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**IEEE Standard for Information Technology—
Telecommunications and Information Exchange between Systems
Local and Metropolitan Area Networks—
Specific Requirements**

# Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

IEEE Computer Society

Developed by the
LAN/MAN Standards Committee

**IEEE Std 802.11™-2020**
(Revision of IEEE Std 802.11-2016)

IEEE

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# Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Developed by the

**LAN/MAN Standards Committee**
of the
**IEEE Computer Society**

Approved 3 December 2020

**IEEE SA Standards Board**

**Abstract:** Technical corrections and clarifications to IEEE Std 802.11 for wireless local area networks (WLANs) as well as enhancements to the existing medium access control (MAC) and physical layer (PHY) functions are specified in this revision. Amendments 1 to 5 published in 2016 and 2018 have also been incorporated into this revision.

**Keywords:** 2.4 GHz, 256-QAM, 3650 MHz, 4.9 GHz, 5 GHz, 5.9 GHz, 60 GHz, advanced encryption standard, AES, audio, beamforming, carrier sense multiple access/collision avoidance, CCMP, channel switching, clustering, contention based access period, Counter mode with Cipher-block chaining Message authentication code Protocol, confidentiality, CSMA/CA, DFS, direct link, directional multi-gigabit, dynamic allocation of service period, dynamic extension of service period, dynamic frequency selection, dynamic truncation of service period, E911, EDCA, emergency alert system, emergency services, fast session transfer, forwarding, GCMP, generic advertisement service, high throughput, IEEE 802.11™, international roaming, interworking, interworking with external networks, LAN, local area network, MAC, management, measurement, medium access control, media-independent handover, medium access controller, mesh, MIS, millimeter-wave, MIMO, MIMO-OFDM, multi-band operation, multi-hop, multi-user MIMO, multiple input multiple output, network advertisement, network discovery, network management, network selection, noncontiguous frequency segments, OCB, path-selection, personal basic service set, PHY, physical layer, power saving, QoS, quality of service, quality-of-service management frame, radio, radio frequency, RF, radio resource, radio management, relay operation, spatial sharing, SSPN, subscriber service provider, television white spaces, TPC, transmit power control, video, wireless access in vehicular environments, wireless LAN, wireless local area network, WLAN, wireless network management, zero-knowledge proof

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# Introduction

This introduction is not part of IEEE Std 802.11-2020, IEEE Standard for Information Technology—Telecommunications and Information Exchange between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

This revision gives users, in one document, the IEEE 802.11 standard for wireless local area networks (WLANs) with all of the amendments that have been published to date.

## Incorporating published amendments

The original standard was published in 1997, revised in 1999 with MIB changes, and reaffirmed in 2003.

A revision was published in 2007, which incorporated into the 1999 edition the following amendments:

- IEEE Std 802.11a™-1999: High-speed Physical Layer in the 5 GHz Band (Amendment 1)
- IEEE Std 802.11b™-1999: Higher-Speed Physical Layer Extension in the 2.4 GHz Band (Amendment 2)
- IEEE Std 802.11b-1999/Corrigendum 1-2001: Higher-speed Physical Layer (PHY) extension in the 2.4 GHz band (Corrigendum 1 to Amendment 2)
- IEEE Std 802.11d™-2001: Specification for operation in additional regulatory domains (Amendment 3)
- IEEE Std 802.11g™-2003: Further Higher Data Rate Extension in the 2.4 GHz Band (Amendment 4)
- IEEE Std 802.11h™-2003: Spectrum and Transmit Power Management Extensions in the 5 GHz band in Europe (Amendment 5)
- IEEE Std 802.11i™-2004: Medium Access Control (MAC) Security Enhancements (Amendment 6)
- IEEE Std 802.11j™-2004: 4.9 GHz–5 GHz Operation in Japan (Amendment 7)
- IEEE Std 802.11e™-2005: Medium Access Control (MAC) Quality of Service Enhancements (Amendment 8)

A revision was published in 2012, which incorporated into the 2007 revision the following amendments:

- IEEE Std 802.11k™-2008: Radio Resource Measurement of Wireless LANs (Amendment 1)
- IEEE Std 802.11r™-2008: Fast Basic Service Set (BSS) Transition (Amendment 2)
- IEEE Std 802.11y™-2008: 3650–3700 MHz Operation in USA (Amendment 3)
- IEEE Std 802.11w™-2009: Protected Management Frames (Amendment 4)
- IEEE Std 802.11n™-2009: Enhancements for Higher Throughput (Amendment 5)
- IEEE Std 802.11p™-2010: Wireless Access in Vehicular Environments (Amendment 6)
- IEEE Std 802.11z™-2010: Extensions to Direct-Link Setup (DLS) (Amendment 7)
- IEEE Std 802.11v™-2011: Wireless Network Management (Amendment 8)
- IEEE Std 802.11u™-2011: Interworking with External Networks (Amendment 9)
- IEEE Std 802.11s™-2011: Mesh Networking (Amendment 10)

A revision was published in 2016, which incorporated into the 2012 revision the following amendments:

- IEEE Std 802.11ae™-2012: Prioritization of Management Frames (Amendment 1)
- IEEE Std 802.11aa™-2012: MAC Enhancements for Robust Audio Video Streaming (Amendment 2)
- IEEE Std 802.11ad™-2012: Enhancements for Very High Throughput in the 60 GHz Band (Amendment 3)
- IEEE Std 802.11ac™-2013: Enhancements for Very High Throughput for Operation in Bands below 6 GHz (Amendment 4)
- IEEE Std 802.11af™-2013: Television White Spaces (TVWS) Operation (Amendment 5)

This revision is based on IEEE Std 802.11-2016, into which the following amendments have been incorporated:

- IEEE Std 802.11ai™-2016 (second printing): Fast Initial Link Setup (Amendment 1)
- IEEE Std 802.11ah™-2016: Sub 1 GHz License Exempt Operation (Amendment 2)
- IEEE Std 802.11aj™-2018: Enhancements for Very High Throughput to Support Chinese Millimeter Wave Frequency Bands (60 GHz and 45 GHz) (Amendment 3)
- IEEE Std 802.11ak™-2018: Enhancements for Transit Links Within Bridged Networks (Amendment 4)
- IEEE Std 802.11aq™-2018: Preassociation Discovery (Amendment 5)

## Technical corrections, clarifications, and enhancements

In addition, this revision specifies technical corrections and clarifications to IEEE Std 802.11 as well as enhancements to the existing medium access control (MAC) and physical layer (PHY) functions. In addition, this revision removes some features previously marked as obsolete and adds new indications of other obsolete features.

Generally, features that are marked deprecated or obsolete are not maintained; there might be technical errors in the material describing these features.

## Renumbering of clauses and annexes

The numbering of certain clauses and annexes has been modified since IEEE Std 802.11-2007.

The evolution of this numbering is shown in Figure 1.

