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Evolution of Networks

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Abstract: Evolution is almost unavoidable. It may be in nature or in the manmade stuffs. GSM (Global System for Mobile Communications) is a standard set developed by the European Telecommunications Standards Institute (ETSI). It describes the protocols for second generation digital cellular networks for mobile phones. The use of GSM is more in 2nd generation digital cellular standard. In 213 countries there are more than 3 billion subscribers. Also 1000 new users being added per minute. Development of GSM was done in 1980. Before this during pre-cell days, mobile operator sets up the calls. GSM uses TDMA and FDMA, which gives wide area voice communications. GSM evolved into a 2.5G standard with the introduction of packet data transmission technology (GPRS) and higher data rates via higher order modulation schemes (EDGE). More recently, GERAN standards organization has been evolving further to coexist with and provide comparable services to 3G technologies. In this paper, we provide an over view of evolution of Mobile Generations and also the framework of 5G technology that will provide access to wide range of telecommunication services, including advanced in mobile services, supported by mobile and fixed networks.

Keywords: Evolution of Networks, GSM, TDMA, FDMA, GERAN, GPRS, ETSI.

I. INTRODUCTION

We see a rapid development of information and communication technologies, particularly the wireless communication technology. In just the past 10 years, we have seen a great evolution of wireless services which we use every day. With the exponential evolution, there has been equally exponential growth in use of the services, taking advantage of the recently available bandwidth around the world. As per market survey data usage around the world exceed 1EB in a month. 1EB is the same as 1 billion gigabytes, 1,000,000,000GB. It should surprise no one that the smartphone revolution is fuelling this growth, and by 2017, half of all mobile devices in the world will be smartphones. The key to keeping users happy is network performance and good value for the money. From the looks of it, we are on track to seeing continued network performance improvements and increasingly easier access to smartphones as developing markets hop on the bandwagon. In this modern world, we cannot think a single day without smart gadgets like mobiles, tabs. Communication makes our life comfortable and simple. The Modern world is being shortened due to the development of the technology. During the past few decades, the world has seen astonishing changes in the telecommunication industry due to advancement in the science and technology. Wireless and mobile communication technologies have been mass deployed.

The Mobile terminals include various interfaces, such as GSM, the most effective technology that is going into its decade of existence. The cellular technologies differ from each other based on the four main aspects: 1.switching schemes, 2.bandwidth, 3.data rates and 4.radio access. Such differences have been noticed in all the previous wireless generations. The most advance cellular technology in the coming years might be 5G. Mobile phones in 5G are configured to use very high bandwidth and are packet switched based wireless system. Area coverage under 5G is very large and throughput of the system is also very high.

II. LITERATURE SURVEY

Pulkit Gupta [1] explains about 2G which is the Second-Generation wireless cellphones, based on digital technologies and also about how GPRS is extension of existing 2G network which have the capacity of launching packet based services while enhancing the data rates supported by these networks. He also explains how GPRS networks evolved to EDGE networks.

Mohammad Meraj and Dr. Sumit Kumar [2] explains about pre-cell days. They also explains how mobile operator sets up the calls. And there were only a handful of channels available. Also these mobiles do not support the handover feature i.e. change of channel frequency.

Mudit Ratana Bhalla and Anand Vardhan Bhalla [3] explains about different 1G standards used in various countries. They gives an idea about standards like NMT (Nordicc Mobile Telephone) used in Nordic countries, TACS (Total Access Communications System) used in the United Kingdom, AMPS (Advanced Mobile Phone System) used in the United States, C-Netz in West Germany.

Priya Goyal and Avtar Singh Buttar [4] explains briefly about all the generations. They also explains about the important challenge in the telecommunication field. That is that the network should be flexible and improved to provide larger number of connections to multiple users

without losing the quality within the limited frequency spectrum available with the increased system capacity. This also gives an about how FDMA, TDMA, CDMA, BDMA technique.

