Wi-Fi Evolution: Towards Wi-Fi 7

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Outline

Current Status: Wi-Fi 6 / Wi-Fi 6E

The next steps: Wi-Fi 7

Wi-Fi and TSN

What is Wi-Fi

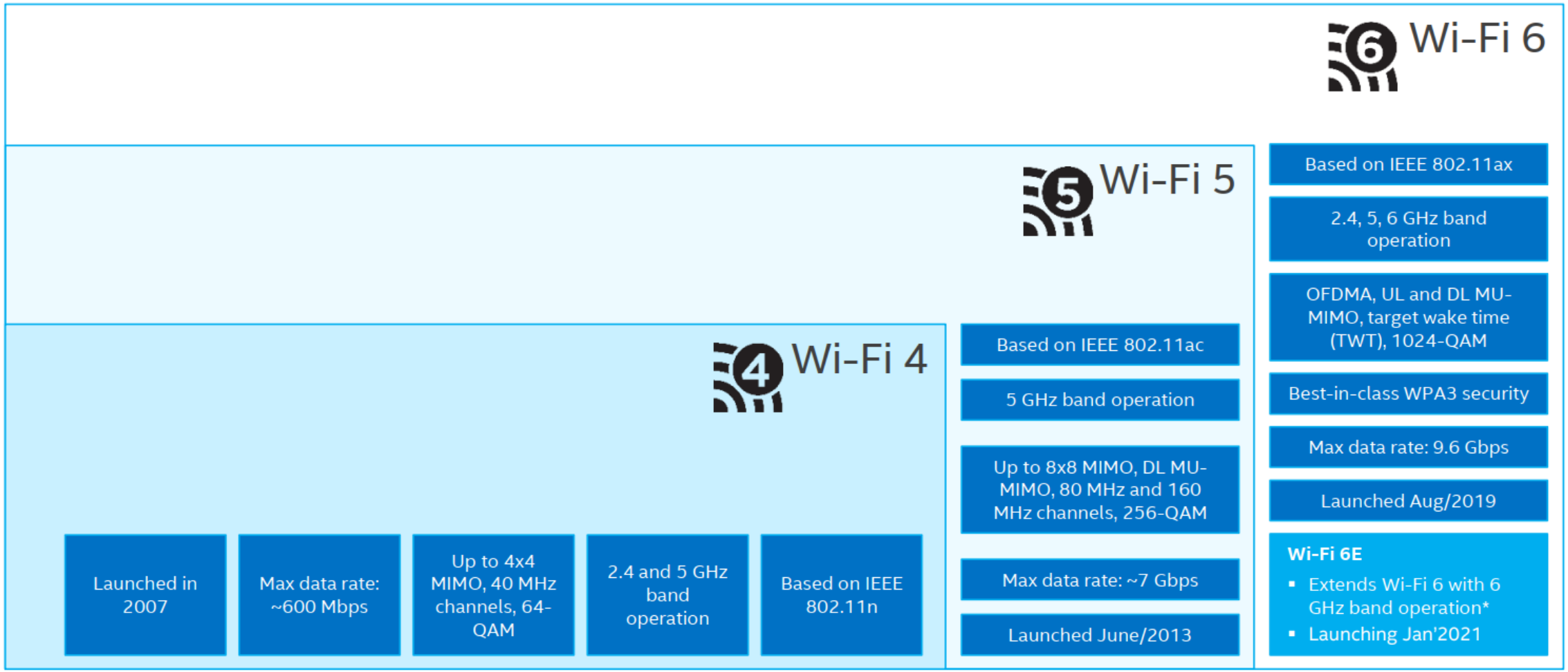
- What is Wi-Fi (Wireless Fidelity) ?
- A technology based on a set of wireless protocols based on the IEEE 802.11 family of standards
- A trademark of the ***Wi-Fi Alliance***, the association in charge of driving global Wi-Fi adoption and evolution, which grants the usage of the 'Wi-Fi CERTIFIED' label to products that complete interoperability certification tests

802.11 meetings
1990 – 2019 (pre-COVID)

- Who define what Wi-Fi is?
- The Institute of Electrical and Electronic Engineers (IEEE) is in charge of the ***IEEE 802*** broad family of standards

- The latest commercially available release of Wi-Fi is based on ***IEEE 802.11ax*** or ***802.11ax-2021*** specification, and branded as ***Wi-Fi 6*** by the Wi-Fi Alliance, operating in license-exempt bands at 2.4 GHz, 5 GHz, and 6 GHz
- **Wi-Fi 6E** (E = Extended) is the label given to products capable of making use of the 6 GHz band

Recent history of Wi-Fi



* 6 GHz operation subject to regulatory rules in each country.

