Orthogonal Frequency Division Multiplexing (OFDM) Technique for 4G Wireless Networks

Amritpal Singh[1], Divya[2]
[1]*Green ThinkerZ Society, Mohali, Punjab, India*
[2]*Department of ECE, CGC Gharuan, Punjab, India*

Abstract - It's very interesting to know that 4G has been rolled out in the developed and developing countries and the whole engineering community is started to think about the 4G. Engineers from the world started to work on 4G. OFDM is one of those techniques which are proposed for this next generation wireless communication systems. Orthogonal Frequency Division Multiplexing (OFDM) is a method that allows transmitting of high data rates over extremely hostile channels at a comparable low complexity. It is a technique for transmitting large amounts of digital data over a radio wave. The technology works by splitting the radio signal into multiple smaller sub-signals that are then transmitted simultaneously at different frequencies to the receiver. So, in this paper, we have discussed the OFDM Technique for next generation.

Keywords - FDM, OFDMA, TDM, CDMA.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a method that allows transmitting of high data rates over extremely hostile channels at a comparable low complexity. It is a special kind of FDM. The spacing between carriers is such that they are orthogonal to one another. So, no need of guard band between carriers. Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transport technology for high data rate communication system. The OFDM concept is based on spreading the high speed data to be transmitted over a large number of low rate carriers. The carriers are orthogonal to each other and frequency spacing between them are created by using the Fast Fourier transform (FFT). OFDM originates from Frequency Division Multiplexing (FDM), in which more than one low rate signal is carried over separate carrier frequencies. In FDM, separation of signal at the receiver is achieved by placing the channels sufficiently far apart so that the signal spectra do not overlap [3]. Figure 1 shows the OFDM Technique.

II. OFDM SYSTEM

Orthogonal Frequency Division Multiplexing (OFDM) systems are commonly used to mitigate frequency-selective multipath fading and provide high-speed data transmission. In the conventional FDM technique, the system bandwidth is divided into non-overlapping sub-channels. However, as each sub-channel requires its own carrier oscillator and narrowband filter with sharp cut-off (both at transmitter and receiver), the number of sub-channels is limited by the implementation complexity. In the orthogonal frequency-division multiplexing technique, a discrete Fourier transform (DFT), is used to modulate and demodulate the OFDM parallel data streams. In this technique, the sub-channels are not band-limited and spectrally overlap, so a high spectral efficiency can be achieved. Figure 2 shows the Frequency Spectrum.

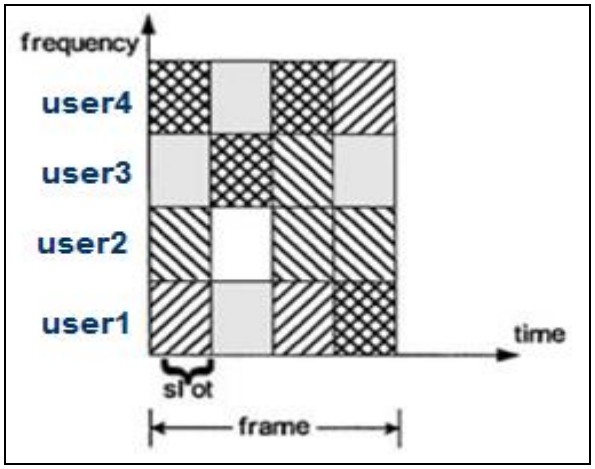

Fig.1: OFDM Technique

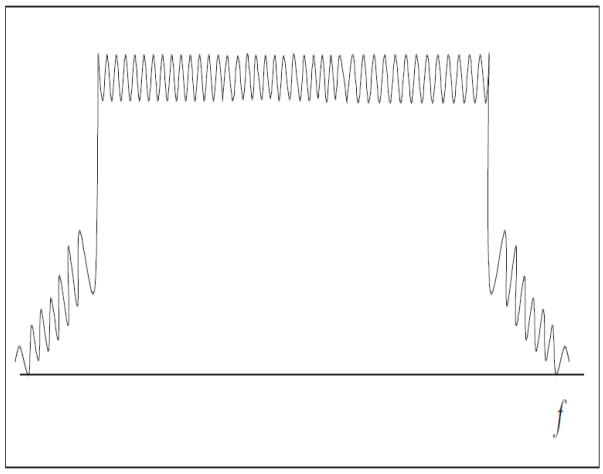

Fig.2: Frequency Spectrum

The center frequency of a sub-channel is called the carrier frequency. In this multi-carrier technique, interference between carriers is eliminated by selecting the carrier spacing equal to the reciprocal of the per carrier symbol period. The transmitter and receiver of Orthogonal Frequency Division Multiplexing (OFDM) can be implemented efficiently by using Fast Fourier transform (FFT) techniques [4]. OFDM is potentially a good technique that has been proposed to offer substantially high data rates and good BER than those currently available to the mobile user. Figure 3 shows the Simple OFDM System.

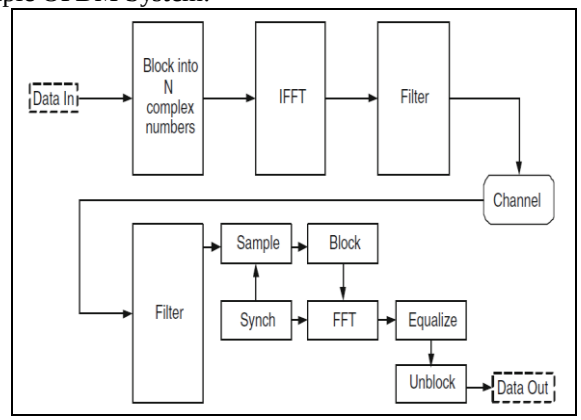

Fig.3: Simple OFDM System

Complete Block Diagram of OFDM transmitter and receiver having OFDM Modulator and OFDM Demodulator as shown in figure 4.

