International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

A Survey on Quality of Service in LTE Networks

Navita[1], Amandeep[2]

[1]M.Tech-CSE, Guru Jambheshwar University of Science & Technology, Hisar, India

[2]Assistant Professor CSE, Guru Jambheshwar University of Science & Technology, Hisar, India

Abstract: ***Long Term Evolution has being standardized by 3rd Generation Partnership Project (3GPP) in order to fulfil the emergent demand of very high data traffic both in magnitude and variety. In order to fulfil the emerging demand of user LTE networks come into existence with the different characteristics such as high data rate, high coverage area improved latency, high spectral efficiency, low cost and a simplified structure etc. Along with these entire characteristics LTE network may also require some improvement in its service quality. Different methods are recommended in order to improve the QoS. This article presents an overview on 4G LTE system about its architecture, its technologies and its features. Also this article presents the QoS concept in LTE system, QoS parameters and QoS provisioning mechanism in LTE networks.***

Keywords: EPC, E-UTRAN, LTE, OFDMA, MIMO.

1. Introduction

Development of LTE is strictly fitted in the prominent proverb "Necessity is the Mother of Invention". As in today's world technology is getting very sophisticated and continues work is going on to make it much better. Telephone technology which started simply from supporting voice, then data, then multimedia data but this is not enough for human being, their satisfaction is not until now. They may demand more than this, they require very high data traffic which may vary both in magnitude and variety. Magnitude mainly refers to amount of data and variety mainly refers to different types of data. They require fast uploading, downloading speed, online video gaming, video conferencing etc. In order to meet this increasing demand of user during 2004, 3rd Generation Partnership Project (3GPP)[1] organised a workshop with various telecommunication industries such as Universal Mobile Telecommunication Unit (UMTS), Universal Terrestrial Radio Access network (UTRAN) and many others. They decide to develop a new system with following key requirements such as [1]:

- Packet-switched domain optimization
- Roundtrip time between server and user equipment (UE) must be below 30ms and access delay below 300ms.
- Uplink peak rate 75Mbps
- Downlink peak rate 300Mbps
- Improvement to mobility and security
- Terminal power efficiency improvements

LTE comes as a new technology which meets these requirements. Main objective of LTE technology is to offer high data rates for both uplink and downlink transmission. LTE comes with the different characteristics such as [1]:

- High data rate
- Improved latency
- High coverage area
- High spectral efficiency
- Low cost
- Simplified structure

Along with all these important characteristics or the services offered by LTE, there may also occur a need to improve the quality of services as offered by LTE. The improving quality of service may include improving downloading speed, improving security, handling congestion etc.

How it works? LTE mainly refers to Long Term Evolution, it mainly consists two parts: the radio access network which is called E-UTRAN (Evolved UMTS Terrestrial Radio Access Network) and the packet core network which is called EPC (Evolved Packet Core).

The E-UTRAN has further two essential components:

- **User Equipment (UE):** may be any device used by an end user to communicate with the base station.
- **eNodeB:** simply a base station used to control all the radio access functions such as radio resource management, IP header compression and encryption of user data stream, scheduling and transmission of paging messages, selection of MME at UE attachment, routing of user plane data towards serving gateway, scheduling and transmission of broadcasting information measurement and reporting configuration for mobility and scheduling.

eNodeB uses two interfaces such as:

S1: interface mainly used to connect eNodeB with Evolved Packet Core (EPC) which allows the user equipment (UE) to communicate with radio access network (EPC).

X2: interface mainly used to interconnect eNodeB and supports enhanced mobility and inter-cell interference management.[3][4][5][6]