Wi-Fi 6E vs. Wi-Fi 5 --- Wi-Fi 6E latest features

- Wi-Fi 6E improvements* vs. Wi-Fi 5 (802.11.ac)
  - **Throughput** enhanced by 400%
  - **Latency** reduced by 75%

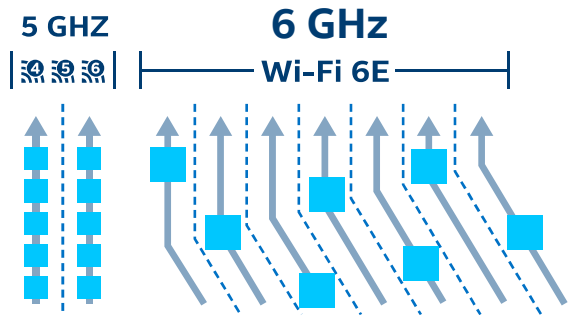
- That is achieved thanks to **several new features**, among which:
  - Orthogonal frequency-division multiple access (**OFDMA**)
  - Higher order **1024-QAM** (Quadrature Amplitude Modulation) mode
  - Improved spectrum utilization thanks to the usage of **160 MHz channels**
  - Improved **power controlling schemes** so to better handle interferences with surrounding networks
  - Advanced multi-user multiple input multiple output **(MU-MIMO) schemes**
  - **Improved security**, thanks to, among others, the usage of the **WPA3 protocol**

* Source: https://www.zdnet.com/article/next-generation-802-11ax-wi-fi-dense-fast-delayed

6 GHz (Wi-Fi 6E) - Products are here

6 GHz SPECTRUM

- Up to 1200 MHz of new spectrum
- Many / larger channels (>2X)
- No legacy Wi-Fi
- Maximized Wi-Fi 6 benefits



ROUTERS/APS

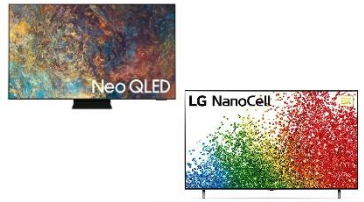
- Asus
  - ROG Rapture GT-AXE11000
- Netgear
  - Nighthawk RAXE500
- TP-Link
  - Archer X206, X96
  - Deco X76, X96 Mesh
- Linksys
  - AXE8400 Mesh, AXE660
- Aruba
  - AP-635

PHONES

- Samsung
  - Galaxy S21 Ultra
- Asus
  - ROG Phone 5
  - ZenFone 8
- ZTE
  - Axon 30 Ultra
- Xiaomi
  - Mi 11
- Oppo
  - Find X3 Pro
- Nubia
  - RedMagic 6

