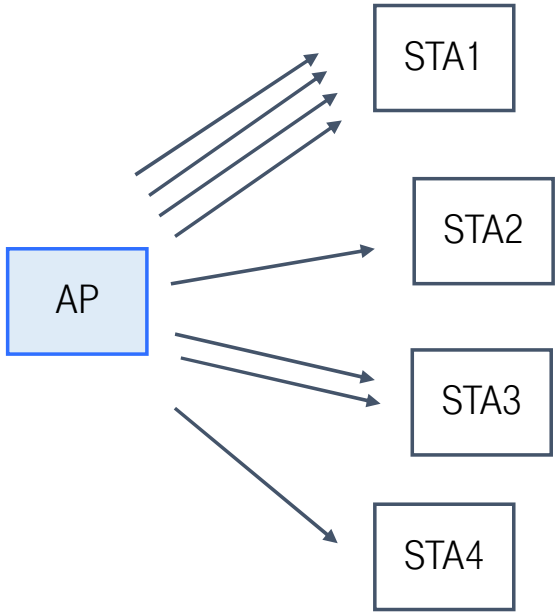
- Single User MIMO (Multiple Input – Multiple Output) allows the AP to send data via several antennas to ONE client
- Data is splitted to parallel streams
- Client needs to provide several antennas as well



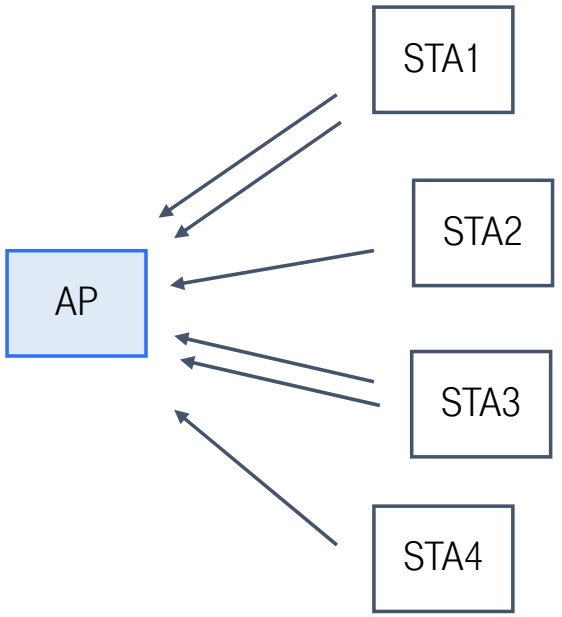
- Multi User MIMO (Multiple Input – Multiple Output) allows the AP to send data via several antennas to SEVERAL client
- MU-MIMO utilises „beamforming”, a technology that allows to focus the electric signal locally to a certain device,
- Available from Wi-Fi5 but optional
- Same MCS should be used by all STA

UPLINK MULTI-USER MIMO (UL MU-MIMO)

WiFi5: Downlink MU-MIMO
Max 8 SS @DS



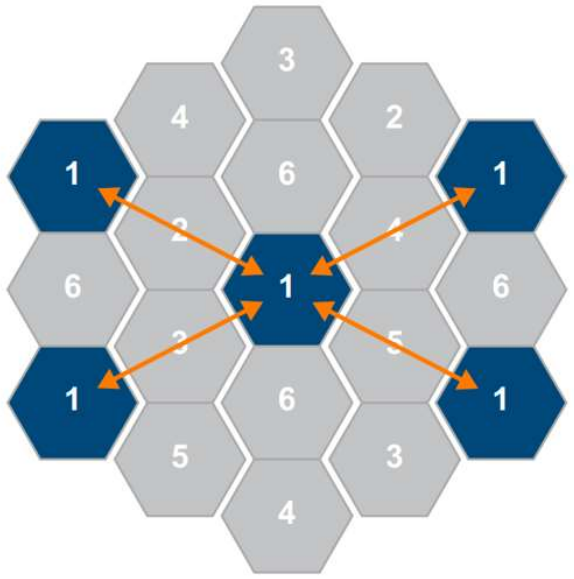
WiFi6: Downlink + Uplink MU-MIMO
Max 8SS@DS and4SS@US



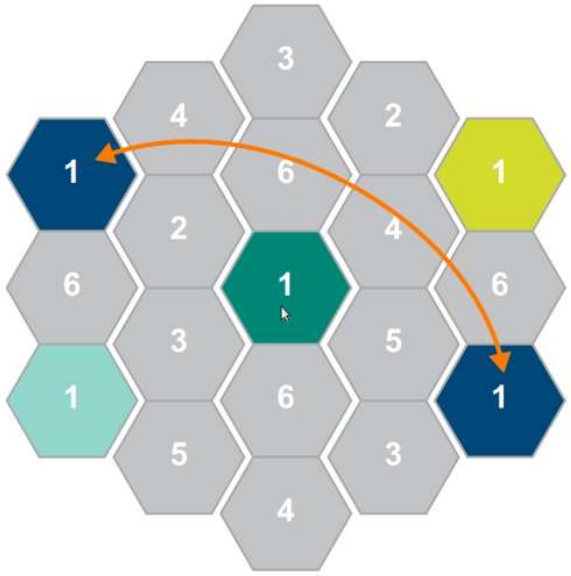
MU-MIMO should be supported by both AP and STA.
MU-MIMO with Wi-Fi6 works in both 2.4 GHz & 5GHz (DS:8, UL:4).
SS depends on the number of antennas (2x2:2, 3x3:3, 4x4:2 etc)


