PERFORMANCE EVALUATION OF 4G AND 5G 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 (4G) and 4G(3GPP 5G) are most important group towards forming the next generation of mobile network standards. The 4G 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 4G 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 5G 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(5G) describes a new physical layer radio access technology based on OFDMA**

Keywords: TDMA,4G,5G,DL,UL.etc

1. Introduction

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 4G and the evolving 5G are most important group towards forming the next generation of mobile network standards. Both 4G and 5G comes from 3GPP family of protocols and expand the Wireless access speeds up-to 1GBps.

4G is the telecommunication technology standardized by 3GPP that 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 Gaming), mobile TV, Web gaming , streaming contents have motivated the 3GPP to work on the 4G. 4G 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 4G is to present an extremely high performance radio-access technology that provides full vehicular speed mobility. 4G, 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, 4G 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. 4G 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. The main goals of 4G are to minimize the system and User Equipment (UE) complications, permit flexible spectrum exploitation in present or new frequency spectrum and to facilitate co-existence with other 3GPP Radio Access Technologies (RATs).

5G is the most recent wireless technology invention. It is yet not deployed commercially but many research activities worldwide have proved that its capability and data rates are can reach up-to 1GBps and even more. 5G mobile systems model is all-IP based model for wireless and mobile networks interoperability. The All-IP Network (AIPN)[3] is capable to fulfill increasing demands of the cellular communications

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market which are available in many forms. It is also a common platform for all radio technologies. The AIPN which uses packet switching and its continuous evolution provides an optimized performance and cost with respect to different evaluation techniques. . In 5G Network Architecture consist of a user terminal(which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies (RAT) [4]. There are still many inventions about physical layer of 5G but the most recent and successful one that has been proven by researchers is Beam Division Multiple Access(BDMA)[13]. When a base station communicates with mobile stations, an perpendicular to the plane beam is allocated to each mobile station which is in the reachable range of communication, which is termed as BDMA. There are many other possible physical layer implementation possible for 5G which are still evolving like OFDMA[13]. We have considered OFDMA for out simulation purpose.

There have been researches done in recent past which analyze the deployment cost for 4G and 5G and choosing which is better[1]. Such researches helped to decide which type of RAT(Radio Access Technology) is better cost effective wise. The idea of choosing which RAT is better as per-use cases motivated us to research on this topic, by which we could decide better technology in a particular use cases.

Current technological improvements facilitate portable computers to be provided with the facility of wireless interfaces, permitting networked communication even though mobile. Wireless networking very much improves the utility of moving a computing device. It offers mobile 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 with more efficiency is expected to see gradually more extensive use and application. The Idea of 4G and 5G 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, multi-hop which are possibly composed of moderately bandwidth constrained wireless links. This work is totally motivates regarding the comparison of 4G and 5G networks in the form of speed and maximum number of supportable users in a particular cell/beam.

Use of wireless communication technology has increased drastically over last decade. Different types of networks have evolved and are still evolving with the same pace. The main reason for this increment of demand is the greater capacity, different application and different types of devices are main factor for this evaluation. If we compare with the past technologies like 3G-UMTS, 3G-HSPA, Wimax, 4G and 4G-Advanced, there has been major changes in the physical or radio layer(layer 1) to meet the increasing high speed capacity demand requirement. These different solutions has solved many problems but they are still lacking an integrated solution for the problem. From that point of view, 5G network not only required more capacity solution of different wireless and wired networks as well. Another term which flipped recently is Many-machine communication (MMC) and Machine to machine communication(M2M) is a form of data communication that involves one or more entities that do not necessarily require human interaction or intervention in the process of communication(M2M). M2M is also named as machine Type communication(MTC) in 3GPP. It is different from current communication models in the ways that it involves. New or different market scenario, lowers costs and efforts a potentially very large number of communication terminals, lesser traffic per terminal. In general, Such networks need self-management, auto integration capabilities which is beyond today's self organizing Network (SON) features. And this is also to be art of network architectural layer to achieved its full potential. Additionally, very precise latency and reliability requirements are required as a part of the architecture. There are few major challenges in front of 5G and the approaches for solving those are still evolving. In below sections we can also see the challenges and approaches for solving the same.

