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Advance WLAN Technologies: A Review

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Abstract:This paper gives an overview of a number of advanced wireless LAN technologies. IEEE 802.11ac introduced multiuser access in the form of Downlink Multi-User Multiple Input Multiple Output (DL MU-MIMO), dynamic or static channel bandwidth operation, and 80 MHz, 160 and 80+80 MHz channels in the 5 GHz band. As a result, 802.11ac advances wireless LAN throughput beyond gigabit rates. Going forward, IEEE 802.11, within the 802.11ax task group, is evaluating more advanced wireless technologies such as simultaneous transmit/receive (STR), downlink and uplink Orthogonal Frequency Division Multiple Access (OFDMA), Uplink MU-MIMO, and dynamic Clear Channel Assessment (CCA).

Keywords: WLAN, IEEE Standards, High speed networks

I. INTRODUCTION

Mobile data traffic grew 80% last year and it is estimated that it will grow 10 times between 2013-2018. By 2018 2/3rd of the mobile traffic will be video and half of the traffic will be offloaded onto Wi-Fi networks. IEEE is developing standards for new high speed specifications like 802.11ac, 802.11ad, 802.11ax and others. WiGig was established to carry research in 802.11ad specifications which operates in Giga Hertz frequency band. Wi-Fi Alliance took over WiGig and merged it with itself. In this paper 802.11ac, 802.11ad and 802.11ax specifications are explained.

IEEE 802.11 is a set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) computer communication in the 2.4, 3.6, 5 and 60 GHz frequency bands. They are created and maintained by the IEEE LAN/MAN Standards Committee (IEEE 802).The absolute and the most widely deployed 802.11 standard have plenty of extension and additional amendments are now under development.

There are three 802.11 standards named 802.11-1999, 802.11-2007, 802.11-2012 and the upcoming one is 802.11-2015. The updates in the standard is referred as amendment. For 802.11-2015 the amendments will be 802.11ah, 802.11ax and likewise.

A. IEEE 802.11

Table 1: Speeds of different standards

Amendment	Frequency	Speed
802.11	2.4 GHz	2 Mbps
802.11a	5 GHz	54 Mbps
802.11b	2.4 GHz	11 Mbps
802.11g	2.4 GHz	54 Mbps
802.11n	5 GHz	150 Mbps
802.11ac	5 GHz	866.7 Mbps (1 Gbps)
802.11ad	60 GHz	6.75 Gbps (7 Gbps)
802.11ah	0.9 GHz	-
802.11ai	-	-
802.11aj	60 GHz	-
802.11aq	-	-
802.11ax	5 GHz	10 Gbps

First introduced in 1999, the IEEE 802.11 standards were primarily developed bearing in minds our home and work environment for wireless local area connectivity. Currently we use IEEE 802.11 b/g/n Wi-Fi specifications and we will discuss new amendments (802.11 ac/ad/ax) which are about to commercialize in upcoming years (2015-2018).

B. 802.11AC

The fastest standard we are having right now is 802.11n which gives us 150Mbps or 300Mbps maximum speed. One of the important standards currently under development is IEEE 802.11ac. This standard is expected to be published by the end of 2014. It is expected to provide a multi station WLAN throughput of at least 1 Gbps and a single link throughput of at least 500 Mbps. This is achieved by extending the air interface concepts which are embraced by 802.11n like wider RF bandwidth (up to 160 MHz), more MIMO spatial streams (up to 8), multi user MIMO, and high density modulation.

SSID	Signal	High Signal	RSSI	High RSSI	Channel
Khushaal	0%	8%	-100 dBm	-86 dBm	13
	0%	74%	-100 dBm	-61 dBm	12
SPiDiGO	68%	76%	-64 dBm	-60 dBm	12
	72%	74%	-62 dBm	-61 dBm	12
	60%	74%	-68 dBm	-61 dBm	12
Sahdevs	10%	12%	-85 dBm	-84 dBm	11
trojen horse	0%	20%	-100 dBm	-80 dBm	11
Wifi	0%	24%	-100 dBm	-78 dBm	11
	0%	26%	-100 dBm	-77 dBm	11
PARTH ENTERPRISE	0%	8%	-100 dBm	-86 dBm	11
MGMNT	26%	28%	-77 dBm	-76 dBm	11
Vivek	22%	34%	-79 dBm	-73 dBm	11
Nawab_Nishu	36%	36%	-72 dBm	-72 dBm	11
	0%	22%	-100 dBm	-79 dBm	11
	0%	22%	-100 dBm	-79 dBm	11
KnowCrazy.com	87%	92%	-47 dBm	-41 dBm	11
	0%	64%	-100 dBm	-66 dBm	10
SPiDiGO	32%	64%	-74 dBm	-66 dBm	10
	50%	64%	-69 dBm	-66 dBm	10
	36%	64%	-72 dBm	-66 dBm	10
SHUKLAS	18%	28%	-81 dBm	-76 dBm	8
SPiDiGO	0%	12%	-100 dBm	-84 dBm	7