SMART TVS

- Samsung
  - Neo QLED 8K (QN900A +QN800A)
- LG
  - OLED, QNED, NanoCell



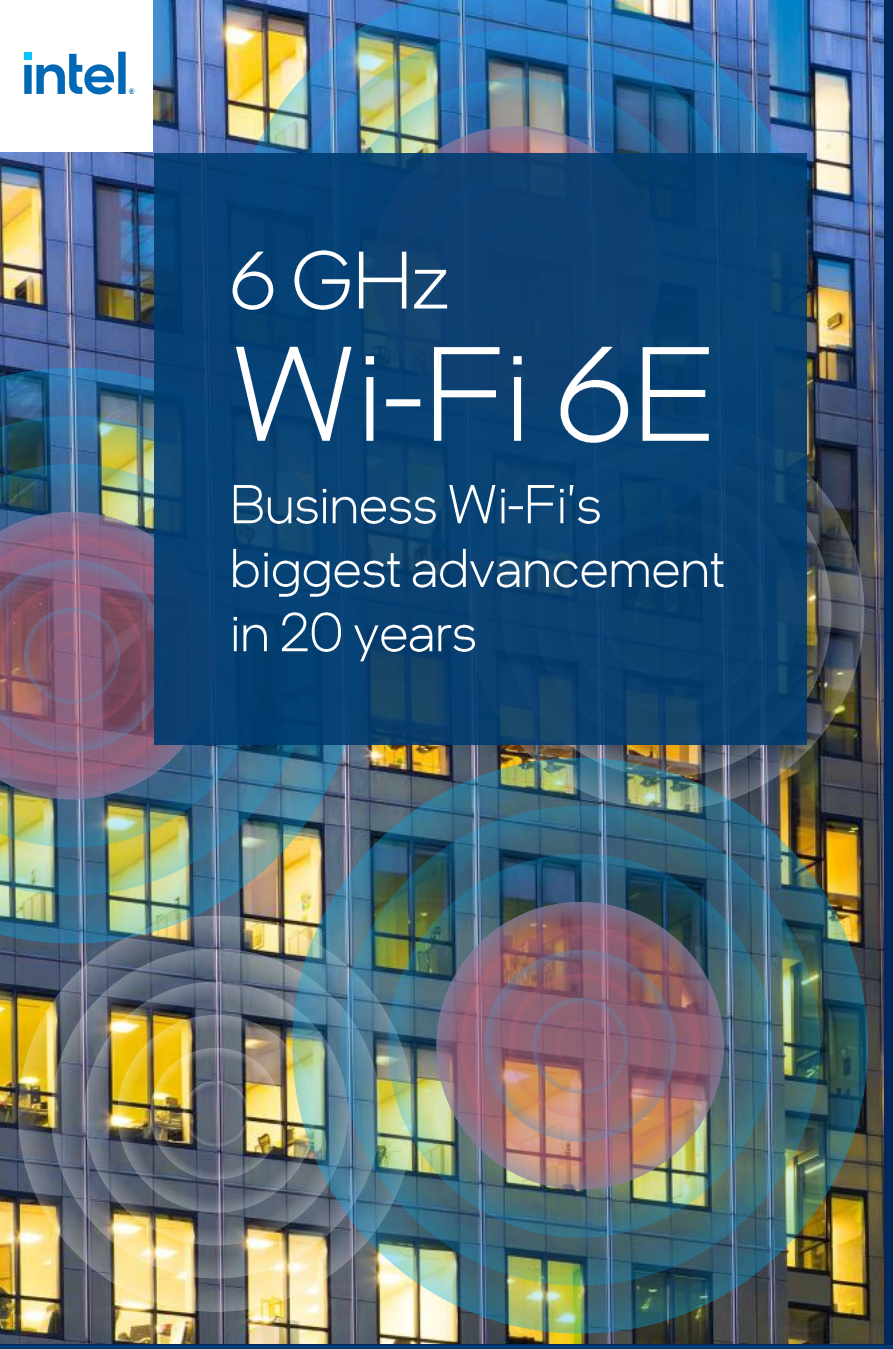
DT PC MOTHERBOARDS

- Asus
- MSI
- Gigabyte
- Asrock

LAPTOPS + DESKTOPS

- Dell
  - Latitude 9420
  - Latitude 5320, 5420/21, 5520/21
  - Precision 3560
  - Alienware X15, X17
- HP
  - Omen 16, 17
- Lenovo
  - ThinkPad X13, X1 Extreme
  - ThinkPad T14, T14s, T15
  - ThinkPad P14s, P15s
- Samsung
  - Galaxy Book Pro 13/15
  - GB Pro 360 13/15
- MSI
  - GE76/GE66 Raider
  - GS76/66 Stealth
  - GP76/66 Leopard
  - GL76/66 Pulse
  - Creator 15, Z16, M16
  - Summit E13, E16 Flip
  - (DT) Trident 3, Aegis Ti5,
  - (DT) Infinite X, Codex 5
- Razer
  - Blade Advanced 15
  - Blade Pro 17

More to come...



