OFDM AS AN ACCESS TECHNIQUE FOR NEXT GENERATION NETWORK

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ABSTRACT

With the rapid growth of digital wireless communication in recent years, the need for high speed mobile data transmission has increased. New modulation and access techniques are being implemented to keep up with the desired more communication capacity. Processing power has increased to a point where OFDM has become feasible and economical in the next generation networks. Some examples of current applications using OFDM include DVB (Digital video broadcasting), DAB (Digital audio broadcasting), and HDTV (high - definition television).OFDM as a transmission technique has been known having a lot of strengths compared to any other transmission technique, such as its high spectral efficiency, its robustness to the channel fading. Orthogonal frequency division multiplexing (OFDM) has become very popular, allowing high speed wireless communications. In this paper, we have implemented the OFDM modulator and demodulator for the next generation network by using different types of digital modulation techniques such as BPSK, QPSK, 16-QAM and 64-QAM and comparing their BER and number of symbols required for each technique. MATLAB environment was used for simulation of proposed algorithm.

Keywords: OFDM, NGN, BPSK, QPSK, QAM, MATLAB

I. INTRODUCTION

High-data-rate transmission over mobile or wirelesschannels is required by many applications. However, thesymbol duration reduces with the increase of the data rate, anddispersive fading of the wireless channels will cause more severeintersymbol interference (ISI) if single-carrier modulation,such as in time-division multiple access (TDMA) or GlobalSystem for Mobile Communications (GSM), is still used. To reduce the effect of ISI, the symbol duration must bemuch larger than the delay spread of wireless channels.. The basic idea of OFDM is to divide the available spectrum into several orthogonal sub channels so that each narrowbandsub channel experiences almost flat fading. Hence, orthogonal frequency division multiplexing (OFDM) is becoming the chosen modulation technique for wireless communications. OFDM can provide large data rates with sufficient robustness to radio channel impairments. Many research centersin the world have specialized teams working in the optimization of OFDM systems. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-carriers are transmitted in parallel. These carriers divide the available transmission bandwidth. The separation of the sub- carriers is such that there is a very compact spectral utilization. With OFDM, it is possible tohave overlapping sub channels in the frequency domain, thus increasing the transmission rate. The attraction of OFDM is mainly because of its way of handling the multipath interference at the receiver. Multipath phenomenon generates two effects (a) Frequency selective fading and (b) Intersymbol interference (ISI).

II. OFDM AS ACCESS TECHNIQUE

OFDM represents a different system-design approach. It can be thought of as a combination of modulation and multiple-access schemes that segments a communications channel in such a way that many users can share it. Whereas TDMA segments are according to time and CDMA segments are according to spreading codes, OFDM segments are according to frequency. It is a technique that divides the spectrum into a number of equally spaced tones and carries a portion of a user's information on each tone. A tone can be thought of as a frequency, much in the same way that each key on a piano represents a unique frequency. OFDM can be viewed as a form of frequency division multiplexing (FDM), however, OFDM has an important special property that each tone is orthogonal with every other tone. FDM typically requires there to be frequency guard bands between the frequencies so that they do not interfere with each other. OFDM allows the spectrum of each tone to overlap, and because they are orthogonal, they do not interfere with each other. By allowing the tones to overlap, the overall amount of spectrum required is reduced.

OFDM is a combination of modulation and multiplexing. Multiplexing generally refers to independent signals, those produced by different sources. In OFDM the question of 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 OFDM carrier.

OFDM is a special case of Frequency Division Multiplex (FDM). In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-carriers are transmitted in parallel. These carriers divide the available transmission bandwidth. The separation of the sub-carriers is such that there is a very compact spectral utilization. As an analogy, a FDM channel is like water flow out of a faucet, a whole bunch of water coming all in one stream. In contrast the OFDM signal is like a shower from which same amount of water will come as a lot of small streams. In a faucet all water comes in one big stream and cannot be sub-divided. OFDM shower is made up of a lot of little streams. Both methods carry the exact same amount of data. But in case of any interfere to some of these small streams, only some part of data in the OFDM method will suffer. These small streams when seen as signals are called the sub-carriers in an OFDM system and they must be orthogonal for this idea to work. The independent sub-channels can be multiplexed by frequency division multiplexing (FDM), called multi-carrier transmission or it can be based on a code division multiplex (CDM), in this case it is called multi-code transmission.

