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Analysis of MIMO-WIMAX communication system under Rayleigh Fadding Channels using STBC

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Abstract: Wireless access networks like WiMAX provide an excellent opportunity for operators to participate in the rapid growth opportunities that exist in emerging markets. The mobile Worldwide Interoperability for Microwave Access (WiMAX) is based on IEEE 802.16 standard and is used for wireless Metropolitan Area Network (MAN). The inclusion of Multiple Input Multiple Output (MIMO) in mobile WiMAX system provides a robust platform for space, time and frequency selective fading conditions and increases both data rate and system performance. The performance of mobile MIMO WiMAX system has been carried out using Space Time Block Code for different modulation schemes under different channel conditions like AWGN, Rayleigh channels etc. The result are encouraging because with respect to other services the WiMax getting better responses in term of WiMAX's users and operators. The simulation of MIMO-mobile WiMAX model is done by using MATLAB.

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I. INTRODUCTION

Broadband wireless sits at the confluence of two of the most remarkable growth stories of thetelecommunications industry in recent years. Both wireless and broadband have on their own enjoyed rapid mass-market adoption. Wireless mobile services grew from 11 million subscribers worldwide in 1990 to more than 2 billion in 2005 [1]. During the same period, the Internet grew from being a curious academic tool to having about a billion users. This staggering growth of the Internet is driving demand for higher-speed Internet-access services, leading to a parallel growth in broadband adoption. In less than a decade, broadband subscription worldwide has grown from virtually zero to over 200 million [2]. Will combining the convenience of wireless with the rich performance of broadband be the next frontier for growth in the industry? Can such a combination be technically and commercially viable? Can wireless deliver broadband applications and services that are of interest to the endusers? Many industry observers believe so. Before we delve into broadband wireless, let us review the state of broadband access today. Digital subscriber line (DSL) technology, which delivers broadband over twisted-pair telephone wires, and cable modem technology, which delivers over coaxial cable TV plant, are the predominant mass-market broadband access technologies today. Both of these technologies typically provide up to a few megabits per second of data to each user, and continuing advances are making several tens of megabits per second possible. Since their initial deployment in the late 1990s, these services have enjoyed considerable growth. The United States has more than 50 million broadband subscribers, including more than half of home Internet users. Worldwide, this number is more than 200 million today and is projected to grow to more than 400 million by 2010 [2]. The availability of a wireless solution for broadband could potentially accelerate this growth. What are the applications that drive this growth? Broadband users worldwide are finding that it dramatically changes how we share information, conduct business, and seek entertainment.

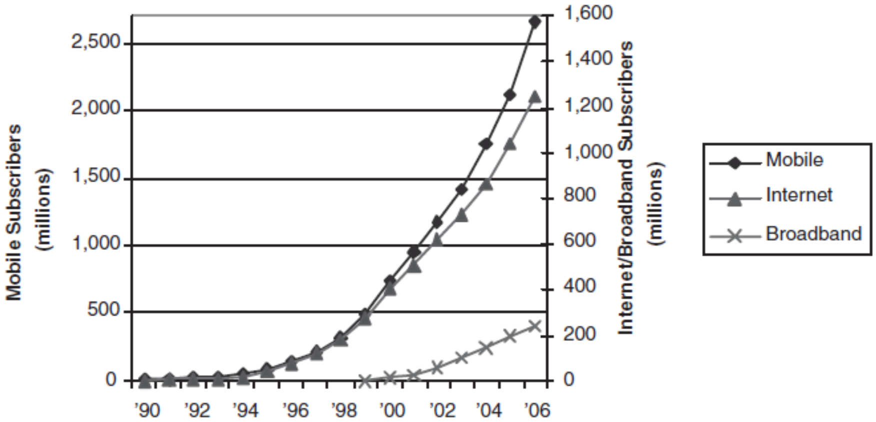

Figure 1. Worldwide subscriber growth 1990–2006 for mobile telephony, Internet usage, and broadband access

II. RELATED WORK

P.Samundiswary, Ravi Ranjan Prasad ,” Performance Analysis of MIMO-Mobile WiMAX System using Space Time Block Codes under Different Channels”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) , Volume-2, January 2013 . Mobile WiMAX has emerged as a starting point of broadband mobile wireless era. Besides plenty of advantages over the prior systems, it also utilizes multiple-antenna techniques to improve the transmission quality. Although this approach has been intensively studied, there are just few published works taking into account channel estimation to obtain realistic performance. This paper studies a joint STBC and channel estimation scheme to investigate the performance of the DL-PUSC mobile WiMAX in various mobile channels. Simulation results show significant improvement, up to 8 dB gain for PER and system throughput is achieved when employing STBC.

