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Performance Analysis of QoS Parameters for WiMAX Network

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Abstract: ***The IEEE 802.16 standard is a promising technology for 4G mobile networks. Though supporting versatile service classes, best effort (BE) service class is expected to dominate WiMAX networks, due to operational simplicity. One of bandwidth request mechanisms that subscriber stations (SS) can utilize to issue bandwidth requests (BW-REQ) for BE connections is contention-based random access. An SS starts a timer T16 when transmitting a BW-REQ. If getting a grant before timer expiration, the SS transmits data packets at the allocated time slots; otherwise it performs truncated binary exponential backoff process for BW-REQ retransmission. The default value of T16 is one frame time. However, T16 impacts on contention and request collision significantly. In the paper, we develop an analytical model for T16 timer setting. Besides, we derive analytical expressions for the average number of tries per BW-REQ and the average packet delay. We compare the theoretical results of fixed and adjustable timers. The results show that adjusting timer reduces both the number of collision and the average packet delay.***

Keywords: WiMAX, Ber, delay, TCP/IP, Fixed

1. Introduction

WIMAX is standard of (world wide introperapiality for micro wave access), WIMAX is an emerging global broadband wireless system based on IEEE 802.16 standard. It does provide internet service to the subscriber's with high speed. Standard wireless metropolitan area net work (MAN) technology that will provide a wireless alternative to cable DSL for last mile broadband access, it will also be used as complimentary technology to connect Wi-Fi 802.11 hot spot to the internet. WIMAX is wireless communication because one of its component's WIMAX tower, the tower is connected with other towers and the subscriber terminal's by wireless.

2. Motivation

To increase the data rate of WIMAX system and to provide broadband service for a long distance.

3. Methodology

Descriptive analysis, Mathematical model, Computer model, Software MATLAB program

4. Specification of WiMAX

A. Introduction of IEEE 802.16 standard:

When a user wants a network service of broadband access, he considers to use digital subscriber line (DSL) and Cable-modem to connect with the network. Some broadband access Technologies like LMDS or MMDS have been proposed early in the past, there was no uniform technical standard for LMDS and MMDS then, and the air interfaces. Provided by different manufacturers were incompatible, which limited the development of the whole communication industry severely.

IEEE802.16 is established to support air interface between WIMAX tower and user terminal.

1) IEEE 802.16-2001: It's a wireless network specification applicable for Wireless Metropolitan Area Network (WMAN), IEEE 802.16-2001 is only suitable for Clear areas because the microwave signals in the frequency range of 1066 GHz have poor penetrability, and the signals are easily affected by rain attenuation. Therefore communication between the base station (BS) and the subscribe station (SS).is line of sight (LOS).

2) IEEE 802.16a: IEEE 802.16 standard he extension of IEEE 802.16-2001. It operates in the frequency range of 211GHz, The signal coverage reaches up to 50km (with radius of 10km), IEEE 802.16a can operate in the NLOS (Non-Line-of-Sight), The support of mesh topology is add to IEEE 802.16a.

3) IEEE 802.16-2004 (IEEE 802.16d): (IEEE 802.16d) or IEEE (802.16-2004) standard is defines details specifically to the physical layer and the media access control (MAC) layer of the 2-66GHZ frequency range.

4) IEEE 802.16-2005 (IEEE 802.16e): IEEE802.16e or IEEE 802.16-2005 IEEE802.16e standard firstly emphasized the application of fixed network. However, resulting from the progress of wireless communication technology and demand of user market, only the mobility features can guarantee a 2 broader market prospect of wireless broadband access service. IEEE802.16e supports the high-speed information transmission in moving, In addition to supporting mobile communication.

Table 2.1: 802.16 standards

	802.16	802.16a	802.16e
Spectum	10-66 GHz	2-11 GHz	2-6 GHz
Channel bandwidth	20, 25, and 28 MHz	1.5 to 20 MHz	1.5 to 20 MHz with UL sub channels
Modulation	QPSK, 16QAM, 64 QAM	OFDM 256 sub carriers QPSK, 16QAM, 64 QAM	OFDM 256 sub carriers QPSK, 16QAM, 64 QAM
Bit rate	32-134 Mbps (28 MHz)	75 Mbps (20 MHz)	15 Mbps (5 MHz)
Channel conditions	LOS	Non-LOS	Non-LOS
Typical cell radius	2-5 Km	7-10 Km, max 50 Km	2-5 Km
Application	Fixed	Fixed and portable	Mobility

5. Physical layer and MAC layer characteristics: A. Physical layer characteristic

It provides:

1. Encoding and decoding.
2. Preamable generation and removal.
3. Bit transmission and reception.

WIMAX adopts various advanced technologies to realize the NLOS and LOS transmission.

