Evolution of Mobile Generation Technology

M.Benisha, R.Thandaiah Prabu, Thulasi Bai

Abstract— Recent developments in the wireless technology has made the communication more familiar and reachable to all peoples. In one way the demand for mobile communication needs the integration of wireless networks into the existing fixed network like local area network(LAN), wide area network(WAN) etc., Otherwise we can say that, it needs advancements, adaptability and compatibility over the mobile services provided by various mobile generation technologies like 1G, 2G, 3G, 4G and 5G. In this paper we deeply discuss about the growth of Mobile generation technologies from 1st Generation to 5th Generation. And this paper gives an idea about how these technologies are operating and providing increased performance over the earlier generation and their merits and applications.

Keywords— LAN, WAN, 1G, 2G, 3G, 4G, 5G.

I. INTRODUCTION

Wireless communication is the fastest growing technology, which became more significant after the arrival of 5G systems. The basic idea about the evolution of wireless communication system is needed for the researchers. The past and progress of wireless communication is as follows. Eelectro Magnetic (EM) waves are the important key factors for the advancement of wireless communication. In 1678 Huygens work on the light reflection and refraction theory. Later in 1819, wired communication turns to wireless because of the wave nature of the light (or we can have electron). Electrons follows particle nature through a wired medium and wave nature in wireless medium (E.g. Air) thereby EM waves comes into the picture. And during 1831 Faraday proves electromagnetic induction and wave equations were formulated by Maxwell. J at 1864. Hertz H validates experimentally the broadcast and response of Electro Magnetic waves over a few meters apart and Marconi established a communication set up over 3 Km at 1896[1]. With this the following establishments were made the wireless communication more popular across the globe. The succeeding table gives a quick overview on the generation and progress of wireless communication systems.

Table I. Wireless communication systems – Evolution and progress.

Year	Development	Specification
1896[1]	Guglielmo Marconi - wireless telegraphy (Morse code - digital)	Operating at 1MHz
1906[1]	1st World Radio Conference	-
1907[1]	Commercial transatlantic connections	Huge base stations
1915[1]	Wireless voice Communication - San Francisco	-
1920[1]	Marconi Detected short waves	-
1958[1]	A-Netz in Germany at 160MHz	Handover effect reduced, 80% coverage,
1985[1]	UK's TACS	-
1986[1]	C-Netz in Germany at 450MHz	-
1992[1]	Introduction of GSM (2G)	Entirely digital, 900MHz, 124 channels. Data with 9.6kbit/s
1994[1]	GSM at 1800 MHz (called Digital Cellular Service (DCS1800))	Smaller cells
1997[1]	Wireless LANs	IEEE-Standard, 2.4 - 2.5GHz, 2Mbit/s
1998[1]	Universal mmobile ttelecommunication ssystem (UMTS)	-
1999[1]	IEEE802.11b	BW increased to 11Mbit/s
2000[1] 2010-2013 2020	Bluetooth Specification & Implementation of 3G 4G Expected launch of 5G	UMTS, HSPA, HSDPA, HSPA+ LTE 3GPP

In this paper the basic ideas about all the mobile generations technologies and the fore coming important mobile technology called mm wave 5G communication are discussed. In chapter II all the mobile generation standards

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are discussed and chapter III concludes the paper.

II. MOBILE GENERATION TECHNOLOGIES

Wireless communication including mobile generation technologies have a very tremendous growth in the past 50 years as given in fig 1. Various mobile generation technologies are discussed below.

