Wi-Fi 8 technology introduction

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Evolution of Wi-Fi

- **802.11ac (Wi-Fi 5)**
  - 8x8 SU-MIMO, DL MU-MIMO
  - Channel bonding, 256 QAM
- **802.11ax (Wi-Fi 6/6E)**
  - OFDMA, UL & DL MU-MIMO
  - TWT, 1024 QAM
- **802.11be (Wi-Fi 7)**
  - Multi-Link Operation (lower latency)
  - R-TWT (improved determinism)
  - Multi-RU, 4K QAM, enhanced QoS

IEEE (Task Group)	Wi-Fi Alliance	Launch	Frequency	Bandwidth (Max)	Physical Rate
802.11	-	1997	2.4 GHz	20 MHz	1-2 Mbps
802.11b	-	1999	2.4 GHz	20 MHz	Up to 11 Mbps
802.11a	-	1999	5 GHz	20 MHz	Up to 54 Mbps
802.11g	-	2003	2.4 GHz	20 MHz	Up to 54 Mbps
802.11n	Wi-Fi 4	2009	2.4, 5 GHz	40 MHz	Up to 600 Mbps
802.11ac	Wi-Fi 5	2013	5 GHz	160 MHz	Up to 6,9 Gbps
802.11ax	Wi-Fi 6 Wi-Fi 6E	2021	2.4, 5, 6 GHz	160 MHz	Up to 9,6 Gbps
802.11be	Wi-Fi 7	2024	2.4, 5, 6 GHz	320 MHz	Up to 23 Gbps (single link)

802.11bn (Wi-Fi 8) Objectives

<u>A paradigm shift</u>:

- From 802.11be EHT (Extremely High Throughput)

  → to **802.11bn UHR** (Ultra High Reliability)

<u>Main improvements from EHT (PAR – Jul. 2023)</u>:

- +25% data rates, even at lower SINR levels.
- -25% tail latency
- -25% loss of MAC protocol data units (MPDUs), even in scenarios with mobility and overlapping BSSs.
- AP Power saving and peer-to-peer operation.
- Carrier frequencies between 1 and 7.125 GHz

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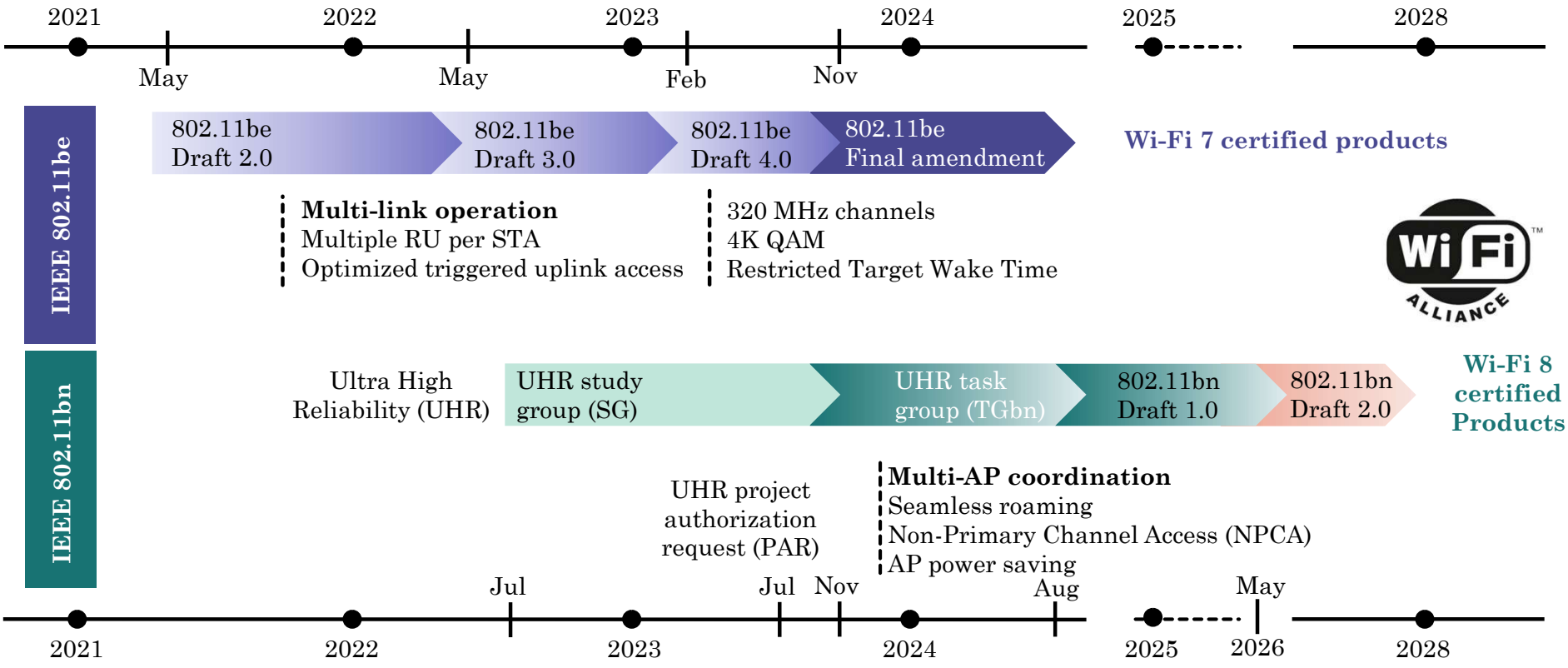
Timeline for 802.11bn