Sapana Singh and Pratap Singh [5] explains about 5G networks technology, applications, hardware 5G technologies and network architecture for 5G wireless technologies. Aleksandar Tudzarov, Toni Janevski [6] explains about functional Architecture for 5G Mobile Networks, Heterogeneous Wireless Networks, Quality of Service (QoS), Policy Routing.

III. WIRELESS NETWORKS

A. Zeroth Generation (0G)

0G refers to pre-cellular mobile telephony technology in 1970s. These mobile telephones were usually mounted in cars or trucks, though briefcase models were also made. Mobile radio telephone systems preceded modern cellular mobile telephony technology. The great ancestor is the mobile telephone service that became available just after World War II. In those pre-cell days, you had a mobile operator to set up the calls and there were only a handful of channels available. 0G refers to pre-cell phone mobile telephony technology, such as radio telephones that some had in cars before the advent of cell phones. Mobile radio telephone systems preceded modern cellular mobile telephony technology. Since they were the predecessors of the first generation of cellular telephones, these systems are called 0G (zero generation) systems. Technologies used in 0G systems included PTT (Push to Talk), MTS (Mobile Telephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced Mobile Telephone System), OLT (Norwegian for Offentlig Landmobil Telefoni, Public Land Mobile Telephony) and MTD (Swedish abbreviation for Mobilelefonisystem D, or Mobile telephony system D). These early mobile telephone systems can be distinguished from earlier closed radiotelephone systems in that they were available as a commercial service that was part of the public switched telephone network, with their own telephone numbers, rather than part of a closed network such as police radio or taxi dispatch system. They were sold through WCCs (Wire line Common Carriers, AKA telephone companies), RCCs (Radio Common Carriers), and two-way radio dealers. The primary users were loggers, construction foremen, realtors, and celebrities. They used them for basic voice communication. Early examples for this technology are: Autoradiopuhelin (ARP) launched in 1971 in Finland and B-Netz launched in 1972 in Germany

B. First Generation (1G)

In 1980 the mobile cellular era had started, and since then mobile communications have undergone significant changes and experienced enormous growth. 1G refers to the first-generation of wireless telephone technology, mobile telecommunications. These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. First-generation mobile systems used analog transmission for speech services. The first commercially automated cellular network (the 1G generation) was launched in Japan by NTT (Nippon Telegraph and Telephone) in 1979, initially in the metropolitan area of Tokyo. By 1981, the cellular era reached Europe. The two most popular analogue systems were Nordic Mobile Telephones (NMT) and Total Access Communication Systems (TACS). Other than NMT and TACS, some other analog systems were also introduced in 1980s across the Europe.

All of these systems offered handover and roaming capabilities but the cellular networks were unable to interoperate between countries. This was one of the inevitable disadvantages of first-generation mobile networks. In the United States, the Advanced Mobile Phone System (AMPS) was launched in 1982. The system was allocated a 40-MHz bandwidth within the 800 to 900 MHz frequency range by the Federal Communications Commission (FCC) for AMPS.

In 1988, an additional 10 MHz bandwidth, called Expanded Spectrum (ES) was allocated to AMPS. It was first deployed in Chicago, with a service area of 2100 square miles2. AMPS offered 832 channels, with a data rate of 10 kbps. Although Omni directional antennas were used in the earlier AMPS implementation, it was realized that using directional antennas would yield better cell reuse. In fact, the smallest reuse factor that would fulfill the 18db signal-to-interference ratio (SIR) using 120-degree directional antennas was found to be 7. Hence, a 7-cell reuse pattern was adopted for AMPS.

Transmissions from the base stations to mobiles occur over the forward channel using frequencies between 869-894 MHz. The reverse channel is used for transmissions from mobiles to base station, using frequencies between 824-849 MHz. AMPS and TACS use the frequency modulation (FM) technique for radio transmission. Traffic is multiplexed onto an FDMA (frequency division multiple access) system.

