

# A Review on OFDM as Multiplexing Scheme in WLAN

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**Abstract-** In wireless communication, higher data rates can be achieved by increased or more efficient use of bandwidth and transmitting power. A key technique for spectral optimization is Orthogonal Frequency Division Multiplexing (OFDM). OFDM is a technique proposed for high-speed wireless LAN by the European Telecommunication Standards Institute and IEEE which is being considered for 4G mobile. OFDM technology is described for physical layer of proposed WirelessLAN standard whose data rate ranges from 6 to 54 Mbit/s depending on Quality of Service (QoS). It is designed to provide Wireless Local Loop (WLL) to core networks, e.g. Asynchronous Transfer Mode, GSM/UMTS or any IP-based multimedia network. Data rate, coding rate and modulation type are determined by the link adoption scheme automatically depending on the channel conditions. There are several ways to utilize the frequency band in a flexible way so that the available bandwidth is utilized to maximal efficiency. These access techniques uses a small portion of available energy with low power spectral density, high data transmission rates, less intercarrier interference and efficient use of bandwidth. The main cause of interference in OFDM system is channel fading, and all the errors are in transmission occurred due to effects of channel. One method that can be implemented to overcome this problem is by introducing channel coding. Channel encoding is applied by adding redundant bits to the transmitted data. The redundant bits increase raw data used in the link and therefore, increase the bandwidth requirement. So, if noise or fading occurred in the channel, some data may still be recovered at the receiver. While at the receiver, channel decoding is used to detect or correct errors that are introduced to the channel. To design an WLAN system with Rectangular QAM Baseband Modulator and OFDM as a multiple access technique. Then, analyze this system with to reduce the interference and improve the BER of system.

**Keywords-** WLAN, BER, OFDM.

## I. INTRODUCTION OF WLAN

A wireless LAN (WLAN) is a wireless computer network that links two or more devices using wireless communication to form a local area network (LAN) within a limited area such as a home, school, computer laboratory, campus, or office building. This gives users the ability to move around within the area and remain connected to the network. Through a gateway, a WLAN can also provide a connection to the wider Internet. Most modern WLANs are based on IEEE 802.11 standards and are marketed under the Wi-Fi brand name.

A WLAN can be either an extension to a current wired network or an alternative to it. WLANs have data transfer speeds ranging from 1 to 54 Mbps, with some companies offering proprietary 108Mbps solutions. A WLAN signal can be broadcast to cover an area ranging in size from a small office to a large campus. Most commonly, a WLAN access point provides access within a radius of 65 to 300 feet. It should be noted that the IEEE 802.11 are the standards that most of the modern wireless LANs are based on.

Private home or small business WLAN: A home or business WLAN employs one or two access points to broadcast a signal around a 100- to 200-foot radius. You can find equipment for installing a home WLAN in many retail stores.

Enterprise class WLAN: An enterprise-class WLAN employs a large number of individual access points to broadcast the signal to a wide area. The access points have more features than home or small office WLAN equipment, such as better security, authentication, remote management.

## II. TYPES OF WLAN

The IEEE 802.11 has two basic modes of operation: infrastructure and ad hoc mode. In ad hoc mode, mobile units transmit directly peer-to-peer. In infrastructure mode, mobile units communicate through an access point that serves as a bridge to other networks (such as Internet or LAN).

Since wireless communication uses a more open medium for communication in comparison to wired LANs, the 802.11 designers also included encryption mechanisms: Wired Equivalent Privacy (WEP, now insecure), Wi-Fi Protected Access (WPA, WPA2, WPA3), to secure wireless computer networks. Many access points will also offer Wi-Fi Protected Setup, a quick (but now insecure) method of joining a new device to an encrypted network.

**Infrastructure:** Most Wi-Fi networks are deployed in infrastructure mode. In infrastructure mode, a base station acts as a wireless access point hub, and nodes communicate through the hub. The hub usually, but not always, has a wired or fiber network connection, and may have permanent wireless connections to other nodes. Wireless access points are usually fixed, and provide service to their client nodes within range. Wireless clients, such as laptops and smartphones, connect to the access point to join the network. Sometimes a network will have a multiple access points, with the same 'SSID' and security arrangement. In that case connecting to any access point on that network joins the client to the network. In that case, the client software will try to choose the access point to try to give the best service, such as the access point with the strongest signal.

