ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Performance Evaluation of WIMAX over OFDMA with Different Modulation Techniques

Haider Mohammed Turki AL-HILFI,
Ph.D Student,
Department of Electronics, Telecommunication and Information Technology,
University Polytechnic of Bucharest, Iraq.

Bassam Abdulmunem Salih
Assistant Lecturer,
Department of Electrical Engineering,
University of kufa/ College of Engineering.

Abstract:
Advancements in broadband and mobile communications have provided many subscribers with a large number of benefits, for instance high speed data connectivity, voice and video applications, at affordable rates and with good quality of service. WiMAX is an eminent technology that provides broadband and IP connectivity on "last mile" scenario. It offers both line of sight and non-line of sight wireless communication. Orthogonal frequency division multiple accesses is used by WiMAX on its physical layer. Orthogonal frequency division multiple access uses adaptive an modulation technique on the physical layer of WiMAX and it uses the concept of cyclic prefix that adds additional bits at the transmitter end. The signal is transmitted through the channel and it is received at the receiver end. Then the receiver removes these additional bits in order to minimize the inter symbol interference, to improve the bit error rate and to reduce the power spectrum. In our research work, we investigated the physical layer performance on the basis of bit error rate, signal to noise ratio, power spectral density and error probability. These parameters are discussed in two different models. The first model is a simple OFDM communication model without the cyclic prefix, while the second model uses CP.

Key Words:
WIMAX, BPSK, QPSK, QAM 16, QAM 64, BER.

1. INTRODUCTION TO WIMAX:

1.1 History of Broadband Communication

Marconi presented the idea of wireless communication in 1895.

Today it is used in satellite transmission, broadcasting of radio and television channels and cellular networks. There have been tremendous advancements in the transmission and reception of voice and data through wireless communication.

1.2 Generations of Mobile Phone:

Before 1977, wireless communication was only used in military applications and for research purposes in satellite communication. The evolution of Advanced Mobile Phone System (AMPS) was the starting and turning point in wireless communication by offering a two way Communication (i.e. Full Duplex Mode). It uses analogue Technology and also supports data streams up to 19.2 Kbps. AMPS are an example of first generation wireless phones.

Table 1: Mobile Generation

Generation	standard	Mobile access	Frequency band	Throughput
2 G	GSM	TDMA/FDMA	890-960(MHz) 1710-1880(MHz)	9.6Kbps
2.5G	GPRS	TDMA/FDMA	890-960(MHz)	171Kps

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

			1710-1880(MHz)	
2.7G	**EDGE**	**TDMA/FDMA**	**890-960(MHz) 1710-1880(MHz)**	**384Kbps**
3G	**UMTS**	**W-CDMA**	**1885-2025(MHz) 2110-2200(MHz)**	**2Mbps**

The 4th Generation mobile phone systems is under research with the objective of attaining a fully Internet Protocol (IP) based integrated system. The only difference with 3G is that it provides an IP based solution for data, voice and multimedia services to subscribers on the basis of two concepts i.e. “Anywhere” and “Anytime”. In this scenario, the users are always connected to the network with good and reliable data connectivity, wherever they go and whatever the time is. The generations that came after the 2.5th generation are also referred to as broadband generations, because these generations have high data rates and provide multimedia services to their subscribers.

1.3 Broadband:

The term Broadband has no specific definition because every country has different characteristics for a broadband connection, but normally broadband is defined as high speed, reliable and on-demand internet connectivity. Broadband access not only offers access to download files more quickly and provides faster web surfing, but also enables multimedia applications like real-time audio, video streaming, multimedia conferencing and interactive gaming.

The broadband connection is also used as voice telephony by using Voice overInternet Protocol (VoIP) technology. Different organizations such as International Telecommunication Union (ITU) or other international regulators specified that if the download speed is in the range of 256 Kbps to 2 Mbps or higher,then it falls in the category of Broadband connections. By considering these points, they drafted the formal definition as: “As an always-on the data connection side that is able to support various interactive services and that has the capability of a minimum download speed of 256 Kbps.” In recent years, a remarkable growth in wireless and broadband technologies has taken place, and these technologies enjoyed rapid market adoption. The graph in Figure 1 indicates the growth rate of broadband and wireless technologies throughout the world in recent years.

