Standardization of Next-generation Wireless LANs in the IEEE 802.11 Working Group

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Abstract

The market of wireless local area networks (LANs) has extended from the original personal computer peripherals to various segments such as information appliances, Internet-of-Things devices, and automobiles. The Institute of Electrical and Electronics Engineers (IEEE) 802.11 working group, which develops the standard of wireless LANs, is working on new projects for next-generation wireless LANs. This article introduces current activities in the IEEE 802.11 working group focusing on the next mainstream wireless LANs such as the IEEE 802.11ax and 802.11be following the 802.11ax. Related activity in the Wi-Fi Alliance for providing interoperability test services of wireless LAN devices based on the IEEE 802.11 standards is also covered in this article.

Keywords: IEEE 802.11, wireless LAN, standardization

1. Standardization activity in the IEEE 802.11 working group

The Institute of Electrical and Electronics Engineers (IEEE) 802.11 [1] is a working group (WG) within the IEEE 802 LAN/MAN Standards Committee [2] that develops various standards related to local area networks (LANs) and metropolitan area networks (MANs) and is responsible for standardization of physical layer and medium access control (MAC) layer technologies of wireless LANs.

1.1 Subgroups within the IEEE 802.11 WG

There are several types of subgroups within the IEEE 802.11 WG. A task group (TG) is a subgroup responsible for developing a technical standard or recommended practice. A study group is a preparatory group to create a TG to discuss use cases, technologies, and feasibilities. As a result of discussion, a study group creates documents called Project Authorization Request and Criteria for Standards Development. There are also a group to discuss a specific topic called a topic interest group (TIG), standing committees, and ad hoc groups. **Table 1** lists the current subgroups in the 802.11 WG.

2. Standardization of the IEEE 802.11ax

The latest wireless LAN products with the brand name “Wi-Fi 6” that can be found in home-electronics retail stores are based on the IEEE 802.11ax standard. Although this standard defines data-transmission speed up to 9.6 Gbit/s, the maximum speed supported by actual products varies from about 1 to 5 Gbit/s depending on the price. The standardization of the IEEE 802.11ax will be completed shortly. The Wi-Fi Alliance [3], which provides interoperability test services, has started certification of 802.11ax devices under the brand name Wi-Fi 6.

2.1 New technologies of the IEEE 802.11ax

For better frequency utilization, the IEEE 802.11ax specified a new multi-user transmission technique called orthogonal frequency-division multiplexing (OFDMA), which has been adopted for LTE (Long Term Evolution) and WiMax (Worldwide Interoperability for Microwave Access) systems for both downlink and uplink. In the 802.11ax, a maximum of

Table 1. Subgroups in the IEEE 802.11 WG.

Subgroup	Mission
TGax	Next-Generation High Efficiency Wireless LAN
TGay	Next-Generation 60-GHz Wireless LAN
TGaz	Next-Generation Positioning
TGba	Wake Up Radio
TGbb	Light Communications
TGbc	Enhanced Broadcast Service
TGbd	Enhancements for Next-Generation V2X
TGbe	Extremely High Throughput
TGbf	Wireless LAN Sensing
TGbh	Randomly Changing MAC address
TGbi	Enhanced Service with Data Privacy Protection
Tgme	IEEE 802.11 Standard Maintenance and Roll Up
AANI SC	Advanced Access Network Interface (Interworking with 5G)
COEX SC	Coexistence (with cellular based systems)
WNG SC	Wireless LAN Next Generation

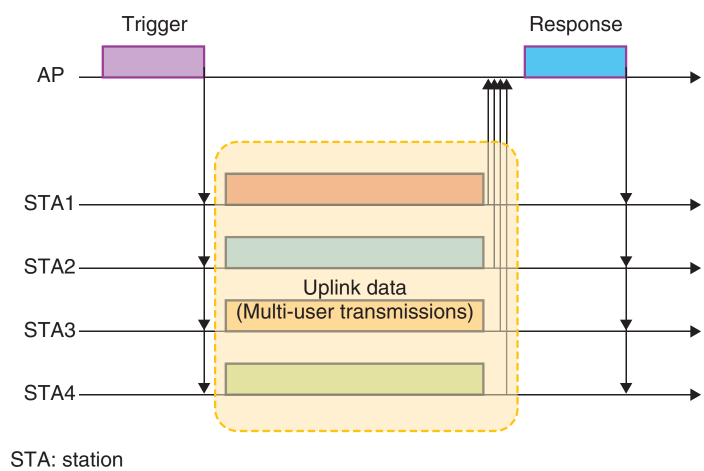

Fig. 1. Uplink multi-user transmission sequence initiated by a trigger frame.