Figure 2: Utilization scenario in 802.11n

Because partially overlapped channels introduce significant in-band interference, extremely complex coexistence schemes would have to be defined to mitigate such interference. To avoid such an in-band interference problem and to simplify protocol design, 802.11ac defines only non overlapping channels. 80 MHz channels are comprised of adjacent 40 MHz channels, with no partially overlapped 80 MHz channels. As well, 160 MHz channels are comprised of adjacent 80 MHz channels, with no partially overlapped 160 MHz channels. Also, channel 144 has been added, which was not included in 802.11n.

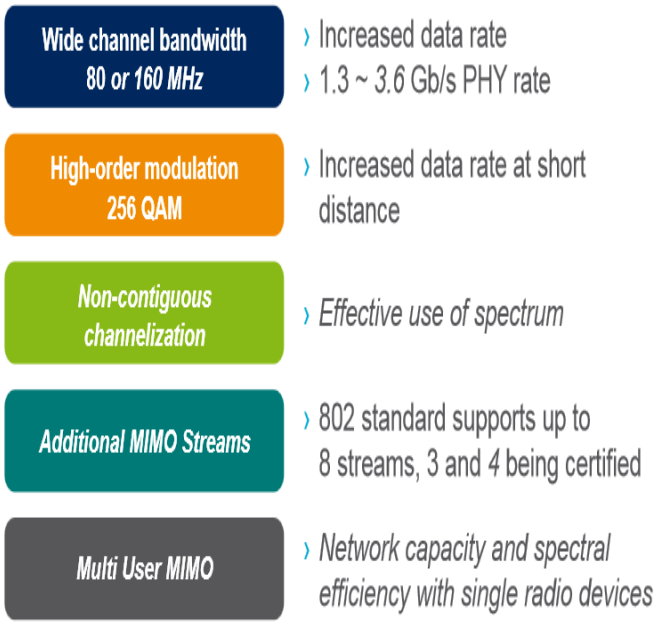

Figure 3: Features of 802.11ac

Technical Specification	802.11n	802.11ac
Frequency	2.4, 4.9, 5 GHz	5 GHz
Modulation Scheme	OFDM	OFDM
Channel Bandwidth	20, 40 MHz	20, 40, 80 MHz (160 MHz optional)
Nominal Data Rate, Single Stream	Up to 150 Mbps (1x1, 40 MHz)	Up to 433 Mbps (1x1, 80 MHz) Up to 867 Mbps (1x1, 160 MHz)
Aggregate Nominal Data Rate, Multiple Streams	Up to 600 Mbps (4x4, 40 MHz)	Up to 1.73 Gbps (4x4, 80 MHz) Up to 3.47 Gbps (4x4, 160 MHz)
Time to Stream 1.5hr HD	~ 30 min (4x4, 40 MHz)	~ 15 min (4x4, 80 MHz)
Spectral Efficiency per Gbps	400 bps/Hz (4x4, 40 MHz)	200 bps/Hz (4x4, 80 MHz)
EIRP	22-36 dBm	22-29 dBm
Range	12-70 m indoor	12-35 m indoor
Through Walls	Y	Y
Non-Line-of-Sight	Y	Y
World-Wide Availability	Y	Y limited in China

Figure 4: Comparison of 802.11n and 802.11ac

With this addition, there is a maximum of six80 MHz channels possible, where regulatory bodies permit. There are only two 160 MHz channels, which is the primary reason for the inclusion of non-contiguous 160 MHz operation. Non-contiguous 160 MHz (80 + 80 MHz) channels are comprised of any two valid, non-adjacent 80 MHz channels. With non-contiguous operation many 80 + 80 MHz combinations are possible.

