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Journey of various Generations of Mobile Technology

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Abstract: *Mobile wireless technology is developing extremely fast in Present times. It is emerging in all the fields of mobile communication such as internet access, location based services, video conferencing system, mobile financial services, mobile entertainment services etc. Mobile networking refers to technology that can support voice and/or data network connectivity using wireless, via a radio transmission solution. In the past, wireless communications predominantly used circuit switching to carry voice over a network; however, more recently both voice and data are being transmitted over both circuit-switched and packet-switched networks. This paper will through the light on evolution of mobile Wireless Communication Technologies along with their significance and to compare the advantages of one over the other.*

Keywords: Wireless Technologies, 1G to 5G, Cellular Architecture, Mobile Radiation

INTRODUCTION

Wireless communication is the transfer of information over a distance without the use of enhanced electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometres for radio communications).The concept of Wireless cellular technology was developed in AT&T's Bell labs in 1970s. A cellular network or mobile network is a radio network distributed over earth areas called cells. Each cell is served by at least 1 fixed-location transceiver and transceiver is known as a cell site or base station. In a mobile network, each cell uses a different set of frequencies from other neighbouring cells and avoids interference.The 1st commercial mobile was developed in Scandinavian country in 1981 with the name of Nordic mobile telephone (NMT) networks [1]. The After this the development of generations for mobile wireless communication takes its start.

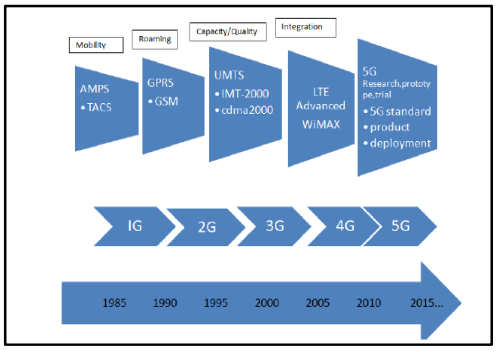

Figure 1: *Mobile Cellular Network Evolution Timeline*

Above Figure: 1 reflects the evolution of network Technologies.

In this paper, we present the detail journey of the different generations of the mobile communication Technologies these are First Generation (1G), Second Generation (2G), Third Generation (3G), Fourth Generation (4G) and Fifth Generation (5G).

I. First Generation (1G)

First generation of wireless telephone technology was launched in between 1980 to 1990.It is based on analogue signals technology also known as Advance Mobile Phone Service (AMPS). The AMPS system was frequency modulation radio system using frequency division multiple access (FDMA) with channel capacity of 30 KHz and frequency band was 824-894 MHz .All 1G systems were analog systems popularly known as early cellular phone technology.Its speed is up to 2.4kbps with a restricted bandwidth which permits the calls within a country. In 1988 10MHz additional bandwidth was allocated to AMPS which was developed in Chicago, with coverage area of 2100 square miles. analog system which was developed in 1980s and continue in use until replace by 2G. In 1G,Analog systems use circuit switching means voice-only, voice call gets modulated at frequency 150 MHz Voice call is transmitted between radio towers and this is done using a technique FDMA (Frequency Division Multiple Access). *Features:*

- Licensed Spectrum
- Frequency Reuse
- Mobile Network

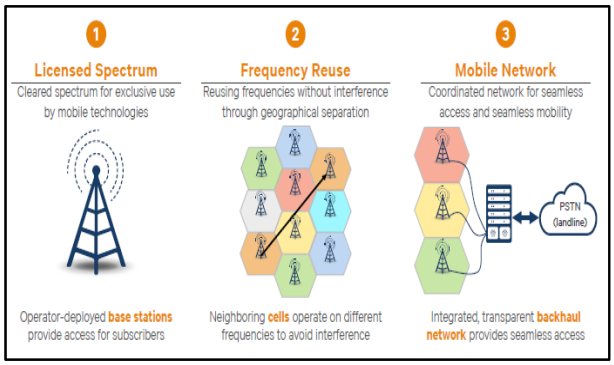

Figure 2: Features of 1G

Technologies under 1G:

1G comprised of the following Mobile technologies: Mobile Telephone Systems (MTS), Advance Mobile Telephone

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Systems (AMTS), Push To Talk (PTT) and Improved Mobile Telephone Service (IMTS).