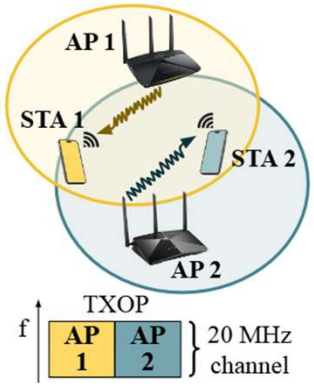
Multi-AP coordination (MAPC)

Nearby APs coordinate TX over the air

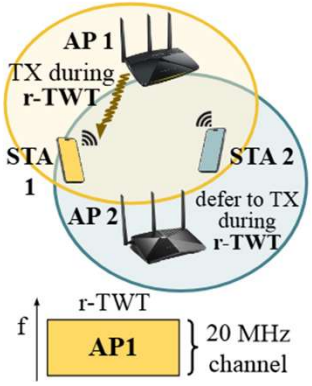
- Pros: Avoid channel contention, improve resource sharing
  → Higher throughput & improved worst-case latency
- Cons: Extra signaling and complexity

Candidate approaches:

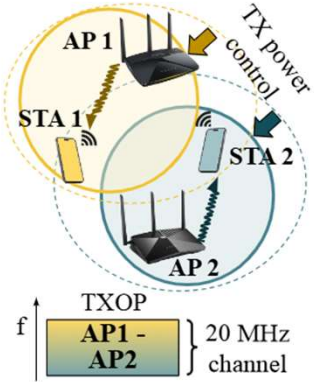
- Co-TDMA, Co-RTWT, time domain
- Co-SR, power domain
- Co-BF, spatial domain



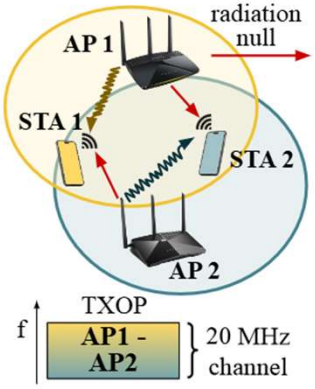
Coordinated TDMA (Co-TDMA)



Coordinated R-TWT (Co-RTWT)



Coordinated spatial reuse (Co-SR)



Coordinated beamforming (Co-BF)

