

# Review on – Improvement in WiMAX System

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## Abstract

Currently the wireless domain is changing very tremendously with a huge demand of highest data rate and lowest error rate. Certain improvement require in system efficiency in terms of capacity and error rate. Two of such strong wireless contenders are the WiMAX system and the DVB systems the research work is basically on making the current 4g standards more efficient by the implementation of antenna diversity techniques such as MIMO-ALAMOUTI and MIMO-VBLAST. The two MIMO techniques have been implemented into it so as to make it more efficient by exploiting their advantages into it and comparing these techniques with currently working techniques SISO.

**Keywords:** Wi-Max, SISO, MIMO, ALAMOUTI, V-BLAST (Vertical Bell Labs Layered Space Time)

## I. INTRODUCTION

WiMAX the Worldwide Interoperability for Microwave Access is the highly anticipated Technology that aims to provide business and consumer wireless broadband services in form of Metropolitan Area Network (MAN). WiMAX is considered today the most Emerging technology, which is supporting coverage area of around 50 KM at a rate of Transmission up to 70 Mbps. It consider the backbone of WIFI – hotspot. WiMAX standard 802.16e is strong contender because of high speed data rate it is a mobile WiMAX standard.

Table - 1  
Wi-MAX Standards

|           |      |                |                                                      |
|-----------|------|----------------|------------------------------------------------------|
| 802.16    | 2001 | 10-66 Ghz      | The First Standard                                   |
| 802.16(a) | 2003 | 2-11 Ghz       | Provide last mile fixed Broadband access             |
| 802.16(d) | 2004 | 2-11 Ghz       | Optimization of power consumption of mobile devices. |
| 802.16(e) | 2005 | 2.3 to 3.4 Ghz | Addresses mobility                                   |

Technically the working of IEEE 802.16 standard is describes by the analysis of its air interface which includes physical layer and medium access control layer (MAC). MAC layer protocols are designed to provide point to multi point services so they also decide the bandwidth allocation algorithms plus error control algorithms. The protocol describes the time and fashion of transmission through base station (BS) or mobile station (MS). Physical layer The IEEE 802.16 WiMAX standard defines the physical layer along with MAC layer so to ensure end to end reliability in wireless scenario. because of certain practical limitations of wireless channel i.e. quoted as multi path structure, fading, effect of Doppler shift, inter symbol interference, etc., the efficiency of the existing standards can not be upgraded.

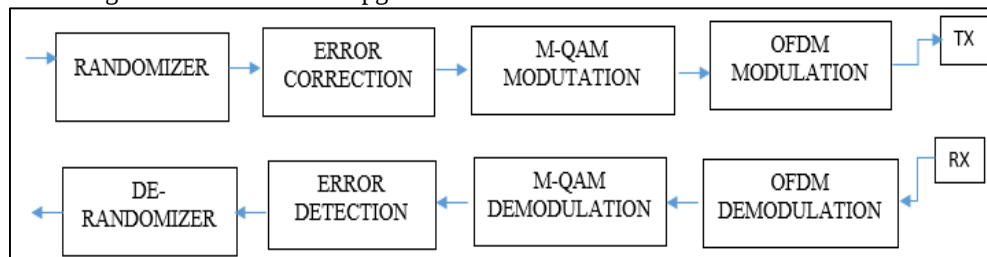


Fig. 1: WiMAX structure

For improvement in traditional WiMAX and to make it more efficient in terms of capacity along with excellent error rates than the existing standard implementation of MIMO antenna diversity is best option. With use of MIMO- ALAMOUTI BER is improved to the great extent and by using MIMO –V BLAST capacity of data rates can be increased.

## II. LITERATURE REVIEW

### A. MIMO-OFDM high data rate wireless system using V-Blast method

In this used some techniques to improve BER and SNR of MIMO wireless techniques are V-blast, D-blast and alamouti which are the methods used in MIMO technology. BPSK modulation system is used and two types of equalizers zero forcing (ZF) and

minimum mean square error (MMSE). Author used MMSE equalizer using Rayleigh channel. OFDM V-blast systems are capable of improving bit rate without increasing total transmit power or required bandwidth. ML detection is too complex to implement for V-blast detection. MMSE scheme gives best results in V-blast method as compared to D-blast method in BPSK modulation in Rayleigh channel.

