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Performance Analysis of WiMAX/LTE System for Single and Multi-User in OFDMA Downlink access

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Abstract— **In this paper we analyzes performance of MIMO OFDMA system in downlink access for Worldwide Interoperability for Microwave Access/Long Term Evolution (WiMAX/LTE) system. We design the OFDMA system and analysis the parameter antenna height, power variation and modulation technique to obtain a good quality signal. The motive is increase the throughput of the system and decrease the BER. By using the grade of service (GOS) in automatic frequency planning (AFP) and propagation model Anderson 2D free-space plus reflection multiple diffraction (RMD). We increase throughput rate, signal to noise plus interference ratio (SINR) and decrease the BER up to optimize level. The performance assessed through SignalPro simulation that shows the results are significant to increase in throughput, reduction in BER and increase in SINR using parameter variations in WiMAX/LTE MIMO system for OFDMA in downlink access.**

Keywords— OFDMA, MIMO, WiMAX, LTE, GOS, AGL, AFP, GOS, RMD.

I. Introduction

The transmitter power can be upgraded individually as well as improves the use of network resources. The succeeding group multiple access technology is Orthogonal Frequency Division Multiple Access (OFDMA). OFDMA divides all frequency band into multiple narrow band sub channels and these sub-channels are provided to each user individually [1]. OFDMA system subchannelization defines subchannels that can be assigned to subcarrier stations depending on their channel conditions and data desires. Data can transmit terminated several sub-channels in the same time slot and coding is set separately for each subscriber. Subchannelization of OFDMA signals are more complex than Orthogonal Frequency Division Multiplexing (OFDM) but offer better performance and scalability. This feature is very useful for WiMAX base stations (BSs) and provide less BER, higher SNR and higher data rate at receiver.

Throughput is the rate of effective message delivery over communication channel. The data delivered over a physical, logical link and it can pass through a certain network node. Throughput is normally measured in bits per second and sometimes in data packets per second. The system throughput is the amount of the data rates that are delivered to all terminals in a network. Throughput is basically identical to digital bandwidth consumption, where the load in packets per time unit is indicated as the arrival rate. The throughput in packets per time unit is indicated as the withdrawal rate. The throughput of a communication system may be affected by various causes, including the limitations of causal analog physical standard, existing processing power of the system components and end-user presentation.

The advancement of multimedia services and internet linked activities needs high data rate communication. The early request for high speed wireless internet access has driven adoring research development efforts toward the next generation wireless communication system. Higher bandwidth was projected to achieve high rates with the Multiple Input Multiple Output (MIMO) system is presented in [2] are used to achieve higher data rate by spatial multiplexing and diversity techniques. WiMAX/Long Term Evolution (LTE) system based on MIMO technology can enhance channel capability, data rate and throughput. WiMAX/LTE system use OFDMA in downlink access which enable it to achieve data rate of order 200Mbps [3].

The OFDMA technology is created on IEEE standard. The concept is shown in the IEEE 802.16 standard that belongs to IEEE 802 family, which applies to Ethernet. WiMAX is a form of wireless Ethernet and whole normal is based on the Open Systems Interconnections (OSI) reference model. In the context of the OSI model, the physical layer is lowest layer. It require frequency band, error-correction methods and modulation pattern. These are organized between transmitter and receiver and they effect on data rate and the multiplexing techniques that provide batter quality of the services (QoS).

The several subcarriers are together at the receiver and recombined to form one high speed transmission. The subchannels then transmit data without being subject to the same intensity of multipath distortion faced by single carrier transmission. The boundaries of both OFDM and OFDMA can be done by splitting a single signal into subcarriers and divide one very fast signal into several slow signals that optimize mobile access. The difference between OFDM and OFDMA is that OFDMA has the ability to vigorously assign a subset of those subcarriers to specific users, results in multi-user variety of OFDM. By using Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) for multiple users [4]. OFDMA separately supports multiple users by assigning them specific subchannels for recesses of time. Point-to-point data transmission is promising in OFDM system and does not support Point-to-multipoint data transmission in static and moveable systems. Point to multipoint is only possible in OFDMA system. OFDM system that provide multiple access technique is known as OFDMA system. OFDMA has been adopted in many wireless principles, such as 3GPP, WiMAX/LTE downlink, IEEE 802.16e and it play an important role in advanced cellular network [5].

