

A Review of Mobile Generations from 1G to 4G

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Abstract

Mobile and Wireless communication is a communication network that is connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices [1]. Today, mobile communication has become the backbone of the society. All the mobile system technologies have improved the way of living [2]. It is developing extremely fast in present times and deals with all the fields of mobile and wireless communications [3]. This paper deals with the evolution of wireless cellular technologies. i.e. First Generation, Second Generation, Third Generation, Fourth Generation and their significance and advantages one over the other. A cellular network is a mobile network that produces large number of services using base stations with limited power and covers limited area i.e. cell. In 1G network ,analog cellular technology was used, in 2G network GSM was used which is stands for Global system for mobile communication , 3g network allows mobile customers to use audio, video and graphics services, 4G uses LTE(long term evolution) technology.

Keywords: 1G, 2G, 3G, 4G, AMPS, NMT, TACS, TDMA, GSM, CDMA, GPRS, UMTS, MAGIC, LTE.

1. Introduction

Wireless communication means any network where there is no physical wired medium between sender and receiver but network is connected through radio or microwaves to communicate. The past few years have witnessed a phenomenal growth in the wireless industry, both in terms of mobile technology and subscribers. [4]The evolution of cellular networks has lead to several generations. The first generation wireless mobile communication network was first introduced in 1980s which is considered to be the first analog cellular technology mainly used for public voice service with speed up to 2.4kbps and have no data services. They were also called NMT (Nordic Mobile Telephone) or AMPS (Advanced Mobile Phone System).It uses circuit switched systems. The second generation network was introduced in 1990s which is based on digital system and network infrastructure and it introduces services such as short messaging and lower data services. These are based on GSM/CDMA technology with speed up to 14.4kbps.After this 2.5G also came with GPRS technology with speed 64-144kbps. After that 2.7G with EDGE (Enhanced Data Rates for GSM Evolution) technology.

The third generation network was introduced in 2000 which is based on UMTS/WCDMA technology. It provides higher data transmission rates and increased speed of capability. 3G uses packet switching technology, which is more effective and faster than the earlier circuit-switched systems. 3G delivers more new features such as Web browsing, e-mail, TV streaming, video conferencing, paging ,11sec-1.5min time to download a 3min Mp3 song, fax and navigational maps. The purpose of the 3G is to provide more coverage and evolution with lowest investment.

The fourth generation network was introduced in 2010 based on the LTE (Long term evolution)/WIMAX (Worldwide Interoperability for Microwave Access) technology. It has the capability to provide speed of 100 Mbps –1Gbpsand has high QoS (Quality of service) and security. It also offers various kind of service at any time as per user requirements at

anywhere. The significant features of 4G technology are video conferencing, location based services, tele-medicine, high security, speed, capacity and low cost per bit [5]. The aim of this research paper is that how rapid speed of emerging technology changed our lives in a short span of time. Till today researchers are using 4G technology in mobile networks and future generations and even we are eagerly waiting for 5G. Without wireless networks our lives will become next to impossible [6].

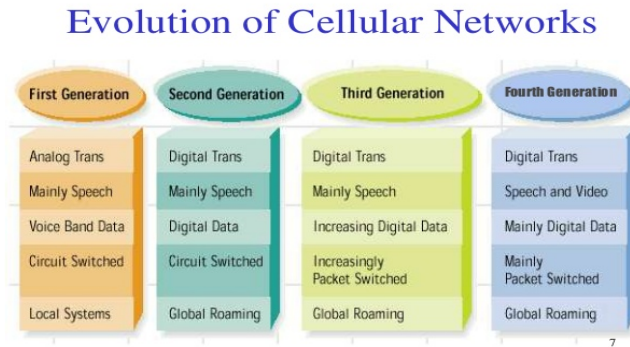


Figure 1: Evolution of Cellular networks

2. Generation of Mobile technology:

The cellular networks are evolving through several generations.

First Generation Technology:

1G stands for First Generation wireless technology which is based on analog signals used for transmitting voice signals. 1G technology also consists of various standards among which most common were Advance Mobile Phone Service (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS).

All standards in 1G uses frequency modulation techniques for voice signals and all the handover decisions were taken at the Base Stations (BS). The spectrum within cell was divided into number of channels and every call is allotted a dedicated pair of channels. Data transmission between the wire part of connection and PSTN (Packet Switched Telephone Network) was done using packet-switched network [7].



