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A Comparison Study of WLAN "IEEE802.11ac" and "IEEE802.11ad" Standards

[1]Wafa S. M. Elbasher, [1]Amin B. A. Mustafa, [2]Ashraf A. Osaman

[1]Faculty of Engineering, Al- Neelain University, Khartoum, Sudan, Email: wafaa.elbasher@gmail.com
[2]Computer Design Senor Engineer, Folsom, CA, USA, Email: ashrafosman08@gmail.com

Abstract: The **m**odern communications is one of the most critical elements of modern cultures depicted in the 21th century. All of the recent civilizations depend on electronics and communication. Mobile wireless communication system is identified by ability to transfer information without using any current carrying conductor. The wireless fidelity WI-FI is the first step towards the adoption of IEEE802.11 standards which include the "IEEE 802ac" and "IEEE 802.11ad" sets. There standards permits wireless throughput rates in the gigabit levels. In this paper, a discussion of these standards will be detailed.

Keywords: *IEEE802.11; Wireless; WIFI; IEEE802.11n; IEEE802.11ac; IEEE802.11ad; 5GHZ and 60GHZ frequency*

1. INTRODUCTION

There has been a drastic change in how mobile communication devices are being used with data transfer and with mobility scenarios. Mobile users have been trafficking more data than voice while using these mobile devices leading to change of communication environment. According to [1], the number of mobile devices subscription outlook during 2014 - 2020 will be as shown in **Table 1**.

From **Table 1**, the vast number of mobile devices as well as the rapid growth of subscribers are evident. Also, it worth noting that the mobile PCs, tablets, and routers growth is much slower than mobile broadband devices and smart phones. To support the aforementioned growth, new networking standards that support higher throughput and high rate services have emerged in the communication market. Examples are the IEEE802.11ac and IEEE802.11ad that support ranges of 1.5Gbps and up to 7Gbps respectively. These three technologies are focused on high speed communications and would be interesting to compare these techniques against each other. Table 2 demonstrate a listing of IEEE802.11 standards for various technologies, and in Fig. 1 a plot of the comparing Spectrum Bands, Data Rate, and channel bandwidth for IEEE802.11 standards is shown.

In this article, the technology specifications of both the IEEE802.11ac and IEEE802.11ad standard will be discussed in details.

2. THE STANDARD IEEE 802.11N

The IEEE 802.11n standard, appeared in 2008, and had become popular due to the jump in application data transfer rates from about 54 Mbps to nearly 600 Mbps. The IEEE 802.11n standard was officially completed in 2009 but most of the technical features were ratified in 2007. Most companies supported the creation of a 60 GHz based standard for WLANs to succeed the 802.11n standard, and a lot of attention and effort was devoted to this activity. However, it was soon realized that the 60 GHz standard is not likely to be an evolutionary move and, therefore, a parallel standardization effort in the 5 GHz band was started to address this intention. As a result, the two 802.11 set of standards, referred to as 802.11ac and 802.11ad have been established. However, the 802.11ac and the 802.11ad are now accepted as the evolutionary upgrade from 802.11n standards.

Table 1. Mobile subscription outlook as stated by [1]

Subscriptions	2014	2020
Total mobile	7.1 billion	9.2 billion
Mobile broadband	2.9 billion	7.7 billion
Smartphones	2.6 billion	6.1 billion
Mobile PCs, tablets and routers	250 million	400 million

Table 2. Comparison between IEEE 802.11 Standards [2]

