AN OVERVIEW OF IEEE 802.11AC FOR HD VIDEO GENERATION

Rami Ahmed Elhashmi Idris[1], Mohammed Awadh Ben Mubarak[1], Yasin Yousif Mohamed[1], Nagmeldeen Mohamed Altigani[1] and Ahmed Yousif Mohamed[1]

[1]*Infrastructure University Kuala Lumpur, Malaysia*

ABSTRACT

IEEE 802.11ac is the fifth generation in Wi-Fi Networking standards and will bring fast, high quality video streaming and nearly instantaneous data syncing and backup to the notebooks, tablets and mobile phones that have become our everyday companions. Improvements in transmission speeds will be dramatic. Entry-level IEEE 802.11ac products will provide a data rate of 433 Mbps (megabits per second), which is at least three times faster than that of the most common devices using the current wireless standard, which is IEEE 802.11n. Because the new standard gives manufacturers the flexibility to offer a range of products with different levels of performance, some high-speed IEEE 802.11ac devices will offer wireless transmission in excess of a Gigabit per second —remarkable speeds that put IEEE 802.11ac wireless networks ahead of most wired networks. In addition, there will be dramatic improvements in wireless reliability, range and coverage. Homes and apartments now plagued with “dead spots” will enjoy vastly improved reception. Faster file transfer also leads to longer battery life in mobile phones. Products based on IEEE 802.11ac will be fully backward compatible with current Wi-Fi devices. Older devices, however, won't be able to take advantage of the improved speeds offered by IEEE 802.11ac. I have reviewed many papers talking about IEEE.11AC. All the previous study are focusing only on 11ac, in my paper I tried to talk about 11ac the performance the speed and data rate. Furthermore I tried to compare 11ac with previous standards like 11g , 11n, etc.

Keywords:
IEEE 802.11ac, Fifth Generation in Wi-Fi, VHT.

INTRODUCTION

To fulfill the promise of increasing Wi-Fi performance, effectively supporting more client devices on a network and delivering multiple HD video streams simultaneously, the IEEE group has been working on 802.11ac, a new standard that is in its advanced stages of standardisation. The 802.11ac Draft 2.0 specification was released in February 2012 and leverages new technologies to provide improvements over.

802.11n. is also the first Wi-Fi standard to exceed the Gigabit–per-second throughput barrier. Wi-Fi is playing an increasingly important role in home networking as it has consumer familiarity and a low cost of installation. There is a growing trend in homes to distribute multiple HD video streams and other high-bandwidth content to devices like HD TVs, laptops, tablets and smart phones. Delivering multiple simultaneous HD video streams wirelessly requires a robust, low-latency, and high throughput Wi-Fi network [8].

Wi-Fi based on 802.11n improved the performance compared to previous 802.11a/b/g Standards. It increased the theoretical peak data rates to 600 Mbps compared to 54 Mbps. In order to get to these high rates and coverage however, it relied on single user MIMO and beamforming. However, beamforming did not get widely adopted by the industry due to lack of a commonly specified mode. In addition, with multiple users, single-user MIMO relied on time-division multiplexing of the MIMO streams, which reduced overall throughput. 802.11ac overcomes the above limitations and achieves a maximum throughput of 6.93 Gbps in 160 MHz bandwidth mode in the 5 GHz band, using eight spatial streams and 256 QAM modulations [1]. 802.11ac has also specified multi-user MIMO (MUMIMO), which allows simultaneous transmission of MIMO streams to multiple client devices. In addition, 802.11ac has defined a single closed-loop method for transmit.

Beamforming is expected to be an optional feature of the Wi-Fi Alliance Certification plan. 802.11ac has also introduced dynamic bandwidth management to optimize the use of available bandwidth. These new features of 802.11ac deliver the next leap in performance, which also includes simultaneous streaming of multiple HD Video streams.

INCREASED NUMBER OF STREAMS

802.11ac allows support for up to 8 spatial streams – up from a maximum of 4 streams in 802.11n. Support for more than one spatial stream is optional, however. It is not clear whether a real-world, single-user MIMO channel can realistically support that many streams [2]. The increased number of streams may be most useful in combination with MU-MIMO as shown in Table 2 [8].