Limitations of 1G:

1.Non-Secure:Analog cellular phones are not very secure. Anyone with an all-band radio receiver connected to a computer can record the 32-bit serial numbers and phone numbers of subscribers when calling can listen in on any conversation. This loophole was exploited in many scandalous ways. There were also reported thefts of airtime. Anyone could collect a large database by driving around and go into business by reprogramming stolen phones and reselling them.This technique fails in some field due to overall connection qualities.1G has low capacity and unreliable handoff. There is no security with poor links.

2. LimitedCapacity: Analog transmissions are inefficient at using limited spectrum.

3. LimitedScalability: Analog devices are large/heavy, power inefficient and high cost.

II. Second Generation (2G-2.7G)

The 2G second generation mobile communication system is digital system. This system was commercially launched in Finland in 1991. 2G Technology was 1 step forward of 1G. Itprovides a facility of SMS (Short Message Service). Itsbandwidth is 30-200kbps.This Technology is still mostly used in different parts of the world. This generation is for data and voice services. In this generation two digital modulation schemes are used; one is time division multiple access (TDMA) and the second is code division multiple access (CDMA). The first digital system was introduced in 1991 in United States. Three types of developments took place in 2nd generation wireless communication system, IS-54 (TDMA) in 1991, IS-95 (CDMA) in 1993, and IS-136 in 1996 .The family of this generation consists of 2G, 2.5G and 2.75G.It uses GPRS(General Packet Ratio Services) which delivers packet switched data to existing GSM network. GSM provides many more services than original network.

GSM (global system for mobilecommunication):- This 2G network is capable of providing all the services such as data service and speech. GSM network is extension of fixed telephone network.

***GSM** AND VAS (value added services):* -This is advancement in GSM technology which iscombination of two platforms. VMS (Voice Mail System) +SMSC (Short Message Service Centre).

GSM ND EDGE (enhanced data rate forglobal evolution): -Under this technology, increase in data rate up to 384kbps. EDGE issuperset of GPRS and function in any network with GPRS.

Technologies under 2G:

2G comprised of the following Mobile technologies: General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA), Global System for Mobile Communication (GSM) and Enhanced Data Rates for GSM Evolution (EDGE).

2.5G – GPRS (General Packet Radio Service)

2.5G, which stands for "second and a half generation," is a cellular wireless technology developed in between its predecessor, 2G, and its successor, 3G. The term "second and a half generation" is used to describe 2G-systems that have implemented a packet switched domain in addition to the circuit switched domain. "2.5G" is an informal term, invented solely for marketing purposes, unlike "2G" or "3G" which are officially defined standards based on those defined by the International Telecommunication (ITU).GPRS could provide data rates from 56 kbit/s up to 115 kbit/s. It can be used for services such asWireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access. GPRS data transfer is typically charged per megabyte of traffictransferred, 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 and directory.

GSM AND GPRS (general packet radio services):- This enables the air interface for sending the data. This enables wireless access to the internet. The bit rate is reaching up to 150kbps inoptimum conditions.

2.75 – EDGE (Enhanced Data rates for GSM Evolution)

EDGE (EGPRS) is an abbreviation for Enhanced Data rates for GSM Evolution, is a digital mobile phone technology which acts as a bolt-on enhancement to 2G and 2.5G General Packet Radio Service (GPRS) networks. This technology worksin GSM networks. EDGE is a superset to GPRS and can function on any network with GPRS deployed on it, provided the carrier implements the necessary upgrades. 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 andintroduced 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. The use of EDGE technology has augmented the use of black berry, N97 and N95 mobile phones. EDGE transfers data in fewer seconds if we compare it with GPRS Technology. For example a typical text file of 40KB is transferred in only 2seconds as compared to the transfer from GPRS technology, which is 6 seconds. The biggest advantage of using EDGE technology is one does not need to install any additional hardware and software in order to make use of EDGETechnology. There are no additional charges for exploiting this technology. If a person is an ex GPRS Technology user he can utilize this technology without paying any additional charges.