The goal of this paper is to examine the cell range and capability of Mobile 4G and 5G networks. We will found maximum allocated bandwidth, minimum demand, and number of maximum supportable users to the 4G and 5G 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 4G and 5G networks, we will find 5G network performs better as comparison to 4G network.

2. RELATED WORK

There have been researches done in recent past which analyze the deployment cost for 4G and 5G and choosing which is better[1]. Such researches helped to decide which type of RAT(Radio Access Technology) is better cost effective wise. Also performance objective of the next generation access-network technology 4G shows in [14]. [14] also talked regarding how mobility is handled in the new system. Motorola role in this improvement of 3GPP 4G technology was also explained.

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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. Mach et al.

According to Sapna singh and Pratap singh the views on 5G technology is as the 5G technology will change the way most high-bandwidth users access their phones. With pushed over a VOIP –enabled device, people will experience a level of call volume and data transmission never experienced before. 5G technology is offering the services in the product engineering and documentation support electronic transactions. In this paper they have considered mainly two views of 5G technology Evolutionary view and revolutionary view. In the evolutionary view 5G systems will be capable of supporting allowing a highly flexible network such as a dynamic ad-hoc wireless network. In the revolutionary view 5G systems should be an intelligent technology capable of interconnecting the entire world without limits. In this paper they have proposed 5G mobile phone concept and architecture which is the main contribution of the paper.

According to Sanskar Jain , Neha Agrawal and Mayank Awasthi today wireless services are the most preferred services of the world. The rapid growth in the service is due to the advancement of technology consecutively. The worldwide revolution in mobile and internet technology have changed our way of living life. In this paper they have considered 1^{st},2^{nd}, 3^{rd} and 4^{th} generation system and predicted the nature of 5G network system its property and data rates and also they have concluded that upcoming 5G technology is the fastest and most important technology of the wireless communication world.

According to Tomislav Shuminoski and Toni Janeveski they have designed a novel concept for advanced mobile terminals with radio network aggregation capability and enhanced QoS provisioning for multimedia services in heterogeneous wireless and mobile networks. They have established a new module that provides the best QoS and lowest cost for any given multimedia service by using simultaneously all available wireless and mobile networks for a given traffic. They have evaluated the performance by using the simultaneous multimode mobile stations carrying multimedia traffic in heterogeneous environment with coexistence of multiple Radio Access Technologies. The conclusion of this paper was novel design of a new module based on radio network aggregation in so-called AMT.

According to Bereket Mathewos Hambebo, The use of orthogonal frequency division multiple access (OFDMA) in Long Term Evolution (4G) and WiMax cellular systems mitigates downlink intra-cell interference by the use of sub-carriers that are orthogonal to each other. Inter cell interference, however, limits the downlink performance of cellular systems. In order to mitigate inter-cell interference, various techniques have been proposed. This paper examines one group of these techniques, static frequency reuse. We present a comprehensive comparison of Reuse-I, Reuse-3, fractional frequency reuse (FFR), and soft frequency reuse (SFR), with varying input parameters, such as inner radius and power ratios. System simulation is used to evaluate the overall system performance in terms of throughput and SINR are evaluated. In addition to the overall system performance, cell-edge user performance, whose performance is severely limited by interference from neighboring cells, for each technique is also evaluated.