In a digital communication, the BER is the received bits with faults at receiver and it is calculated by dividing the faults bits with total number of bits that have been transmitted over a given time period. The bit error rate is normally expressed as 10 to the negative power (eg. 10^{-3}).

The BER may be better with choosing a strong signal strength by using a slow and robust modulation system, line coding system and by also applying channel coding system such as dismissed forward error correction codes. The transmitted BER is the ratio of number of sensed bits that are incorrect before error improvement and the total number of transferred bits. The information BER is approximately equal to the decoding error probability, the number of translated bits that remain incorrect after the error improvement and alienated by the total number of decoded bits [6]. Normally the transmission BER is larger than the information BER [7]. The information BER is affected by the strong point of the forward error correction code.

The motive to proposal OFDMA model is estimated to optimize the balance between fairness and quality of service (QoS). It target at allocating equal data rate to each mobile station (MS) decrease the interference affect using the appropriate variation in the parameters. Our main objective of this paper is to increase data rate up to optimum level, increase the SINR performance and reduce the BER of OFDMA system in downlink access.

The rest of the paper organized as follows. In section II we describe the related previous work, in section III we represent the proposed OFDMA system model and problem formulation. In section IV we discuss the simulation results. Finally, section V provide concluding remarks regarding our proposed model.

II. related work

In this section we describe the previous related work. The research have been exploiting the multi-channel capacity in the wireless network for a long time. Several wireless standard are supporting multiple channels for parallel transmissions. The previous work is given below.

Kuhne and Klein [4] observed the channel quality information (CQI) available at the transmitter assumed to be imperfect due to estimation error, quantization at the receiver side, time delay and feedback error. OFDMA system using imperfect CQI and uncoded M-QAM modulation is derived. CQI imperfectness, one can achieve higher throughput using adaptive mode.

Kaneko et. al. [7] proposed the resource-allocation schemes for one relay station (RS) and multiple RSs in the cell. The amount of required channel-state information (CSI) and algorithm complexity are minimized for suitable practical use. Simulation result shown that algorithms achieve a very good throughput.

Jang et. al. [8] designed the time division duplexing frame with variety of pilots for multi-user (MU)-MIMO OFDMA. Simplified scheduling algorithm was proposed and computational complexity analyzed. The achievable rates of system increased up to 86% and throughput increased by 22.5% as compared to MIMO OFDMA system.

Tao et. al. [9] established the linear optimal distribution (LOD) algorithm and they considered the resource allocation with power control and showed that the minimum coast network flow (MCNF) based algorithms. Simulation result shows that proposed algorithms can significantly enhance the overall system throughput.

Wang et. al. [10] proposed a cross layer design, termed attachment learning (AT-Learning), to achieve multi-channel allocation with low cost and high efficiency in distributed OFDMA based networks. The result improved the throughput by up to 300% over slotted ALOHA.

Chao and Chiou [11] proposed an enhanced proportional fair (E-PF) scheduling algorithms, which aim to maximizing quality of services (QoS), throughput while still retaining fairness as well as maximizing system throughput in downlink OFDMA system. The result shows that E-PF achieves higher system throughput.

Aghababaiyan and Pakravan [12] proposed a method that was implemented by the femtocells in a self-organizing manner and increased frequency reuse factor. Simulation result shown improvement in throughput up to 120%.

Ping et. al. [13] used the OFDM-IDMA principle and compare the result with OFDMA the SNR was more in OFDMA system.

Chawla and Gupta [6] presented BER performance comparison of LTE and A-LTE MIMO-OFDM system with referenced to features like coordinated multipoint (CoMP) and multimedia broadcast and multicast services (MBMS). Results shown increasing the number of user it degrades BER performance.

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III. formulation and proposed methodology

In this section we describe the proposed model and algorithm. We Studied basic structure of OFDMA based system in downlink access. Paper focuses on the downlink (DL) transmission from a base station (BS) to mobile unit (MU) and system model used is MIMO downlink state in a time division duplexer (TDD) mode.