INCREASED BANDWIDTH

The most notable feature of 802.11ac is the extended bandwidth of the wireless channels. 802.11ac mandates support of 20, 40 and 80 MHz channels (versus 20 and 40 MHz in 802.11n) Optionally, the use of contiguous 160 MHz channels or non-contiguous 80+80 MHz channels is also allowed. The doubling of the channel bandwidth (from 40 to 80 MHz) is a very efficient way to increase performance in a cost-efficient way. Alternatively, an 80 MHz system can use a lower number of antennas to provide the same performance as a 40 MHz system. However, this approach should be weighed against other spectrally efficient techniques that provide performance increase [3]. In addition, in most realistic scenarios the performance is not only a function of the PHY rate, but will also be affected by interference from other networks in close proximity. Different bandwidth levels will be affected differently in interference scenario. Also, reducing the number of antennas eliminates diversity and reduces the robustness of the transmission. These aspects will be discussed further below [5].

Table 1: The Evolution of the 802.11 Standards

THE EVOLUTION OF THE 802.11 STANDARDS						
Protocol	*Year Introduced*	*Maximum Data Transfer Speed*	*Frequency*	*Highest Order Modulation*	*Channel Bandwidth*	*Antenna Configurations*
80.11a	1999	54 Mbps	5 GHz	64 QAM	20 MHZ	1x1 SISO
80.11b	1999	11 Mbps	2.4 GHz	11 CCK	20 MHZ	1x1 SISO
80.11g	2003	54 Mbps	2.4 GHz	64 QAM	20 MHZ	1x1 SISO
80.11n	2009	65 to 600 Mbps	2.4 or 5 GHz	64 QAM	20 and 40 MHZ	Up to 4x4 MIMo
80.11ac	2012	75 Mbps to 32 Gbps	5 GHz	256 QAM	20.40.80 and 160 MHZ	Up to 8x8 MIMO MU-MIMO

POWER CONSUMPTION OF INCREASED-BANDWIDTH SOLUTION

When enhanced bandwidth is used to deliver the same data rate with fewer RF chains, the power consumption of the device will be lower by virtue of the lower number of RF components. This gives an advantage to the 80 MHz system over a 40 MHz system with two streams from this perspective. However, one has to consider the fact that a single antenna will not suffice for certain services [7].

REQUIRED ANTENNA DIVERSITY

Increasing the bandwidth enhances the performance of a single stream. If the target is to improve the PHY rate or the maximum throughput of a system regardless of QoS considerations, this may be all that is needed. One has to recognize, however, that transmission of high-quality content such as video has more requirements than just increasing the maximum ideal PHY rate. To ensure stable delivery of video, the number of antennas should be higher than the number of spatial streams. Diversity is a critical part of stable data delivery with QoS. Therefore, even 80 MHz systems will have to be built using multiple antennas if they are going to be used in applications that require stable and reliable transmission of data (such as video). This narrows the cost and power advantage between a (single-stream) 80 MHz bandwidth system and a (two-stream) 40 MHz system [2].

PERFORMANCE IN INTERFERENCE ENVIRONMENT

The use of the 5 GHz band has significantly increased the amount of bandwidth available for wireless transmission. However, even this band is ultimately a limited resource, and ever-increasing competition for bandwidth share will be a reality for any 802.11 system operating in this band [8].

802.11ac specifies that 80 MHz channels consist of two adjacent 40 MHz channels, without any overlap between the 80 MHz channels.

RTS/CTS OPERATION FOR WIDER BANDWIDTH

Because of the wider bandwidth used in 802.11ac and the limited number of 80 MHz channels, hidden Nodes on the secondary channels are an important problem to address. The RTS/CTS mechanism has been updated to better detect whether any of the non-primary channels are occupied by a different transmission [6] To this end, both RTS and CTS (optionally) support a "dynamic bandwidth" mode. In this mode, CTS may be sent only on the primary channels that are available in case part of the bandwidth is occupied. The STA that sent the RTS can then fall back to a lower bandwidth mode. This helps to mitigate the effect of a hidden node. Note however that the final transmission bandwidth always has to include the primary channel [2].

Next-generation system would include some truly next-generation features (such As MU-MIMO) in addition to the channel bandwidth increases that are readily available in this new technology. The bandwidth increase of 11ac is currently a concern in situations with limited bandwidth resources. Frequency is a scarce resource that needs to be used as efficiently as possible. Exploiting channel diversity by using a higher number of spatial streams allows more efficient spectrum use than simply doubling the bandwidth of the transmission. Channel and antenna diversity, therefore, remain important requirements, even for systems that are capable of wider bandwidth. It is believed that a 4x4 system with a maximum number of spatial streams and MU-MIMO will be required, at a minimum, in order for 11ac to fully realize its potential [8]. Such a system would provide higher bandwidth in sparsely populated networks, while providing QoS, good performance and coexistence in denser network environments [4].

