PERFORMANCE EVALUATION OF LTE AND WIMAX NETWORK AS PER USE CASES

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***Abstract*— The novel wireless network architecture forces a demanding performance requirement on the radio resource to provide broadband internet access. The Communication industry has been preparing new standards to efficiently transport high speed broadband mobile access in a solitary air interface and network architecture at little cost to operators and end users. Two standards, IEEE 802.16 (WiMAX) and 4G(3GPP LTE) are most important group towards forming the next generation of mobile network standards. The WiMAX comes from IEEE family of protocols and expand the Wireless access from the LAN to MAN and WAN. The radio resource is divided as bursts in time and frequency domains and used by mobile stations (MS) in a best way. It utilizes a novel physical layer radio access technology called OFDMA for UL and DL. The initial iteration of WiMAX was supported with the TDMA TDD and FDD with line of sight (LOS) propagation across the 10 to 66 GHZ frequency range which was afterward increased to consist of operation in the 2 to 11 GHZ range with non line of sight (NLOS) capability via robust OFDMA PHY layer with sub-channelization permitting dynamic allotment of time and frequency resources to several users. The LTE on the other hand develops from the 3G technology and describes the long term evolution of the 3G(3GPP UMTS/HSPA) cellular technology. The arrangements of these efforts are formally identified as the Evolved UMTS Terrestrial Radio Access Network (E- UTRAN). 4G(LTE) describes a new physical layer radio access technology based on OFDMA.**

Keywords: TDMA,WiMax,LTE,DL,UL.etc

1. Introduction

The WiMAX technology, based on the IEEE 802.16 Air Interface Standard is quickly establishing itself as a technology that will take part of key role in broadband wireless metropolitan area networks. IEEE 802.16 standard for BWA (Broadband Wireless Access) and its related industry association WiMAX forum guarantee to offer high data rate over large coverage areas to a large number of users where broadband is unavailable. Fixed WiMAX, based on the IEEE 802.16-2004 Air Interface Standard, has confirmed to be a cost efficient fixed wireless substitute to cable and DSL services. In 2005 the IEEE approved the 802.16e improvement to the 802.16 standard. This improvement includes the characteristics and attribute to the standard essential to hold mobility. The WiMAX Forum describes the network architecture mandatory for implementing an end-to-end Mobile WiMAX network. Mobile WiMAX is a broadband wireless solution that permits meeting of mobile and fixed broadband networks throughout a common wide area broadband radio access technology and flexible network architecture.

The first version of the IEEE 802.16 standard activates in the 10-66 GHz frequency band and needs line of sight (LOS) towers. Afterward the standard broadened its operation through different PHY specification to 2-11 GHz frequency band enabling non line of sight (NLOS) connections. The Mobile WiMAX Air Interface approves Orthogonal Frequency Division Multiple Access (OFDMA) for enhanced multi-path performance in non-line-of-sight (NLOS) environments. IEEE 802.16 standards are intended for the transmission of multimedia services (voice, Internet, email, games, video and others) at high data rates. Mobile WiMAX systems present scalability in both radio access technology and network architecture, therefore offering an immense deal of flexibility in network exploitation options and service providing [13].

LTE is the most recent telecommunication technology standardized by 3GPP and is the part of the GSM evolution path further to 3G technology. The modern enlarge of mobile data usage and emergence of new applications such as MMOG (Multimedia Online Gaming), mobile TV, Web 2.0, streaming contents have motivated the 3GPP to work on the LTE. LTE is the most recent standard in the mobile network technology tree that earlier recognized the GSM/EDGE and UMTS/HSPA network technologies [6]. The purpose for LTE is to present an extremely high performance radio-access technology that provides full vehicular speed mobility. LTE,

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whose radio access is called E-UTRAN, is expected to significantly pick up sector capacity, end-user throughputs, and reduce user plane latency, bringing extensively improved user experience with full mobility [7]. With the emergence of Internet Protocol (IP) as the protocol of choice for carrying all types of traffic, LTE is scheduled to offer IP-based traffic with end-to-end Quality of service. Voice traffic will be supported mainly as VoIP enabling better integration with other multimedia services. LTE has been put hostile performance requirements that rely on physical layer technologies, like as, OFDM and Multiple-Input Multiple-Output (MIMO) systems, Smart Antennas to accomplish these targets.