The physical layer supports two kinds of wireless duplex multiple access, i.e., TDD/TDMA and FDD/TDMA, to adapt to the requirements of system in different countries or regions. The physical layer may change subject to the performance of transmission channel. The modulation mode and parameters of physical layer can be adjusted dynamically to guarantee good transmission quality.

B. 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.

The MAC layer is divided into three sub-layers:

a) Service Specific Convergence Sub-layer (CS).
b) Common Part Sub-layer (CPS).
c) Privacy Sub-layer (PS).

1) 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).

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

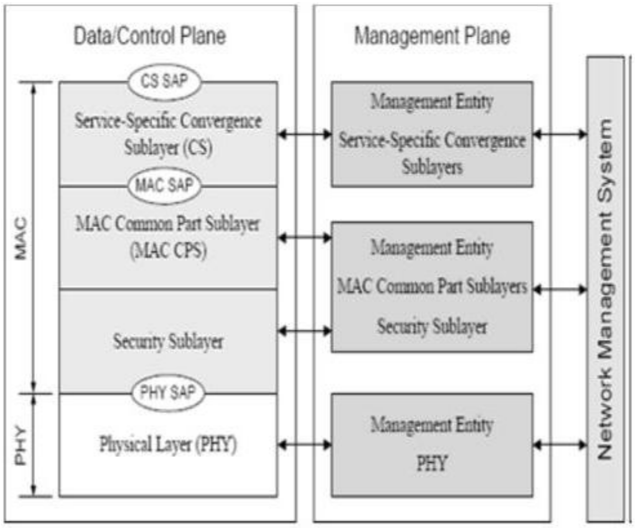


Figure 2.1: MAC Layer and PHY Layer of WIMAX

6. Structure of WIMAX Network System

A. PMP:

As shown in Figure, 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.

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.

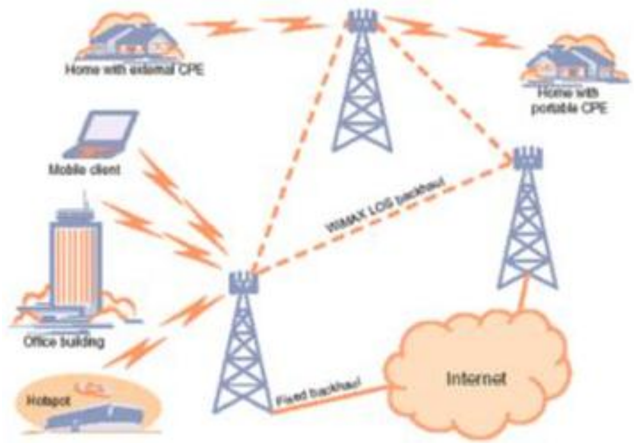


Figure 2.2: PMP architecture

B. Mesh:

As shown in Figure, 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).

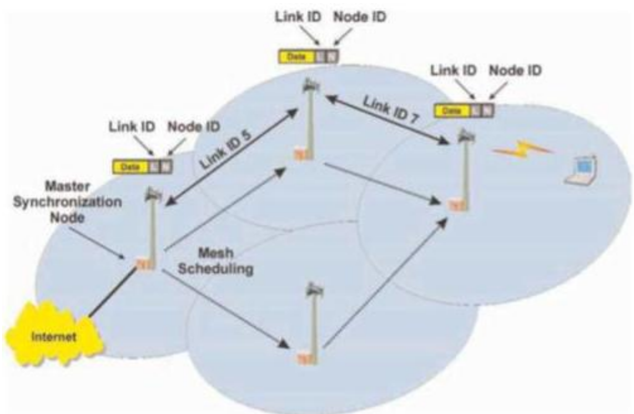


Figure 2.3: Mesh architecture

The Mesh application mode is characterized by the mesh network structure, which can be arranged flexibly to realize elastic extension of network in accordance with the actual situation. For areas such as suburban areas far away from the backbone network, which is seldom covered by the cable network, this application mode can be used to expand the coverage. The scale depends on the radius of base station, the size of the covered areas, etc.

