A Review Paper on Multiple Input Multiple Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM)

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***Abstract*: A Broadband wireless communication system of MIMO-OFDM (Multiple-Input Multiple Output-Orthogonal Frequency Division Multiplexing) is more popular because of good data transmission rate and its robustness against multipath fading and good spectral efficiency. To obtain more high performance in broad band wireless communication system MIMO-OFDM is used. In MIMO-OFDM technology, Orthogonal Frequency Division Multiplexing (OFDM) is used to improve spectral efficiency and Multiple Input Multiple Output (MIMO) is used to improve spatial diversity. This system provides wide coverage and reliable communication. In this paper description of MIMO & OFDM concepts, MIOMO-OFDM advantages, disadvantages and applications has been discussed.**

Index Terms: MIMO, OFDM, IFFT, FFT

I. Introduction

To obtain more high performance in broad band wireless communication system MIMO-OFDM is used. During the last years MIMO-OFDM system has gained an increased interest in that topic. In MIMO-OFDM technology, Orthogonal Frequency Division Multiplexing (OFDM) is used to improve spectral efficiency and Multiple Input Multiple output (MIMO) is used to improve spatial diversity [1].

MIMO is a system which has multiple inputs and multiple outputs. It is used to send and receive the multiple signals at the same time by using the multiple antennas at the transmitter and receiver side. The use of multiple antennas at the transmitter and receiver side will create the problem caused by multipath fading. To send the signal the system also needs the modulation techniques [2]. It requires modulation technique because of the message signal or voice signal cannot travel long distance because of the low frequency. Modulation technique is just a technique where the change in characteristics of carrier signal occurs with respect to the instantaneous properties like message/voice signal. Let us talk about the generation of multiple signals at the same time then we see that it drops us towards the signal interference, so whenever MIMO comes in forefront, it is comes with Orthogonal Frequency Division Multiplexing (OFDM). Both of these peculiar techniques MIMO and OFDM stand as promising choices for prospect high data rates. These techniques can be used to transmit the signal and to receive the signal with a minimum error rates at the receiver side. It shows robustness for multipath fading and interference.

II. Multiple Input Multiple Output (MIMO) - Orthogonal Frequency Division Multiplexing (OFDM)

It is a modern wireless broad band technology which has a great capability of high data rate transmission and its robustness against multi path fading and other channel impairments [1].

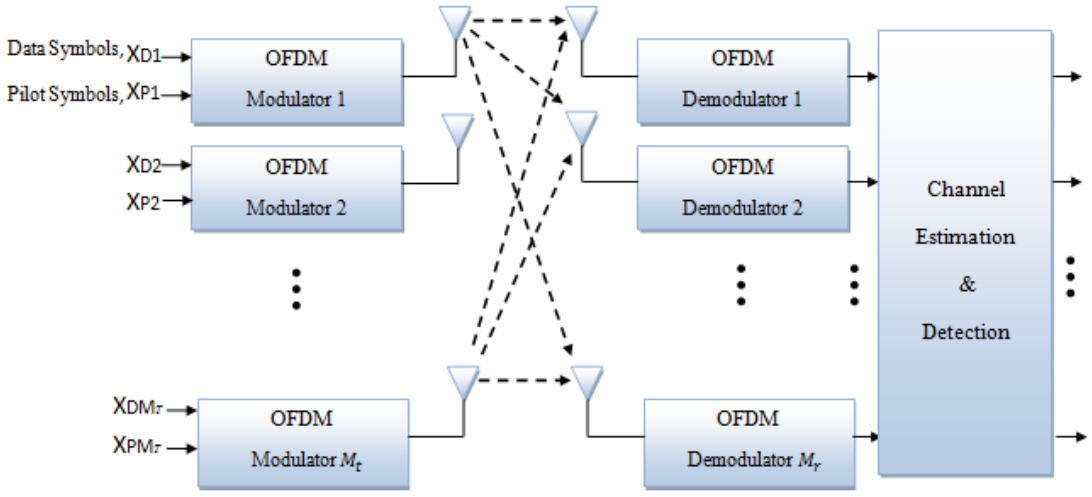

Fig.1. Block Diagram of MIMO-OFDM System [1]

A simple block diagram of MIMO-OFDM system is shown above. In this system multiple numbers of transmitters at one point and multiple numbers of receivers at other end and are effectively combined to improve the channel capacity of wireless system. It also highly improves the spectrum efficiency, reliability of system and coverage area.

