OFDM: A COMPLETE REVIEW

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Abstract: OFDM is a very attractive modulation and multiplexing technique that is used in wideband optical systems as well as optical wireless systems. Several advantages of optical orthogonal systems is good efficiency of spectrum utilization and channel robustness. Number of small subcarriers is used to transmit data from one source and generally termed as multicarrier transmission. OFDM, a modulation as well as multiplexing technique is the origin of several telecommunications standards counting DTT and radio broadcasting. OFDM is even the source of nearly all DSL standards, and within this situation OFDM is generally known as discrete multitone (DMT). Regardless of the benefits offered by OFDM and its prevalent usage in wireless communications, it has been considered for optical communications during the last years. This paper reviews about the OFDM and OFDM characteristics.
Keywords OFDM, Wireless System

I. INTRODUCTION

Now-a-days, OFDM is of great interest to researchers all over the world [1]. In OFDM, the entire channel is splitted into many narrow parallel sub channels, so the duration of symbol is increased and the inter symbol interference (ISI) produced by the multi-path environments is reduced or eliminated [1].OFDM supports high data rate traffic because the incoming serial data stream is divided into parallel low-rate streams that are transmitted on orthogonal sub-carriers simultaneously [1]. OFDM system has the ability of extenuating a frequency-selective fading channel to a set of parallel flat fading channels, which require simple processes for channel equalization. The available spectrum in an OFDM system is divided into manifold sub-carriers and all these subcarriers are orthogonal to each other [1]. OFDM has been standardized for several applications, such as digital audio broadcasting (DAB), digital television broadcasting, wireless local area networks (WLANs), and asymmetric digital subscriber lines (ADSLs).

Channel estimation is one of the most salient processes in communication system [1]. A perfect channel estimation algorithm should comprise both the time and frequency domain characteristics of the OFDM systems [2]. The performance of OFDM system can be improved by allowing for coherent demodulation using an exact channel estimation algorithm [1]. In OFDM transmission system, numerous channel estimation methods have been developed under the assumption of a slow-fading channel, wherein the channel transfer function remains stable within one OFDM data block [2]. Several channel estimation techniques have already been developed for MIMO–OFDM systems. These techniques are broadly classified into three categories: (1) training-based technique, (2) blind technique, and (3) semi-blind technique, which is a combination of the first two techniques [2].

Orthogonal frequency division multiplexing (OFDM) is a widely used modulation and multiplexing technology, which has become the basis of many telecommunications standards including wireless local area networks (LANs), digital terrestrial television (DTT) and digital radio broadcasting in much of the world. In the past, as well as in the present, the OFDM is referred in the literature as Multi-carrier, Multi-tone and Fourier Transform. The OFDM concept is based on spreading the data to be transmitted over a large number of carriers, each being modulated at a low rate. The carriers are made orthogonal to each other by appropriately choosing the frequency spacing between them. A multicarrier system, such as FDM (aka: Frequency Division Multiplexing), divides the total available bandwidth in the spectrum into sub-bands for multiple carriers to transmit in parallel [1]. It combines a large number of low data rate carriers to construct a composite high data rate communication system. Orthogonality gives the carriers a valid reason to be closely spaced with overlapping without ICI.

II. PRINCIPLE OF OFDM

In digital communications, information is expressed in the form of bits. The term symbol refers to a collection, in various sizes, of bits [2]. The main features of a practical OFDM system are as follows:

Some processing is done on the source data, such as coding for correcting errors, interleaving and mapping of bits onto symbols. An example of mapping used is QAM.

The symbols are modulated onto orthogonal sub-carriers. This is done by using IFFT.

- Orthogonality is maintained during channel transmission. This can be achieved by adding a cyclic prefix to the OFDM frame to be sent. The cyclic prefix consists of the L last samples of the frame, which are copied and placed in the beginning of the frame. It must be longer than the channel impulse response.
- Synchronization: cyclic prefix can be used to detect the start of each frame. This is done by using the fact that the L first and last samples are the same and therefore correlated.
- Demodulation of the received signal by using FFT.
- Channel equalization: the channel can be estimated either by using a training sequence or sending known so-called pilot symbols at predefined sub-carriers.
- Decoding and de-interleaving.

Basic OFDM system

The OFDM signal generated by the system in Fig. 1 & 2 is at baseband, in order to generate a radio frequency (RF) signal at the desired transmit frequency filtering and mixing is required. OFDM allows for a high spectral efficiency as the carrier power and modulation scheme can be individually controlled for each carrier. However in broadcast systems these are fixed due to the one-way communication. The basic principle of OFDM is to split a high-rate DataStream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. The block diagram showing a simplified configuration for an OFDM transmitter and receiver is given in Fig.1 & Fig. 2.