Current technological improvements facilitate portable computers to be provided with wireless interfaces, permitting networked communication even though mobile. Wireless networking very much improves the utility of moving a computing device. It offers mo- bile users with adaptable and flexible communication among people and uninterrupted access to networked services with much more flexibility than cellular phones or pagers. With these performance improvements in computer and wireless communications technologies, advanced mobile wireless computing is expected to see gradually more extensive use and application. The Idea of WiMAX and LTE networks is to maintain robust and proficient operation in mobile wireless networks by incorporating mobility functionality for the subscriber nodes. Such networks are visualized to have dynamic, every so often rapidly changing multihop which are possibly composed of moderately bandwidth constrained wireless links. This work is totally motivates regarding the comparison of WiMAX and LTE networks in the form of speed and maximum number of supportable users in a particular cell.

The goal of this paper is to examine the cell range and capability of Mobile WiMAX and LTE networks. We will found maximum allocated bandwidth, minimum demand, and number of maximum supportable users to the WiMAX and LTE networks after reducing the all overhead related to physical and MAC layer. Physical layer overhead related to DL and UL, and MAC layer overhead related to MAC Protocol data unit will examine. After doing the comparison of both LTE and WiMAX networks, we will find LTE network performs better as comparison to WiMAX network.

2. RELATED WORK

Chakchai et al. [4] enlightened how to calculate the capability of a Mobile WiMAX system and account for various overheads. In this work Chakchai have computed capability with the modulation technique used. This work demonstrated the methodology using three sample workloads consisting of Mobile TV, VoIP, and data users. though, there are a few assumptions in the analysis such as the consequence of bandwidth request mechanism, two dimensional downlink mapping, and the vague calculation of slot-based versus bytes-based. The number of supported users is calculated with the assumption that there is only one traffic type. Fixed UL-MAP is forever in the DL sub-frame though there is no UL traffic such as Mobile TV. The graph shows between coding scheme and maximum number of users supportable. Performance objective of the next generation access-network technology LTE shows in [14] also talked regarding how mobility is handled in the new system. Motorolas role in this improvement of 3GPP LTE technology was also explained.

The IEEE 802.16 OFDM physical layer was implemented with MATLAB to better under- standing of the standard and the system performance by Hasan et al. [11]. This involves studying, through simulation, variety of PHY modulations, coding schemes and interrupting in the form of bit error rate (BER) and block error rate (BLER) performance under reference channel models. The overall system performance was also estimated under dissimilar channel conditions. A key performance calculate of a wireless communication system is the BER and BLER. The BER and BLER curves were used to contrast the performance of different modulation and coding scheme used. The outcomes of the FEC and interleaving were also calculated in the form of BER and BLER. These granted us with a widespread evaluation of the performance of the OFDM physical layer for different states of the wireless channel. This white paper [15] discuss the analysis sequence flow for calculating the bandwidth capacity. WiMAX quality of service model for estimating system bandwidth capacity in hand was also discussed by partitioning of the available bandwidth into the three basic service types. Mach et al. [10] has given One of the probable solutions how to enhance capacity is to improve BS cell by relay stations. Therefore also more distant users may experienced better channel quality and system potential may be fully used.

H. A. Rahim et al. [1] proposed that Orthogonal Frequency Division Multiplexing (OFDM) is predicted to be implemented in future broadcasting and Wireless Local Area Network (WLAN) systems due to its robustness in transmitting a high data rate. This paper presents the design and implementation of an OFDM transceiver system for high speed Wireless Local Area Network (LAN) using MATLAB simulation. The bit error rate (BER) performances for DQPSK, D16PSK and D256PSK have been evaluated in additive white

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Gaussian noise (AWGN) channel and compared to the theoretical BER. The system performance has been evaluated on AWGN channel and BER versus signal to-noise (SNR) ratio has been measured for each modulation scheme.

Natalia Y. Ermolova [18] addressed the problem of OFDM analytical error rate evaluation over fading channels under nonlinear amplification. The approximate solutions to the problem over Nakagami and compound gamma log-normal fading radio channels can be obtained.