nine users can be allocated in a 20-MHz channel and can transmit or receive data to and from an access point (AP), respectively. OFDMA is extremely useful for transmitting short packets such as voice and TCP ACK (Transmission Control Protocol acknowledgment). The 802.11ax also extended the multi-user multiple-input multiple-output (MIMO) technique, which was originally specified by the IEEE 802.11ac standard for downlink, to both downlink and uplink.

The IEEE 802.11ax defined the uplink multi-user transmission data transmission protocol sequence using a *trigger frame*, as shown in **Fig. 1**. The trigger frame enables client devices to adjust parameters, such as transmission timing and transmit power, for the following uplink transmissions by the designated clients.

The 802.11ax also defined another mechanism, called spatial reuse, to enhance frequency utilization by mitigating the effect of transmissions from other devices [4].

2.2 Support of the 6-GHz band

In the United States, the 6-GHz band (from 5.925 to 7.125 GHz) was allocated for unlicensed wireless

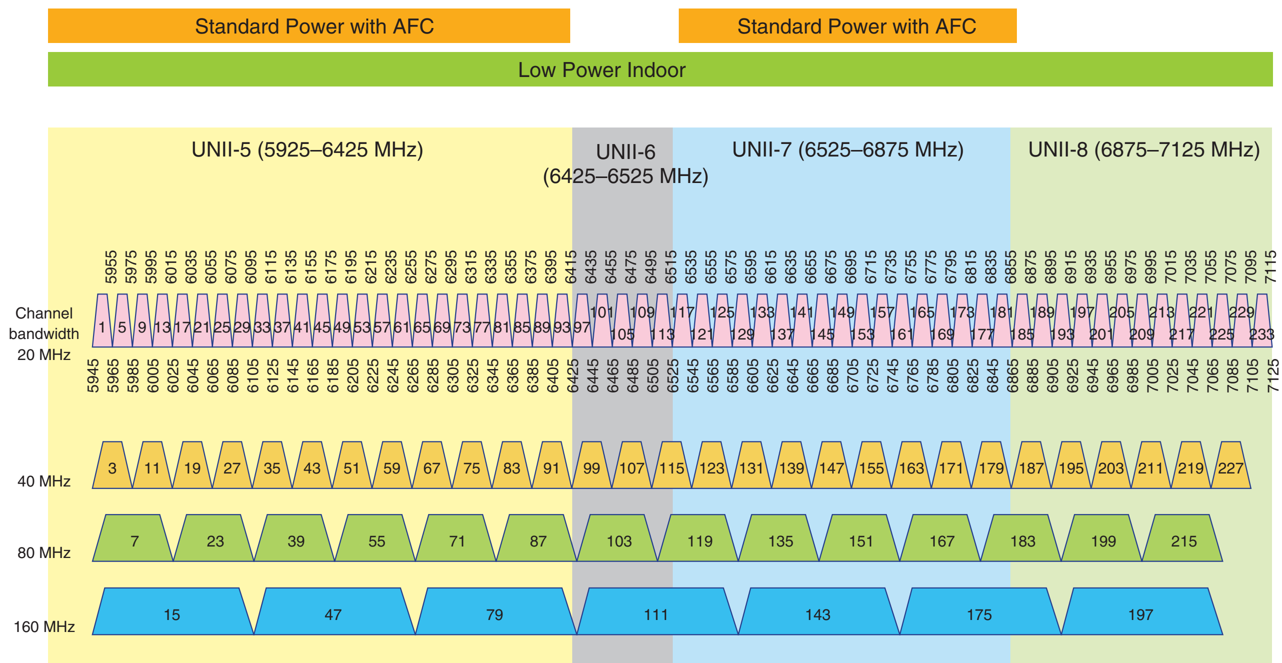

Fig. 2. Channelization in the 6-GHz band agreed in the IEEE 802.11ax.

