IEEE 802.11ac: Next Generation High Speed Wireless LAN Technology

Ms. Laxmi Chaudhary ¹, Ms. Pooja Verma ², Ms. Aisha Jangid ³, Mr. Arun Vyas ⁴

(1) Asso. Professor, laxmichaudhary1911@gmail.com, Jodhpur Institute of Engg. & Technology, Jodhpur
(2) Asso. Professor, pooja.pearl12@gmail.com, Jodhpur Institute of Engg. & Technology, Jodhpur
(3) Asst. Prof., aishajangid@gmail.com, Jodhpur Institute of Engg. & Technology, Jodhpur
(4) Asst. Prof., arunvyas.7@gmail.com, Jodhpur Institute of Engg. & Technology, Jodhpur

Abstract - This paper gives an overview of the IEEE 802.11ac which has been proposed to enhance the throughput of IEEE 802.11n beyond Gigabit-per second rates. 802.11ac adds multi-user access techniques in the form of downlink multi-user (DL MU) multiple input multiple output (MIMO) and 80 and 160 MHz channels in the 5 GHz band for applications such as multiple simultaneous video streams throughout the home. For this the IEEE 802.11ac task group is working on the amendment that has goal of reaching maximum network throughput of at least 1 Gbps on bands below 6GHz & continuing to support the legacy of 5GHz 802.11 devices. In this paper we describe the 802.11ac key features, channelization, MAC modifications and modulation enhancements and its various applications in wireless technology.

Keywords: IEEE 802.11ac, WLAN, data rates, Wireless communication.

I. INTRODUCTION

The wireless broadband technologies were developed to provide services comparable to those provided to the wire line networks. Cellular networks now provide support for high bandwidth data transfer for numerous mobile users simultaneously and also provide mobility support for voice communication. Wireless data networks can be divided into several types on the basis of their coverage area as: WLAN: Wireless Local Area network, in area with a cell radius up to hundred meters, mainly in home and office environments, WMAN: Wireless Metropolitan Area Network; which covers wider areas as large as entire cities and WWAN: Wireless Wide Area Network with a cell radius about 50 km, cover areas larger than a city. Out of all of these standards, our main area of study in this paper is the IEEE 802.11 standards for Wireless LAN [2].

Institute of Electrical and Electronic Engineers (IEEE) have defined IEEE 802.11 standard for wireless communication that keeps on developing [1]. These standards have made a huge impact on the market such that laptops, PCs, printers, cell phones, and VoIP phones, MP3 players in our homes, in offices and even in public areas have incorporated the wireless LAN technology. All IEEE 802.11 WLAN standards use unlicensed radio spectrum under 2.4 GHz and 5 GHz Industrial, Science and Medical (ISM) frequency bands. WLAN has become a part of every device and is also compatible with them as it continuously advanced from 802.11 a/b/g/n and now 802.11ac [1]. There are amendments in IEEE 802.11 standards in every few years by industry in order to increase its data rates and capabilities. As new standards developed like IEEE 802.11n and 802.11ac are compatible with the devices using previous WLAN standards 802.11[2]. IEEE 802.11ac, also known as Gigabit Wi-Fi is also the latest WLAN standard which is builds upon 802.11n incorporating the improvement in data rates, reliability, network robustness and RF bandwidth utilization efficiency. IEEE 802.11ac was developed in from 2011 through 2013 and was approved in year 2014 for the WLAN on 5GHz band. This standard is able to supply the wireless data rates over 1Gbps and is also known as Very High Throughput (VHT) has improved data rate, reliability, robustness & RF bandwidth utilization[3]. It introduces new features and also known client capacity which are demanded by bandwidth intensive applications like HDTV and uncompressed video [5].IEEE 802.11ac is the 5th generation in Wi-Fi networking standards and provides fast, high quality video streaming and nearly instantaneous data syncing and backup to the notebooks, tablets, and mobile phones which are most common gadget in present century.

IEEE 802.11ac is also known as Gigabit Wireless LAN has many improvements in both the MAC (Medium Access Control) and Physical Layer (PHY) of the IEEE 802.11ac standard in order to achieve gigabit transmission rates. In this paper we will include the different key features and enhancements, channelization and application of IEEE 802.11ac in Wireless LAN [7].
II. KEY FEATURES OF IEEE 802.11AC

A. Frequency Band of 5GHz

As compared to 802.11n which are operating in both 2.4 GHz and 5 GHz RF bands, the 802.11ac devices restrict the usage at 5 GHz RF band in order to make wider channel bandwidth [2]. Compared to the legacy standard, IEEE 802.11ac operates exclusively in the 5-GHz band, which avoids interferences from any other devices operating at 2.4 GHz.