Sunil Singh* and RanjeetPrajapat” A Review WiMAX in Orthogonal Space Time Block Coding”, International Journal of Electrical, Electronics and Computer Engineering, November, 2014. MIMO-OFDM technology is a combination of multiple-input multiple-output (MIMO) wireless technology with orthogonal frequency division multiplexing (OFDM) that has been recognized as one of the most promising techniques to support high data rate and high performance in different channel conditions. The purpose of this research work is to implement of Wi-MAX system for MIMOOFDM receiver. To improve system performance of Wi- MAX Radio Technology communication, using transmit and receive mode and with suitable modulation technique. We have focused on developing the six symbol detection algorithm of WiMAX system for the MIMO-OFDM Receiver. To find best signal detection technique for WiMAX system in MIMO-OFDM environment. MIMOOFDM system gives BER that we required for next generation wireless system i.e. WiMAX and also gives high data rates that can be useful for many wireless systems.

G. J. Foschini and M. J. Gans, “On limits of wireless communications in a fading environment when using multiple antennas,” WirelessPersonal Communications, vol. 6, no. 3, pp.311–335, 1998. This paper is motivated by the need for fundamental understanding of ultimate limits of bandwidth efficient delivery of higher bit-rates in digital wireless communications and to also begin to look into how these limits might be approached. We examine exploitation of multi-element array (MEA) technology, that is processing the spatial dimension (not just the time dimension) to improve wireless capacities in certain applications. Specifically, we present some basic information theory results that promise great advantages of using MEAs in wireless LANs and building to building wireless communication links. We explore the important case when the channel characteristic is not available at the transmitter but the receiver knows (tracks) the characteristic which is subject to Rayleigh fading. Fixing the overall transmitted power, we express the capacity offered by MEA technology and we see how the capacity scales with increasing SNR for a large but practical number, n, of antenna elements at both transmitter and receiver.

We investigate the case of independent Rayleigh faded paths between antenna elements and find that with high probability extraordinary capacity is available. Compared to the baseline $n = 1$ case, which by Shannon's classical formula scales as one more bit/cycle for every 3 dB of signal-to-noise ratio (SNR) increase, remarkably with MEAs, the scaling is almost like n more bits/cycle for each 3 dB increase in SNR. To illustrate how great this capacity is, even for small n, take the cases $n = 2$, 4 and 16 at an average received SNR of 21 dB. For over 99% of the channels the capacity is about 7, 19 and 88 bits/cycle respectively, while if $n = 1$ there is only about 1.2 bit/cycle at the 99% level. For say a symbol rate equal to the channel bandwith, since it is the bits/symbol/dimension that is relevant for signal constellations, these higher capacities are not unreasonable. The 19 bits/cycle for $n = 4$ amounts to 4.75 bits/symbol/dimension while 88 bits/cycle for $n = 16$ amounts to 5.5 bits/symbol/dimension. Standard approaches such as selection and optimum combining are seen to be deficient when compared to what will ultimately be possible. New codecs need to be invented to realize a hefty portion of the great capacity promised.

III. DESIGN AND IMPLEMENTATION

MIMO OFDM:

MIMO based wireless systems equipped with multiple antennas at both transmitting and receiving ends have promised enormous capacity gains over Single-Input Single- Output (SISO) based wireless systems.[6] MIMO systems are considered to be suitable technology because they have the ability to exploit non line-of sight (NLOS) channels, and hence they can increase spectral efficiency compared to SISO systems. The MIMO wireless system is shown in Figure 2.