To study the OFDMA system we selected the region having with latitude 44^0 3' 32.46" north and longitude 123^0 5' 41.48" west has been choose. The basic structure as shown in figure 1 by using simulator EDX SignalPro version 7.1. The site elevation is 207.5m. We consider the downlink WiMAX/LTE system of single cell site having four sectors they covered 5.700 km^2 and the grid spacing 0.0250 km. WiMAX/LTE MIMO adaptive system is used in our work.

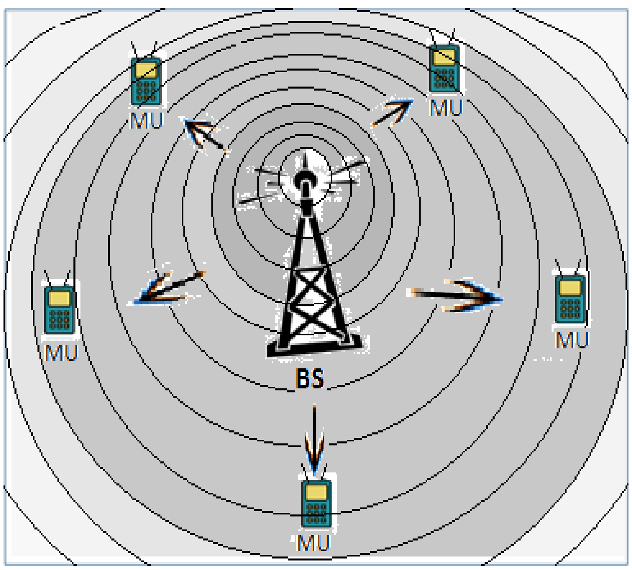

Fig. 1. Basic structure of study area.

We use the special multiplexing 2X2 MIMO system and having independent data streams are 500. The adaptive modulation in downlink access is 64QAM and the adaptive modulation techniques used and the uplink modulation technique is 16QAM and having rate ½ and replication single time. In traffic database, the traffic data rate is 1000 mbps/km^2 and voice 1000 miliErlangs/km^2. In adaptive transmission mode with adaptive modulation and subcarrier allocation using channel quality information (CQI) parameters at BS. As CQI the digitized sudden available SINR for different users assigned with different subcarriers is applied advantage for multi-user diversity. Digital modulation used quaternary phase shift keying (QPSK), Gaussian minimum shift keying (GMSK), 16 quadratic amplitude modulation (16QAM), 64 quadratic amplitude modulation (64QAM) and 128 quadratic amplitude modulation (128QAM). Our target to determined bit error rate of 10^{-6} and SINR 20dB to 40dB.

There are total number of four server and used in transmitter side in WiMAX/LTE system allocate radio resource to all MU within the cell. LTE allocate radio source based on a basic time frequency unit. Each sectors having Omni directional antennas and they are vertical polarized and each sector is detached by the 90^0 with beam tilt by -2^0. The minimum transmitted power per channel is 30 dBmW and varies according to terrain with antenna gain of 18.15 dBi. At receivers side vertical polarized adaptive antennas are used. Cross polarized rejection is 15.00 dB and diversity gain is 20.00 dB. The suggested model of the OFDMA system shown in figure 2 the transmitter and receiver parameters are design by using the 2X2 MIMO system. They affords the wide coverage for all mobile unit where all mobile unit (MU) communicate with LTE base station and only selected the best server using automatic frequency planning (AFP) algorithm.