802.11 Network PHY standards								
802.11 protocol	Release date	Frequency (GHz)	Band-width (MHz)	Stream Data Rate Min-Max (Mbit/s)	Allowable MIMO streams	Modulation Antenna Tech.	Approx. range In (m)	Approx. range Out (m)
802.11	Jun 1997	2.4	22	1-2	1	DSSS, FHSS	20	100
a	Sep 1999	5	20	6-54	1	OFDM	35	120
		3.7				(SISO)	—	5K
b	Sep 1999	2.4	22	1-11	1	DSSS (SISO)	35	140
g	Jun 2003	2.4	20	6-54	1	OFDM, DSSS (SISO)	38	140
n	Oct 2009	2.4/5	20	7.2 -72.2 (6.5- 65)	4	OFDM (MIMO)	70	250
			40	15 - 150 (13.5 - 135)			70	250
ac	Dec 2013	**5**	20	7.2 - 96.3 (6.5 - 86.7)	8	OFDM (MU-MIMO)	35	
			40	15 - 200 (13.5 - 180)			35	
			80	32.5 - 433.3 (29.2 - 390)			35	
			160	65 - 866.7 (58.5 - 780)			35	
ad	Dec 2012	60	2	Up to 6,912 (6.75 Gbit/s)	NA	OFDM, single carrier, low-power single carrier	60	100
			160				200	300

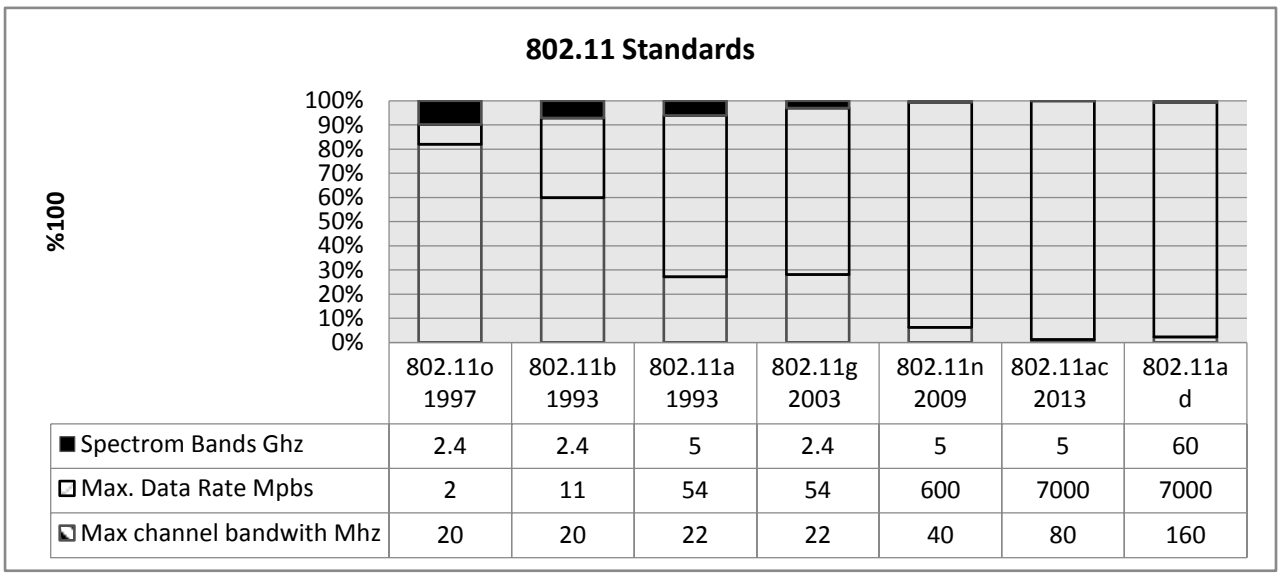

Fig.1. Bar plot comparing Spectrum Bands, Data Rate, and channel bandwidth for IEEE802.11 standards

3. THE IEEE802.11AC STANDARD

IEEE 802.11ac is a wireless networking standard in the 802.11 family. The 802.11ac has been updated on 2011, and 2013 and approved in January 2014. It is generally marketed with brand name Wi-Fi. As shown in Table 2, this standard throughput rates are about 5 GHz band. This specification has expected multi-station WLAN throughput of at least 1 gigabit per second and a single link throughput of at least 500 megabits per second (500 Mbit/s). This is accomplished by extending the air interface concepts embraced by 802.11n: wider RF bandwidth (up to 160 MHz), more MIMO spatial streams (up to eight), downlink multi-user MIMO (up to four clients), and high-density modulation (up to 256-QAM).