C. 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.

D. 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 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.

7. Application Scenarios of WIMAX

A. Fixed Application Scenario:

The fixed access service is the most fundamental mode of 802.16 operation network, including the services of Internet access, transmission carrying, and Wi-Fi hotspot Backhaul.

B. Nomadic Application Scenario:

The nomadic service is the nest development stage of fixed access. The terminal connects to an operators network via different access points. In the connection of each conversation, the user terminal only realizes the access of station type. For different network accesses, the data transmitted will not be reserved. The nomadic and all Subsequent application scenarios support the roaming service and have the function of terminal power supply management.

C. Portable Application Scenario:

In this scenario, the user can connect to the network in walking. The connection will not be interrupted except for switching between residential areas. The portable service develops on the basis of nomadic service. Since this stage, the terminal is allowed to switch between different base stations. When the terminal holds still, the application model of portable service is the same as fixed service and nomadic service. When the terminal switches, the user experiences a momentary (maximum 2s) service interruption or delay. After the completion of switching, TCP/IP application refreshes the current IP address or re-establishes the IP address.

D. Simple Moving Application Scenario:

In this scenario, the user can use the broadband wireless access service in walking, driving or taking bus, etc. However, when the moving speed of terminal reaches 60120km/h, the data transmission speed descends. It is the first scenario allowing switching between neighboring base stations. In the process of switching, the data package losses are controlled within certain scope. In the worst case, TCP/IP conversation is not interrupted, but the service of application layer might be interrupted. After the completion of switching, QoS resets to the initial level. The simple moving and mobile networks are required to support the suspend mode, idle mode, and paging mode. The mobile data services are the main applications in mobile scenario (including simple moving and mobile), including the popular mobile E-mail, streaming media, videophone, mobile games, mobile VoIP, which occupy more wireless resources.

E. Mobile Application Scenario:

In this scenario, the user can use the broadband wireless access service at a moving speed of 120km/h or higher. If no network connection is available, the user terminal is in a state of low power consumption.

8. Descriptive Analysis

This demo showcases the main components of the WMAN 802.16-2004 OFDM physical layer using two models: one with STBC and one without, which has all the mandatory coding and modulation options.

The tasks performed in the communication system models include Generation of random bit data that models a downlink burst consisting of an integer number of OFDM symbols. Forward Error Correction (FEC), consisting of a Reed-Solomon (RS) outer code concatenated with a rate-compatible inner convolution code (CC). Data interleaving. Modulation, using one of the BPSK, QPSK, 16-QAM or 64-QAM constellations specified.

Orthogonal Frequency Division Multiplexed (OFDM) transmission using 192 sub-carriers, 8 pilots, 256-point FFTs, and a variable cyclic prefix length. Space-Time Block Coding using Alamouti's [3] scheme. This is implemented using the OSTBC Encoder and Combiner blocks in Communications Block set. A single OFDM symbol length preamble that is used as the burst preamble. For the optional STBC model, the single symbol preamble is transmitted from both antennas. A Multiple-Input-Single-Output (MISO) fading channel with AWGN for the STBC model. A choice of non-fading, flat-fading or dispersive multipath fading channel for the non-STBC model. OFDM receiver that includes channel estimation using the inserted preambles. For the STBC model, this implies diversity combining. Hard-decision demodulation followed by deinter leaving, Vitter decoding, and Reed-Solomon decoding.

Both models also use an adaptive-rate control scheme based on SNR estimates at the receiver to vary the data rate dynamically based on the channel conditions. The models use the standard specified set of seven rates for OFDM-PHY, each corresponding to a specific modulation and RS-CC code rate as denoted by rate-ID.