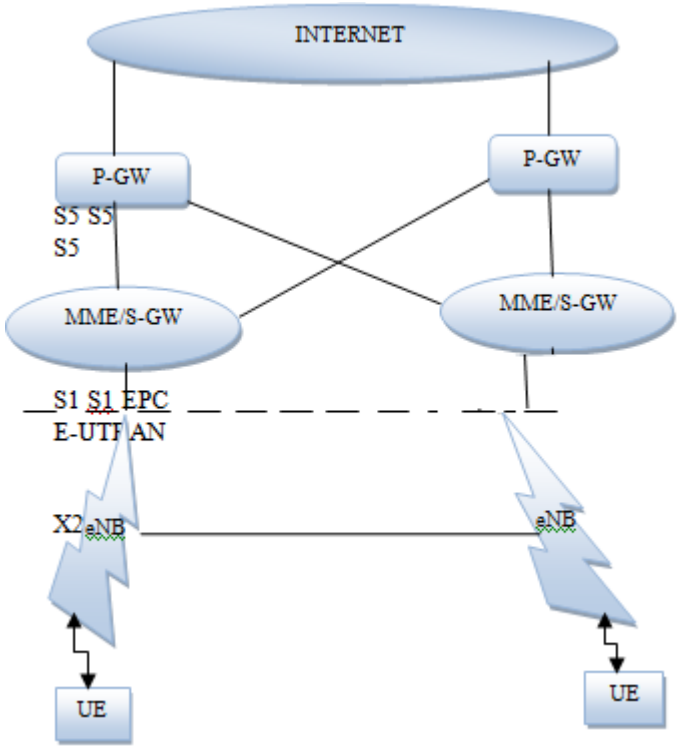

Figure 1: LTE Network Architecture

The EPC supports packet switched architecture. EPC is composed of several components:

- **The Mobility Management Entity (MME):**

MME is responsible for all the control plane functions related to subscriber and session management. In short MME controls mobility, UE identity, performs security control, idle state mobility control.

- **Serving Gateway (S-GW):**

S-GW is the ending point of packet data interface towards E-UTRAN. Major functionalities of S-GW are: acts as local mobility anchor, exchanging packets with eNodeB, allow packet routing and forwarding, QCI granularity.

- **Packet Data Network Gateway (PDN-GW):**

P-GW acts as an interface between the core network and external packet data network (PDN).Major functionalities of P-GW are IP address allocation, policy enforcement, uplink and downlink service level charging, packet classification and routing. It also acts as a mobility anchor for non-3GPP access networks.

- **Policy and Charging Rules Function (PCRF):**

The main responsibility of PCRF to begin QoS if a user requests for better QoS, along with that PCRF also detects service flow and enables charging policy and IP Multimedia Subsystem(IMS) configuration of each user.[2][3][4][6]

Technologies: LTE network system mainly works on three important technologies such as:

OFDMA

Orthogonal Frequency Division Multiple Access **(**OFDMA) is a better-quality air access method as compared to its antecedent. OFDMA is used in the downlink of LTE and for uplink Single Carrier Frequency Division Multiple Access (SC-FDMA) technology is used. This technology was preferred because it can attain the targeted high data rates with straightforward implementation which involve reasonably low cost and power-efficient hardware. OFDM is simply a form of Multicarrier Modulation (MCM) which is a parallel transmission method that divides the given radio frequency channel into numerous more narrow-bandwidth subcarriers and then transmits data on each sub-carriers.

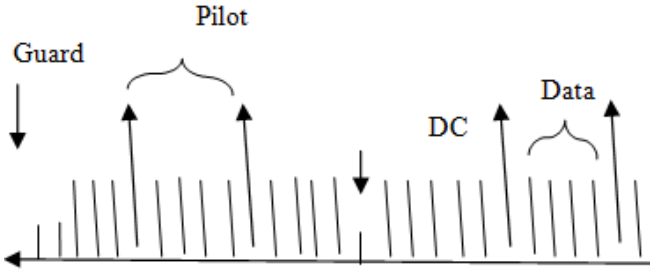

Figure 2[8]: OFDM Sub-Carriers

In the same way OFDMA divides the frequency bandwidth in narrow orthogonal sub-parts called sub-carriers. The sub-carrier consists of data carriers, pilot carrier, and a DC. Data carriers are mainly used to carry data, pilot carriers are used for channel sensing purposes and DC simply mark the centre of channel. Aggregation of a number of sub-carriers forms a sub-channel. Thousands of these narrow sub-channels are deployed to send many messages simultaneously which improve the data rates and overall throughput.

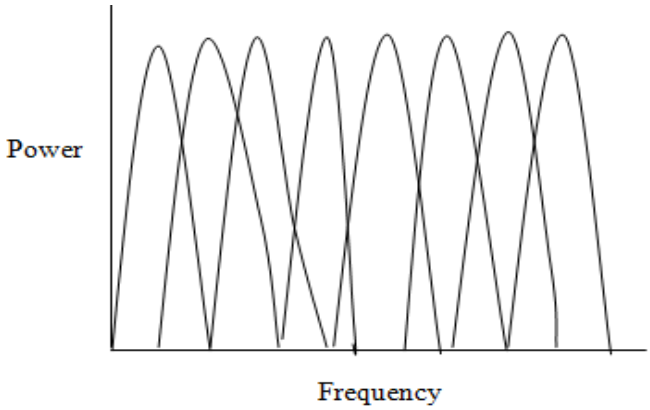

Figure 3[8]: Orthogonal Frequency Division

SC-FDMA:

Single-Carrier Frequency Division Multiple Access (SC-FDMA) mainly used for uplink transmission. Like various other multiple access technology (TDMA, FDMA, CDMA, OFDMA), SC-FDMA deals a single communication channel must be assigned to multiple users. This technology was chosen in uplink simply to reduce Peak to Average Ratio (PAR) which is the important issue behind OFDMA in uplink. This technology benefits the mobile devices mainly in terms of better transmit power efficiency and reduced cost of the power amplifier.

MIMO:

Multiple Input Multiple Output (MIMO) is an important technology used in LTE .This technology is mainly used to minimize the effects of noise and to improve link reliability. MIMO technique is mainly used by LTE in order to send data. In MIMO the transmitter and receiver having multiple

antennas to significantly increase the air interface. The basic idea behind its working is that a transmitter sends multiple streams on multiple transmit antennas and each transmitted stream goes through different paths to reach each receiver antenna. Different paths are followed by the same stream to reach multiple receivers which allow canceling of errors by using superior signal processing technique.

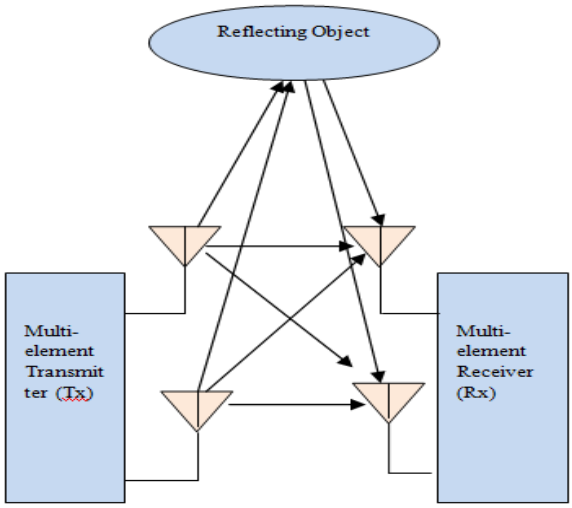

Figure 4: MIMO

Applications of LTE [9]:

- Voice over Internet Protocol (VoIP) over mobile
- Video streaming
- Content Downloading
- Gaming and social media applications

QoS in LTE

4G/LTE as an important technology which is mainly used for handling fast growing data rate traffic. Quality of Service in LTE has become a significant part of network planning and designing when deploying fixed broadband for different data and voice services. [12]Many of the subscribers make use of LTE services for various critical operations (e.g. voice calls, bank transactions, hospital operations), and many other subscribers who just only want to enjoy Internet & applications experiences (e.g. game playing, searching, web browsing). All such types of services or applications may require different quality of service. For example a VOIP is less sensitive to delay; file transfer is more sensitive to delay etc. LTE was designed in order to meet the increased data rate and application demands with reliable and trustworthy connections and at a low cost of deployment. In order to withstand with these future challenges, a highly flexible QoS framework must be designed.

In LTE based Network QoS is implemented between UE and PDN Gateway [10][11]. This QoS is applied through a set of bearers. These set of bearers may include radio bearer, S1 bearer and S5/S8 bearer and collectively called as Evolved Packet System (EPS).A bearer simply acts as a traffic separation element that enables differential treatment of traffic with different QoS requirements. Bearer provides a virtual path between a UE and PDN Gateway.

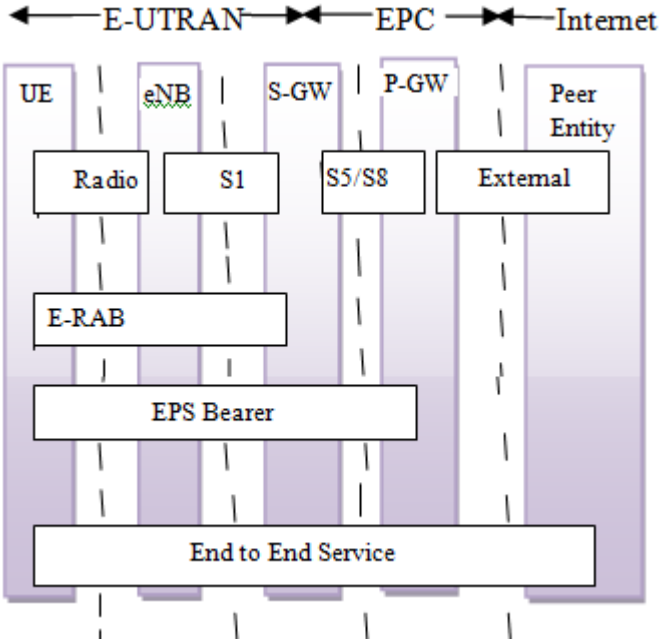

Figure 4: QoS Bearer MODEL

There are mainly two types of Bearer such as:

1. Default Bearer

When a mobile device or User Equipment (UE) initiates the connection to the LTE network for first time. Mobile device or UE will be assigned the default bearer based on its service requirement and remain connected until the UE disconnect from the network. Default bearer doesn't support any guaranteed bit rate service, it only offer best effort service. Each default bearer comes with a separate IP address. Quality of Service Class Identifier (QCI) 5 to 9 (Non-Guaranteed Bit Rate) can be assigned to default bearer.

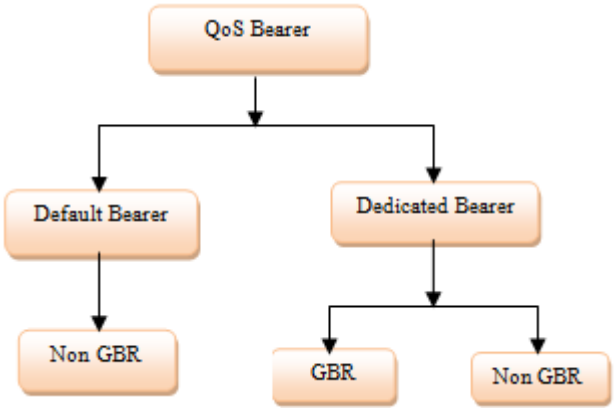

Figure 5: QoS Bearer

2. Dedicated Bearer

Dedicated bearer is another important bearer on the top of default bearer. This bearer acts as a dedicate tunnel to give suitable treatment to specific services (i.e. VoIP, video). It doesn't require additional IP address but it shares the address assigned by the default bearer. Dedicated bearer offers both Guaranteed Bit Rate (GBR) and Non-Guaranteed Bit Rate Service (Non-GBR). Dedicated bearer uses a TFT (Traffic Flow Templates) to give special treatment to specific services. Dedicated Bearer further classified as [9][10][11][12]:

- **Guaranteed Bit Rate Bearer (GBR):**

Minimum guaranteed bit rate (GBR) bearers are mainly used for applications such as VoIP and other real time voice calling applications. Each bearer associated with a predetermined GBR QoS parameter value. If the traffic carried by the GBR bearer conforms to the value associated with the GBR bearer, then there is no chance of congestion related packet loss on the service which utilizing the GBR bearer. A Guaranteed Bit Rate (GBR) bearer usually is established "on demand basis" because it blocks all transmission resources by reserving them during an admission control function.

- **Non-Guaranteed Bit Rate Bearer(Non-GBR)**

Non-GBR bearer doesn't guarantee any particular bit rate service. This bearer is mainly used for applications such as web browsing and FTP transfer. A service which utilizing Non-GBR bearer is highly prone to congestion related packet losses. It does not block any specific transmission resources. A non-GBR bearer is established in the default or dedicated bearer and get remain established for a longer period of time.

QoS Parameters:

A bearer has two or four QoS parameter depending on whether it is providing real time or best effort service [11]:

- QoS Class Indicator (QCI)
- Allocation and Retention Priority (ARP)
- Guaranteed Bit Rate (GBR) – real-time services only
- Maximum Bit Rate (MBR) – real-time services only

1. QoS Class Indicator (QCI):

QCI an important QoS parameter which specifies the forwarding treatment to the traffic or the IP packets received on a specific bearer. The forwarding treatment to a specific traffic may include scheduling weights, admission thresholds, queue management thresholds, link-layer protocol configuration, etc.

