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WHAT THE IEEE 802.11AX HAS TO OFFER IN YEAR 2019

By

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Abstract: 802.11ac was birthed on the success of 802.11n to meet up with the expectations of more throughput capabilities on Gigabit Ethernet. Features like wider channels, higher encoding density and increased number of spatial streams have made the standard more superior, for example one of its wave could send and receive data at a maximum physical link rate of 1.3Gbps on Single User Multiple Input Multiple Output (SU-MIMO) and the Multiple User Multiple User Multiple Output (MU-MIMO). Greg Ennis, WiFi Alliance's VP of technology said the IEEE anticipates the 802.11ac standard will be succeeded by 802.11ax, also Huawei, who has an engineer in the IEEE 802.11ax working group reported WiFi connection speed up to 10.53Gbps on the 5GHz frequency band. This paper is aimed at explaining the progress made so far on the IEEE 802.11 emerging standard. According to the Institute of Electrical and Electronics Engineers (IEEE) 802.11 WLAN standard plenary meeting held 12-15 May, 2014 in Hawaii, Dr. Osama Aboul Magd from Huawei was elected as the 802.11ax WLAN standard task group chair to focus on the development of the next generation 10Gbps WiFi standard planned for a commercial launch in 2018 (Jackson, 2015). 802.11ax will be built on the new radio technology MIMO-OFDM, which will be responsible for power increase using more than one antenna to send multiple data streams to devices. This paper discusses why do users need more speed, frequency the standard will be deployed upon, what MIMO and OFDM is, and the strategy behind the combination of the two technology MIMO-OFDM.

Key words: 802.11ax, 802.11ac, 802.11n, Gigabit Ethernet, Wider Channels, Higher encoding density, MIMO, MIMO-OFDM

1. Introduction

Considering the power of network connections and need for users to consume more, and the fact that, the more you consume, the more it becomes a habit of addiction and thereby the more of what used to be enough will become insufficient and you will demand for more. We have experienced the growth of the WiFi networks from the IEEE 802.11 standard protocol. The evolution started with a legacy released in June 1997, and from then we have had: a, b, g, n, ac, ad, af, ah, ai, aj, aq and now ax. Current statistics have shown that there is tremendous increase in the usage of mobile and tablets devices than desktop PCs, even though some of these desktops still use wireless cards for data connection. The shift towards WiFi adoption has been overwhelming, and this has given room for more reliance on the infrastructure and the increase in the demand for more speed or better still more throughput. The standard has its survival on the operating frequency range of 2.4GHz and 5GHz. The onus has always been on the data rate, 802.11b delivered 11Mbps on 2.4GHz, 802.11g delivered 54Mbps on 2.4GHz, 802.11a delivered also 54Mbps but on the 5GHz, 802.11n delivered about 600Mbps (theoretical max), the 802.11ac is delivering a data rate of up to 433.3Mbps per spatial stream, 1300Mbps in total, while the promising 802.11ax according to Huawei has delivered about 10.53Gbps in the test lab. According to Michelle et al (2015), global mobile data traffic grew by 81% and it is projected to increase 11-fold between 2013 and 2018. Further, it is predicted that by 2018, over two-thirds of the world's mobile traffic will be video and more than half of all traffic from wireless connected devices will be offloaded to Wi-Fi networks and femto-cells. Consequently, wireless LANs need major upgrades to improve both throughput and efficiency. IEEE 802.11ac is an amendment to the 802.11n standard that was just ratified by IEEE

802.11. Promising up to additional data rates, many Wi-Fi products are being built based on this specification. In addition to technologies that improve throughput, IEEE 802.11ax is investigating and evaluating advanced wireless technologies that enable more efficient utilization of the existing spectrum.

2. Why more speed on the 802.11ax

Humans are insatiable, Charles Baudelaire quoted “The insatiable thirst for everything which lies beyond, and which life reveals, is the most living proof of our immortality.” We have a constant unsatisfying appetite as humans, a philosophy that could be explained using a family scenario, the more money you bring home, the more the spending of the family members will increase and the less you bring home, the more the family will complain about the need for more as their lifestyle and expenditure patterns are already trained towards certain needs. The internet community has been in existence for a long time now, users cannot do without this resource, in fact most internet users are addicted to this resource. Sussex Publishers (2015) defined addiction as "a condition that results when a person ingests a substance (e.g., alcohol, cocaine, nicotine) or engages in an activity (e.g., gambling, sex, shopping) that can be pleasurable but the continued use/act of which becomes compulsive and interferes with ordinary life responsibilities, such as work, relationships, or health. Users may not be aware that their behavior is out of control and causing problems for themselves and others." We can attribute this resource to the air we breathe. This need has its root from the smallest clue of speed of RAM of PCs, flashbacking on when the IBM ThinkPad PC runs 256MB RAM and now uses 16GB RAM which is still not meeting users expectations, am sure am raising the question "what kind of unrealistic expectations do you have?". Same question goes for the 802.11ax, speed in this context is literally talking about faster throughput, meaning the pipe where we use to get our resource is now getting bigger. So, was it small initially? the current 802.11n that most devices embrace at the moment seem to meet the current expectations of users at least, may be in Africa where most places are yet to be connected but in countries where this resource is constantly been consumed, it is high time the pipe got bigger for more access to the resource. Although this is relative in the sense that, the speed of the total bandwidth available has a direct correlation between the speed the NIC card and access points was chipped to work with. This clarity needs to be made because some users who do have an initial slow aggregated bandwidth will not see a significant increase in speed. 802.11ax will be more revealing from the perspective of users who have sufficient bandwidth but the pipe has a fixed width on the amount of resource that can pass at a specified time, so meaning they will have more additional access to the resource. Illustratively on an average, for example if it currently takes a user about 10 minutes to stream a 20TB video on an organizations corporate intranet using the 802.11ac, it will take the user about 20 minutes on the 802.11n, and 1 minute on the promising 802.11ax.

