

A Study on Evolution of Cellular Communications

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Abstract—Today, cellular communications act as an important role in the data/voice network and have become an integral part of our lives. Cellular communication is growing at a rapid pace in last few years and is still going on. The wide spread success of cellular network led to the development of newer wireless systems with better, efficient, high – speed wireless connectivity and accurate access to information. The cellular technologies differ from first generation to fifth generation, each other based on their switching schemes, bandwidth, data rates and radio access. In this paper, an attempt has been made to review various existing generations of cellular technology in terms of their performance, advantages and disadvantages.

1. INTRODUCTION

Cellular communications is the transfer of information over a distance without use of electrical conductors or “wires”. In 1895, Guglielmo Marconi opened the way for modern wireless communications by transmitting the three-dot Morse code for the letter ‘S’ over a distance of three kilometres using electromagnetic waves. From this beginning, wireless communications has developed into a key element of modern society. The Mobile wireless industry has started its technology creation, revolution & evolution since early 1970s [1]. The wireless mobile networks have traditionally been based on the cellular concept and relied on good infrastructure support, in which mobile devices communicate with access points like base stations connected to the fixed network infrastructure. To access the services seamlessly is required to have supportive network and infrastructure whereby the service can be accessed within local area network as well as in wider area [2, 3].

The 1st commercial mobile was developed in Scandinavian country in 1981 with the name of Nordic mobile telephone (NMT) networks [4]. The first mobile communication trial was placed in Chicago in 1978. After that, this launch occurred in Chicago in 1983 commercially. Meanwhile, other parts of the world were making progress in mobile communication. In 1979 the mobile phone system was introduced in Japan. The European countries were also very active in mobile communication; the first mobile system was launched in 1981 in Sweden, Norway, Denmark and Finland [5].

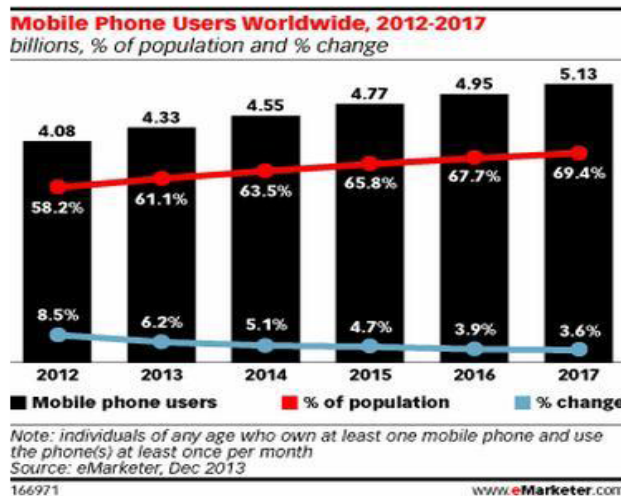


Fig. 1: Growth of Mobile Phone Users Worldwide

Cellular communications is the fastest growing segment of communication industry. Cellular systems have experienced exponential growth over the last decade and there are currently around two billion users worldwide. Also, cellular phones become a critical business tool and part of everybody life in most developed countries. Fig. 1 shows the growth of mobile phone users worldwide from 2012 to 2017. The growth of mobile wireless technologies has been classified as zero generation (0G), first generation (1G), second generation (2G), third generation (3G), fourth generation (4G) and fifth generation (5G). The 1G technology is the cellular technology. The older analogy communication is replaced by digital communication in 2G. The next evolved 3G technology appended the data communication to the voice and as a result of this; a network supporting both data and voice communication has emerged. The 4G technology which is an extension of 3G technology, with higher bandwidth, supports high quality audio/video streaming over an end to end Internet protocol [6]. In this advanced world, a high speed broadband communication technology is required for the efficient utilization of resources. So the next generation, which is the 5G technology, concentrates on broadband wireless connectivity. It is an all-IP based model for mobile and wireless network operations capable of fulfilling the increased demands of cellular communication [7, 8, 9, 10].

2. EVOLUTION OF CELLULAR NETWORKS

The number of telecom subscribers is increasing day by day with the evolution of new technologies, performance and capacity. With the rapid development of cellular networks, people can access information at anytime, anywhere through a cellular network. The evolution of generations from 1G - the first generation, 2G- the second generation, 3G - the third generation, 4G - the fourth generation, and then the 5G - the fifth second generation as shown in Fig. 2.

