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A brief overview on OFDM MIMO Technology for high speed transmission

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Abstract

The claim for reliable communication at high speeds and economical data rates in wireless and mobile communication is dramatically hiking owing to the manifold mobile data usage and services. In the todays scenario, high data rates are provided by WLAN, LTE, LTE-A (Advanced). [5]The key challenge is modifying a wireless system which is able to the transmission with limited spectrum. In wireless communication system, MIMO aims to attain high data speed and lower bit rate. This system becomes reliable and efficient when it is coupled with OFDM to obtain high transmission rates, terminate ISI and deliver highest capacity throughout with minimal error. Hence it is overtook by different standards and used in different wireless systems. In this paper, a introduction on OFDM, MIMO, integration of both is compiled and a comprehensive study is conducted on OFDM, its modulation along with techniques to boost the performance of OFDM along with channel estimation, mitigation of ISI, PAPR, ICI has been presented [7] and a brief summary of

the applications of OFDM in current systems and standards are also depict in this paper.

***Key Words*:**MIMO, OFDM, Spectral efficiency, Channel efficiency, Channel capacity.

1 Introduction

: In wireless communication systems, various techniques are used for signal transmission like TDMA, CDMA, FDMA and OFDM. In TDMA, the information is transmitted into time slots so that one user can transmit or receive in single slot. In CDMA, many users can transmit or receive but then interference occurs[8]. Hence we opt for OFDM which has collected an ample of recognitions in the domain of wireless communication.

Introduction of MIMO: Bell Laboratories MIMO system was successfully demonstrated under specified conditions in 1998. MIMO, the antenna technology availing the use of multiple antenna at both source (transmitter) and destination (receiver)[5]. They are designed so as to optimize data speed and exterminate probability of error, increase range, reliability and throughput[6].

For E.g: 4*4 MIMO 4 antennas can transmit signals (base station) and another 4 antennas can receive signals (mobile terminal). This is known as Downlink MIMO.

The figure depicts that generally a signal takes many ways to travel between transmitter and receiver.

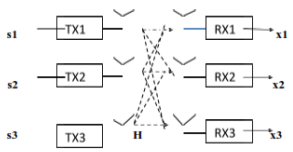

Figure1:signal transmission

MIMO uses this characteristic of a signal as a boon to provide extra robustness by enhancing signal to noise ratio and increase link data capacity.

The formats of MIMO are listed below:

1. Spatial Multiplexing
2. Spatial Diversity

Spatial Multiplexing: is given to impart increased data capacity through capabilities by various path transmission.

Spatial Diversity: is given to diversify transmitted and received signal. Since it is known that spectral bandwidth is an esteemed commodity in the communication arena, it is mandatory to use it assiduously.

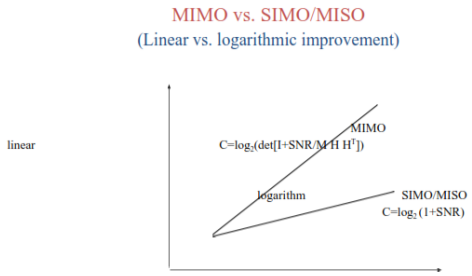

Figure 2:Chart of MIMO vs MISO

Advantages of MIMO in contrast to SIMO/SISO: Notable rise in data capacity and spectral efficiency has been observed in MIMO. Rate of data transmission is boosted by spatial multiplexing format in which it can be carried out without utility of more frequency and transmission power. Additionally there is significant reduction in fading effect attributable to the increase of diversity is seen in MIMO. This is predominantly favorable when the channels fade autonomously.

Principle of MIMO:

Taking aid of multipath propagation i.e,direct and reflected signals, it uses several antennas for the emission of parallel multiple signals.

An algorithm or DSP is adopted to sort out multiple signals thereby assisting for the production of a single signal having the original transmitted data.

Transmission of multiple data stream happens in a particular channel simultaneously and multipath signal is received at the receiver end.

In a metropolitan scenario, signals tend to bounce off high rise buildings. Thus the signals traverse
through various path to attain the receiver.

In OFDM MIMO, IFFT is used at the transmitter and FFT at the receiver.

Introduction of OFDM:

It is said to be the most dominant air interface for 4G and 5G networks. It efficiently brings about mitigation of intersymbol Interference(ISI)[4].It is a multicarrier multiplexing technique where transmission of data occurs at lower rate through several parallel sub channels . The key merit of OFDM is the single radio channel can be further sub-divided to multiple narrow band, lower rate, non-selective frequency sub-channels[10]. Different users are propagated with different information by each sub-carrier resulting in simple multiple-access technique known as orthogonal frequency divisional multiple access. This facilitates various media like video, graphics, speech depending on the service type of Quality of Service (QOS) requisites.