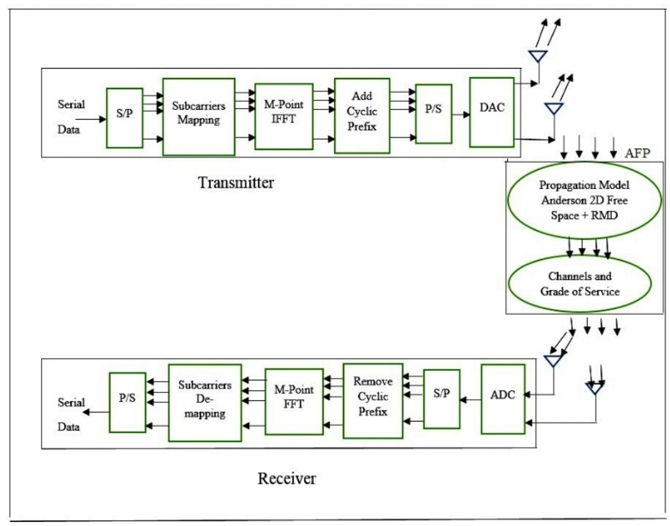

Fig. 2. Block diagram of proposed model for OFDMA system in downlink access.

In this paper automatic frequency planning technique is used for frequency channels allocation and reuse frequency is done in such a way that maximize coverage and capacity achieve with minimum interference. The optimization of the frequency plan is based on the variety of parameters like antenna tilt, azimuth angle that govern the cell coverage profiles and traffic capacity distributions with power variation.

The propagation model is Anderson 2D, terrain + clutter is the propagation model and free space + RMD (reflection multiple diffraction) model type is used. This model is a complete point-to-point radio propagation technique for calculating field strength and path loss in the frequency range of 30 MHz to 60 GHz. This model drawn upon the WiMAX/LTE MIMO system and improved by making use of widely available terrain elevation. The local land use database for reflections result in multipath and time-dispersed signal energy at the receiver. With the Free Space + RMD method, excess path loss (XPL) is calculated using terrain obstacle factors and changeability factors in urban area. In the line of sight region no terrain obstacle blocks the direct ray from the transmitter to the receiver. Path loss is determined by considering the contribution of a single ground reflection added vector ally to the directly received ray. The basic element that affects the predicted field strength at receiver is represented below [15].

$$\theta_{t-r} = \frac{h_r - h_t}{d_r} - \frac{d_r}{2a}$$

where θ_{t-r} is the depression angle relative to horizontal from the transmitter to the receiver in radians, h_t is the elevation of the transmit antenna center of radiation above mean sea level in meters, h_r is the elevation of the receive antenna center of radiation above mean sea level in meters, d_r is the great circle distance from the transmitter to the receiver in meters, a is the effective earth radius in meters taking into account the atmospheric refractivity The atmospheric refractivity is usually called the K factor. A typically value of K is 1.333.

The depression angle from the transmitter to any terrain elevation point can be found as in [15].

$$\theta_{t-p} = \frac{h_p - h_t}{d_p} - \frac{d_p}{2a}$$

Where θ_{t-p} is the depression angle relative to horizontal for the ray between the transmitter and the point on the terrain profile, h_p is the elevation of the terrain point above mean sea level in meters, $d\ p$ is the great circle path distance from the transmitter to the point on the terrain path in meters. The variable θ_{t-p} is calculated at every point along the path between the transmitter and the receiver and compared to θ_{t-p}. If the condition $\theta_{t-p} > \theta_{t-r}$ is true at any point, then the path is considered non line of sight (NLOS).

Grade of service GOS estimate the maximum required capacity and channels then allocate for system. GOS measure the congestion of the system and specified as probability of call. GOS is related to the ability of a mobile phone to access trunked mobile phone system during busiest hour. GOS is the ratio of number of lost calls to number of offered calls [16].

$$\text{Grade of Service} = \frac{\left(\frac{A^N}{N!}\right)}{\left(\sum_{k=0}^{N} \frac{A^k}{k!}\right)}$$

A= expected traffic intensity, N=number of circuits in group

The SINR value of each MU changes as a function of mobility, frequency and time discriminating multi-path fading. The effect of path loss and fading are determined for each resource block but throughput remain continuous at transmission duration. MU having time-varying channel conditions. The three factors that affect the wireless link are path loss, shadowing and fast multipath-fading. The distance between transmitter and receiver depends on path loss. Shadowing is due to diffraction and fading effects are due to multipath reception. In downlink transmission from BS to the mobile users is on time frame basis and each frame consisting of OFDM symbol. All MU estimate their instantaneous channel state and report CQI to base station. Using the channel state information together with the signal to interference plus noise ratio and the required bit error rate, adaptive modulation and coding scheme dynamically determine the instantaneous data rate for each MU.

