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High Throughput Optimization of Lte Network

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Abstract

The design of Long-Term Evaluation (LTE) in cellular technology is characterized by the user to access the internet data through mobile phones and other electronic devices. LTE is a 3GPP (third generation partnership project) standard in the form of release-8, which provides high-speed for uplink and down-link. With the proposed LTE system can achieve the high data-rate up to 100Mb/s, when compare with the existing cellular technology. The design and network architecture of the 4G cellular network structure and its responsibilities are discussed with the network description of the LTE System Architecture Evolution (SAE).

Keywords: HSDPA, code detection, memory conflict, bit-rate, turbo decode process.

Introduction

The first generation (1G) network technology was launched by Nippon Telegraph and Telephone (NTT) in 1979. The NTT network was expanded within five years to the whole world and become the first nationwide 1G network. And the first mobile phone network was designed by Nordic Mobile Telephone[1], has the feature of international roaming. The Global System for Mobile communications[2] (GSM) identifies the standardization which is developed by ETSI to describe protocols for 2G mobile phones. The speed range of GSM will vary for every prominent and network. Generally the GSM phones are not only used for voice, also used for network access in the GSM through the GPRS core network. The General packet radio service[3] (GPRS) is a mobile data service, where services are transmitted by packets on the 2G and 3G cellular system GSM. It can transmit up to a data rate of 60KBps, which is more enough to send/receive the data and browse the internet. The reliable GPRS network can transmit the data with moderate speed, which is limited by GPRS standard. After the 2G standard design, 3G standard part is designed by ITU 3G by considering EDGE. The Global Evaluation of Data usage is classified by the 3g standard, which can transmit the data at more speed. The aim of designing a 3G network is not only to make the video call, also increase the efficiency of internet browsing and voice over IP communication on smart phones. HSDPA[4] (High Speed Downlink Packet Access) is one of the high speed technology, which is designed based on the 3G network supports up to 7.2 Mbps speed.

The other side of HSUPA is HSDPA, which is rarely considered for mobile devices. The two technologies HSDPA and HSUPA make HSPA standard, which is allowed by the 3g standard to maximize the download speed. The existing 3G network was designed with massive bandwidth, which is compatible with the 4G network design. The idea and implementation about HSPA is to move the carrier from the 3G network to the 4G network to increase the data rate without any new radios and mates. The main advantage of designing HSPA is backward compatibility about HSDPA using mobile receivers will work on them. Now all the devices are capable of HSPA and LTE receiver for high speed.

Now LTE toward 4G technology is available for pedestrian and moving points, also the data rate for downloading is also high. LTE radio access evolved UMTS Terrestrial Radio Access Network (E-UTRAN) is also designed to improve user throughputs, reduce user plane latency and also improve the user experience with full mobility. To avoid this issue LTE is designed with scheduling with end-to-end Quality of service and IP based traffic support. And by enabling the better integration of Voice over IP with other multimedia devices, voice traffic will be supported. Another method to improve the performance of LTE is, adding Orthogonal Frequency Division Multiplexing (OFDM) and multiple inputs and multiple output (MIMO) system to the physical layer technologies. The main aim of designing LTE is to reduce the user equipment complexity, which allows flexible spectrum deployment with 3gpp.

Architecture of LTE Network

The main components of the higher level network architecture of LTE[7] are: i. The User Equipment (UE), ii. Evolved UMTS Terrestrial Radio Access Network (E-UTRAN), iii. Evolved Packet Core (EPC)[5].