Alok Joshi et al. [19] proposed that in fading environments the bit error rate (BER) increases. The performance can be improved by using some kind of channel coding. This form of OFDM is called coded-OFDM (COFDM). OFDMA system with different code rate and modulation schemes using the bit-error rates (BER) versus the bit energy-to-noise density ratio (Eb/No) curves. The obtained graph can be used to set threshold signal to noise ratio (SNR), so that adaptive modulation schemes can be used to attain highest transmission speed with a target BER. In this paper, IEEE 802.16e OFDM PHY layer was implemented using SIMULINK in order to evaluate the PHY layer performance under frequency selective channel. The implemented PHY layer supports all the modulation and coding schemes. The BER vs. Eb/No curves were used to compare the performance of different modulation and coding scheme under AWGN and multipath fading channel. It is observed that the lower modulation and coding scheme provides better performance with less SNR, accept for schemes employing rate 3/4 codes have noticeable degradation compare to other schemes under multipath fading.

Abhishek datta et al. [23] described a new simulator that can perform the BER analysis using OFDM technology and generate respective plots for bit errors vs signal energy (Eb/No) for several modulation schemes & different noise effects in three types of channels (namely AWGN, Rayleigh and Rician).

Multiplexing Techniques

OFDM uses the idea of Multi Carrier Modulation (MCM) transmission technique. The principle of MCM explains the splitting up of input bit stream into numerous parallel bit streams and then they are used to modulate numerous sub carriers. Appling the cyclic prefix (CP) can entirely get rid of Inter-Symbol Interference (ISI) [2] [11]. The CP is normally a repetition of the last samples of data section of the block that is affixed to the beginning of the data payload as shown in Fig.3.1. The CP avoids inter-block interference and formulates the channel appear circular. An apparent disadvantage of CP is that it initiates overhead, which efficiently reduces bandwidth effectiveness. OFDM utilizes the

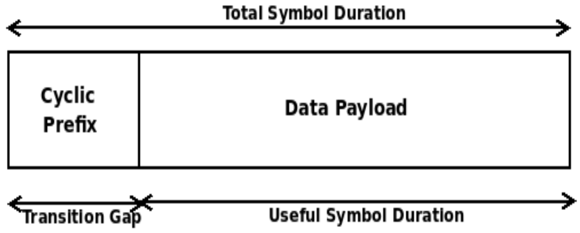

Fig.1: OFDM Symbol Structure

frequency diversity of the multipath channel by coding and interleaving the data across the sub-carriers earlier to spreads. Resources are presented during the time domain by means of OFDM symbols and in the frequency domain by means of sub-carriers in an OFDM scheme. The time and frequency resources can be organized into sub-channels for allocation to individual users. OFDMA is a multiple-access scheme that provides multiplexing operation of data streams from multiple users onto the downlink sub-channels and uplink multiple accesses by means of uplink sub-channels. WiMAX uses OFDMA for both Up- link (UL) and Downlink (DL) in physical layer. OFDMA is basically a hybrid of FDMA and TDMA. Users are dynamically allocated subcarriers (using FDMA) in different time slots (using TDMA). UL part of physical layer uses scalable OFDMA i.e. bandwidth of the channel may be depends on the number of users connected to it. OFDMA is used for performance modeling of Mobile WiMAX. Guard time between OFDM symbols is used for maintain each OFDM symbol independent of the others after going through a wireless channel. OFDMA make use of several closely spaced sub-carriers, although the sub- carriers are partitioned into groups which are named a sub-channel. The sub-carriers that Fig. a sub-channel must not be adjacent. In the DL, a sub-channel may be anticipated for different recipients. Each OFDMA symbol contains data sub-carriers used for carry information, pilot sub-carriers as reference frequencies used for various synchronization and estimation purposes, DC sub-carrier like the center frequency, and guard sub-carriers for keeping the space between OFDMA signals [5]. DC sub-carrier and guard sub-carriers both together are called Null subcarriers.