BSS COLORING

BSS COLORING REDUCES INTERFERENCE AMONG DEVICES USING THE SAME CHANNELS



Without BSS coloring, all overlapping channels interfere



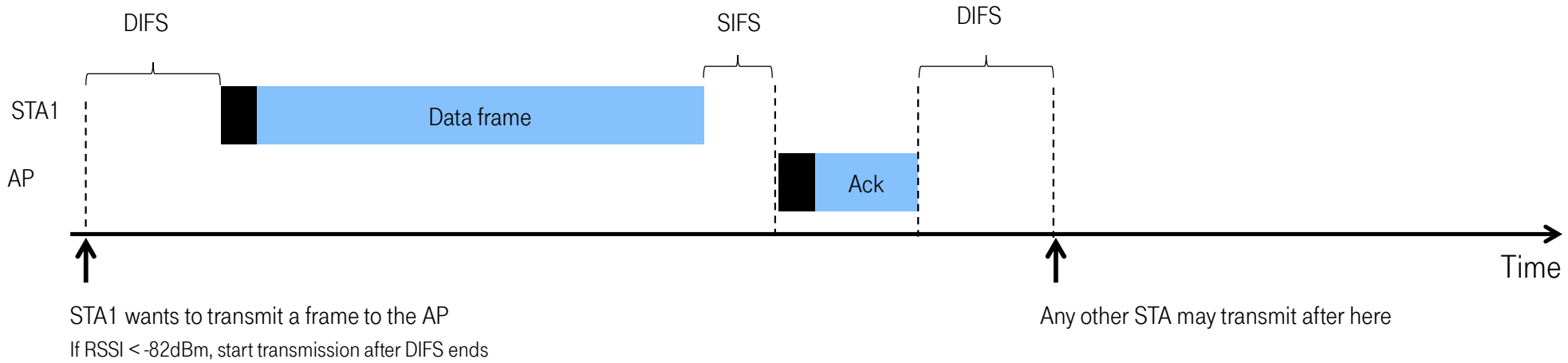
With BSS coloring only matching colors interfere

802.11 MEDIUM ACCESS CONTROL

Wireless LAN is using CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) as medium access control scheme

Before transmission, a STA has to sense that the channel is free (DIFS (DCF Inter-Frame Space, 34 us))

It may then send the frame and expects an ACK from the receiving STA after a SIFS (Short Inter-Frame Space, 16us)



802.11 MEDIUM ACCESS CONTROL (2)

In case a STA sense the transmission of another STA during DIFS, it has to wait until the transmission is over.

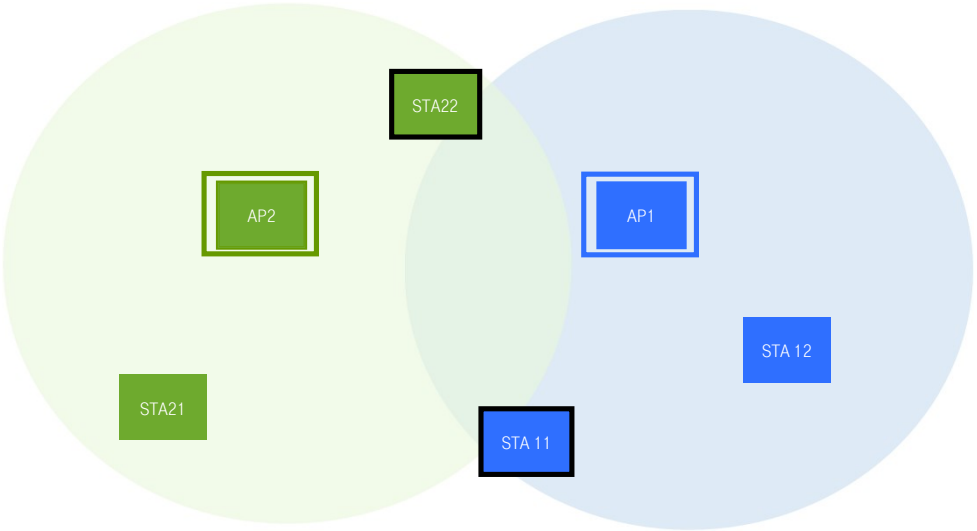
Then is waits for another DIFS plus a random duration

BSS COLORING

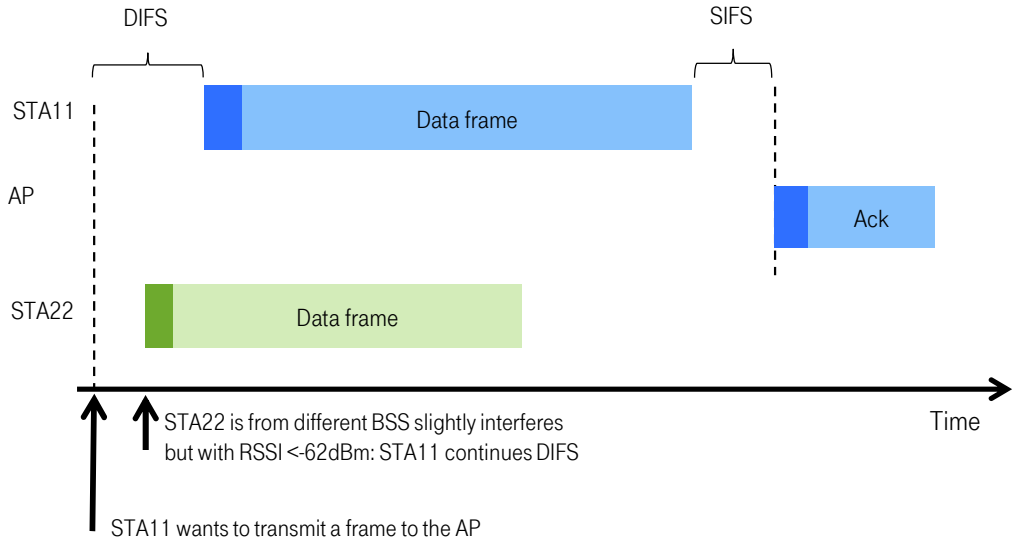
With Wi-Fi6 BSS Coloring each AP is automatically assigned a value in the range 1-63 („color”), which is included in the preamble of each frame of the AP and its STA in the BSS.

When waiting a DIFS, a STA ignores frames of other STAs that have a different color and the RSSI is less than -62dBm.

This increases the density in which Wi-Fi6 network can be deployed.



