A Review on MIMO OFDM Technology

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Abstract: The spectral efficiency of the wireless network can be increased with the application of several overlapping yet normalized subcarriers for simultaneous transfer of data. Known as the Orthogonal Frequency Division (OFDM), this technique has been used in many wireline and wireless networks. Another very common technology today is Multiple Input Multiple Output (MIMO). It will increase network performance and/or use MIMO technology to make the transmission more efficient. This strategy of employing numerous antennas can be merged with OFDM to attain spectral efficiency and reliability at both ends of the communication network. This is often seen as an desirable option for designing and building the wireless networks for the next decade, requiring higher data transfer speeds. This paper discusses the essence of wireless technologies OFDM and MIMO, and provides a description of the combination MIMO-OFDM.

Keywords: MIMO, OFDM, Equalization schemes, Beamforming, Channel Estimation.

1. Introduction

In the conventional wireless communications, One to one antenna from transmitter and receiver side. Sometimes this leads to rise in the multipath effects problems. When radio signal meet with any of obstacles such as mountains, buildings then the signal get scatter, and therefore they took numerous ways to reach target.The delayed entrance of scattered signal's portion led to many problems such as intermittent reception ,fading etc.In system of digital communications along with remote Internet, it led to loss in speed of data and rise in the errors number.The usage of 2 or extra antennas,alongwith the multiple signals transmission (1 for every one antenna) at source & target,removes trouble being caused by propagation of multipath wave,and can else take benefit of effect. MIMO technique have roused interest for the reason that of its promising uses in WLAN ,Digital television, ,metropolitan area network & mobile communicatios. MIMO is an antenna technique where data is transmitted in multiple streams on multiple transmitters in the direction of multiple receivers.MIMO increases the data rates and range both.The capacities of antenna systems obtained varies in various systems of MIMO.The expressions are estimated, but they provide perception for the derive channel capacity terms when consuming multiple antennas.[1].

2. Types of MIMO antenna technology

2.1 Single Input, Single Output (SISO)

Fig. 1 Single Input, Single Output (SISO)