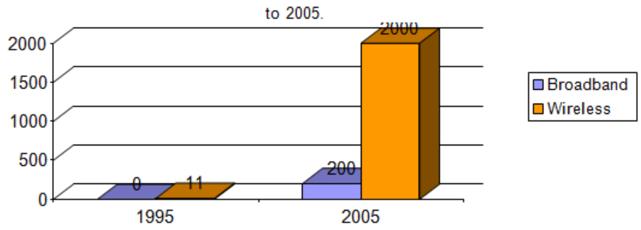

Figure 1.Increase in the No. of Subscribers in Millionsbetween 1995 and 2005.

Cable Modem:

Cable Modem is a type of modem that provides broadband connectivity to subscribers over coaxial television cables. It is used to deliver sound and pictures to the subscriber’s TV set. A cable modem enables users to connect their PC to a local cable TV line and enjoy transmission speeds of 1.5 Mbps or more. A cable modem is an external device with two connections; one for the TV cable wall outlets while the other one is for the PC.

Optical Fiber:

Fiber or Optical Fiber uses either transparent glass or plastic or a combination of these two materials. It is a newer technology that permits transmission at much higher data rates as compared to other sources of

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

communication, over longer distances.This technology converts the electrical signal that carries data to a light source and sends it through transparent glass fiber. The optical fiber cable diameter is the same as the diameter of a human hair. The optical fiber connection not only provides broadband connectivity but at the same time also delivers voice and video services such as VoIP and Video on Demand. Optical fiber cables can be classified into single mode fiber and multi-mode fiber cables. Single mode fiber is used for transmission over longer distances, while multi-mode fiber is used for shorter distances (up to 500 meters). The transmission speed in optical fiber communications is much higher than current DSL and cable modem speeds. It is typically in the range of tens or even hundreds of Mbps.

Broadband over Power line (BPL):

It is also called Power Digital Subscriber Line (PDSL) and uses Power Line Carrier (PLC) for sending and receiving radio signals over the existing electric power distribution network. The PLC modems can transmit data in medium and high frequencies, i.e., in the range of 1.6 MHz to 80 MHz electrical carriers. The modem has a speed range of 256 Kbps to 2.7 Mbps, whereas the use of repeaters boosts data rates to up to 45 Mbps. BPL is a new emerging technology, and so far it has been deployed in very limited areas.but it is an evolving technology because power distribution networks are installed everywhere and thus this is the only technique that perfectly provides broadband facilities to every customer.

Wireless Broadband Technologies:

Wireless broadband technologies are bringing the broadband experience closer to their subscribers by providing certain features, convenience and unique benefits. These broadband services can be categorized into two types; Fixed Wireless Broadband and Mobile Broadband. The fixed wireless broadband provides services that are similar to the services offered by fixed line broadband, but the wireless medium is used for fixed wireless broadband and that is their only difference.

Mobile broadband offers broadband services with an addition, namely the concept of mobility and the nomad city. The term nomad city can be defined as the “Ability to establish a connection to the network from different locations via different base stations” while mobility is “the ability to keep ongoing connections engaged and active while moving at vehicular speeds”. Examples of wireless broadband technologies are Satellite communication, Wireless LAN and WiMAX.