Two Aps with different colors and slightly overlapping ranges

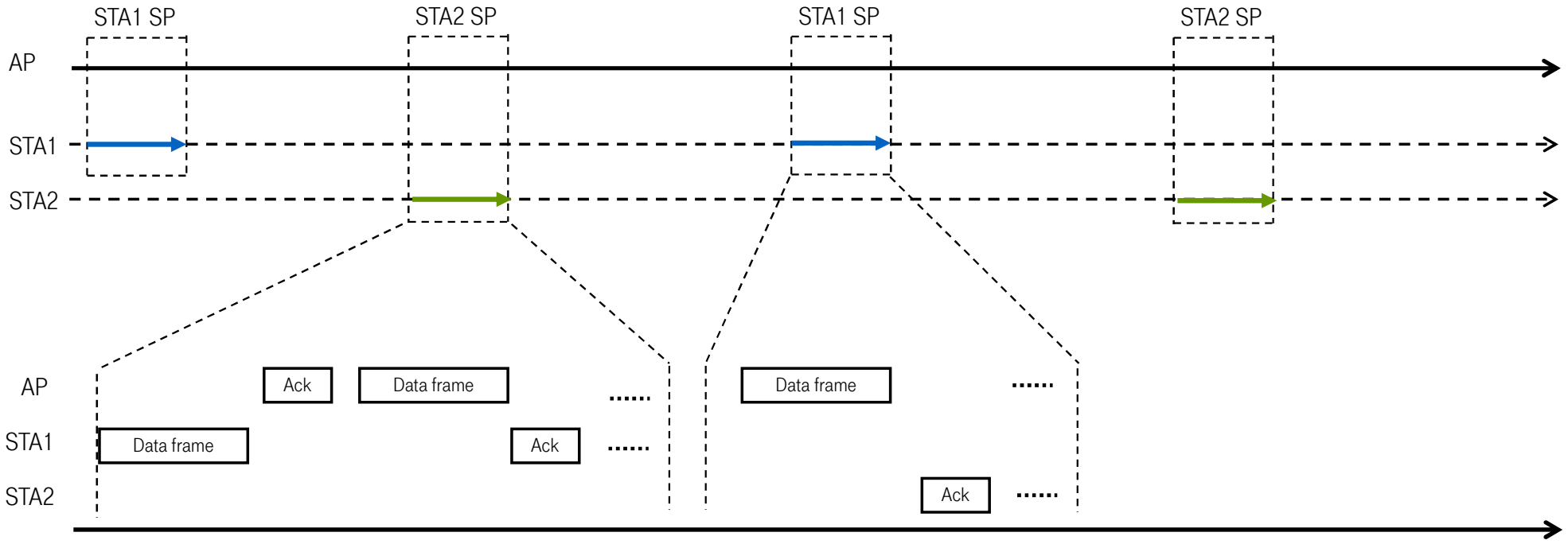



TARGET WAKE TIME

TARGET WAKE TIME („DRX FOR WI-FI) SAVES BATTERY

AP and STA may define periodical Service Periods (SP).

During a SP a STA may send or receive frames. Outside the SP the STA sleeps. This saves battery.



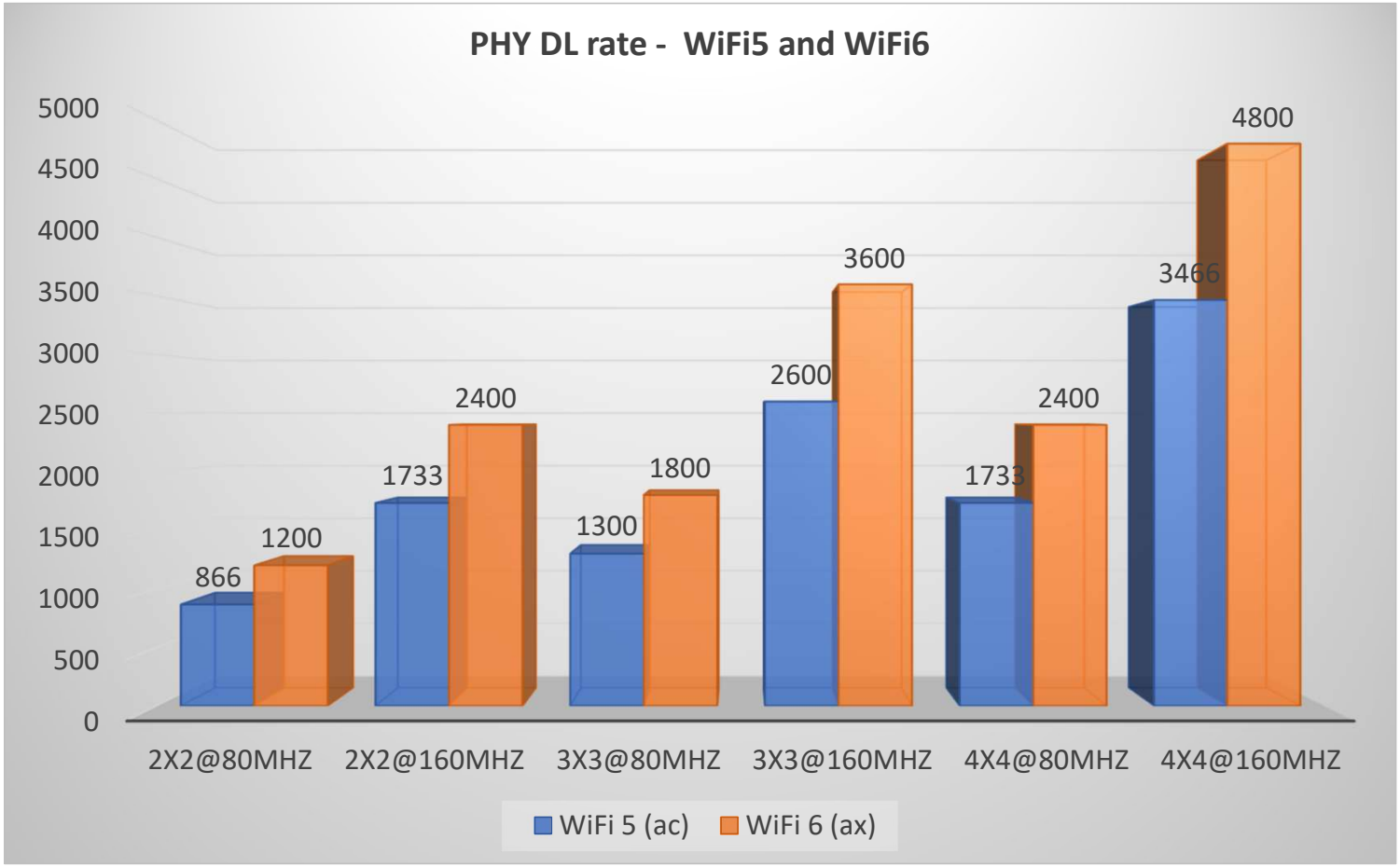
WI-FI IN REAL ENVIRONMENT

PERFORMANCE

40% BOOSTED SPEED ON WIFI 6 COMPARE TO WIFI5

DEPENDENCIES

- MCS INDEX
  - NUMBER OF ANTENNAS
  - BANDWIDTH
  - MODULATION/ CODING (MCS)
  - NO. OF SPATIAL STREAM
- ENVIRONMENT (NOISE, CLIENTS)