B. Higher modulation and coding scheme

IEEE 802.11ac uses Orthogonal Frequency-Division Multiplexing (OFDM) to modulate bits for transmission. While the modulation method is the same as that used in 802.11n but it adds 256 QAM. With 256-QAM, each symbol can carry eight information bits, increasing the number of transmitted bits per hertz. This increases the number of bits per packet so higher data rate are available.

C. Wider Channel Bandwidth

In addition, 802.11ac uses non-overlapping channels at 5 GHz, which can be bonded together to obtain wider channels to get wider bandwidth. IEEE 802.11ac supports 20, 40 and 80 MHz channels and optional support of 160 MHz channels so by increasing channel width increases the data rates.

D. System Performance

Maximum single station throughput and multi-station aggregate throughputs achieved of more than 500 Mbps and 1 Gbps respectively. This is measured at the MAC data service access point (SAP), with no more than 80 MHz of channel bandwidth in the 5 GHz band. As the data rate requirement is at MAC rather than PHY, it implies that MAC efficiency must be addressed, not just an improvement to the PHY data rate.

E. Backwards Compatibility

802.11ac provides backwards compatibility with 802.11a and 802.11n devices operating in the 5 GHz band. This means that IEEE 802.11ac frame structure can accommodate transmission with devices supporting 802.11a and 802.11n technologies.

F. Beam forming

Transmitter beam forming will help to increase throughput by improving the quality of the signal sent to wireless clients. The beam forming techniques will optimize the signal strength for each individual wireless client station. Beam forming works by changing the characteristics of the transmitter to create a focused beam that can be more optimally received by a wireless station[8]. Previous standards, such as 802.11n, only transmit and receive Omni directional signals, which are susceptible to interference. So, IEEE 802.11ac will support improved beam forming, which provide directional signal reception and transmission.

G. Multi-user performance

802.11ac uses multiple antennas to simultaneously transmit to multiple clients to extend data rates and throughput. This aims at supporting applications that include video streaming, HD digital video, HDTV etc that consumes much more bandwidth than voice communication or other applications. Transmission speeds using Wi-Fi device increases in direct proportion to the number of antennas.
III. IEEE 802.11AC—THE TECHNICAL DETAILS AND ADVANCEMENTS

A. Channelization:
Channel Width Supported In 802.11.ac uses 20, 40, and 80 MHz channel and also it provides optional support for operation on 160 MHz channels. In this standard 80 and 160 MHz can be formed by a combination of two adjacent non-overlapping 40 and 80 MHz channels, respectively. By this amendment it could be specified that two non-adjacent 80 MHz channels can be used to form a 160 MHz one. The device operating on non-contiguous 80+80 MHz should be capable of communicating with devices operating on contiguous 160 MHz if the former segments are placed in frequency to match the tone allocation of the latter case [3].

![Figure 2. Channel allocation in U.S. region.](image)

In 802.11ac channels are divided into primary and secondary sub-channels. As 40 MHz or wider always require a primary 20 MHz wide sub-channel and 80 MHz channels have a primary 40 MHz which includes the primary 20 MHz sub-channel and a secondary 40 MHz sub-channel. The same applies for 160 MHz and 80+80 MHz channels, which consist of a primary 80 MHz and a secondary 80 MHz sub-channels. The Figure 3 relationship between the primary and secondary sub-channels based on the different bandwidth options. For all the cases, the primary sub-channel is used for carrier sensing in order to sense that no other device is transmitting [4].

![Figure 3. Primary and secondary channel selection](image)

For the guarantee coexistence and backward compatibility the presence of the 20 MHz primary sub-channel is also necessary with legacy 802.11 devices. Only the primary sub-channel performs full Clear Channel Assessment (CCA), which involves packet detection starting with the preamble whereas the secondary sub-channel is not required to perform full CCA. The CCA sensitivity of the primary sub-channel is -82 dB for a valid 802.11 20 MHz signal, -79 dB for a valid 802.11 40 MHz signal, -76 dB for a valid 80 MHz signal and -73 dB for a 160 MHz one[7]. On the other hand, for the secondary sub-channel the sensitivity was improved from -62 dB to -72 dB for both 20 and 40 MHz channels, compared to 802.11n (and -69 dB for 80 MHz channels), an 802.11ac device should detect whether the primary sub-channel is busy within 4 μs with a probability greater than 90%. In contrast, on the secondary sub-channel the device has up to 25 μs to detect if it is busy with the same probability [5].

