IEEE 802.11ac: Enhancing Throughput and MAC Layer Performance with Rate Adaptation Algorithm

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Abstract---The IEEE 802.11ac is anemerging very high throughput (VHT) WLAN standard, targeted to achieve data rates close to 6.9 Gbps for 5GHz spectrum band. The paper presents the throughput analysis of 802.11ac MAC layer with help of Rate Adaptation algorithm to show efficacy of 802.11ac over 802.11n WLAN standard since MAC layer performance is important for higher download speeds. The paper aims to bring out the high throughput of IEEE 802.11ac and adoptability in enterprise and corporate environments.

Keywords -IEEE 802.11ac, Throughput, Media-Access Layer and RATE ADAPTION ALOGRITHM.

I. INTRODUCTION

In recent years, the continued effort in pursuit of gigabit wireless communication has been most noticeable in IEEE 802.11 WLAN [1]. The next generation of the IEEE 802.11 standard – know as IEEE 802.11ac – promises to break the wirelessEthernet gigabit barrier. For example in 2010, the Wireless Gigabit (WiGig) Alliance, formed by a consortium of industry leaders, has completed the first draft of the WiGig specification that defines unified architecture to enable tri-band communications over the frequency bands of 2.4 , 5 , 60 GHz [2]. IEEE 802.11ac is currently draft amendment that set out break 1 Gbps barrier, to improve Wi-Fi's spectral efficiency, and to expand on the capabilities introduced by IEEE 802.11n-MIMO, wider channel bandwidths and faster Wi-Fi.

In this paper, focusing on 1 Gbps threshold in 5GHz of 802.11ac is an exciting accomplishment and gaining higher throughput than previous standard. The emerging IEEE 802.11ac amendment could provide a maximum PHY data rate of close to 7 Gbps [3]. To be more specific, it promises MAC throughput of more than 450Mbps for single user scenario and aggregated MAC throughput of more than 1 Gbps for multi-user scenario,

both utilizing no more than 80MHz of channel bandwidth [4].802.11ac can be considered the next step after 802.11n, along the path running from 11b, to 11a/g, then 11n, and now 802.11ac. And it is likely to be introduced along with related amendments to 802.11 including video-relatedimprovements in 802.11aa (video transport streams) and 802.11ad (very high throughput, short-range at 60 GHz).New products that incorporate 802.11ac will become available near the end of 2013.IEEE 802.11ac supports MU-MIMO,means the increase in spatial streams to 8.This feature only increases 33% of throughput than previous standard.

The remainder of this paper is organized as follows. Section II presents an overview of key and mandatory PHY features and MAC enhancements of 802.11ac over the existing 802.11n. Section III presents the implementation and calculation of performance in terms of maximum throughput with help of Rate Adaptation algorithm. Section IV gives performance of 802.11ac and 802.11n with the technique of rate adaptation algorithm. Finally Section V concludes this paper with some directions for future work.

II. MANDATORY PHY AND MAC LAYER FEATURES

IEEE 802.11ac is a set of physical layer enhancements for higher throughput in the 5 GHz band, chiefly video in mind, and to achieve this it extends the techniques pioneered in 802.11n: more antennas, wider channels and more spatial streams, along with a number of new features to boost throughput and reliability. In general, 802.11ac could be seen as a extension of 802.11n in which two basic notations of multiple input multiple output(MIMO) and wider channel bandwidth, anchored in 802.11n are enhanced [5] [6]. Fig. 1 illustrates the mandatory and key PHY features, as well as the MAC enhancements introduced in 802.11ac.
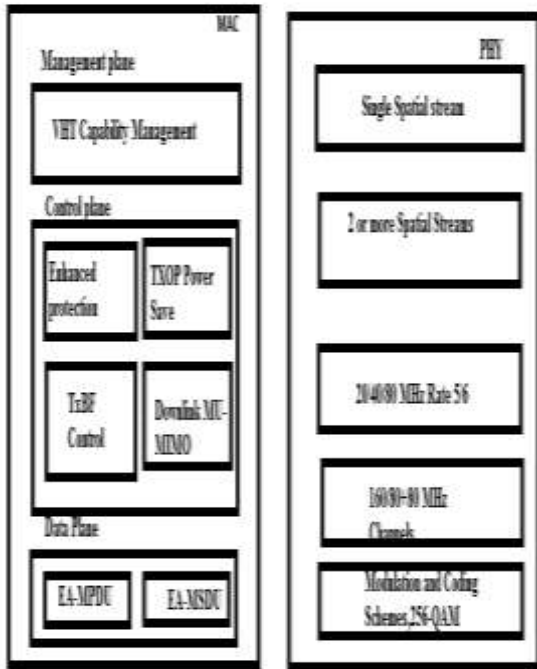
Fig 1.Key and mandatory PHY features and MAC enhancements in 802.11ac.