3. ZERO GENERATION (0G)

The mobile telephone services came into existence after the Second World War. Radio telephones were the major attractions of this generation technologies. 0G refers to pre-cellular mobile telephony technology in 1970s. Since 0G was the predecessors of 1G of cellular telephones, these systems are called 0G systems. The main technologies coming under 0G includes Push-To-Talk (PTT), Mobile Telephone System (MTS), Improved Mobile Telephone Service (IMTS), Advanced Mobile Telephone System (AMTS), Norwegian for Offentlig Landmobil Telefoni, Public Land Mobile telephony (OLT) and Advanced Mobile Telephone System (MTD). PTT is a conversation method on half-duplex communication line which uses a button to switch from voice receiving mode to transmit mode. The problem with this method is that, it requires an operator for controlling the calls. MTS is a VHF (Very High Frequency) radio system used to connect to the external PSTN (Public Switched Telephone Network). It is equivalent to land dial phone service. This technique was used till 1980s. It used 25 VHF radio channels in USA and Canada. IMTS is a VHF/UHF (Ultra high frequency) radio system used to connect to the external PSTN like MTS technique and replaced the operator assisted system with direct dial system. The major disadvantage is that it constantly limits the number of subscribers. OLT was the first land mobile telephone network in Norway. It was introduced in 1966 and continued till 1990. AMTS is a zero generation technology for radio communication. AMTS operates at a frequency band of 900MHz. The successor of AMTS is called High Capacity Mobile Telephone System (HCMTS). MTD is a manual mobile phone system having a frequency band of 450 MHz [1, 11, 12].

4. FIRST GENERATION (1G)

1G mobile network used analog system for communication of speech services. Mobile telecommunication in 1G first introduced in 1980s and continued till 1990. Analog Mobile Phone Systems (AMPS) was first established in USA in mobile networks. It has simple voice only cellular telephone parameters. It allows end users to make voice calls only within one country [13, 14, 15]. 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 [D]. Advantages of 1G

cellular network is it survives longer distances as the analog signals have a smooth curve as compared to the jagged angular curve of digital signal. Its drawbacks include low capacity, poor voice links, unreliable handoff and unsecured data transmission, making these calls susceptible to unwanted eavesdropping by third parties [11]. Different 1G standard were used in various countries. One such standard is NMT (Nordic Mobile Telephone), used in Nordic countries, Eastern Europe and Russia. Others include AMPS (Advanced Mobile Phone System) used in the United States, TACS (Total Access Communications System) in the United Kingdom, C-Netz in West Germany, Radiocom 2000 in France, and RTMI in Italy [1,12].

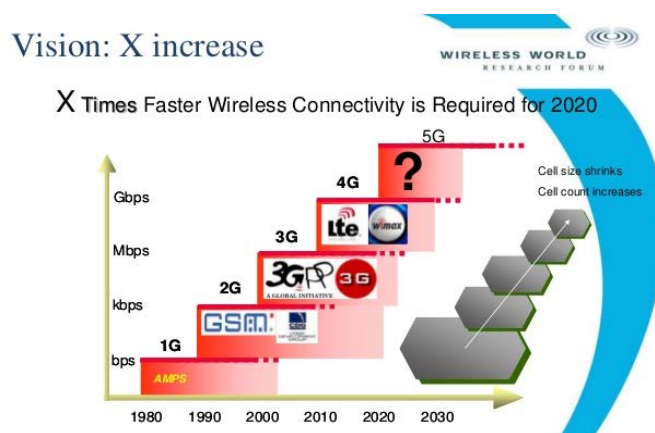


Fig. 2: Evolution of Cellular Generation

5. SECOND GENERATION (2G)

2G is based on digital technologies and is basically for voice communications. 2G cellular network were launched based on Global System for Mobile (GSM) standard in Finland by Radiolinja (now part of Elisa Oyj) in 1991. 2G network allows for much greater penetration intensity. 2G technologies enabled the various mobile phone networks to provide the services such as text messages, picture messages and MMS (multimedia messages). The access techniques used in 2G are TDMA (time division multiple access) and CDMA (code division multiple access) along with the frequency division duplexing (FDD) technique. Features of 2G System are it uses CODEC (compression and multiplex algorithm) to compress and multiplex digital voice data. Some benefits of 2G were digital signals require consume less battery power and are environment friendly. Digital coding improves the voice clarity and reduces noise in the line. The use of digital data service assists mobile network operators to introduce short message service over the cellular phones. Digital encryption has provided secrecy and safety to the data and voice calls. The disadvantage of 2G technology is that it requires strong digital signals to assist connection of mobile phones. If there is no network coverage in any specific area, digital signals would be weak. . Different TDMA technologies are GSM, PDC (Pacific Digital Cellular), iDEN (integrated Digital

Enhanced Network), iS-136 (Interim standard 136). CDMA technology is IS-95 (Interim standard 95) [1, 12, 15, 16, 17].