C. Second Generation (2G)

2G is the Second-Generation wireless cell phones, based on digital technologies and in early 1990's. In 1991 2G was launched in Finland. 2G provided services such as text message, picture messages and MMS. 2G has greater security for both sender and receiver. All text messages are digitally encrypted, which allows for the transfer of data in such a way that only intended receiver can receive and read it. 2G system uses digital mobile access technology such as TDMA and CDMA. TDMA divides signal in time slots while as CDMA allocates each user a special code to communicate over a multiplex physical channel. Different TDMA technologies are GSM, PDC, iDEN, iS-136. GSM was first 2G System. CDMA technology is IS-95. GSM (Group Special Mobile) has origin from Europe. GSM is most admired standard of all the mobile technologies used in more than 212 countries, in the world. GSM standard makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM uses TDMA to multiplex upto 8 calls per channel in the 900 and 1800 MHZ bands. GSM can't only deliver voice but also circuit switched data at sped upto 14.4kbps.

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In US FCC also auctioned a new block of spectrum in the 1900MHZ band.

The GSM system consists of three subsystems. Base station subsystem (BSS), Network and switching subsystem (NSS), Operation and support subsystem (OSS). BSS consists of Base transceiver stations (BTSs), Base station controller (BSC). The role of the BSS is to provide transmission paths between the mobiles and the NSS. The BTS is the radio access point. Each BTS serves one cell. The main functions of the BSC are cell management, control of a BTS and exchange functions.

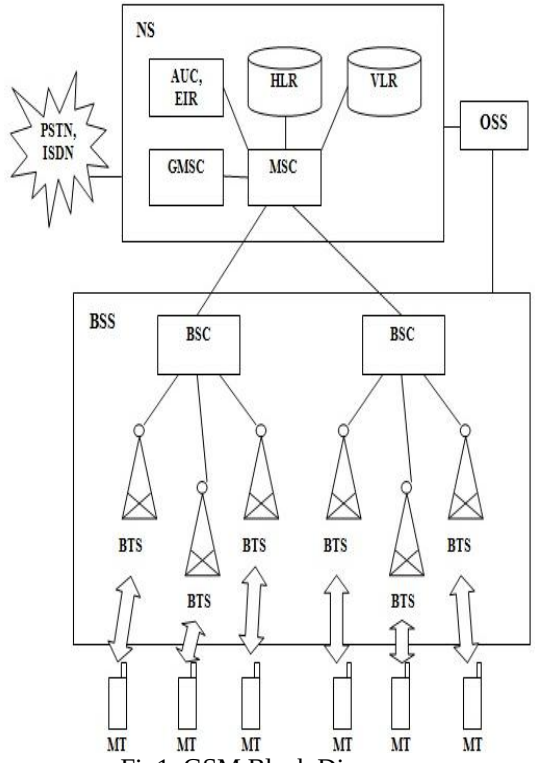

Fig1. GSM Block Diagram

NSS includes switching and location management functions. NSS consists of Mobile switching center (MSC), Home location register (HLR), Visitor location register (VLR), Gateway MSC (GMSC), Authentication centre (AuC), Equipment identity register (EIR). The MSC is a complete exchange with switching and signalling capabilities. GMSC provides interface between the mobile network and public switched telephone network (PSTN), public land mobile network (PLMN) and integrated services digital network (ISDN). MSC is capable of routing calls from the BTS and BSC to mobile users in the same network (through BSC and BTS) or to users in the PSTN, PLMN and ISDN (through GMSC) or to answering machines integrated within the MSC.

HLR and VLR are databases for location management. The HLR stores the identity and user data of all subscribers belonging to the mobile operator for both local and aboard (roaming) users. The VLR contains the permanent data found in the HLR of the user's original network for all subscribers currently residing in its MSC serving area. That is, VLR contains data of its own subscribers of the network that are in its serving area, as well as that (temporary data) of roamers from other GSM networks. The AuC is related to HLR and contains sets of parameters needed for authentication procedures for the mobile stations. EIR is an optional database that contains numbers of the mobile phone equipments. The purpose of EIR is to prevent usage of stolen mobile stations or to bar malfunctioning equipment.