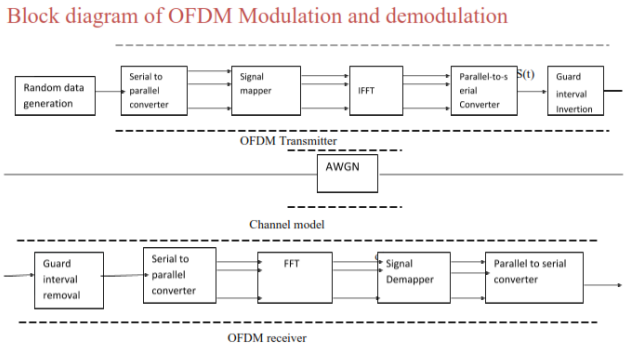

Figure 3: Block Diagram of OFDM Modulation and Demodulation

OFDM MIMO:

Both OFDM and MIMO are integrated since OFDM facilitates the feasibility of usage of various antennas and wider bandwidths as it elucidates equalization effectually in MIMO systems. By acquiring both OFDM and MIMO, data rates can reach up to some M/bits and spectral efficiencies up to some tens of bits/Hz/s which

are insurmountable for conventional wireless systems. These are the parallel transmission technologies in the domain of frequency and space. When OFDM signal is emitted through several antennas to attain better spectral efficiency and diversity of signals then it is known as OFDM MIMO.

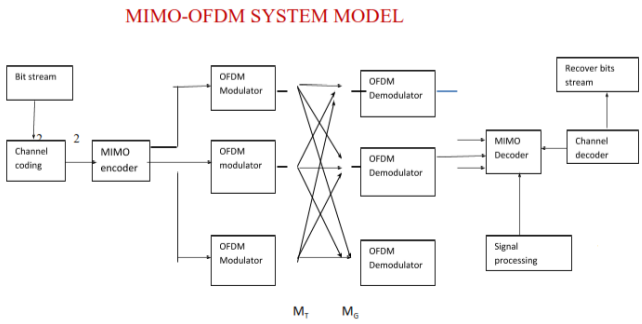

Figure 4: MIMO-OFDM System Model

These systems efficiently implement fast Fourier transforms algorithm and MIMO coding such as Alamouti Space time block coding and Golden space time trellis code. With the availability of thousands of sub-carriers, every user is provided with a small percentage of sub-carrier. In LTE, the spacing of the subcarrier is 15KHZ. While accessing of 10MHz band the net possibility of subcarriers would be 666. But practically, a smaller numeral like 512 is used. Suppose each subscriber is allotted 6 subcarriers, 85 users need to be accommodated in the band. The assignment of subcarriers to the users will be depend on the bandwidth and speed requirements of the user.

Channel Capacity: In comparison with standard single antenna system, the multiple antenna systems channel capacity with Nr transmit and Ng receive antenna can be uplifted by a multiple of minimum value of (N r , N g) without usage of extra transmit power and increased bandwidth spectrum. Since faster data transmission is on high demand in the near future telecommunication systems, the investigation of multiple antenna systems is actively going on. Derivation of expression of deterministic MIMO channel where the information of channel state (CSI) is familiar to both receiver and transmitter side and CSI is notable to the side where in

the transmitter side is present but remains unknown to the where receiver side is present. Let, the channel matrix H is probabilistic and it is an usual assumption that H represents Rayleigh fading. Whenever the channel transmission occurs, realization of H takes place. In this scenario, new ideas about coding along with some consideration of throughput must be included into account. The models of MIMO are correlated between sender and receiver antennas because the MIMO is dependent on the antennas and its correlation.

Channel Estimation: The wireless system is highly complicated. Channel Estimation is a chief task in wireless system. In place to receive the information without any forms of loss, [1]the receiver must have an characteristic to evaluate the response of frequency. The main aim of the channel estimation scheme is that received data must be selfsame as transmitted data at the source. Many methods are used in the channel estimation are employed. Some of them are listed below:

1. Adaptive Channel Estimation Scheme: one among the most vital research field in communication arena wherein the channel is rapidly varying proportional to time. In adaptive algorithm, system parameter varies as it procures more data in a dynamic environment. Adaptive filters are used to track the channel when it is quickly changing. Here basically two schemes are used

a) Recursive mean square(RMS)

b) Least mean square (LMS).

The block diagram of adaptive filter is shown below:

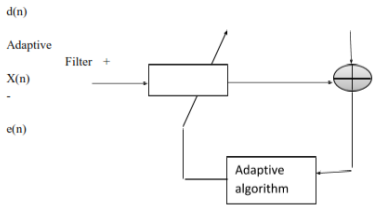

Figure 5: Adaptive Filter

LMS CE: This algorithm proposes to depreciate the square of differences between the received and estimated signal. Its design is such that optimal weight vector can be establish and mean square error can be minimized. In this algorithm, the estimator changes its parameters accordingly with the environmental changes.