IV. Simulation result

In this section, we design the OFDMA system on the basis of the proposed technique under QPSK, GMSK, 16QAM, 64QAM, 128QAM modulation per subcarrier is considered with different parameter. Also the user one pair need to exchange their own data on band before transmission to MU. We observe that the performance in various levels inter user quality by using simulation. All users are randomly spread and the relay are uniformly distributed on a centered circle. The design model and the simulator system specification of the parameter is given below.

Study Area	5.700 km^2
Transmission Bandwidth	10 MHz
Carrier frequency	3.4 GHz
Cellular layout	1 cell-site, 4 sectors
Channel estimation	Ideal
Antenna configuration	2x2
Duplexing mode	TDD
FFT size	1024
Data subcarriers	720
Frame Duration	5.00 ms
Cyclic Prefix Ratio	1/4
Subcarrier spacing	.0098 MHz
Code rate	1/2
TDD u/d ratio	1.00
Modulation used	QPSK, GMSK, 16QAM, 64QAM, 128QAM

Table 1. System specification for simulation.

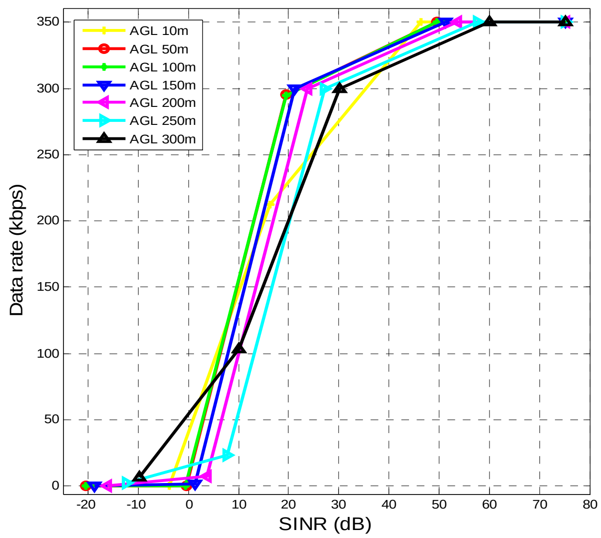

Fig. 3. Performance analysis with QPSK modulation system for data rate vs. SINR in OFDMA downlink access.

In figure 3. shows the result for the load on the system, load on subcarriers, channel rate for single and multi-user in WiMAX/LTE MIMO system. The data rate performance relate to the throughtput of the system. Result shown for digital system subcarrier downlink data rate vs carrier to interfrance plus noise ratio at receiver. The maximum achiveable data rate per subcarriers is 350 kbps and SINR varies around 10 to 80dB with variation in the antenna height. The data rate depends on the value of the SINR that increase the data rate.

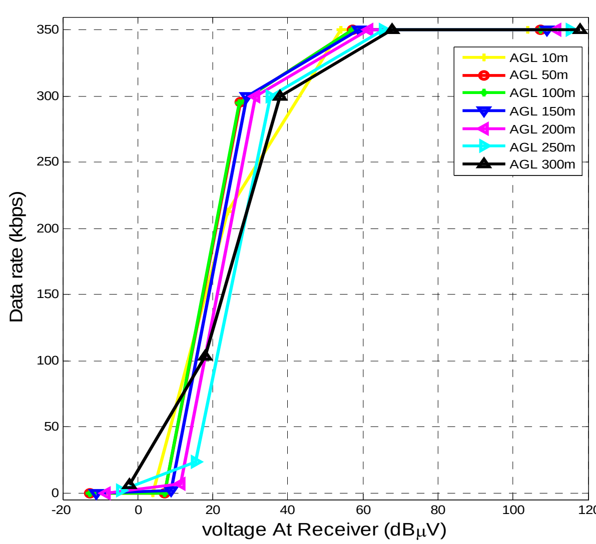

Fig. 4. QPSK digital system Data rate vs Voltage performance analysis for OFDMA in downlink access.