Table 4.1: specific modulation and RS-CC code rate as denoted by rate-ID

Rate_ID	ModulationRC_CC rate	
1	BPSK1/2	
2	QPSK1/2	
3	QPSK3/4	
4	_QAM3/4	16
5	_ QAM3/416	
6	_QAM3/4	16
7	_QAM3/464	

The STBC link model uses a MISO fading channel to model a two transmitter, one receiver (2x1) system. The fading parameters specified are assumed to be identical for the two links. The Space-Time Diversity Combiner block uses the channel estimates for each link and combines the received signals. The combining involves simple linear processing using the orthogonal signaling employed by the encoder.

Furthermore, the models include blocks for measuring and displaying the bit error rate after FEC, the channel SNR and the rate-ID. A scatter plot scope is used to display the received signal, which helps users visualize channel impairments and modulation adaptation as the simulation runs.

The subsystems and blocks used in the models are color-coded to make viewing easier. The communication system operations are in blue, control systems and signals are in orange and the performance evaluation, displays and plots are in yellow.

To view any of these operations in detail, double-click the corresponding subsystem to open the underlying subsystem implementation. For the ones that have mask dialogs, choose Look Under Mask from the window's Edit menu.

A. Mathematical model:

The mathematical model was described using different types of modulation such as Bpsk, QPSK, QAM and the Bit Error Rate (BER) for these different types of modulation was given in form of equation as shown below.

Bit error rate in BPSK is given by:

P e; BP SK = Q2 (4.1)

Where: Q = x1=2e(u2)du (4:2)

Q(s) is the Gaussian integral, sometimes referred to as the

Q-function = Eb=N o = SN R (4.3)

Bit error rate in QPSK is given by:

P e; QP SK = Q2 (4.4)

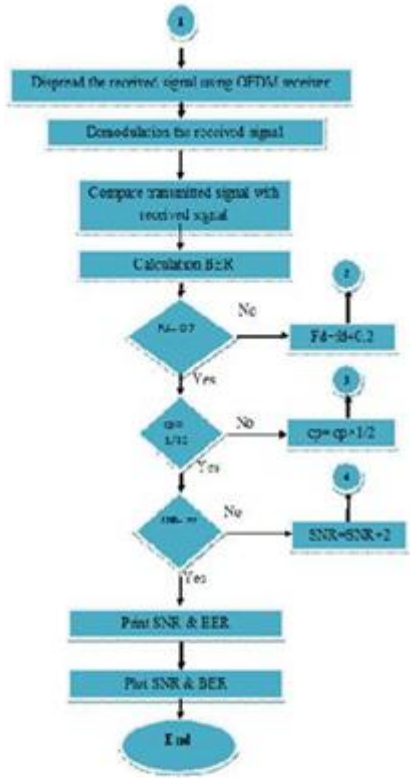
Bit error rate in M-QAM is given by:
P e; M QAM = 1=log2M1 1=M[4P (CI) + 4(M 2)P (CII) + (M 2)2P (CIII] (4:5)

Where:

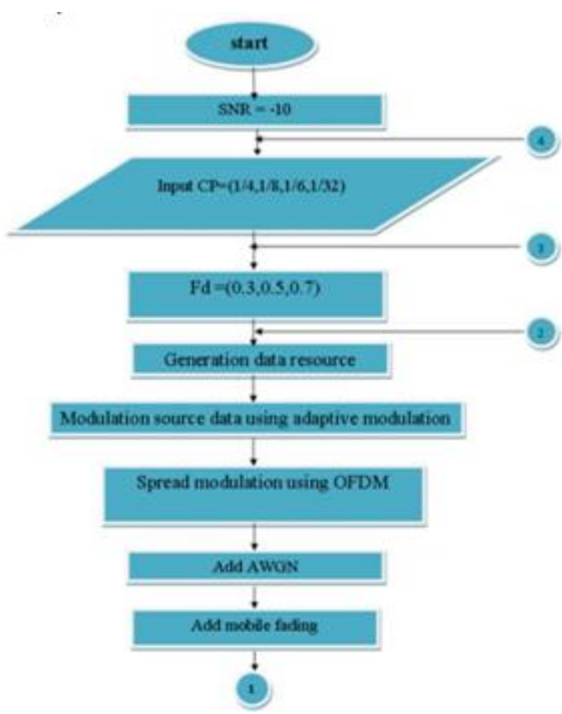
P (CI) = [1 Q((2a2=N(0)))]2 (4.6)