B. MAC Improvements
In 802.11n the MAC enhancements includes two different kinds of frame aggregations comprising of A-MSDU and A-MPDU which improves its MAC efficiency. And also by possible combination of both A-MSDU and A-MPDU which is referred as hybrid A-MSDU/A-MPDU aggregation can be included. Whereas in 802.11ac the key MAC enhancements includes the capability of multi-channel operations. The 802.11ac supports enhanced A-MSDU and AMPDU in which the maximum A-MSDU size and maximum A-MPDU size are increased for further improvement in its MAC efficiency along with higher PHY data rates. The
maximum size of an A-MPDU can optionally be increased to a maximum of 1,048,575 octets (compared to a maximum of 65,535 octets in 802.11n)[6]. The RTS/CTS mechanism has been updated for better detection whether any of the non-primary channels are occupied by a different transmission because some hidden nodes on the secondary channels are an important problem to address. Both RTS and CTS (optionally) support a “dynamic bandwidth” mode in which CTS can be sent only on the primary channel whereas the RTS can than fall back to a lower bandwidth mode. This will help to mitigate the effect of a hidden node. It is to be noted that the final transmission bandwidth always has to include the primary channel. IEEE 802.11 used Reduced Inter Frame Spacing (RIFS) [4] to reduce gap between successive transmissions and its purpose was to increase MAC efficiency by reducing the gap between successive transmissions [7]. 802.11ac uses aggregation in place of RIFS, as it is more efficient way for MAC [9].

C. Modulation Enhancements
IEEE 802.11ac uses Orthogonal Frequency Division Multiplexing (OFDM) to modulate bits for transmission over the wireless medium which is the most recent wireless communication technique. The modulation approach is same that was used in 802.11n, 802.11ac optionally allows the use of 256 QAM in addition to the mandatory Quadrature Phase Shift Keying (QPSK), Binary PSK (BPSK), 16 QAM and 64 QAM modulations. The best suitable 256 QAM increases the number of bits per sub-carrier from 6 to 8, which results 33% increase in PHY rate under. It should be noted however that 256 QAM can only be used in high signal to noise ratio (SNR) scenarios (across the used spectrum and desired streams); i.e. for very favorable channel conditions. The support of 256 QAM will increase the maximum PHY rate that can be supported by the system, but will have no effect in typical scenarios and will not lead to any reach increase for the service [5]. Also, supporting 256 QAM requires transmitter and receiver to be designed such that the inherent SNR (transmit and receive Error Vector Magnitude, or EVM) of the system is able to accommodate the higher constellation.

IV. USES OF IEEE 802.11AC

802.11ac can improve the performance and user experience in most common WLAN applications, and enable several new ones, in various fields as follows:

A. Mobile Application
Various applications in mobile entertainment devices such as music players, handheld gaming devices, and wireless-enabled cameras and camcorders are equipped with the increased data rate and higher energy efficiency of 802.11ac. With limited power consumption feature of these devices, 802.11ac can enable the rapid synchronization and backup of large data files between these devices and a personal computer (PC).

B. Portable Computers
PCs, laptops, slates and tablets, which are categorized as portable computing devices are obvious ideal candidates for 802.11ac. With increase in wireless applications supported by these devices, and the demand for faster connectivity by their users, will be the key drivers for adoption of 802.11ac. These devices will use 802.11ac, as mentioned, for rapid synchronization and backup of large data files with other 802.11ac-enabled devices, and also for streaming of HD video and other content.

C. Entertainment
IEEE 802.11ac is also best suitable for TVs, Set-Top Boxes, and Networked Game Consoles to enable in-home distribution of HDTV and other content, with adjacent features of streaming of HD video to multiple clients throughout the home.

D. At Work
In the present scenario Wi-Fi is becoming important at work in offices and home. With IEEE 802.11ac, coverage can be accomplished with fewer devices, even while transmission rates increase. The new IEEE 802.11ac standard will also be useful for companies experimenting with new seating arrangements, such as “virtual teams,” in which workers assemble themselves into ad hoc groups.

V. CONCLUSIONS

In this paper we presented a brief description about the most important enhancements in the 802.11ac amendment which state that the new 802.11ac standard is an improved version of 802.11n. It offers higher speeds over wider bandwidths, increased performance gains dictated by this new amendment. In particular, it proposes mandatory use of frame aggregation to increase channel utilization and MAC efficiency. The changes to the channelization techniques as well as the multi-user MIMO capabilities are identifies as the paramount strategies for reaching gigabit wireless transmissions. Moreover, the standard specifies the use of different frame
aggregation schemes. The main categories are wireless display, in home distribution of HDTV and other content, rapid upload and download of large files to/from server, backhaul traffic, campus and auditorium deployments, and manufacturing floor automation.

REFERENCES