Limitations of 2G

1.In less populated areas, the weaker digital signal deployed on higher frequencies may not be sufficient to reach a cell tower. Analog Signals have a smooth decay curve while digital has a steppy one. This was seen as both an advantage as well as a disadvantage.

2.Under good conditions, digital sounded better. Underslightly bad conditions, analog experienced static, while digital has occasional dropouts. As conditions worsened, digital signals started to completely fail, while analog got worse gradually, generally holding a call longer and allowing at least a few words to get through. While digital calls tend to be free of static and background noise, the lossy compression used by the codecs takes a toll; the range of sound that is conveyed is reduced. You hear less of the tonality of someone's voice talking on a digital cell phone, but you will hear it more clearly.

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III.Third Generation (3G– 3.75G)

The third generation mobile technology is based onwide band wireless network and fulfilling the InternationalMobile Telecommunications 2000(IMT-2000) specifications.According to IMT-2000 standards, a system is required toprovide data rates of at least 200 Kbit/s. 3G functions in therange of 2100 Hz. Its bandwidth is 15-20 MHz. It providesenhanced clarity and perfection like the real conversation. 3Goffers a vertically- integrated, top-down and service-providerapproach to delivering wireless Internet access. 3G is atechnology for mobile service providers. Mobile serviceproviders use licensed spectrum which provide wirelesstelephone coverage over large geographic serving area. Itoffers (near) ubiquitous and continuous coverage e.g. aconsumer can carry on a telephone conversation while drivingalong a highway at 100Km/hour. 3G can supportdata rates of 384Kbps up to 2Mbps. 3G offers narrower bandwidth but over a wider calling area.

Goals of3G:

1.Global standards to allow for low cost
2.High Quality of Service (QoS) especially forvoice.

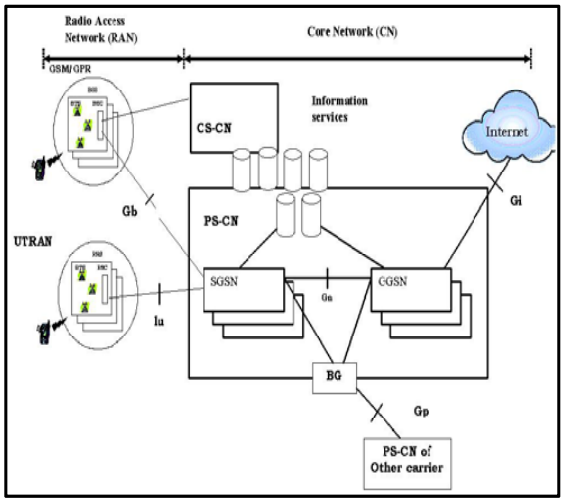

***Figure**: 3 Architecture of 3G*

As can be seen in Figure: 3 the 3G network has two mainparts
1. The Radio Access Network (RAN)
2. The Core Network (CN)

The RAN consists of the existing GPRS/GSM RANsystem which is connected to the Packet SwitchedNetwork (PS-CN) and also to the circuit switched network(CS-CN). The PS-CN will eventually connect to theUTRAN system as part of the full transition to 3G. TheUTRAN consists of subsystems, with each subsystemconsisting of one Radio Network Controller (RNC) whichis connected to several Base Transceiver Stations (BTN).The GRPS RAN has a similar architecture.The Core Network consists of the PS-CN and the CSCN.The PS-CN consists of several information servers,the SGSN and the GGSN. Each SGSN connects one ormore RSC and BSC with the PS-CN. Its functionalityincludes access control, mobility management, paging androute management. The GGSN is the logical gateway tothe Internet. The BG interface can be used to connect to another PS-CN or to another carrier. The informationservers provide several functions. The Home Location Register (HLR) maintains subscriber information and theAuthentication Center (AuC) maintains authenticationinformation. There are also IP based servers such as DNS,DHCP and RADIUS servers which interact with theSGSN/GGSN and provide control and managementfunctions.