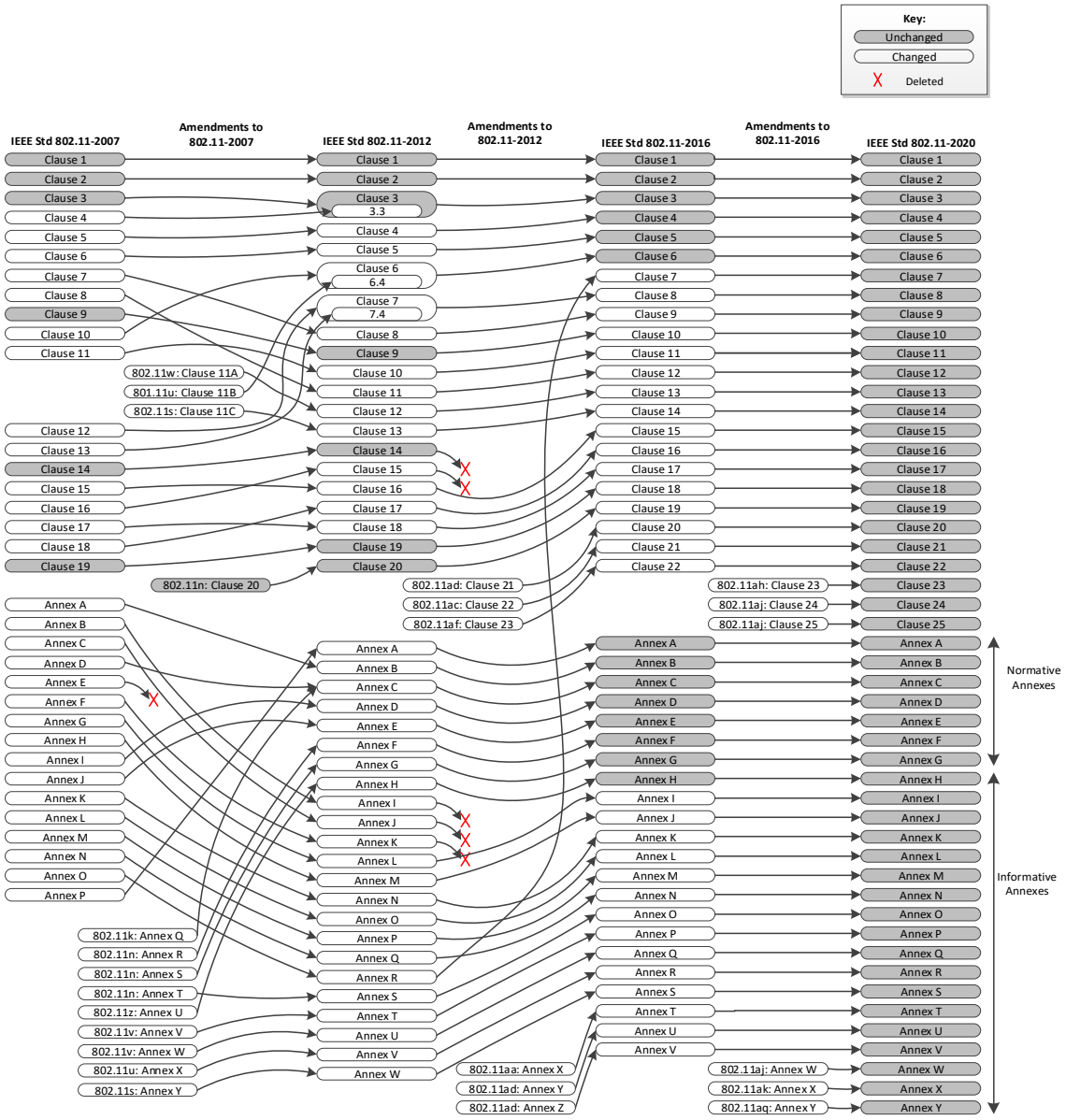


**Figure 1—The evolution of numbering in IEEE Std 802.11**

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# Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

## 1. Overview

### 1.1 Scope

The scope of this standard is to define one medium access control (MAC) and several physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area.

### 1.2 Purpose

The purpose of this standard is to provide wireless connectivity for fixed, portable, and moving stations within a local area. This standard also offers regulatory bodies a means of standardizing access to one or more frequency bands for the purpose of local area communication.

### 1.3 Supplementary information on purpose

Specifically, in the context of IEEE 802.11™-compliant devices, this standard

- Describes the functions and services required by a device to operate within independent, personal, and infrastructure networks as well as the aspects of device mobility (transition) within those networks.
- Describes the functions and services that allow a device to communicate directly with another such device outside of an independent or infrastructure network.
- Defines the MAC procedures to support the MAC service data unit (MSDU) delivery services.
- Defines several PHY signaling techniques and interface functions that are controlled by the MAC.
- Permits the operation of a device within a wireless local area network (WLAN) that coexists with multiple overlapping IEEE 802.11 WLANs.
- Describes the requirements and procedures to provide data confidentiality of user information and MAC management information being transferred over the wireless medium (WM) and authentication of devices.
- Defines mechanisms for dynamic frequency selection (DFS) and transmit power control (TPC) that may be used to satisfy regulatory requirements for operation in any band.