### **B. V-Blast a space-division multiplexing technique providing a spectral efficiency necessary for high data rate wireless networks**

V-blast implements a zero-forcing (ZF) non-linear detection algorithm which is based on a spatial nulling process combined with symbol cancellation to improve the performance. STC introduces for the improvement of information protection and SDM is used to enhance the data rate and M-QAM and OFDM to sphere detection (SD). V-blast is an SDM based MIMO system which seems to provide the best trade-off between system performance and system implementation complexity. M-QAM and OFDM can produce a very high spectral efficiency.

D-blast faced certain implementation complexities.

V-blast seems to provide the best trade-off between the system performance and implementation complexity so D-blast can be replaced by V-blast.

### **C. Performance evolution of different detection techniques in v-blast**

V-blast architecture is explained with use of modulation techniques like BPSK, 8-QAM and 8-PSK which is used for detection. V-blast system is analyzed with zero forcing (ZF) and minimum mean square error (MMSE) detection. MATLAB tool is used to analyze the performance of BER and SNR it is analyzed that detection technique is improved at higher SNR and from this it prove that BPSK has higher SNR than 8-PSK and 8-QAM.

Performance of any detection technique is improved at higher SNR it is proved by simulation. MMSE detection technique performs 1-5 dB SNR improved than ZF detection in BPSK, 8-QAM and 8-PSK

### **D. MIMO performance analysis with ALAMOUTI STBC code and V-blast detection scheme**

In this paper some detection algorithm based on STBC is used. and comparing the performance of Alamouti STBC with other method D-blast and V-blast where more promising method used for detection and suppression of the interference in MIMO systems. most useful one is V-blast. It has been observed that the ML detection has better BER performance than the MMSE and ZF detections by 15db. in D-blast there were complexity of implementing the algorithm by using the adaptive scalar recursion for fast fading, the complexity order reduces to square and the computation becomes less compared to other techniques.

## **III. ANTENNA DIVERSITY**

Antenna diversity can be implemented at either transmitter side or receiver side or on both the sides.

- FIRST- TX-diversity is realized by placing more than one antenna on the transmitting part and transmitting either same or different signals through all of them.
- SECOND- RX-diversity is implemented by putting multiple antennas which will receive and reconstruct the signal approaching from different paths having different kinds of fading effects.
- THIRD- More than one number of antennas on the transmitting and on the receiver side. By considering the sufficient separation between the individual antennas, independent signal paths can be achieved that are also faded independently.

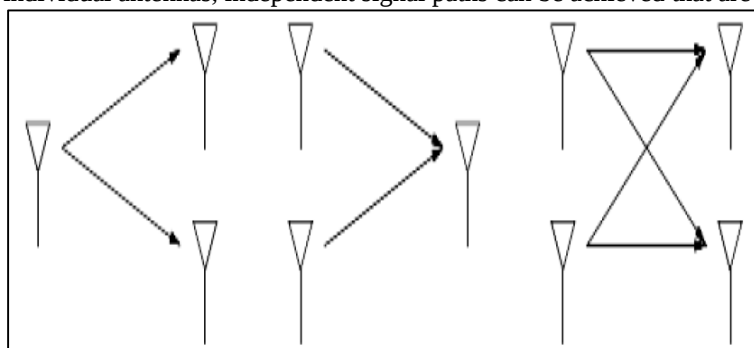


Fig. 2: Antenna diversity techniques

MIMO channel also provide array gain, multiplexing gain and diversity gain due to these three properties of MIMO it is highly acceptable in modern communication system. The channel capacity of MIMO system is

$$C_{MIMO} = B \cdot \log_2 [1 + M \cdot N \cdot SNR] \text{ (bps/Hz)} \quad (1)$$

Signal to noise ratio is given by,

$$SNR = M \times N \times SNR \quad (2)$$

M= no. of transmitting antennas

N=no. of receiving antennas

For the detection of multiple no. of transmitted signal on the receiver side, there are various space time coding (STC) and Space Multiplexing (SM) techniques are available. Aim of STC is improvement of information protection and aim of SM is to enhance the data rates. These two system is namely (space-time block coding) STBC and (vertical Bell Labs layered space time) V-BLAST.

