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Migration from 2G to 4G Mobile Technology

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Abstract

Mobile communications systems revolutionized the way people communicate, joining together communications and mobility. Wireless connectivity is almost everywhere and getting highly affordable even for people who are in the bottom of the pyramid. Wireless Communication is the transfer of information over long distances without the use of wires Wireless networking is slowly pushing out wired networking and ideal solution for a user that wants the ability and freedom to roam without having a fixed cable determining the distance that that user can go before having to stop due to a cable. In this review paper we have presented the evolution of wireless technology as first generation of mobile technology and migration from second generation to fourth generation of mobile technology. We have compared the different technologies of mobile in terms of bandwidth,, data transfer rate, switching technique, architecture etc. LTE (Long Term Evolution) is a transition from 3G to 4G that provides improved performance compared to legacy cellular systems and is based on OFDM (Orthogonal Frequency Division Multiplexing), it works by splitting the radio signal into multiple smaller sub-signals that are then transmitted simultaneously at different frequencies to the receiver. OFDM reduces the amount of crosstalk in signal transmission. The fourth generation (4G) wireless networks are all set to turn the current networks into end-to-end IP networks.4G – "connect anytime, anywhere, anyhow" promising ubiquitous network access at high speed to the end users, has been a topic of great interest

especially for the wireless telecom industry. The maturity and stability of 4G technologies therefore breeds innovation at faster pace and hence possibilities for novel and people-centric services are huge.

1. Introduction

Wireless connectivity is increasingly pervasive and persuasive for enabling the true mobility. Anywhere anytime communication, computation and collaboration are the new norm being prescribed for every individual to be extremely productive .

Competent and compact wireless technologies have emerged and evolved in order to fulfill the soaring expectations of businesses as well as end-users. The ability to communicate with people on the move has evolved enthusiastically and was adopted by the people throughout the world [1]. The number of mobile subscribers has increased tremendously during the last decade More than 1 million new subscribers per day have been added globally, that is more than ten subscribers on average every second. In the mid of 1980's,the initial wireless telephone technology is referred to as First Generation and 1G networks use analog signals .It supports only voice services. The second generation is totally digital and supports additional services like SMS (Short Message services).The third generation of mobile technology came into picture to achieve higher data rate and support services like mobile T.V. video calls etc. Finally fourth generation is getting ready to storm the markets [2]. LTE (Long Term Evolution) is developed to cater the increasing demands of higher data rates at decent costs.

2. Evolution of Mobile Technologies

2.1 First Generation Technology(1G)

The big boom in mobile phone service really began with the introduction of analog cellular service called Analog Mobile Phone Service (AMPS) starting in 1981.The first generation of wireless telecommunication technology supports only voice calls which are provided with circuit switching. The limitation is that data is not encrypted and thus prone to miscommunication, sound quality is poor and data transfer rate is 9.6 Kbps. It uses the Frequency Division Multiplexing technique [2].

2.2 Second Generation Technology(2G)

The next generation, quick on the heels of the first, is digital cellular. One standard uses a digital version of AMPS called D-AMPS .The second generation of wireless telecommunication technology supports SMS services in addition to voice calls. The 2G technology is based on Time Division Multiplexing and Code Division Multiplexing. Based on TDMA, Global System for Mobile communication is the first European standard used by the 2G telephony. The data transfer rate is 14.4 Kbps and a 2G GSM network uses 800/900 MHz frequency spectrum .Data services such as Internet access, text messaging, sharing pictures and video are inherently digital [2].

2.2 2.5G-GPRS(General Packet Radio Service)

The 2.5 generation of wireless technology supports multimedia messages and provides the access to Internet. This technology have implemented packet switched domain in addition to circuit switched domain. The data transfer rate is 115 Kbps. The demand for greater bandwidth right now has spawned intermediate generations called 2.5G and even 2.75G. One such standard is General Packet Radio Services (GPRS), which is an extension of the GSM digital cellular service popular in Europe [2].

