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Multiple-Input Multiple-Output of Wimax Network: Review

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Abstract: *WIMAX stands for the Worldwide Interoperability for Microwave Access and is additionally called the IEEE 802.16 wireless metropolitan area network. From wimax technology, we can able to conquer the current problems of mobile communication systems like precise coverage of area, flat data rate and dearth of security.WiMax physical layer is relies on technique of Orthogonal Frequency Division Multiplexing , which is very powerful to multipath propagation and enables direct usage of MIMO techniques. Multiple-input multiple-output communication mean to the which wireless communication systems having an array of antennas at each of the transmitter or the receiver. Multiplexing would contains some interference, but Multiple-input multiple-output systems use smart selection and combining techniques at the receiving end to transmit many information and to enhancement signal quality. MIMO systems provide a major capability gain over standard single antenna systems.It is acknowledged that the complexity of OFDM with MIMO is overwhelming attributable to the need for multiple Fast Fourier Transforms (FFTs) at the receiver. In this paper the general review of the (4G) technology focusing on the WiMax network system along with MIMO technique.Moreover general description for MIMO-WIMAX applied descriptive methodology.*

Keywords: *FFTs , MIMO , OFDM,WIMAX.*

I. Introduction

With the further development of the communication network, IEEE 802.16 standard based technology WiMAX (Worldwide Interoperability for Microwave Access) is positioned on Broadband Wireless Access . The IEEE 802.16e air interface standard depends on technology named, OFDM, to mitigate the Inter-Symbol Interference (ISI) over delay spread for the wideband wireless networks. The WiMAX standard 802.1 6e supports firm, roving, handy and versatile wireless wideband connection without the need of straight shot with the base station. This WiMAX is different with earlier ones by its mobility. Adding MIMO feature is mainly to improve the performance of WiMAX system and its capacity too. MIMO is required mainly for efficient communication as using one antenna at both the ends do not work, so, we move for multiple antennas called as MIMO. By transferring absolute information from the specific antennas, we get spatial multiplexing in MIMO systems.The original WiMAX standard (IEEE 802.16) indicated WiMAX for the 10 to 66 GHz go with a hypothetical maximum bandwidth of 120 Mb/s and maximum transmission extent of 50 km, supporting however just LOS transmission. The 802.16a standard, updated in 2004 to 802.16-2004 (also known as 802.16d) [1], added specifications for the 2 to 11 GHz range and adopts Orthogonal Frequency Division Multiple Access (OFDM) at the PHY layer. The 802.16-2004 standard was subsequently updated to 802.16e in 2005 and uses Scalable OFDM (SOFDMA) supporting channel bandwidths of between 1.25 MHz and 20 MHz with up to 2048 sub-carriers, instead of the OFDM version with 256 sub-carriers (of which 200 are used) in 802.16d. More advanced versions, including the 802.16e standard, furthermore bring Multiple Antenna Support through Multiple-Input Multiple-Output communications (MIMO). This gets potential advantages in terms of coverage, self installation, power exhaustion, frequency re-use and bandwidth effectiveness. The 802.16e (Mobile WiMAX) standard furthermore adds an ability for full mobility support [2]. Most commercial benefit is in the 802.16d and 802.16e standards, since the lower frequencies utilized in these variants suffer less from ingrained signal attenuation and therefore give enhanced range and in-building penetration. As of now today, a number of networks throughout the world are in commercial operation using certified WiMAX equipment Compatible with the 802.16d standard.

II. Overview Of Mimo Techniques

MIMO communication achieves high data rates than wireless channels. The large potential flexibility and adaptively of OFDM transmission technique in frequency selective and time variant radio channels are described by comparing different demodulations methods and channel coding with soft decision decoding and multilevel coding for improving BER performance. Maximum likelihood estimation of OFDM carrier frequency offset in the presence of virtual carriers is considered and showed that it extends to cases involving multiple blocks on comparing with music like algorithm[3].