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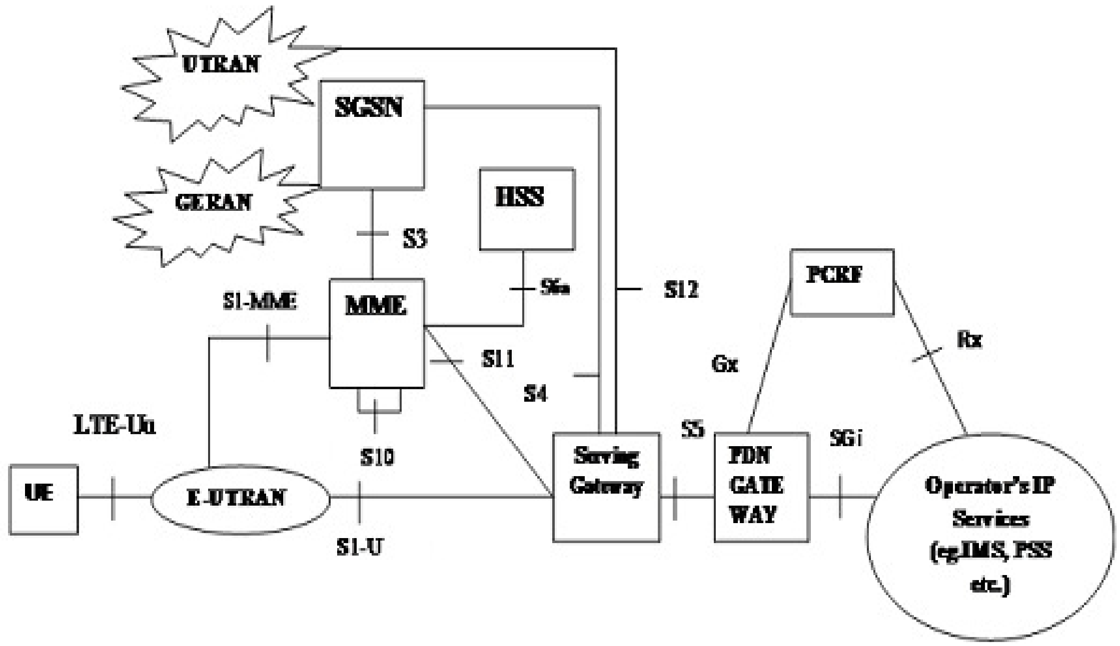

Figure-1
High level architecture of 3GPP LTE

User Equipment (UE): The LTE[6] user equipment is a Mobile Equipment (ME), it is utilized by both UMTS and GSM. The design of mobile equipment is to handle the communication functions, which is comprised of Mobile Termination (MT). The termination of data streams is done by Terminal Equipment. LTE equipments run Universal Identity Module (USIM) by utilizing Universal Integrated Circuit Card (UICC). The user-specific data storage of USIM is similar to 3G SIM, which keeps the information about the phone number, security keys, etc. User equipment types are also compatible with the existing interface access with the dual mode GSM.

The UMTS provides a wide variety of services like speech and multimedia services by enabling a wide range in the terminal. Although user equipment types of UMTS will not be standardized, it needs different power classes for cell planning reasons. Cell planners have to plan to achieve higher bit rates on the cell border primarily. But the maximum power will affect the performance of the upper range of bit rate services over the coverage area of UTMS. Based on the characteristics of input speech signal default speech codec for UMTS user equipment will be generated.

The E-Utran (The Access Network): The E-UTRAN Terminals support both 3GPP UTRA[7] and 3GPP GERAN systems. The efficient design of E-UTARN is to support inter-RAT measurement with reduced terminal complexity and increased performance. But the design of E-UTARN with UE will provide the measurement opportunities through uplink and downlink scheduling. During this scheduling the interruption time between the E-UTRAN and UTRAN with real time services and non-real time will be reduced to 300 msec and 500 msec.

THE EPC (Evolved Packet Core): The high performance and high-capacity of IP core network in LTE is designed by new packet core evolution. The requirements for achieving packet core evolution in LTE provides advanced real time services with enhanced Quality-of-Experiences. And it is achieved by the separation of control and data planes through the flattened IP architecture, which reduces the complexity between the data elements. These complexities will be reduced by adding LTE and EPG to the 4G communications provide the clear communication between the two end users. Using this method, the applications based on the IP can access any mobile operator or any access through the internet.