OFDM is a modulation technique in that it enables user data to be modulated onto the tones by adjusting the tone’s phase, amplitude or both. An OFDM system takes a data stream & splits it into N parallel data streams, each at rate 1/N of the original rate. Each stream is then mapped to a tone at a unique frequency combined together using the IFFT (Inverse Fast Fourier Transform) to yield the time-domain waveforms to be transmitted. Note that the peak of each tone corresponds to a zero level or null for every other tone.

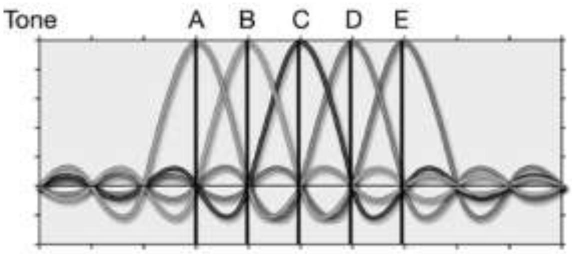

Fig.1. Tones for OFDM

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Thus each user can be assigned a predetermined number of tones when they information to send, or alternatively a user can be assigned a variable number of tones based on the amount of information that they have to send. The assignments are controlled by the media access control [MAC] layer, which schedules the resource assignments based on user demand. By adding guard time, called a cyclic prefix. The channel can be made to behave as if the transmitted waveforms ensure orthogonality, which essentially prevents one subcarrier from interfering with another. The cyclic prefix is actually a copy of the last portion of data symbol appended to the front of the symbol during the guard interval as in Fig.2.

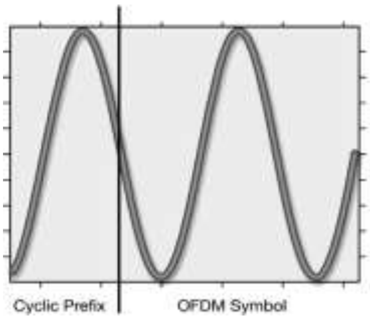

Fig.2. Cyclic Extension of Sinusoid

Multipath causes tones and delayed replicas of tones to arrive at the receiver with some delay spread. This leads to misalignment between sinusoidal which need to be aligned be orthogonal. The cyclic prefix allows the tones to be realigned at the receiver, thus regaining orthogonality.

III. OFDM SIMULATION MODEL

Figure 3 shows the block diagram of a typical OFDM transceiver. The transmitter section converts digital data to be transmitted, into a mapping of sub carrier amplitude and phase. It then transforms this spectral representation of the data into the time domain using an Inverse Fast Fourier Transform (IFFT).

In order to transmit the OFDM [4] signal the calculated time domain signal is then mixed up to the required frequency. The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing, then using a Fast Fourier Transform (FFT) to analyze the signal in the frequency domain. The amplitude and phase of the sub carriers is then picked out and converted back to digital data. The IFFT and the FFT are complementary function and the most appropriate term depends on whether the signal is being received or generated. In cases where the signal is independent of this distinction then the term FFT and IFFT is used interchangeably respectively. Various components of the block diagram have been discussed below under different heads:-

• Serial to Parallel Conversion Data: The input serial data stream is formatted into the word size required for transmission, e.g. 2bit/word for QPSK and 4bit/word for 16- QAM shifted into a parallel format. The data is then transmitted in parallel by assigning each data word to one carrier in the transmission.

• Modulation of Data: The data to be transmitted on each carrier is then differential encoded with previous symbols, then mapped into a phase shift-keying format. Since differential encoding requires an initial phase reference an extra symbol is added at the start for this purpose. The data on each symbol is then mapped to a phase angle based on the modulation method. For example QPSK the phase angles used are 0, 90, 180, and

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270 degrees. The use of phase shift keying produces a constant amplitude signal and was chosen for its simplicity and to reduce problems with amplitude fluctuations due to fading.