2.4 2.75G-EDGE(Enhanced Data rates for GSM Evolution)

EDGE is a digital mobile technology which was invented by AT&T and is an extended version of GSM. It supports fast transmission of data with data transfer rate of 236.8 Kbps

2.5 Third Generation Technology(3G)

The third generation of mobile telecommunication technology is based on set of standards defined by ITU (International Telecommunication Union). 3G has proven to be a tough generation to launch. It enables telephones to also become Internet computers, video phones and television receivers, its maturity phase will find it competing with wireless VoIP telephone services on Wi-Fi, WiMAX, WiTV and the new wireless mobile standard 802.20. The data transfer rate of Universal Mobile Telecommunication System,3G mobile technology is 2 Mbps. It supports services like video calls. live T.V,

e- mailing and accessing high speed internet [4].

2.6 Fourth Generation Technology(4G)

The development and augmentation of 4G networks and related technologies in today's scenario is imperative indicator of advancement in the field of wireless communication and technology. The main features of 4G services of interest to users are application adaptability and high dynamism. It means services can be delivered and available to the personal preference of different users and support the users traffic, radio environment ,air interfaces, and quality of service. The fourth generation of mobile technology is the extension of 3G which offers higher bandwidth. The 4G technology offers high data rates and high quality audio or video streaming over end to end Internet Protocol. In India, the Reliance Industries headed by Mukesh Ambani revealed to The Economic Times to provide 4G connectivity to 700 cities till the mid of 2013.[7]The data transfer rate of 4G technology is 100 Mbps and up to as fast as 1 Gbps.

The 4G Mobile communications will be based on the Open Wireless Architecture (OWA) to ensure the single terminal can seamlessly and automatically connect to the local high-speed wireless access systems when the users are in the offices, homes, airports or shopping centers where the wireless access networks ATM, etc) are available. When the users move to the mobile zone, the same terminal can

automatically switch to the wireless mobile networks. etc. Based on this OWA model, 4G mobile will deliver the best business cases to the wireless and mobile industries.[3]

2.8 Long Term Evolution(LTE)

It is 4G wireless communication standard which was developed by the 3rd Generation Partnership Project (3GPP), a collaboration between group of telecommunication associations. The idea was proposed in Toronto conference of 3GPP in 2004 and was started as LTE work in 2006. The aim was to achieve high data rate mobile services [3].

3. GSM Architecture

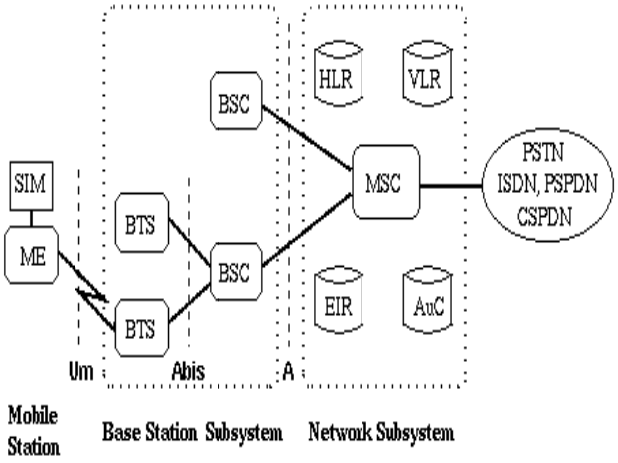

Fig.1: Architecture of 2G mobile technology.

In 1982, Conference of European Post & Telecommunication (CEPT) worked on wireless communication and establishes a GSM group in order to develop the standards for a pan-European cellular mobile system.

In 1988, the Group Special Mobile committee was transferred from CEPT to the European Telecommunications Standard Institute (ETSI) and then GSM came to be known as Global System for Mobile [2].

The spectrum band reserved for GSM is 900 MHz. In all over world , the same frequency (900 MHz) is being used ,that is why it is being called “global”.