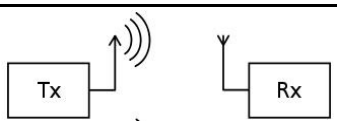
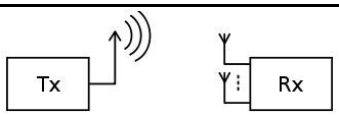
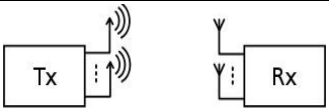
3. Which frequency will the 802.11ax be deployed

The 802.11n was ratified and released to the market on the 2.4GHz and 5GHz, reasons are that the benefit of the two (2) where needed for the objective of the standard to be achieved, so it was logical for the 802.11ac to inherit the already successful features of the 802.11n to be stable, only that it had to compensate for more data rate. In a nutshell, it could be predicted that 802.11ax will be deployed on both the 2.4GHz and 5GHz frequencies. It was published that the standard will cover wider channels, higher encoding density and increased number of spatial streams. A brief on the collaborative effort of the two (2) frequencies is that: the 5GHz is more expensive, has more non-overlapping channels - 23, the frequency is higher but the range is shorter, given it limitations for wall/object penetration. The 2.4GHz on the other hand has fewer channels (3 non-overlapping channels: (Miklav, 2014) A well known set of the non-overlapping channels are 1, 6 and 11, meaning that the spectral overlap does not affect the performance of networks which use them) which will give rise to conflicts and interference because other gadgets like phones, garage doors and home appliances run on this frequency. It is now obvious that the new features promised in 802.11ax must create superior channels (wider channels): this is how the standard can reduce overlapping and increase the number of spatial streams to provide the additional data rate medium using the MU-MIMO or SU-MIMO as the case may be. According to (Jackson, 2015) "Huawei Statement on 802.11ax: By utilizing innovative technologies such as MIMO-OFDA, intelligence spectrum allocation, interference coordination and hybrid access, the next generation of Wi-Fi networks will provide dense networking for ultra-hot-zone services

with a tenfold increase in spectrum efficiency." A superior argument could be made why the 802.11ax embraced the dual-mode frequency, the probable answer is in the recurrent reality of what is faced on a day to day basis. Users will always operate from location either outdoor or indoor (Aqsa Malik, 2014), the walls where these devices will operate from is an anticipated challenge, as penetration into walls may be deterred. The low frequency of 2.4GHz is instrumental for the success of the wall penetration of this frequency, even though the entire frequency only offers 80MHz. Each channel of the 5GHz offers 20MHz even though it is high frequency has significant effect on its penetration ability.

4. What is MIMO?

MIMO means Multiple-Input Multiple-Output, a way of using multiple antennas to transmit and receive data. This was created as a method of improving performance of communication equipment through radio link capacity exploitation, this method was deployed on the 802.11n and 802.11ac standards. It can be predicted that MIMO will feature in the 802.11ax in that, the IEEE 802.11 standard already forecasted features like, increased number of spatial streams. The streams will have to be increased to achieve wider channels, if it can be recalled, one of the major shortfalls of the 802.11b or 802.11g, besides the fact that they were deployed on the 2.4GHz frequency is fewer channels, which is one of the reasons why the standards have interference, conflicts and limited channel overlapping. 802.11a increased this 3 channels to 23 for more non-overlapping channels, which also was combined to achieve more speed. Coming back to 802.11ax, even though we cannot tell how many wave the standard will have, insights from Huawei shows that one of the 802.11ax wave could send and receive data at a maximum physical link rate of 1.3Gbps. So, predictively as reported, connection speed up to 10.53Gbps, then the 802.11ax will have nothing less than 8 streams to achieve this data rate, this is just a possibility because it could just be a report per channel, so more surprises might still show up. MIMO uses a concept called beamforming, a method aimed at increasing signals received by making emitted signals add together to reduce the multipath fading effect. MIMO also employs spatial multiplexing, a method whereby signals in high-rate are sliced into low-rate multiple streams, and each stream is transmitted from different transmitting antennas on the same frequency channel. This technique was embraced to increase channel capacity at a higher Signal-to-Noise Ratio (SNR). There are different forms of MIMO: Single-Input and Single-Output (SISO), Single-Input and Multiple-Output (SIMO), Multiple-Input and Single-Output (MISO), Multiple-Input Multiple-Output (MIMO).