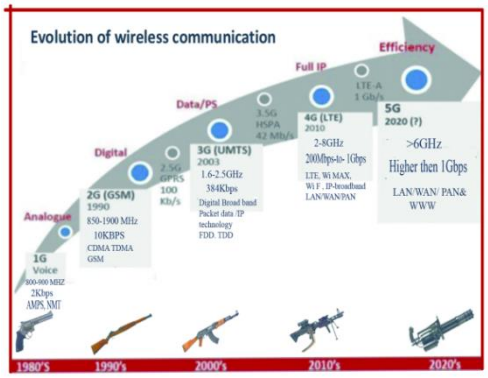

Fig 1. Growth of Wireless communication

2.1. 0G technology / PRE-CELLULAR technology:

0Generation technology, which is designed former to the cellular system is also identified as Mobile Radio Telephone Systems. Generally, it uses analog carriers and provides only half duplex transmission. It comprises of various techniques such as advanced mobile telephone system (AMTS), mobile telephone system (MTS), Mobile telephony system (MTD), Norwegian for offending land mobile telephone (OLT), push to talk (PTT) and improved mobile telephone service (IMTS) as referred in [2]. They have two main parts transceiver and head; it will connect to local telephone network within the range of 20Km with the capacity of 25 channels per city. The foremost weakness of the technology is the roaming facility was not supported. All these confines lead to the expansion of next generation mobile technology.

2.2. 0.5G technology:

The progressive form of 0 Generation technology with the introduction of ARP (Autor adipophilin) is 0.5 Generation, implemented in 1971 at Finland. It was operated with the frequency of 150MHz and support full duplex system for communication and the network is divided into number of cells with the 30 Km of cell size. The calls will get disconnected since it doesn't support handover. These restrictions directed to origination of Autotel. Autotel are also known as PALM (Public Automated Land Mobile). Autotelic is a technology lies between MTS and IMTS and called as radio telephone service. It uses digital signals for messages like call step up, channel assignment, ringing, etc. only voice channel was analog. This system uses existing high-power VHF channels as an alternative of cellular system. It was established in Canada and Columbia.

2.3. 1G technology:

1G technology is a very basic voice analog phone system using circuited switched technology [3] for the transmission of radio signals. All voice calls get Frequency modulated to higher frequency of 150MHz transmitted with frequency division multiple access (FDMA) technology in the frequency band of 824-894 MHz with channel capacity of 30 KHz [4], which was based on a technology called advance mobile phone service (AMPS) or total access communication system (TACS). similar technologies which can support 1G are Nordic mobile telephone (NMT) standard, Radiocom 2000 (RC 2000) standard, C-450 standard, etc [5]. A small overview about all these technologies is given in Table 2. It provides data rate up to 24Kbps and support mostly voice calls only.

RESULTS & DISCUSSIONS

Table II. Technologies Supporting 1G

Type/ Parameters	AMPS	TACS	NMT	NTT	RC 2000	C-450
Modulation & Multiple access Type	Frequency Modulation (FM) & Frequency Division Multiple Access (FDMA)					
Uplink Frequency (MHz)	824 - 849	890 - 915	453 - 458/ 890 - 915	925 - 940	414.8 - 418	450-455.74
Downlink Frequency (MHz)	869 - 894	935-960	463-468/935 - 960	870 - 885	424.8 - 428	460-465.74
Channel Spacing (KHz)	30	25	25/12.5	25	12.5	10
Number of Channels	832	1000	180/1999	600	256	573

The architecture of AMPS technology used in first generation [6] is shown below in Fig 2.

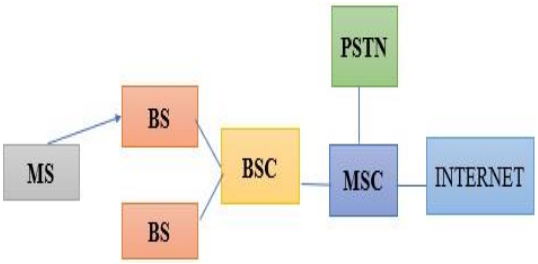

Fig 2. Architecture of AMPS

Mobile station (MS),
Base station (BS),
Base station controller (BSC),
Mobile switching center (MSC),
Public switched telephone network (PSTN).

1G technology doesn't attracted people because of the following disapproving subjects such as less capacity, handoff problems, lack of security, very poor voice connection because of only one carrier per channel, less battery life and Large size. Thus, we moved on to the next step towards 2G technology.