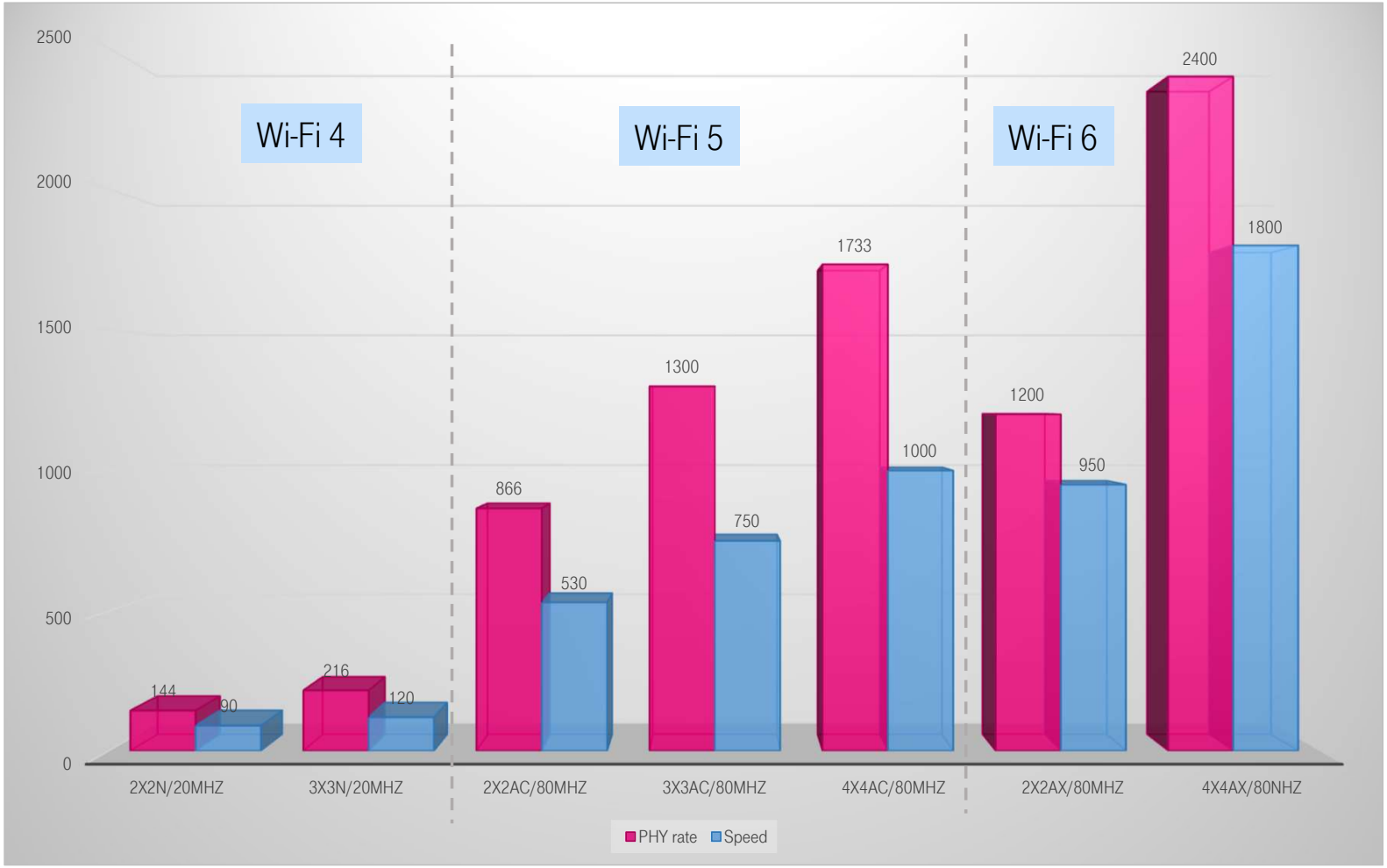


Max Phy rate

WiFi5: 6.9Gbps (160MHz, 8SS, 256QAM)

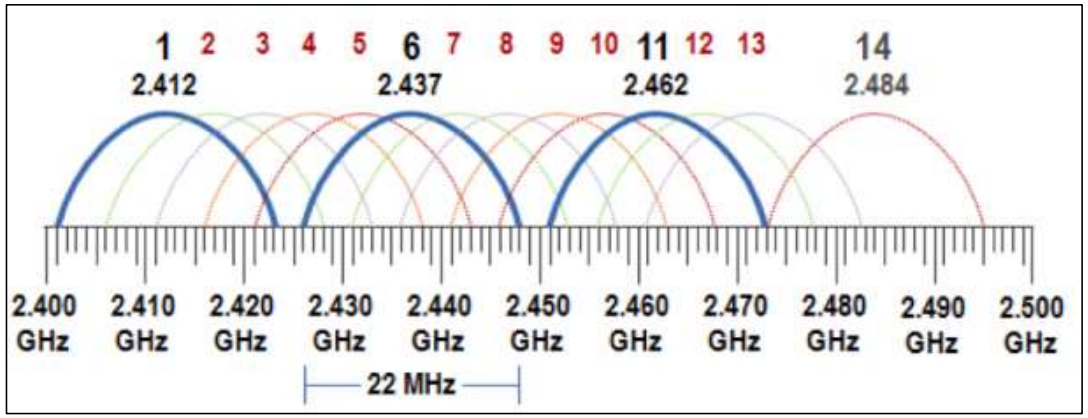
WiFi6: 9.6Gbps (160MHz, 8SS, 1024 QAM)