In figure 4. shows the result for the load on subcarriers for single and multi-user WiMAX/LTE MIMO system. The data rate- performance relate to the throughtput of the system. Result shows the digital system downlink data rate vs voltage ratio at receiver. The maximum achiveable data rate per-

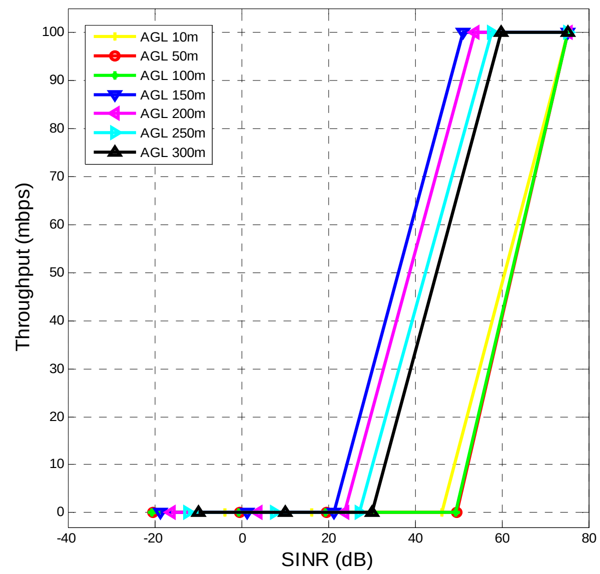

Fig. 5. QPSK adaptive modulaton for minimum achieved downlink data rate vs SINR.

subcarriers is 350 kbps that achieve at voltage around 10 to 70dBμV with the variation in antenna height from groung level to optimum level. Result shows the effect of the voltage on data rate and variation occurs in data rate when voltage increase.

Figure 5. shows the result between the data rate and signal to carrier plus interfrance ratio. We have obtained the minimum adaptive modulation downlink data rate 0.0 to 100.0 mbps and achiavable SINR around 20 to 80dB.

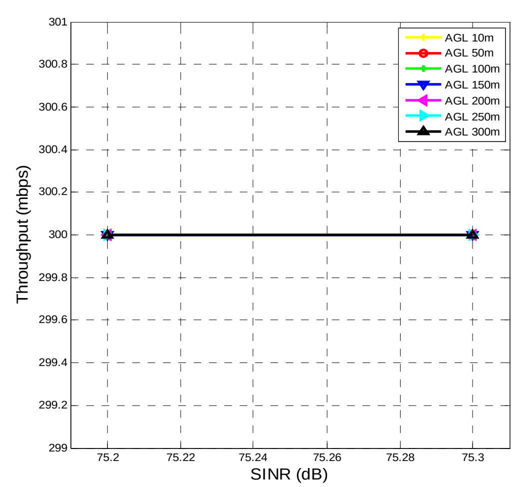

Fig. 6.QPSK adaptive modulaton for maximm achieved downlink data rate vs SINR.

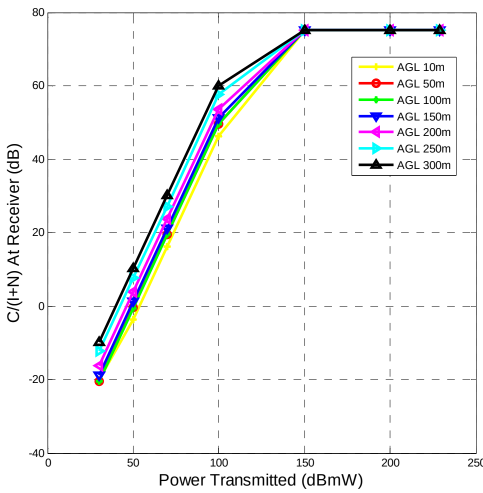

Fig. 7. Power transmitted vs SINR at receiver in OFDMA downlink access.

In figure 6. shows the results for single and multi-user WiMAX/LTE system with QPSK digital system, adaptive modulation downlink data rate vs signal to interfrance plus noise ratio (SINR) at receiver. The maximum achieved adaptive modultion downlink data rate of system is around the 300 mbps is obtained at SNIR of around 72.2 to 72.3dB.