Satellite Broadband:

Satellite Communication is also used to provide broadband services for those locations where fixed broadband infrastructure is not available and for those subscribers who live in remote areas. These days, satellite broadband services are used in ships and land vehicles. Satellite Broadband is classified into two types, as follows:

1. One Way Satellite Broadband
2. Two Way Satellite Broadband

Wireless LAN:

Wireless Local Area Network (WLAN) is a wireless technique that has begun to replace wired networks. It connects a number of devices or computers through radio waves. WLAN gives more flexibility and provides mobility to subscribers within a campus or workplace. WLAN not only offers mobility.it also ensures provides ease of installation, affordability and scalability as compared to wired networks. The basic WLAN structure comprises an Access Point (AP) or transceivers placed at fixed locations, which are connected to the wired network through ordinary LAN or Ethernet cables. Devices fitted with wireless Network Interface Cards (NICs) communicate with APs for transmission and reception of data. There are two types of modes in WLAN; Infrastructure Mode and Ad-Hoc mode. Infrastructure mode is comprised of APs connected to the wired network, and these APs communicate with devices that have Wireless NICs. This is also referred to as Basic Service Set (BSS). In Ad-Hoc mode, devices communicate directly with each other and they do not use any AP or any wired network.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

It is also termed as Peer to Peer network or Independent Basic Service Set (IBSS). The Infrastructure and Ad-Hoc networks are shown in Figures 2 & 3.

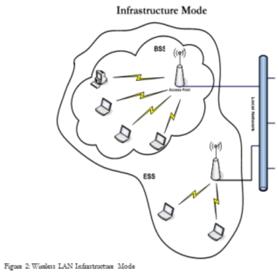

Figure 2:Infrastructure Mode

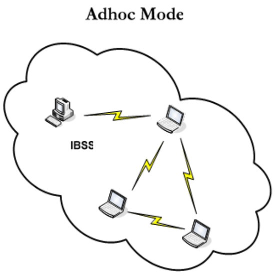

Figure 3: Wireless LAN Adhoc Mod

WiMAX is the abbreviation of Worldwide Interoperability for Microwave Access and is based on Wireless Metropolitan Area Networking (WMAN). The WMAN standard has been developed by the IEEE 802.16 group which is also adopted by European Telecommunication Standard Institute (ETSI) in High Performance Radio Metropolitan Area Network, i.e., the Hiper MAN group. The main purpose of WiMAX is to provide broadband facilities by using wireless communication. WiMAX is also known as “Last Mile” broadband wireless access technology. WiMAX gives an alternate and better solution compared to cable, DSL and Wi-Fi technologies, as depicted in Figure 4.

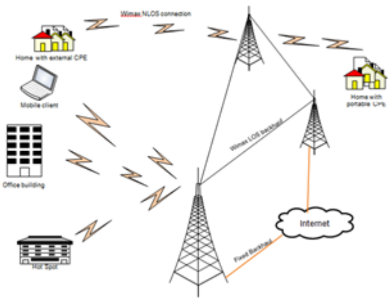

Figure 4: WiMAX Overview

Evolution of WiMAX IEEE 802.16 Working Group:

In 1998, the IEEE 802.16 working group focused on developing the WMAN solution for Line of Sight (LOS) based point to point and point to multipoint wireless broadband systems. It was also decided that the frequency range for IEEE 802.16 will be 10 GHz to 66 GHz. The first WiMAX standard was completed in December 2001 which employs single carrier physical (PHY) layer with burst Time Division Multiplexed (TDM) on the MAC layer.

WiMAX Objectives:

WiMAX has been standardized with different goals, as depicted in Figure 5.

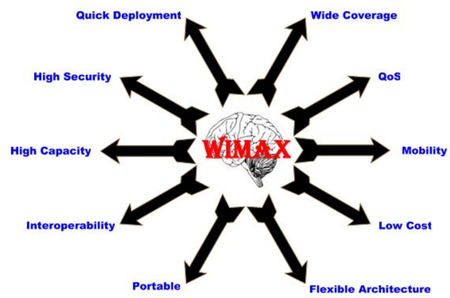

Figure 5: WiMAX Objectives

Interoperability:

The main objective of WiMAX is interoperability. Based on international standards, interoperability make it easier for users to move and use their subscriber module with different operators. All operators can select equipment from different vendors because of the standardized adoption. Wide Coverage: WiMAX can adopt techniques that support several modulation levels, i.e., QPSK, 16 –QAM and 64 – QAM and thus WiMAX systems are capable of covering a large area.

