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Examination of 4G (LTE) Wireless Network

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Abstract

Recently, the mobile wireless communication technology has become one of the most important fields which still in a significant growth that because to keep abreast of the progress that occur in broadband services field such as video on demand, images, internet protocol TV, video conferencing, and high definition TV. The mobile wireless network in every ten years appears a new generation since the first appearance by 1G system, the first introduced in the year 1980 which was based on the technology of analogue transfer for only voice calls., then the 2G system which begun appearance in the year of 1992, while this technique adopted to digital transmission technique which allowed the transfer of data on communications networks, in addition to voice calls that adoption one of a standard GSM or CDMA for calls and speed of these networks was about 9.6Kbps, and later to the intermediate networks called 2.5G, which appeared with the standard GPRS which allowed for transfer the better data with speeds of about 400Kbps. Then emerged the largest 3G networks at speeds up to 2Mbps, the third generation (3G) that started to roll out in 2001 and this technique provides a package of services and audio separately. The next development of generation systems is the 4G (fourth generation) which started appearance in the year 2010.

The main objective of this paper is to display a comparison of all generations of mobile technologies before the 4G LTE Network, the architecture of 4G LTE Network, QoS and bearer service architecture of the 4G LTE Network.

Keywords: 4G LTE Network, analogue transfer, digital transmission, package of services.



Introduction:

In last little periods the development in telecommunication community is severe. Where wireless mobile communication industry is the key support technology in this development. The result of this growth has produced a number of generations. These generations are 1G, 2G, 3G, and 4G, where every generation has several capacities, standards, techniques and novel characteristics that differs it from preceding generations. A number of mobile phone subscribers is rising every as a result of these novel characteristics.

The generations' naming denotes to a modification in the primary nature of the service, where non-backwards appropriate broadcast technique and novel frequency bands. The first movement was from 1G in 1981 used analogue to 2G digital transmission in 1992. After that, in 2002, followed by 3G supports multi-media, spread spectrum broadcast and at minimal 200 kbit/s, then 4G was followed, which mentions to all-IP packet-switched nets, multi-carrier transmission and mobile ultra-broadband (gigabit speed) access.

1.First generation (1G):

During 1979 the First-generation (1G) introduced, which is wireless telecommunication technology utilized analog transport for communication serving. Also, in Japan, Tokyo Nippon Telephone and Telegraph (NTT) discovered the foremost operational cellular in the world. Europe reached the cellular after two years. In 1982, the Advanced Mobile Phone System (AMPS) was launched in the U.S.A. Total Access Communication Systems (TACS) and Nordic Mobile Telephones (NMT) is the most two common analogue systems at that time. Where (TACS) was launched in the U K, C-Netz was launched in West Germany, Radiocom 2000 in France, and RTMI in Italy. 1G supplied voice transmissions through applying analogue modulation and frequencies almost 900 MHz [4].

1G has low capacity, poor quality of voice links, untrusted handoff and lack of security at all, when voice calls were established backwards in radio towers, leading these calls to be vulnerable to undesirable eavesdropping through third parties [1].

2. Second Generation (2G):

At the end of 1980s the Second-generation (2G) of wireless telecommunication technology was deployed. Where 2G systems employ digital multiple access, technology compared to 1G



system, as code division multiple access (CDMA) and time division multiple access (TDMA). Thus, 2G is better data services, higher spectrum efficiency and more advanced roaming compared with 1G system. Three of 2G digital cellular systems were developed In the U.S.A. During 1991 the first digital system was introduced, which was the IS-54 (North America TDMA Digital Cellular), in 1996; (IS-136) was launched as a new type supporting extra services. Also, Throughout1993, IS-95 (CDMAOne) was introduced [3]. 2G of wireless telecommunication technology is mostly connected by Global System for Mobile (GSM) services. Radiolinja in 1991 deployed 2G of wireless telecommunication technology were commercially launched on the GSM criterion in Finland. Where, GSM service is exercised by more than two billion users over more than 212 countries and territories. The international roaming became very popular between mobile phone operators due to the ubiquity of the GSM standard and permitting subscribers to use their phones in various areas of the world. Moreover, 2G uses Compression-Decompression Algorithm (CODEC) to compressing and multiplex digital voice data. 2G network can pack more calls per amount of bandwidth by this technique [1] [4].