Features of 3g

*1.DataRates:*ITU has not provided a clear definition of the datarate users can expect from 3G equipment or providers.

*2.Security:*3G networks offer greater security than their 2Gpredecessors. In addition to the 3G networkinfrastructure security, end-to-end security is offeredwhen application frame works such as IMS areaccessed.

Technologies under 3G:

2G comprised of the following Mobile technologies: 3G Technology comprises of Wideband CDMA, WLAN, Bluetooth, Universal Mobile telecommunication Systems (UMTS), High Speed Downlink Packet Access (HSDPA). Data are sent through packet switching. Voice calls are interpreted using circuit switching. It also provides facilities such as Global Roaming Clarity in voice calls, Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming and Multiplayer-Gaming.

3.5G-HSDPA (High-SpeedDownlink Packet Access)

High-Speed Downlink Packet Access(HSDPA) is amobile telephony protocol, also called 3.5G (or"3½G"), which provides a smooth evolutionary pathfor UMTS-based 3G networks allowing for higherdata transfer speeds.HSDPA is a packet-based data service in W-CDMAdownlink with data transmission up to 8-10 Mbit/s(and 20 Mbit/s for MIMO systems) over a 5MHzbandwidth in WCDMA downlink. HSDPAimplementations includes Adaptive Modulation andCoding (AMC), Multiple-Input Multiple-Output(MIMO), Hybrid Automatic Request (HARQ), fastcell search, and advanced receiver design.

***Code Division Multiple Access*(CDMA)**CDMA (Gharavi et al., 2001) is a type ofmultiplexing which doesn't share the channels byfrequency or time (like FDMA or TDMA), howeverit en-codes information by some unique codes relatedto each channel and exploits dynamic interferenceseffects of a particular code to do multiplexing. Inaddition, it refers to a digital cellular telephonysystem which utilizes these multiple access schemes.CDMA has since been applied in a number ofcommunication systems (i.e., Omni-TRACS satellitesystem (Freeman et al., 2004) and Global PositioningSystem (GPS) (Hatch et al., 2002)). Figure presentsa general architecture of a CDMA system.

Wideband Code Division Multiple Access(WCDMA)

WCDMA (Bidaud, 2001) is a type ofwideband digital radio-access technology. In 1998,the European Telecommunications Standard Institute(ETSI) used it to support 3G multimedia applicationsfor wideband digital radio-access. WCDMA offers aninnovative service capability, improved networkspeed and low-cost for services (data and voice)compared to 2G technologies. It is the foremostworldwide 3G-standard preferred by eight of theworld's ten largest service-providers. Operators cansoftly progress from GSM on the way to

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WCDMA,hence saving investments via reutilizing the GSMsetups and services (Gozalvez et al., 2001).