GPRS (General Packet Radio Service) (2.5G): GPRS is extension of existing 2G networks to have the capacity of launching packet based services while enhancing the data rates supported by these networks. The term "Second and a half generation" is used to describe 2G-Systems that have implemented a packet switched domain in addition to circuit switched domain. "2.5 G" is an informal term. GPRS provided data rates from 56 Kbps upto 384 Kbps, using database HLR, VLR, EIR, and AuC with GPRS and EDGE technologies. It provides services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS) and for internet communication services such as e-mail and World Wide Wireless Web (WWW) access. GPRS data transfer is typically charged per megabyte of traffic transferred, while data communication via traditional circuit switching is billed per minute of connection time, independent of whether the user actually is utilizing the capacity or is in an idle state. 2.5G networks may support services such as WAP, MMS, SMS mobile games, and search directory and well internet access.

GPRS is a hardware and software upgrade to the existing GSM system. Two new network nodes are added. Serving GPRS support node (SGSN) and Gateway GPRS support node (GGSN) SGSN is responsible for the delivery of packets from/to mobile stations within its service area. Its main tasks are Mobility management, Location management, Attachment/detachment, Packet routing, Logical link management, Authentication, Charging functions. GGSN acts as an interface between the GPRS packet network and external packet-based networks like the Internet. It converts protocol data packet (PDP) address from the external packet-based networks to the GSM address of the specified user and vice versa. There may be several SGSNs or GGSNs. All GPRS support nodes are connected through an IP-based GPRS backbone network. HLR stores user profile, current SGSN address, PDP address. MSC/VLR is extended with additional functions that allow coordination between GSM circuit-switched services and GPRS packet-switched services.

EDGE (Enhanced Data rates for GSM Evolution (2.75G): GPRS network s evolved to EDGE networks with the introduction of 8PSK encoding. Enhanced Data rates for GSM Evolution, Enhanced GPRS (EGPRS), or IMT Single Carrier (IMT-SC) is a backward-compatible digital mobile phone technology that allows improved data transmission rates, as an extension on top of standard GSM. EDGE was deployed on GSM networks beginning in 2003 initially by Cingular (now AT & T) in the United States. EDGE is standardized by 3GPP as part of the GSM family, and it is an upgrade that provides a potential three-fold increase in capacity of GSM/GPRS networks. The specification achieves higher data –rates (up to 236.8 Kbits/s) by switching to more sophisticated methods of coding (8PSK), within existing GSM timeslots. EDGE

technology is an extended version of GSM. It allows the clear and fast transmission of data and information. It is also termed as IMT-SC or single carrier. EDGE technology was invented and introduced by Cingular, which is now known as AT& T. EDGE is radio technology and is a part of third generation technologies. EDGE technology is preferred over GSM due to its flexibility to carry packet switch data and circuit switch data.

C. Third Generation (3G)

International Mobile Telecommunications-2000 (IMT--2000), better known as 3G or 3rd Generation, is a generation of standards for mobile phones and mobile telecommunications services fulfilling specifications by the International Telecommunication Union. The use of 3G technology is also able to transmit packet switch data efficiently at better and increased bandwidth. 3G mobile technologies proffers more advanced services to mobile users. Transmission speeds from 125kbps to 2Mbps. In 2005, 3G is ready to live up to its performance in computer networking (WCDMA, WLAN and Bluetooth) and mobile devices area (cell phone and GPS) Data are sent through technology called packet switching voice calls are interpreted using circuit switching access to global roaming clarity in voice calls. Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming, Multi-Gaming etc are also available with 3G phones

In EDGE, high-volume movement of data was possible, but still the packet transfer on the air- interface behaves like a circuit's switch call. Thus part of this packet connection efficiency is lost in the circuit switch environment. Moreover, the standards for developing the networks were different for different parts of the world. Hence, it was decided to have a network which provides services independent of the technology platform and whose network design standards are same globally. Thus, 3G was born. The International Telecommunication Union (ITU) defined the demands for 3G mobile networks with the IMT-2000 standard. An organization called 3rd Generation Partnership Project (3GPP) has continued that work by defining a mobile system that fulfills the IMT-2000 standard. In Europe it was called UMTS (Universal Terrestrial Mobile System), which is TSI- driven. IMT2000 is the ITU-T name for the third generation system, while cdma2000 is the name of the American 3G variant. WCDMA is the air- interface technology for the UMTS. The main components includes BS (Base Station) or nod B, RNC (Radio Network Controller), apart from WMSC (Wideband CDMA Mobile Switching Centre) and SGSN/GGSN.