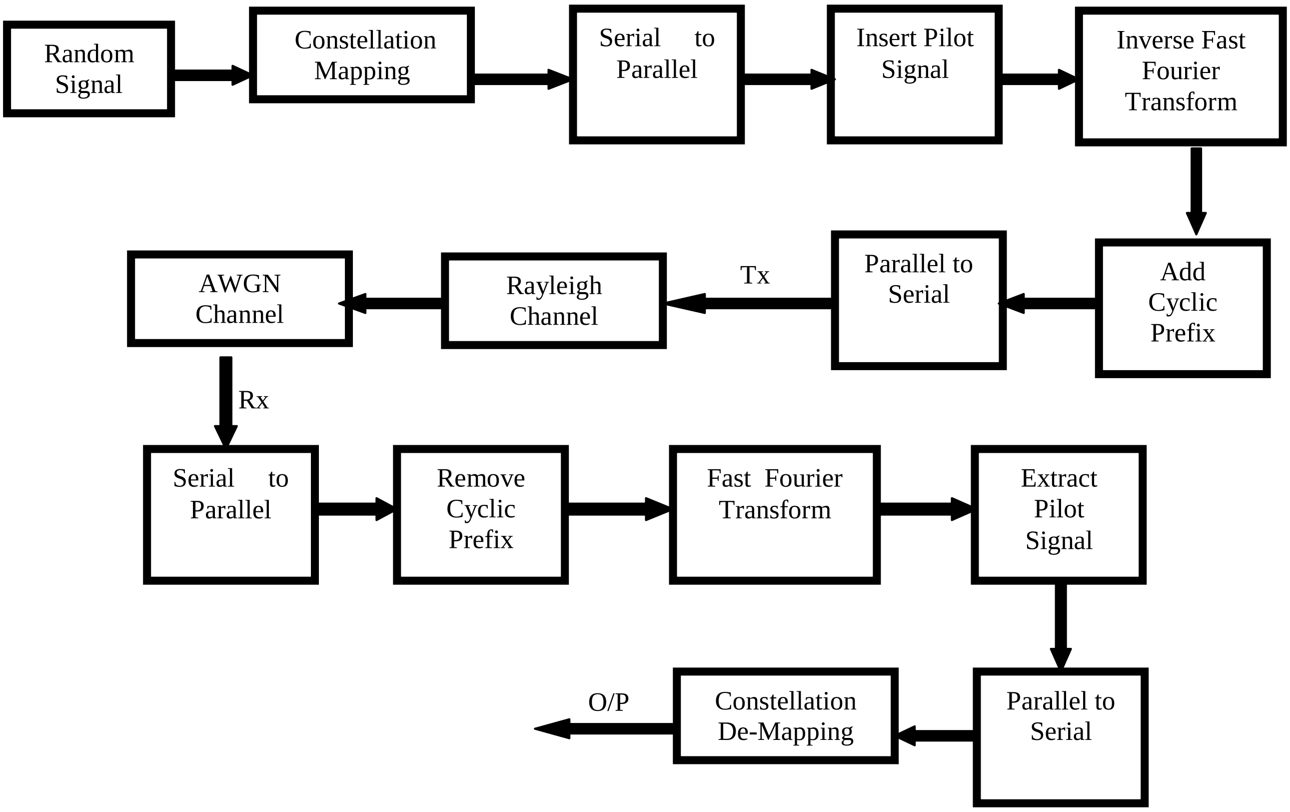

Fig. 3. OFDM Simulation Model

• Inverse Fourier Transform: After the required spectrum is worked out, an inverse Fourier transform is used to find the corresponding time waveform. The guard period is then added to the start of each symbol.

• Guard Period: The guard period used was made up of two sections. Half of the guard period time is a zero amplitude transmission. The other half of the guard period is a cyclic extension of the symbol to be transmitted. This was to allow for symbol timing to be easily recovered by envelope detection. However it was found that it was not required in any of the simulations as the timing could be accurately determined position of the samples. After the guard has been added, the symbols are then converted back to a serial time waveform. This is then the base band signal for the OFDM transmission.