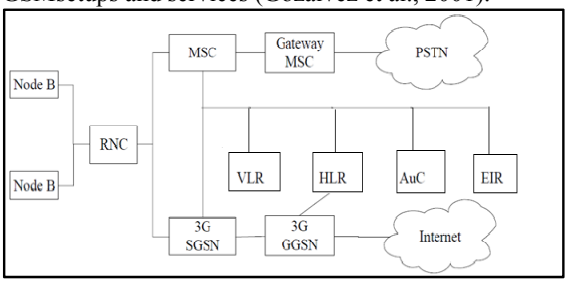

Figure: *4 Architecture of WCDMA*

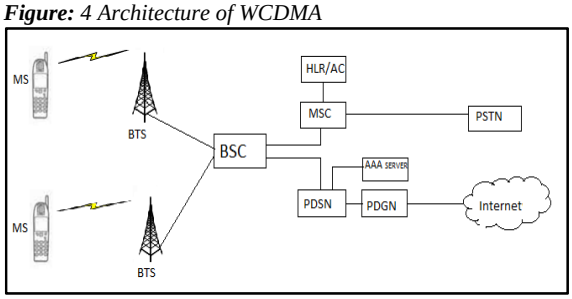

Figure: *5 Architecture of CDMA*

3.75G – HSUPA (High-SpeedUplink Packet Access)

The 3.75G refer to the technologies beyond the well-defined 3G wireless/mobile technologies. HighSpeed Uplink Packet Access (HSUPA) is a UMTS /WCDMA uplink evolution technology.The HSUPA mobile telecommunicationstechnology is directly related to HSDPA and thetwo are complimentary to one another.HSUPA will enhance advanced person-to-persondata applications with higher and symmetric datarates, like mobile e-mail and real-time person topersongaming. Traditional business applicationsalong with many consumer applications will benefitfrom enhanced uplink speed. HSUPA will initiallyboost the UMTS / WCDMA uplink up to 1.4Mbpsand in later releases up to 5.8Mbps.

Limitations of 3G

1. With WCDMA based 3G, as the data speed increases thecoverage area of the cell become smaller and smaller.
2. There has been some improvement with HSPDA, butstill it is impossible to connect these by wireless links incellular technology.
3. Using WCDMA cells, with increase in data rate, thespeed of movement of user terminal also become lesserand lesser.
4. We still have circuit voice, circuit data and packet databearers.

IV.Fourth Generation (4G)

In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users). A 4G Technology not only provides voice and other 3G services but also provides ultra-broadband network access to mobile devices. Applications vary from IP telephony, HD Mobile Television, video conferencing to gaming services and cloud computing. One of the initial devices to access 4G network was USB wireless modem which was later followed by cellular phones with WiMax and LTE technology. Although still 3Ghas not been fully implemented in the real world, peoplehave started talking about the features of 4G. Some of the4G services talked about are incorporating quality ofservice (QoS) and Mobility.

Features of 4G

1. High usability: Anytime, anywhere and with anytechnology.
2. Support for multimedia services at low transmissioncost.
3. Personalization.
4. Integrated services.

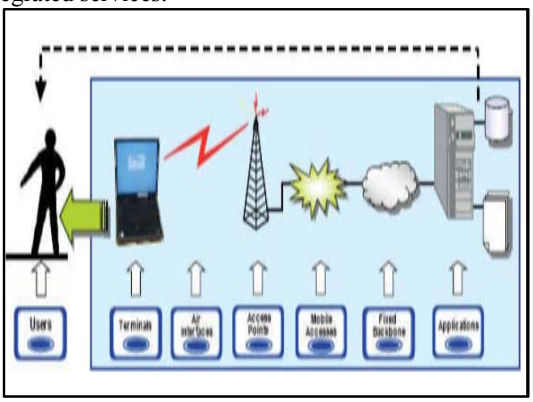

Figure*: 6. Architecture of 4G*

The Key Elements of Architecture are:

1. Terminals Till date the "terminal" for accessing mobile services has been the mobile phone.User interfaces of terminals will vary from traditional keyboard, display, and tablet, to new interfaces based on speech, vision, touch, soft buttons, etc. These will be general-purpose computing and communication devices, and devices with more specific purposes to serve particular marker segments. There will still be recognizable mobile phones.

2. Networks

Worldwide roll-out of 3G networks are delayed in some countries by the enormous Costs of additional spectrum licensing fees. In many parts of the world 3G networks do not use the same radio frequencies as 2G, requiring mobile operators to build entirely new networks and license entirely new frequencies.