Figure 2: 1G Mobile Phone

AMPS (Advance Mobile Phone Service): It was first U.S cellular telephone system developed by Bell Labs in 1980s. The AMPS system uses 7-cell reuse pattern with provisions for sectoring and cell splitting to increase capacity when

needed.[8] It uses Frequency modulation(FM) and Frequency division duplex(FDD) for radio transmission. It also uses FDMA multiple access with channel bandwidth of 30 kHz.

NMT (Nordic Mobile Telephone):

There are two variants of NMT i.e. NMT-450 and NMT-900. The numbers indicate the frequency bands used. NMT-450 was first operated in Scandinavia on 1st October 1981. It provides 250 channels with frequency band of 450 MHz. NMT was first full duplex cellular network that provides automated calling and international roaming. NMT was popular but due to increase in number of users lead to congestion in network due to the limited number of channels. This lead to the development of NMT-900. NMT-900 was introduced in 1986 in Nordic countries. It provides more number of channels compared to NMT-450. It uses frequency range of 900 MHz

TACS (Total Access Communication System):

It was firstly introduced in United Kingdom and later it was used by Ireland and other European countries. It operates in 900 MHz frequency and provides 1000 channels. It is derived from AMPS. This technology is developed to accommodate large number of users. It also provides roaming facilities and provides full duplex communication.

Drawbacks in 1G

- There is no security of data as analog signals does not support advance encryption techniques. Anyone could listen conversation by simple techniques.
- User identification number can be stolen easily and could be used to make any call and the user whose identification number has been stolen had to pay for call charges.
- Analog signals can be affected by interference and affect the voice quality.
- Battery backup is poor
- Phone size is large

Second Generation Technology

2G technology was launched in 1991 in Finland. It is based on the technology global system for mobile communications(GSM). 2G networks uses digital signals which enable services like text messages, picture message and MMS(Multimedia messages). 2G technology provides security for sender and receiver because all text messages are digitally encrypted. So it allows the transfer of data in such a way that only the intended receiver can receive and read it.[9]



Figure 3: 2g Mobile Phone

Technologies used in 2G network are TDMA (time division multiple access) and CDMA (code division multiple access).

TDMA (time division multiple access):

TDMA divides the signals into time slots. TDMA technologies are GSM, PDC (Personal Digital Cellular), IDEN (Integrated Digital Enhanced Network).

- **GSM** technology was the first to establish international roaming and enabled the mobile subscribers to use their phone connections in many different countries of the world. It also allows the users to send SMS to any mobile network at any time. This technology is beneficial to both the network operators and ultimate users at the same time.
- **PDC** was developed in Japan. It uses 25 KHz frequency. Docomo launched its first digital service of PDC in 1993.
- **IDEN** (integrated digital enhanced network) was developed by MOTOROLA. It enabled the mobile users to make use of complex trunked radio and mobile phones. IDEN has a frequency of about 25Khz. IDEN allows three or six user per mobile channel [9].

CDMA (code division multiple access):

It allots each user a special code to communicate over a multiplex physical channel.

Drawbacks of 2G

- 2g technology requires strong digital signals to help mobile phones work. If there is no network coverage in any specific area, digital signals would be weak.
- Cannot handle complex data such as videos

Advancement of 2G

2.5G :

2.5G combines the 2G cellular system with General Packet Radio Services (GPRS). GPRS provide data rates from 56 Kbps to 384 Kbps.

It provides services like Wireless Application Protocol (WAP), Multimedia Messaging Service (MMS) and for internet communication services such as e-mail and World Wide wireless web (WWW) access. [10]

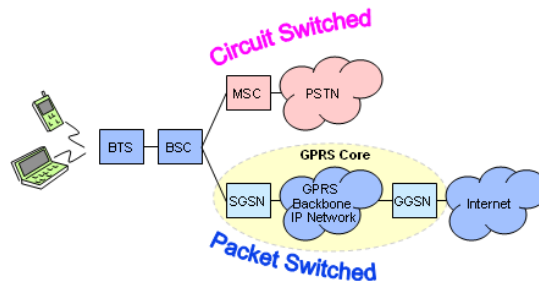


Figure 4: GPRS architecture

2.7G:

GPRS network enhanced to EDGE (Enhanced Data rates for GSM Evolution) networks with the introduction of 8PSK encoding.

EDGE is also known as Enhanced GPRS (EGPRS) or IMT Single Carrier (IMT-SC) or Enhanced Data rates for Global Evolution.

It enables data to be sent over a GSM TDMA system at speed up to 384 kbps. EDGE transfers data within few seconds as compared to GPRS.

Third Generation Technology

3G technology developed to overcome the drawbacks of 2G and 2.5G. 3G technology mainly designed for higher speed internet access. Apart from this, 3G technology also provides various services like video calling, live streaming, mobile internet access, IPTV etc on mobile phones. 3G spectrum provides necessary bandwidth.