According to Hsin-Hung Cho Wireless networks have evolved from 1G to 4G networks, allowing smart devices to become important tools in daily life. The 5G network is a revolutionary technology that can change consumers' Internet use habits, as it creates a truly wireless environment. It is faster, with better quality, and is more secure. Most importantly, users can truly use network services anytime, anywhere.With increasing demand, the use of bandwidth and frequency spectrum resources is beyond expectations. This paper found that the frequency spectrum and network information have considerable relevance; thus, spectrum utilization and channel low interactions should be simultaneously considered. We considered that software defined radio (SDR) and software defined networks (SDNs) are the best solution. They propose a cross-layer architecture combining SDR and SDN characteristics. As the simulation evaluation results suggest, the proposed architecture can effectively use the frequency spectrum and considerably enhance network performance. Based on the results, suggestions are proposed for follow-up studies on the proposed architecture. Because the 5G wireless network is an actual environment, mobile devices are expected to be several times that of the present, thus, there will be inevitable challenges in accessing a network. Meanwhile, the frequency spectrum, bandwidth, security, and various factors pose a

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trade-off issue. This study believes that the co-existence of SDR and SDN is necessary, and the best effect can be achieved only by co-existence and mutual compliments. The evaluation of this study simplified the problem of SDR and SRN into a two-value trade-off problem in order to confirm the feasibility of the proposed architecture. The performance, power saving, security, and optimization problems derived from the interactions of the controller and two layer policy should be explored with greater effort in the future.

Multiplexing Techniques

OFDMA and SC-FDMA are used by 4G physical for DL and UL respectively. OFDMA structure of symbol in 4G. Also SC-FDMA is like as OFDMA, whereas numerous users can be assigned to a shared communication resource in SC-FDMA. SC- FDMA however takes advantage of low peak to average power ratio as compared to S-OFDMA in WiMAX, [8] which makes it appropriate for UL transmission user terminal. SC-FDMA covered the bandwidth is alike multi-carrier OFDMA. SC-FDMA is having advantage in the form of robust resistance to multipath without the problem of high peak to average power ratio. The area of SC-FDMA is limited to UL because the increased time-domain processing would be a considerable load on the BS

Table 1: Modulation Technique for 4G

Modulation Type	Coding Rate	Weight	K
QPSK	.076	2.6%	2
QPSK	.117	2.6%	2
QPSK	.188	2.6%	2
QPSK	.301	2.6%	2
QPSK	.438	2.6%	2
QPSK	.588	2.6%	2
16-QAM	.369	4%	4
16-QAM	.479	4%	4
16-QAM	.602	4%	4
64-QAM	.455	12%	6
64-QAM	.554	12%	6
64-QAM	.650	12%	6
64-QAM	.754	12%	6
64-QAM	.853	12%	6
64-QAM	.926	12%	6

Channel Modulation and Coding

4G uses QPSK, 16-QAM, 64-QAM Techniques for modulation purpose in UL and DL. Both Convolutional Coding and Convolutional Turbo Coding are used in 4G same as WIMAX but with different parameters [12]. Channel Modulation and Coding scheme are shown in Table 2

4G Frame Structure

As shown in Fig.1 4G 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 4G 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.

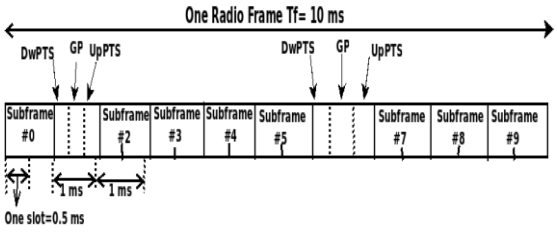

Fig.1 4G Frame Structure

MAC LAYER

In 4G 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 4G 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. 8.

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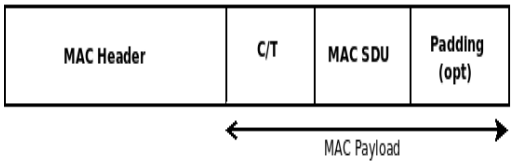