P (CII) = [1 2Q((2a2=N0))][1 Q((2a2=N(0)))] (4.7)

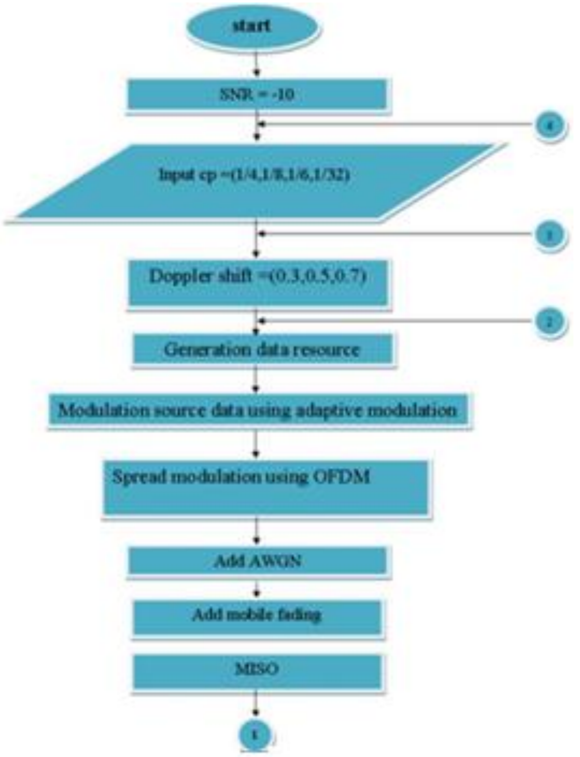
P (CIII) = [1 2Q((2a2=N0))]2 (4.8)



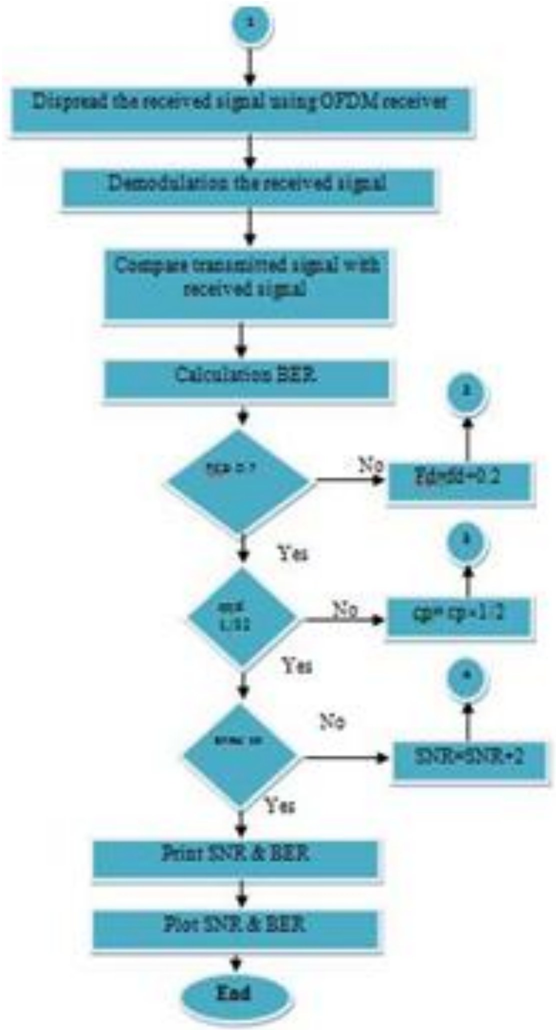
Computer model



Computer model without enhancement



Computer model with enhancement



Computer model with enhancement

9. Simulator Environment

Table 4.2: SNR with BER

SNR	BER
-10	0.499
-8	0.4997
-6	0.4988
-4	0.494
-2	0.4799
0	0.3952
2	0.1251
4	0.006144
6	0.08367
8	0.01669
10	0.00002025
12	0
14	0.0001475
16	0.0001103
18	0
20	0