#### A. Space Time Block Coding scheme

Space time Block Coding method fulfills the advantage of diversity gain. Which is proportional to the no. of antennas at the transmitting and at the receiving side. one of the method is Alamouti scheme for two transmits antennas. both time and space domains are utilized by Alamouti algorithm for data encoding thereby improving the system performance. During the first time interval, both the transmitting antennas are radiating two data symbols  $s_0$  and  $s_1$  at a time. In the second time interval, their complex conjugates  $s_1^*$  and  $s_0^*$  will be transmitted. At the receiver side the data vector is created by accommodating two subsequent samples at a time.

$$r = \frac{1}{\sqrt{2}} sh + n \quad (3)$$

$r = [r_0, r_1]^T$  is the symbolical representation of the received vector

$h = [h_1, h_2]^T$  is the complex channel gain

$n = [n_0, n_1]^T$  is the noise vector

$S$  = specifies space time coding

$$S = [S_1 \ S_2] = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$$

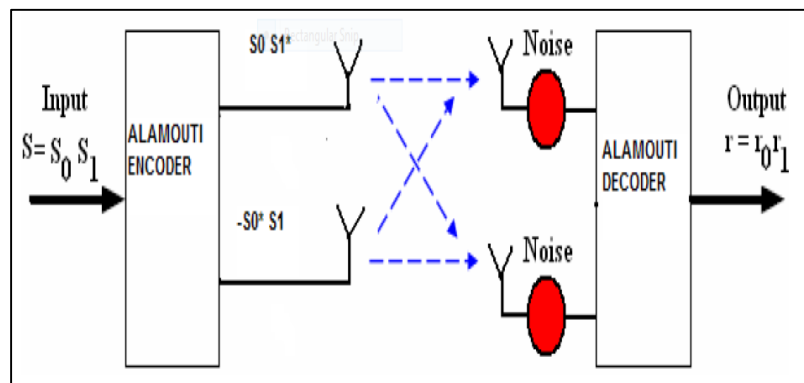


Fig. 3: MIMO Alamouti Scheme

#### B. Blast Technique

In these advantages of fading techniques is taken which are known as multiplexing gain properties of this structure. The idea behind the technique is to increase transmission of the system. Mainly two techniques of blast are popular which is D-blast and V-blast.

In D-blast the ordering and decoding structure follow the diagonal pattern or circular pattern which will become more and more complex when number of transmitter and receiver is increases. Simple structure is V-blast In this the data stream is bifurcated into sub streams proportional to the no. of transmitting antennas and then individual antenna will transmit each independent sub stream which all are going to received and detected by multiple receivers by using this For 30 khz channel bandwidth, data rate ranges from 0.5 Mbps to 1 Mbps while with traditional techniques data rate range is of only 50 kbps. Here number of receiver is same or greater than the number of transmitter and power is scaled by  $1/M$ . So, total power remains constant independent of number of the transmitters is  $M$ .

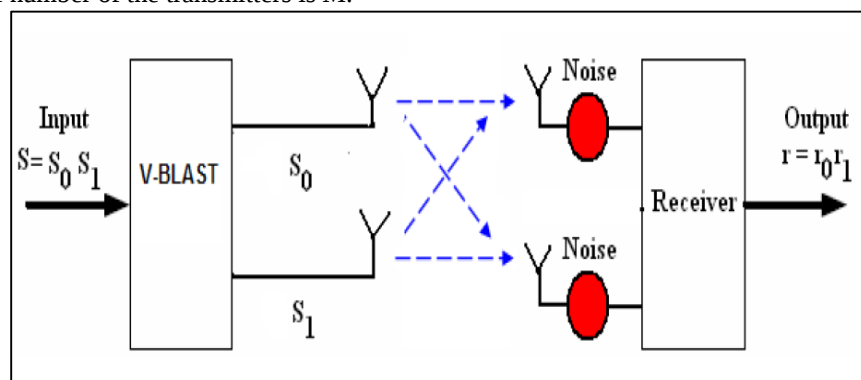


Fig. 4: V-Blast Arrangement

The received signal is designated by means of the following matrix. Where

$$r = Hs + v \quad (4)$$

$$\begin{pmatrix} r1 \\ \vdots \\ rM \end{pmatrix} = \begin{pmatrix} S1 \\ \vdots \\ SN \end{pmatrix} \begin{pmatrix} h11 \dots h1N \\ \vdots \\ hM1 \dots hMN \end{pmatrix} + \begin{pmatrix} v1 \\ \vdots \\ vN \end{pmatrix}$$