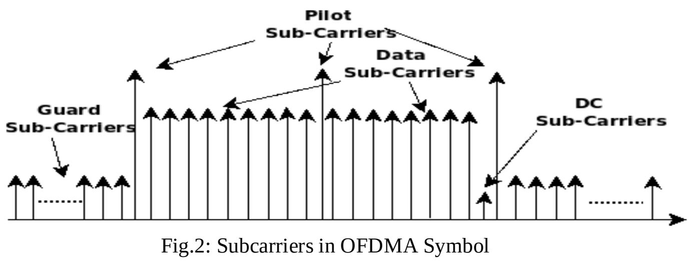

Fig.2: Subcarriers in OFDMA Symbol

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LTE Frame Structure

As shown in Fig.4.1 LTE Frame length is 10 ms, which is divided into 10 sub-frames which are each of 1 ms and are type of DL sub frame, UL sub-frame, and special sub-frame. DL sub-frame and UL sub-frame are divided further into two slots of .5 ms each. Special frame of 1 ms length contains three fields DwPTS (Downlink Pilot Timeslot), GP (Guard Period) and UpPTS (Uplink Pilot Timeslot) which are maintained by LTE TDD. Sub- frames 0, 5 and DwPTS are always reserved for downlink transmission [14]. UpPTS and the sub-frame immediately following the special sub-frame are always reserved for uplink transmission. The initial OFDM symbol in the downlink sub-frame is used for spreading the DL preamble that is used for a variety of PHY layer actions, such as initial channel estimation, noise and interference estimation, time and frequency synchronization. DL Frame Control Header indicates some characters of the bursts such as length and number of the bursts. The UL MAP and DL MAP introduces channel allocation information that is broadcasted to all users. Listening to MAP messages, the data region (sub-carriers) assigned for its use in both DL and UL is recognizable every user. A burst profile is allotted to a data burst and holds the data for an individual user.

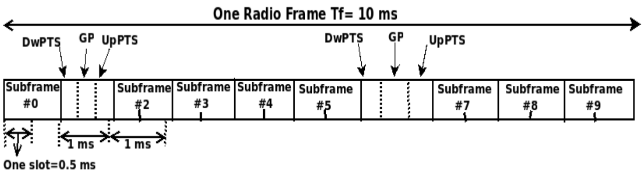

Fig.3: LTE Frame Structure

In LTE MAC Layer provides service to RLC layer by logical channel, error correction through HARQ, MAC Control contains the Element Control information and MAC payload. Data from RLC layer is received by MAC layer in the form of MAC SDU description regarding the size of MAC PDU structure for LTE is shown in MAC Overhead part. The Hybrid Automatic Repeat request (HARQ) is handled at the MAC layer. MAC PDU structure is shown in Fig.4.2.

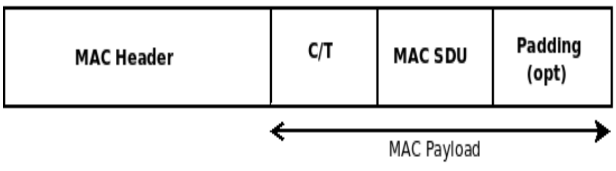

Fig..4: MAC PDU Structure of LTE

Downlink Overhead

In DL sub-frame overhead consist of DC-subcarrier and Guard, preamble, FCH, UL-MAP, DL-MAP, burst used in DCD (DL Channel Descriptor) and UCD (UL Channel Descriptor). Here DC-subcarrier (transmission gap) and guard is used to separate the DL/UL sub-frame and the cyclic prefix in OFDM symbol structure represents it. FCH provides some properties of burst like duration and number of the bursts. Broadcasted Channel allocation information is provided by DL/UL MAP. DL and UL MAP information for WiMAX contain 8 and 11 bytes respectively for header, 4 and 6 bytes respectively for information element. After listening the MAP information user can identify the subcarriers allocated to user in both DL and UL. DCD and UCD in WiMAX contain DL/UL burst profile information which occupied 9 and 4 bytes respectively. DL and UL MAP information for LTE contains 40 and 48 bytes respectively for header, and 36 and 40 bytes respectively for information element.