Evolved Packet Core Components Description: The packet core components, mainly consist of following new elements: i. Serving Gateway (SGW), ii. Packet Data Network (PDN) Gateway (PGW), iii. Mobility Management Entity (MME) and iv. Policy and Charging Rules Function (PCRF).

While 3gpp releasing Release 7, the PCRF introduces the Gateway saving, Packet Data Network and Mobility management has some performance issue which is modified by the 3gpp Release 8. This essential operation of LTE is done by the interpolation of the EPC gateways.And the architecture for LTE-SAE is shown in figure-2 with the specifications from the release 8.

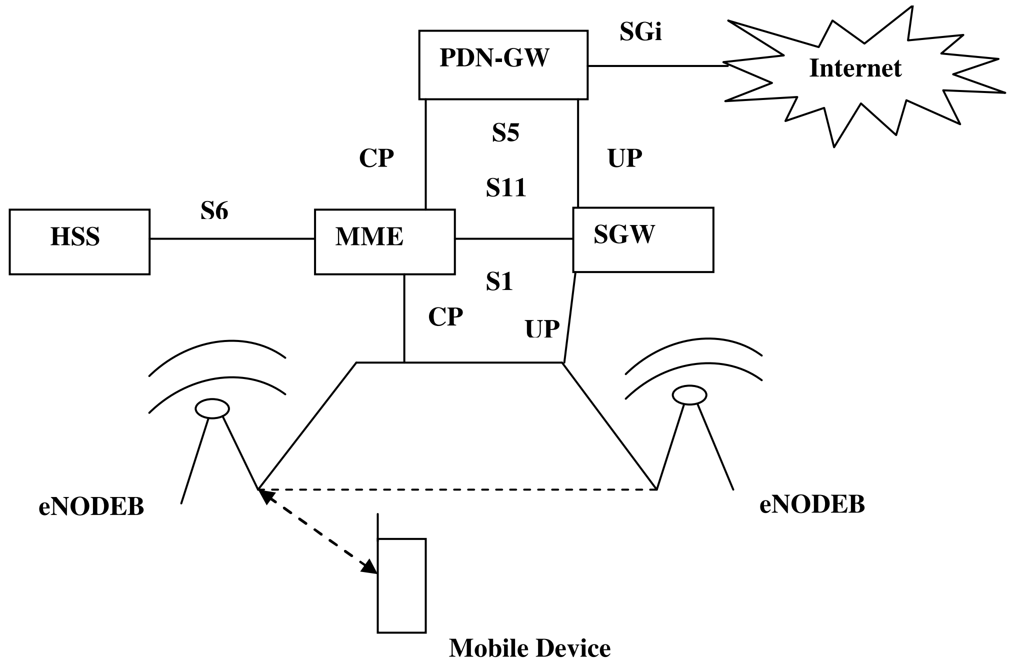

Figure-2
Simplified view of the LTE-SAE architecture

Serving Gateway: The aim to manage IP between eNODEB[8] and packet data network gateway is for gateway serving. And serving gateway is achieved by connecting to eNODEB through S1- user interface and to PDN gateway through the S5-UP interface, where S1 and S5 tunnels are individual users and independent of each other in the modification. This function will provide the modification and creation to the tunnels by connecting MME through S11. And the message transfer from the MME to SGW is done by interfacing GTP-C (GPRS tunneling protocol-control) with S11. But while considering network (same network or different network) MME and SGW standard are defined independently based on the operator's choice. Now the wireless standardization bodies majorly working on the independent operation of signalling traffic and user traffic. Because, if any signal is added to the processor it may increase the signaling and traffic of the processor, on the other hand it increases the user traffic and create complexity in network interfaces and routing capacity.

Packet data network gateway (PDNGW): For the user equipments in the network, connectivity to the external packet data network is handled with packet data network gateway as an entry or exit medium for data traffics. This gateway can have concurrent connectivity with other (more than one) Packet Data Network Gateway for accessing multiple PDNs. The focus of effective utilization of PDN gateways are found in packet filtering for users and lawful interception.