communication systems, including wireless LANs, in the spring of 2020 (see **Fig. 2**). By this allocation of a large frequency band, it is anticipated that interference among wireless LAN devices will be reduced. Therefore, better throughput and latency performance can be expected, which enables the accommodation of new applications requiring more bandwidth such as augmented reality and virtual reality.

In the 6-GHz band, however, there are several incumbent wireless communication systems, and the wireless LAN system needs to satisfy specific requirements to coexist with those systems. In the United States, the 6-GHz band is divided into four segments, and the technical requirements are defined for each one. There are two categories of wireless LAN devices, Low Power Indoor (LPI) and Standard Power (SP). LPI devices are allowed to use any frequency segment of the 6-GHz band but are only allowed for indoor environments. SP devices, on the other hand, are allowed to emit higher power, but are allowed to operate in only specific frequency segments, and the use of automated frequency coordination (AFC) is mandated to protect existing wireless systems. There is another category called Very Low Power (VLP) under discussion. In Japan, discussion on the unlicensed use of the 6-GHz band has not begun; however, there is strong demand from industries, and it is very likely that discussion will begin shortly.

3. The IEEE 802.11be—the extremely high throughput wireless LAN

To achieve more than 30 Gbit/s for maximum throughput at the MAC service access point (SAP), the TGbe was created in May 2019. The IEEE 802.11be standard will be published in May 2024 in accordance with the results of the discussions in the TGbe. The IEEE 802.11be will succeed the 802.11ax as the mainstream wireless LAN standard. In addition to technical topics, the TGbe is currently discussing the framework of the draft standard called Specification Framework Document. The TGbe plans to continue this discussion until May 2021 and plans to release draft version 1.0. The following features are currently being discussed for the IEEE 802.11be standard.

3.1 Improvement in frequency-utilization efficiency and utilization of wider bandwidth

The IEEE 802.11ax adopted modulation schemes up to 1024 quadrature amplitude modulation (QAM), maximum of 8 spatial streams for MIMO, and channel bandwidth of a maximum of 160 MHz. The TGbe is considering a maximum of 4096 QAM, 16 spatial