6 GHz Wi-Fi 6E

Business Wi-Fi's biggest advancement in 20 years

Intel® Wi-Fi 6/6E (Gig+)

Best of both worlds (Legacy + New)

Many large high-speed channels

Legacy
5 GHz

4 5 6

New
6GHz

Wi-Fi 6E only

Improved performance & reliability
No legacy Wi-Fi interference/congestion

Office Wi-Fi challenges

- Many Access Points needed
- Small channels required
- Speed / capacity limitations

20/40 MHz channels

VS.

80/160 MHz channels

6 GHz: larger channels possible

- Up to 6x speeds[1]
- Ultra-low latency

Protect your PC investment Intel® Wi-Fi 6/6E (Gig+)

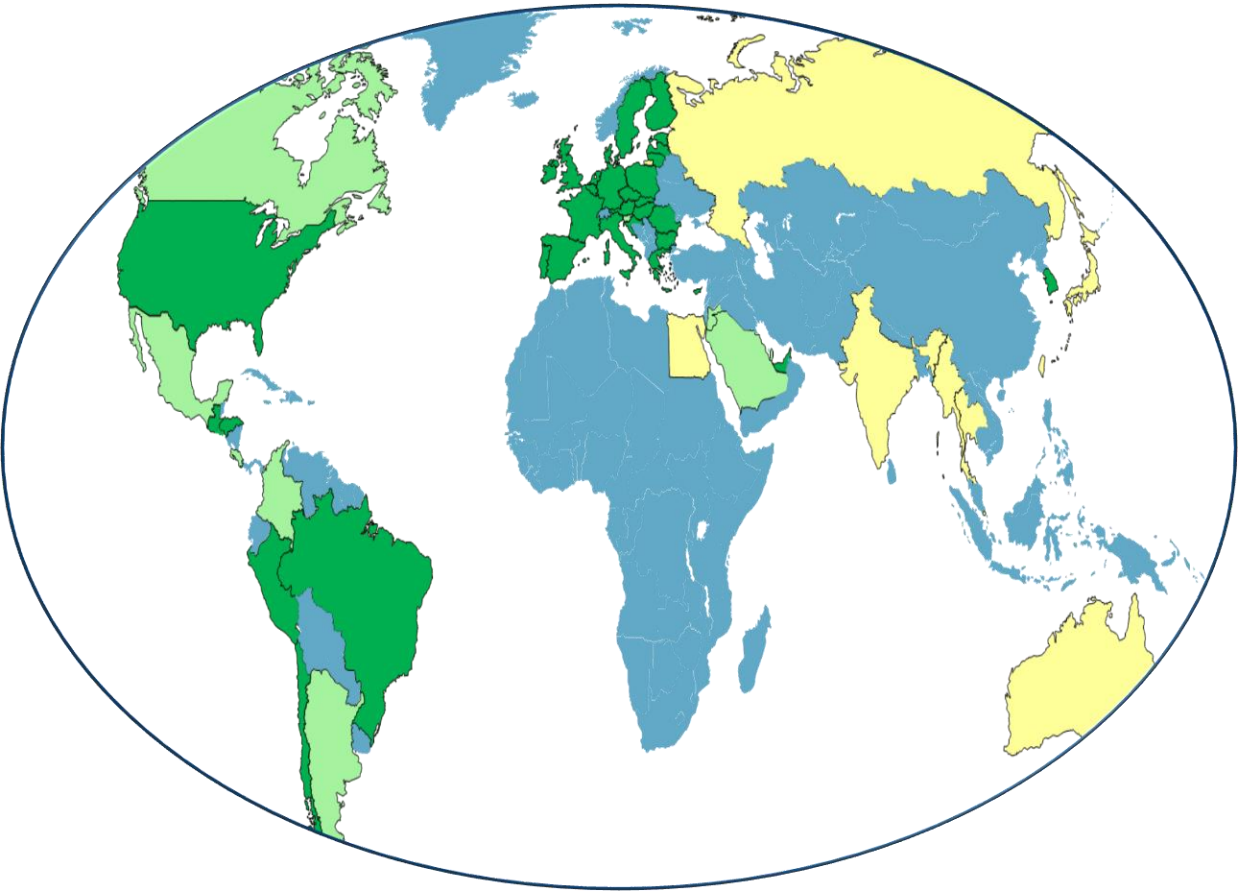
- Amazing 6 GHz capabilities (when available)
- Legacy Intel® Wi-Fi 6 (Gig+) (when needed)