3G networks enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency. Services include wide-area wireless voice telephony, video calls, and broadband wireless data, all in a mobile environment. Additional features also include HSPA (High Speed Packet Access) data transmission capabilities able to deliver speeds up to 14.4 Mbps on the downlink and 5.8 Mbps on the uplink.

In many countries, 3G networks do not use the same radio frequencies as 2G, so mobile operators must build entirely new networks and license entirely new frequencies; an exception is the United States where carriers operate 3G service in the same frequencies as other services. The license fees in some European countries were particularly high, bolstered by government auctions of a limited number of licenses and sealed bid auctions. Other delays were due to the expenses of upgrading equipment for the new systems. Still several major countries such as Indonesia have not awarded 3G licenses and customers await 3G services. China delayed its decisions on 3G for many years. In January 2009, China launched 3G but interestingly three major companies in China got license to operate the 3G network on different standards, China Mobile for TD-SCDMA, China Unicom for WCDMA and China Telecom for CDMA2000.

D. Fourth Generation (4G)

4G refers to the fourth generation of cellular wireless standards. The bandwidth and location information available to 3G devices gives rise to applications not previously available to mobile phone users.

Fourth (4G) generation mobile communication systems tend to mean different things to different people: for some it is merely a higher-capacity new radio interface, while for others it is an interworking of cellular and wireless LAN technologies that employs a variant of the Mobile IPv6 mobility management protocol for inter-system handoff and IETF AAA technologies for seamless roaming.

4G is known as beyond 3G,stands as an acronym for Fourth-Generation Communications System. It is used to describe the next step in wireless communications. A 4G system will be able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an Anytime, Anywhere basis, and at higher data rates than previous generations. There is no formal dentition for what 4G is; however, there are certain objectives that are projected for 4G.

Some of the limitations are: Operating Area: One major limitation of 4G is operating area. Although 2G networks are becoming more ubiquitous, there are still many areas not served. Rural areas and many buildings in metropolitan areas are not being served well by existing wireless networks.

Cost: Another limitation is cost. The equipment required to implement a next generation network is still very expensive. Carriers and providers have to plan carefully to make sure that expenses are kept realistic. One technique currently being implemented in Asian networks is a Pay-Per-Use model of services.

The big makers: Most of the big manufacturers, including Alcatel and Samsung, have alsoshowed interest in 4G technology although not so openly. In August 2004,Samsung organized a 4G Forum, which was attended by 120 mobile communications representatives from 18 countries. However, 4G has still a long way to go as far as regulations and standardization are concerned.

Technical challenges: Some of the technical challenges posed by 4G are daunting. Apart from all the intrinsic di-

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culties networks have, they must cope with others: the signal diminishes when the terminal moves more than a kilometre away from the base station; there is great dicult in moving huge amounts of data within a limited area of the spectrum; the mobile prototypes are too big and their energy consumption too high.

E. Fifth Generation (5G)

Figure below shows the system model that proposes design of network architecture for 5G mobile systems, which is all-IP based model for wireless and mobile networks interoperability. The system consists of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies. Within each of the terminals, each of the radio access technologies is seen as the IP link to the outside Internet world. However, there should be different radio interface for each Radio Access Technology (RAT) in the mobile terminal. For an example, if we want to have access to four different RATs, we need to have four different access - specific interfaces in the mobile terminal, and to have all of them active at the same time, with aim to have this architecture to be functional.