2.2 Single Input, Multiple Output (SIMO)

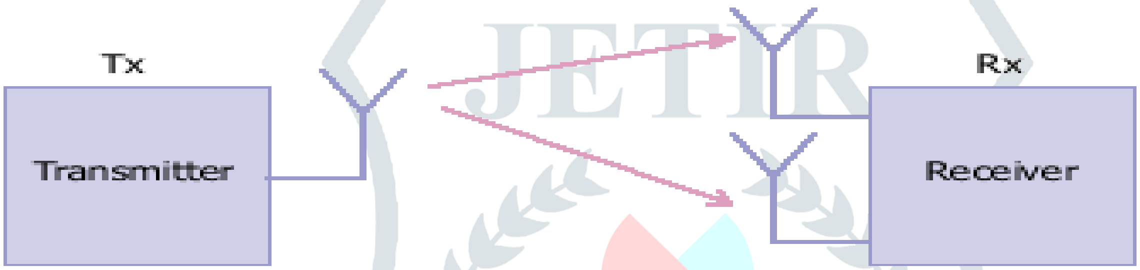

Fig. 2 Single input, multiple output

2.3 Multiple Input, Single Output (MISO)

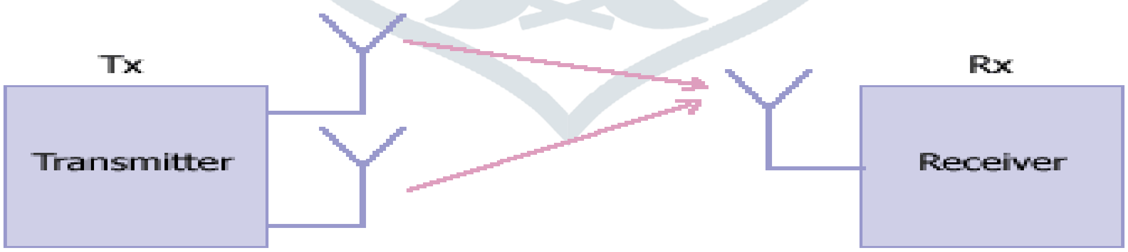

Fig. 3 Multiple Input, Single Output

2.4 Multiple Input, Multiple Output (MIMO)

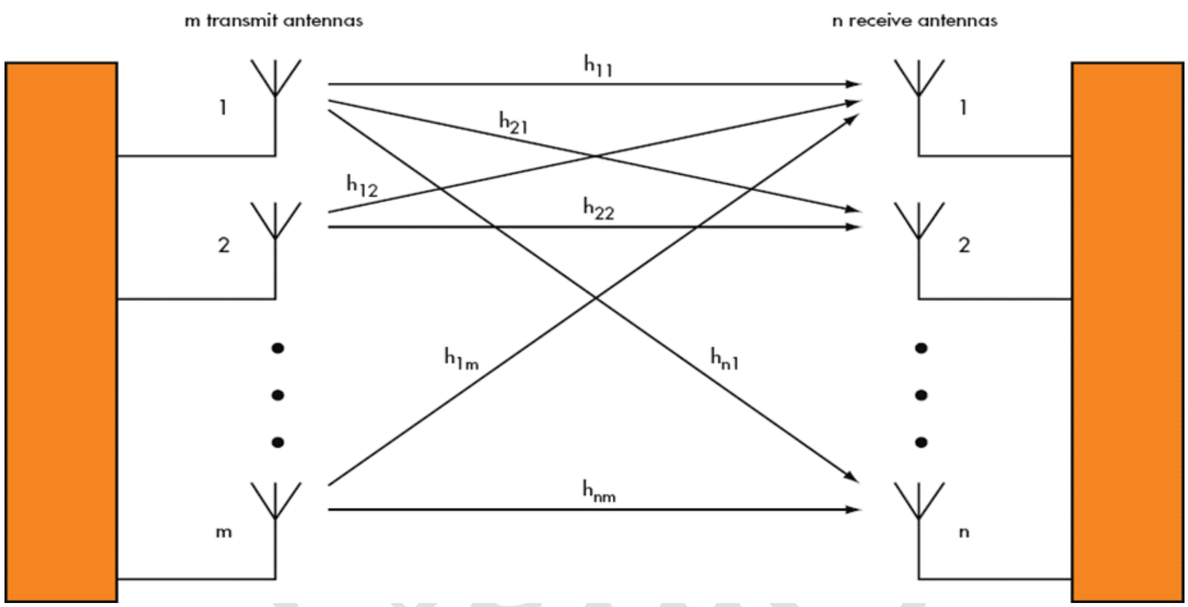

Fig. 4 Multiple Input, Multiple Output

3. Benefits of Multiple Antenna System

Array gain: An average rise in SNR value at Rx, which increases from a comprehensible linking consequence of everlasting Antennas. The Rx-side incoming signals have different amplitudes and phase. The Rx will coherently connect up the signals to broaden the ultimate signal. It could increase reliability, and so increase machine capability.

Spatial Diversity (SD): Power of signal vary in remote channel. When power of the signal falls considerably means that there is the problem in channel called as channel fading. Diversity may be used to avoid effect of fading. SD means transfer of many, duplicates of signal at Rx. Thus, we exploited rich scattering channel nature, which suggests that probability of entire copies go through deep fading is much less. At least certain copies would be existed at Rx for merging. That is accomplished by accommodating numerous antennas at Tx known Transmit diversity & at Rx known Receive diversity.

Spatial multiplexing: This recommends linear transmission rate for identical BW deprived of somewhat extra power disbursement. SM, describe with 2x2 configuration. It can be applied to any MIMO network though. The data to be transported are de-multiplexed into by rate of 2 sub-streams, cumulatively communicated & modulated from individually transmitting antenna. The spatial ciphers of the signal produced by the Rx antenna are segregated. The Rx with the estimation about the channel can separate among the signals of the co-channel an the two extracted.

Reduction in Interference: Interference of Co-channel is there to reuse of frequency in remote channels. When numerous antennas used,distinction between cochannel signals & spatial signatures of signal desired could be exploited to lessen the interference.

Linear Power Growth: The MIMO device power increases linearly with antenna quantities. 2x2MIMO has capacity 2 times, and 4x4MIMO has multiple capacity 4.

Compatible with Backwards: It support FDD & TDD technique so could be used with previous version of 802.11x to rise data rate.MIMO make use many Tx and Rx antennas permit for enlarged throughput of data over spatial multiplexing & increase range by using spatial diversity & it helps in creating products that may have Prolonged battery, Immersive entertainment and Extended wireless connectivity.