- **Role of MIMO and OFDM**

In the MIMO-OFDM the role of MIMO and OFDM is shown here in Fig.2

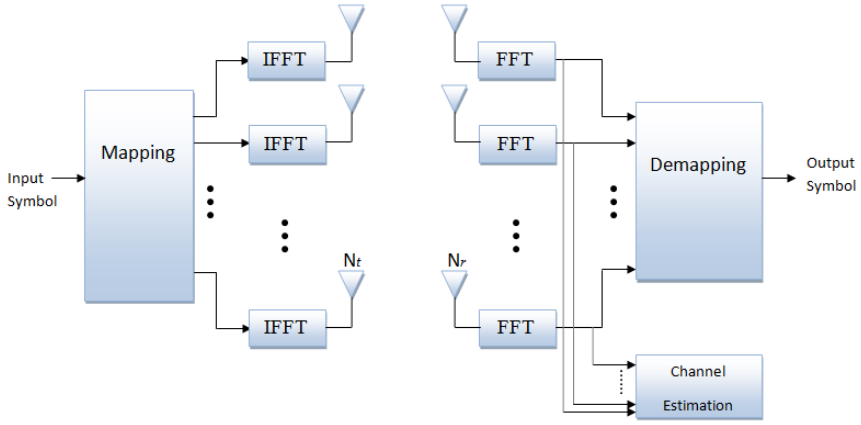

Fig.2. Roles of MIMO and OFDM in wireless communication system [9]

It using multiple antennas at the transmitter and receiver ends of a wireless communication link just to transmit multiple data streams concurrently with in the same frequency band [3]. It does not need additional power of spectrum this transmission creates parallel channel over the same time and frequency. Thus MIMO transmission technique exploits the multipath fading mechanism to increase data rate and system capacity. Using the multiple antenna configurations these parallel low rate subcarriers can then be transmitted and received. OFDM (Orthogonal Frequency Division Multiplexing) is a multicarrier modulation technique that creates these parallel sub-channels that are narrow band and low rate in nature. Between these sub-channels by inserting cyclic prefix orthogonality is maintained and inter-symbol interference is totally eliminated.

Hence a combination of OFDM and MIMO, i.e. MIMO-OFDM not only improves channel capacity and data rates, it also combats frequency-selective fading thereby improving link reliability [1].

III. Orthogonal Frequency Division Multiplexing (OFDM)

Modulation: - A mapping of the information on changes in the carrier amplitude, frequency or phase and combination.
Multiplexing: - Method of sharing a bandwidth with independent data of other channel.
OFDM is the combination of both modulation and multiplexing. Multiplexing basically refers to Independent signals, those produced by different signals. In that the signal itself is firstly split into independent channels, modulated by data and the finally are multiplexed to create the OFDM carrier. OFDM is generally a special case of Frequency Division Multiplexing (FDM). In this scheme, a large number of overlapping, orthogonal and narrow band sub-carriers are transmitted in parallel. The available transmission bandwidth is divided by these carriers. The separation of sub-carriers is just like that there is very compact spectral utilization [2].
As an analogy, FDM channel is just like a water flow out of a faucet, a whole bunch of water coming out of all in one stream. In contrast the OFDM signal is just like a shower from where a same amount of water will come as a lot of small streams. As shown in Fig.2.1 (a) in a faucet all water comes in one big stream and cannot be sub-divided where as OFDM shower is made up of a lot of little streams as shown in Fig.2.1 (b).

Fig.2.1 (a) FDM single carrier –Regular [10]

Fig.2.1 (b) FDM single carrier – Orthogonal [10]

One of the most advantages of one over another is that if we put our thumb over the faucet hole, we can stop the water flow but we cannot do the same for the shower. Although both of them do the same thing but they respond differently to interference.

Both of these methods carry the exact same amount of data. But in case of someone interference to some of these small streams, then in OFDM method only some part of data will suffer.
As shown in above figure these small streams when seen as signals are called the sub-carriers in an OFDM system and they must be orthogonal to each other for this idea to work.
In this model serial transmitted data is send to QAM modulator which is used to convert parallel signal and convert and IFFT is used to mix frequency of different values. Guard band are inserted in order to avoid ISI. For time division transformation of signals, DAC is used to convert digital to analog conversion of the signal [1]. At receiver side analog to digital converter is used and for the removal of guard bands, guard retrieval. Then using QAM decoder and FFT, de-mapping and parallel to serial conversion proceed. Figure 3.represents the block diagram of OFDM [4].