3.Third Generation (3G):

The third generation (3G) of mobile phone technology, which is replace 2G, and preceding 4G. 3G is founded on the International Telecommunication Union (ITU) family of international standards based on the International Mobile Telecommunications programmed (IMT-2000). 3G technologies provide consumers an inclusive range of advanced services and improved spectral efficiency to achieve better network capacity. These services comprise video calls, wide-area wireless voice of mobile phone technology, and broadband wireless data of mobile phone technology. Further characteristics contain High-Speed Packet Access (HSPA) data transmission capabilities that have ability to transmit data over a network of speed up to 5.8Mbit/s on the uplink and 14.4Mbit/s on the downlink. Where, spectral efficiency denotes to the how many of information that allowed to transmit a cross of particular bandwidth in a specific digital communication system. HSPA is a gathering of mobile phone protocols that improve and extend the performance of present UMTS protocols. The TDMA and CDMA are used in 3G, where 3G techniques make use of value supplied extra services as Global Positioning System (GPS), mobile television and video conferencing.



The key feature of 3G technique is fast speed data transmit rates. Moreover, the ability of 3G technology to support the five main radio technologies makes it more flexible, and these radio technologies work under TDMA, CDMA and FDMA. FDMA has a single radio interface called frequency code or IMT-FC. TDMA accounts for IMT-TC (time code), IMT-SC (single carrier). CDMA holds for IMT-DS (direct spread), IMT-MC (multi carrier). 3G has a number of technologies as GSM EDGE, W-CDMA, UMTS, WiMax, CDMA 2000 and DECT. Improved data rates for GSM evolution or EDGE is known as a backward digital technique, for the reason that it can work with older devices.

3G has a number of enhancements over earlier networks as higher data speed, Greater video and audio streaming, Web and WAP browsing at higher dispatch speeds, support of Video-conferencing and support of the TV through the Internet (IPTV).

3G is a set of standards that can be work together. An institute known as 3rd Generation Partnership Project (3GPP) has running the effort by providing a mobile system that accomplishes the IMT-2000 technology. The 3G system name by the ITU-T is IMT2000, whereas 3G of the American name is CDMA2000. WCDMA is the air-interface technology for the UMTS. The initial commercial version of 3G network was introduced by NTT Do Co Mo in Japan where branded FOMA and based on W-CDMA technique on October 2001 [2] [4].

4.Fourth Generation (4G)

The key objective from 4G technology was to offer high speed of packet transmission, high capacity, high quality of data and low-cost facilities for instance multimedia, voice and internet over IP. In 2005 in the first effective trial for 4G was introduced in Tokyo by NTT Do Co Mow. It has a success in reaching 1Gbps real time packet broadcast in the downlink by a speed of moving around 20km per hour.

The Long-term evolution (LTE) and Worldwide Interoperability for Microwave Access (Wi-MAX) are two technologies categorized under the 4G umbrella. After 3G the following stage was 3GPP Long-Term Evolution (LTE). Where aimed to improving the Universal Mobile Telecommunication System (UMTS) to overcome the future demands [1] [2].

The LTE developed through 3rd Generation Partnership Project (3GPP) which is more elevated flexible for radio interfacing. During 2009 LTE started deployment process, wherever the first



version of LTE appear is making maximum rate up to 300 Mbps, less than 5msec delay of radio network, a spectrum important growing incompetent of spectrum whether matching with any other cellular systems, besides to reducing the cost and to shorten the operations a number of uniform architectures in radio-network was designed. Frequency Division Duplex (FDD) and Time Division Duplex (TDD) technique are supported by LTE systems as a various collection of bandwidths to working in an inclusive amount of different spectrum distributions. The LTE system has been set up as a standard evolution of UMTS and GSM at 2009 [4].

