STANDARDS

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IEEE 802.11be: Extremely High Throughput

In previous "Standards" columns, we reviewed and discussed a few projects that are active in the IEEE 802.11 working group. These projects focus on developing physical and medium-access protocol layers for new wireless local area network technologies, including P802.11ax [1] and P802.11ay [2].

A new project, IEEE 802.11be, Enhancements for Extremely High Throughput, was initiated during the IEEE 802.11 2019 May interim [3]. The project authorization request form [4], which is approved by the IEEE Standards Association, states that it focuses on defining

> standardized modifications to both the IEEE Std. 802.11 physical layers (PHY) and Medium Access Control Layer (MAC) that enable at least one mode of operation capable of supporting a maximum throughput of at least 30 Gb/s, as measured at the MAC data service access point (SAP), with carrier frequency operation between 1 and 7.250 GHz while ensuring backward compatibility and coexistence with legacy IEEE Std. 802.11 compliant devices operating in the 2.4 GHz, 5 GHz, and 6 GHz bands. This amendment defines at least one mode of operation capable of improved worst case latency and jitter.

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DURING THE STUDY GROUP PHASE OF THIS PROJECT, MANY DIFFERENT TOPICS WERE PRESENTED, AND EXTENSIVE DIALOGUE TOOK PLACE ABOUT ENHANCING THE PERFORMANCE OF IEEE 802.11AX.

During the study group phase of this project (September 2018–March 2019) [4], many different topics were presented, and extensive dialogue took place about enhancing the performance of IEEE 802.11ax. The following is a list of topics for which consensus was reached as the main candidate features for further discussion in IEEE 802.11be.

- *Use of additional spatial streams, specifically 16, and the corresponding multiple-input, multiple-output (MIMO) protocol enhancement*: IEEE 802.11ax supports and includes up to eight spatial streams, so increasing the spatial stream from eight to 16 can double the peak throughput.
- *Wider bandwidth, including 320 MHz, and the feasibility of possibly using the more efficient noncontiguous spectrum*: IEEE 802.11ax supports and includes up to a contiguous 160-MHz bandwidth and a noncontiguous 80-MHz + 80-MHz bandwidth. A doubled bandwidth results in either higher peak throughput or

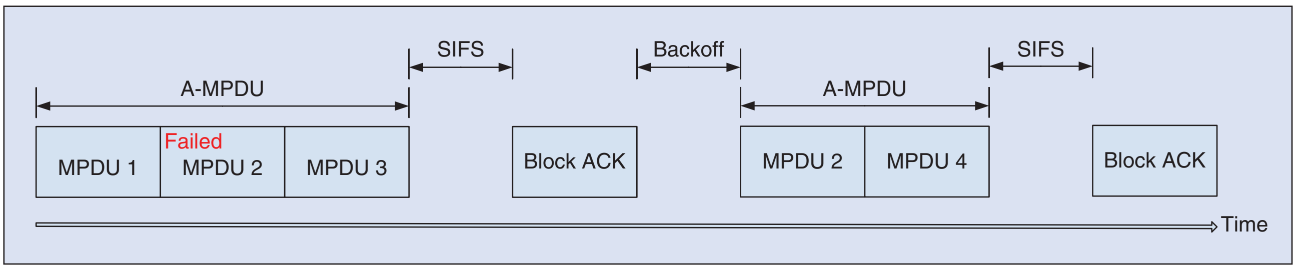

FIGURE 1 An existing mechanism for retransmission in IEEE 802.11ax. ACK: acknowledgment; SIFS: short interframe space.

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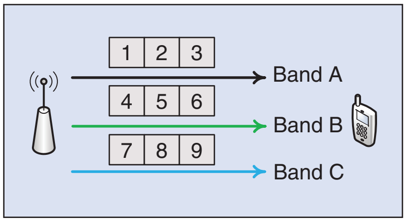

FIGURE 2 A potential benefit of using multiband operation is improving throughput by allocating data of one traffic stream among multiple bands.

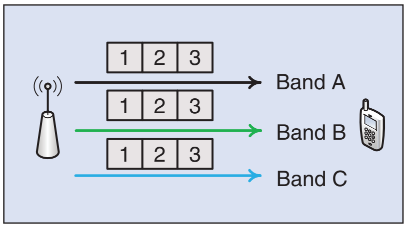

FIGURE 3 An alternative potential benefit of using multiband operation is reducing the transmission error by sending the duplicate data of one traffic stream over multiple bands.

an increased capacity that would be shared among users by considering multiuser MIMO.

- *Consideration of enhanced link-adaptation and transmission protocols, e.g., hybrid automatic repeat request (HARQ)*: Note that HARQ has not been applied in IEEE 802.11 so far. For example, for retransmission in IEEE 802.11ax (see Figure 1), the transmitters send Aggregate MAC Protocol Data Unit (A-MPDU),

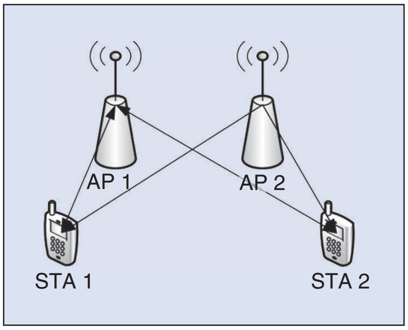

FIGURE 4 An illustration of multiaccess-point coordination. STA: station.

in which each MPDU contains a check-sum the receiver uses to verify whether it was decoded without errors. The receiver then responds with an acknowledgment (ACK)/Block ACK, indicating which MPDU was decoded correctly. Any incorrectly decoded MPDUs are transmitted and can be aggregated with new MPDUs.
- *Multiband or multichannel aggregation and operation*: Potential benefits include improved efficiency because mechanisms such as traffic steering and load balancing can be managed over multiple frequency bands, while concurrent transmissions can occur in multiple frequency bands or channels for the sake of improving throughput (Figure 2) or enhancing reliability (Figure 3).
- *Multiaccess-point coordination*: The feasibility of using coordinated and joint transmission would clearly be a potential improvement for many access-point (AP) configurations, especially in response to the increased use of mesh APs for both residential and managed deployments (Figure 4).

For the project's timeline, an initial draft of the standard's amendment is to be completed by September 2020, and the final version is scheduled to be published in May 2024.

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