High Capacity:

WiMAX provides higher bandwidths as compared to Global System for Mobile communication (GSM) and Universal Mobile Telecommunication System (UMTS). It uses the 64-QAM modulation technique which provides channel bandwidths of up to 10 MHz.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

WiMAX supports the latest encryption standards like AES and Triple-DES. It encrypts the links between the base station and the subscriber module, ensuring users confidentiality, integrity, and authentication.

Flexible Architecture:

WiMAX supports several system architectures including:

- Point-to-Point
- Point-to-Multipoint
- Ubiquitous coverage

Quality of Service (QoS):

For ensuring QoS, WiMAX can be optimized for different types of traffic:

- VoIP
- Multimedia applications
- Data

1.4.3 Network Architecture of WiMAX:

The network architecture of WiMAX has been developed by the WiMAX Forum Network Group (WiMAX NWG) to ensure interoperability among different vendors and their equipment. The network architecture is based on the IP network service model and supports fixed, nomadic and mobile standards of WiMAX, as shown in Figure 6. The network architecture of WiMAX is logically divided into three parts:

• Mobile Station (MS) is the device which is used by the subscribers to access the network.

• Access Service Network (ASN) consists of Base Stations (BS) or a group of base stations through ASN gateways that connects tothe core network.

• Connectivity Service Network (CSN) provides the IP connectivity and is responsible for the entire suite of core IP network functions.

Access Service Network:

The ASN consists of BS and the Access Service Network gateways (ASN-GW), while the CSN consists of a number of network functions and provides IP connectivity to the mobile stations. The details of these entities are discussed below.

Mobile Stations (MS):

Devices used by the subscribers to use different services provided by the WiMAX operators. The subscriber unit is either a fixed terminal or a portable, mobile terminal.

Base Stations (BS):

The base station is responsible for providing the air interface to the subscriber units. It is also responsible for handoff decisions, Quality of Service (QoS) policy enforcements, DHCP proxy, session managements and radio resource management.

Access Service Network Gateway (ASN-GW):

The Access Service Network Gateway (ASN-GW) acts as a layer 2 traffic aggregation point and works within the Access Service Network (ASN). The ASN-GW is also responsible for intra-ASN location management and paging, radio resource management, admission control, encryption, security issues like AAA, mobility management, QoS and routing to CSN.

Connectivity Service Network (CSN):

The CSN comprises the Network Service Provider (NSP) that provides IP connectivity to ASN, Application Service Provider (ASP) which offers value added services like multimedia applications using IP Multimedia Subsystem (IMS), the Authentication Authorization and Accounting (AAA) servers for users, devices and specific services. CSN also contains the mobile IP home agent that carries the subscriber database. The other networks are interconnected with CSN through gateways (the other network may be PSTN or 3GGP etc). CSN is also responsible for IP address management, mobility and roaming between different Core IP Network network service providers.

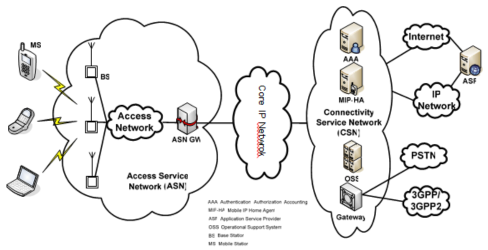

Figure 6: WiMAX Network IP based Architecture

Silent Features of WiMAX:

WiMAX is a wireless broadband technology that offers silent features and flexibility in terms of deployment and services as compared to other broadband technologies. Some silent features offered by WiMAX are:

OFDM-based Physical layer:

OFDM is a technique that is used by the PHY of WiMAX. This technique provides good resistance to multipath interference and enables WiMAX to operate in a NLOS environment.

Extremely High Data Rate:

WiMAX can support extremely high data rates, which can be high as 75Mbps. These extreme date rates can be achieved when the system is operating at 20 MHz wide spread spectrum. Also, 10 MHz spectrum uses the TDD scheme with a downlink-to-uplink ratio of 3:1, which means that at the PHY layer, the data rate is 25 Mbps for Downlink and 6.7 Mbps for uplink.