3. Applications

The 4G technology will be able to support Interactive services like Video Conferencing (with more than 2 sites simultaneously), Wireless Internet, etc. The bandwidth wouldbe much wider (100 MHz) and data would be transferred at much higher rates.

Technologies under 4G:

4G comprised of the following Mobile Technologies:

Long Term Evolution (LTE) Standard based on the GSM/EDGE and UMTS/HSPA, 3rd Generation Partnership Project (3GPP), Multiple In Multiple Output (MIMO) smart antenna technology, Orthogonal Frequency Digital Multiplexing (OFDM), 802.16e - Worldwide Interoperability for Microwave Access (WiMAX), 802.20 - Mobile Broadband Wireless Access (MBWA)

***Limitations of 4G*:**

1.3G and 4G components made for one continent is not always compatible with another continent sue to carrying frequency bands.

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2. Another prominent issue in 4G systems is to make higher bit rates available in larger portion of the cell, especially to users in an exposed position in between several base stations. In current research, this issue is addressed by macro-diversity techniques, also known as group cooperative relay, and also by Beam-Division Multiple Access (BDMA). Pervasive networks are a hypothetical amorphous concept where the user can be simultaneously connected to several wireless access technologies and can seamlessly move between them. This technology has not yet been efficiently implemented.

V.Fifth Generation (5G)

5G Technology stands for 5th Generation Mobiletechnology. 5G technology has changed the meansto use cell phones within very high bandwidth. Usernever experienced ever before such a high valuetechnology. Nowadays mobile users have muchawareness of the cell phone (mobile) technology.The 5G technologies include all type of advancedfeatures which makes 5G technology most powerfuland in huge demand in near future.Currently 5G is not aterm officially used for any particular specificationor in any official document yet made public bytelecommunication companies or standardizationbodies such as 3GPP, WiMAX Forum or ITU-R.New 3GPP standard releases beyond 4G and LTE
Advanced are in progress, but not considered asnew mobile generations.

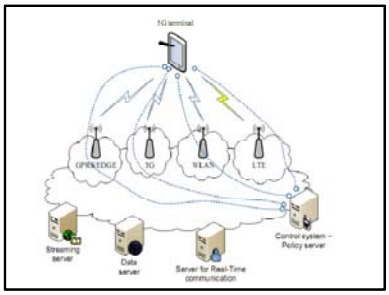

Figure:*7. Architecture of 5G*

5G Architecture

The system model that proposes the design of network architecture for 5G wireless systems, which is all-IP based model for wireless and mobile networks interoperability is as shown in Figure 7the system consists of a user terminal 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 will be different radio interface for each Radio Access Technology (RAT) in the terminal.For example, if we want to have access to four different RATs, we need to have four different access specific interfaces in the terminal, and to have all of them active at the same time, with aim to have this architecture to be functional .Application connections are realized between clients and servers in the Internet via sockets. Internet sockets are endpoints for data communication flows. Each socket of the web is a unified and unique combination of local IP address and appropriate local transport communications port, target IP address and target appropriate communication port, and type of transport protocol. Considering that, the establishment of communication from end to end between the client and server using the Internet protocol is necessary to raise the appropriate Internet socket uniquely determined by the application of the client and the server. This means that in case of interoperability between heterogeneous networks and for the vertical handover between the respective radio technologies, the local IP address and destination IP address will be fixed and unchanged. Fixing of these two parameters will ensure handover transparency to the Internet connection end-to-end, when there is a mobile user at least on one end of such connection. In order to preserve the proper layout of the packets and to reduce or prevent packets losses, routing to the target destination and vice versa will be uniquely using the same patheach radio access technology that is available to the user in achieving connectivity with the relevant radio access is presented with appropriate IP interface. Each IP interface in the terminal is characterized by its IP address and net mask and parameters associated with the routing of IP packets across the network. In regular inter-system handover the change of access technology (i.e., vertical handover) would mean changing the local IP address. Then, change of any of the parameters of the socket means closing the socket and opening a new one. This means, ending the connection and starting a new one. This approach is not-flexible, and it is based on today's Internet communication. To enable the functions of the applied transparency and control or direct routing of packets through the most appropriate radio access technology, in the proposed architecture, a control system is introduced in the functional architecture of the networks, which works in complete coordination with the user terminal and provides a network abstraction functions and routing of packets based on defined policies. At the same time this control system is an essential element through which it can determine the quality of service for each transmissiontechnology. It is on the Internet side of the proposed architecture, and as such represents an ideal system to test the qualitative characteristics of the access technologies, as well as to obtain a realistic picture regarding the quality that can be expected from applications of the user towards a given server in Internet (or peer).