TYPICAL PERFORMANCE VALUE OF WI-FI 4, WI-FI 5 & WI-FI 6

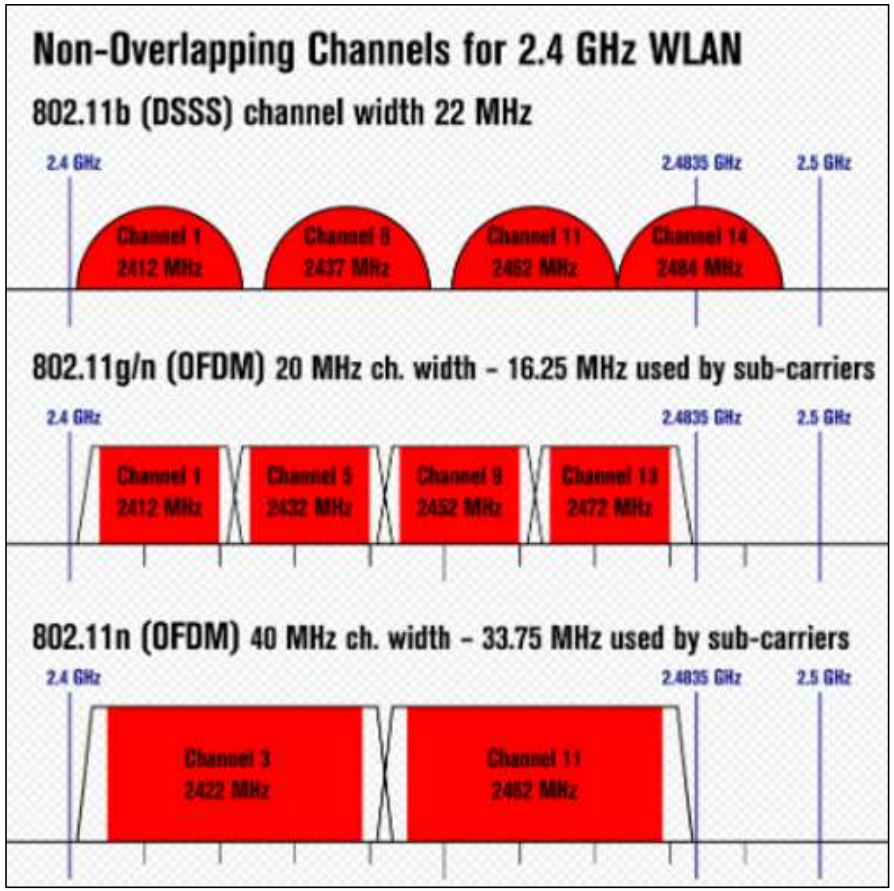



SPECTRUM
WI-FI 6E

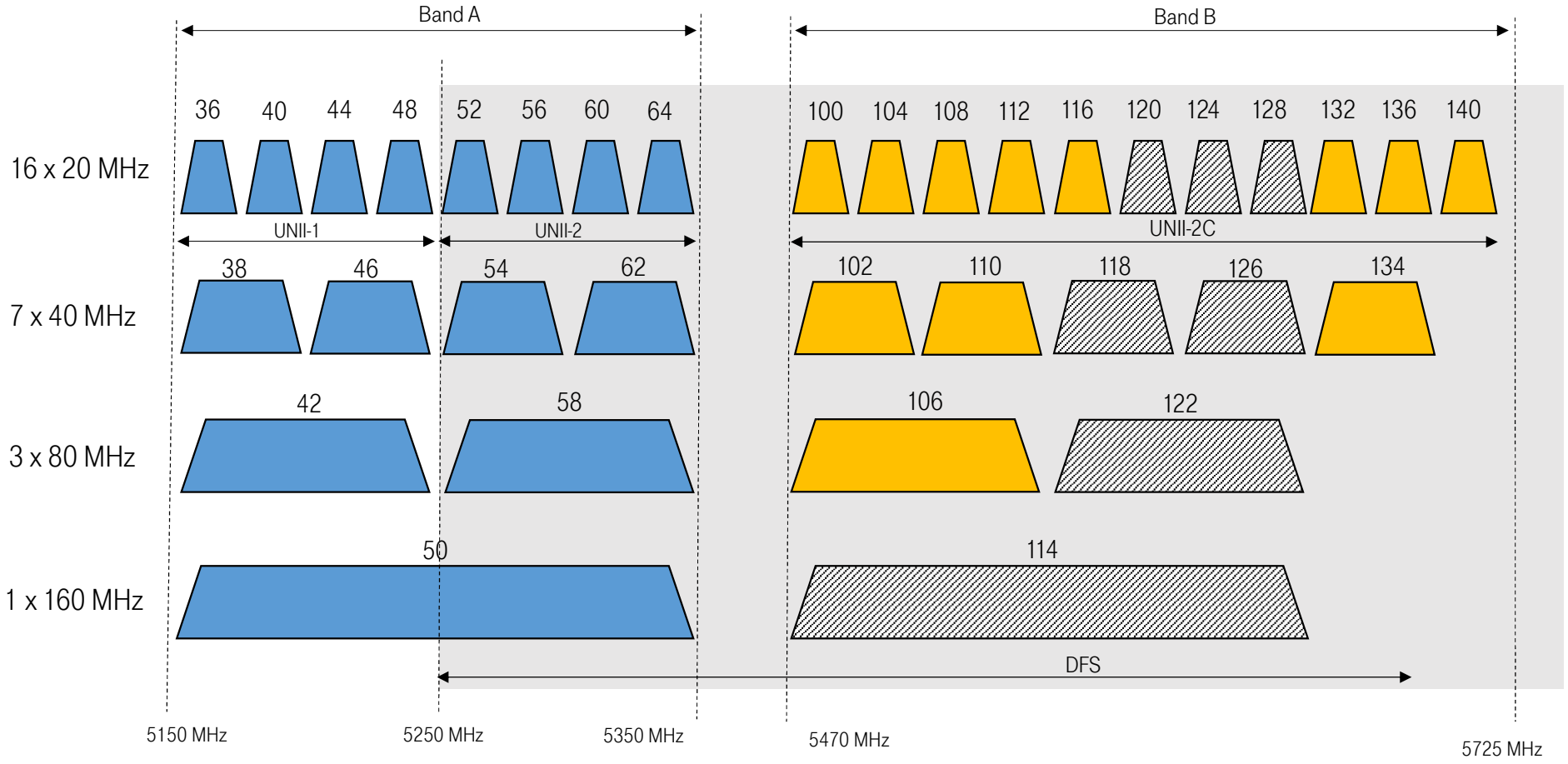
2.4 GHZ SPECTRUM



US: 1-11 channels
EU: 1-13 channels
Japan: 1-14 channels

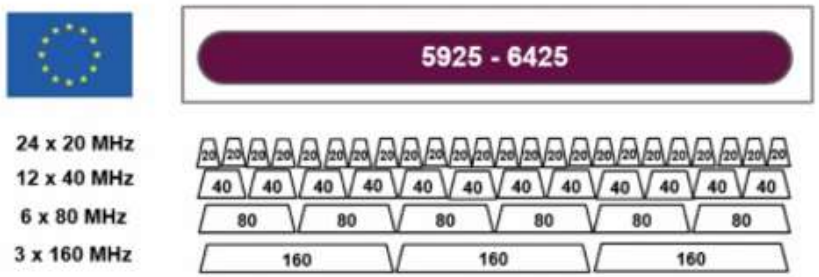


5 GHZ SPECTRUM – EU (HUNGARY)

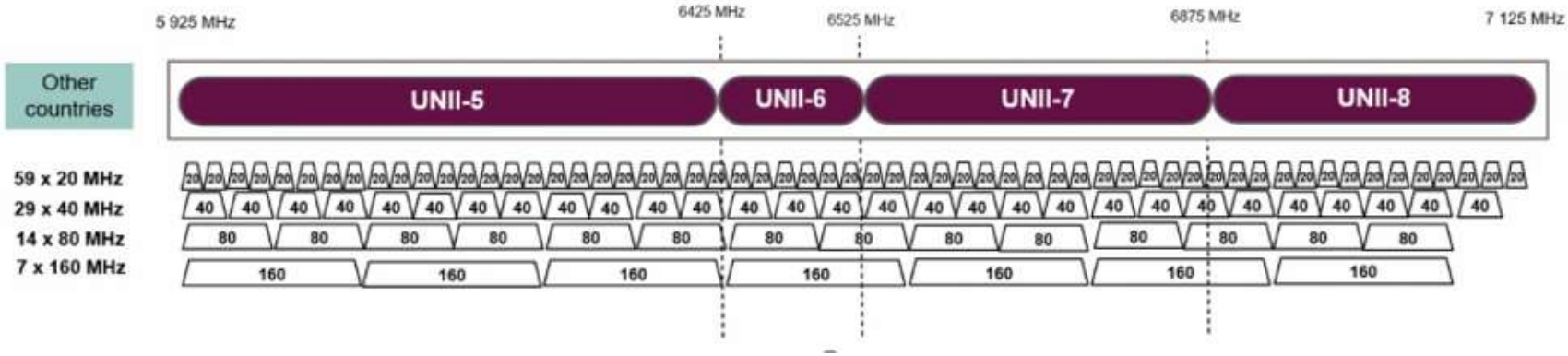


DFS: Dynamic Frequency Selection
36-64 channels - indoor (200mW)