Scalable bandwidth and data rate support:

The subscribers can get different data rates, depending solely on how wide the spread spectrum is. Bandwidth is directly proportional to data rates and the channel bandwidth in WiMAX is scalable. The channel bandwidth can be varied, and hence the data rates can be increased. The OFDM mode supports scalability by using the Fast Fourier Transform (FFT). The WiMAX system uses 128, 512 and 1048 bits FFT for 1.25, 5 and 10 MHz of channel bandwidths respectively. WiMAX supports numeral modulation and Forward Error Correction (FEC) coding schemes. Modulation schemes are continuously changing on the basis of channel conditions. Adaptive modulation and coding scheme is an effective mechanism to maximize the throughput in a time varying channel. This algorithm calls different modulation and coding schemes on the basis of signal-to-noise and interference ratio at the receiver end in such a way that each user is provided with the highest possible data rate according to their respective links.

Link Layer Retransmission:

WiMAX supports the Automatic Repeat Request (ARQ) algorithm at the link layer for enhanced connectionreliability. Due to this, each transmitted packet must be acknowledged by the receiver and if any packet is lost and no acknowledgement is received then the packet is retransmitted. WiMAX optionally supports the hybrid-ARQ.

TDD and FDD Support:

WiMAX standards, IEEE 802.16-2004 and IEEE 802.16e-2005 use both Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD). But in most cases, TDD is used for implementation because it offers flexible ratios for uplink to downlink data, the ability to utilize channel reciprocity. TDD has a less complicated transceiver design.

Orthogonal Frequency Division Multiple Accesses (OFDMA):

IEEE 802.16e-2005 uses OFDMA as a multiple-access technique in which different subsets of the OFDM tones are allocated to different users. OFDMA significantly improves the system capacityby facilitating the exploitation of frequency diversity and multi user diversity.

User on Demand Resource Allocation:

Resource allocation for both uplink and downlink is controlled by a scheduler located in the base station. Capacity is distributed among different users on an on-demand basis while using a burst TDM scheme. In case OFDM-PHY mode used, then multiplexing is done additionally on the basis of frequency dimension by allocating different subsets of OFDM sub carrier among different users. Resources are allocated not only in the spatial domain but also when using the advanced optimal antenna systems. The Standard has a flexible mechanism to convey the resource allocation information on a frame-by-frame basis, but it also allows for the bandwidth resources to be allocated in time, frequency and space.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

II. OFDMA SYSTEM MODEL:

LTE (Long Term Evolution) uses OFDMA and SC-FDMA at downstream and upstream for downlink and uplink transmission. The OFDMA system model is shown in Figure I. A brief description of the model is provided below. At first, S symbols/second data are transmitted to the transmitter and the data symbols are passed through a serial to parallel converter and the data rate on every X line is SIX symbols [3].The input data stream on each carrier is then mapped by using different types of modulation schemes such as QPSK, 16-QAM, 64QAM etc. Then Inverse fast Fourier Transform is used to find the corresponding Time wave form, which means that M symbols are sent to an Inverse Fast Fourier Transform that performs N-point IFFT operation. The output is N time sample [4]. The Guard interval is then introduced at the start of each sample which is known as addition of cyclic extension in the prefix. Then the length of the output sample is N+LP. The cyclically extended symbols are passed through a parallel to serial converter and then transmitted through a channel [5].

A channel model is then applied to the transmitted signal. The model allows for the signal to noise ratio of the channel to be controlled. The signal to noise ratio is set by adding a known amount of white noise to the transmitted signal which is known as A WGN Additive white Gaussian noise [lO].The Receiver basically does the reverse operation of the transmitter. The transmitted signals which pass through the channel are then converted by using a serial to parallel converter and the cyclic extension is also removed. The signals pass through an N-point Fast Fourier Transform which converts the time domain signal into frequency domain. Then the signal is de-mapped and performs parallel to serial conversion using Parallel to serial convert block and the resultant signal is a M sample output [3].