Features of 5G Technology

The main features of 5G the technologies are as follows:

1.1000times more devices which have High speed, high capacity, and low cost per bit and also increased data volume per area.

2.10 to 100times increased number of connected devices which Support interactive multimedia, voice, streaming video, Internet, and other broadband services, more effective and more attractive, Bidirectional, accurate traffic statistics.

3. 10 to 100 times increased typical user data rate as well as wide range of application.

4. It is not only more software option but also 10 times extended battery life for low power Massive Machine Communication (MMC) devices.

5. Reduced End-to-End (E2E) latency or virtually „0" latency.

6. Very high capacity as well as response time is faster.

Threats of 5G implementation

The following threats are expected from the application implementation of 5G network as a future system;

i) Since all the network operators and service providers would share a common core network infrastructure, compromise of a single operator will lead to the collapse of the entire network infrastructure, if not carefully guide against.

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ii) Third-parties can masquerade as legitimate users resulting in theft of service and billing frauds can easily arise.
iii) Since 5G is a secure IP based solution it will be vulnerable to all the security threats as the current Internet world.
iv) On the lines of email-spam, the Spam over Internet telephony (SPIT), the new spam over VoIP may become serious and become serious threats.

Table 1.Comparison of all Technologies

Technology/Features	1G	2G/2.5G	3G	4G	5G
Start/ Development	1970/ 1984	1980/ 1999	1990/ 2002	2000/ 2010	ρ010/ 2015
Data Bandwidth	2 kbps	14.4-64kpbs	2 Mbps	2000 Mbps to1 Gbps for low mobility	1 Gbps and higher
Standards	AMPS	2G:TDMA, CDMS, GSM 2.5:GPRS, EDGE, 1xRTT	WCDMA, CDMA-2000	Single unified standard	Single Unified standard
Technology	Analog Cellular technology	Digital cellular technology	Broad bandwidth CDMA, IP technology	Unified IP and seamless combination of broadband, LAN/WAN/PAN and WLAN	Unified IP and Seamless combination of broadband, LAN/WAN/PAN /WLAN and wwww
Service	Mobile Telephony (voice)	2G: Digital voice, Short Messaging 2.5G: Higher capacity Packetized data	Integrated Higher Quality audio, video and data	Dynamic Information Access, Wearable devices	Dynamic Information Access, wearable device with IA capabilities
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Switching	Circuit	2G: Circuit 2.5G: Circuit for access network & air interface; packet for core network and data	Packet except circuit for air interface	All packet	All packet
Core Network	PSTN	PSTN	Packet network	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal and vertical	Horizontal and vertical

CONCLUSION

In this paper wereview the various generations of mobile wirelesstechnology, their performance, advantagesand disadvantages ,comparison of one generation over other.1G had fulfilled the need for a basic mobile voice, the 2G had introduced capacity and coverage, followed by 3G, which had a quest for data at higher speeds to open the gates for truly a mobile broadband experience, which was further realized by the 4G.5G wireless technology is one of the high demand technology because 5G promises to bring higher data transfer speeds (reaching up to few gigabits per sec) and various other high quality services. 5G is a promising Generation of wireless communication that will change people¨s lives.

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