The 3rd Generation Partnership Project (3GPP) has defined a set of standardized QCI types, which are summarized in Table [9][10][11] listed below:

Table1[9][10][11]: 3GPP Standardized QCI Attributes

QCI	*Bearer Type*	*Priority*	*Packet Delay Ms*	*Packet Error Loss Rate*	*Example of services*
1	GBR	2	100	10^2	Conversational voice(VoIP)
2	GBR	4	150	10^3	Conversational video (live Streaming)
3	GBR	3	50	10^3	Real-time gaming
4	GBR	5	300	10^5	Non-conversation video (Video streaming)
5	Non-GBR	1	100	10^3	IMS signalling
6	Non-GBR	6	300	10^5	Video (Buffered streaming) TCP-based (e.g., www, Email, chat, FTP P2P files sharing, prog. Video, etc.)
7	Non-GBR	7	100	10^5	Voice, video (live streaming), interactive gaming
8	Non-GBR	8	300	10^3	Video (buffered streaming) TCP-based (e.g., www, email, chat, FTP P2P file sharing, progressive video, etc.)
9	Non-GBR	9	300	10^5	Video (buffered streaming) TCP-based (e.g., www, email, chat, FTP P2P file sharing, progressive video, etc.)

2. Allocation and Retention Priority (ARP):

This priority parameter is mainly used to indicate the priority of allocation and retention of service data flow. The ARP indicates whether a bearer establishment/modification request can be accepted or rejected in case of conflicts in demand for network resources or during network congestion. ARP can be used by the eNodeB in order to drop a flow which having a low ARP in order to free up the network capacity. ARP can become an important parameter in case of handover when a mobile user moves to a highly congested cell.

3. Maximum bit rate (MBR):

Maximum bit rate is specified for GBR bearers and is applicable only for real-time services. MBR specifies the maximum bit rate that traffic on bearer can't exceed.

4. Guaranteed bit rate (GBR):

Guaranteed bit rate is mainly defined for GBR bearer only. It mainly specifies the bit rate that a network guarantees for a particular bearer. In 3GPP Release 8 and beyond, the MBR must be set equal to the GBR, which means that the guaranteed rate is also the maximum bit rate that is allowed by the system.

In addition to all above four parameters, 3GPP also add a new parameter called the aggregate maximum bit rate **(AMBR)** parameter which is applied only on a group of non-GBR bearers. AMBR enables operators to limit the total amount of bit rate consumed by a single subscriber. This AMBR parameter is enforced both in uplink and downlink direction [9][11][13].

QoS Provisioning Mechanism:

There are various types of QoS based mechanism. These are discussed below [6]:

Scheduling:

Scheduling mainly refers to the process of dividing and allocating resources such as available bandwidth, delay etc. among the users that are involved in data transmission process. Various scheduling algorithms are used for providing better QoS. All these scheduling algorithms aim at providing better performance in terms of throughput, link utilization, fairness and complexity. In LTE, OFDMA is

used for downlink (DL) transmission and SC-FDMA mainly used for uplink (UL) transmission. These two scheduling method take having main focus on power consumption issue of mobile terminal. A better scheduling algorithm must be chosen in order to support better QoS in network.

Inter-Cell Mitigation
In LTE network, inter-cell interference may limit the performance of system in terms of spectral efficiency and data rates, especially at cell edges. Various Inter-cell mitigation techniques are used in LTE and categorized as:

- Interference cancellation by receiver processing
- interference randomization by frequency hopping using scrambling sequence
- Interference co-ordination through resource usage restriction.

Different approaches mainly formulate the ICIC (Inter-cell Interference Co-ordination) problem. This is also an important QoS mechanism.

Uplink Power Control:
Power control mechanism mainly refers to the process of setting up the power levels with the goal keeping in mind such as improving system capacity, coverage, data rates and reduction in power consumption. As for uplink transmission SC-FDMA is mainly used but it may be susceptible to some problem. So a better uplink power control mechanism may improve QoS of system or a network.

Rate Policing:
In LTE network system a better rate policing mechanism must be required both for uplink and downlink transmission**.** Rate policing mechanism mainly applied on each bearer. In LTE upper limit for GBR (Guaranteed Bit Rate) bearer is provided by MBR (Maximum Bit Rate) and for a group of non-GBR bearer is provided by AMBR (Aggregate Maximum Bit Rate). A better rate policing mechanism must be required for better QoS.

Pre-emption Handling for Radio Resource Allocation:
A pre-emption handling mechanism plays a vital role in QoS provisioning in wireless network, in case of congestion due to network overload. Based on QoS attributes and priority associated with each attribute, these pre-emption mechanisms, allow the higher priority process to pre-empt resources from low priority process. A better pre-emption handling mechanism must be required.