2.4. 2G technology:

Mobile wireless system was dubbed after the invention and

execution of 2G which permits data and voice services together such as short message services (SMS), multimedia message services (MMS) and e-mail with high capacity and coverage. It follows completely digital multiple accessing techniques called time division multiple access (TDMA) and code division multiple access (CDMA) standards. All the discussions were numerically encoded and thus it provides greater security. It avails the frequency band of 850-8900MHz and uses the technologies like global system for mobile (GSM), PDC, iDEN, IS-136 or north American digital cellular system (NADC) with TDMS process and IS-95 with CDMA process. GSM technology uses 8 channels in a single carrier with a net rate of 13Kbps [7]. Table 3 gives necessary details about the 2G supporting Technologies.

Table III. Technologies Supporting 2G

Type/ Parameters	GSM	IS-136	PDC	IS-95(CDMA)
Modulation & Multiple access Type	GMSK/TDMA/SDH	π/4 D-QPSK/ TDMA	π/4 D-QPSK/ TDMA	BPSK/ QPSK/ CDMA
Uplink Frequency (MHz)	890-915	824 - 849	940 - 956, 1429 - 1453	824- 849
Downlink Frequency (MHz)	935-960	869 - 894	810 - 826, 1477 - 1501	869 - 894
Channel Spacing (KHz)	200	30	25	1250
Number of Channels	1000	832	1600	2300
Enhanced Version (2.5G)	HSCSD / GPRS/ EDGE			IS95b

The core shortcoming of 2G technology is it is difficult to support complex data's such as videos. Thus, we need an improvement towards its successors.

2.5. 2.5G technology:

2.5G is a cellular wireless technology established in between its precursors 2G and its inheritors 3G and it describe the 2G system with both circuit and packet switched services. The General Packet Radio Services are designated by the term "second and half generation" and it offers 56Kbit/s to 115Kbits/s data rate. It can be used for facilities such as wireless application protocol (WAP), access multimedia messaging services (AMMS), and for communication network services such as Email and World Wide Web access. It also supports SMS, MMS and WAP, Mobile games etc.

2.6. 2.75G technology:

2.5G networks advanced to enhanced data rates for GSM evolution (EDGE) links with the starter of 8PSK encoding, but the symbol rate remained the same at 270.833 samples per second. Instead of three bits each symbol carried in one bit. enhanced data rates for GSM evolution (EDGE), enhanced GPRS (EGPRS), or IMT single carrier (IMT-SC) is a regressive compatible digital mobile phone technology that allows improved data transmission rates, as an extension on top of standard GSM.

2.7. 3G technology:

3G technology usually referred as universal mobile telecommunications standard (UMTS) is found to be 3 times better than GSM, so called 3GSM with maximum date rate of 8Mbps. It assigns low data rate channel for voice calls and large data rate channel for video calls. To frame the International standard for 3G cellular networks, international telecommunication union (ITU) signed the international mobile telecommunications 2000 (IMT 200) in the year 1999. Thereby the 3G was supported by 2 main technologies UMTS and CDMA2000 with the support of 3GPP and 3GPP2 respectively [8].

UMTS uses the air interface as wideband CDMA (WCDMA) often called as universal terrestrial radio access (UTRA). It is configured to support up to 2Mbps data rate with frequency division duplexing (FDD) and time division duplexing (TDD), whereas CDMA 2000 uses multiple narrowband CDMA carriers. It requires higher bandwidth that becomes the drawback of the technology.

2.8. 3.5G technology:

3.5G also termed as high-speed data packet access (HSDPA) is 6 times faster than UMTS technology thereby supporting data date up to 14.4 Mbps [9].