Uplink Overhead

Useful bandwidth calculation procedure in UL is alike to the DL in numerous steps. BRH is used for bandwidth request allocation within the contention intervals that are periodically assigned in the UL sub-frame. But here in UL initial ranging and contention interval also used. The network administrator defines the size of initial ranging and contention interval. Initial and periodical ranging permits the BS and the MS to achieve time and power synchronization. Initial ranging take place once per connecting user and the periodical ranging should be done at least each 1.5 seconds in WiMAX and 2 seconds in LTE. Ranging overhead in WiMAX and LTE can be calculated as

$NRanging = FrameLength/PeriodicRangingTime) \times (4/NS-UL)$

$NS-UL$ is the total number of symbols in UL sub-frame. Contention interval may be calculated as:

$NContention = (FrameLength/PPI) \times (N \times (BRH\ Size/MAU) + 1)/NS-UL$

Here PPI is the Periodic polling interval to send one BRH. N is the number of users connected. BRH size is the total size of Header and CRC, MAU is the Minimum Allocation Unit for user.

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3. PROPOSED WORK

Mobile WiMAX and LTE are essentially focused on PHY and MAC layers applications with the aim of offering interoperability between different system specifications. Thus, a high amount of flexibility is believed in each and every of the application services pro- vided by WiMAX and LTE Networks. Those that are correlated to access provision such as resource allocation and scheduling process are considered significantly flexible. So a specific system performance simulation is hardly attainable [9]. In addition, the dynamic channel allocation and scheduling makes it complicated to initiate a practical capacity estimation procedure. On the other hand, the amount of signaling overhead is not constant and alters with the number of users in an un-predictable way. In other words, as the subscribers may have different capabilities in their supporting technologies the required signaling procedure is different from one subscriber to the other in both DL and UL. In addition, since the system holds different QoS specifications, different service provision methodologies, those are used in resource allocations and scheduling processes on a subscriber based manner.

APPLICATION DISTRIBUTION

A key component in network arrangement is to calculate the maximum number of users that each BS may hold. To know regarding the maximum number of subscribers that a usual BS can serve the information of probable different traffic types and their parameters are necessary [15]. Although, since the Mobile WiMAX and LTE networks have not been set up yet in a large scale, the market tendencies and users demands are not undoubtedly determined. On the other side, mixed application packet data networks are disgracefully complicated to treat with statistical methods for the general case. The traffic engineering for how the bandwidth is allocated to a variety of active connections is typically left to operator configuration and is not contained in the standard.

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4. SIMULATION AND RESULTS

To Analyze the performance of WiMAX and LTE network, we build the simulation model developed using MATLAB. Two different case studies are deliberate base on dissimilar system parameters and traffic services. We have analyzed the performance of WiMAX and LTE network in the form of Capacity and Demand. We have two different types of user urban class and suburban class for both WiMAX and LTE Networks

4.1 CASE 1

As in first case we have taken 60% urban users and 40% sub urban users, require data rate for urban and sub urban class users are 1200 Kbps and 1000 Kbps respectively. Contention ratio for urban and sub urban class users are 30, 10 respectively. WiMAX and LTE system input parameters are given in TABLE IV. As can be examined, in this case study, on the basis of input parameters, 80, 83 users can be simultaneously supported with the specified sector for WiMAX and LTE networks respectively. Peak offered data rate for WiMAX in DL is 9147.62 Kbps that decreases to 5288.26 Kbps as the number of users reaches to 80 and for LTE it is 17196.2 Kbps that decreases to 5623.16 Kbps as the number of users reaches to 83.

TABLE I : INPUT PARAMETERS OF WIMAX AND LTE

Parameters	Values	Values
Channel Bandwidth	5	10
DL/UL Frame Ratio	3/1	5/3
DL/UL Traffic Ratio	4	4
Cyclic Prefix Rate	8	16.7
Number of	3	5
Connections per PDU	3	5

Minimum demand in DL for simultaneously connected 83, 80 users in LTE and WiMAX network are 5337.62 Kbps, 5537.78 Kbps. Both the demand in LTE and WiMAX can be accomplish by available bandwidth. The result shows that out of WiMAX and LTE network, LTE is having best performance. All the results related to DL/UL demand and capacity for LTE and WiMAX are shown in Fig. given below.

