

Understanding IEEE 802.11ad

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Abstract— In this paper we give an overview of IEEE 802.ad, which is ready to define the next generation multi-Gbps WiGig. Taking into account the need for more capacity and high speed of transmission of data, there is a need for standards which comparing with previous will enable greater bandwidth, flexibility and opportunities which will not be limited in size of data that we want to transmit. These opportunities enables us 802.11ad standard which will be given in this paper by analyzing its characteristics it possesses challenges and potential pitfalls that arise during the implementation of this standard. The review of infrastructure of standard will be described in details Also will be given properties of 60GHz channel and absorption issues happening during propagation process.

Keywords— IEEE 802.11ad, WiGig, Absorption, Standard.

I. INTRODUCTION

IEEE 802.11ad is an enhancement to the 802.11 standard that enables multi-gigabit wireless communications in the 60 GHz band. The Wi Gig specification was contributed to the IEEE 802.11ad standardization process, and was confirmed in May 2010 as the basis for the 802.11ad draft standard. [1]

The first popular standards for wireless LAN (IEEE 802.11a and b) were designed primarily to serve the needs of a laptop PC in the home and office, and later to allow connectivity “on the road” in airports, hotels, Internet cafes, and shopping malls. Their main function was to provide a link to a wired broadband connection for Web browsing and email. Since the speed of the broadband connection was the limiting factor, a relatively low-speed wireless connection was sufficient – 802.11a provided up to 54 Mb/s at 5 GHz, and 802.11b up to 11 Mb/s at 2.4 GHz, both in unlicensed spectrum bands. To minimize interference from other equipment, both used forms of spread-spectrum transmission and were heavily encoded. A later revision of the standard, 802.11g in 2003 consolidated use in the 2.4 GHz band but maintained the maximum data rate at 54 Mb/s.

However, by the same time, new usage models with the need for higher throughput had been recognized: data sharing amongst connected devices in the home or small office and wireless printing as examples. [2]

The primary goal of 802.11ad is to allow faster networking speeds in dense deployment environments and ultrafast speeds in the home, which is partly achieved because 60GHz has a shorter range and thus other networks are far less likely to intercept and interfere with your connection (more secure).

II. STRUCTURE

The WiGig specification defines Physical (PHY) and Medium Access Control (MAC) layers and is based on IEEE 802.11. This enables native support for IP networking over 60 GHz.

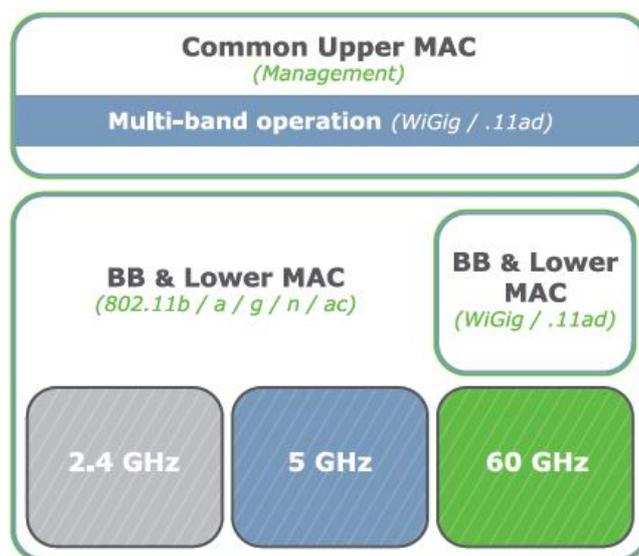


Fig.1 IEEE 802.11ad architecture

The IEEE 802.11ad PHY supports three distinct modulation methods:

- Spread-spectrum modulation; the Control PHY.
- Single carrier (SC) modulation; the Single Carrier PHY and the Low Power Single Carrier PHY.
- Orthogonal Frequency Division Multiplex (OFDM) modulation; the OFDM PHY.