Mobility Management Entity (MME): In LTE access network, the Mobility Management Entity plays as a major control node. The tracking of idle state user equipments and paging procedure in retransmissions are controlled by MMEs. During the initial connection establishment MME involves as a carrier in activation/deactivation process. In certain cases, temporary identities for UEs are generated and allocated by non-access stratum. This Non-Access Stratum signaling is terminated at the MME point. Is also verifies the authorization of user equipments to camp on the service provider's Public Land Mobile Network and enforces UE roaming restrictions. At the same time, the MME is the termination point for ciphering or integrity protection for NAS signaling network and also handles the key management issues in the security gateway. The backward compatible feature between 2G/3G access network is also controlled by MME. The MME also terminates the S6a interface towards the home HSS for roaming UEs.

Home Subscriber Server (HSS): In the mobile networks, handling the user database itself finds a huge challenging task. Home subscriber server manipulates information of the entire users in the network. With this vast database of user information, authorization and authentication for individual users are provided as per their service requirement. The database in the LTE system is termed as home subscriber server. Whereas UMTS and GSM, terms the database as home location register (HLR). For information and data traffic exchange between MME and HSS were performed using *Diameter* protocol. While considering the fact that, when HSS and HLR are combined together for high throughput seamless roaming can be made possible in a effective way. Users credential parameters like IMSI number, users authenticity, switching properties. In contrast with other mobile network protocols, identity of current MSC is used to route the incoming switch circuit calls without faults. MME's ID or SGSN is used if user's HSS profile is updated and changes could be notified these nodes (MME or SGSN) and packet switched properties.

ENodeB: OFDM based structure of E-UTRAN is effective than other conventional radio access network due to the network element called eNodeB. During the earlier evolutions in 3G and 2G, Radio Network Controllers where inherited from one another. But this radio network controller does not find importance in LTE network and hence it is remove and replaced by eNodeB directly to the core network using S1 interface. ENodeB is directly connected to the Core Network using the S1 interface. In order to cope-up with the replacement, the functionality of the radio network controller has been distributed to eNodeB or core network MME or serving gateway entities.

Policy and Charging Rules Function: With reference to the rel 7 of 3GPP, a new converged architecture allows to optimize the interactions between rules functions and policies. This development includes policy and charging rules function (PCRF) and a new network node. The development in PCRF is a concatenation to policy decision function and charging rules function. The scope of policy and charging control framework in PCRF functionality is further improved in release 8, for smoothening the progress of non-3GPP element access to the network.

Long Term Evolution of 3GPP Release 8

The LTE deployment is based on rapid growth in mobile data usage. The main motivation for this work is due the increased demand for high user data rates, lower latencies. These issues have been tackled on several levels in both the radio access part of LTE (E-UTRAN) and the core network (SAE).

In 3G cellular technologies, LTE inherits the cellular concept and many of its features from legacy systems, but it also introduces a whole set of new concepts and features. Code Division Multiple Access (CDMA) used in third generation systems has been replaced by Orthogonal Frequency Division Multiple Access (OFDMA) for the multiple access method in downlink for its good spectral properties and bandwidth scalability. OFDMA is well compatible with the MIMO (Multiple Input Multiple Output) multi-antenna transmission techniques used in LTE. The downside of OFDMA introduces a high Peak-to-Average Power Ratio (PAPR) in the transmitter side and it increases transmitter complexity and power consumption, which is a critical factor in the mobile terminal side. So, a multiple access scheme that minimizes the terminal power consumption, SC-FDMA was chosen for uplink. Peak data rates in LTE release 8 are around 100Mbps for downlink and 50Mbps for uplink per cell. Latency is reduced to approximately 10ms in round trip times. Therefore, these figures are a significant improvement from those of High Speed Packet Access (HSPA) not to mention earlier 3G or 2G releases. After a saturation level in 3G mobile communication advancements, UTRAN Long Term Evolution (LTE) and System Architecture Evolution network were introduced in the field of mobile communication. There are two classifications in mobile communication. They are packed switched data traffic and circuit switched voice traffic. These two networks traffics are not separated in LTE/SAE architecture. Evolved packed switching system uses both the data traffic and voice traffic in a single channel itself. The network elements of LTE/SAE are MME, SAE gateway and eNodeB. eNode B acts as the base station of the LTE/SAE network. Again, when considering SAE gateway, there comes two classifications. They are Serving-SAE gateway and Public Data Network SAE gateway. A contact point for LTE type networks are established under Serving-SAE gateway. Whereas, the Public Data Network SAE is a counterpart element for external networks. The major use of these two gateways is related to mobility management in LTE not in the process of user-plane data. For mobility management, signaling of control plane is processed under MME.