Seamless Roaming

Problem

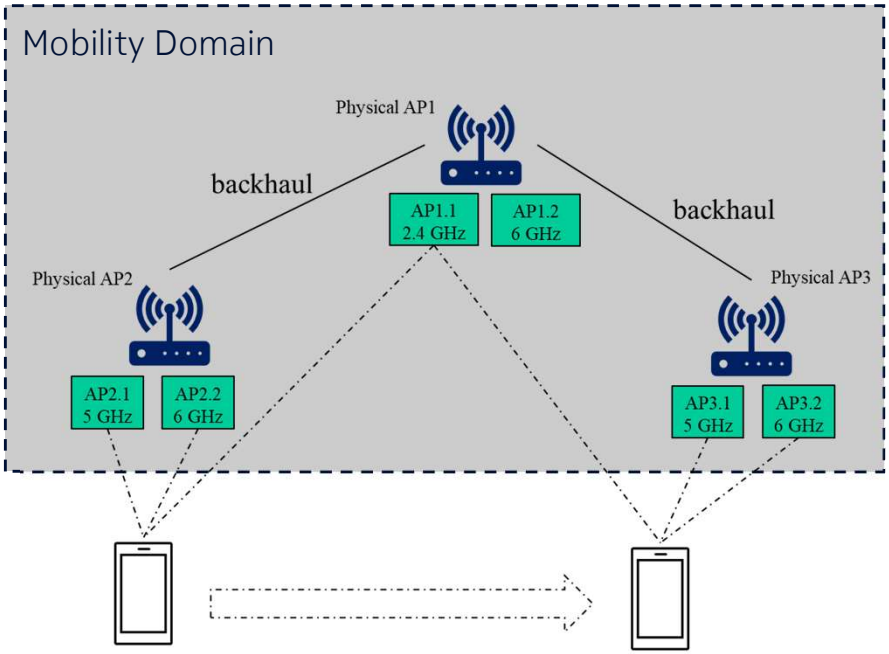
- Roaming between APs is a major cause of unreliability.

Approach

- Transfer essential information of the moving device (context) within a mobility domain to avoid re-association.

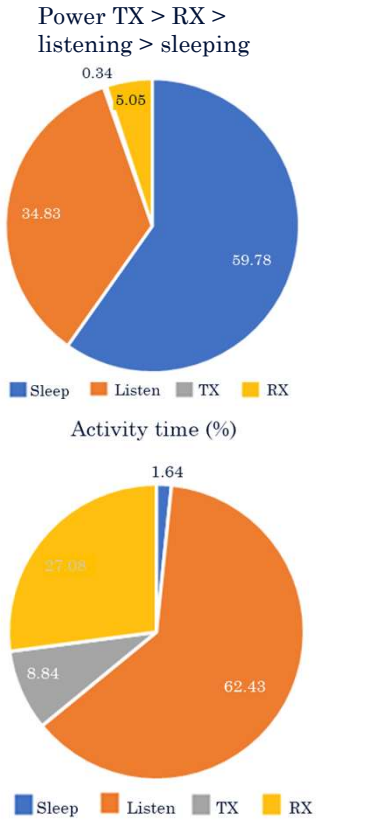
Opportunity

- A moving device could have an active connection over multiple links, not necessarily belonging to the same physical AP.



AP power saving

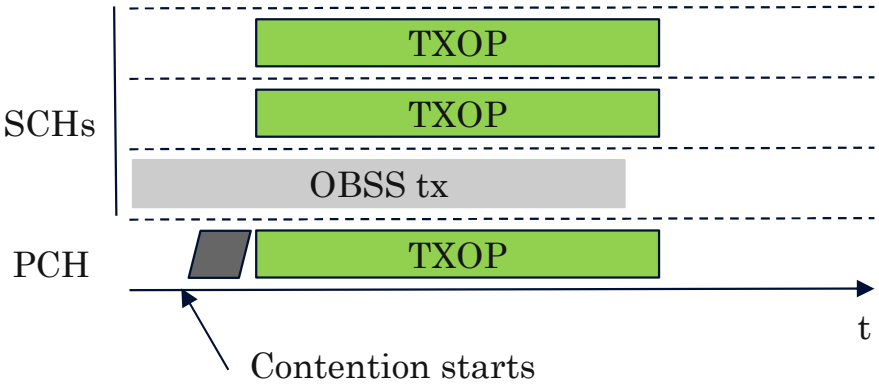
- Historically, focus was on STAs (e.g. TWT in Wi-Fi 6).
- Motivation: environmental concerns, energy costs, and rising AP complexity.
- Highest consumption when AP is in listening mode.
- Dynamic Power Save (DPS): switch between High Capability (HC) to Low Capability (LC) modes.
  - LC mode: e.g. only 1 link active, only 20 MHz bandwidth, reducing MIMO streams or MCS.
  - LC during listening, switching to HC when TX/RX
  - Preserve uninterrupted communication with the associated devices (including legacy)