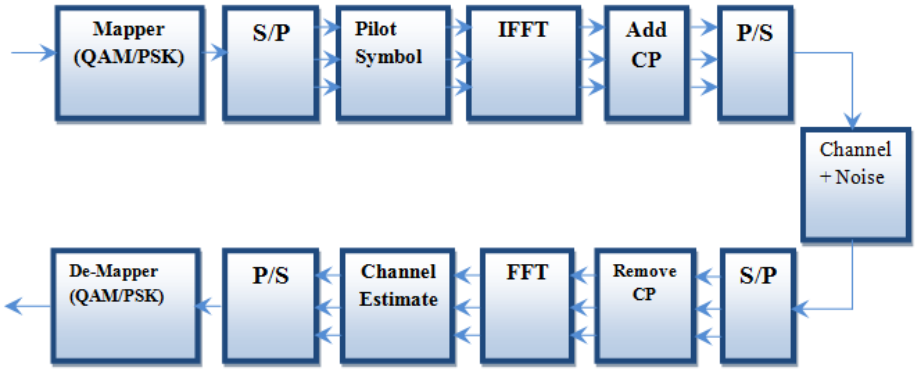

Fig.3. Block Diagram of OFDM signal

As shown in above figure the basic block diagram it work as follows:

1. Data In: Firstly data inputs are generated randomly. Its output is a one dimensional array of bits and then serial to parallel conversion is performed.
2. Signal Mapping: In this step various modulation techniques is used just to mapping. These techniques may be M-PSK and QAM. Then it aligns the bit stream over the sub-carriers.
3. Serial to Parallel Converter: It is done to allot the bit stream generated in the previous step to the various sub-carriers.
4. Pilot PN Sequence Insertion: The pilot carriers are reserved sub-carriers which are inserted in between the sub-carriers that carry-information.
5. IFFT: After the pilot carrier insertion, we must have a fast way to create OFDM symbols. Hence IFFT then quickly computes the time domain signal and then adding.
6. Cyclic Prefix: It is an extra extension that is duplicated from the end of symbol and inserted at the front of the symbol. For the reduction of the ISI effect it is applied to the signal. Cyclic prefix length is denoted by T_G and OFDM symbol duration becomes T_{sym}=T_{sub}+T_G.
7. Parallel to serial conversion: After all these process as described above the parallel OFDM symbols is converted into serial OFDM.
8. UP-conversion: It is the last stage of transmitter in terms of translating the frequency, the stage of converting the baseband OFDM signal to the desired band. There is a combination of baseband signal and RF signal. At this point the desired center frequency of the pass-band signal is chosen.
9. Channel: It is a medium through which data transmitted. There are 3 kinds of channel: AWGN Channel, Rayleigh Channel, Rician Channel.
10. Serial to Parallel conversion: After the signal that is received is down-converted successfully and both the OFDM transverse sides are synchronized in time. Then obtained OFDM sequence will be converted to shorter OFDM symbols.
11. Remove Cyclic Prefix: At this stage, on the transmitter side the guard period that was inserted previously can be removed.
12. Fast Fourier Transform: After removing the guard periods, FFT is used on OFDM symbol to convert the time domain signal into frequency domain signal.
13. Channel Estimation: At this stage pilot symbols are needed to perform and implement the channel estimation.
14. Symbol- Demapping: This stage recovers the input-binary information that went through all these steps on both sides of the systems.

IV. Advantages of MIMO-OFDM

Optical OFDM has various advantages and some of the advantages are as follows [8], [4]:-

1. The combination MIMO-OFDM is beneficial since OFDM enables support of more antennas and larger bandwidth.
2. By adopting MIMO-OFDM indoor wireless systems could reach data rates up to several hundreds of M bits/sec. and achieves spectral efficiencies of several tens of bits/Hz/s.
3. Combining of OFDM with Multiple Input Multiple Output technique increases spectral efficiency
4. It also improves link reliability.

5. It has low sensitivity to time synchronization error.
6. It is capable of power overloading and dynamic bit.
7. It has extra resistance to fading.
8. High bandwidth spectral efficiency.
9. Low complexity for FFT and IFFT.
10. At receiver simple equalizer is used to detect a large amount of data.

V. DISADVANTAGES OF MIMO-OFDM

MIMO-OFDM has various disadvantages are as follows [8], [4]:

1. Mostly the need of multiple antennas.
2. High cost of equipment compared to existing equipment available.
3. Accuracy of the synchronization should be very high.
4. Computational Complexity.
5. Cost of Added antennas.
6. Limited open source driver support.
7. Accuracy of synchronization must be very high.

VI. APPLICATION OF MIMO-OFDM

MIMO-OFDM has various applications are as follows [8], [4], [2]:-

1. Worldwide Interoperability for Microwave Access (WIMAX).
2. Digital Video Broadcasting (DVB).
3. Digital Audio Broadcasting (DVB).
4. High Definition TV and Digital Television.
5. Long Term Evolution (LTE)
6. In wireless ATM transmission system.
7. IEEE802.11a
8. Wireless Fidelity (WIFI)
9. Using wireless media in Local Area Networks.

VII. Conclusion

In today's any user's don't want just the mobile phone connected to the network or their PC, they want their MP3 player, their camera, their vehicle, they want everything connected to a single network. Hence what's the customer waiting is the development of the system that could combine the low speed WLAN to high speed WLAN. This technique has potentially the capability to answer the growing demand of such system. We can say that this technique is the solution of 4G wireless standard.

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