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Survey on Effective OFDM Technology for 4G

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***Abstract* – In the new era of mobile communication system aimed to seamlessly integrate a wide variety of services such as high speed, data, video and multimedia traffic along with voice signal. In today's scenario OFDM become more popular modulation technique for radio network. This paper provides an up-to-date survey on OFDM techniques to tackle defects occur in CDMA and fulfill all the demands for 4G communication. So OFDM provides efficient evolution for wireless mobile communication by increasing capacity, speed and quality of wireless network.**

***Index Terms* – OFDM, 4G, CDMA, Quality of Service.**

I. Introduction

In a mobile communication world of fast emerging technology, there is a demand in telecom market of people to communicate and get connected with each other to have appropriate and timely access to information regardless of the location of the each individual. The increasing demands for wireless communication systems have led to the betterment of fundamental issues in communication world and the design of highly capable Wireless systems. The challenge of future wireless communication systems is to provide high data rate wireless access at high quality of service. Since the availability of radio spectrum is limited and communication capacity needs cannot be met without a significant increase in communication spectral efficiency. The key to achieving this higher level of service delivery is a new air interface, called OFDM, which is in turn enabled by the high level of performance.

OFDM uses bandwidth very efficiently also provides a robust signal that requires little power. In OFDM system Carriers will benefit from greater flexibility, since more channels able to work in the same spectrum including higher bandwidth channels, with more types of services, such as Data, Voice & Multimedia. Currently these systems are still being defined and prototyped. Achieving higher data rates requires OFDM systems to make more efficient use of the bandwidth than CDMA systems.

In OFDM, usable spectrum bandwidth is divided into a large number of smaller bandwidths that are mathematically orthogonal using fast Fourier transforms (FFTs). Reconstruction of the band is performed by the inverse fast Fourier transform (IFFT). One beneficial feature of this technique is the ease of adaptation to different bandwidths. The smaller bandwidth unit can remain fixed, even as the total bandwidth utilization is changed. For example, a 10'MHz bandwidth allocation may be divided into 1,024 smaller bands, whereas a 5'MHz allocation would be divided into 512 smaller bands. These smaller bands are referred to as subcarriers and are typically on the order of 10 kHz. One challenge in today's wireless systems is an effect called 'multipath.' Multipath results from reflections between a transmitter and receiver whereby the reflections arrive at the receiver at different times. The time span separating the reflection is referred to as delay spread. This type of interference tends to be problematic when the delay spread is on the order of the transmitted symbol time. Typical delay spreads are microseconds in length, which are close to CDMA symbol times. OFDMA symbol times tend to be on the order of 100 microseconds, making multipath less of a problem. In order to mitigate the effect of multipath, a guard band of about 10 microseconds, called the cyclic prefix, is inserted after each symbol. Achieving higher data rates requires OFDM systems to make more efficient use of the bandwidth than CDMA systems. The number of bits per unit hertz is referred to as the spectral efficiency. One method of achieving this higher efficiency is through the use of higher order modulation. Modulation refers to the number of bits that each subcarrier transmits.

II. Literature Review On OFDM

The OFDM transmission scheme seems to be a promising candidate for future broadband radio systems. That transmission scheme is currently deployed in the well known standard IEEE 802.16a/d [1]. The crucial part which determines the performance is thereby the combination of dynamic sub-carrier allocation, transmission power allotment, and adaptive modulation. Many communication systems require knowledge of the signal-to-noise ratio (SNR), with efficient signal detection and link adaptation as most prominent examples. Signal-to-Noise ratio (SNR) is an indicator commonly used to evaluate the quality of a communication link. More specifically, SNR knowledge enables wireless systems to improve propagation channel estimation and is a key decision parameter in adaptive processes such as dynamic reconfiguration of cognitive radios, adaptive modulation and coding (AMC) or adaptive power allocation. Frequency division multiplexing (FDM) extends the concept of single carrier modulation by using multiple sub carriers within the same single channel. The total data rate to be sent in the channel is divided between the various sub carriers [3]. An OFDM baseband signal is the sum of a number of orthogonal sub-carriers, each subcarrier being independently modulated (for instance using QAM or PSK) by its own data. The orthogonality allows simultaneous transmission on a lot of sub-carriers in a tight frequency space without interference from each other. Thus, they are able to overlap without interfering. As a result, OFDM systems are able to maximize spectral efficiency without causing adjacent channel interference. BPSK is the simplest form of phase shift keying (PSK) A digital signal alternating between +1 and -1 (or 1 and 0) will create phase reversals, i.e. 180 degree phase shifts as the data shifts state. *QPSK* Higher order modulation schemes, such as QPSK, are often used in preference to BPSK when improved spectral efficiency is required [6]. QPSK uses four points on the constellation diagram. With four phases, QPSK can encode two bits per symbol. Quadrature Amplitude Modulation refers to QPSK with Amplitude Modulation. Basically, it is a mix of phase modulation and amplitude modulation. QAM phase modulates the carrier and also modulates the amplitude of the carrier [5] [8]Additive White Gaussian Noise (AWGN) channel is a Channel Model used for analyzing modulation schemes used for transmission of radio OFDM Signal. In this Model the channel adds a white Gaussian noise to the OFDM signal which is passing through it. By this the signal gets two properties like the amplitude frequency response is flat which means that can signal pass through channel without any amplitude loss and having infinity bandwidth. Phase frequency response is linear, so that no phase distortion of frequency component occurs. *Rayleigh fading channel* is used when there is no direct path between transmitter and receiver [4]. If there is no line of site then the constructive and destructive nature of Multipath Signal in flat fading can be approximated by Rayleigh Distribution [7].