In figure 7. shows that the effect of power variation on the SINR. Result shows with increase in the power it also increase the SINR values. Maximum achieved value of SINR is around 75dB at power around of 150dBmW after that SINR value remain continuous.

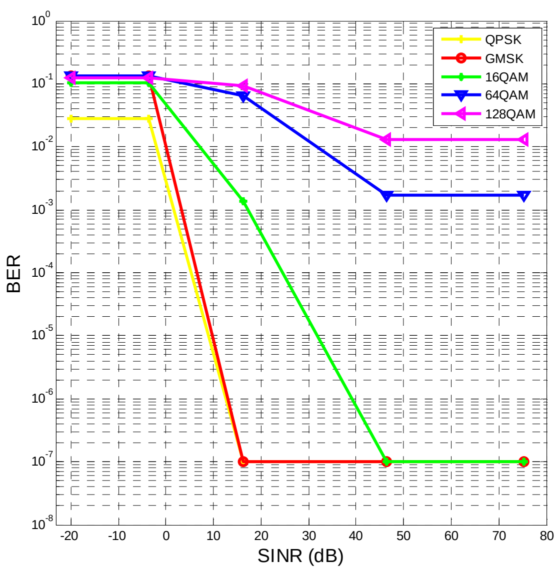

Fig. 8. SINR vs BER with different modulation for AGL 10m

In figure 8. the simulation results performance in term of system BER vs SINR. It shows result with all digial modulation for single and multi-user WiMAX/LTE system. The BER of modulations techniques QPSK, GMSK and 16QAM are up to 10^{-7} and SINR around 15 to 80dB. In digital system modulation 64QAM and 128QAM there is BER 10^{-3} and SINR is around 45dB to 80dB. By using the higher modulation technique it shows increase the BER but lower modulation techniques has less BER. In this system 16QAM is providing the betters results.

In figure 9. the simulation results performance in term of system BER vs SINR. It shows result with all digial modulation for single and multi-user WiMAX/LTE system. The BER of modulations techniques QPSK, GMSK and 16QAM are up to 10^{-7} and SINR around 25 to 80dB. In digital system modulation 64QAM and 128QAM there is BER 10^{-3} and SINR is around 25dB to 80dB. By using the higher modulation technique it shows increase the BER but lower modulation techniques has less BER.

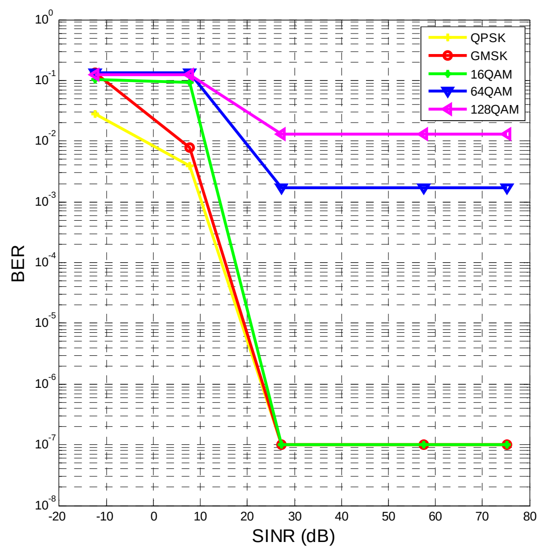

Fig. 9. SINR vs BER with different modulation for AGL 250m

V. conclusion

In this paper proposed model using automatic frequency planning (AFP) in grade of service and propagation model Anderson 2D free-space + RMD that the proposed technique tremendously reduce the BER and improve the throughput of WiMAX/LTE MIMO system for OFDMA in downlink transmission. The improvement occurs in results through the parameter variation power, antenna ground level (AGL) and with the appropriate combination of the modulation techniques. The variation in power, AGL and modulation technique they provide the better throughput, increase system capacity, reduce the BER and increase in SINR up to optimum level. The future work is we can use the BPSK modulation with more transmission site with different parameter variation.

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