**Peer – to – peer:** An ad hoc network (not the same as a WiFi Direct network) is a network where stations communicate only peer to peer (P2P). There is no base and no one gives permission to talk. This is accomplished using the Independent Basic Service Set (IBSS). A WiFi Direct network is another type of network where stations communicate peer to peer. In a Wi-Fi P2P group, the group owner operates as an access point and all other devices are clients. There are two main methods to establish a group owner in the Wi-Fi Direct group. In one approach, the user sets up a P2P group owner manually. This method is also known as Autonomous Group Owner (autonomous GO). In the second method, also called negotiation-based group creation, two devices compete based on the group owner intent value. The device with higher intent value becomes a group owner and the second device becomes a client. Group owner intent value can depend on whether the wireless device performs a cross-connection between an infrastructure WLAN service and a P2P group, remaining power in the wireless device, whether the wireless device is already a group owner in another group or received signal strength of the first wireless device. A peer-to-peer network allows wireless devices to directly communicate with each other. Wireless devices within range of each other can discover and communicate directly without involving central access points. This method is typically used by two computers so that they can connect to each other to form a network. This can basically occur in devices within a closed range. If a signal strength meter is used in this situation, it may not read the strength accurately and can be misleading, because it registers the strength of the strongest signal, which may be the closest computer. IEEE 802.11 defines the physical layer (PHY) and MAC (Media Access Control) layers based on CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). This is in contrast to Ethernet which uses CSMA-CD (Carrier Sense Multiple Access with Collision Detection). The 802.11 specification includes provisions designed to minimize collisions, because two mobile units may both be in range of a common access point, but out of range of each other.

**Bridge:** A bridge can be used to connect networks, typically of different types. A wireless Ethernet bridge allows the connection of devices on a wired Ethernet network to a wireless network. The bridge acts as the connection point to the Wireless LAN.

**Wireless distribution system:** A wireless distribution system (WDS) enables the wireless interconnection of access points in an IEEE 802.11 network. It allows a wireless network to be expanded using multiple access points without the need for a wired backbone to link them, as is traditionally required. The notable advantage of a WDS over other solutions is that it preserves the MAC addresses of client packets across links between access points. An access point can be either a main, relay or remote base station. A main base station is typically connected to the wired Ethernet. A relay base station relays data between remote base stations, wireless clients or other relay stations to either a main or another relay base station. A remote base station accepts connections from wireless clients and passes them to relay or main stations. Connections between clients are made using MAC addresses rather than by specifying IP assignments. All base stations in a WDS must be configured to use the same radio channel, and share WEP keys or WPA keys if they are used. They can be configured to different service set identifiers. WDS also requires that every base station be configured to forward to others in the system as mentioned above. WDS capability may also be referred to as repeater mode because it appears to bridge and accept wireless clients at the same time (unlike traditional bridging). Throughput in this method is halved for all clients connected wirelessly. When it is difficult to connect all of the access points in a network by wires, it is also possible to put up access points as repeaters.

### III. OFDM IN WLAN

OFDM is a multicarrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low rate data stream. OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels, that are then allocated to users. However, OFDM uses the

spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another, preventing interference between the closely spaced carriers.

In FDMA each user is typically allocated a single channel, which is used to transmit all the user information. The allocated bandwidth is made wider than the minimum amount required to prevent channels from interfering with one another. This extra bandwidth is to allow for signals from neighboring channels to be filtered out, and to allow for any drift in the center frequency of the transmitter or receiver. In a typical system up to 50% of the total spectrum is wasted due to the extra spacing between channels. This problem becomes worse as the channel bandwidth becomes narrower, and the frequency band increases. Most digital phone systems use vocoders to compress the digitized speech. This allows for an increased system capacity due to a reduction in the bandwidth required for each user. However, simple FDMA does not handle such narrow bandwidths very efficiently.

TDMA partly overcomes this problem by using wider bandwidth channels, which are used by several users. Multiple users access the same channel by transmitting in their data in time slots. Thus, many low data rate users can be combined together to transmit in a single channel which has a bandwidth sufficient so that the spectrum can be used efficiently[12].

There are however, two main problems with TDMA. There is an overhead associated with the change over between users due to time slotting on the channel. A change over time must be allocated to allow for any tolerance in the start time of each user, due to propagation delay variations and synchronization errors. This limits the number of users that can be sent efficiently in each channel. In addition, the symbol rate of each channel is high (as the channel handles the information from multiple users) resulting in problems with multipath delay spread.