4. INTRODUCTION TO OFDM

OFDM is multi-carrier technique accepted by several wireless communication standards. A system of multicarrier communication with orthogonal sub-carriers is known as Orthogonal Frequency Division Multiplex (OFDM) system. The word "orthogonal" displays that there is specific mathematic relationship between the carriers' frequencies of system. The OFDM basic principle is to splitting high data rate sequences into numeral of sequences with low-rate that consecutively transferred over a no. of subcarriers. As symbol interval is increased for parallel subcarriers of low rate, the comparative amount of time dispersion caused by multipath delay spread get reduced. Inter-symbol interference (ISI) is also get removed almost completely on beginning of every symbol of OFDM with guard interval. The symbol of OFDM extended cyclically in guard interval so as to exclude ICI. Thus, a selective channel of high frequency is get changed into huge set of flat fading, narrowband channels and non-frequency selective[2].

4.1 OFDM generation

To produce OFDM well the link among all carriers need to prudently control to keep the normality of the carriers. For this purpose, OFDM is created by 1st chooses the spectrum needed, based on data input, & modulation system used. Individual carrier to create is allocated certain data to transfer. The require phase & ampl of carrier is then be calculated based on scheme of modulation. The necessary spectrum is then changed back to signal in time domain using an IFT. In maximum applications, an IFFT is used. The IFFT does the conversion efficiently, and gives easy way of confirming that carrier signal produced are orthogonal. The FFT transforms a cyclic signal of time domain into corresponding spectrum of frequency. That is ended by finding of correspondent waveform, produced by amount of components that are orthogonal sinusoidal. The phase & amplitude of the sinusoidal modules signify the spectrum of frequency of signal in time domain. The IFFT accomplishes back method, altering spectrum (phase &amplitude of every component) into signal of time domain. The orthogonal carriers needed for the signal of OFDM could be simply generated by setting phase & amplitude of every data point, then carrying out IFFT.

4.2 Orthogonality

A system's spectral efficiency is well described in frequency domain by the transferred bit rate. The differences between two subcarriers are necessary in a multi-carrier transmission in order to provide a bandwidth-efficient network. Because there is more space between the subcarriers, a higher bandwidth would be needed to transmit a signal at the same rate and thus the spectral efficiency is lower. As can be seen in Fig. 5, avoiding overlapping subcarriers removes inter-channel interference at the expense of inefficiency in the bandwidth.

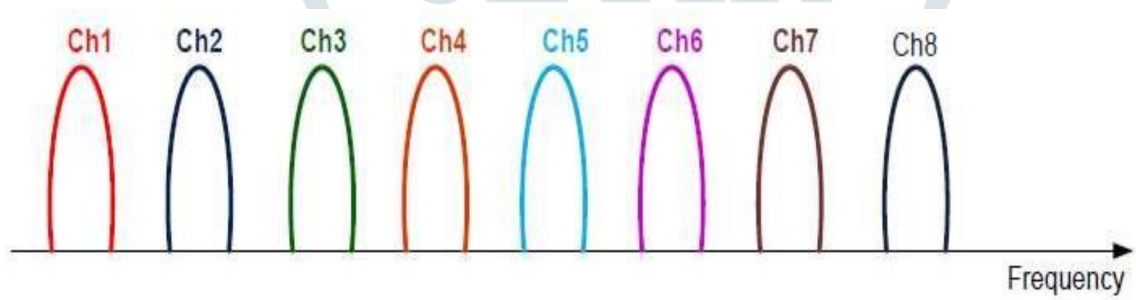

Fig. 5: Conventional Multicarrier Technique

To overcome the inefficiency of the bandwidth, OFDM was introduced where the center of a subcarrier is located in such a way that it reaches the nullity of the neighboring subcarrier as shown in Figure 1-6, saving nearly 50 percent of the bandwidth by making subcarrier overlap.