For Bit Error Rate (BER) performance and output correlation function of non-linear device, analytical expressions are obtained and AM/AM and AM/PM non-linearity's represented by Bessel series expansion are

derived. On comparing performances of Wi-fi and WiMAX technology by including issues likes security,seamless handover, locate on and emergency services,cooperation and QoS etc. along with their performances which showed WiMAX is more secure and reliable[4]. To understand the basic RS code techniques, modulation performance, cyclic prefix tasks and factors and OFDM symbol on WiMAX PHY layer is studied. Use of Reed Solomon Encoding and Convolution Encoding is also encountered to analyze BER vs. SNR. The effect of Block Interleaving on BER performance of WiMAX PHY layer is considered. Using digital modulation schemes which showed improvement in FEC system performance by reducing burst errors during transmission[5].The use of different channel equalizers and with STBC is introduced and analyzed on WiMAX PHY layer. Results showed error free transmission in it. To improve the problems of 802.16e protocol, 802.16g protocol is introduced.They equated working principles of 802.16e protocol and 802.16g protocol and used technologies like OFDM,MIMO, SC-FDM which improves spectral efficiency of frequency band. Introduction of two MIMO profiles (Alamouti's STC and 2*2 spatial Multiplexing scheme)and compared them. They evaluated their performance with ITU conventional B channel model with 3 km/hr speed of pedestrian and revealed BER of 10^-4 of two MIMO systems give rise to same performance. At inferior BER values, Matrix A and B gives suitable performances.The comparison of MIMO with SISO is performed on adding Singular Value Decomposition (SVD) in MIMO and channel capacity is developed which resulted in high throughput of SISO and carrying high traffic load by MIMO[6].Obstacles like important feedback aloft, performance deterioration due to feedback delay and huge storage necessity at mobile devices prevents precoding from wide deployment. On adding fifteen antenna/feedback configurations to vector-based, structured codebooks with low intricacy is proposed. To improve BER performance it is analyzed that under obstruction, the channel capacity of intended MIMO system is high than traditional systems and they are based on V-BLAST having two schemes i.e.Spectrum Domain Encoding (SDE) and Wavelet Domain Encoding (WDE). A transmission scheme is developed to eliminate channel distortion to improve noise immunity and BER. Various Transmit Diversity schemes and Diversity combining techniques are compared by simulations[7].Various methods to evaluate MIMO-WiMAX in multi cell, multi sector and multi user environment for single frequency reuse. They used both uplink and downlink where SM of downlink show 10% improvement over SIMO and uplink increase the spectral efficiency by 9% over SIMO system same as beamforming. Two MIMO PHY layer modifications (STBC) and (SM) are investigated and provided high bandwidth effectiveness,turnout and data rates. With the help of MATLAB simulations they obtained mechanisms to improve WiMAX PHY layer with high spectral efficiency. To study time synchronization errors in OFDM system, its major effects, performances with BER and compared with some synchronization algorithms with OFDM system which showed fading environment and gives good picture of practical scenario[8]. Proposed method of parallel combination scheme to reduce PAPR in MIMO-OFDM system below Rayleigh fading environment which reduces PAPR and complexity of system and maintain BER also.Effects, estimation and correction of frequency offsets are done along with MIMO-OFDM combinations and techniques in presence of CFO. Comparison is done between 2*1 STBC-OFDM, 2*2 STBC-OFDM, 2*1 SFBC-OFDM.and gave better results. Diversity is also adversely affected by CFO.Introduction of real MIMO-WiMAX platform to simulate space, time and frequency selective fading conditions and used this platform to simulate Space-Time Codes (STC), Space-Frequency Codes (SFC) and Space-Time-Frequency Codes (STFC) where STFC showed multiplicity gain compared to STC and SFC[9]. Downlink performance of two full-rate STC's of IEEE 802.16e i.e.Matrix B and Matrix C which showed Matrix c has long and complex decoding and least used in current WiMAX system[10]. Using multiple antenna options and comparing their performance we got same spectral efficiency,Matrix A perform better than Matrix B and throughput is maximized by combining MIMO with adaptive modulation and coding. Measurement of turnout is done to compare with channel capability and shared information which obtain SNR detriment at turnout of 5 Mbits/s to 6 db through channel code and channel estimator.