Table 2: 802.11ac Technical Specifications

Operation frequency	5-GHz unlicensed bond only
Bandwidth	20.40.and 80 MHz 160 and 80+80 MHz (optional)
Modulation schemes	BPSK,QPSK,160QAM,64QAM,256QAM (Optional)
Forward error correction coding	Convolutional or LDPC (optional) with a coding rate of 1/2.2/3.3/4 or 5/6
MIMO	Space time coding. Single-user MIMO. Multi-user MIMO (all optional)
Spatial streams	Up to eight (optional)
Beamfroming	Respond to transmit beamfroming sounding (optional)
Aggregated MPDU (A-MPDU)	1,048.575 octets (65.535 octets in 802.11n)
Guard interval	Normal guard interval short guard interval (optional)

MU-MIMO

Most wireless networks have multiple active clients that share the available bandwidth. If this sharing is done in time, then the overall throughput can only be increased by increasing the link rate for all clients. Many clients cannot transmit at the highest 802.11ac rates though because they only have one or two antennas. For such clients, MU-MIMO is the solution to get significant network throughput gains. A MU-MIMO capable transmitter can transmit multiple packets simultaneously to multiple clients. In 802.11ac, a MU-MIMO mode is defined with up to eight spatial streams divided across up to four different clients. For example, in 80 MHz mode it would be possible to send packets to four clients simultaneously at a data rate per client of 866.6 Mb/s, assuming all clients can receive two spatial streams. This means the total data rate of 3.46 GB/s is four times larger than it would have been without MU-MIMO. The data rate per client is also larger, because the MU-MIMO packets can be transmitted at the maximum data rate per client while without MU-MIMO, each client can only be transmitted to about a quarter of the time such that the effective per-user throughput is a quarter of its maximum. In practice, the throughput gain of MU-MIMO is reduced a bit by the fact that ACKNOWLEDGEMENTs are still sent sequentially in time. Also, depending on the signal-to-noise ratios for all clients, it may not be possible to maintain the maximum data rates in a MU-MIMO packet because a MU-MIMO link does as shown in Figure 1.

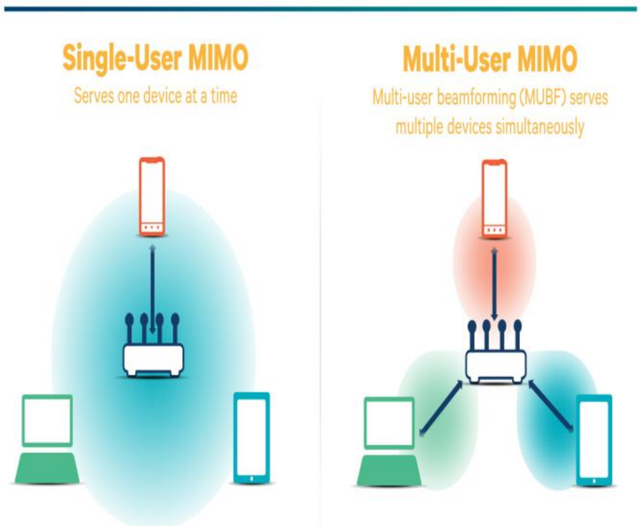

Figure 1: Multi-User MIMO

Table 3: 802.11n vs. 802.11ac

Frequency Band	2.4 GHz and 5 GHz	5 GHz Only
Channel Widths	20, 40 MHz	20, 40, 80, (160 optional) MHz
Spatial Streams	1 to 4	1 to 8 total Up to 4 per client
Multi-user MIMO	No	Yes
Single Stream (1x1) Maximum Client Data Rate	150 Mbps	450 Mbps
Three Stream (3x3) Maximum Client Data Rate	450 Mbps	1.3 Gbps

802.11AC PROVIDE A BETTER PERFORMANCE FOR HD VIDEO APPLICATION COMPARING TO 802.11N

802.11ac will boast several improvements over 802.11n. The new wireless flavour will offer speeds surpassing 1 Gigabit per second, almost three times that of 802.11n. It also promises to provide better coverage throughout an entire home with fewer dead spots. From a technical standpoint, the new standard will use such technologies as beamforming and higher amplitude modulation to send more data faster and more efficiently than 802.11n, NPD In-Stat analyst Gregory Potter told CNET. And 802.11ac will help smartphones and other mobile devices by providing higher bandwidth and a savings in power compared with 802.11n. As 802.11ac starts to hit a variety of gadgets, including laptops, smartphones, tablets, and TVs, Potter sees high-definition video as the major beneficiary.