Learn more at
intel.com/wireless

1) Performance varies by use, configuration and other factors. For details on performance claims, learn more at www.Intel.com/PerformanceIndex (connectivity).
No product or component can be absolutely secure. Your costs and results may vary. Intel technologies may require enabled hardware, software or service activation.

6 GHz (Wi-Fi 6E) – Band Allocation Worldwide

Updated



May'21 Update	APJ	EMEA	NA	SA
Approved	South Korea	UK, EU, UAE	USA, Guatemala El Salvador, Honduras	Chile, Brazil Peru
Expected This Year		Saudi Arabia, Jordan, Slovenia, Qatar	Canada, Mexico, Costa Rica,	Colombia, Argentina
In Progress	Japan, Taiwan, Myanmar, India, Thailand, Singapore, Australia, NZ	Egypt, Russia		

6 GHz Wi-Fi 6E spectrum footprint growth expected 2021-22

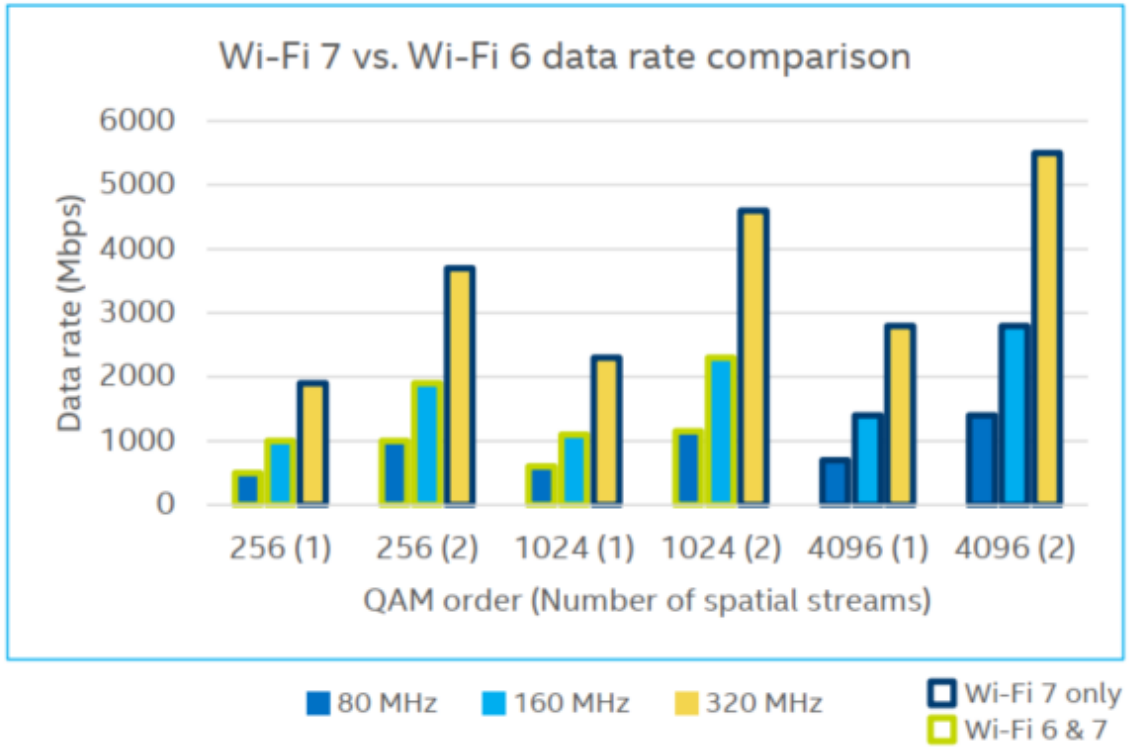
Wi-Fi 7 - aka ‘Wi-Fi Extreme High Throughput’