III. Structure of WIMAX Network System

3.1 PMP (POINT-TO-MULTI POINT)

As shown in Figure1, centering on the base station, the PMP application mode uses the point-to-multipoint connection to compose a WIMAX access network of star structure.The base station plays the role of service accessing point.By the dynamic allocation of band width, the base station selects the beam antenna, the Omni-directional antenna or multi-section techniques, subject to the conditions of users in the coverage, to satisfy the demand of a mass of subscriber station equipment accessing the core network. If necessary, it expands the wireless coverage by repeater stations. It also allocates the channel bandwidth flexibly based on the quantity of user groups, and thereby expands the network capacity to realize the coordination between benefits and costs [11]. PMP is a conventional application form of access network,characterized by the simple network architecture. The application mode is similar to the access form of cables such as XDSL. Therefore, it is an ideal option as replacement of cables.

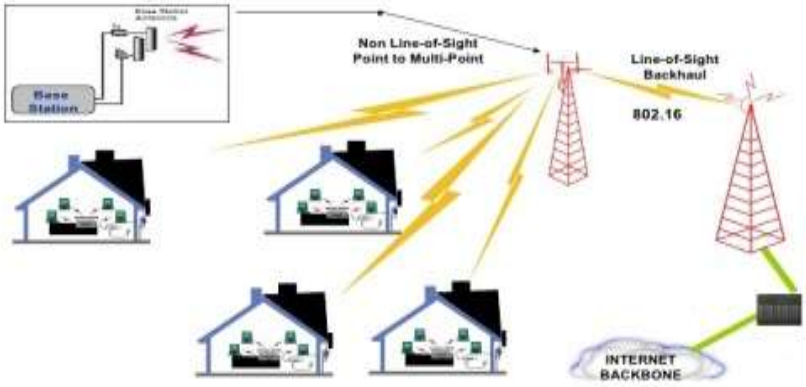

Figure 1: PMP Architecture

3.2 Mesh

As shown in Figure2, Mesh application mode adopts multiple base stations (BS) to expand the wireless coverage by mesh network. One of the base stations connects to the core network as a service access point(SAP), and others connects to this SAP via wireless links.Consequently, the base station as SAP is used as not only a service access point but also a junction point of accessing,and other base stations are service access points instead of simple repeater stations (RS).

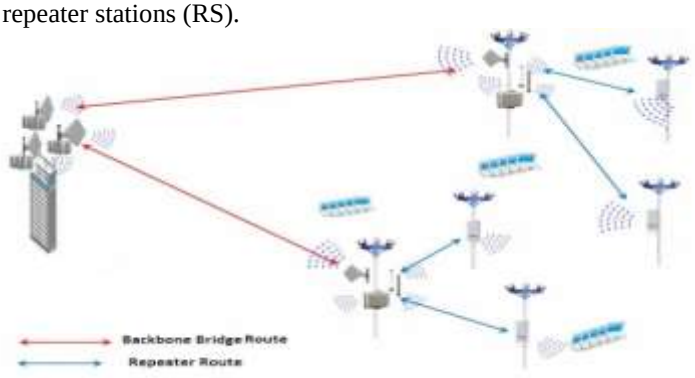

Figure 2: Mesh Architecture

3.3 Access Network

The base station provides a connection between the subscriber station and the core network. It generally uses a sector/beam antenna or umbrella antenna, which provides flexible arrangement and configuration of sub-channels,the subscriber station is a kind of base station, which provides the repeater connection.