Fig.2 MAC PDU structure of 4G

Overview about 5G and its Architecture

5G is the most recent wireless technology invention. It is yet not deployed commercially but many research activities have proved its capability and data rates. Fifth generation mobile systems model is all-IP based model for wireless and mobile networks interoperability. The All-IP Network (AIPN) is capable to fulfill increasing demands of the cellular communications market. It is a common platform for all radio access technologies. The AIPN uses packet switching and its continuous evolution provides optimized performance and cost. In fifth generation Network Architecture consist of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies (RAT) [1.2]. 5G networks make use of this flat IP concept to make it easier for different RAN to upgrade in to a single Noncore network. Our 5G network uses Nanotechnology as defensive tool for security concern that arises due to flat IP. Certainly Flat IP network is the key concept to make 5G acceptable for all kind of technologies. To meet customer demand for real-time data applications delivered over mobile broadband networks, wireless operators are turning to flat IP network architectures. Flat IP architecture provides a way to identify devices using symbolic names, unlike the hierarchical architecture such as that used in "normal" IP addresses.

3. PROPOSED WORK

4G and 5G 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 provided by 4G and 5G Networks. Those that are correlated to access provision such as resource allocation and scheduling process are considered significantly flexible. 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 a4Grs 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. Considering all doubts over the actual throughput calculation seems to be tremendously difficult. The raw bandwidth of the DL channel can be calculated with the help of below formula and modulation distribution technique used in Table.1 and Table 2

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 4G and 5G 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.

4. SIMULATION AND RESULTS

To Analysis the performance of 4G and 5G network, we build the simulation model developed using Matlab. Four different case studies are deliberate base on dissimilar system parameters and traffic services. We have analyzed the performance of 4G and 5G network in the form of Capacity and Demand. We have two different types of user urban class and suburban class for both 4G and 5G Network

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 20000 Kbps and 10000 Kbps respectively. Contention ratio for urban and sub urban class users are 30, 10 respectively. 4G and 5G system input parameters are given in Table 4. 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 4G and 5G networks respectively. Minimum demand in DL for simultaneously connected 83, 80 users in 4G and 5G network are 7452.8 Kbps, 115738 Kbps. Both the demand in 4G and 5G can be accomplish by available bandwidth. The result shows that out of 4G and 5G network, 5G is having best performance. All the results related to DL/UL demand and capacity for 4G and 5G are shown in figures given below.

TABLE 3: INPUT PARAMETERS OF 4G AND 5G

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Parameters	4G	5G
Channel Bandwidth	10	100
DL/UL Frame Ratio DL/UL	3/1	5/3
Traffic Ratio Cyclic Prefix Rate	4	5
Number of Connections per	8	16.7
PDU Number of PDUs per data	3	5
burst	3	5

Minimum demand in DL for simultaneously connected 83, 80 users in 4G and 5G network are 7452.8 Kbps, 115738 Kbps. Both the demand in 4G and 5G can be accomplish by available bandwidth. The result shows that out of 4G and 5G network, 5G is having best performance. All the results related to DL/UL demand and capacity for 4G and 5G are shown in figures given below.