- Planned **new features:**
  - Increased **throughput**: from 9.6 Gbps of Wi-Fi 6 to **46 Gbps of Wi-Fi 7**
    - hence ‘Wi-Fi Extreme high throughput’
  - Support of **320 MHz channels**
  - Even higher order **4096-QAM** mode
  - Allocation of **multiple resource units**, e.g., groups of OFDMA tones
  - **16 spatial streams**
  - **Multi-Resource Unit (RU)** (also known as puncturing), allowing to exploit non-contiguous spectrum bands
  - **Deterministic low latency**

Wi-Fi 7 vs. Wi-Fi 6 – PHY Data Rate Enhancements

- Max Data Rate planned to increase ~5x vs. Wi-Fi 6

Parameter	Wi-Fi 6	Wi-Fi 7
Max channel bandwidth	160 MHz	320 MHz (3 channels in 6 GHz)
Highest modulation order	1024-QAM	4096-QAM
Max number of spatial streams	8	16
Max data rate*	~9.6 Gbps	~46.1 Gbps

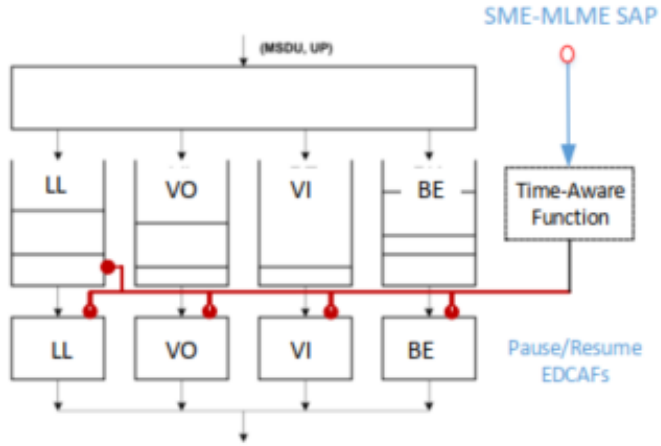


Wi-Fi 7 – Deterministic low latency enhancements

- **Wi-Fi 6 can achieve single-digit millisecond** latency, but the worst-case latency can be high in congested environments
- With the introduction of features like multi-link operation, multi-AP and 320 MHz channels in Wi-Fi 7, latency will be reduced even further
- However, to provide deterministic low latency required by some usages (e.g., industrial IoT, AR/VR), new schemes need to be defined