3.4 Core Network

The WIMAX core network is mainly responsible for the user authentication, roaming service, network administration and providing interface to other networks.Its network administration system is used to monitor and control all base stations and subscriber stations in the network, and system parameters configuration. The IP network connected to the WIMAX system is generally a traditional switching network or the Internet or other networks. The WIMAX system provides the connection interface between the IP network and base stations.
between the base station and the equipment of user terminal.Adaptive modulation mode of the signal is used between base station and subscriber station. MS mainly refers to the mobile WIMAX terminal and handheld devices responsible for realizing the wireless access for mobile WIMAX users[12].

IV. WIMAX OFDM Physical Layer

The main undertaking of the physical layer is to conceal input details of binary digits into signals and to make them applicable to wireless channel, signals are transmitted and received. This chore is done by the following process as shown below. The block diagram for WiMAX system (802.16e standard) is shown in Figure 3.

4.1 RANDOMIZATION

The First and foremost task in WiMAX physical layer where randomization is done to remove copied patterns, like long sequence of nulls and ones. Mainly generates random sequence to improve coding performance.

4.2 FORWARD ERROR CORRECTION (FEC)

It encodes data and redundant bit stream to permit receiver to observe and correct errors. Coding system involved in FEC are RS codes, TURBO codes, convolution codes etc. It increases the capacity of channel.

4.2.1 RS CODES

They are symbol error correcting codes. They are a class of non-binary codes having strong error correcting ability.

4.2.2 CONVOLUTION CODES

It corrects random errors in data transmission. Here every coded bit is a linear combination of some encoded bits. The input is information bits applied to shift register and output is not only a function of current input but also a function of K-1 inputs. Coding rate is defined as ratio of data rates assigned for substitute frames to maximum data rate that can perfectly be assigned in substitute frame.The output of convolution encoder is then penetrated to eliminate additional encoded bits and number of bits displaced depends on code rate used.

4.3 INTERLEAVING

It is process to make system more efficient fast by arranging data in chaotic manner before transmission. It reorders the data that is to be dispatched so that bytes of data dispensed over large sequence of data to diminish burst errors. The number of bits in each block is known as interleaving gulf, which represents deferment introduced by interleaver at transmitter side. Block interleaver is a type of matrix in which, to read the data, we go for row and switch to column for writing the data and vice versa.

4.4 MODULATION

After interleaving bits are organized into slots. Due to burst errors, large adjacent bits are corrupted. So, mapping is done. Data bits enter serially to constellation mapper and signal is balanced by digital modulating arrangement; such as M-QAM and M-PSK, where M is a number pattern of points in the constellation diagram and demodulation is done to recover the authentic transmitted digital information.

4.5 INVERSE FFT

It mainly converts symbols from frequency region to time region and serve OFDM subcarrier as a channel in time region. If N no. of subcarriers is used then IFFT receives N no. of sinusoidal and N symbols at a time.

4.6 CYCLIC PREFIX

It imitates some samples from the end of the symbol in front to add some tautology to symbols. These cloned samples are called Cyclic Prefix. Main purpose is to avoid inter symbol interference caused by multipath propagation.

4.7 RECIEVER

They are totally opposite of transmitter block. Main purpose is to obtain original data bits. Cyclic prefix is removed as guard interval is removed. Then FFT is performed and transformed in frequency domain. Then demodulation, de interleaving and de randomization takes place smoothly.