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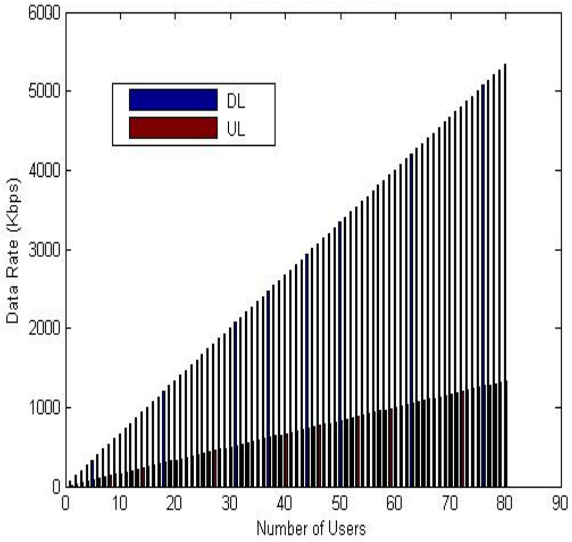

Fig. 5: DL/UL Demand of WiMAX

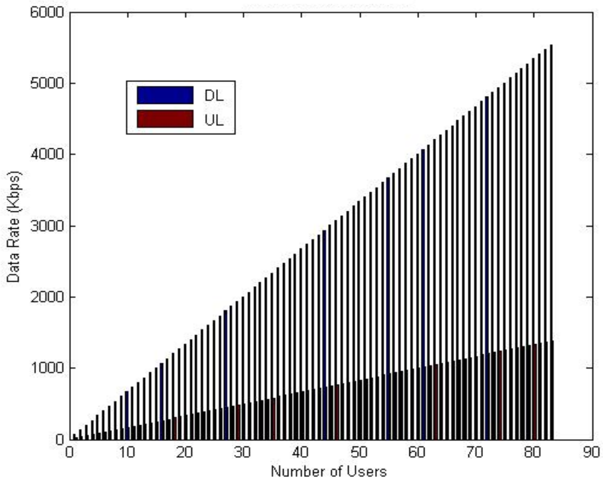

Fig 7 DL/UL Demand of LTE

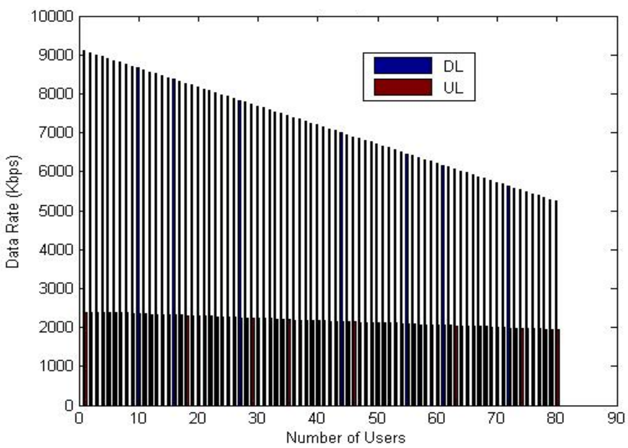

Fig.8: DL/UL Capacity of WiMAX

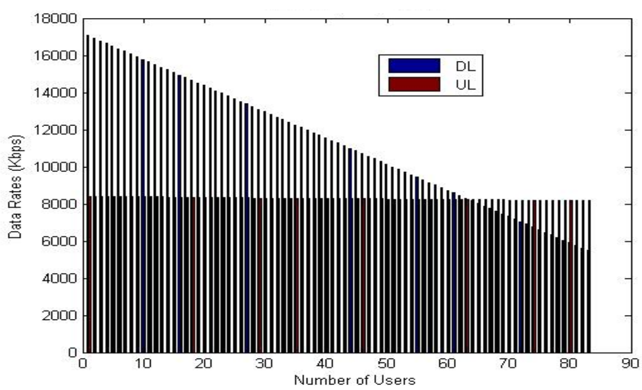

Fig.9: DL/UL Capacity of LTE

4.2 Case Study 2

In second case we have taken 55% urban class users and 45% sub urban class users, require data rate for urban and sub urban class users are 2000 Kbps and 1000 Kbps respectively. Contention ratio for urban and sub urban class users are 25, 15 respectively. WiMAX and LTE system input parameters are given in TABLE V which is used in this case study.. As can be examined in this case study, on the basis of input parameters 68, 77 users can be simultaneously supported with the specified sector for WiMAX and LTE networks