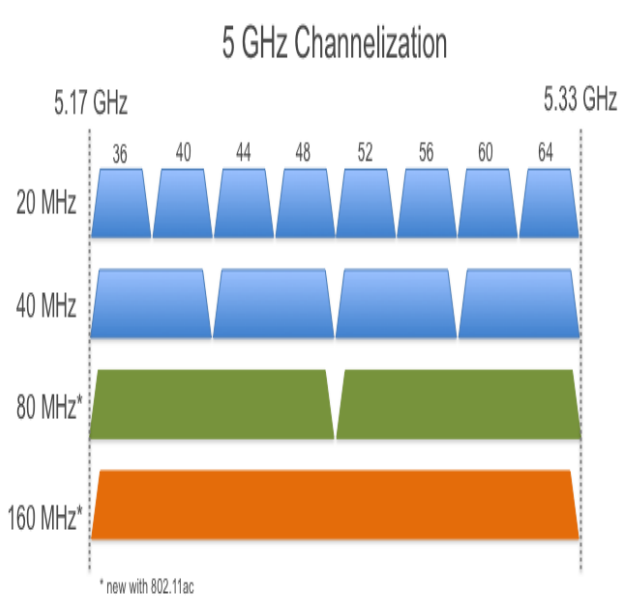

Figure 5: Channelization in 802.11ac

With the numerous 20 and 40 MHz channels in the 5 GHz band in 802.11n, overlapping channels between BSS's are largely avoided if each AP surveys the available channels and selects an unused or little-used channel.

In the worst case if an overlap between neighbors using 40 MHz is unavoidable, the primary 20 MHz sub-channels are chosen to match to maximize coexistence capability. With much wider channels in 802.11ac, it becomes much harder to avoid overlap between neighboring BSS's. In addition it becomes harder to choose a primary channel common to all overlapping networks. To address this problem, 802.11ac improves co-channel operation with extended dynamic channel bandwidth operation, and an enhanced RTS/CTS mechanism.

C. 802.11AD

IEEE 802.11ad is an amendment that defines a new physical layer for 802.11 networks to operate in the 60 GHz millimeter wave spectrum. This frequency band has significantly different propagation characteristics than the 2.4 GHz and 5 GHz bands where Wi-Fi networks operate.

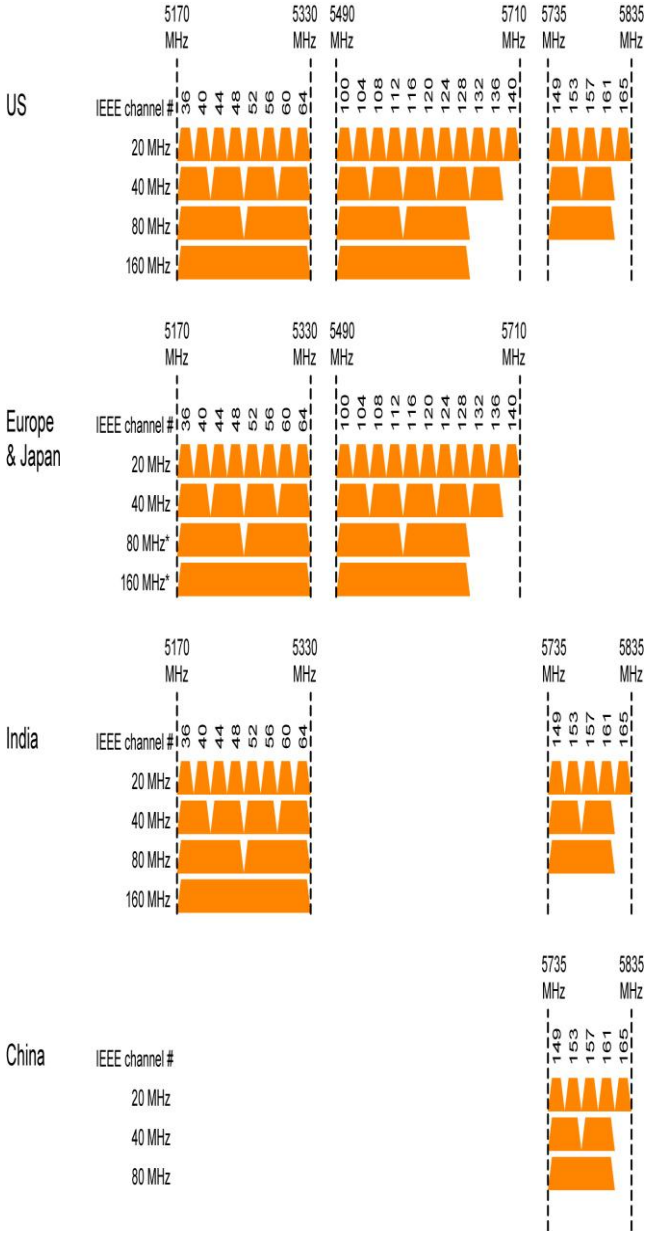

Figure 6: Usable bandwidth in different countries

Samsung recently have developed 60 GHz Wi-Fi technology (802.11ad) which boosts data transmission speeds of up to 4.6 gigabits per second (Gbps), or 575 megabytes (MB) per second.