Potential Wi-Fi 7 features for deterministic low latency

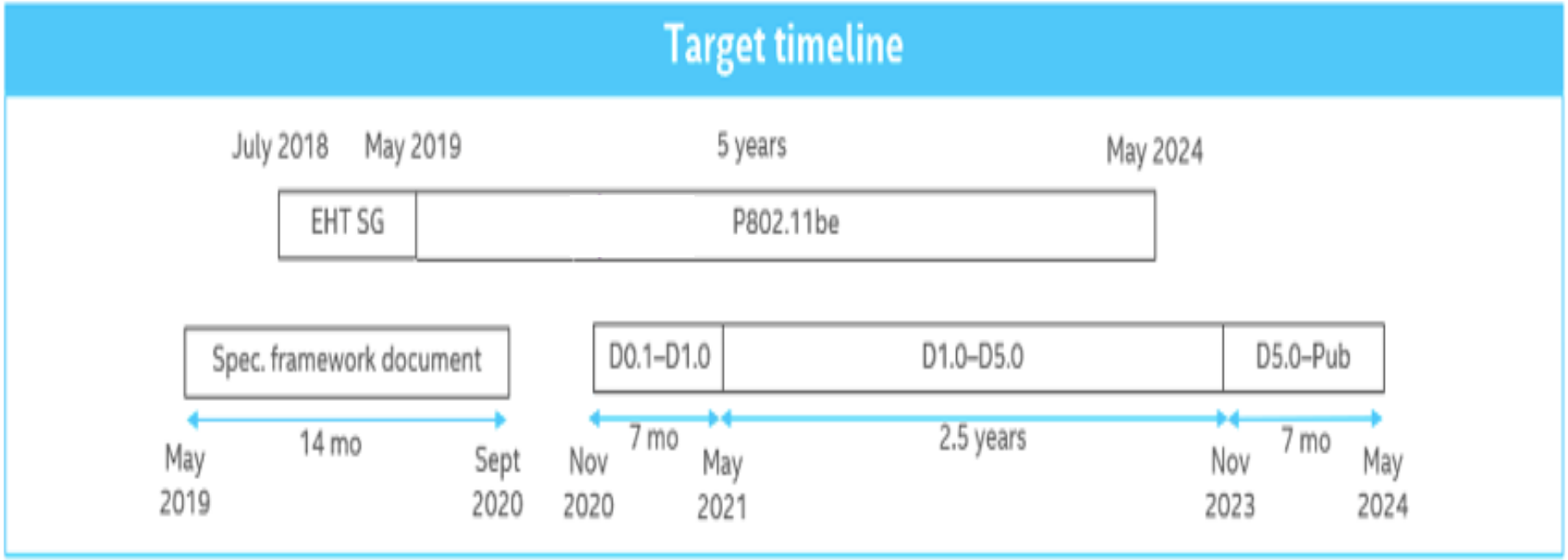
- Define QoS provisioning model with dedicated, deterministic, low-latency (LL) and reliable access category
- Scheduled channel access with 802.1 TSN functionality
- Packet preemption for predictable channel access
- Limit TXOP duration across networks



* Source: https://mentor.ieee.org/802.11/dcn/20/11-20-0418-01-00be-low-latency-service-in-802-11be.pptx

Wi-Fi 7 – IEEE Standardization Work Schedule

- Wi-Fi 7 will be based on the **IEEE 802.11be** standard
- Work is progressing well, though with a small delay