3.1 Basic terminology of Wireless Technology

1. Subscriber Identity Module (SIM) Card The subscriber is identified in the system when he inserts the SIM card in the mobile equipment as it provides flexibility of communication to the subscriber.[2]

2. MSISDN (Mobile Station Integrated Service Digital Network)The real telephone number of a mobile station is the mobile subscriber ISDN number (MSISDN).
3. IMSI (International Mobile Subscriber Identity)It is stored in the subscriber identity module (SIM) .A mobile station can only be operated if a SIM with a valid IMSI is inserted into equipment with a valid IMEI
4. TMSI (Temporary Mobile Subscriber Identity) The VLR, which is responsible for the current location of a subscriber, can assign a TMSI which has only local significance in the area handled by the VLR.
5. IMEI(International Mobile Equipment Identity) It is a kind of serial number which is allocated by the equipment manufacturer.

3.2 Need of GSM

I. Frequent faults in landline.
II. Increasing complexity.
III. Uninterrupted services and security in mobile.

3.3 Specifications

- Access Method - FDMA/TDMA
- Uplink Frequency - 890-915 MHz
- Downlink frequency - 935-960 MHz
- Bandwidth - 25 MHz
- Channel Bandwidth - 200 KHz
- No. of Channels - 124 channel pairs (25 MHz/200 KHz)

3.4 Network Elements of GSM Architecture

- Mobile Station
  When a SIM is inserted in a mobile equipment ,then it is called mobile station. A mobile transmits and receives messages to and from the GSM system over the air interface to establish and continue connections through the system [2].

- Base Transceiver System
  It is radio interface between mobile station and other network elements.

- Base Station Controller (BSC)
  The BSC performs the intercell handover for MSs moving between BTS in its control. It is connected to the MSC on one side and to the BTS on the other.

- Transcoder
  It convert the data rate from 64 kbps to 16 kbps from BSC output to MSC input and vice versa as mobile equipment works on 64 Kbps and range of air transmission is 16 Kbps.

- Mobile Switching Centre (MSC)
  It is the heart of the system. It is the overall network controller. The MSC decides when and which types of channels should be assigned to which MS.

- Visitor Location Register (VLR)
  The VLR constitutes the databases that support the MSC in the storage and retrieval of the data of subscribers present in its area
- Home Location Register (HLR)
  The HLR is a database that permanently stores data related to a given set of subscribers.

- Authentication Center (AUC)
  The AUC stores information that is necessary to protect communication through the air interface against unwanted disclosure, to which the mobile is vulnerable.. In the authentication procedure, a random number (RAND) is sent. In order to gain access to the system, the mobile must provide the correct Signed Response (SRES) in answer to a random number (RAND) generated by AUC.

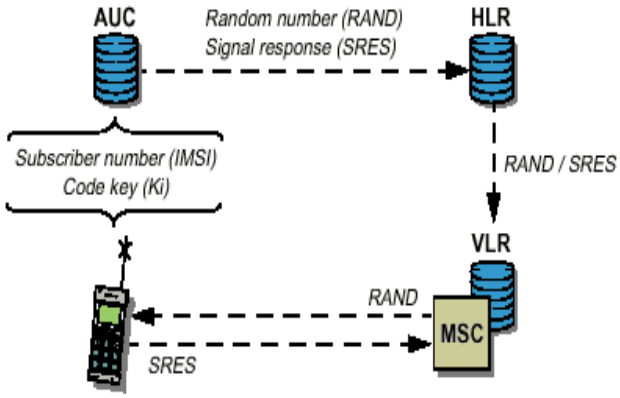

Fig. 2: Authentication Procedure

- Equipment Identity Register (EIR)
  EIR is a database that stores the IMEI numbers for all registered ME units. There are three classes of ME that are stored in the database, and each group has different characteristics:-
  - White List: contains those IMEIs that are known to have been assigned to valid MS's. This is the category of genuine equipment
  - Black List: contains IMEIs of mobiles that have been reported stolen.
  - Gray List: contains IMEIs of mobiles that have problems

4. 3G Architecture

The third generation of mobile technology offers higher data transfer rate than 2G and 2.5G.