respectively. Peak offered data rate for WiMAX in DL is 9969.97 Kbps that decreases to 6750.35 Kbps as the number of users reaches to 68 and for LTE it is 17969.3 Kbps that decreases to 5692.89 Kbps as the number of users reaches to 77. Minimum demand in DL for simultaneously connected 73, 68 users in LTE and WiMAX network are 5551.34 Kbps and 4902.48 Kbps respectively. Both the demand in LTE and WiMAX can be accomplish by available bandwidth. This result shows that LTE network have best performance. All the results related to DL/UL demand and capacity for WiMAX and LTE are shown in Fig. given below.

TABLE II: INPUT PARAMETERS OF LTE AND WIMAX

Parameters	Values	Values
Channel	5	10
Bandwidth	7/2	3/1
DL/UL Frame	3	4
Ratio DL/UL Traffic	16	4.7
Ratio Cyclic Prefix	2	5
Rate	2	5
Number of		

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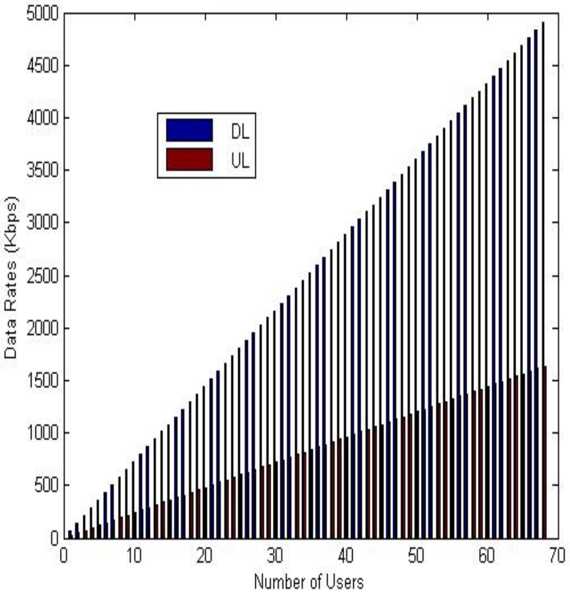