10. Simulator Block Diagram

A. Simulator block diagram without enhancement

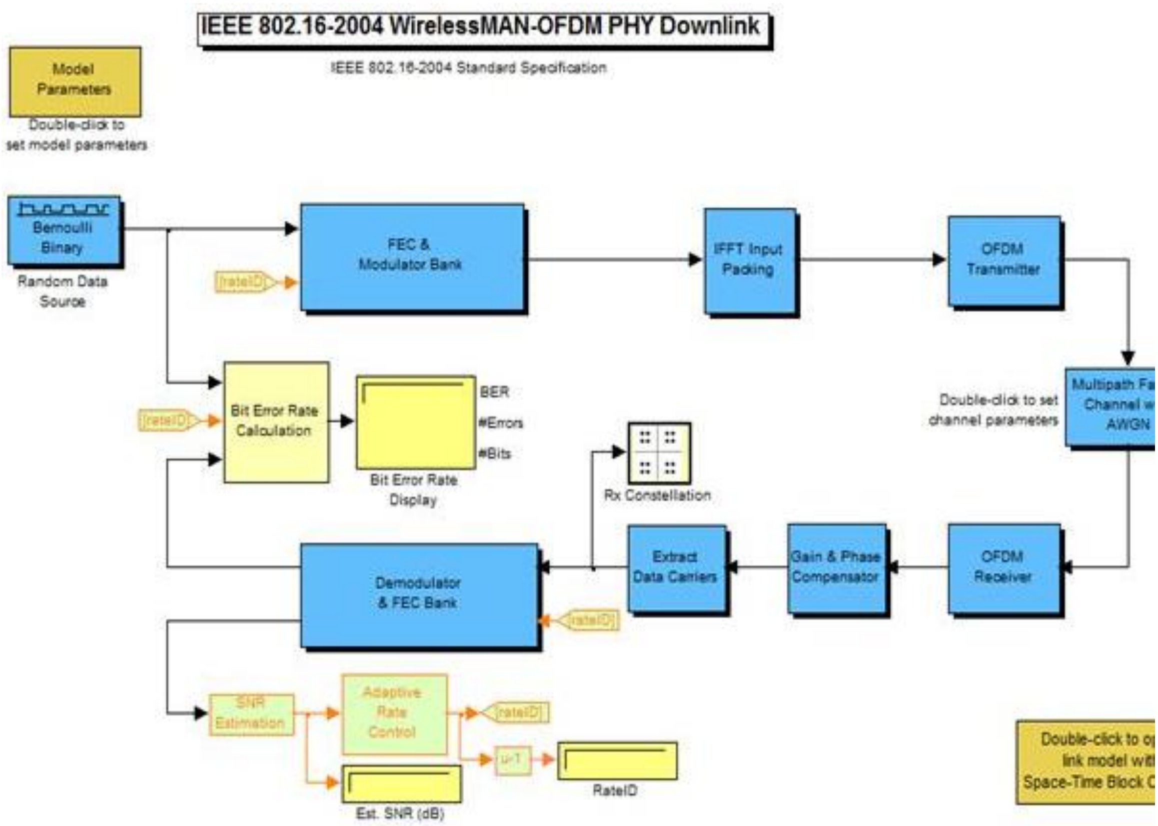


Figure 4.1: simulator block diagram without enhancement

B. Simulator block diagram with enhancement

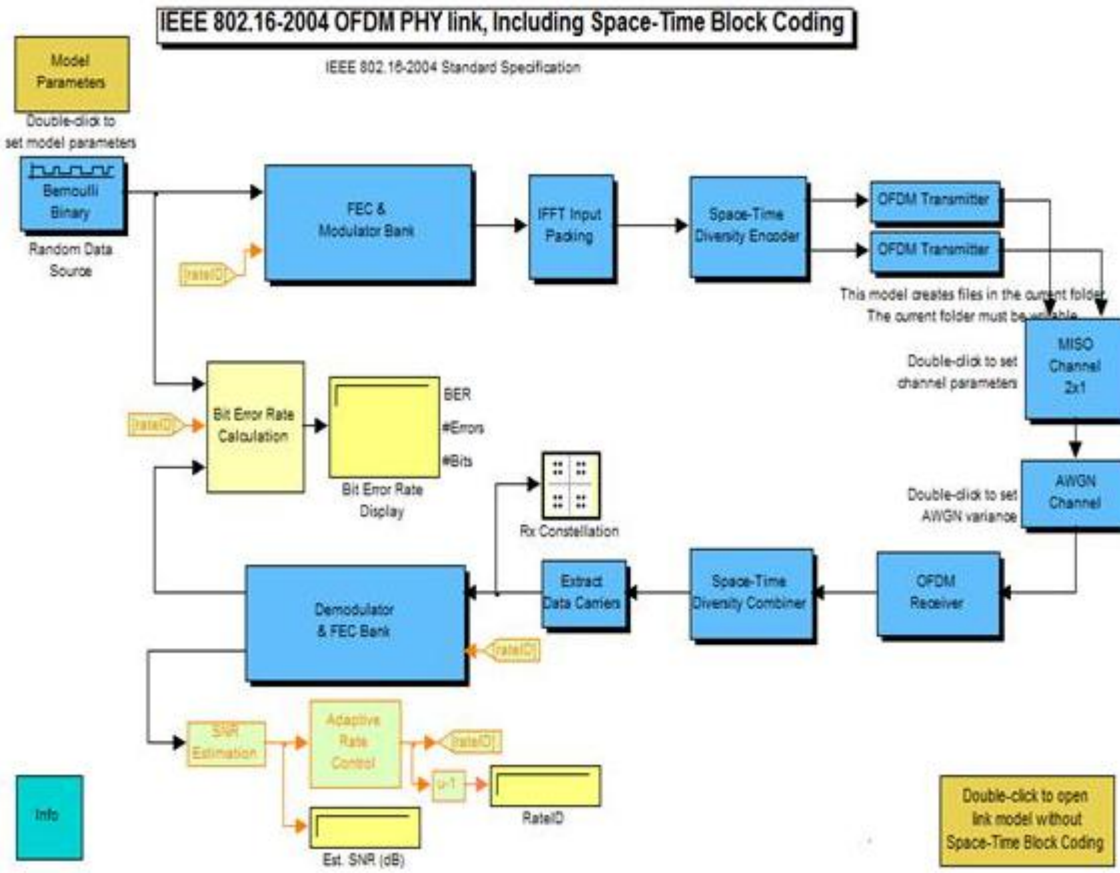


Figure 4.2: Simulator block diagram with enhancement

11. Result

A. Results Without enhancement

Cp = 1=4; fd = 0:5; BW = 3:5MHZ

Table 4.3: Cp = 1=4; fd = 0:5; BW = 3:5MHZ

SNR	BER
-10	0.5009
-8	0.4996
-6	0.5017
-4	0.4926
-2	0.4829
0	0.3926
2	0.1188
4	0.004462
6	0.09365
8	0.01442
10	0.00005105