100-140 channels – indoor/outdoor (1000mW, TPC (Transmission Power Control))

6 GHZ SPECTRUM FOR WI-FI 6E & WI-FI7 FROM 2021



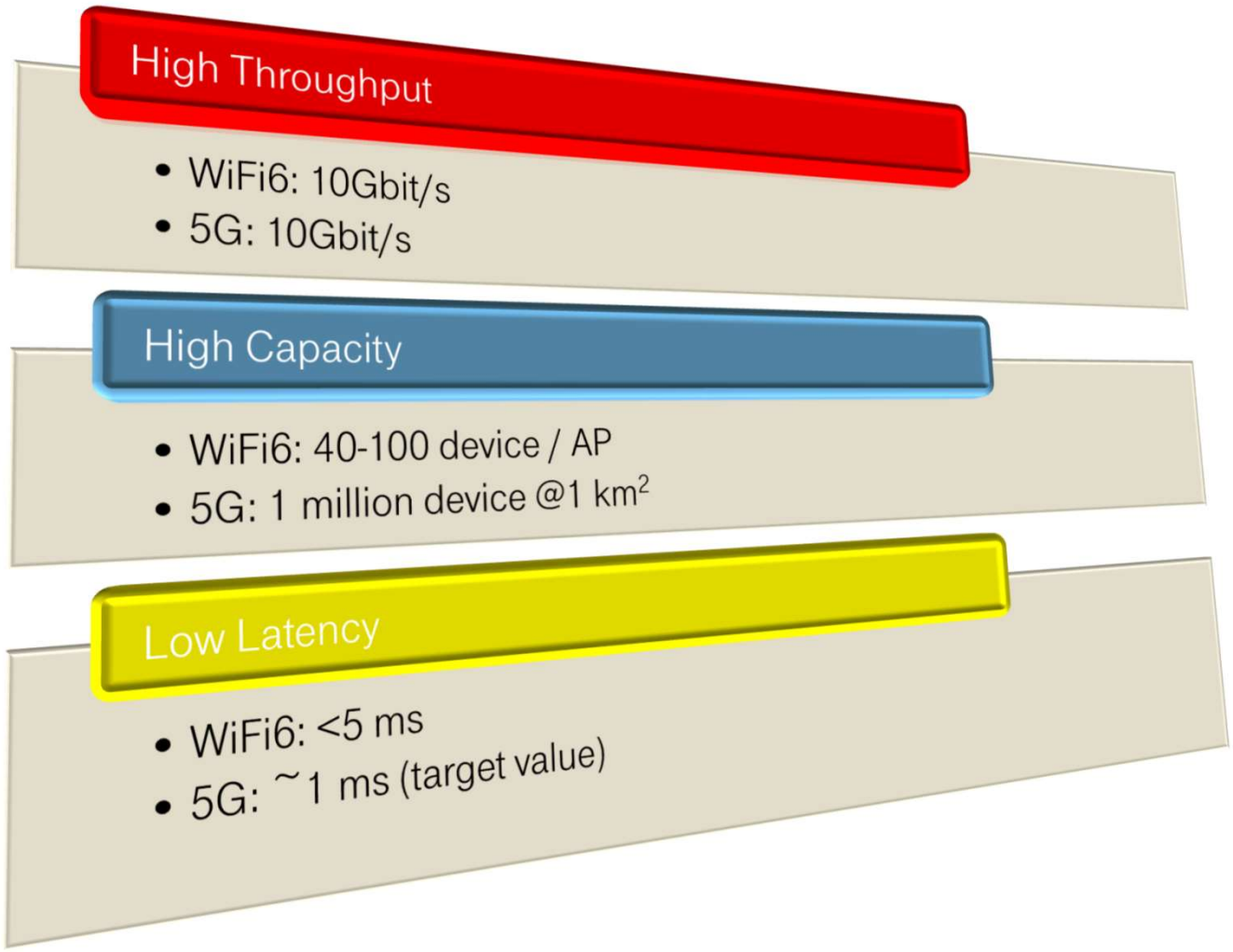
- Dynamic random spectrum access and contention-based protocols require access to **multiple channels** to maintain acceptable performance
- **IEEE 802.11be** designed for Extremely High Throughput -- channel bandwidth of up to **320 MHz**