Figure 5: 3G phones

3G technology is categorized in two types as follows:

- **3GPP :**

3GPP is known as 3rd generation partnership project. This project is developed to overcome the drawbacks of GSM and IS-136/ PDC. 3GPP standard includes WCDMA (wideband code division multiple access), TD-SCDMA (time division synchronous code division multiple access) and EDGE (enhanced data for GSM evolution). WCDMA also known as UMTS (universal mobile telecommunication system). It uses both FDD (frequency division duplexing) and TDD (time division duplexing). [8]It increases data transmission rates in GSM systems by using the CDMA air interface. It forwards channel bandwidth upto 5GHz. The data rate is upto 2Mbps.

TD-SCDMA uses TDD (Time division duplexing). Its bandwidth is upto 1.6MHz. The channel bitrate is upto 2.227Mbps.

- **3GPP-2:**

3GPP-2 is basically designed for CDMA2000 systems which are based on CDMA (code division multiple access). From the above two 3GPP specifications are widely used due to the fact that most of the cellular networks on the planet are based on GSM.

Fourth Generation Technology

4G technology came after 3G technology. 4G technology uses packet switching instead of circuit switching. 4G provides features such as video conferencing, gaming services, IP telephony, High definition mobile TV. It also provides internet access facility with high data rates which is known as mobile ultra-broadband internet access [8]. It has the capability to provide speed of 100 Mbps – 1Gbps and has high QoS (Quality of service) and security. It also offers various kind of service at any time as per user requirements at anywhere [4]. 4G technology uses OFDMA (orthogonal frequency-division multiplexing) instead of TDMA and CDMA. 4G also uses LTE (Long term evolution). LTE is a standard for 4G wireless communication developed by 3GPP that is designed to provide up to 10x the speeds of 3G networks for mobile devices[11]. 4G also uses Wi-Max (Worldwide Interoperability for Microwave Access) technology. Wi-Max has the capability to broadband internet access.

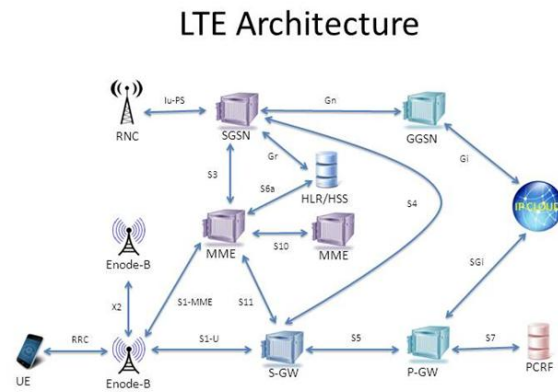


Figure 6: LTE architecture



Figure 7: 4G phones

There is a basic keyword which describes the 4G technology i.e. MAGIC:

MAGIC- Mobile multimedia, anytime anywhere, Global mobility support, integrated wireless solution and customized personal service. This means 4G provides any type of service to remote users anytime anywhere. Features include low cost in roaming network, high speed and high capacity.

- There are also some drawbacks like it consumes much battery; Implementation of hardware is difficult, complicated hardware is necessary.

3. Comparison of Mobile Generations:

Generation	1G	2G	2.5G	3G	3.5G	4G
Start	1970-1980	1990-2000	2001-2004	2004-2005	2006-2010	2011-Now
Data Bandwidth	2 Kbps	64 Kbps	144 Kbps	2 Mbps	More than 2 Mbps	1 Gbps
Technology	Analog Cellular	Digital Cellular	GPRS, EDGE, CDMA	CDMA 2000 (1xRT, EVDO) UMTS, EDGE	EDGE, Wi-Fi	WiMax LTE Wi-Fi
Service	Voice	Digital Voice, SMS, Higher Capacity Packet Size Data	SMS, MMS	Integrated High Quality Audio, Video & Data	Integrated High Quality Audio, Video & Data	Dynamic Information access, Wearable Devices
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit, Packet	Packet	Packet	All Packet	All Packet
Core Network	PSTN	PSTN	PSTN	Packet N/W	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal & Vertical

4. Conclusion

This paper gives a detailed survey of various mobile generation technologies from 1G to 4G with their advantages and drawbacks. From the above discussion we can conclude that 1G was the starting of cellular network which gives only the facility of voice signals. Then 2G came with the facility of roaming services. 3G gives various multimedia services. Then 4G increases the data rates at a very high speed. This paper also presents a comparison between 1G to 4G technologies.

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