UMTS network architecture consists of three domains:

- Core Network (CN): To provide switching, routing and transit for user traffic [2].
- UMTS Terrestrial Radio Access Network (UTRAN): Provides the air interface access method for User Equipment [4].
- User Equipment (UE): Terminals work as air interface counterpart for Node B. The various identities are: IMSI, TMSI, MSISDN, IMEI.

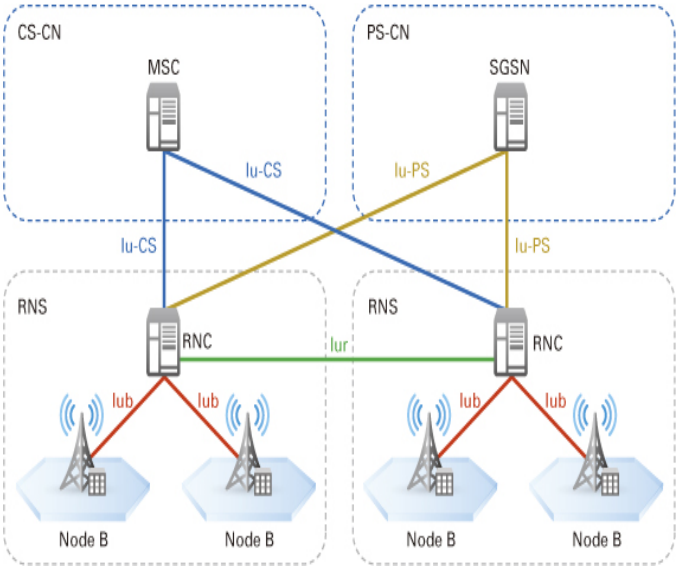

Fig 3: Architecture of 3G mobile technology.

4.1 UMTS Interfaces

- lu: Interface between RNC and Core Network[3].
- lucs: lu circuit switched(voice from/to MSC).
- lups: lu packet switched(data from/to SGSN).
- lub: Interface between RNC and Node B.
- lur: Interface between two RNC's.

4.2 Network Elements of 3G Architecture

1. Node B

   Node B known as 3G BTS is responsible for transmission and reception of radio signals to or from MS[2].

2. Radio Network Controller (RNC)
   It is responsible for controlling the node Bs that are connected to it. The RNC is the point where encryption is done before user data is sent to and from the mobile [4].
   The RNC connects to the Circuit Switched Core Network through Media Gateway (MGW) and to the SGSN (Serving GPRS Support Node) in the Packet Switched Core Network.

3. Serving GPRS Support Node (SGSN)
   SGSN has security and access control in 3G and is used for routing packet data with GGSN. It stores subscription information and location data of customer.

4. Gateway GPRS Support Node (GGSN)
   The GGSN is responsible for internetworking between GPRS network and external packet switched network.
   It allocates IP addresses to mobile users, keeps record of active mobile users and is responsible for the billing.

5. 4G Architecture

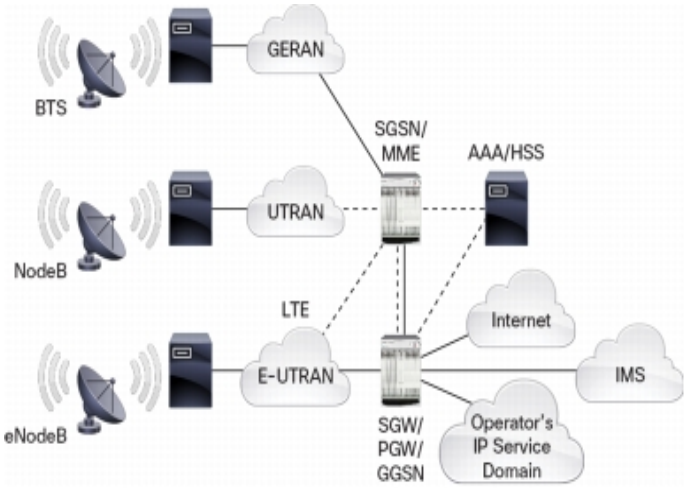

Fig 4: Architecture of 4G Mobile Technology

5.1 Network Elements of 4G Architecture

1. User Equipment (UE)
   UE is the device that the end user uses for communication. UE contains the Universal Subscriber Identity Module (USIM) which is often called Terminal Equipment (TE). USIM is used to identify and authenticate the user.