Table 4. Evaluation of Mobile Generation machineries

Generations	1G	2G	
Data capacity	2Kbps	10Kbps	
Deployment from	1984	1990	
Throughput	14.4 Kbps		20
Standard	AMPS, NMT, TACS, MTS, AMTS, IMTS	CDMA TDMA GSM	
Web Standard	------	WWW	
Multiplexing	FDMA	TDMA CDMA	
Service	Voice only	Voice data	
Main network	PSTN	PSTN	
Hand off	Horizontal	Horizontal	
Disadvantages	Poor handoff, Less security, Spectral efficiency.	Digital depending proximity, Need strong signals to h phones, Les	

2.9. 3.75G technology:

A high-Speed uplink packet access technology (HSUPA) is the version of UMTS/WCDMA uplink evolution technology drives the 3.75 Generation technology beyond the applications of 3G. It is established to boost the uplink data rate to 1.4 Mbps and later up to 5.8 Mbps [10]. The two techniques HSDPA and HSUPA are complementary to each other and are directly related, whereas HSUPA has many applications with advanced data rate such as mobile e-mail, real time gaming, Various business applications etc.

2.10. 3.9G technology:

Long term evolution (LTE) is thought as a lead towards the 4G technology and hence named as 3.9G technology. It uses evolved UTRA (E-UTRA) as the air interface and is supported by single carrier – frequency division multiple access (SC-FDMA) to achieve 50 Mbps data rate at the uplink. In downlink 100 Mbps data rate is achieved through Orthogonal frequency division multiple access (OFDMA) [8].

2.11. 4G technology:

4G technology is established to incorporate the major requirements such as quality of service (QoS) and data rate. This is done by small applications such as MMS, Video chat, HDTV, digital video broadcasting (DVB) and wireless mobile broadband access (WMBA) etc. [11]. It is attracted by the property of inter-operability between various networks. For a stationary user – server it provides 1Gbps data rate and for a moving user it offers 1- 100 Mbps data rate.

OFDMA technique a new method which is the combination of CDMA and IS-95 is implemented in 4G by dividing the channel in narrowband to transmit data packets with greater efficiency. IEEE 802.16m and IEEE 802.16e developed the WMBA techniques to provide downlink data rate of 128 Mbps and uplink data rate of 58Mbps.

There are some major issues in 4G, one is Position management and the other is handoff management [3]. LTE and Wi Max are the driving forces of 4G technology, these two are suffering by security issues to destroy data availability, integrity, confidentiality and authentication. Wi Max is suffered by denial of service (DOS) attacks, replay attacks, Eavesdropping, Key Management and reducing Quality of service. Whereas in LTE DOS attack, Data modification and scrambling attack are the major issues [12].

2.12. 5G technology:

The number of users is increasing very rapidly and there is a necessity for simultaneous connection to be employed for the final users and the deployed sensors. And to increase coverage, spectral efficiency, data rate, security and signaling efficiency and to reduce latency we must find a new technology beyond 4G and is called as 5G technology [13] descendant of 4G called LTE Advance (LTE-A) which supports FDD mode and TDD mode [14].

Thus, 5G offers 1Gbps data rate and allow us to experience a real wireless world – wireless world wide web (WWWW) [15]. It follows all IP model to provide inter-operability between all networks and uses packet switching rather than circuit switching [16].

As the technology grows the requirement of spectrum increases significantly. 2G requires 8 times additional spectrum than 1G, similarly 3G requires 25 times that of 2G and 4G needs 4 times more spectrum than 3G. 5G should support ultra-high-speed data(1Gbps) and ultra-low latency (<1ms), it requires a wide bandwidth which is not very easy to provide. Thus, 5G is revolutionized with Cloud RAN/ Edge Computing and Network Slicing [17]. Frequency permitting and spectrum organization problems might have solved by the software defined radio link (SDR), thereby it can allow more than hundred channels simultaneously without streaming [18].