Multi-antenna types		
SISO	Single-input-single-output means that the transmitter and receiver of the radio system have only one antenna.	
SIMO	Single-input-multiple-output means that the receiver has multiple antennas while the transmitter has one antenna.	
MISO	Multiple-input-single-output means that the transmitter has multiple antennas while the receiver has one antenna.	
MIMO	Multiple-input-multiple-output means that the both the transmitter and receiver have multiple antennas.	

Source: (Institution, 2015)

MIMO exploits the space dimension to improve wireless systems capacity, range and reliability. It offers significant increases in data throughput and link range without additional bandwidth or increased transmit power. MIMO achieves this goal by

spreading the same total transmitting power over the antennas to achieve an array gain that improves the spectral efficiency (more bits per second per hertz of bandwidth) or to achieve a diversity gain that improves the link reliability (reduced fading).

4.1 MIMO-OFDM System

There is two (2) types of MIMO systems: Single User Multiple-Input Multiple-Output (SU-MIMO) and Multiple-User Multiple-Input Multiple-Output (MU-MIMO) (Ruizhi, 2014). Orthogonal Frequency Division Multiplexing (OFDM), is a form of signal modulation that divides a high data rate modulating stream placing them onto many slowly modulated narrowband close-spaced subcarriers, and in this way is less sensitive to frequency selective fading Parker (2015). The 802.11ax will use the MIMO-OFDM technology as stated by (Parker, 2014) "A key change in 802.11ax will be the use of MIMO-OFDA, which combines multiple antennas (the MIMO, multiple in-multiple out, part) with orthogonal frequency division multiple access (which is abbreviated OFDMA or OFDA). OFDA is based on existing OFDM schemes, which encode data on multiple subcarrier frequencies. Improving both the system and user throughput requires the improved use of channel resources. IEEE 802.11ax-2019 aims for a 4-fold throughput increase compared with IEEE 802.11ac-2013. To achieve this goal, some new wireless technologies such as Dynamic CCA (Clear Channel Assessment), OFDMA (Orthogonal Frequency Division Multiple Access), and advanced multiple-antenna techniques may be used (Bellalta,

2015). OFDM is already used in LTE and earlier Wi-Fi standards. But OFDA adds a new twist, the multiple-access component, meaning subsets are assigned within those subcarrier frequencies to essentially create a bigger pipe delivering data to individual devices." OFDMA has proven to be suitable for even railroad communication environment (Baik Kim, 2014). The reason for the choice of the MIMO-OFDM is to chose path of least interference as witted by Matt Hamblen (2014) "The word 'orthogonal' refers to a kind of frequency division technology that sends out data streams at right angles to each other, and then captures and decodes the streams at the receiving end. That approach aims to find a frequency pathway that has the least interference, especially in crowded environments like airports or outdoor venues." MIMO does not only work with OFDM, it can also work with other technology such as Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA), so MIMO was combined with OFDM to achieve high spectral efficiency having in mind high capacity and high throughput. What Gregory Raleigh had in mind when he invented MIMO in 1996 was to show how different data streams could be transmitted at the same time on the same frequency. Initially, there was a problem with multipath propagation as researched by Guglielmo Marconi, the Italian inventor known for pioneering long-distance transmission. Raleigh believed that this challenge could be addressed and solved by using multiple antennas and special processing techniques to transmit multiple data streams at the same time on the same frequency, meaning his discovery changed radio engineering practices. He further published that series of greater enhancement could be achieved with the use of OFDM method with MIMO. These techniques are visible in LTE, WiMAX, 802.11n and the 802.11ac standards. Raleigh and his colleagues floated a company to harness the power of his discoveries, the company was "Clarity Wireless" which was later acquired by Cisco in 1998. He further founded another company called Airgo Networks in 2001 to develop the MIMO-OFDM chipsets for wireless LANs, Qualcomm acquired Airgo Networks in 2006. In summary, the patents citations found in Gregory G. Raleigh (2004) and Vincent K. Jones (2009) shows that MIMO-OFDM has great significance in the 802.11ax standard.

5. Conclusion

The WiFi industry has grown and is constantly growing to meet the demands of the ever evolving technological revolution. The expectations of these demands will not have been possible without the passionate mind of inventors. Albert Einstein exclaimed "The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift". This paper is an opportunity to appreciate the works of great contributors to the WiFi industry especially Gregory Raleigh whose work changes some practise and now we can write and discuss 802.11ax before its arrival.

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