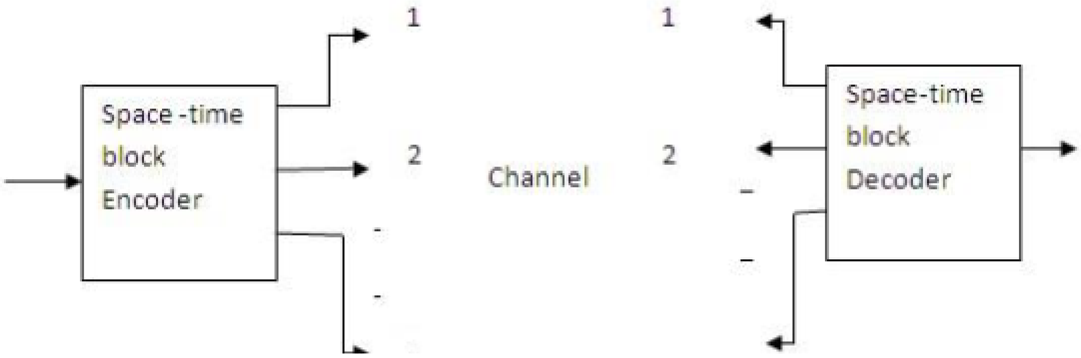

Fig 2 MIMO wireless model [1]

MIMO-WiMAX Transmitter and Receiver:

The MIMO-WiMAX Transmiter and Receiver system is shown in Figure 2. At transmitter side, the information source generates the binary information to be transmitted. The binary information is converted to symbols for digital modulation. The modulated symbols are encoded by (Space time Block Code) STBC encoder and the reverse processes are carried out by different blocks at the receiver.

A. Transmitter

Transmitter consists of information source, modulator and STBC encoder.

a. Information Source

The Bernoulli binary generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter p produces zero with probability p and one with probability 1-p. The Bernoulli distribution has mean value 1-p and variance p (1-p). The probability of a zero parameter specifies p, and can be any real number between zero and one.

b. Symbol Modulation

The binary information generated by information source is coo groups of bits to form binary symbols. These symbols are modulated using digital modulation schemes such as BPSK QPSK, 16-QAM and 64-QAM.

c. STBC Encoder

This block is used for space time diversity coding which is used to reduce the effect of noise and increase the bandwidth by reducing the Bit Error Rate. Alamouti [13] STBC is one of most important technique to achieve diversity using MIMO systems, and secure mean of exchange information. It is usually design under certain assumption and consideration of having knowledge about response of channel i.e. perfect channel state information (CSI) at

1.Transmitter site only

2.Receiver site only

3.The both site.

The block then transmits the encoded symbol by a space time block code to spread each of the N-transmit antennas according to the type of coding technique used.

B. Receiver

Receiver mainly consists of STBC decoder and demodulator.

a. STBC Decoder

This block is used for space time diversity decoding which is used to decode encoded data. It is usually design under certain assumption and consideration of having knowledge about response of channel.

b. Demodulation

The received data is demodulated by demodulator to get recovered data. This recovered data is compared with transmitted random data which gives Bit Error Rate (BER).

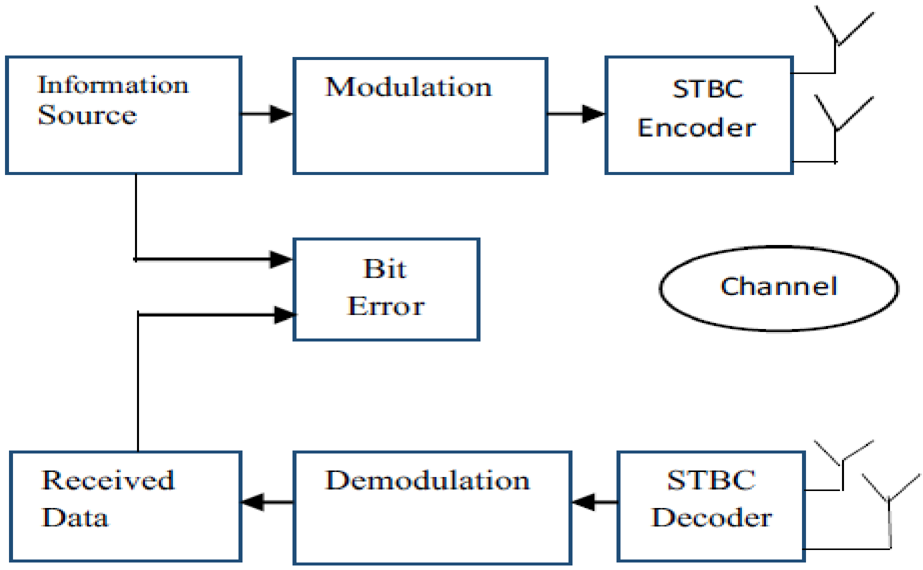

Fig 3 MIMO-WiMAX Transmitter and Receiver

Types of Channels:

a. Additive White Gaussian Noise (AWGN)