Fig.10: DL/UL Demand of WiMAX

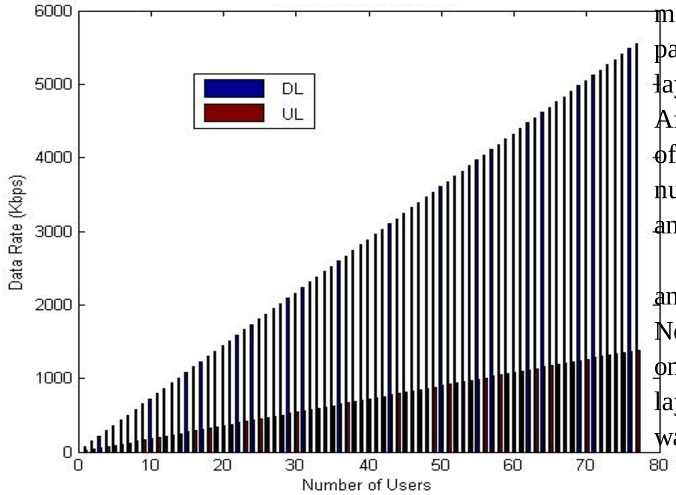

Fig.11: DL/UL Demand of LTE

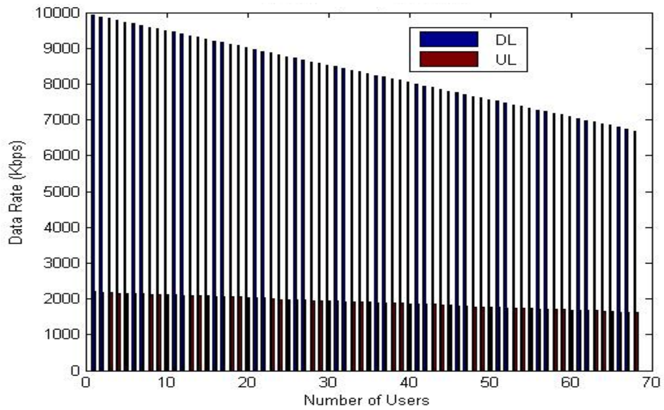

Fig.12. DL/UL Capacity of WiMAX

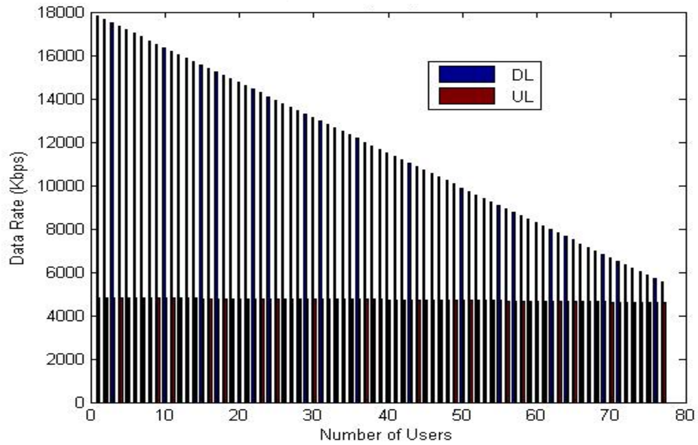

Fig.13: DL/UL Capacity of LTE

CONCLUSION AND FUTURE WORK

In this thesis we have analyzed the cell range and capability of Mobile WiMAX and LTE network. Some overview part of LTE and WiMAX network is presented by this thesis then we have find the maximum capacity and minimum demand for the network after reducing the overhead part. Physical layer Overhead(Uplink and Downlink), MAC layer in mobile LTE and WiMAX are analyzed by this thesis. After reducing the all overhead we have done the comparison of WiMAX and LTE network in the form of maximum number of user supportable, allocated bandwidth to each user and minimum demand.

This work reduces all the overhead related to physical layer and MAC layer in both Mobile WiMAX and 4G(LTE) Networks and then find the actual bandwidth to transfer the only data. All the overhead related to DL and UL in Physical layer a well as overhead related to MAC PDU in MAC Layer was analyzed by this work.

We have divided the whole network into two types of user which are Urban and sub- urban with different applications use like VOIP, streaming media, video, on line gaming etc for analysis purpose. In this work analysis has been done in DL by using different multiplexing, modulation, and coding scheme for both WiMAX and 4G(LTE) Networks. After reducing all the overhead we have found how many maximum number of users can be supported, actual allocated bandwidth to each users, and minimum demand of all the users. And in last we have compared both WiMAX and 4G(LTE) then it shows 4G(LTE) network is good as comparison to WiMAX.

In our algorithm, no Contention Ratio is applied over the assured partition of the channel bandwidth. Though, in future developments allocating a CR over reserved bandwidths that correspond to the error or blocking

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probability of every application will outcome in a more accurate traffic modeling. As Mobile WiMAX and LTE are new standards and neither many certified products are exist in the market nor lots of trials and deployments are prepared, it can be seen as a topic that has enormous researching potentials. Many experts consider that the future 4G platform will be shaped as a combination of LTE and WiMAX standards. So the most controversy would be upon the global market share for all of these mobile broadband technologies. Hence, each of the innovate service providers are competing to comprise the state-of-art technologies in their supporting standard as soon as they appear.

Advanced releases of Mobile WiMAX and LTE will implement a significant number of pioneering technologies such as AAS (Adaptive Antenna System) and beam forming. Exploitation of each of these techniques can have an effect on the capacity by increasing the total throughput and resource effectiveness, via different signaling procedure. On the other side, new modifications such as higher velocity support are an example of applications that will limit the systems actual throughput. Therefore, raising the capacity algorithm presented in this thesis based on these additional parts can be appeared as an interesting future work.

Finally, developing a user friendly setting up tool by exploring the capacity calculations and transmission and coverage modeling that wrap the overall network consideration over a city-wide implementation would be a enormous area of interest for researchers and software developers.

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