Table 1: 4G of mobile technologies

Generation	Starts from	Data capacity	Technology	Multiplexing	Switching	Main network	Hand off	frequency
4G	2010	200Mbps-to-1Gbps	LTE Wi MAX	MC-CDMA OFAM	Packet	Internet	Horizontal & Vertical	2-8GHz

The comparison of all generations of mobile technologies is described in the following table:

Table 2: comparison of all generations of mobile technologies

Technology Feature	1G	2G	3G	4G
Start/ Deployment	1970 – 1980	1990– 2004	2004-2010	Now
Data Bandwidth	2kbps	64kbps	2Mbps	1 Gb/s
Technology	Analog Cellular Technology	Digital Cellular Technology	CDMA 2000 (1xRTT, EVDO) UMTS, EDGE	Wi-Max LTE Wi-Fi
Service	Mobile Telephony (Voice)	Digital voice ,SMS, Higher capacity packetized data	Integrated high quality audio, video and data	Dynamic Information access, Wearable devices
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA
Switching	Circuit	Circuit, Packet	Packet	All Packet
Core Network	PSTN	PSTN	Packet N/W	Internet

5.The architecture of 4G LTE Network:

The IP protocols are the base of all the network interfaces. The eNBs are interrelated via using of an X2 interface and to the MME/GW entity through an S1 interface, where the eNBs is



the device that is linked to the network of mobile phone which interconnects directly with mobile handsets. As shown in Figure 1. a many-to-many relationship are supports by S1 interface among MME/GW and eNBs [3].

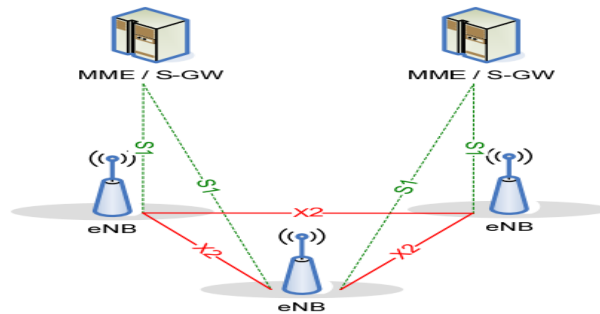


Figure 1. 4G LTE Network architecture [3].

The Figure2 illustrates the functional split between MME/GW and eNB. Serving gateway (S-GW) and the packet network gateway (P-GW) are two logical gateway entities, which are defined. The first logical gateway which is S-GW gateway performs as domestic mobility anchor sending and getting packets to and from the eNB serving the UE. The function of second gateway (P-GW) interfaces with outer packet data networks (PDNs) as the IMS and the Internet. Moreover, The P-GW implements some IP jobs like policy implementation, address allocation, packet routing and filtering.

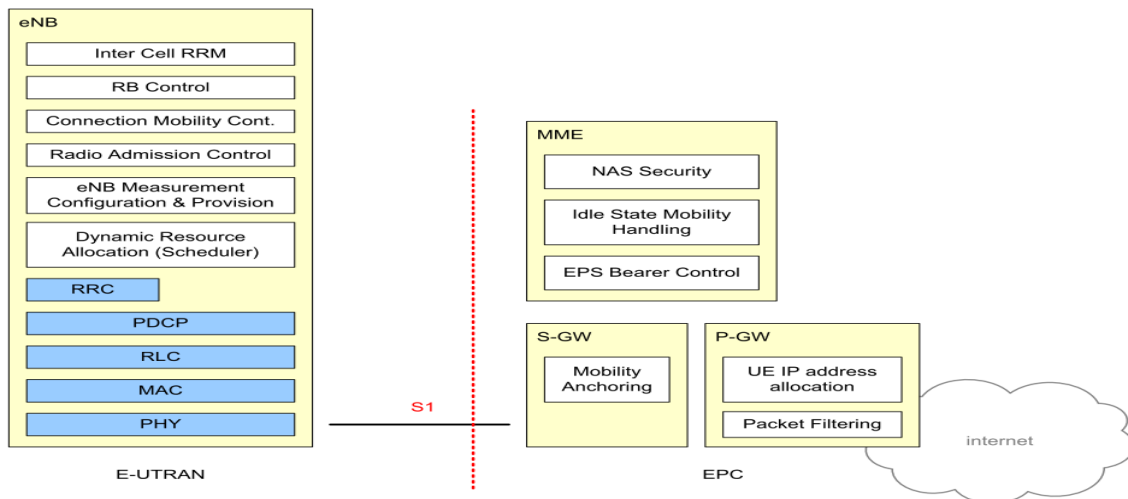


Figure 2. Functional split between eNB and MME/GW [3].