W est (m + 1) = W est (m) + S (m)e*(m)

W est (m + 1)

indicate the weight vector to be calculated at m+1

is LMS step size relative to the rate of convergence

S (m)e*(m) is factor of correlation

RLS CE: Past samples of its income and desired outcome are a requisite for recursive channel estimation. In every iteration, the data must be present. While RLS is highly complex than LMS, the RLS has superior anti-noise and tracking ability. It adopts recursive method in a manner that signal change because of noise and decision error is eliminated.

W (m) = W (m 1) + K (m)H (m)

(m) denotes prior estimation error

(m) = H (m) W H (m-1)S(m)

Space time block coding(STBC): Alamouti proposed this scheme in 1998. It is the effective techniques as it makes provision for complete diversity and simple linear decoder. [5]STBC for MIMO-OFDM with different antennas is basically a sort of coding which has to be implemented in domain of time. To reach high specificity Alamoutis code is considered and portrayed to be most favourable block codes.

To obtain full diversity, space codes are generated to plot information symbols to respective antennas. Here STBC are used both for spatial and frequency diversity

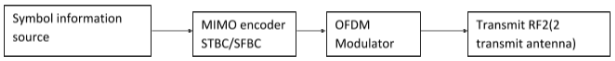

Figure 6: Block Diagram

Survey of Channel Estimation Techniques:

Case 1: In 2009, An improved Space time coding was proposed by Rick S Blum for MIMO OFDM acclimated QPSK modulation for four source and four destination antennas. Going a step ahead they also showed a 4-antenna, 16 state codes that is able to achieve extra 2-dB improvement which is lesser complex and a 256-state code that also acquires an additional 2dB gain when performed within an outage capacity of 3dB.

Case2: In 2004, Numerous physical layer issues related to the execution of OFDM MIMO system was discussed by Garden L. Stuber where they considered space time coding methods for closed loop MIMO OFDM systems wherein at the transmitter, the channel information is present. Adaptive analog beam forming strategies were reviewed that can possibly give the most suitable environment for MIMO channel.

Case 3: In 2006, Multiuser channel estimation technique build on simple blocked pilot grid was presented by Toufiqal Islam.. Multiuser channels were estimated on basis with least square (LS) and minimum mean square estimation (MMSE) schemes.

Case 4: In 2011, Zang jie et al presented a simulation model of OFDM MIMO system on the foundation of STBC which inbuilt and performances of transmission are analyzed. The simulation outcome conclude that other MIMO-OFDM system without STBC can be outperforms by the MIMO OFDM system based on STBC.

Case 5: In 2013, Andre Antonio dos Anjos noticed the issues in accuracy of channel estimation. The interpolation techniques

influence on channel estimation error and MER were also studied and analysis of different channels having different delay profiles was also done. A similarity between the estimated channel error and the MER was suggested. Case 6: In 2014, Analysis of least mean square and recursive mean square algorithms was done, and this was applied to MIMO OFDM system depends on STBC. Results of the simulation showed that RLS is better in comparison to LMS algorithm and practical aspects of this analysis were shown in MATLAB environment.

Industry standards for numerous services:

IEEE 802.11n for WLAN standards: provides a sequence of enhancement techniques to physical and MAC layers resulting output relative to input up to 100 Mbps [3]. Its maximum operating net data rate ranges from 54Mbit/s to 60Mbit/s. The amendment was approved by IEEE. Prior to its approval, enterprises already had begun migrating to 802.11n networks.

IEEE 802.16a for WiMax standards: The utility of WiMax is to provide broadband wireless connectivity over a significantly large geographical area such as an urban environment. It out into use multicarrier OFDMA scheme along with MIMO antenna technique in pursuance to obtain rate of data transmission higher than 155Mbps. This apparatus can work in various configurations like FDD and TDD and in different frequency bands of 5.8GHz, 3.5GHz and 2.5GHz.

LTE/LTE-A: Third generation partnership developed a 4G wireless broadband technology known as Long Term Evolution (LTE). It describes the next step (4G) in progress from GSM which was used since a very long time span so it is named as LTE. It provides increased data rates with the capacity of 100Mbps downstream and 50/30Mbps upstream along with reduction in latency and backwards compatibility in comparison with other existing technologies.

LTE utilizes both (OFDM and MIMO) antenna technology. It makes provision for improved coverage and throughput in metropolitan areas.LTE possesses a potential to deliver pandemic to the global audience for mobile-users with a wire-like experience, wirelessly.

2 Applications:

It provides high speed internet services whose download speed will range from 100Mbps to 1Gbps[9] and also services like Surveillance systems and intelligent transport system with high bandwidth applications.

3 Conclusion:

From the survey, it is deduced system make breakthrough in wireless communication technology if there is further modification in channel estimation techniques and increase in channel capacity. The high efficiency bandwidth procured through this makes it valuable for the future. Thus further process will be conducted on the improvement in techniques of channel estimation and channel capacity for MIMO OFDM systems.

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