BASIC CONCEPT AND BER IMPROVEMENT OF MIMO- OFDM SYSTEM

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Abstract: The brief paper present the MIMO-OFDM is one of the promising technologies to improve the spectral efficiency, enhance system capacity and mitigate inter-symbol interference in fourth generation broadband mobile communication system. In this article main objective is to concentrate on the basic concept of MIMO, OFDM, MIMO-OFDM and improvement of BER in MIMO-OFDM systems by using various techniques. For BER improvement main need is to identify various factors on which BER depend so that by varying those factors BER improvement can be done. Need of BER improvement is because it not only increases throughput but also improve reliability of wireless communication

Keywords: BER, LLMS, LMS, MIMO-OFDM, MMSE, ZF.

Introduction: In wireless communication MIMO antenna systems [1]-[2] is regarded as an efficient solution to reach the growing demand of high speed, spectral efficiency, assisting fading link reliability without sacrificing bandwidth efficiency.[3]-[4]

In modern high data rate communication system e.g. digital video broadcasting (DVB), OFDM multi-carrier[5] modulation technique is preferred. In OFDM a single high data rate stream is divided into multiple low rate data stream and each stream is modulated with subcarrier which is orthogonal to remaining once. OFDM provide efficient transmission over limited bandwidth. On the other hand, a combination of OFDM and MIMO referred to as MIMO-OFDM has emerged as a very promising technology for the future generation of wireless system. MIMO-OFDM has been proposed as an efficient solution for communication over frequency selective multipath fading channel. Above all high data rate is one of the main requirements for every wireless communication system, in this way of achieving high data rate BER improvement is one of the main problem. The factors on which BER improvement depend is tried to find out up to some extent. Those factors are type of modulation/demodulation, equalization technique, coding (encoding/decoding) technique, transformation applied etc.

MIMO System: MIMO is basically a technology in which multiple antennas are used both at transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology. Here the term input and output refers to the radio channel carrying the signal not to the device having antenna. Main objective is to study the basic principle behind this technology. MIMO uses technology named as spatial multiplexing and beam forming.

Spatial Multiplexing: In spatial multiplexing, a high rate signal is split into multiple lower rate streams and each stream is transmitted from a different transmit antenna in the same frequency channel. In this signal coming from different antenna are combined and appropriate mathematical function is applied to get sufficient output. Below two fig shows spatial multiplexing with and without SM which basically tells us that in first visual the output obtained at receiving antenna is with and without delays that is definitely not the efficient output to work upon instead of one in second visual which depicts that output obtained at computer are definitely much more stronger and further can be improved by applying appropriate mathematical function according to the type of application.

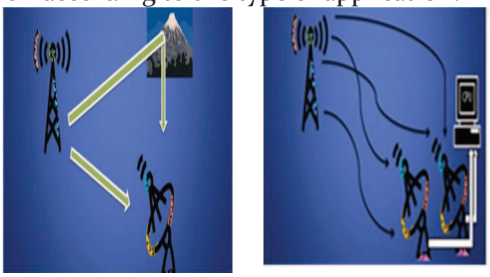

Fig 1 Spatial multiplexing with and without

Beam forming: - Beam forming or spatial filtering is a signal processing technique used in sensor arrays for directional signal transmission or reception. This is achieved by combining elements in a phased array in such a way that signals at particular angles experience constructive interference while others experience destructive interference. Beam forming can be used at both the transmitting and receiving ends in order to achieve spatial selectivity.The improvement compared with omnidirectional reception/ transmission is known as the receive/transmit gain (or loss).

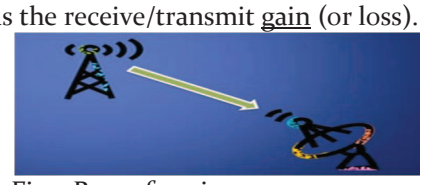

Fig 2 Beam forming

There are mainly three types of MIMO system which are as follows:-

(1) Space Time Transmit Diversity:- In this same data is coded and transmitted through different antenna's which effectively doubles the power in the channel. This improves S/N ratio for cell edge performance.