MME is a signaling just entity and hence operator IP packets do not run over MME. a benefit of a split-up network entity for signaling is that the network capacity for signaling and traffic can be increase individually.

The fundamental of MME are idle-mode UE reachability including the control and execution of paging retransmission, tracking area list management, roaming, authentication, authorization, P-GW/S-GW selection, bearer management including dedicated bearer establishment, security negotiations and NAS signaling, etc.

Evolved Node-B implements Node-B functions as well as protocols traditionally implemented in RNC. The main functions of eNB are compression of header, delivery of packets with ciphering and reliable. On the control side, eNB incorporates functions such as admission control and radio resource management. Particular benefits of a single node in the access network are to reduced latency and the distribution of RNC processing load into multiple eNBs [3].

The user plane protocol stack is shown in Figure 3. Packet data convergence protocol (PDCP) and radio link control (RLC) layers traditionally terminated in RNC on the network side are now terminated in eNB.

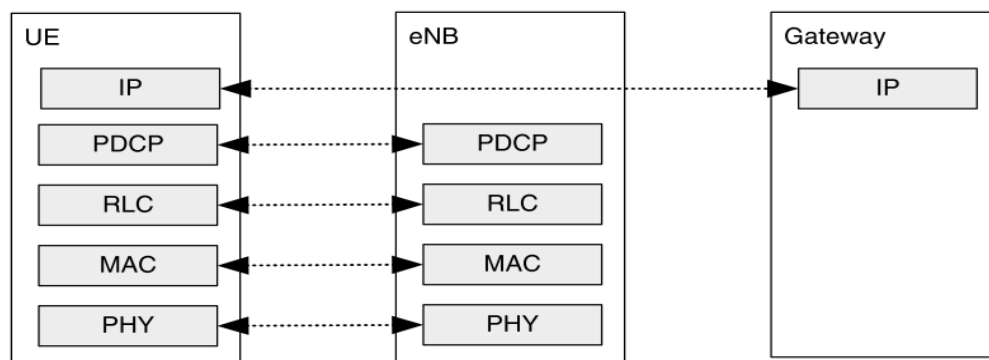


Figure 3. User plane protocol [3].

Figure 4 shows the control plane protocol stack. RRC functionality traditionally implemented in RNC is now incorporated into eNB. The RLC and MAC are performs the same functions for the user plane. The RRC performs many functions like, include system information broadcast, paging, radio bearer control, RRC, mobility functions and UE report measurement and control.

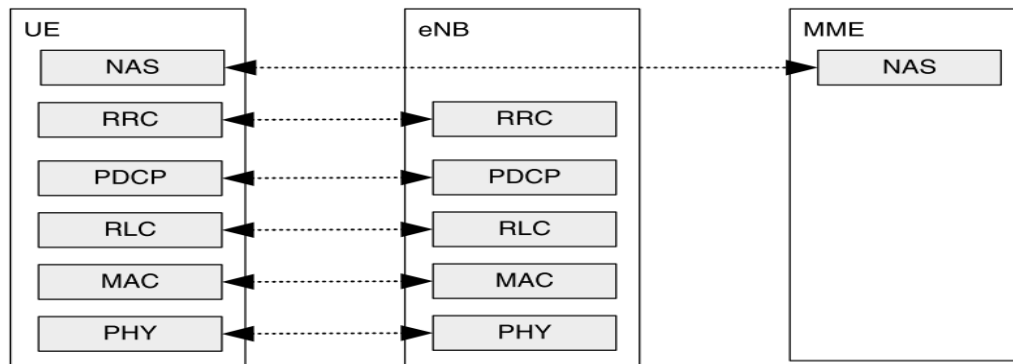


Figure 4. Control plane protocol stack [3].