OFDM overcomes most of the problems with both FDMA and TDMA. OFDM splits the available bandwidth into many narrow band channels typically 100 – 8000[15]. The carriers for each channel are made orthogonal to one another, allowing them to be spaced very close together, with no overhead as in the FDMA example. Because of this there is no great need for users to be time multiplex as in TDMA, thus there is no overhead associated with switching between users.

The orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. Due to this, the spectrum of each carrier has a null at the centre frequency of each of the other carriers in the system. This results in no interference between the carriers, allowing them to be spaced as close as theoretically possible. This overcomes the problem of overhead carrier spacing required in FDMA. Each carrier in an OFDM signal has a very narrow bandwidth, thus the resulting symbol rate is low. This results in the signal having a high tolerance to multipath delay spread, as the delay spread must be very long to cause significant inter-symbol interference.

### **Basic Principle of OFDM**

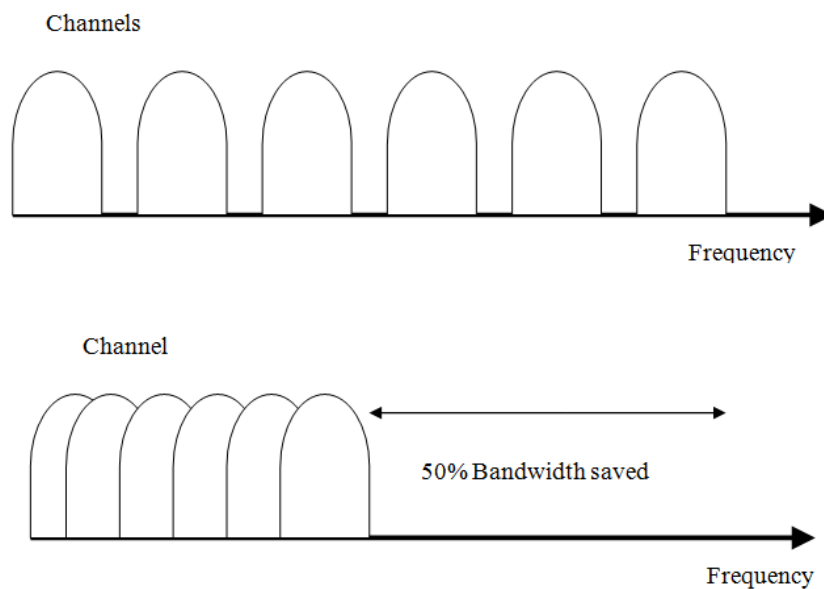
OFDM is very similar to the well known and used technique of FDM. OFDM uses the principles of FDM to allow multiple messages to be sent over a single radio channel. It is however in a much more controlled manner, allowing an improved spectral efficiency. A simple example of FDM is the use of different frequencies for each FM radio stations. All stations transmit at the same time but do not interfere with each other because they transmit using different carrier frequencies. Additionally they are bandwidth limited and are spaced sufficiently far apart in frequency so that their transmitted signals do not overlap in the frequency domain. At the receiver, each signal is individually received by using a frequency tunable band pass filter to selectively remove all the signals except for the station of interest. This filtered signal can then be demodulated to recover the original transmitted information[16].

OFDM is different from FDM in several ways. In conventional broadcasting each radio station transmits on a different frequency, effectively using FDM to maintain a separation between the stations. There is however no coordination or synchronization between each of these stations. With an OFDM transmission the information signals from multiple stations is combined into a single multiplexed stream of data. This data is then transmitted using an OFDM ensemble that is made up from a dense packing of many subcarriers. All the subcarriers within the OFDM signal are time and frequency synchronized to each other, allowing the interference between subcarriers to be carefully controlled. These multiple subcarriers overlap in the frequency domain, but do not cause Inter-Carrier Interference due to the orthogonal nature of the modulation. Typically with FDM the transmission signals need to have a large frequency guard-band between channels to prevent interference[5]. This lowers the overall spectral efficiency. However with OFDM the orthogonal packing of the subcarriers greatly reduces this guard band, improving the spectral efficiency as shown in Figure below.

All wireless communication systems use a modulation scheme to map the information signal to a form that can be effectively transmitted over the communications channel. A wide range of modulation schemes has been developed, with the most suitable one, depending on whether the information signal is an analogue waveform or a digital signal. Some of the common analogue modulation schemes include Frequency Modulation, Amplitude Modulation, Phase Modulation, Single Side Band, Vestigial Side Band, Double Side Band Suppressed Carrier. All wireless communication systems use a modulation scheme to map the information signal to a form that can be effectively transmitted over the communications channel. A wide range of modulation schemes has been developed, with the most suitable one, depending on whether the information signal is an analogue waveform or a digital signal.