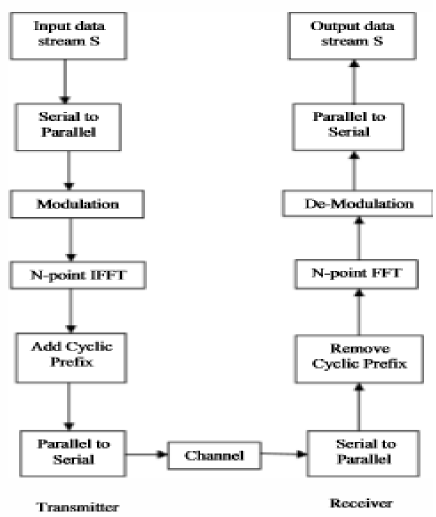

Figure 7: OFDMA System model

SIMULATION DESION AND RESULTS:

In 30PP LTE design, BER performance with various subcarrier modulations under A WON and fading channels are simulated using a bandwidth of 10MHZ in A WGN channel and 3MHZ in fading channel. This design contains signal source, Noise, Receiver and BER performance. A QPSK and 16 QAM symbol constellation is considered.

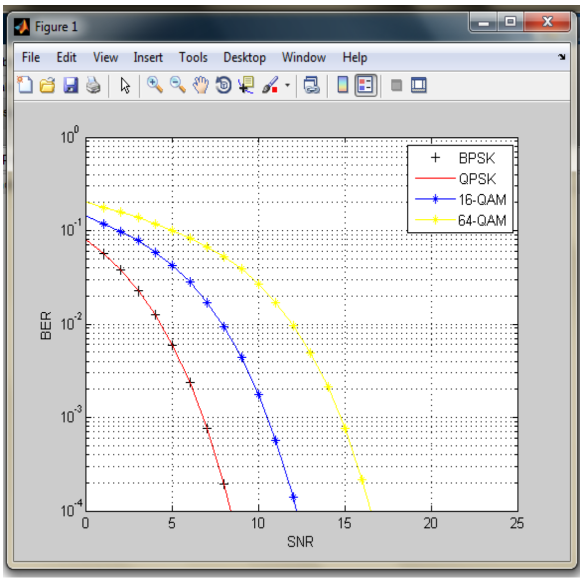

Figure 8:SNR Vs BER plot

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

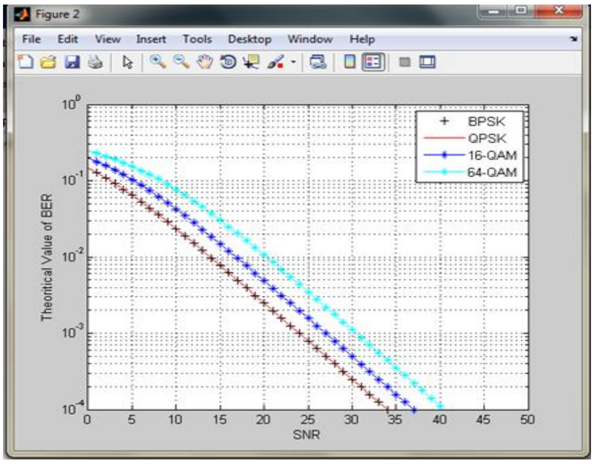

Figure 9:Theoretical SNR Vs BER.

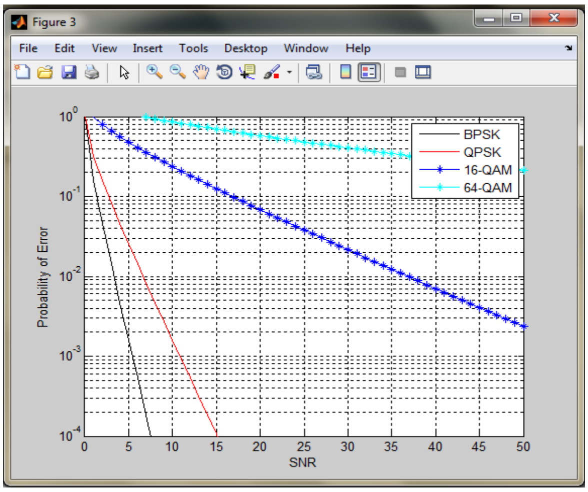

Figure 10: SNR Vs probability of Error

.