In LTE[9], Voice over IP is developed for the voice calls which are transmitted over the Internet or other IP networks in packet-based session. LTE outperforms other existing mobile networks like GSM and UTMS and will also face the complexity in the network because of the huge symbolic representation among the elements of the LTE system. The evolution from third generation to fourth generation systems in terms of performance indicators such as data rates and latency are summarized in table 1.

Table-1
Evolution from 3G to 4G

	HSPA HSDPA/HSUPA	HSPA+	PA-LTE
Downlink Speed(Mbps)	14	28	100
Uplink Speed (Mbps)	5.7	11	50
Round trip time latency (ms)	100	50	10
3GPP releases	Rel 5/6	Rel 7	Rel 8
Approx years of initial roll out	2005/6 HSDPA 2007/8 HSUPA	2008/9	2009/10
Access methodology	CDMA	CDMA	OFDMA/ SC-FDMA

LTE Services Now Available: Earlier, major air components of mobile broadband are described for LTE[10]. In the real world implement the LTE standard is suggested for public safety applications and are deployed into the field by Federal Communications Commission at the 700 MHz band. LTE finds its own recognition in the commercial broadband world as almost major wireless carriers along the world started to adopt this mobile standard. According to the 3GPP standards LTE mobile network are much faster than other existing networks used within public safety, by achieving data transfer rate up to 10 times faster than 3G networks. As LTE has not been implemented fully, the public safety application has to get a lease line services from the commercial service providers or should build a 700MHz independent band for wireless communications.

The Advantages of LTE: Until the evolution of LTE, mobile broadband users have never experienced the high data speed access in uplink/downlink. This proposal lays a road way for many real time applications which requires high speed data connectivity for their effective performance. The bandwidth allocation in LTE will respond to the users of wider range without uninterrupted transmissions. Rapid response digital technology is fully utilized by the LTE customers during their uplink and downlink. Health oriented safety issues like monitoring of patients from remote places require high speed data access and timely response from both the ends. Illustrations shown in figure 1 explain the measures in enhancing data speed through LTE technology. As speed in wireless data networks has a great improvement in LTE, it has been adopted as a global standard. Latency factor in terms of time taken for connection establishment in LTE is much lower than other networking standards. With these significant applications, LTE is used in high speed mobility applications like public safety with GPS tracking systems. A portable radio for public safety which is used in a LMR system is very much expensive than the, smart devices capable of accessing broadband LTE networks for its communications.

The Challenges of LTE: Like any other technology, when this proposal is deployed in the real world environment, there are certain challenging issues to be faced by the public safety planners. To overcome the challenging issues, intensive care should be given in the following areas. In the emerging modern world, cost effectiveness is the major expectation by smart remote users. Though LTE broadband network is also available from wide range of wireless carriers the maintenance cost and bandwidth allocation will be more expensive.

Conclusion

The proposed LTE-SAE communication protocol elaborates the developments in this scenario. LTE-SAE offers a peak data rate of 100 Mbps in the downlink, has a round-trip time less than 10ms. This proposed architecture finds its own recognition for mobile broadband services in terms of high throughput and area utilization. The simulation result meets out the goal of our research work by reducing the channel capacity of the system. It is also noted that the cut down in the channel capacity did not degrade the data transmission in the channel. Considering the matter of discussion, our research work is able to sustain a throughput of 1Gbps as per the standard of 3GPP protocol.

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