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Common single carrier modulation schemes for digital communications include, Amplitude Shift Keying, Frequency Shift Keying, Phase Shift Keying and Quadrature Amplitude Modulation.



**Figure 1. Concept of OFDM signal (a) Conventional Multi-carrier technique (b) Orthogonal Multi-carrier modulation technique.**

Each of the carriers in a FDM transmission can use an analogue or digital modulation scheme. There is no synchronization between the transmission and so one station could transmit using FM and another in digital using FSK. In a single OFDM transmission all the subcarriers are synchronized to each other, restricting the transmission to digital modulation schemes. OFDM is symbol based, and can be thought of as a large number of low bit rate carriers transmitting in parallel. All these carriers transmit in unison using synchronized time and frequency, forming a single block of spectrum. This is to ensure that the orthogonal nature of the structure is maintained. Since these multiple carriers form a single OFDM transmission, they are commonly referred to as 'subcarriers', with the term of 'carrier' reserved for describing the RF carrier mixing the signal from base band. There are several ways of looking at what make the subcarriers in an OFDM signal orthogonal and why this prevents interference between them.

### **Orthogonality**

Signals are orthogonal if they are mutually independent of each other. Orthogonality is a property that allows multiple information signals to be transmitted perfectly over a common channel and detected, without interference. Loss of orthogonality results in blurring between these information signals and degradation in communications. Many common multiplexing schemes are inherently orthogonal. TDM allows transmission of multiple information signals over a single channel by assigning unique time slots to each separate information signal. During each time slot only the signal from a single source is transmitted preventing any interference between the multiple information sources. Because of this TDM is orthogonal in nature. In the frequency domain most FDM systems are orthogonal as each of the separate transmission signals are well spaced out in frequency preventing interference. Although these methods are orthogonal the term OFDM has been reserved for a special form of FDM. The subcarriers in an OFDM signal are spaced as close as is

theoretically possible while maintain orthogonality between them[7]. OFDM achieves orthogonality in the frequency domain by allocating each of the separate information signals onto different subcarriers. OFDM signals are made up from a sum of sinusoids, with each corresponding to a subcarrier. The baseband frequency of each subcarrier is chosen to be an integer multiple of the inverse of the symbol time, resulting in all subcarriers having an integer number of cycles per symbol. As a consequence the subcarriers are orthogonal to each other.

### **OFDM Generation**

To generate OFDM successfully the relationship between all the carriers must be carefully controlled to maintain the orthogonality of the carriers. For this reason, OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit. The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM). The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform. In most applications, an Inverse Fast Fourier Transform is used. The IFFT performs the transformation very efficiently, and provides a simple way of ensuring the carrier signals produced are orthogonal.

The Fast Fourier Transform transforms a cyclic time domain signal into its equivalent frequency spectrum. This is done by finding the equivalent waveform, generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal components represent the frequency spectrum of the time domain signal. The IFFT performs the reverse process, transforming a spectrum (amplitude and phase of each component) into a time domain signal. An IFFT converts a number of complex data points, of length which is a power of 2, into the time domain signal of the same number of points[6]. Each data point in frequency spectrum used for an FFT or IFFT is called a bin. The orthogonal carriers required for the OFDM signal can be easily generated by setting the amplitude and phase of each bin, then performing the IFFT. Since each bin of an IFFT corresponds to the amplitude and phase of a set of orthogonal sinusoids, the reverse process guarantees that the carriers generated are orthogonal. The signal generated is a baseband, thus the signal is filtered, then stepped up in frequency before transmitting the signal.

### **IV. CONCLUSION**

In the present scenario, massive growth in wireless and mobile communications, the emergence of multimedia applications as well as high-speed Internet access and the deregulation of the telecommunications industry are the key drivers towards a new demand for radio-based broadband access networks. The telecommunication companies designed many multiple access technologies for occupying maximum number of users without changing the frequency bandwidths. One of these systems called Wireless Local Area Network shall provide high-speed communications between mobile terminals and various broadband infrastructure networks by using Orthogonal Frequency Division Multiple Access. As the number of users increases the complexity of system increases. So Wireless LAN system is designed to withstand with interference and fading in communication channel. Channel coding and Interleaving is needed for a system in order to sustain in any type of environment especially in multipath fading channel.

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