While 802.11ac promises big increase in PHY rates, it is important to see performance improvement in context to throughput of wider bandwidth systems. Table 1 summarizes some of advanced features used in both 802.11ac and 802.11n.

Features	802.11n	802.11ac
MIMO	Supported	Supported
Channel Bandwidth	20 and 40 MHz	20,40,80 MHz(mandatory) and 160 MHz(optional)
MU_MIMO	Not Supported	Supported(optional)
Spatial Streams	1-4 2 SS (mandatory)	1-8 (>1 SS mandatory)
MAC Enhancements Block ACK,A-MPDU Frame Aggregation	Supported	Supported
MAX A-MPDU	65,535 octets	1,08,575 octets
RTS/CTS	Supported	Supported Mandatory at receiver and optional at transmitter

Table 1 summarizes some advanced features used in both 802.11ac and 802.11n.

A. Mandatory and Optional PHY features

As shown in Fig 1, 802.11ac maintains most of the mandatory PHY features of 802.11n such as binary convolution coding (BCC) for forward error correction, MIMO and modulation and coding schemes. The key difference in mandatory features is the support of 80MHz channel bandwidth for an approximately twice increase in data rate as compared to 802.11n where 40MHz is the largest channel bandwidth. As result 802.11ac mandates only a single spatial streams instead of two or more as specified in 802.11n.The reason for such change is increase in number of antennas often relates to higher cost. Hence the mode of utilize more than one spatial stream are optional in 802.11ac. In addition, two MCSs 8 and 9 are introduced based on 256-QAM increased from 64-QAM as specified in 802.11n. In order to support wider channel bandwidths, 802.11ac defines its channelization for 20, 40, 80,160 MHz channels [7]. For example 80MHz transmission band is formed by two contiguous 40 MHz band in which one of 20 MHz is primary channel and rest are secondary channels. The primary and secondary channels can be used to construct wider channel bandwidths.

B. MAC Enhancements

There are two kinds of frame aggregations comprising of A-MSDU and A-MPDU in order to improve MAC efficiency. It is also possible to combine both A-MSDU and A-MPDU which is referred as A-MSDU/A-MPDU[7]. The key MAC enhancements are capability of multi-channel operations. IEEE 802.11ac supports enhanced A-MSDU and A-MPDU in which maximum size and PHY convergence procedure (PLCP) service data unit (PSDU) length increased from 7935 to 11426 bytes and 65535 to 1048576 bytes, respectively to further improve its MAC efficiency along with higher PHY data rates.

IEEE 802.11ac supports enhanced protection in which the RTS/CTS handshake mechanism is modified to support static or dynamic bandwidth reservation and carry the channel bandwidth information [8]. The RTS/CTS defined in 802.11ac deals hidden node problem.RTS and CTS frames areused only to manage access to the network medium, and they work in part because theymay be transmitted at lower rates so that they may be received and understood by allstations. The 802.11ac also provides support of VHT capabilities such as transmit beam forming (TXBF) control with sounding protocol and compressed beam forming (V) feedback, downlink multi-user, multiple input, multiple output(MU-MIMO) and transmission opportunity (TXOP) power saving through its VHT capabilities Info field of the management frame. TXOP power save is introduced so that non-AP VHT STA could enter power save mode when ascertains that it is not the intended recipient during that TXOP by filtering based on the RXVECTOR parameter of group ID.

III. THROUGHPUT WITH HELP OF RATE ADAPTATION ALGORITHM

Throughput in terms of computer networks can be given as average rate of successful packet delivery over a communication channel. Throughput is nothing but actually received speed out of maximum bandwidth available. This term also keeps up a correspondence to digital bandwidth consumption.