Orthogonal frequency-division multiplexing (OFDM) is an efficient bandwidth signaling scheme for wideband digital communications. One important difference between OFDM and frequency division multiplexing (FDM) is that, the individual carriers mutually overlaps in the OFDM spectrum. OFDM carriers exhibit orthogonality property based on a symbol interval if their spacing in frequency is exactly at the reciprocal of the symbol interval, which can be accomplished by utilizing the Discrete Fourier Transform (DFT) [1]. OFDM is a technique based on multicarrier communication. The basic approach of multicarrier communications is to divide the total available signal bandwidth into a number of subcarriers, and information is transmitted on each of the subcarriers. Unlike the conventional multicarrier communication scheme, in which spectrum of each subcarrier is non-overlapping and band pass filtering is used to extract the frequency of interest. The spectra of subcarriers overlap but individual subcarrier can be extracted by baseband processing. This overlapping property makes OFDM technique more spectral efficient than the conventional multicarrier communication scheme. With the development of modern digital signal processing technology, OFDM technique has become practical to implement and has been proposed as an efficient digital modulation scheme for applications ranging from modems, digital audio broadcast, to next-generation high-speed wireless data communications. Orthogonal Frequency Division Multiplexing (OFDM) and Multiple-Input Multiple-Output (MIMO) are cutting edge physical layer technologies to be employed in fourth generation (4G) wireless cellular standards such as 3GPP Long Term Evolution (LTE/LTE-A), Worldwide Interoperability for Microwave Access (WiMAX) and high speed Wireless LAN standards. Such 4G cellular standards are expected to support data rates exceeding 100 Mbps through OFDMA, MIMO, dynamic carrier aggregation and thus enable a diverse number of applications in the wireless system such as broadcast/multicast video, on demand HDTV, high speed access to internet, interactive gaming amongst others.[10] At the same time there is an impressive effort towards fixed mobile convergence to enable smooth and effortless mobility across future Wireless LAN and cellular networks. Such factors are driving the wireless telecommunication system designers and operators to invest hugely in the development of OFDM compatible technologies and applications with the aim of tapping into the potentially vast revenue opportunity in futuristic 4G cellular network systems. High capacity and variable bit rate transmission information with high bandwidth efficiency are some of the requirements that the modern transceivers have to meet a variety of new high value added quality services to be delivered to the customers. A worldwide convergence has occurred for the use of Orthogonal Frequency Division Multiplexing (OFDM) as an emerging technology for high data rates. In particular, many wireless standards have adopted the OFDM technology as a mean to increase dramatically future wireless communications. The main reason behind OFDM's increased popularity is the desire for high speed wireless technologies and the increased demand for multimedia applications, which require higher data rates. Because in the wireless environment signals are usually impaired by fading and multipath delay spread phenomenon, traditional single carrier mobile communication systems do not perform well. In such channels, extreme fading of the signal amplitude occurs and Inter Symbol Interference (ISI) due to the frequency selectivity of the channel appears at the receiver side [2]. This leads to a high probability of errors and the system’s overall performance becomes very poor. Techniques like channel coding and adaptive equalization have been widely used as a solution to these problems. However, due to the inherent delay in the coding and equalization process and high cost of the hardware, it is quite difficult to use these techniques in systems operating at high bit rates.