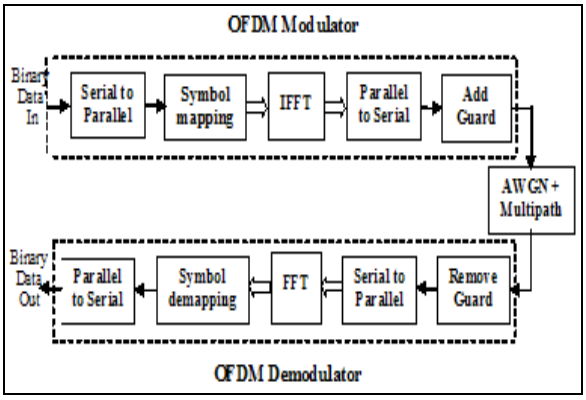

Fig.4: Block Diagram of OFDM System [1]

III. PRINCIPLE OF ORTHOGONALITY

A, B, C vectors in space is orthogonal to each other:

- A.B=B.C=C.A=0
- (A+B+C).A=(mod A)^2
- (A+B+C).B=(mod B)^2
- (A+B+C).C=(mod C)^2

Fig. 5 shows the Principle of Orthogonality.

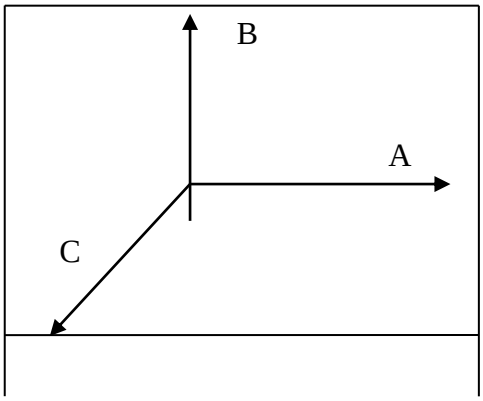

Fig.5: Principle of Orthogonality

With OFDM Technique, Bandwidth can be saved as showing in the figure 6.

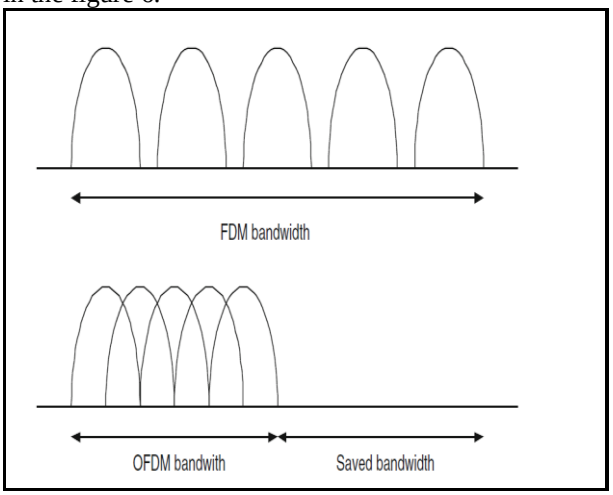

Fig.6: Saved Bandwidth in OFDM Technique

IV. ADVANTAGES OF OFDM

- High spectral efficiency.
- Resistant to RF interference.
- Lower multi-path distortion.
- In typical terrestrial broadcasting scenario there are multi path-channels (i.e. the transmitted signal arrives at the receiver using various paths of different length).
- Interference's within the cell are averaged by using allocation with cyclic permutations.
- Enables orthogonality in the uplink- by synchronizing users in time and frequency, multi path mitigation without using Equalizers and training sequences.
- Enables Single Frequency Network coverage, where coverage problem exists and gives excellent coverage, spatial diversity by using antenna diversity at the Base Station and possible at the Subscriber Unit.

- Adaptive modulation- enables adaptive modulation for every user, making the 4G backward compatible with 2.5G and 3G wireless mobile systems.
- Frequency diversity-offers Frequency diversity by spreading the carriers all over the used spectrum, time diversity by optional interleaving of carrier groups in time.
- Omni-directional antennas- enables the usage of Indoor Omni Directional antennas for the users.
- Multiple channels can operate within close frequency levels without impacting the integrity of any of the data transmitted in any one channel.
- Reduces the amount of crosstalk in signal transmissions.
- Boost the speed of an Internet connection over a standard telephone line.

V. FDM vs OFDM [4]

FDM	OFDM
The channel is like water flow out of a faucet	The signal is like a shower
All water comes in one big stream and cannot be subdivided	OFDM shower is made up of lot of little streams
Whole bunch of water coming in one stream	Same amount of water coming from a lot of small streams
If thumb is put over faucet hole the water can be stopped	This can't be done in case of a shower. Hence it is an advantage over FDM
	

VI. APPLICATIONS OF OFDM

The OFDM spread-spectrum scheme is used for many broadly used applications, including:

- Digital TV broadcasting in Australia, Japan and Europe.
- Digital audio broadcasting in Europe.
- Asynchronous Digital Subscriber Line (ADSL) modems.
- Wireless networking worldwide [2, 5].

VII. CHALLENGE IN OFDM

A problem encountered in the OFDM technique is that channel dispersion destroys the orthogonality between the carriers, causing interference between symbols. This problem is solved by inserting a cyclic extension of the OFDM signal. When the duration of the cyclic prefix exceeds the duration of the impulse response of the dispersive channel, the orthogonality between the carriers is maintained and interference between symbols is avoided.

VIII. CONCLUSION

This paper has provided a comprehensive overview of OFDM Technique for 4G, to further enhance the performance beyond the IMT-Advanced requirements while maintaining backwards compatibility with previous generations of Wireless technologies.

IX. REFERENCES

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