Rate Adaptation algorithm considers three aspects on selection of bit-rate in order to increase throughput of the network [9]. The three aspects are Channel Quality Estimation, Channel Feedback and Bit-rate selection. First Channel Quality Estimation keeps track of events such as packets are received successful, retransmission or failure of packets. It also checks the signal strength of received packets. This aspect records the measurements about channel conditions. Second aspect Channel Feedback, the rate control is called at sender so as to assign bit rate for transmitted packet from transmission history. The sender should have the information of channel to decide the bit rate. So Channel feedback is necessary aspect in rate adaptation. Third aspect Bit rate selection, that is when channel variation is detected the accordingly the bit rate is selected by sender in order to maximize throughput for the corresponding channel condition detected. Generally Rate Adaptation algorithm depends more on acknowledgement and RTS/CTS frame to access the channel.

The design techniques of rate adaptation algorithm with respect to the IEEE 802.11ac wireless standard. As the previous standards also incorporate rate adaptation algorithm, the there is difference in standard MAC and PHY layer features. The techniques of the rate adaptation algorithm can increase or decrease the transmission bit rate depending on the channel condition. This technique definitely increases the bit rate because as 802.11ac standard has wider channels of 80MHz or 160MHz and also fine modulation and coding schemes (MCS). As it supports MU-MIMO the spatial streams are increased to 8 streams the wider channels bring higher throughputs [10]. Another technique is the use of RTS/CTS frame in rate adaptation algorithm which helps in convey of channel information to the sender to adapt bit rate according to channel conditions. The more information of rate adaptation algorithm for 802.11 networks is explained in [9].

IV. PERFORMANCEOF 802.11AC and 802.11N

The algorithm states as initial the sender transmits data at initial rate to receiver and if receiver acknowledges by use of RTS/CTS frame that it can receive more bits, then sender adjust the bit rate hence throughput is increased. If we have wider channels and all parameters of rate adaptation algorithm are supported then high throughput can be experienced.

The performance of rate adaptation algorithm measures on condition; that is wider channels. The first condition wider channels as the IEEE 802.11ac supports wide channels of 80MHz and 160 MHz as optional then by adapting algorithm enhances throughput due high bit rate can be selected because of wider channel than 802.11n which support only 40 MHz channel bandwidth. Figure 2 the channel bandwidth in 802.11ac and Figure 3 shows the channel bandwidth in 802.11n. Hence by adaptation of rate adaptation algorithm for wider channels enhance throughput.
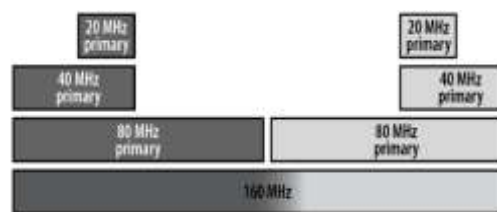

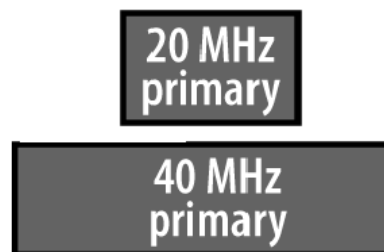Fig 2: Channel bandwidth in 802.11ac

Fig 3: Channels bandwidth in 802.11n

The channel estimation and bit-rate is selected at receiver end. If best is estimated then high throughput is expected. When Channel rate is more, then SNR is also high which a good parameterfor rate adaptation algorithm. The SNR triggered approach is used for the best channel estimation. As the MAC layer keeps interaction with the channel of network, if MAC has efficient features then high throughput is expected.

.V. CONCLUSION

802.11n is an excellent historical case study to help set expectations for 802.11ac. For example, even though 802.11n providesa maximum of four spatial streams, today's 802.11n products hit the ceiling at 450 Mbps (3 spatial streams), not 600 (4 spatialstreams). And even then, achieving 450 Mbps in a real world scenario is rare, requiring nearly perfect RF conditions and shortdistances. Most enterprise WLAN suppliers continue to sell far more 2x2:2 802.11n APs than 3-stream APs, largely because thehigher costs of high-end 802.11n don't often match the level of benefit for their business.802.11ac is an optimistic protocol with impressive theoretical gains, but the features that improve capacity and enable suchhigh data rates are

difficult to use, both because of engineering limitations and because of client device limitations, radio environments,and business factors. 802.11n with MIMO was a massive improvement for Wi-Fi, and 802.11ac will continue to drivewireless adoption.

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