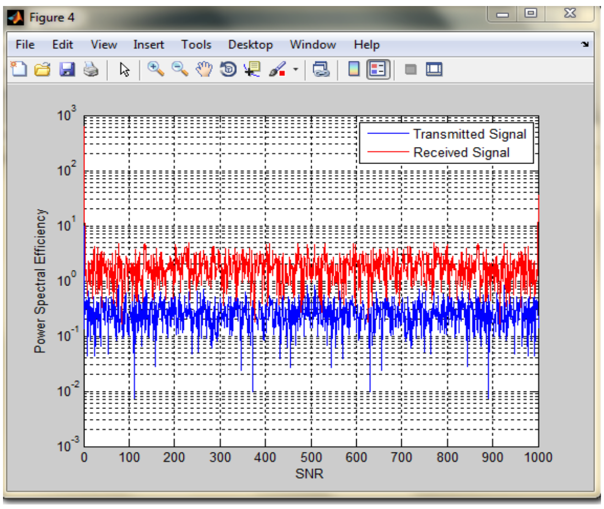

Figure 11: SNR Vs power spectral Efficiency

CONCLUSION:

In this paper, we compare the various subcarrier modulations of 3G L TE downlink of OFDMA. In A WGN channel, QPSK error rate is less has compared to 16QAM and 64QAM. 16 QAM has lower error rate has compared to 64 QAM in A WGN channel. We concluded that BPSK is more power efficient and need less bandwidth amongst all other modulation techniques used in an OFDM adaptive modulation. In case of bandwidth utilization the 64QAM modulation requires higher bandwidth and gives an excellent data rates as compared to others.While the QPSK and the 16QAM techniques are in the middle of these two and need higher bandwidth and less power efficient than BPSK. But they required lesser bandwidth and lower data rates than 64QAM.

References:

[1] Kioskia.net, Mobile Telephony,Nov.8, 2008.

[2] Richard C. Dorf, The Engineering Handbook, 2nd ed., Illustrated and Published by CRC Press

[3] William Stalling, “Wireless Communications & Networks”, 2nd ed., Prentice Hall, 2005.

[4]Theodore S. Rappaport, “Wireless Communications: Principles & Practice”, 2nded., Prentice Hall, 2001.

[5] Simon Haykin, “Digital Communications”, Wiley, John & Sons, Incorporated, 1998, ISBN- 13: 9780471629474.

[6] Jeffrey G. Andrews, Arunabha Ghosh, Rias Muhamed, “Fundamentals of WiMAX: Understanding Broadband Wireless Networking”, Prentice Hall, 2007.

[7] IEEE CASCOM post Graduate student paper conference 2010 Jadavpur University, Kolkata, India nov.27.2010; pp13-16 “Performance Analysis of WiMAX PHY” by S.M. Lalan Chowdhury, P. Venkateswaran.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

[8] IEEE 802.16-2004, "IEEE standard for local and Metropolitans Area Network. Part-16; Air Interface for Fixes Broadband Wireless Access Systems." Rev. of IEEE 802.16-2001, pp 1-857, Oct 2004.

[9] S. Venkatesh, K. Baskaran: "Comparative Study of SUI Channels in IEEE802.16d using Different Cyclic Prefix", European Journal of Scientific Research ISSN 1450-216X Vol.48 No.2 (2010), pp.305-314.

[10] A. Md. Anamul Islam, C. Md. Julkarnain. "BER performance analysis of a real data communication through WiMAX-PHY layer over an AWGN and Fading channel" International journal of electrical & computer Sciences IJECS-IJENS Vol; 10 No; 04.

[11] J.G. Andrews, A. Ghosh, R. Muhamed, "Fundamentals of WiMAX: Understanding Broadband Wireless Networking," Prentice Hall Communications AND Engineering Technologies Series, 2007.