AWGN is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density expressed as watts per hertz of bandwidth and a Gaussian distribution of amplitude. The model does not account forfading, frequency selectivity, interference, nonlinearity or dispersion. In the study of communication systems, the classical (ideal) AWGN channel, with statistically independent Gaussian noise samples corrupting data samples free of inter-symbol interference (ISI), is the usual starting point for understanding basic performance relationships. An AWGN channel adds white Gaussian noise in the signal that passes through it.

b. Rayleigh Fading Channel

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal such as that used by wireless devices. It assumes that the power of a signal that has passed through such a transmission medium (also called a communications channels) will vary randomly or fade according to a Raleigh distribution, the radial component of the sum of two uncorrelated Gaussian random variables. It is reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built up urban environment on radio signals. Raleigh fading is most applicable when there is no line of sight between the transmitter and receiver. In a multipath propagation environment, the received signal is sometimes weakened or intensified.

c. Rician Fading Channel

Rician fading is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself. The signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others.

4.4 Space Time Codes

a. Alamouti Space-Time Code

Space-time block codes (STBC) are a generalized version of Alamoutischeme , but have the same key features. These codes are orthogonal and can achieve full transmit diversity specified by the number of transmit antennas. In other words, space-time block codes are a complex version of Alamouti's space-time code, where the encoding and decoding schemes are the same as there in the Alamouti space-time code on both the transmitter and receiver sides. The data are constructed as a matrix which has its columns equal to the number of the transmit antennas and its rows equal to the number of the time slots required to transmit the data. At the receiver side, the signals received are first combined and then sent to the maximum likelihood detector where the decision rules are applied. [4]

b. Space-Time Block Code (STBC)

Space–time block coding is a technique used in wireless communication to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer. The fact that the transmitted signal must traverse a potentially difficult environment with scattering,reflection, refraction and so on and may then be further corrupted by thermal noise in the receiver means that someof the received copies of the data will be 'better' than others. This redundancy results in a higher chance of being able to use one or more of the received copies to correctly decodethe received signal.

IV. SIMULATION RESULTS AND DISCUSSIONS

The MIMO-WiMAX model is simulated for different digital modulation schemes (QPSK, 8-PSK,16-QAM,64- QAM) with under AWGN, Rayleigh and Rician channels with the help of MATLAB. The performance parameter in terms of BER of MIMO-WIMAX systems is determined and compared for different modulation schemes. The simulation is carried out using MATLAB.

A. BER of MIMO-WiMAX System For DifferentModulation Scheme under AWGN Channel:

Figure. 4, shows BER vs SNR performance of MIMOWiMAX using different modulation schemes under AWGN channel. A lower modulation scheme gives better BER performance as compared to higher modulation schemes.

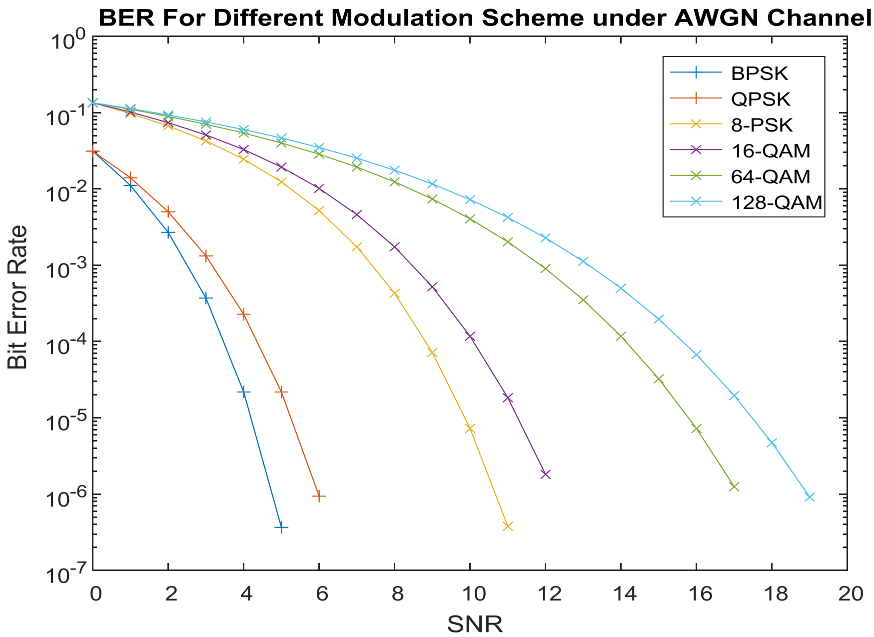

Fig 4 BER of MIMO-WiMAX System For Different Modulation Scheme under AWGN Channel