+500MHz in Europe
+1.2GHz in US


WI-FI & 5G

BOTH WI-FI6 AND 5G ARE BUILT FROM THE SAME FOUNDATION



Feature	5G	Wi-Fi 6
DS		
US		
Latency		
Frequency	licensed	unlicensed
Area	outdoor	indoor

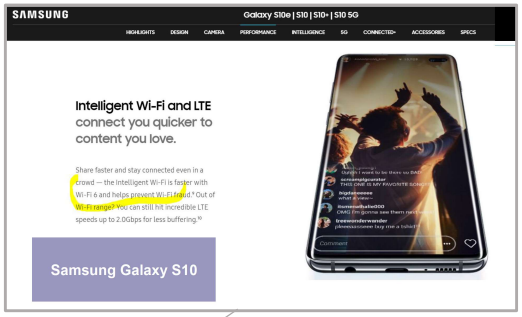
WI-FI6 AND 5G COMPLEMENT EACH OTHER

Source: Intel


MARKET OVERVIEW

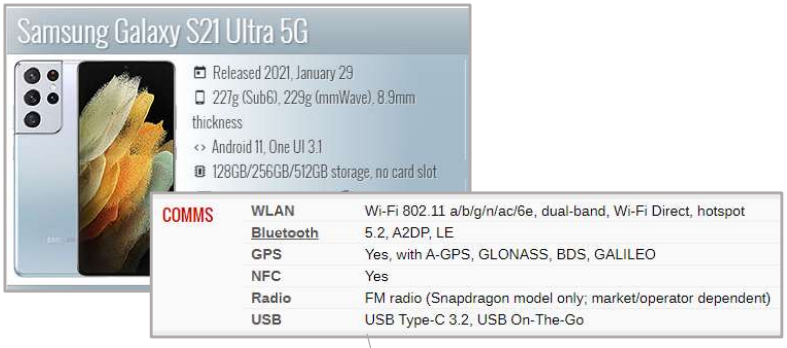
ALL AROUND WI-FI 6

Samsung Galaxy S10 (Wi-Fi6)



Routers (Wi-Fi6)

Samsung Galaxy S21 Ultra (Wi-Fi6e)



2019 March

2019 Sept

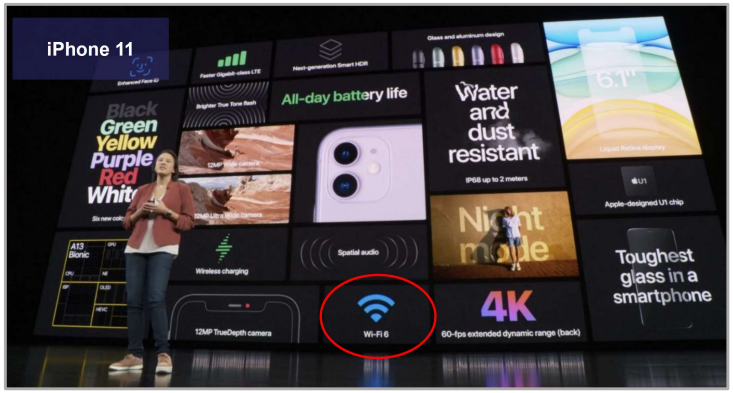
2020.Sept.

2020.Nov

2021 Febr.

2021 Jan.

Iphone 11 (ax)



2x2ax, 80MHz

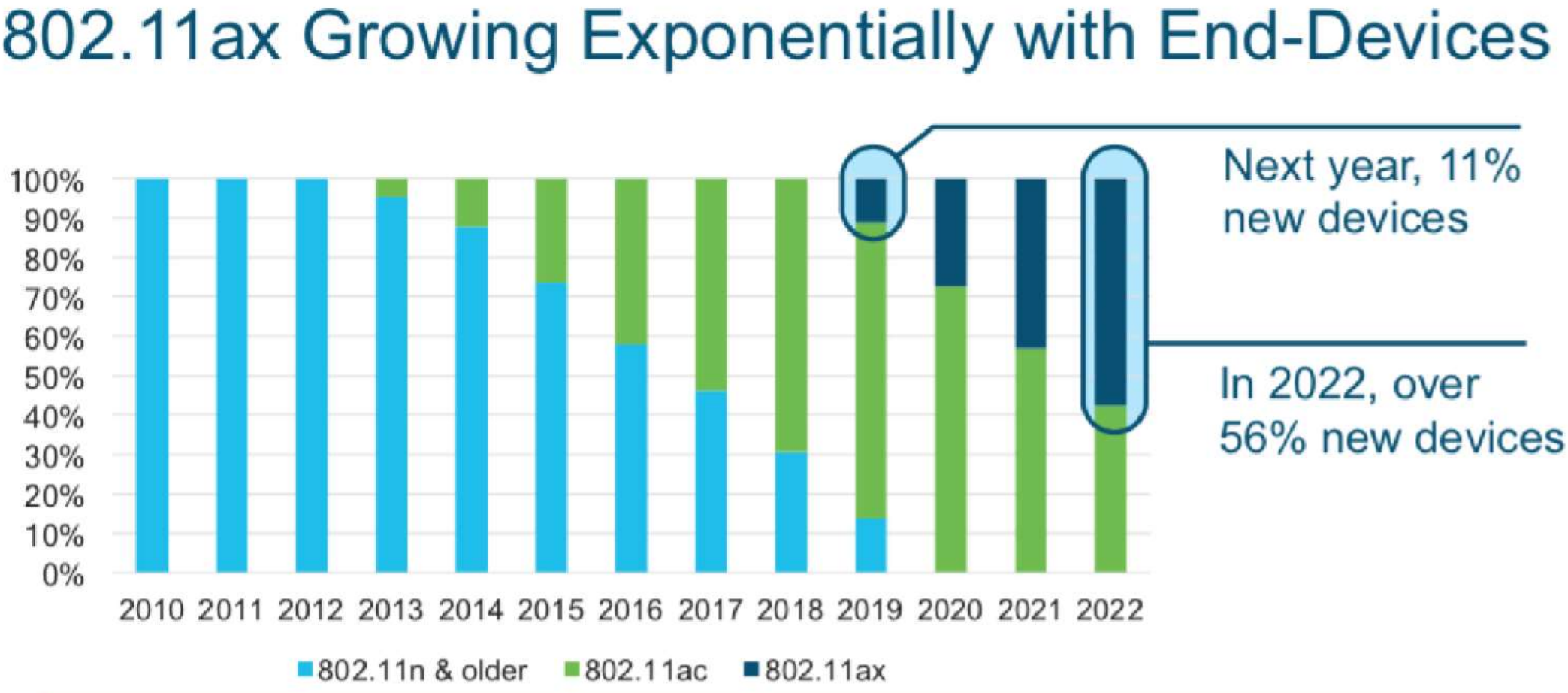
Sagemcom 5670
(GPON/Wi-Fi6)