R = received vector

H= gain factor

S= transmitted data

V= noise vector

There are three most important algorithms in v-blast architecture

- Maximum likelihood (ML) detection algorithm
  - Zero forcing (ZF) detection algorithm
  - Minimum mean square error (MMSE) detection algorithm
- 1) ML detection- optimal detection algorithm the method uses the fundamental of comparison between the signals of the receiving end and the transmitted symbols of the sender end and estimates the transmit symbol vector according. but by doing this complexity increases.
  - 2) ZF detection- sub optimal detection algorithm known as Zero Forcing (ZF) algorithm. Within each time slot, initially the strongest signal is detected and then its effect is eliminated from the rest of the symbols and then the process continues until the last data is detected. But the problem with this technique is that it only considers the effect of interference produced on one symbol The change due to noise components will not be recognized or even corrected.
  - 3) MMSE detection method- limitation of ZF detection is eliminated by MMSE detection method because it remove the effect of noise and interference that transmitted symbols and their estimated versions are differing with small error so in presence of noise MMSE is better than ZF detection.

#### IV. SIMULATION RESULTS

- Simulation of traditional Antenna Technique in WiMAX
- Simulation of MIMO-Alamouti scheme in WiMAX
- Simulation of MIMO-VBLAST scheme in WiMAX

First three parameters remain constant for simplicity in all the diversity techniques for comparison point of view and only the number of antenna varies with different diversity techniques.

Table – 2  
Wi-MAX parameter

| Parameters                                                 | Values                 |
|------------------------------------------------------------|------------------------|
| Cyclic prefix                                              | ¼                      |
| OFDM symbols                                               | 256                    |
| Modulation order                                           | 16 QAM ¾ (rate id = 4) |
| No. of Transmitting Antenna As per the diversity technique | As per requirement     |
| No. of Receiving Antenna As per the diversity technique    | As per requirement     |

##### A. Wi-MAX SISO

For Wi-MAX SISO number of transmitting and receiving antenna remain same which equal to one. Where the BER is solely dependent upon SNR as it is a traditional single input single output system as the value of SNR increases, BER will get improve to certain extent. It can be observed that at lower values of SNR, the value of BER is comparatively very high that indicates poor performance of Wi-MAX system. Therefore to achieve lower BER at some manageable value of SNR, the antenna diversity technique is useful.

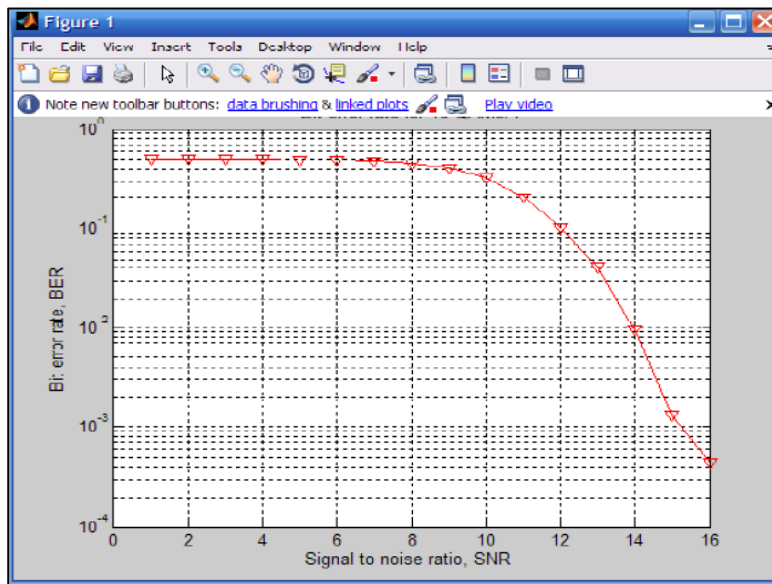


Fig. 5: BER v/s SNR curve of Wi-MAX SISO

### B. Wi-MAX MIMO ALAMOUTI

For Wi-MAX MIMO number of transmitting and receiving antenna remain same which equal to two. Where the BER is solely dependent upon SNR as it is a traditional single input single output system as the value of SNR increases, BER will get improve to certain extent. here the BER improvement is much much better than that of the traditional antenna System Under the poor channel condition, the BER can further be improved up to a considerable amount because of antenna diversity mechanism.