• Channel: A channel model is then applied to the transmitted signal. The model allows for the signal to noise ratio, multipath, and peak power clipping to be controlled. The signal to noise ratio is set by adding a

• known amount of white noise to the transmitted signal. Multipath delay spread then added by simulating the delay spread using an FIR filter. The length of the FIR filter represents the maximum delay spread, while the coefficient amplitude represents the reflected signal magnitude.

• Receiver: The receiver basically does the reverse operation to the transmitter. The guard period is removed. The FFT of each symbol is then taken to find the original transmitted spectrum. The phase angle of each transmission carrier is then evaluated and converted back to the data word by demodulating the received phase. The data words are then combined back to the same word size as the original data.This model was used by us in the next generation scenario to find the use of OFDM as an access technique with different modulation techniques.

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IV. SIMULATION PARAMETERS AND RESULTS

The simulation parameters used for simulation of the given scenario are given in Table 1.

PARAMETER	VALUE
SUB CARRIERS	52
FFT SIZE	64 FFT
CYCLIC PREFIX LENGTH	16
PILOT CARRIER	1-6,32-33,60-64
MULTIPLEACCESS	BPSK,QPSK,16-QAM, 64-QAM
FADING CHANNEL	RAYLEIGH

Table 1OFDM system parameters

The results obtained by simulation of the given scenario are shown below. The scatter plots for BPSK, QPSK, 16-QAM and 64-QAM are shown in figure 4, 5, 6 and 7 respectively. Figure 4 shows the spectrum of OFDM.