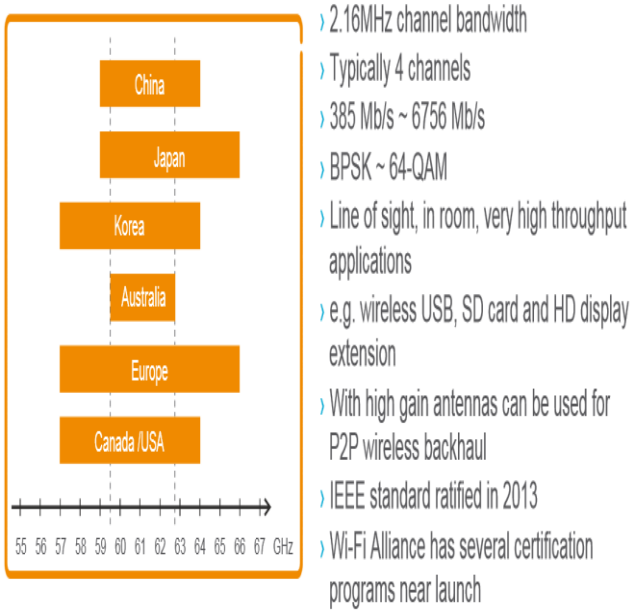

Figure 7: Features of 802.11ad

This would be about five times faster than the current ceiling for Wi-Fi speeds for consumer electronics devices, which stands at around 866.7 megabits per second (Mbps), or 108MB per second (802.11ac).Unlike the existing 2.4GHz and 5 GHz Wi-Fi technologies, Samsung's 802.11ad standard 60GHz Wi-Fi technology maintains maximum speed by eliminating co-channel interference, regardless of the number of devices using the same network.

D. 802.11AX

Table 2: Comparison of 802.11ac and 802.11ax

	802.11ac	802.11ax
Main Frequency Bands	5 GHz	2.5 GHz and 5 GHz
Channel Bandwidth (MHz)	20, 40, 80, 160, 80+80	Unlikely to change from 802.11ac
Number of spatial streams	1, 2, 3, 4, 5, 6, 7, 8	Unlikely to change from 802.11ac
Modulation	BPSK, QPSK, 16QAM, 64QAM, 256QAM	Unlikely to change from 802.11ac
Maximum PHY Data Rate	6933 Mbps (8SS, 160 MHz, 256QAM, short guard interval)	Unlikely to change from 802.11ac
Advanced Technologies	Downlink MU MIMO, Dynamic/static channel bandwidth operation with RTS/CTS	STR, Downlink and Uplink OFDMA, Uplink MU MIMO, Dynamic CCA

The easiest way to think of 802.11ax is to start with 802.11ac — which allows for up to four different spatial streams (MIMO) — and then to massively increase the spectral efficiency (and thus max throughput) of each stream. Like its predecessor, 802.11ax operates in the 5GHz band, where there's a lot more space for wide (80MHz and 160MHz) channels. With 802.11ax, you get four MIMO (multiple-input-multiple-output) spatial streams, with each stream multiplexed with OFDA (orthogonal frequency division access).

OFDA refer to methods of frequency-division multiplexing basically, each channel is separated into dozens/hundreds of smaller sub channels, each with a slightly different frequency. By then turning these signals through right-angles (orthogonal), they can be stacked closer together and still be easily demultiplexed.

Chinese equipment maker Huawei — which is heading up the IEEE 802.11ax working group — is already doing trials of MIMO-OFDA systems and it's hitting 10.53 Gbps in the lab using Wi-Fi's traditional 5 GHz band.Huawei says the key technologies that give it a ten-fold speed boost over 802.11ac's current gigabit capability are "MIMO-OFDA, intelligent spectrum allocation, interference coordination, and hybrid access".

CONCLUSION

802.11n is most used standard currently providing maximum speed of 300 Mbps. 802.11ac is also commercialized and gaining popularity rapidly. With improvements in technology like MIMO and Beam forming we will soon have Wifi connection that speeds in Gigabits. It would be interesting to see how WLAN competes with other advancements like Lifi in future.

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