2. E-UTRAN Node B
   It is the hardware which is connected to the mobile network to communicate with handsets (UE).It is responsible for radio interface transmission and reception. It is also responsible for Radio Resource Management, i.e. allocating requests based on requests ,scheduling traffic[6].

3. Mobility Management Entity (MME)
   The MME keeps track of the location of all UEs in its service area. It also supports authentication and security services[3].

4. Serving Gateway (S-GW)
   It is responsible for routing and forwarding packets to
   Packet Data Network Gateway (P-GW), gathering accounting information and handovering of inter eNOdeB.

5. Packet Data Network Gateway (P-GW)
   The P-GW allocates the IP address to the UE and the UE uses that to communicate with other IP hosts in external networks. It serves as the interface between the LTE networks and other packet data networks.

6. GERAN
   GERAN is an abbreviation for GSM EDGE Radio Access Network. GERAN is the radio part of GSM/EDGE together with the network that joins the base station.

7. Information Management System (IMS)
   IMS facilitate the storage, organization and retrieval of information.[3]

8. Home Subscription Server
   The HSS stores the master copy of the subscriber profile which contains information about the services that are applicable to the user., whether roaming to a particular visited network is allowed or not[5].

9. Policy and Charging Resource Control Function (PCRF)
   It is a software component that accesses subscriber database and other functions such as charging system. It makes decision on how to handle services in terms of QoS .It is the network element that is responsible for Policy and Charging Control (PCC) [3].

5.2 Key Features of 4G

- To support advanced services and
- applications.

- Enhanced peak data rates (100 Mbps for
- high mobility and 1 Gbps for low mobility).
- Low latency, improving the consumer
- experience.
- Flexible network connections, efficient
- use of spectrum and impressive user
- applications.
- Worldwide roaming capability.
- Compatibility of services within IMT
- and with fixed Networks .
- Capability of interworking with other
- radio access systems.
- High quality mobile services.
- User equipment suitable for worldwide
- use.[7]

5.3 New Challenges

1. Security and Privacy

In the development of 4G Networks, security measures must be established that enable data transmission to be as safe as possible. Specifically, "The 4G core addresses mobility, security, and QoS through reuse of existing mechanisms while still trying to work on some mobility and handover issues" [8]. Therefore, it is necessary for the organization to develop an effective series of tools that support maximum 4G security measures as a means of protecting data that is transmitted across the network from hackers and other security violations. Because of the nature of the 4G network, there is an increased likelihood of security attacks, and therefore, multiple levels of security, including increased requirements for authentication, will be necessary to protect data and information that is transmitted across the network.

2. Quality of Service

With respect to network quality, many telecommunications providers are promising that there will be enhanced connectivity, and the quality of data that is transmitted across the network will be of the highest possible quality. As a result, it is important for providers to develop an effective approach to the 4G Network that will enhance quality, provide effective security measures, and will ensure that all users are provided with extensive alternatives for downloading video, music, and picture files without delays.[9] The main challenge that 4G networks are facing is integrating non-IP-based and IP-based devices. It is known that devices that are not IP address based are generally used for services such as VoIP. On the other hand, devices that are IP address based are used for data delivery. 4G networks will serve both types of devices.