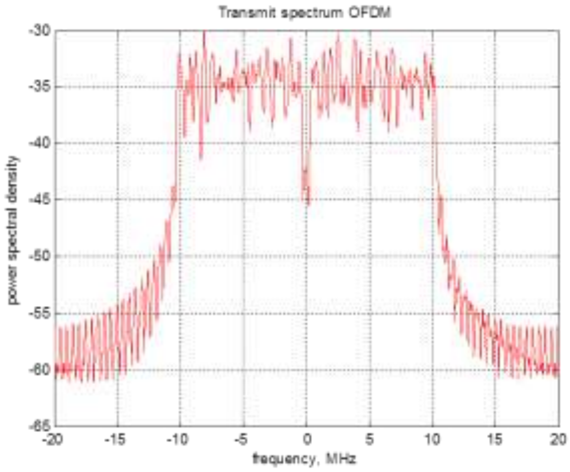

Fig. 4. Spectrum of OFDM signal

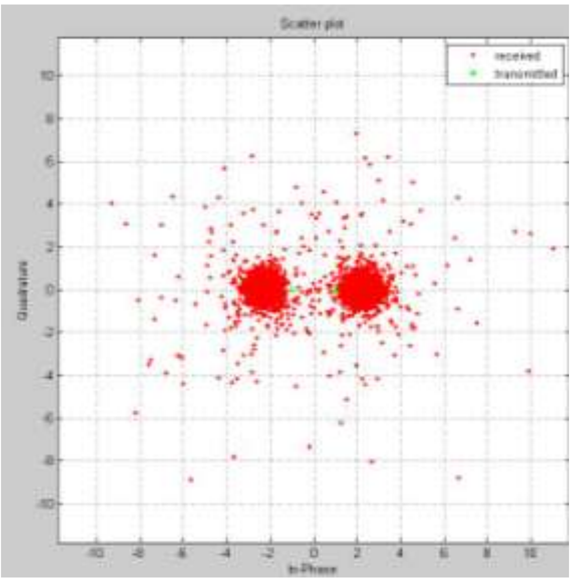

Fig. 5. Scatter Plot BPSK

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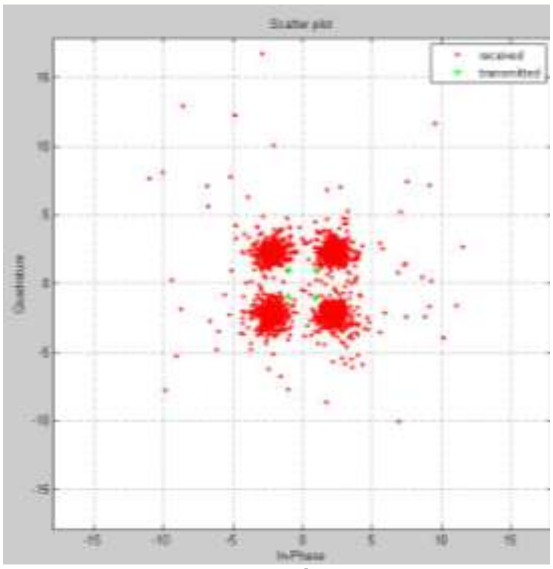

Fig. 6. Scatter Plot QPSK

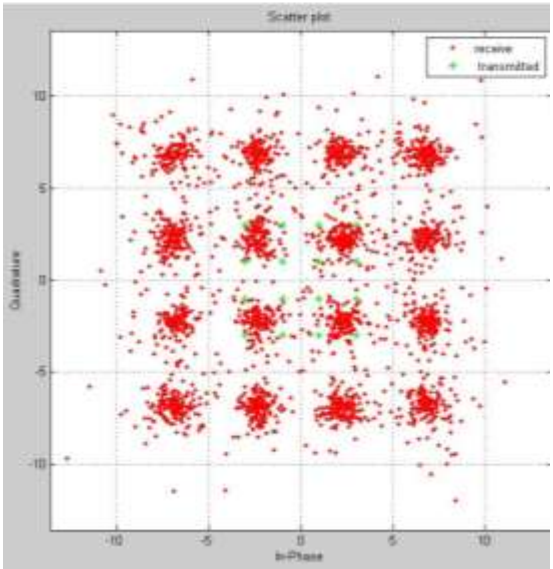

Fig. 7. Scatter Plot 16-QAM

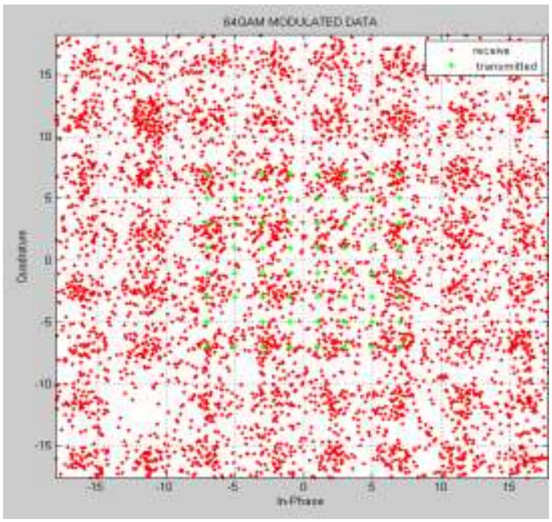

Fig. 8. Scatter Plot 64-QAM

The comparison between different modulation techniques using OFDM as access technique and the tradeoff between

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bit error rate and energy required is shown in figure 9. The comparison between number of symbols required for transmission of data using different modulation techniques is shown in figure 10.