12	0
14	0.0001217
16	0.0001382
18	0
20	0

Table 4.4: Cp = 1=8; fd = 0:5; BW = 3:5M HZ

SNR	BER
-10	0.5002
-8	0.5008
-6	0.4988
-4	0.4947
-2	0.4798
0	0.3927
2	0.1229
4	0.004447
6	0.08875
8	0.01836
10	0.000049
12	0
14	0.0001502
16	0.0001547
18	0
20	0

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Table 4.5: Cp = 1=8; fd = 0:5; BW = 3:5MHZ

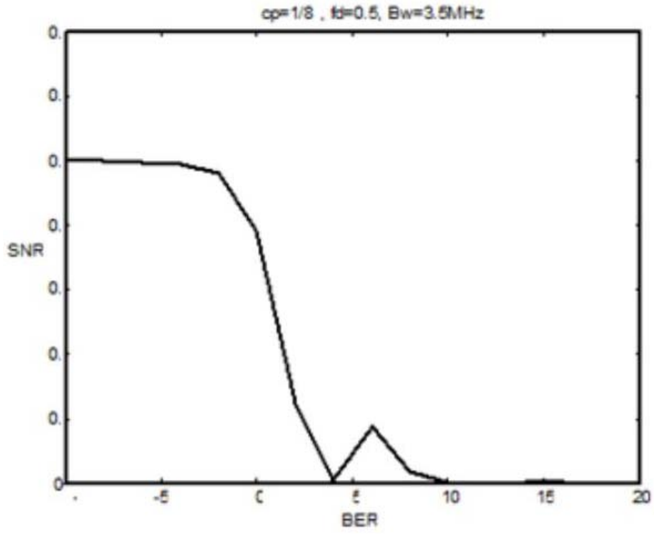
SNR	BER
-10	0.499
-8	0.4997
-6	0.4988
-4	0.494
-2	0.4799
0	0.3952
2	0.1251
4	0.006144
6	0.08367
8	0.01669
10	0.00002025
12	0
14	0.0001475
16	0.0001103
18	0
20	0