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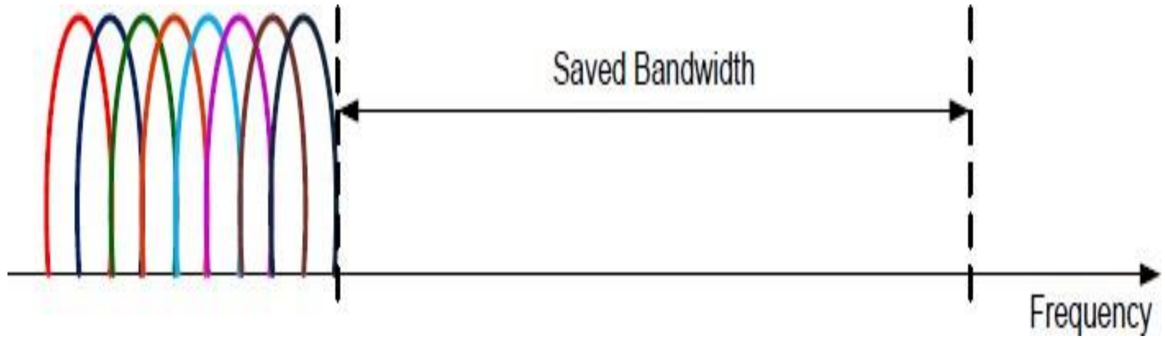

Fig. 6 Orthogonal Multicarrier Modulation Technique

5. Cyclic Prefix

In terrestrial systems the addition of cyclic prefix (CP) between two successive OFDM symbols shown in Fig.7 is used to reduce the effect of multipath channel delay spread. To simplify the synchronization, before the data stream, a copy of the last end of the transmitted OFDM symbols is inserted, afterwards the IFFT operation. The length of the CP is adjustable and must be set to maintain an effective bandwidth system.

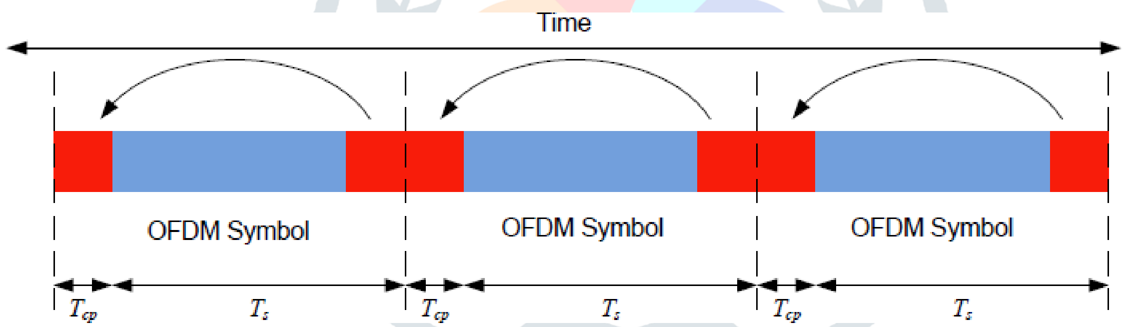

Fig. 7 Temporal Representation of OFDM Symbols

Let *D* denote the set of symbols at last of symbol of OFDM where *Ns* is complete no. of subcarriers. The interval of the CP depends on 4 factors:

1. **Channel length:** To validate a complete equalization, the length of the channel, L, should be less than the length of CP, D, that is, D > L.

2. **Performance of System:** Since the CP shows a redundancy of the end of the OFDM symbol, the spectrum efficiency is reduced and Ns/(Ns+D) is given. Ns would need to be infinity, in order to

achieve spectral efficiency close to 1.

3. **Complexity:** The FFT processes are rendered on Ns block size, hence the Ns value can not be indefinitely increased in order to provide a feasible method. In such instances, there needs to be a trade-off between complexity and spectral efficiency. The value of Ns is usually selected equals 4D, giving a spectral efficiency of 25 percent.

4. **Channel type:** To get the convolution's circularity, the channel needs to stay constant throughout the transmission of a single OFDM symbol. In these instances, the system's diversity cannot be increased even though Ns grow. The selection of Ns therefore depends on the form of channel (channel diversity, slow or quick fading).

6. Advantages of OFDM

- OFDM is also an effective BW modulation technique because the parallel subcarriers overlap but are orthogonal without interfering with each other.
- Each subcarrier could be modulated using different M-PSK or M-QAM modulation techniques depending on the system's need.
- OFDM tends to be a very effective modulation technique for systems operating under selective frequency channels.
- OFDM has comparatively large PAPRs that appear to decrease the power efficiency of RF amplifiers.