Each PHY type has a distinct purpose and packet structure, shown in Figure 2

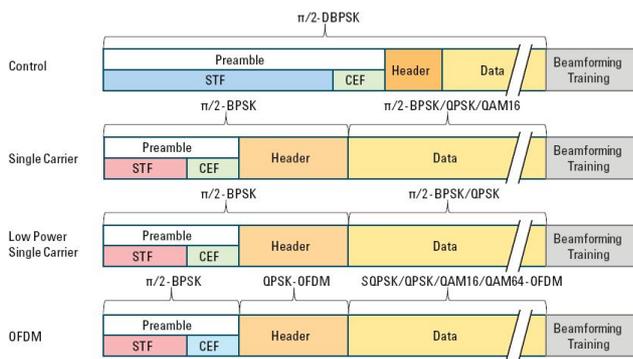


Fig.2 Structure of three modulation types

A. Physical Layer (PHY)

The IEEE 802.11ad standard specifies two operating modes working in 2.16 GHz channel bandwidth. The orthogonal frequency division multiplexing (OFDM) mode is designed for high performance applications on frequency selective channels. The single carrier (SC) mode is used for low power and low complexity transceivers. It is also employed for control signalling. We investigate the OFDM mode performance in this paper. The scrambled data is firstly encoded with a LDPC encoder. The irregular LDPC (672, 336), LDPC (672, 420), LDPC (672, 504) and LDPC(672, 546) codes are used for the coding rates of 1/2, 5/8, 3/4, and 13/16 respectively. The 60 GHz band has much more spectrum available than the 2.4 GHz and 5 GHz bands – typically 7 GHz of spectrum, compared with 83.5 MHz in the 2.4 GHz band.

This spectrum is divided into multiple channels, as in the 2.4 GHz and 5 GHz bands. Because the 60 GHz band has much more spectrum available, the channels are much wider, enabling multi-gigabit data rates. The WiGig specification defines four channels, each 2.16 GHz wide – 50 times wider than the channels available in 802.11n.

B. Medium Access Control (MAC)

A hybrid multiple access of contention-based CSMA/CA (carrier sense multiple access with collision avoidance) and Contention-free TDMA (time division multiple access) is used in IEEE 802.11ad. The CSMA/CA is used for a burst-type of application such as web browsing because of the lower average latency, while the TDMA is more desirable for video transmission due to its better quality of service and efficiency. Polling is used on the top of the access periods in order to dynamically allocate the channel time.

The MAC layer throughput is determined by the amount of information bits exchanged between the transceivers MAC, and the duration needed for successfully delivering the information.

It can be calculated by the following equation:

$$\text{MAC Throughput} = \text{Payload/Transmission Duration}$$

C. Modulation and Coding schemes at IEEE 802.11ad

The specification supports two types of modulation and coding schemes, which provide different benefits:

- ✓ Orthogonal frequency-division multiplexing (OFDM) supports communication over longer distances with greater delay spreads, providing more flexibility in handling obstacles and reflected signals. Furthermore, OFDM allows the greatest transmission speeds of up to 7 Gbps.
- ✓ Single carrier (SC) typically results in lower power consumption, so it is often a better fit for small, low-power handheld devices. SC supports transmission speeds up to 4.6 Gbps.

III. CHANNEL PROPERTIES OF 60GHz

This 60 GHz band comes with a large free space propagation loss (about 20 dB more than that in 5 GHz band) which must be compensated for by high gain directional antennas in order to reach decent range, such as more than 1 meter. Fortunately, high gain directional antennas are feasible to implement even for small form factor devices due to the relatively short wavelengths of about 5 mm. Such directional antennas can be implemented either with a sector antenna that can be switched from sector to sector or an adaptive antenna array that can be configured into different radiation patterns.

Secondly, 60GHz channel generally exhibits quasi-optical properties, meaning the strongest components tend to be Line of Sight (LOS). Non Line of Sight (NLOS) components do exist, but mostly in the form of reflection. However, the short wavelengths in this band impose some serious challenges such as greater signal diffusion and difficulty diffracting around obstacles. 60 GHz band measurements show that in general, the strongest reflected components are at least 10 dB below the line of sight (LOS) component. [3] Even more challenging are the problems caused by obstructions. A human body walking into the path between the transmitter and the receiver can attenuate the signal by 15 dB or more and easily break the link. Common objects such as furniture, walls, doors and floors found in indoor environments can also be problematic. As a result, the practical indoor operation range at 60 GHz is likely to be limited by penetration loss instead of free space propagation loss and therefore mostly confined to a single room. In comparison, the link characteristics are very different in the lower frequency bands such as 2.4/5 GHz, where penetration loss is less, rich multi-path exists to provide diversity, and the range can reach up to hundreds of meters.

A. Absorption from Oxygen and Rain

Systems operating at 60 GHz have been used for many years by the intelligence society for high security communications and by the military for satellite-to satellite communications. Their interest in this frequency band stems from a phenomenon of nature: the oxygen molecule (O₂) absorbs electromagnetic energy at 60 GHz like a piece of food in a microwave oven (see Figure 3). This absorption occurs to a

much higher degree at 60 GHz than at lower frequencies typically used for wireless communications.[3]This absorption weakens (attenuates) 60 GHz signals over distance, so that