The first two OSI levels (data-link and physical levels) are defining the radio access technologies through which is provided access to the Internet with more or less QoS support mechanisms, which is further dependent upon the access technology. Then, over the OSI-1 and OSI-2 layers is the network layer, and this layer is IP (Internet Protocol) in today's communication world, either IPv4 or IPv6, regardless of the radio access technology. The purpose of IP is to ensure enough control data (in IP header) for proper routing of IP packets belonging to a certain application connections - sessions between clientapplications and servers somewhere on the Internet. Routing of packets should be carried out in accordance with established policies of the user.

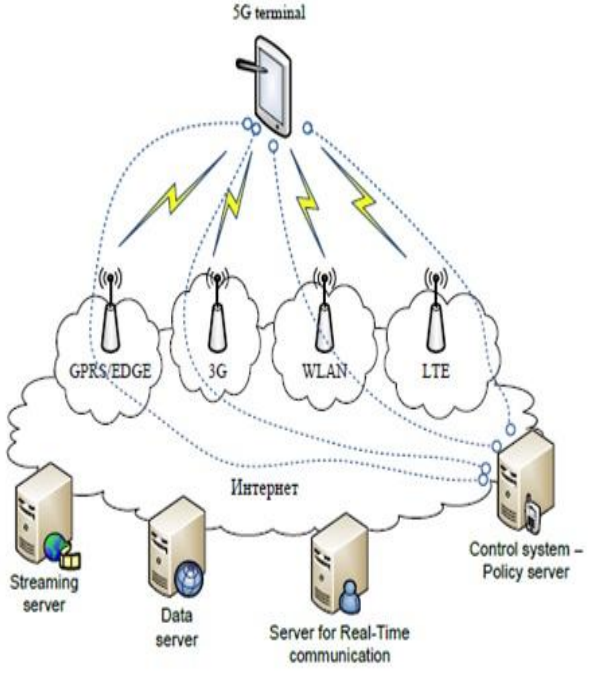

Fig. 2. Architecture of 5G Networks

5G technology requirements: As a result of this blending of requirements, many of the industry initiatives that have progressed with work on 5G identify a set of eight requirements:

- 1-1Tbps connections to end points in the field
- 1 millisecond end-to-end round trip delay
- 1000x bandwidth per unit area
- 10-100x number of connected devices
- (Perception of) 99.999% availability
- (Perception of) 100% coverage
- 90% reduction in network energy usage
- Up to ten year battery life for low power, machine-type devices

Features:

- The advanced billing interfaces of 5G technology makes it more attractive and effective.
- 5G technology is providing large broadcasting of data in Gigabit which supporting almost 65,000 connections.
- 5G technology offers transporter class gateway with unparalleled consistency.
- The traffic statistics by 5G technology makes it more accurate.
- Through remote management offered by 5G technology a user can get better and fast solution.
- The remote diagnostics is also a great feature of 5G technology.
- The 5G technology is providing up to 25 Mbps connectivity speed.
- The 5G technology also support virtual private network.
- The uploading and downloading speed of 5G technology touching the peak.
- The 5G technology network offering enhanced and available connectivity just about the world
- 5G technology offers high resolution for crazy cell phone user and bi- directional large bandwidth shaping

IV. CONCLUSION

The last few years have witnessed a phenomenal growth in the wireless industry. The ever increasing demands of users have triggered researchers and industries to come up with a comprehensive manifestation of the up-coming fifth generation (5G) mobile communication system. As the history of mobile communications shows, attempts have been made to reduce a number of technologies to a single global standard. The first generation (1G) has fulfilled the basic mobile voice, while the second generation (2G) has introduced capacity and coverage. This is followed by the third generation (3G), which is further realized by the fourth generation (4G). Fifth Generation (5G) will bring higher data transfer speeds (reaching up to few gigabits per sec) and other high quality services

In this paper we have proposed 5G mobile phone concept, which is the main contribution of the paper. The 5G mobile phone is designed as an open platform on different layers, from physical layer up to the application.

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Currently, the ongoing work is on the modules that shall provide the best QoS and lowest cost for a given service using one or more than one wireless technology at the same time from the 5G mobile phone.

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