7. MIMO-OFDM MODEL

OFDM converts the selective frequency channel into a wide range of individual

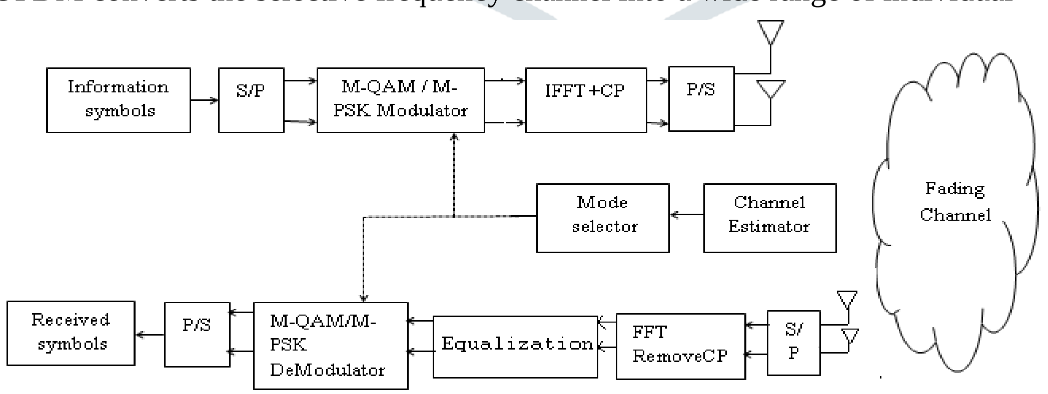

Fig. 8 MIMO-OFDM Model

Non-selective narrowband frequency channels appropriate for MIMO systems requiring non-selective frequency characteristics on each channel when the transmission rate is higher and necessary to render the entire frequency selective channel. That is why MIMO engages OFDM, referred to as MIMO-OFDM, capable of achieving greater spectral efficiency. The acquisition of multiple antenna elements at Tx for spatial transmission, however, resulted in the superposition of various transmitted signals at Rx skewed by identical multi-path channels and made the reception of signals very difficult. This put real test on the project system basically offering true spectral efficiency information. If there is channel with selective frequency, then the received signal is deformed by ISI, which led to difficult identification of transmitted signals. OFDM had emerged as the most effective way of removing ISI[3-5].

Description of model is given below:

a) Conversion from Serial to Parallel

The input stream of information in serial is organized into size of word necessary for broadcast, & moved to format of parallel.The data can then transferred parallel by allocating each one data word to single carrier in transmission.

b) Data Modulation

Data to transferred on every carrier is encoded differentially with earlier symbol, then plotted into format of PSK. As differential encoding required an inital phase reference further symbol is being added at beginning for it purpose. The data in every symbol is plotted to phase angle built on method of modulation.

c) Inverse Fourier Transform

After mandatory spectrum worked out, an IFT is used to detect corresponding waveform of time.At beginning of each symbol ,guard period is then summed up.

d) Insertion of Guard Period

The guard period has 2 sections. Partial of time of guard period is 0 amplitude transmission. The another partial of guard period is symbol's cyclic extension to be transferred.This is to permit for timing of symbol to be simply recovered by envelope detection.However it is find that it is not require in any simulation as timing can be precisely determined samples position.

e) Mode of Channel

A channel is then employed for signal transfer. The model permits for the SNR, clipping of peak power & multipath to controlled. The S/N ratio set by addition of known quantity of white noise to transferred signal.

f) Multiple Antennas

Many Antennas (MIMO)are used on either Tx or Rx side to provide the improved efficiency with a smaller amount of interference.

g) Receiver

The Rx mainly does opposite operation to Tx. The guard period get remove. FFT of every symbol took to find original transferred spectrum. The phase angle of every transmission carrier is assessed & changed back to data word by received phase demodulation. The data words are then combining back to same size of word as data in original.

8. Advantages of MIMO-OFDM

- Lesser amount of Interference.
- Diversity in gain.
- Data Capacity rises.
- Efficiency of power
- Gain in Bandwidth

9 Limitations of MIMO-OFDM

- Antenna space should be suitable depending on the type of channel.
- Complex transmitter and receiver[6].

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