2. Conclusion

The 3rd Generation partnership Project (3GPP) LTE is a future oriented radio access system which is mainly designed in order to support the huge traffic demand of user which vary both in magnitude and variety. Future end users may require high speed internet, Mobile TV, Online gaming, video calling etc. The 3GPP Release 8 gave a flat Architecture of LTE which includes E-UTRAN and EPC. LTE come into existence with features such as High data rate, improved latency, High coverage area, High spectral efficiency, Low cost and simplified structure .LTE based on OFDMA, SC-FDMA and MIMO technologies. In LTE QoS is provided through bearer. A QoS bearer mechanism must be provided with different QCI. Different QoS provisioning mechanism such as scheduling, inter-cell mitigation, rate policing mechanism and rate control etc. QoS also provide future work related to its QoS supporting mechanism. By selecting anyone and finding its related problem and then find solution is a better future related work.

References

[1] Ville Eerola,"LTE Network Architecture," Helsinki University of Architecture.
[2] LTE Network Infrastructure and Elements (LTEencyclopedia); https://sites.google.com/site/lteencyclopedia/lte-network-infrastructure-and-elements
[3] Chapter 4 Long Term Evolution (Professor Ramon Ferrus (UPC)).
[4] "Policies for Public Safety Use of Commercial commercial Wireless Networks" by Ryan Hallahan and Jon M.Peha, Carnegie Mellon University, October 2010;http://users.ece.cmu.edu/~peha/public_safety_priority_access.pdf.
[5] 3GPP TS 36.300, "E-UTRA and E-UTRAN Overall Description", Version.8.4.0, (2008-03).
[6] S.M. Chadchan, Member, IEEE and C.B. Akki,"3GPP LTE/SAE: An Overview" published by *International Journal of Computer Science and Engineering Technology (IJCSET) ISSN*: 1793-8169, Vol-No.-2, pp.806-814, October, 2010.
[7] LTE: The Future of Mobile Broadband Technology, white paper Verizon Wireless
[8] SubharthiPaul," LTE and Ultra -Mobile Broadband (UMB) technologies for broadband wireless access," *A Survey Paper*, pp. 1-15.
[9] Masoud Mojtahed**,** Wireless Software Engineer Sindhu Xirasagar,"QUALITY OF SERVICE OVER LTE NETWORKS," white Paper.
[10] "The LTE Network Architecture. A comprehensive tutorial", a white paper by Alcatel Lucent.
[11] "Quality of Service (QoS) and Policy Management in Mobile Data Networks", a white paper by IXIA.
[12] "Quality of Service (QoS) in LTE", white paper by BEC Technologies.
[13] Najah Abu Ali,Abd-Elhamid M.Taha Hossam S.Hassanein,"Quality of Service in 3GPP R12 LTE-Advanced," IEEE Communication Magazine, August 2013,pp. 103-109.
[14] E. Dahlman, S. Parkvall, J. Skold, P. Beming, "3G Evolution: HSPA and LTE for Mobile Broadband", Academic Press, 2007.
[15] R. Van Nee and R. Prasad, "OFDM for Wireless Multimedia Communications",Artech House publications, 2000.
[16] H. Ekstrom et al., "Technical Solutions for the 3G Long-Term Evolution", IEEE Communication Magazine, Vol.44, No.3, Mar.2006, pp.38-45.
[17] G. L. Stuber et al., "Broadband MIMO-OFDM Wireless commn.",Proceedings of IEEE, Feb.2004, Vol.92, No.2, pp.271-294.
[18] 3GPP TR 25.913, "Requirements for EUTRA and EUTRAN", Version.9.0.0 (2009-12).

[19] 3GPP TS 25.892, "Feasibility Study for Orthogonal Division Multiplexing (OFDM) for UTRAN enhancement (Rel.6)", Version.6.0.0. (2004-06).
[20] 3GPP TS 23.107, "Quality of Service (QoS) concept and Architecture", Version.8.0.0, (2008-12).
[21] 3GPP TS 23.207, "End-to-end Quality of Service (QoS) concept and Architecture", Version. 8.0.0, (2008-12).
[22] Abhishek Nayak, Saurabh Verma, Anurag Jain," Effective ARP Based Call Admission Control (CAC) Scheme for LTE Systems" *ICWMC 2013: The Ninth International Conference on Wireless and Mobile Communications.*
[23] Géza Horváth and Péter Fazekas," End-to-end QoS Signaling Protocol and its Performance Analysis for LTE Networks", Telfor Journal, Vol. 6, No. 1, 2014.