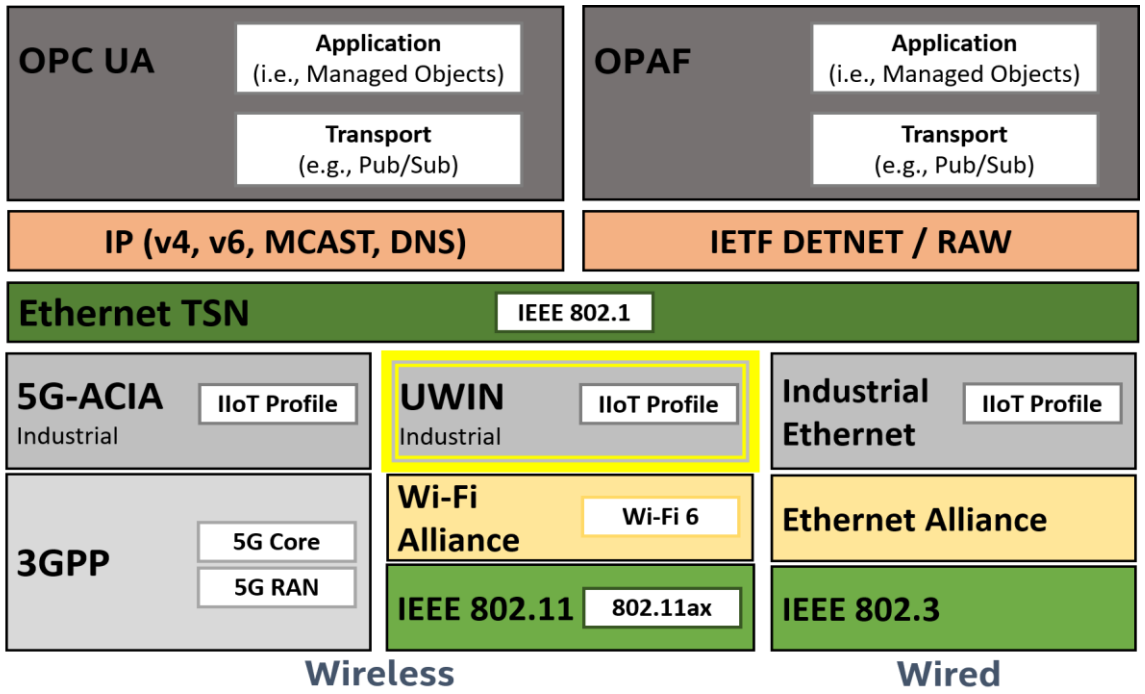
Wi-Fi, IIoT and TSN

- **Wireless connectivity** is a **key technology enabler for Industrial IoT (IIoT)**
- **Both 5G and Wi-Fi** bring value in the **Digital transformation of the Industry**
- **Time Sensitive Networking (TSN)** is standard part of IEEE 802 family
- An **Unlicensed Wireless Industrial IoT (UWIN)** Special Interest Group (SIG) was launched to address synergies between TSN, Wi-Fi and IIoT
  - Define specific IIoT use-cases and requirements for wireless communications
  - Identify a wireless IIoT profile (recommendations, configuration, etc.) based on open standards (IEEE 802.11, 802.1 TSN)
  - Interact with relevant standards organizations to drive interoperability & certification
  - Demonstrate value of IIOT Profile via PoC/trial in an industrial environment
  - Joint messaging & marketing the economic/TCO and technical advantages of Wi-Fi in IIOT

* Source: Intel and Cisco White Paper on UWIN SIG, 2020

IIoT Communication Stack and Standards

- (One of the) Scope of UWIN SIG is to bridge the gap between unlicensed technologies and IIoT applications (including TSN)
- Wi-Fi - being based on 802.11 - interacts smoothly with Ethernet, therefore co-existence with IEEE 802.1 TSN protocol can be much better guaranteed



* Source: Intel and Cisco White Paper on UWIN SIG, 2020

TSN – Standards, moving towards wireless access

- TSN is going to move from wired (Ethernet) to wireless (Wi-Fi), thanks to the Wi-Fi evolution:
  - Latency
  - Reliability
  - Interference management
  - Flexibility of deployment
  - Lower cost
  - Allowing for mobility

IEEE Standard	Capability
1588, 802.1AS	Time synchronization
802.1Qca*	Path control and reservation
802.1Qav†	Credit-based traffic shaping
802.1Qbv*	Time-aware scheduling
802.1Qbu* and 802.3br	Frame preemption
802.1Qcc	Configuration models
802.1Qci*	Filtering and policing
802.1CB	Redundancy (frame replication and elimination)
802.1Qat*	Stream Reservation Protocol (distributed resource reservation)

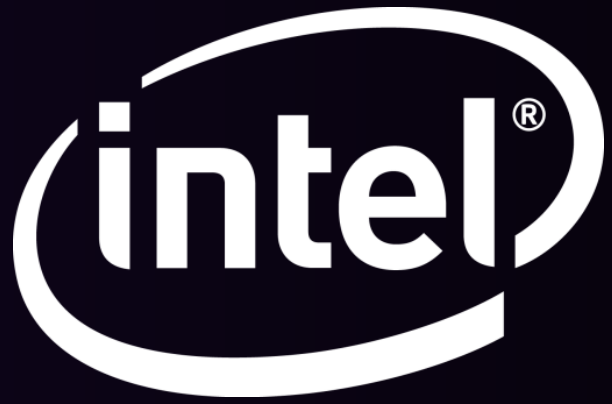
* Source: AVNU Alliance White Paper, 2020

TSN – Wi-Fi and Cellular support

- **5G (Cellular)** is not natively based on 802 LAN technology
  - 3GPP since Release 16 has started looking for TSN support
  - Release 17 is going to further work on removing some hurdles
  - Major breakthrough is expected in Release 18, due to the even increased focus on 5G-Advanced Verticals requirements

- **Wi-Fi** is based on 802 LAN technology and will work on an even better integration with TSN, mainly on:
  - Worst-case latency (guaranteed latency)
  - Jitter requirements

Time for your questions …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