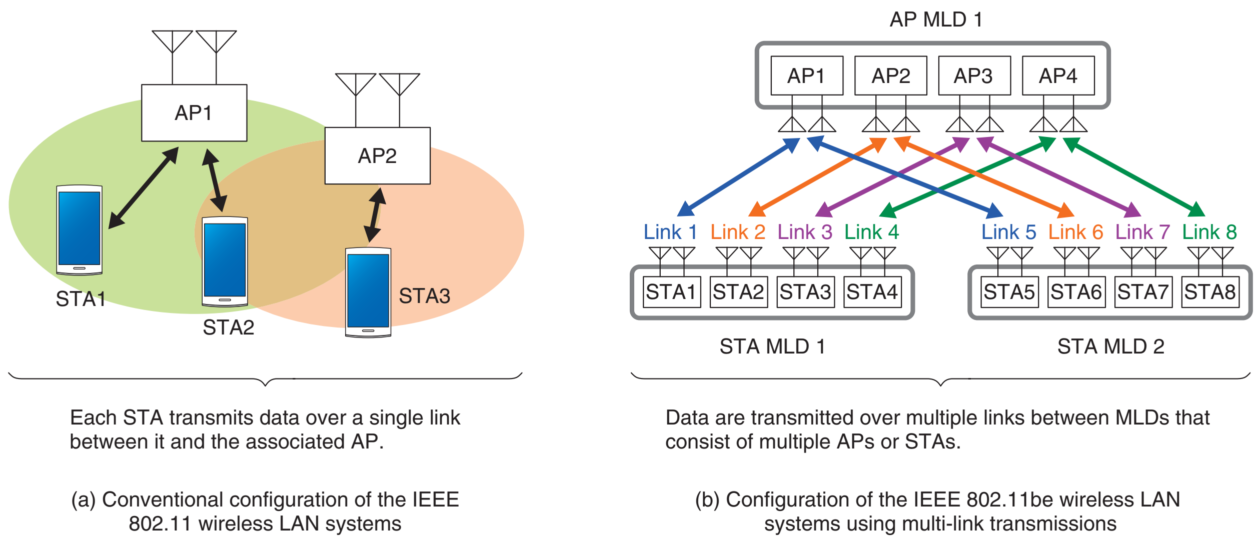

Fig. 3. Multi-link transmission.

streams, and 320 MHz. Hybrid automatic repeat request will also be adopted to improve the efficiency of data retransmission.

3.2 Multi-link transmission

The TGbe will define multi-link transmission as a new feature. In legacy wireless LANs including the 802.11ax, each station (STA)* transmits/receives data over a single link between it and the associated AP. In multi-link transmission, it is assumed that wireless LAN devices (multi-link devices: MLDs) consisting of multiple APs or STAs and multiple links between MLDs, which operate on different channels, can be used for data transmission and reception (**Fig. 3**). Multiple links are established between MLDs that consist of multiple APs and those that consist of multiple STAs. This enables faster and more reliable transmission. For example, high-speed transmission will be possible by transmitting different data frames on multiple different links in parallel. Reliability can be improved by using multiple links for transmitting duplicated identical frames. Choosing the highest quality link for priority traffic or control frames also enables highly reliable data transmission.

3.3 Multi-AP coordination

The TGbe will define multi-AP coordination as another new feature. The following functions are being discussed in the TGbe for this feature. Coordinated spatial reuse (Co-SR) optimizes parameters such as the transmit power of each AP; coordinated beamforming (Co-BF) enables simultaneous transmission from multiple APs to avoid generating interference in the same frequency band and time; joint transmission (JT) enables receiver STAs to combine data from multiple APs; and coordinated orthogonal frequency-division multiple access (Co-OFDMA) assigns resource units flexibly between multiple APs.

3.4 Low-latency features

Features for achieving low latency and low jitter communications, even if there are many competing STAs or in interference environments, will be defined in the TGbe. Features for notifying the latency of a specified link; mechanisms that can ensure transmission time for periodic latency-sensitive traffic; and the combination of IEEE 802.1 Time Sensitive Networking and the access control mechanism of IEEE 802.11 are being discussed in the TGbe.

3.5 Other features

National security and emergency preparedness that enables the prioritization of emergency communications and a mechanism for direct communication between STAs with assistance from APs are also being proposed in the TGbe.

4. Interoperability test in the Wi-Fi Alliance

The Wi-Fi Alliance is an organization to promote

* Station (STA) is a client device of wireless LAN.

the adoption of wireless LAN devices and services into various market segments. It provides interoperability test services for wireless LAN products based on the IEEE 802.11 standards. A wireless LAN device that passed the interoperability test of the Wi-Fi Alliance is allowed to use the Wi-Fi certified logo.

The Wi-Fi Alliance has started interoperability testing for 802.11ax products under the brand name Wi-Fi 6 based on the draft version of the IEEE 802.11ax standard. As mentioned previously, Wi-Fi 6 certified products are currently available on the market. There are two more interoperability test services for 802.11ax products under development. One is called "Wi-Fi 6E" to test features for operations in the 6-GHz band in addition to the current Wi-Fi 6 interoperability test. The Wi-Fi 6E certification program will be launched shortly. The other one is "Wi-Fi 6 R2," which is based on the official standard of the IEEE 802.11ax.

5. Summary

In this article, standardization activities of the IEEE 802.11ax and 802.11be wireless LANs were briefly introduced. The IEEE 802.11ax standardization is close to completion, and products based on the draft standard are currently available. The IEEE 802.11be is the next mainstream wireless LAN standard succeeding the 802.11ax. The standardization is still in the early phase, and the TGbe in the IEEE 802.11 WG is actively discussing the features and technologies for it.

References

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