Table 4: Comparison between 802.11 Standards

Standard	Year	Band	Bandwidth	Modulation	Antenna Technology	Data Rate
802.11b	1999	2.4 GHz	20 MHz	CCK	—	11 Mb/s
802.11a	1999	5 GHz	20 MHz	OFDM	—	54 Mb/s
802.11g	2003	2.4 GHz	20 MHz	CCK, OFDM	—	54 Mb/s
802.11n	2009	2.4 GHz, 5 GHz	20 MHz, 40 MHz	OFDM (up to 64-QAM)	MIMO with up to four spatial streams, beamforming	600 Mb/s
802.11ac	—	5 GHz	40 MHz, 80 MHz, 160 MHz	OFDM (up to 256-QAM)	MIMO, MU-MIMO with up to eight spatial streams, beamforming	6.93 Gb/s
802.11ad (WiGig)	—	2.4 GHz, 5 GHz, 60 GHz	2.16 GHz	SC/OFDM	Beamforming	6.76 Gb/s

CONCLUSION

802.11ac has the potential to provide the next generation in high throughput wireless systems. To fully realize this potential, 802.11ac systems will have to go beyond a minimal implementation that simply exploits the wider bandwidth channels available to this technology. Any new system will be measured against currently available 802.11n systems that already implement MIMO processing with space division Multiplexing, LDPC, and STBC, beamforming, multiple streams and a variety of other PHY, MAC and coexistence enhancements. First generation 802.11ac systems must be evaluated in light of this comparison. As a minimum, such systems would have to match the feature set that is already provided by current generation 802.11n. Preferably, any next generation system would include some truly next generation features (such as MU MIMO) in addition to the channel bandwidth increases that are readily available in this new technology. The bandwidth increase of 11ac is currently a concern in situations with limited bandwidth resources. Frequency is a scarce resource that needs to be used as efficiently as possible. Exploiting channel diversity by using a higher number of spatial streams allows more efficient spectrum use than simply doubling the bandwidth of the transmission. Channel and antenna diversity, therefore, remain important requirements, even for systems that are capable of wider bandwidth. It is believed that a 4x4 system with a maximum number of spatial streams and MU MIMO will be required, at a minimum, in order for 11ac to fully realize it's potential. Such a system would provide higher bandwidth in sparsely populated networks, while providing QoS, good performance and coexistence in denser network environments.

ACKNOWLEDGEMENT

The authors wish to thank the HOD of Networking, Faculty of Creative Media and Innovative Technology University Kuala Lumpur (IUKL) for his support to participate in ICEITS 2014 Special thanks to Eng. Mohamed Barier Mohamed and Eng. Tarek Mosbah for their help and support.

REFERENCES

[1] Myles, A., & De Vegt, R. (2008, March 19). Wi-Fi Alliance (WFA) VHT Study Group Usage Models. IEEE 802.11-07/2988r4
[2] Stacey, R., Perahia, E., Stephens, A., et al. (2011, January 19). Specification Framework for TGac. IEEE 802.11-09/0992r21.
[3] Loc, P., & Cheong, M. (2011, January 19). TGac Functional Requirements and Evaluation Methodology. IEEE 802.11-09/0451r16, Retrieve from https://mentor.ieee.org/802.11/dcn/09/11-09-0451-16-00ac-tgac-functional-requirementsand-evaluation-methodology.doc.
[4] Breit, G., Sampath, H., Vermani, S., et. al. (2010, March 18). TGac Channel Model Addendum.
IEEE 802.11-09/0308r12, Retrieve from https://mentor.ieee.org/802.11/dcn/09/11-09-0308-12-00ac-tgac-channel-model add endum document.doc.
[5] De Vegt, R. (2009, March 9). 802.11ac Usage Models Document. IEEE 802.11-09/0161r2.
[6] Gong, M., Perahia, E., Stacey, R., Want, R., & Mao, S. (2010, December). A CSMA/CA MAC Protocol for Multi-User MIMO Wireless LANs," IEEE Globecom 2010.
[7] Perahia, E., (2008). IEEE 802.11n Development: History, Process, and Technology. *IEEE Communications Magazine, 46(7)*, 48-55.
[8] http://www.litepoint.com/whitepaper/80211ac_Whitepaper.pdf Retrieved 10 10, 2014
[9] IEEE802.11ac: The Next Evolution of Wi-Fi, 15.