b. BER of MIMO-WiMAX System for different modulation Scheme under Rayleigh Channel:
Figure 5 shows BER vs SNR performance of MIMO Wi-MAX using different modulation schemes under Rayleigh channel. QPSK scheme gives better BER performance as compared to other modulation schemes in Rayleigh fading. From fig.5at SNR 6 dB QPSK gives BERvalue 10-4 where as in 8-PSK gives BER 10-2.5,16-QAM gives BER value 10-1.5 and 64-QAM gives 10-1.2., gives 10-0.9

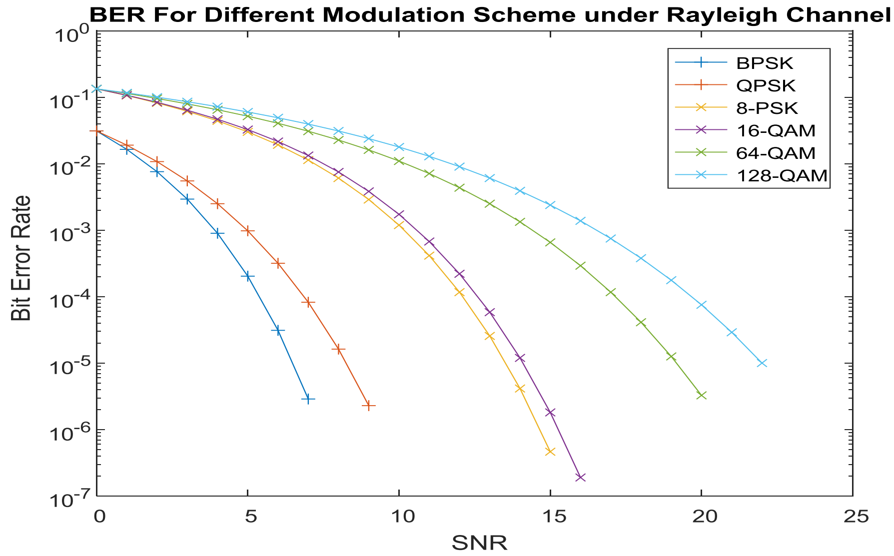

Fig 5 BER of MIMO-WiMAX System For Different Modulation Scheme under Rayleigh Channel

c. BER of MIMO-WiMAX System for different modulation Scheme under Rician Channel:

From Fig.6 shows BER vs SNR performance of MIMO WiMAX using different modulation schemes under Ricianchannel. From fig.6 lower modulation scheme gives better BER value as compared to higher modulation schemes at low values of SNR. As SNR value increases then higher modulation schemes gives better BER performance as compared to lower modulation schemes. Also, at SNR value 6 dB QPSK gives BER 10-5, 8-PSK gives 10-2.5,16-QAM gives BER 10-1.5 and 64-QAM gives 10-1.2.