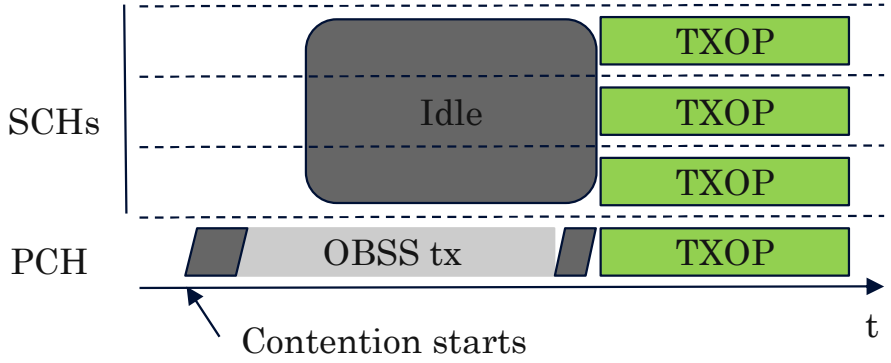


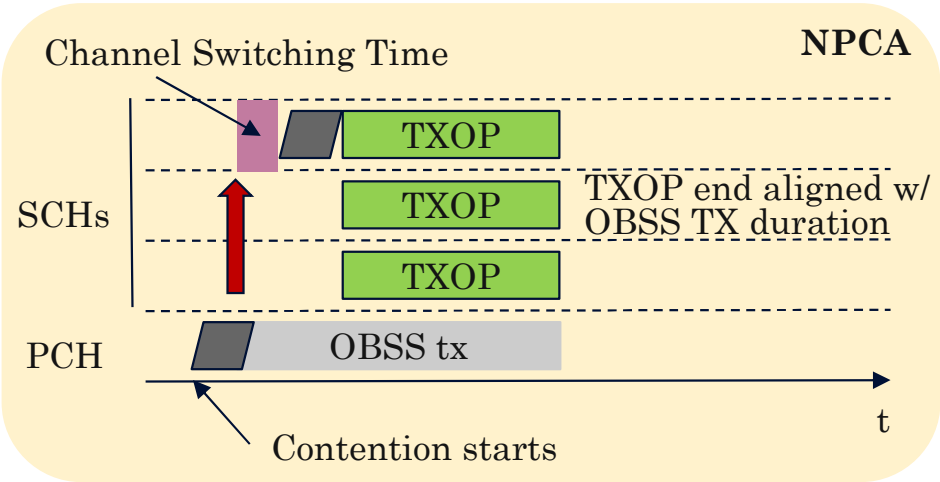
Source: ZEKU, "Follow up on the low power listening mode", IEEE 802.11-22/1841r0.

Non-primary Channel Access (NPCA)

- Motivation: Avoid deferring when the primary channel is occupied by OBSS transmissions → Low spectrum utilization
- Solution: Switch and perform contention on a secondary (primary) channel (pre-defined)
- Potential: It can be a good solution for low-latency short packets