In the PSK digital modulation techniques, the Phases the main parameter on which work is carried out. In our configuration we have taken AWGN channel (Gaussian Channel) where white Gaussian noise is added to the signal and that noisy signal is sent towards the receiver that is recovered with appropriate demodulator and decoders. The Wireless LAN standard, IEEE 802.11b, uses a variety of different PSKs depending on the data' rate required. At the basic rate of 1Mbit/s, it uses DBPSK (differential BPSK). To provide the extended rate of 2 Mbit/s, DQPSK is used. In reaching 5.5 Mbit/s and the full rate of 11 Mbit/s, QPSK is employed, but has to be coupled with complementary code keying. The higher speed wireless LAN standard, IEEE 802.11g has eight data rates: 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s. The 6 and 9 Mbit/s modes use OFDM modulation where each sub carrier is BPSK modulated. Many parameters for managing basic QoS for next generation network have been discussed in past Multi Carrier Modulation (MCM) is the principle of transmitting data by dividing the stream into several parallel bit streams, each of which has a much lower bit rate, and by using these sub streams to modulate several carriers. OFDM abandoned the use of steep band pass filters that completely separated the spectrum of individual subcarriers, as it was common practice in older Frequency Division Multiplex (FDMA) systems. OFDM time domain waveforms are chosen such that mutual orthogonality is ensured even though subcarrier spectra may overlap. It appeared that such waveforms can be generated using a Fast Fourier Transform at the transmitter and receiver.

III. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

OFDM is a combination technique between modulation and multiplexing. Modulation is a mapping of the information on changes in the carrier phase, frequency or amplitude or their combination. Meanwhile, multiplexing is a method of sharing a bandwidth with other independent data channel. In multiplexing, independent signals from different sources are sharing the channel spectrum. In OFDM, multiplexing is applied to independent signals but these independent signals are a sub set of the one main signal. In OFDM the signal itself is first split into independent channels, modulated by data and then re multiplexed to create the multicarrier transmission technique uses the discrete Fourier transform. By using a DFT, the whole bandwidth will be split into N sub channels. As a result, a high data stream will be transformed into N low rate streams, which are transmitted over different sub channels. OFDM symbols, which contain several modulation symbols, are formed as linear combinations of mutually orthogonal complex exponentials of finite duration [12].

The splitting of high rate data stream into a number of lower rate streams results in the increase of symbol duration. Mean while a lower rate parallel subcarriers reduces the relative amount of dispersion in time caused by multipath delay spread. Therefore OFDM is an advanced modulation technique which is suitable for high speed data transmission due to its advantages in dealing with the multipath propagation problem and bandwidth efficiency. Fig: 1 show the spectrum of individual sub channel and the spectrum of the entire OFDM signal respectively. It can be noticed that there is no crosstalk from other channels at the center frequency of each subcarrier. As Fig: 1 show the parallel transmission of data over multiple simultaneous carriers makes the OFDM system to be more robust against frequency selective fading or narrowband interference; some subcarriers may be degraded. Fig: 2 show the Orthogonal of subcarriers. To maintain orthogonality between subcarriers, it is necessary to ensure that the symbol time contains one or more multiple cycle of each sinusoidal carrier waveform. In the case of OFDM, the sinusoidal of subcarrier will satisfy this requirement since each is a multiple of fundamental frequency. Orthogonality, is critical since it prevents inter-carrier interference.