KAON AR1344
(Wi-Fi6 / MESH)

Xiaomi AX60000 (Wi-Fi6e)

4x4, 160MHz

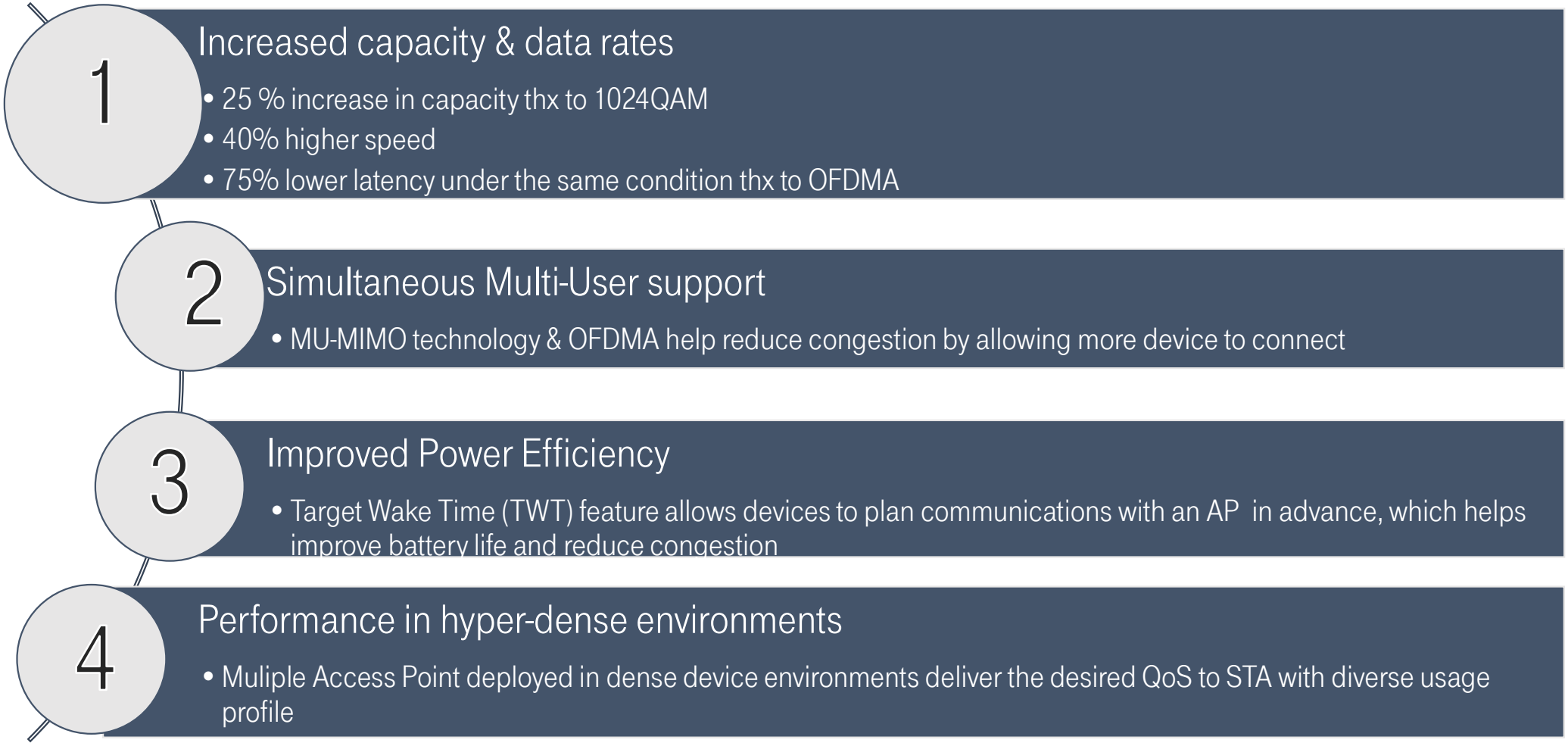
MARKET TREND: WI-FI6 ECOSYSTEM IS AN INDUSTRY GAME CHANGER



Source: WI-FI NOW


SUMMARY

WIFI 6 PROVIDES HIGHER SPEED AND RELIABLE CONNECTION IN DENSE AREA




BACKUP

WHAT IS WI-FI? WHAT IS WI-FI6?

- Stands for „Wireless LAN are specified by 802.11 working group of the IEEE 802 LAN/MAN Standards Committee.
- Wireless LAN standards: IEEEE 802.11 b/a/g/n/ac/ax/....
- The Wi-Fi Allience is a consortium of hardware manufactureres that holds the „Wi-Fi" and „Wi-Fi-CERTIFIED" trademarks and certifies WLAN hardware.

Wi-Fi Alliance Marketing Name	IEEE Standard Name	Release date
Wi-Fi 6	IEEE 802.11 ax	2019/2020(jan)
Wi-Fi 5	IEEE 802.11 ac	2013 (wave2)
Wi-Fi 4	IEEE 802.11 n	2009
Wi-Fi 3	IEEE 802.11 g	2003
Wi-Fi 2	IEEE 802.11 a	1999
Wi-Fi 1	IEEE 802.11 b	1999