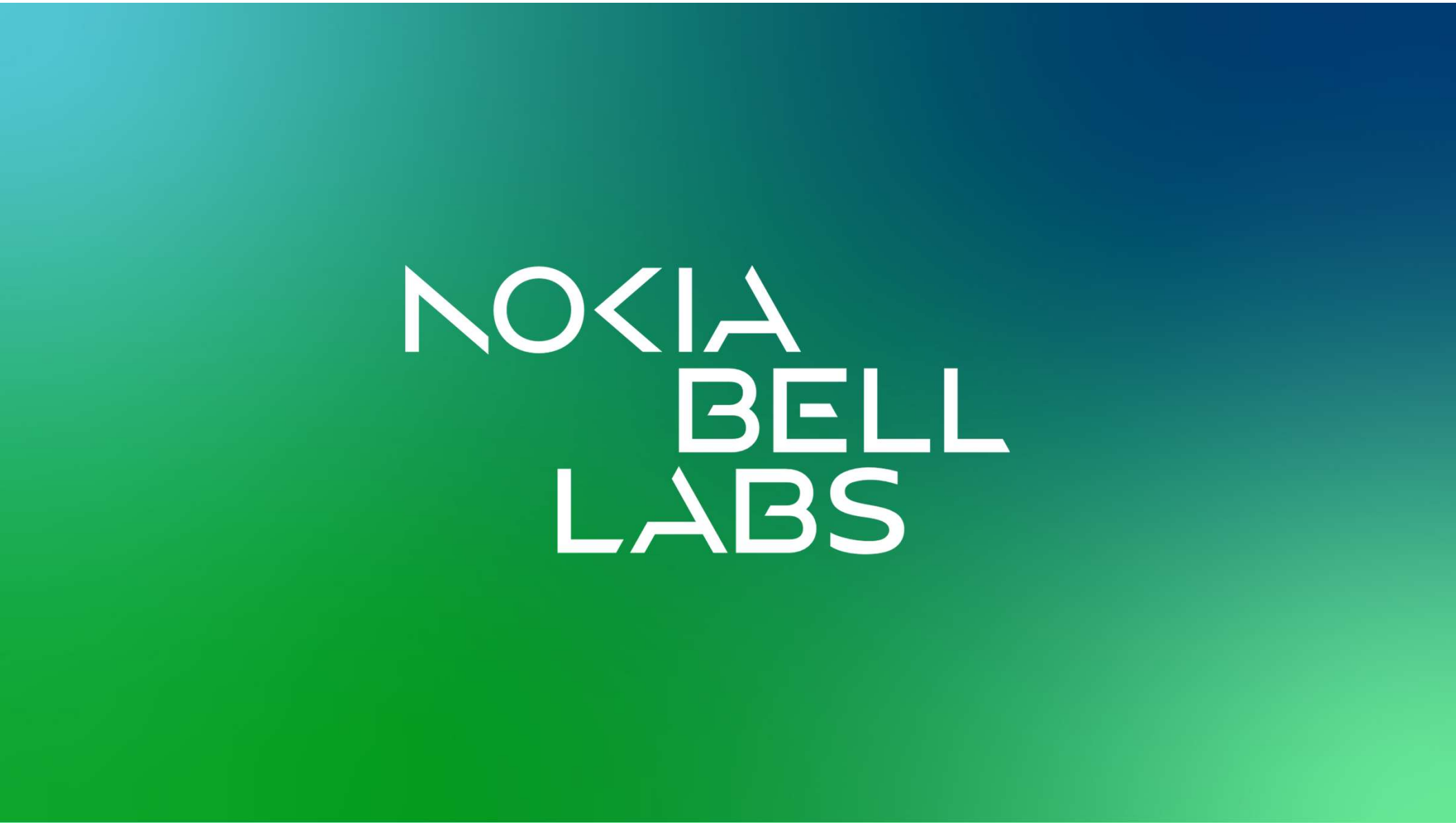




Summary and references

- 802.11bn Ultra High Reliability → Wi-Fi 8
  - Study group formed in July 2022
  - Currently Draft 1.0 is under review
  - First Wi-Fi 8 certified products expected in 2028
  - Paradigm shift towards low-latency support via more coordination and determinism

- References:
  - L. Galati Giordano, G. Geraci, M. Carrascosa, B. Bellalta "What Will Wi-Fi 8 Be? A Primer on IEEE 802.11bn Ultra High Reliability" in IEEE Communications Magazine, vol. 62, no. 8, pp. 126-132, August 2024.
  - G. Geraci, F. Meneghello, F. Wilhelmi, D. Lopez-Perez, I. Val, L. Galati Giordano, C. Cordeiro, M. Ghosh, E. Knightly, B. Bellalta, "Wi-Fi: Twenty-Five Years and Counting", Proceedings of IEEE 2025 (under review).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