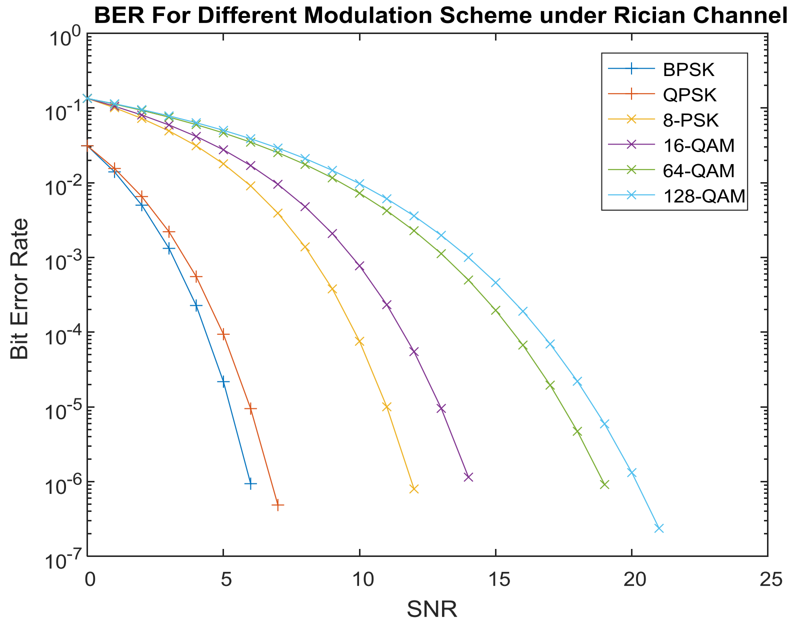

Fig 6 BER of MIMO-WiMAX System For Different Modulation Scheme under Rician Channel

d. Performance for different diversity techniques for QPSK:

Figure 7 shows BER performance comparison ofQPSK with MRC and Alamouti(2x1) and no diversityschemes. From fig.7it is observed that MRC (1x4) andMRC (1x2) gives better BER performance as compared withNo diversity(SISO) and Alamouti (2x1) schemes. At SNRvalue 8 dB No diversity(SISO) and Alamouti (2x1) schemesgive same BER 10-1.3 where as in MRC (1x2) gives 10-2.5and MRC (1x4) gives 10-3.5

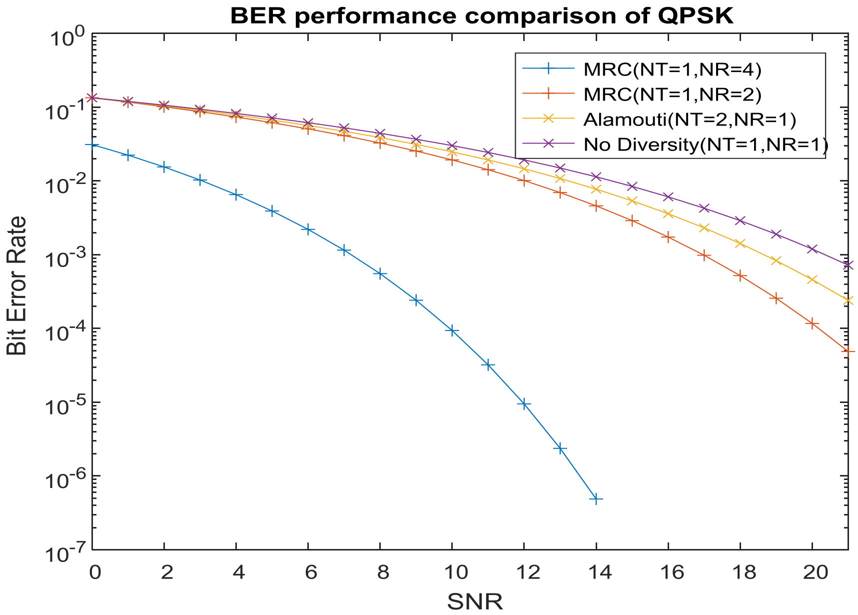

Fig 7 The BER performance comparison of QPSK with MRC, Alamouti(2x1) & no diversity (1x1) in Rayleigh fading.

V. CONCLUSION

Broadband Wireless Access (BWA) has emerged as a promising solution for providing last mile internet access technology to provide high speed internet access to the users in the residential as well as in the small and medium sized enterprise sectors. IEEE 802.16e is one of the most promising and attractive candidate among the emerging technologies for broadband wireless access. The emergence of WIMAX protocol has attracted various interests from almost all the fields of wireless communications. MIMO systems which are created according to the IEEE 802.16-2005 standard (WIMAX) under different fading channels can be implemented to get the benefits of both the MIMO and WIMAX technologies. In this paper, the MIMO-mobile WiMAX system is simulated for different modulation schemes (QPSK,8-PSK,16-QAM,64-QAM,128-QAM) with ½ code rate to analyse BER performance under AWGN, Rayleigh and Rician channels with the help of MATLAB. Simulation results have shown that MIMO-mobile WiMAX system with different modulation schemes give better BER performance at different values of SNR under different channels. Lower modulation schemes give better BER performance as compared to higher modulation schemes. As SNR value increases, higher modulation schemes give better BER performance.

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