Table 5. Comparison of Mobile Evolution technologies

Generations	3G	3.5G	3.75G	4G	5G
Deployment from	2001	2003	2003	2010	2020
Frequency	1.6-2.5GHz	1.6-2.5GHz	1.6-2.5GHz	2-8GHz	>6GHz
Data capacity	384Kbps	2Mbps	30Mbps	200Mbps-to- 1Gbps	Higher than 1Gbps
Technology	Digital Broad band Packet data /IP technology FDD TDD	GSM/ 3GPP		Digital Broadband Packet All, more throughput	IP-broadband LAN/WAN/ PAN&WWW
Throughput	200Kbps	1-3 Mbps		100-300Mbp	
Multiplexing	CDMA	CDMA	CDMA	MC-CDMA, OFDMA	CDMA
switching	Circuit Packet	Packet	Packet	Packet	All packet
Service	High speed voice/data/video	High speed voice/data/video	High speed internet/multi media	High Speed access, HD Capability, Worldwide roaming, Wearable devices.	Dynamic Information access, wearable devices with AI capabilities
Main network	Packet network	GSM TDMA		Internet	Internet
Hand off	Horizontal			Horizontal &Vertical	
Disadvantages	Need more network capacity, Failed in real time applications			More battery usage, Complicated and expensive hardware.	Yet to Deploy

5G can be viewed as a multi core reconfigurable technology inbuild with nanotechnology, cognitive radio networks (CRN), Cloud Computing to connect all networks such as GSM, CDMA, Wi -Max and Wire line into a single core [19] and all the knowledges such as big data, smart grids (SG), mobile cloud computing (MCC), internet of things (IoT), internet of vehicles (IoV), augmented reality (AR), virtual reality (VR), and D2D Communication into a common network [20] and these smart applications of 5G are listed in following figure.

The major prerequisites of 5G technology, such as larger bandwidth, data rate, low latency is achieved by shifting the operating frequency towards the mm-wave frequencies.

Due to the increased demand of spectrum, frequency band below 6GHz is been over crowded [21] and 5G is research is concentrated in 10-15 GHz, local multipoint services at 28-30GHz, 38-40 GHz, Unlicensed band 57-66 GHz, 71-76 GHz, 81-86 GHz, and 92-95 GHz [22]. Also, the performance can be improved by mm wave beam forming, Multiple antenna technologies, device to device (D2D) communication, Simultaneous transmission and reception, network cooperation and interference management.

5G systems are more secure than the 4G. And it is done by the important techniques such as New Trust models, Modified Drivers, Regularized privacy policies, Flexible architecture and cloud computing security [12].

Still there are many matters to be addressed in 5G system deployment such as, Scheduling, QoS Guarantee, Reliability, Security etc.

2.13. 6G technology:

The main aim of 6G technology is to assimilate all wireless mobile networks into single global coverage effectively without roaming. This can be accomplished by using low earth orbit (LEO) Satellite and provide speed up to 1000 Gbps [4].

2.14. 7G technology:

The goal of 7G is to interrelate four GPS systems which are in space roaming into a single network. It can offer data transmission rate of the order of 1Tbps.

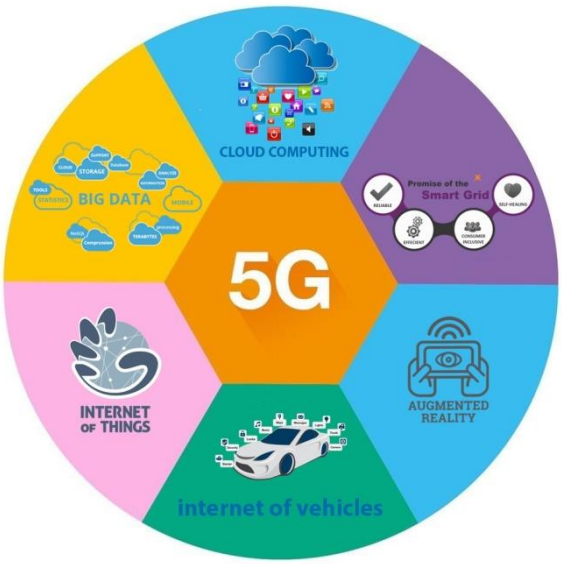

Fig 3. Smart applications of 5G system

III. CONCLUSION

From this paper we can say that the number of mobile generation technologies which are grown very rapidly with the time span of over 50 years. The challenges in each technology leads to the generation of newer one. And now we are concentrating on the research towards the deployment of 5G technology which is the one makes us feel everything connected as real-world with the very high data rate and capacity. There are as many challenges in the deployment, that should be seriously addressed for the better connectivity and applications of the mobile user.

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