6. THIRD GENERATION (3G)

3G was adopted by Japan and South Korea in 2001 for the first time. 3G UMTSTM (Universal Mobile Telephone Service) is developed by ETSITM with in ITU’s (International Telecommunications Union) IMT-2000 framework. . It makes use of both TDMA and CDMA. The features of 3G technology include wireless web base access, enhanced multimedia (voice ,data ,video and remote control), Usability on all popular models (cellular phones , e-mails , pagers , fax , video conferencing and web browsing), Broad bandwidth and high speeds, International roaming capability, Excellent quality of voice, Applications include: Still photography, video data transmission service, file transfer from internet, multimedia e-mail, Web Browsing, on-line services, time schedules. The drawbacks of 3G are expensive fees for 3G Licenses Services, big size of mobile phones, expensive in nature, higher bandwidth requirements etc. The 3G standard is categorized in two types. They are 3GPP (3G partnership project for wideband CDMA standard) and 3GPP-2(3G partnership project for CDMA-2000 standard) [1, 15, 16, 17, 18].

7. FOURTH GENERATION (4G)

4G is the high-speed mobile wireless communication designed for new data services and interactive TV through mobile network. International Telecommunication Union using Radio defined 4G mobile technology as IMT-Advanced (International Mobile telecommunication Advanced). The features included in 4G are Video conferencing, gaming services, IP telephony, high definition (HD) mobile TV. It also provides Internet access facility at a very rapid speed which is known as mobile ultra-broadband internet access. The fourth generation mobile system uses Orthogonal Frequency Division Multiplexing (OFDM), Multiple Input Multiple Output (MIMO), Software Defined radio (SDR) technologies. The OFDM technology uses a Fast Fourier transform (FFT) to convert the time domain signal in to frequency domain signal. The use of FFT algorithm reduces the computational time and also increases the overall of multiple antennas is used at receiver to improve the efficiency of the system. In MIMO system number of multiple antennas is used at transmitter and the number Bit Error Rate (BER) and data rate so as to maintain the system capacity. SDR is developed to reduce the problems of global roaming. IPv6 is approved by Version as a 4G standard on June 2009 [1, 16].

Table 1: Comparison of All Generations of Cellular Technology

Technology/Features	1G	2G	3G	4G	5G
Evolution	1970 – 1980	1990 – 2004	2000 – 2010	2010	2015

Technology	Analog cellular technology	Digital cellular technology	CDMA 2000 (1xRTT, EVDO), UMTS, EDGE	WiMax LTE Wi-Fi	WWWW
Frequency Band	824 – 894 MHz	850 – 1900 MHz	1.8 – 2.5 GHz	2 – 8 GHz	3 – 300 GHz
Data bandwidth	2Kbps	64Kbps	144kbps-2Mbps	100Mbps-1Gbps	Higher than 1 Gbps
IEEE standards	802.11	802.11b	802.11g/a	802.11n	802.11ac
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA, OFDM	CDMA
Switching	Circuit	Circuit, Packet	Packet	All Packet	All Packet
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Service	Mobile Telephony (Voice)	Digital voice, SMS, Higher capacity packetized data	Integrated high quality audio, video and data	Dynamic information access, Wearable devices	Dynamic information access, Wearable devices with AI capabilities

8. FIFTH GENERATION (5G)

The 5th generation of wireless mobile communication is wireless internet network which is supported by OFDM, MC-CDMA, LAS-CDMA, UWB, Network-LMDS and IPv6. The basic protocol for running on both 4G and 5G is IPv6. The 5G is complete wireless communication system having no limitation and is called as Real world wireless or WWW (World Wide Wireless Web). In 5G network architecture all IP based mobile applications and services such as Mobile portals, Mobile commerce, Mobile health care, Mobile government, Mobile banking and others, are offered via Cloud Computing Resources (CCR). Features of 5G technology are very high speed, high capacity and low cost per bit. It supports interactive multimedia, voice, video, Internet, and other broadband services, more effective and more attractive, and have Bi-directional, accurate traffic statistics. It supports interactive multimedia, voice, video, Internet, and other broadband services, more effective and more attractive, and have Bi-directional, accurate traffic statistics. It offers Global access and service portability. It is providing large broadcasting capacity up to Gigabit [7, 12, 18, 19, 20]. Table 1, shows the comparison of all generations of cellular technology.

9. CONCLUSION

This paper gives a review on various generations of cellular technology in terms of their performance. The cellular technology is advancing day by day and is obtaining each year

more processing power, more memory on board and longer battery life for the same applications. From all above discussion, it can be concluded that cellular technologies are developed at very rapid growth. The 1G cellular systems gives a start up to the cellular concept while 2G systems provide various features to the users. The 3G mobile systems provide various attractive multimedia services. 4G system increases the data rates to a great extent and also have high spectrum utilization ratio, low transmitting power. The 5G technologies include all type of advanced features such as cognitive radio, SDR, nanotechnology, cloud computing and based on All IP Platform which makes 5G technology most powerful and in huge demand in near future.

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