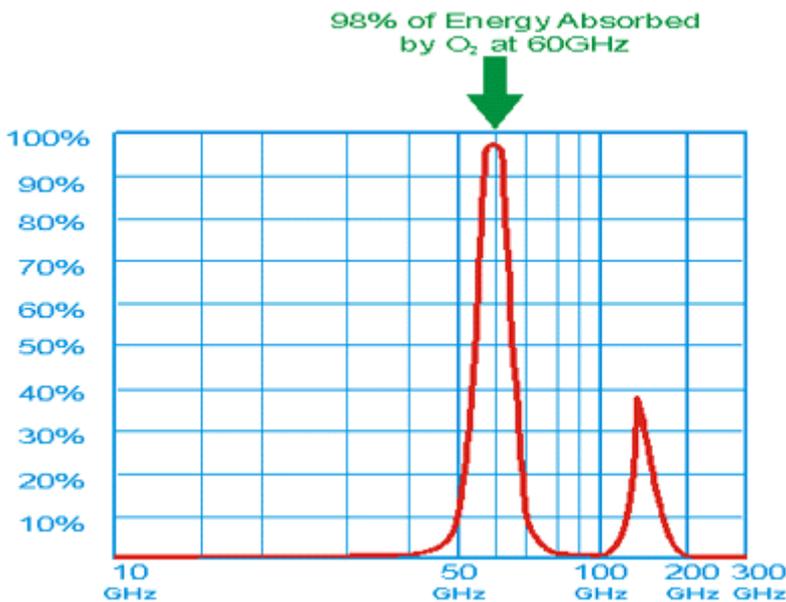


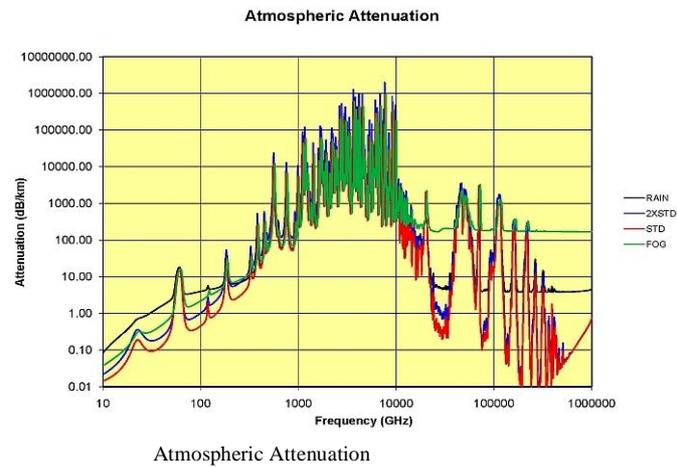
Fig. 3 Oxygen Absorption at 60GHz

signals cannot travel far beyond their intended recipient.

Another consequence of O2 absorption is that radiation from one particular 60 GHz radio link is quickly reduced to a level that will not interfere with other 60 GHz links operating in the same geographic vicinity. This reduction enables higher “frequency reuse” – the ability for more 60 GHz links to operate in the same geographic area than links with longer ranges. Link distances of millimeter-wave radios operating in the real world are limited primarily by rain. Users of these products typically want the links to provide robust communication capability, such as the “five nines” of availability demanded by most carriers. In this application, the rainfall rates where the product is used will typically be more of a limiting factor than O2 absorption. [3]

In moderate rain regions, the rain attenuation is about twice the oxygen attenuation, and in heavy rain regions, the rain attenuation is more than three times the oxygen attenuation. Therefore, in designing a 60 GHz link to provide robust communication capability in the real world, rain attenuation is a larger factor than oxygen absorption.

Fig. 4



Atmospheric Attenuation

IV. CONCLUSIONS

The IEEE 802.11ad is perfect choice for high-speed Internet, data, and voice communications offering the following key benefits:

- ✓ Unlicensed band – no need to obtain a license from FCC
- ✓ Highly secure process – resulting from short transmission distances due to oxygen absorption and narrow antenna beam width
- ✓ Virtually interference-free operation – resulting from short transmission distances due to oxygen absorption, narrow antenna beam width, and limited use of 60 GHz spectrum
- ✓ High level of frequency re-use enabled – communication needs of multiple customers within a small geographic region can be satisfied
- ✓ Fiber optic data transmission speeds possible – 7 GHz of continuous bandwidth available compared to <0.3 GHz at the other unlicensed bands
- ✓ Mature technology – long history of this spectrum being used for secure communications

Although standard is still under development we are waiting soon to be the most used network for data transmitting.

IEEE 802.11ad are standardizing 60 GHz 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. Future evolution of 802.11ad towards full MIMO support can further increase its data rate. With the advent of new technologies to make these protocols practical, and with standardization by bodies such as WiGig and IEEE, truly wireless broadband will be achieved with 60 GHz, and all wires in PANs will be eliminated.

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