Table 4.6: Cp = 1=16; fd = 0:5; BW = 3:5M HZ

SNR	BER
-10	0.4994
-8	0.5002
-6	0.4961
-4	0.4929
-2	0.4846
0	0.3933
2	0.1241
4	0.004637
6	0.07474
8	0.01795
10	0.00008711
12	0
14	0.0001992
16	0.0003368
18	0
20	0

B. Results without enhancement

Figures without enhancement



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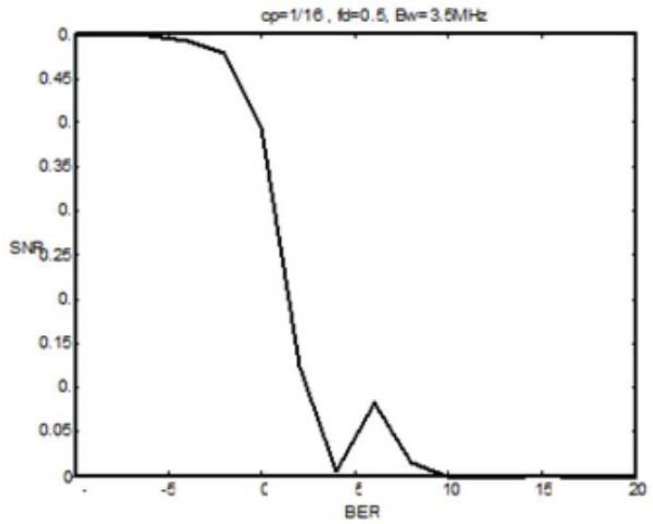

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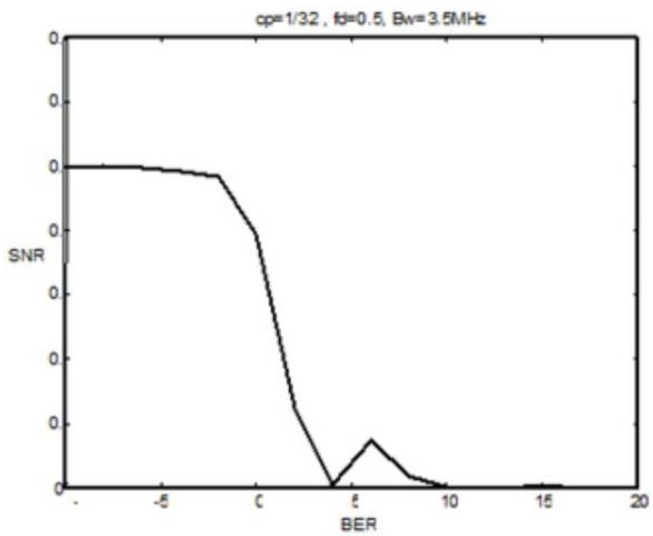

Without enhancement

12. Results Discussion

Increase the signal to noise ratio we find the bit error rate decrease, because increasing SNR mean the signal power is stronger than noise power, there the system performance will increase, but there are some abnormalities in SNR value (i.e. increasing SNR, the BER also increase) this reefer's to adaptive modulation select the suitable modulation for suitable communication environment.

The evaluation of WIMAX system before and after enhancement process.

13. Conclusion

The study, analyze, simulation and evaluation of WIMAX system before and after enhancement process have been done using MATLAB software program.

The parameter's which were taken into consideration of simulation were cycle prefix, Doppler shift, signal to noise ratio and bandwidth.

The results were obtained in terms of bit error rate against signal to noise ratio in tables and graphs.

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