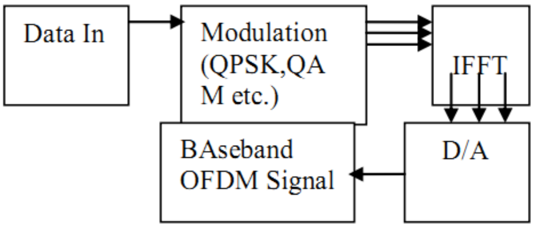

Fig. 1 Transmitter

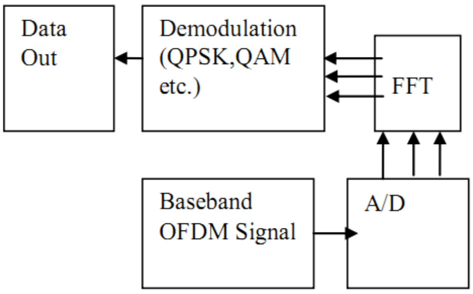

Fig. 2 Receiver

OFDM Advantages & Disadvantages
Advantages of OFDM
OFDM has several advantages over single carrier modulation systems and these make it a viable alternative for CDMA in future wireless networks. In this section, will discuss some of these advantages.

Multipath delay spread tolerance:
OFDM is highly immune to multipath delay spread that causes inter-symbol interference in wireless channels. Since the symbol duration is made larger (by converting a high data rate signal into N, low rate signals), the effect of delay spread is reduced by the same factor. Also by introducing the concepts of guard time and cyclic extension, the effects of inter-symbol interference (ISI) and inter-carrier interference (ICI) can be removed completely.

Immunity to frequency selective fading channels:
If the channel undergoes frequency selective fading, then complex equalization techniques are required at the receiver for single carrier modulation techniques. But in the case of OFDM the available bandwidth is split among many orthogonal narrowly spaced sub-carriers. Thus the available channel bandwidth is converted into many narrow flat-fading sub-channels. Hence it can be assumed that the sub-carriers experience flat fading only, though the channel gain/phase associated with the sub-carriers may vary. In the receiver, each sub-carrier just needs to be weighted according to the channel gain/phase encountered by it. Even if some sub-carriers are completely lost due to fading, proper coding and interleaving at the transmitter can recover the user data.

Efficient modulation and demodulation:
Modulation and Demodulation of the sub-carriers is done using IFFT and FFT methods respectively, which are computationally efficient. By performing the modulation and demodulation in the digital domain, the need for highly frequency stable oscillators is avoided. OFDM makes efficient use of the spectrum by allowing overlap.
High transmission bitrates
Chance to cancel any cannel if is affected by fading

- Flexibility: each transceiver has access to all subcarriers within a cell layer.
- Easy equalization: OFDM symbols are longer than the maximum delay spread resulting in flat fading channel which can be easily equalized.
- High spectral efficiency,
- Resiliency to RF interference.
- Lower multi-path distortion.

Disadvantages of OFDM
Despite the many advantages of OFDM, actual implementations revealed some challenges. It has been found that that OFDM technique is sensitive to carrier frequency offset and time-varying channels [5].The orthogonality of OFDM relies on the condition that transmitter and receiver operate with exactly the same frequency reference. If this is not the case, the perfect orthogonality of the subcarriers is lost, causing subcarrier leakage, also known as Inter-Carrier Interference (ICI). Frequency errors typically arise from a mismatch between the reference frequencies of the transmitter and the receiver local oscillators. This difference between the reference frequencies is widely referred to as Carrier Frequency Offset (CFO). OFDM system is also affected by time offset. Actually a tight timing and frequency synchronization is needed. Frame synchronization at receiver side is needed to make a decision about the starting time of the FFT symbol. Errors in frame synchronization can cause ISI and intercarrier interference (ICI) in OFDM systems. In order to minimize these interferences detection of the carrier frequency of the received signal and finding the start point of the OFDM symbols are required. Therefore it is an essential requirement for the OFDM systems to have frame synchronization. Further, as we know the typical OFDM system has smaller subcarrier spacing and these can be vulnerable to Doppler shift observed in high mobility situations. Doppler shift can cause significant ICI [4][5].

III. CONCLUSION

This paper reviews about the concept of the OFDM ,its Basic System , its structure and components and also about the OFDM advantages and disadvantages.

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