4. THE IEEE802.11AD STANDARD

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. Products implementing the 802.11ad standard are being brought to market under the WiGig brand name. The certification program is now being developed by the Wi-Fi Alliance instead of the now defunct WiGig Alliance. The peak transmission rate of 802.11ad is 7 Gbit/s. The key advantage of IEEE 802.11ad over the other standardization activities in the 60 GHz arena is that it builds on the already existing strong market presence of Wi-Fi in the 2.4/5 GHz bands. The 802.11ad task group also initially developed a functional requirements document, evaluation methodology document, and channel model document which is released in Dec 2012.

5. IEEE802.11AC AND IEEE802.11AD TECHNOLOGY DETAILS

Table 3 shows the timeline of IEEE802.11ac and IEEE802.11ad of development and release. **Table 4** shows a comparison between the IEEE802.11ac and IEEE802.11ad standers and characteristics [5-6].

Eldad Perahia and Michelle X. Gong [5] have presented a review of the IEEE802.11ac channelization, PHY design, MAC modifications, and DL MU MIMO. For IEEE802.11ad, the new PHY layer, MAC enhancements, and beamforming are also presented

Table 3. IEEE802.11ac and IEEE802.11ad Development and Release Timeline [3].

Standards	Idea	Project Approval Process	Develop Draft Standard in Working Group	Sponsor Ballot	IEEE SA Standards Board Approva	Publish Standard
IEEE802.11ac	2008	2008	2009/2012	20013	Dec 2013	2014
IEEE802.ad	2007	2007	2008/2011	20012	Dec 2012	2013

Table 4. Basic differences between IEEE802.11ac and IEEE802.11ad standards

Feature	802.11ac	802.11ad
Access Technology	Multi-user + Spatial Division Multiplexing⁄OFDM	Single-user, one spatial stream ⁄Single Carrier orOFDM
Frequency Band	5 GHz	60 GHz
Maximum Data Rate(Mbps)	Y80 MHz, 4 spatial streams: 1733 160 MHz,4 spatialStreams:6933	Single Carrier:4620 OFDM: 6756
Channel Bandwidth(MHz)	20,40,80,160	2160
Over-the-Air (OTA) Estimates	Up to 867 Mbps with 2 antennas and 80 MHz; Up to 1.3 Gbps with3 antennas and 80 MHz	At least 1.1 Gbps up to 4.6 Gbps in some first Generation products
Allowable MIMIO Stream	8	N/A
Media Access Control Layer, Service Access Point (MAC SAP) Estimates	Up to 600 Mbps with 2 antennas and 80 MHz; Up to 900 Mbps with antennas and 80 MHz	Up to 700 Mbps for 1.1 Gbps OTA (up to 3 Gbps for 4.6 Gbps OTA)
Release date	Dec 2013	Dec 2012

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6. CONCLUSIONS

The standard IEEE802.11ac and IEEE802.11ad are compared from the technical features point of view. Both standards represent an evolution on communication when it comes to the giga bit per sec throughput rates. The IEEE802.11ac evolved into the 5 GHz bands type of applications with wider channels and multi-user capability to address broader coverage use cases that are typical of Wi-Fi devices. Examples are higher resolution video coverage around the home. The IEEE802.11ad on the other hand, is suitable for the 60 GHz band technology to facilitate multi-gigabit-per-second communications over shorter distances. This standard has many new features to improve and sustain high-speed communications with TDMA single-carrier and OFDM schemes. They allow for scheduled and contention-based access, beamforming, and power-save mechanisms that decrease power consumption and increase throughput. Future evolution of IEEE802.11ad towards full MIMO support and channel bonding can further increase its data rate. The IEEE802.11ad will make use of directional antennas and beamforming to enhance link quality, and modifies channel access to address directionality and spatial reuse.

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