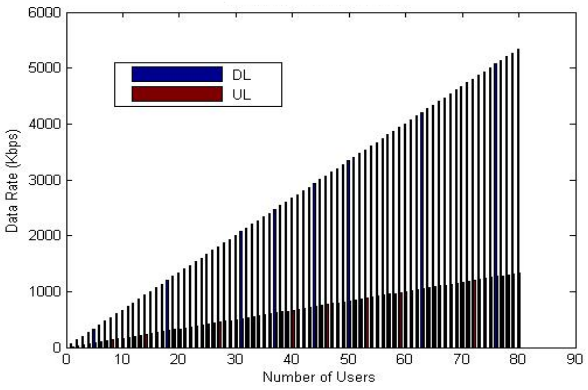

Fig. 3: DL/UL Demand of 4G

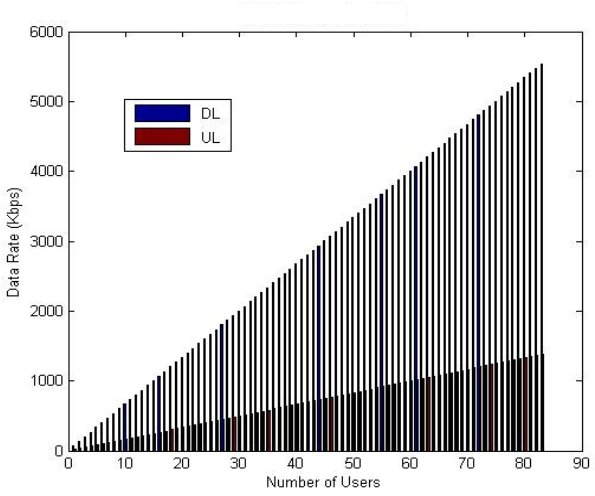

Fig 4 DL/UL Demand of 5G

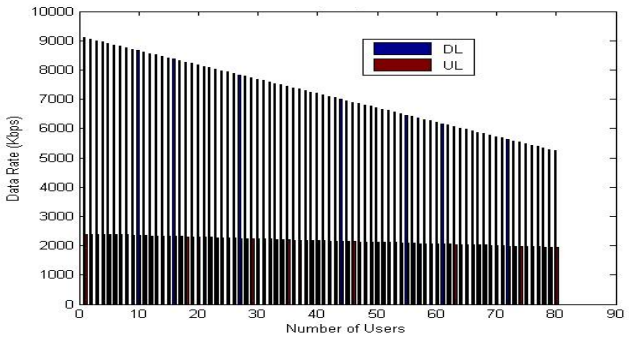

Fig.5: DL/UL Capacity of 4G

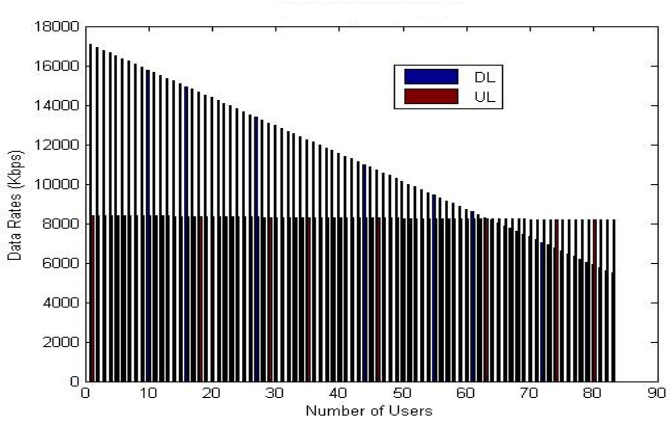

Fig.6: DL/UL Capacity of 5G

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. 4G and 5G 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 4G and 5G 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 5G and 4G network are 5551.34 Kbps and 4902.48 Kbps respectively. Both the demand in 5G and 4G 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 4G and 5G are shown in Fig. given below.

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TABLE IV: INPUT PARAMETERS OF 4G AND 5G

Parameters	(4G)	5G
Channel Bandwidth	5	10
DL/UL Frame Ratio	7/2	3/1
DL/UL Traffic Ratio	3	4
Cyclic Prefix Rate	16	4.7
Number of Connections per PDU	2	5
Number of PDUs per data burst	2	5