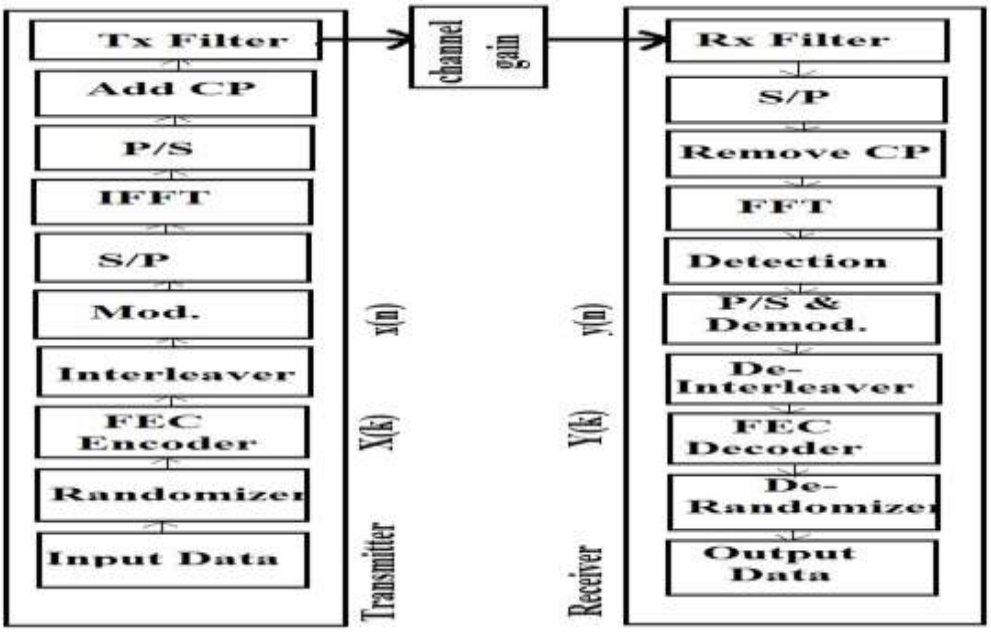

Figure 3: WiMAX physical layer model

V. WIMAX MAC/Data Link Layer

The 802.16 Medium Access Control (MAC) layer uses a scheduling algorithm for which the subscriber station need compete once, i.e. for initial entry into the network). After that it is allocated an access slot by the base station. The time slot can enlarge and contract, but remains assigned to the subscriber station, which means that other subscribers cannot use it. In addition to being stable under overload and over-subscription (unlike 802.11), the 802.16 scheduling algorithm can also be more bandwidth efficient. The scheduling algorithm also allows the base station to control QoS parameters by balancing the time-slot assignments among the application needs of the subscriber stations.

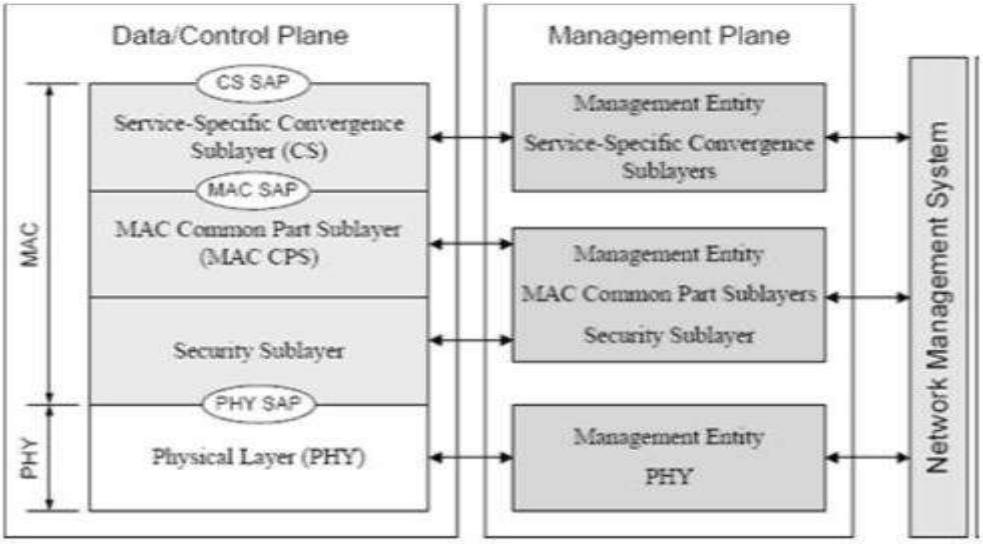

Figure 4: MAC Layer and PHY Layer of WIMAX

Characteristic of MAC Layer :

The Mac is provides assembly of data into frame with address and error detection fields, It also disassembly of frame at receiver and detection the error.