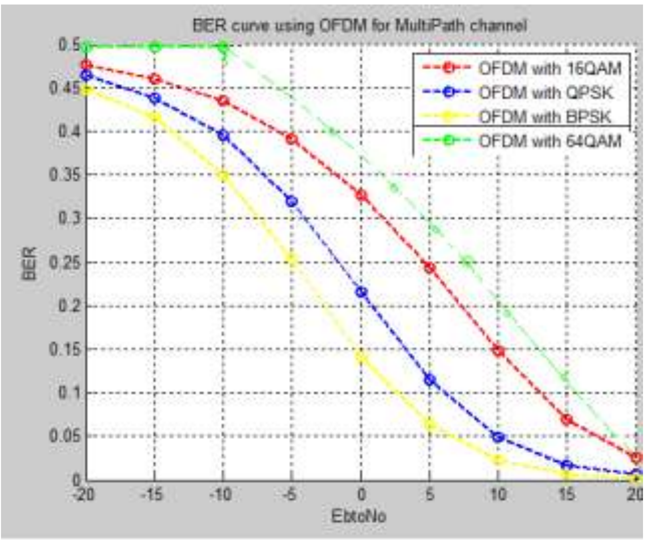

Fig. 9. BER comparison

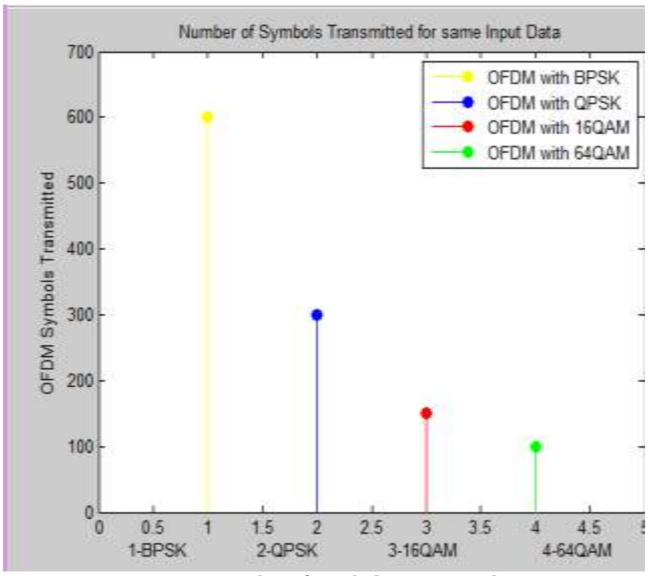

Fig. 10.Number of Symbols Transmitted

V. CONCLUSION AND FUTURE SCOPE

This paper highlights the unique design challenges faced by mobile data systems that result from the vagaries of the harsh wireless channel. OFDM has been shown to address these challenges and to be a key enabler of a system design that can provide high performance mobile data communication. Also OFDM is well positioned to meet the unique demands of mobile packet data traffic. OFDM is expected to support the next generation network technology. The OFDM makes efficient use of available spectrum by allowing overlapping among the carriers. It basically converts the high data rate stream in to several parallel lower data rate streams and thereby eliminating the frequency selective fading. It has been seen that the OFDM is a powerful modulation technique that is capable of high data rate and is able to eliminate ISI. It is computationally efficient due to the use of FFT techniques to implement modulation and demodulation functions.

Using MATLAB software, the performance of OFDM system was tested for three digital modulation techniques namely BPSK, QPSK, 16-QAM and 64-QAM in the next generation network. From the simulation results, it is observed that the BPSK allows the BER to be improved in a noisy channel at the cost of maximum data transmission capacity. Use of QPSK allows higher transmission capacity, but at the cost of slight increase in the probability of error. Use of 64-QAM allows highest transmission capacity but with further increase in the bit error rate. This is because of the fact that 64-QAM uses six bits per symbol. Hence QAM is easily affected by the noise. Therefore OFDM with 64-QAM requires larger transmit power. From the results, use of OFDM with QPSK or 16 and 64 QAM is beneficial for short distance transmission link, whereas for long distance transmission link OFDM with BPSK will be preferable in the next generation networks.

During the past decade, OFDM has been adopted in many wireless communication standards, including European digital audio broadcasting, terrestrial digital video broadcasting, and satellite–terrestrial interactive multiservice infrastructure in China. In addition, OFDM has been considered or approved by many IEEE standard working groups, such as IEEE 802.11a/g/n, IEEE 802.15.3a, and IEEE 802.16d/e. The applications include wireless personal area networks, wireless local area networks, and wireless metropolitan networks. Currently, OFDMA is being investigated as one of the most promising radio transmission techniques for LTE of the 3rd Generation Partnership Project (3GPP), International Mobile Telecommunications—Advanced Systems as well as for use for the next generation networks.

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