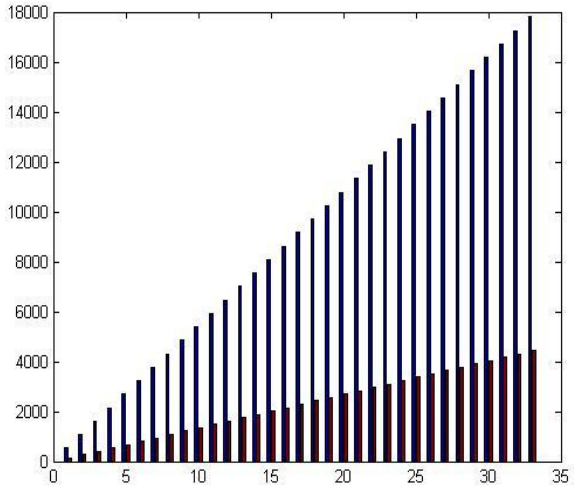

Fig.7: DL/UL Demand of 4G

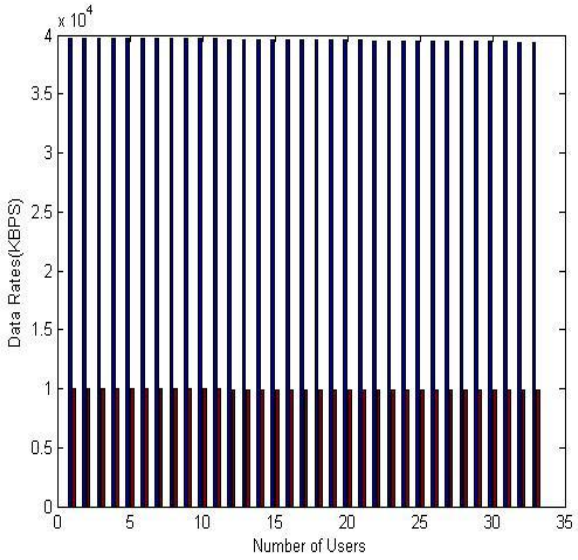

Fig81: DL/UL Demand of 5G

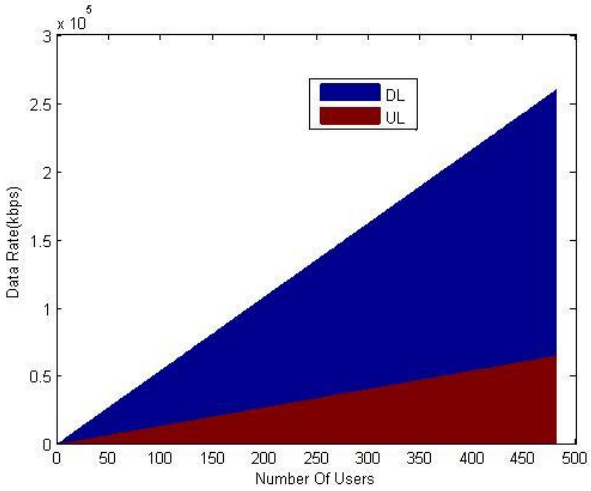

Fig.9. DL/UL Capacity of 4G

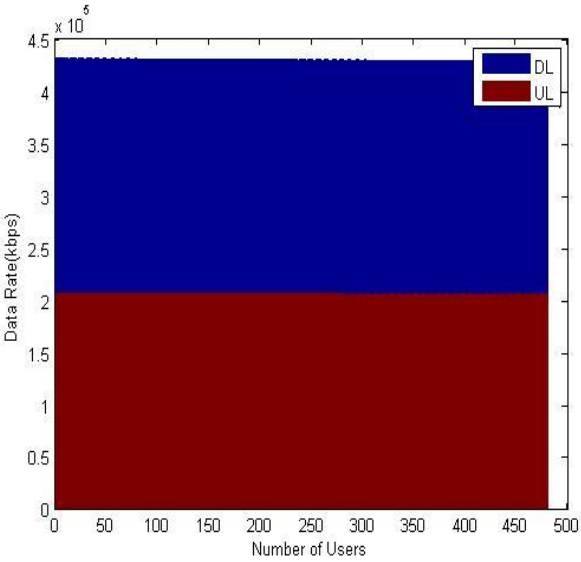

Fig.13: DL/UL Capacity of 5G

CONCLUSION AND FUTURE WORK

In this paper we have analyzed the cell range and capability of 4G and 5G network. Some overview part of 4G and 5G 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 4G and 5G are analyzed by this thesis. After reducing the all overhead we have done the comparison of 4G and 5G network in the form of maximum number of user supportable, allocated bandwidth to each user and minimum demand.

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 probability of every application will outcome in a more accurate traffic modeling.

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As 4G and 5G 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. 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 4G and 5G 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.

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.

Also in the future this research can be extended to compare and decide better 5G technologies as there are many different physical layer at 5G which are still getting evolved and proven day by day

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