5.1 The MAC layer is divided into three sub-layers:

5.1.1 Service Specific Convergence Sub-layer (CS).

5.1.2 Common Part Sub-layer (CPS).

5.1.3 Privacy Sub-layer (PS).

The main function of CS is to convert and map the external network data received by service access point (SAP) to the MAC services data unit (sdu).

The main function is receive the data from CS and classifies them into specific connections.It implements QOS control to the data transmitted and dispatched on the physical layer.

The main function of PS is to provide authentication, key exchange and encryption/decryption processing.

VI. MIMO Systems

MIMO was presented to satisfy the aspirations for providing reliable great rapid wireless communication connections in severe surroundings. Numerous antennas are used in cellular communication at both transmitter and receiver sides to achieve high data rate through spatial multiplexing. Here multiple transmitters send unique data to various receivers as shown in Figure 5. MIMO requires better SNR and increases data rates along with provide high capacity which is directly proportional to antennas. It mainly consists of three categories. There are already many communication systems is used which occupy available bandwidth and nowadays bandwidth communication is required and using one antenna at both the ends will not work. So, we move for multiple antennas, where sender and receiver send more than one data signal with same radio channel. It mainly has three categories.Beam forming for controlling the inclination to impart and conceal of radio signals. By sending same data to transmitter and receiver so that they experience different fading is spatial diversity. Third category includes spatial multiplexing where different data is set at two different antennas and we get maximum throughput. Some of the MIMO techniques are listed below:

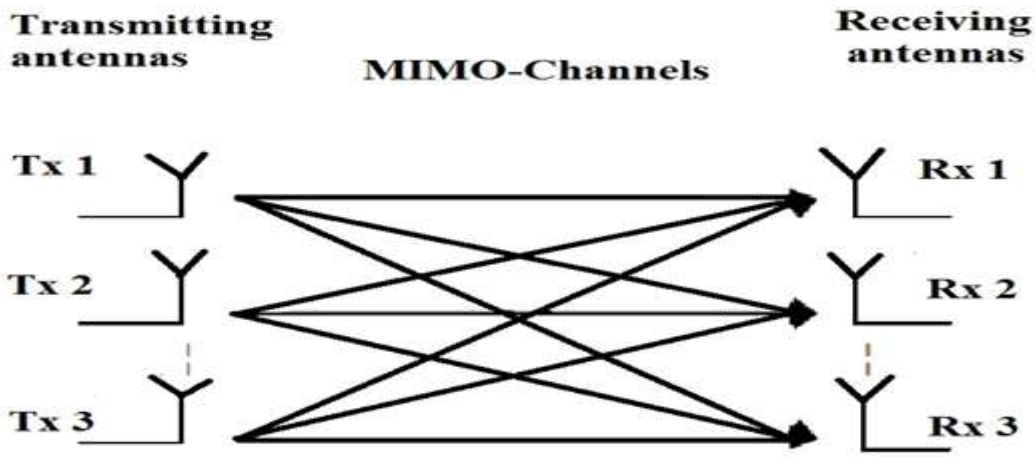

Figure 5 : Block diagram of MIMO system

6.1 Spatial Diversity (SD)

A technique that provides two or more inputs at the receiver such that inputs of the fading phenomena are not connected.If one radio path undergoes intense fade at certain time, another autonomous path may have a stable signal at that input. Multiple branches and low correlation between the branches are the particular requirements of diversity. All connected properties of the radio channel are used as average to provide multiple independent copies of the same signal. Assuming two antennas at transmitter side and we use them to send same data. Since these two antennas are set far enough from each other, the same data are transmitted to receiver via different paths that is experiencing different signals called as spatial diversity or transmit diversity. It combats channel fading and provides reliable communications.