(2) Spatial Multiplexing: - SM delivers parallel stream of data to CPE by exploiting multipath. It can double MIMO or quadruple capacity and throughput. SM gives higher capacity when RF conditions are favourable and user are closer to the BTS.

(3) Uplink Collaborative MIMO Link:- Leverages conventional single power amplifier at device . Tw device call collaboratively transmit the same subcarrier which ca also double uplink capacity.

To improve the data rate or throughput of wireless access even under condition of interference, signal fading for long distance along this use of limited bandwidth effectively. If the disadvantages are to be considered of MIMO system are basically its designing, multichannel synchronization, DSP engineers are required to implement more sophisticated baseband processing algorithm to better interpret the channel model.

OFDM : Orthogonal frequency division multiplexing signal consists of basic principle according to which OFDM consists of number of closely spaced modulated carrier, although the sideband from each carrier overlap, they can still be received without the interference that might be expected because they are orthogonal to each other. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period means that they will have a whole number of cycle in the symbol period and their contribution will sum to zero i.e there is no interference contribution. This technique overcomes the effect of multipath fading available in UMTS. In this techniques a large number of parallel narrow band sub carriers instead of single wider band carrier to transport information.

If OFDM is observed in terms of positive point of view it can be seen that this modulation format is very easy and efficient in dealing with multipath, along with it is robust against narrow band interference.

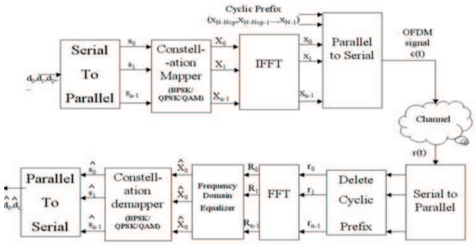

Fig 3 OFDM

Orthogonal frequency division multiplexing (OFDM) is generally known as an effective modulation technique in highly frequency selective channel conditions. In OFDM systems , the entire channel is divided into many narrow sub-channels. Splitting the high-rate serial data stream into many low-rate parallel streams, each parallel stream modulates orthogonal subcarriers by means of the inverse fast Fourier transform (IFFT). If the bandwidth of each subcarrier is much less than the channel coherence bandwidth, a frequency flat channel model can be assumed for each subcarrier. Moreover inserting a guard interval results in an intersymbol interference (ISI) free channel assuming that the length of the guard interval is greater than the delay spread of the channel. Therefore the effect of the multipath channel on each subcarrier can be represented by a single complex multiplier, affecting the amplitude and phase of each subcarrier. Hence the equalizer at the receiver can be implemented by a set of complex multipliers, one for each subcarrier. Limitation of OFDM is basically sensitivity to frequency offset and phase noise. Peak to average problem reduces the power efficiency of RF amplifier at the transmitter.

MIMO-OFDM: Multiple-input multiple-output (MIMO) wireless technology in combination with orthogonal frequency-division multiplexing (MIMO-OFDM) is an attractive air-interface solution for next-generation wireless local area networks (WLANs), wireless metropolitan area networks (WMANs), and fourth-generation mobile cellular wireless systems. When both MIMO-OFDM both these technologies are combined or integrated they cancel out disadvantages of each other and proved to be a good solution for LTE system. One building block for next-generation wireless access, MIMO (multiple-input, multiple-output), is an advanced antenna technology that can carry 4 to 5 times more data traffic than today's most advanced UMTS-HSDPA-ready (3G) networks. A network design incorporating MIMO technology provides the scalability needed to quickly deliver multimedia content to the mass market. The main motivation for using OFDM in a MIMO

channel is the fact that OFDM modulation turns a frequency-selective MIMO channel into a set of parallel frequency-at MIMO channels.