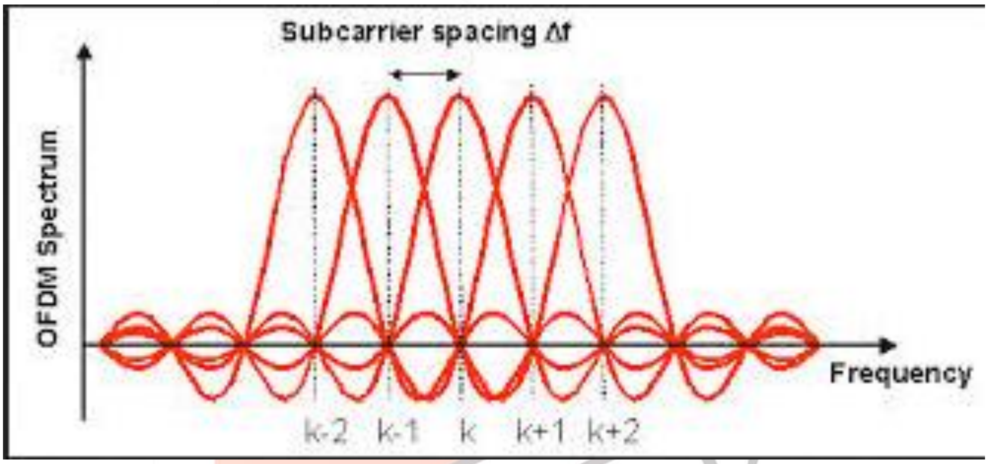

Figure 1: OFDM Subcarriers

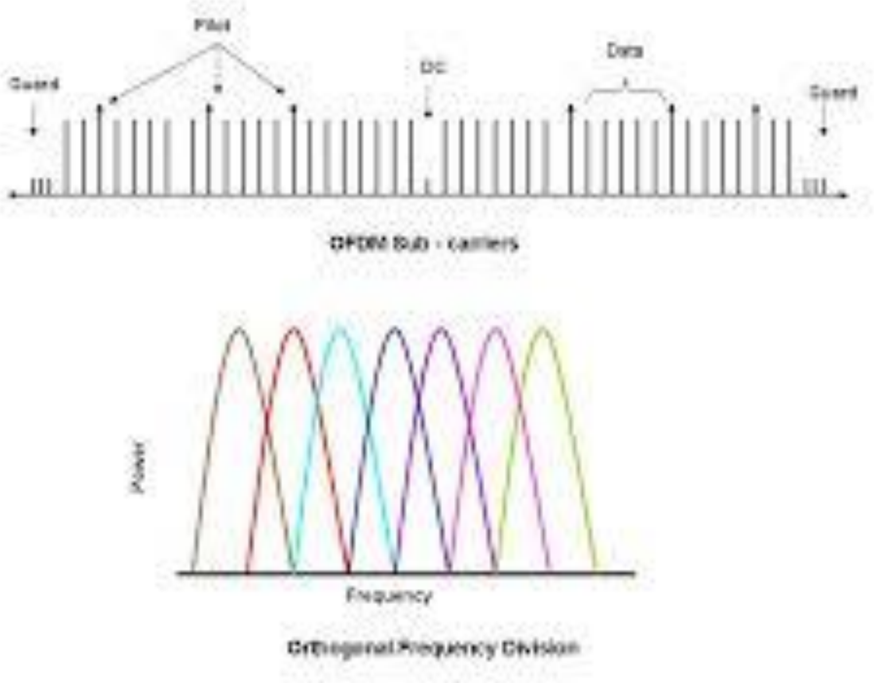

Figure 2: Orthogonal of Subcarriers

IV. OFDM SYSTEM MODEL

For performing the simulations, the chain shown in Fig: 3 was developed under MATLAB environment. This paper is mainly dependent on this system model. This model has implemented the basic characteristics of OFDM systems. MATLAB environment has assisted to implement that purposes.

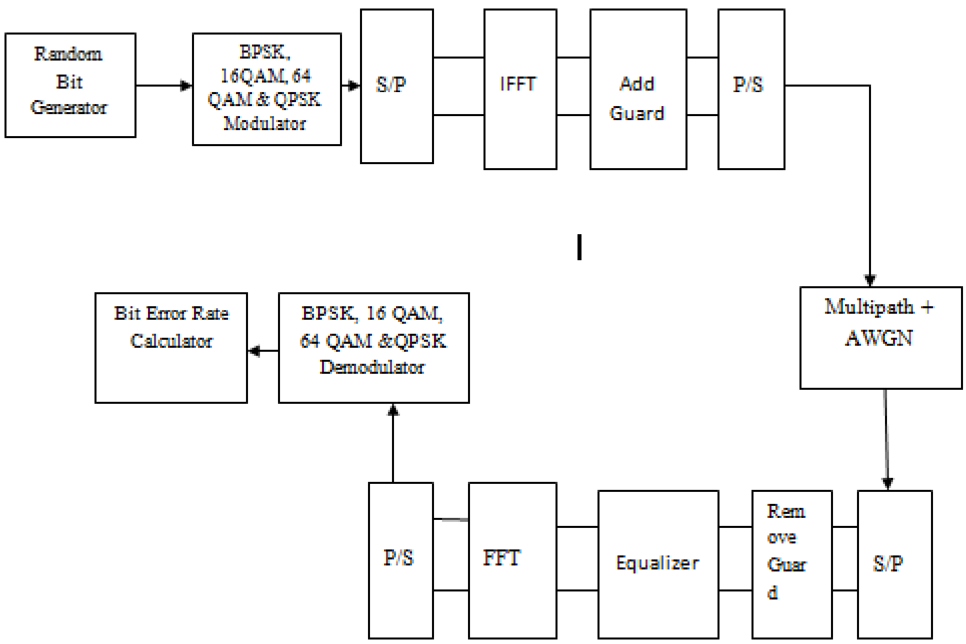

Figure 3: OFDM System Model

V. CONCLUSION

In this paper, we have briefly discussed OFDM for wireless system. As per literature survey, Carriers will benefit from greater flexibility by using OFDM, since in the same spectrum they will be able to offer more channels, including higher-bandwidth channels, with more types of services. Currently these systems are still being defined and prototyped. Achieving higher data rates requires OFDM systems to make more efficient use of the bandwidth than CDMA systems. One method of achieving this higher efficiency is through the use of higher order modulation. In this paper we have compared two digital modulation techniques QPSK and DQPSK used for digital transmission of data. Our main objective to develop this configuration is to compare the performance of each modulation techniques

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