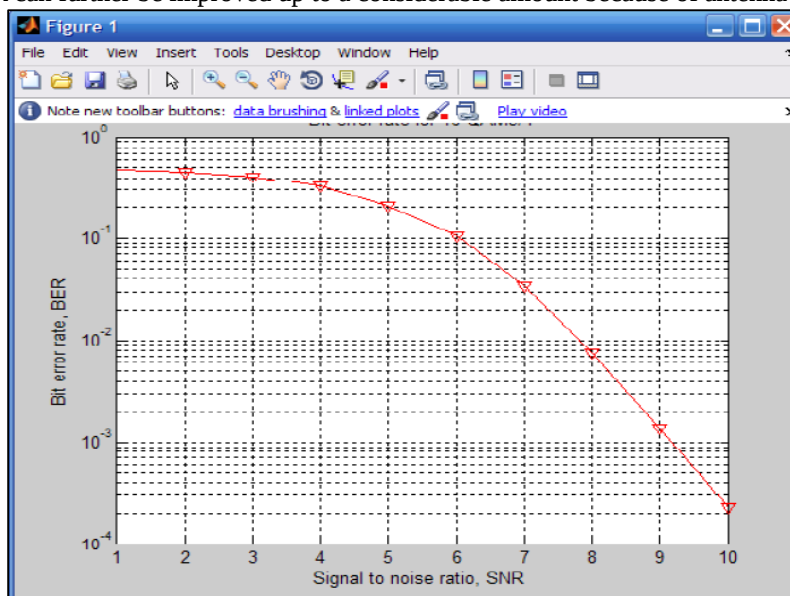


Fig. 6: BER v/s SNR curve of Wi-MAX MIMO]

### C. Wi-MAX MIMO V- BLAST

The simulation of Wi-MAX VBLAST system has been carried out using three detection sub techniques of VBLAST which is Zero Forcing (ZF), Minimum Mean Square Error (MMSE) and Maximum Likelihood (ML). With increment in SNR the BER variations are different for all three methods in V-blast. The best performance at increasing SNR is observed with ML detection of VBLAST among all three. The only drawback with it is the complexity of algorithm.

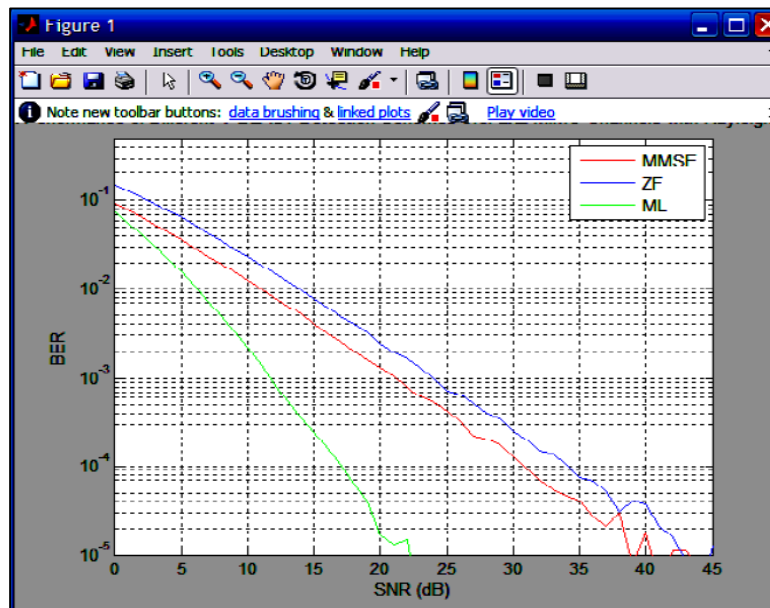


Fig. 7: comparative analysis of v-blast]

Table – 3  
SNR v/s BER values for different detection]

| SNR   | SISO | MIMO    | ML detection | ZF detection | MMSE detection |
|-------|------|---------|--------------|--------------|----------------|
| 2 db  | 0.5  | 0.5     | 0.0002       | 0.0003       | 0.0001         |
| 10 db | 0.3  | 0.0002  | 0.00001.     | 0.00003      | 0.00002        |
| 15 db |      | 0.00001 | 0.0001       | 0.01         | 0.005          |

## V. CONCLUSION

By simulation result we can say that SNR is bound limitation in traditional WiMAX system which has been overcome by the implementation of antenna diversity algorithms. and can be concluded that, implementation of MIMO techniques in any type in WiMAX system will make it more efficient. With MIMO-Alamouti, the WiMAX system will become efficient in terms of BER and with MIMO-V BLAST, the system will become more efficient in terms of Data Rate.

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