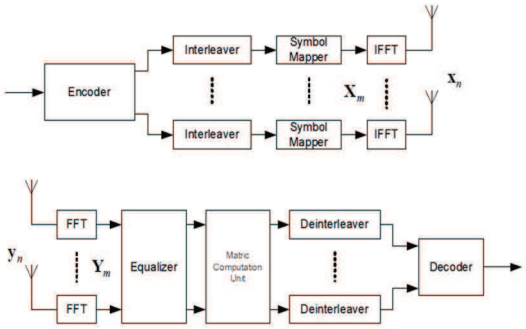

Fig 4 MIMO-OFDM

The main requirement of MIMO-OFDM system is encoder/decoder, FFT/IFFT, serial to parallel/parallel to serial converter, equalization technique, interleaver/deinterleaver, modulation/demodulation techniques, multiple antennas at transmitter and multiple antennas at receiver. The main challenges faced by MIMO-OFDM technology is mainly PAPR, BER, SNR etc .

Factors for BER Improvement : BER stands of bit error rate it is basically a ratio between number of bits in error to the number of bits transmitted. There are various factor on which BER depend are as follows :-

1. Encoding/Decoding technique:- There are mainly two type of encoding/decoding technique that can be used with MIMO-OFDM systems either convolution codes or turbo codes as turbo codes . So for the improvement of BER turbo codes are used instead of convolution codes[7]
2. FFT/IFFT technique:- FFT and IFFT are both two linear transformations on signals and are the reverse of each other. Hence applying FFT on a signal x followed by IFFT will reproduce x. Similarly, applying IFFT on the same signal x followed by FFT will again re-produce x. Hence, as a fact, it does not matter whether you apply FFT (IFFT) at transmitter as long as you apply the reverse transform; i.e. IFFT (FFT) at the receiver. In multicarrier modulation, we require separate oscillator tuned to different frequency. IFFT block is OFDM remove this requirement. The Fourier transform breaks a signal into different frequency bins by multiplying the signal with a series of sinusoids. This essentially translates the signal from time domain to frequency domain. But, we always view IFFT as a conversion process from frequency domain to time domain. Now a better transform technique then FFT is available i.e DWT(discrete wavelet transform) [9] because it removes the need of cyclic prefix in the system. Cyclic prefix are added to avoid inter symbol interference
3. Modulation/Demodulation:-Modulation demodulation is main requirement of every communication. Now modulation can be BPSK, QPSK, 16PSK, 256PSK or QAM, M-QAM depending upon the requirement of application.[7][9][11]
4. PSC/SPC: - Parallel to serial and Serial to parallel converter both are required in transmitter and receiver section.
5. MIMO antennas: - MIMO antennas must be used both at transmitter and receiver side they must be highly directional so that they can transmit maximum power in required direction. There radiation pattern should be highly directional.
6. Equalization technique: - There is need of equalizer and the receiving end. In MIMO-OFDM either MMSE or ZF equalizer can be used. MMSE performance is better than ZF[10] [12]
7. Channel estimation technique:- To estimate the desire channel at the receiver channel Estimation techniques are used and also enhance system capacity of system. The MIMO-OFDM system uses two independent space-time codes for two sets of two transmit antennas.

Channel estimation can either be done through LMS or LLMS beam-forming algorithms the proposed method not only has good ability of suppressing interference, but also significantly improves the bit error rate (BER) performance of MIMO-OFDM system.[7]

Conclusion : In this paper we studied the basic concept, prospective, challenges of MIMO, OFDM, MIMO-OFDM systems, along with this we saw various factor under consideration while going through the study of this latest technology (MIMO OFDM) .This papers main consideration is on BER

and how to improve this BER using different techniques either in terms of encoder/decoder, FFT/IFFT, serial to parallel/parallel to serial converter, equalization technique, interleaver /deinterleaver, modulation/demodulation techniques, multiple antennas at transmitter and multiple antennas at receiver. Now our objective is to choose best from all that is turbo codes for encoding/decoding, DWT in case of transformation, MMSE in case of equalizer, M-QAM in terms of modulation/demodulation technique, LMS for channel estimation. When all these are combined together they will definitely improve the MIMO-OFDM system BER and proved to be a good technology in the recent future.

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