Consequently, integrating the mechanisms of providing services to both non-IP-based as well as IP-based devices is one of key challenges 4G networks have to address. [10]

3. Complex Architecture

3.1..Multimode End-User Terminals

To reduce operating costs, devices that operate on 4G networks should have the capability to operate in different networks. This will not only reduce the operating cost but will also simplify design problems and will reduce power consumption. However, accessing different mobile and wireless networks simultaneously is one of the major issues 4G networks have been addressing. One mechanism that has been proposed to handle this problem is termed “multi-mode devices”. This mechanism can be achieved through a software radio that allows the end-user device to adapt itself to various wireless interfaces of the networks.

3.2.System Discovery and Selection

Due to the heterogeneity of 4G networks, wireless devices have to process signals sent from different systems, discover available services, and connect to appropriate service providers.[12] Various service providers have their own protocols which can be incompatible with each other as well as with the user’s device. This issue may complicate the process of selecting the most appropriate technology based on the time, place and service provided, and thus, may affect
the Quality of service provided to the end user.
One solution to resolve this issue is called “System-initiated discoveries”. This mechanism allows automatic download of software modules based on the wireless system the user is connected to. [11]

3.3.Service and Billing

Managing user accounts and billing them has become much more complicated with 4G networks. This is mainly due to heterogeneity of 4G networks and the frequent interaction of service providers.

5.4 Services Provided By 4g

4G will likely become a unification of different wireless networks including wireless LAN technologies public cellular networks (2.5G, 3G), and even personal area networks. Under this umbrella, 4G needs to support a wide range of mobile devices that can roam across different types of networks. These devices would have to support Different networks, meaning that one device would have to have the capability of working on different networks. QoS assurance is important for real time traffics like Voice over IP (VoIP), online gaming, IP TV and video streaming etc. [5] QoS enables network administrators to avoid network congestion and manage the network resources

efficiently. The goal of the 4G is to provide the users the facility of Always Best Connected (ABC concept). Fourth generation of networks is a combination of different networks. It gives a platform for various technologies to be accessed. To provide QoS in 4G is not simple and easy job as one has to deal with different parameters in different technologies. Like if a user is moving and changing his coverage network, so to provide service under QoS framework is challenging. While a mobile user is moving from one network to another network his communication session needs to be maintained seamlessly irrelevant of the coverage network. Similar is the case with video conferencing and video streaming, the users like to receive the services seamlessly. There are some protocols designed to maintain the seamless communication of the users while moving or in other words to minimize the latency and packet loss of the ongoing communication session. The mobility protocols are Mobile IPv6, Hierarchical MIPv6, Fast MIPv6. These protocols can help in improving the mobility management of mobile users.[7]

5.5 Comparison

1.1G is the first generation that existed in 1980s	2G is the second generation that existed in late1980s	3G is the third generation that existed in l1990s	4G is the fourth generation that evolved in late 1990s
2. It is based on analog signals.	It is based on digital voice	It based on high capacity broadband data	It is based on wireless communication which is IP based.
3. Poor or no security.	Safe for consumers to use.	Secured	High security.
4. Peak speed up to1.9 kbps.	Peak speed may be up to 14.4 kbps.	Peak speed up to 2 Mbps	Peak speed up to 150 Mbps.
5.It uses FDMA	It uses TDMA and CDMA	It uses WCDMA	It uses OFDMA
6.It supports circuit switching	It supports circuit switching	It supports packet switching	It supports packet as well as message switching.
7.It supports only voice calls	It supports data services in addition to voice calls	It provides video access	It provides HD video access

6. Conclusion

Mobile phone penetration worldwide is approaching. 60%. Voice communication has become mobile in a massive way. The first generation of wireless telecommunication technology supports only voice calls. The second generation of wireless

telecommunication technology supports SMS services in addition to voice calls. The third generation of mobile telecommunication technology finds application in wireless voice telephony, mobile internet access, video calls and mobile T.V.

LTE is already meeting the requirements of next generation mobile requirements. It enables operators to offer high -performance, mass-market mobile broadband services , through a combination of high bit-rates and system throughput –in both the uplink and downlink –with low latency.

LTE infrastructure is designed to be as simple as possible to deploy and operate, through flexible technology that can be deployed in a wide variety of frequency bands.

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