6.2 Spatial Multiplexing (SM)

Mainly used for high throughput with spatial multiplexing,numerous data streams are transmitted at similar time. They are transmitted on same channel but by various antennas. They are combined at the receiver via MIMO signal processing. Here, data reliability is not fixed. Data rate of the system increases as each spatial channel hoist separate information. And compared to Orthogonal Frequency Division Multiplexing (OFDM) technique,where, different frequency sub channels carry different parts of the adjusted data. But in spatial multiplexing, if there is strong collision, several independent sub channels are generated in the same assigned bandwidth. Thus the compounded growth is useful in both bandwidth and power. It increases channel capacity at high SNR and add complexity and expenses at both transmitter and receiver.

6.3 Beam forming (BF)

Beam forming makes use of fading channels and improves gain of received signals and communication system.Beam forming enlarges the performance of mobile communication at average ranges. At short ranges, the SNR will support the maximum data rate because of high signal power. At long ranges, beam forming does not propound a significant gain over a non-directional antenna and data rates will be similar to non-beam formed transmissions.Beamforming makes use of antenna array and to make best use of signal strength, signal processing techniques are used.

VII. MIMO-WIMAX

WiMAX based companies are trying to have something better for future prospectus in this field using the term MIMO along with it. Using MIMO systems with WiMAX gives better BER performance compared to simple WiMAX. The MIMO schemes under WiMAX technology are determined by space-time coding and spatial multiplexing where each of them performs different functions. WiMAX includes Matrix A and Matrix B MIMO.

7.1 MATRIX A (RELIABLE COMMUNICATION)

7.1.1 Improves SNR at receiver side.
7.1.2 Expand cell radius.
7.1.3 Use of high order modulation to increase transmission speed.
7.1.4 Better throughput.

7.2 MATRIX B (INCREASED CHANNEL CAPACITY)

7.2.1 Unconventional data streams over each antenna.
7.2.2 Perfect signal conditions.
7.2.3 Use of data rate according to the number of antennas used.

To improve high data rate and spectral efficiency it is more advisable to use MIMO with WiMAX technology as shown in Figure 3. At low BER values, Matrix A has good performance due to expansion in diversity arrangement and Matrix B at SNR values grows the turnout. By using various MIMO schemes in WiMAX system, best BER performance can be maintained through adaptive MIMO switching and by using this, it make use of both MATRIX A and MATRIX B type of modulation. If we simulate modern coding techniques Space Time Coding (STC),Space Frequency Coding (SFC), Space Time Frequency Coding (STFC) on MIMO-WiMAX platform then it contains link between antenna at transmitter and receiver and huge multipath delays. MIMO-WiMAX provides many directions in which independent result can occur and to use them exclusively to find maximum diversity from the channel.

If performance of WiMAX system is estimated by adaptive modulation then there are bigger chances for BER to improve and also it is mostly seen that in frequency selective fading channel is stirred by Inter Symbol Interface ISI in huge number as compared to flat fading.

VIII. Conclusion

Multiple Input Multiple Output (MIMO) techniques are important part of IEEE 802.16 2005 specifications in adaptable WiMAX systems. MIMO has ability is to Increase spectral efficiency compared to SISO systems,flexible sub-channelization and Adaptivev Modulation and Coding (AMC) enables MIMO-WiMAX technology to improve system coverage,capacity, better BER, throughput and efficiency. By merging both techniques, MIMO-OFDM can offer both robustness and high throughput. In a multiuser situation where many users communicate with a central station (base station or access point), MIMO-OFDM becomes even more attractive because it provides an additional opportunity to exploit due to many users. In this paper we have studied ,discussed and analyzed the MIMO WiMAX in terms of specifications , technique and structure . This study that we've made will be a pattern for other paper will be taken into consideration in studying the performance enhancement for WiMAX-MIMO networks.

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