6.QoS and bearer service architecture

Applications such as web browsing, video telephony, VoIP, and video streaming have special needs of QoS. An important feature of any group of packets network is the provision of a QoS mechanism to enable differentiation of packet flows based on QoS requirements. In EPS (**Evolved Packet switched System**), QoS flows called EPS bearers are established between the UE and the P-GW as shown in Figure 5. A radio bearer transports the packets of an EPS bearer between a UE and an eNB. Each IP flow for example in VoIP is associated with a different EPS bearer and the network can prioritize traffic accordingly. When IP packet received from the Internet, packet classification performs by P-GW based on certain predefined parameters and sends it an appropriate EPS bearer [5].

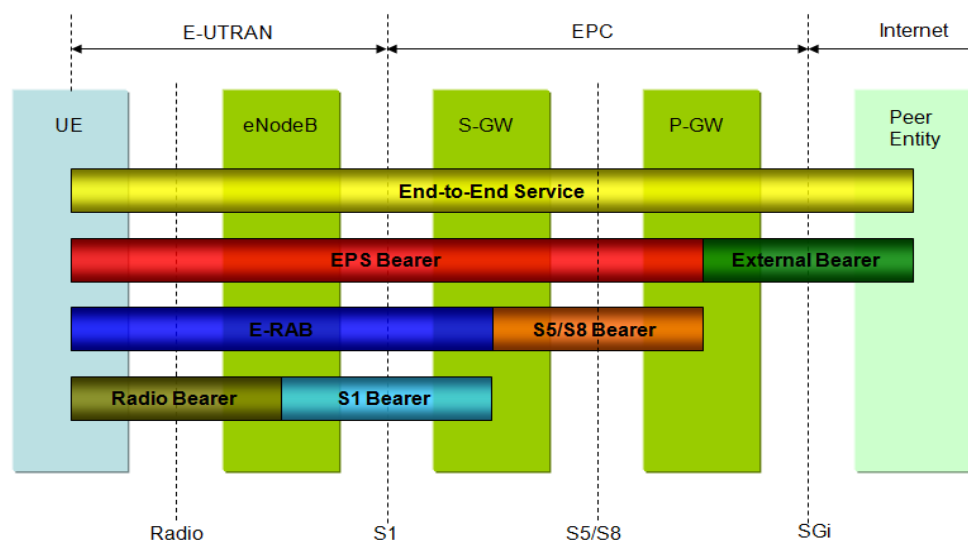


Figure 5. EPS bearer service architecture [3].



There are two types of EPS Bearer. One is 'Default EPS Bearer' and Dedicated EPS Bearer [3].

A. Default EPS Bearer:

- Be established during Attach Process
- Allocate IP address to UE
- Does not have specific QoS (only Nominal QoS is applied).
- Similar to Primary PDP Context in UMTS

B. Dedicated EPS Bearer

- Normally be established during the call setup after idle mode.
- Does not allocate any additional IP address to UE
- Is linked to a specified default EPS bearer
- Have a specific (usually guaranteed) QoS
- Similar to Secondary PDP Context in UMTS

Conclusion

Wireless and Internet technologies continue to evolve at a fast pace adopting global calculating schemes. It is marked that 4G technologies will increased on web-based communications around the world. This technology will tolerate for enhanced applications such as telemedicine that maybe save our lives. The technology is a fully IP-based network and will increase data transfer intensely. Minimal Signal disturbances, and downloads will be done in seconds, faster than ever in the past. The 4G LTE evolution is nothing less than ground breaking. The innovations that have been made from 3G to 4G LTE alone are Mind boggling. With the high-speed data processing being increased to at least 100 Mbit/sec the possibilities are limitless in the wireless communication. The whole thing with this new knowledge has been carried to a new standard. The confidence, with the fully IP-based solutions tolerates the user to use the full capability of the phone as well as feel completely secure at the same time, which is some of the greatest vital features that has been upgraded from the previous wireless communication technologies.



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