

# Evolution of Cellular Network: From 1G to 5G

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## Abstract:

The need and demand of mobile and internet is increasing every day. Creation of technology and evolution of mobile industry has been initiated by mobile industry since early 1970s. First generation only provided voice communication facility, whereas second generation provided voice as well as data services. Further with more advancements in mobile wireless technology 3G provided us with video conferencing and etc. With increasing demand 4G came into existence and provided us with ultra-broadband internet access. 5G will be able to provide us facilities that one has never experienced till date. Our diversity of culture also plays a crucial role for this tremendous growth of mobile technology as they adopted this technology in friendly manner.

**Keywords –Introduction, Cellular network first generation, second generation, third generation, fourth generation and fifth generation.**

## 1.INTRODUCTION

As far as mobile technology is concerned it would be incautious to say that we haven't come a long way. Initially cell phones hardly keep a call connected but now with advancement in the technology we can keep a call connected, stream content and can carry out much more activities at the very same time. So, **Fig1.** shows an evolution of cellular networks i.e. cellular networks has evolved through various generations. Public voice service which was provided by the very first generation (1G) with speed up to 2.4kbps was based on analog system whereas the second generation was based on digital system [4]. Text messaging was supported by the second generation and so its success and expansion of demand increased. This resulted in improved data connectivity. 3G networks were launched in 1998[9]. Services provided by 3G telecommunication can transfer information at the rate of at least 200kbit/s [9]. 3G also have its later releases such as 3.5G, 3.75G [4]. Packet-switched progress of 3G technologies gave birth to 4G network. 4G is an IP-based technology that uses voice communication. LTE (long term evolution), UMB (ultra-mobile broadband) and the IEEE 802.16(wimax) are considered to be 4G standards [6].

Table 1 tells about data speeds for LTE, LTE advanced, WiMax as follows [4]

Network	Peak value of download	Peak value of upload
LTE	100 Mbit/s	50 Mbit/s
LTE advanced	1000 Mbps	500 Mbps
WiMAX	128 Mbit/s	56 Mbit/s

5G (fifth generation) mobile network is progressive version of the present 4G /IMT-Advanced standards [1]. The capacity of this fifth generation is aimed to be much higher than current fourth generation [1]. Higher capacity would allow higher density of mobile users, ultra-reliability and massive communications. Also research that is going on fifth generation aims at lower suspension and low battery consumption. The contour of this research paper consists of 7 sections. As we have already seen, section 1 gives introduction of emergence of cellular networks. Section 2, section 3, section 4, section 5, section 6 proposed idea of first generation that was based on analog system, second generation, third generation, fourth generation and fifth generation respectively. Section 7 is the main domain of this research paper in which all the important parameters associated with 1G, 2G, 3G, 4G and 5G are tabulated. Then, all these sections followed by conclusion and references.

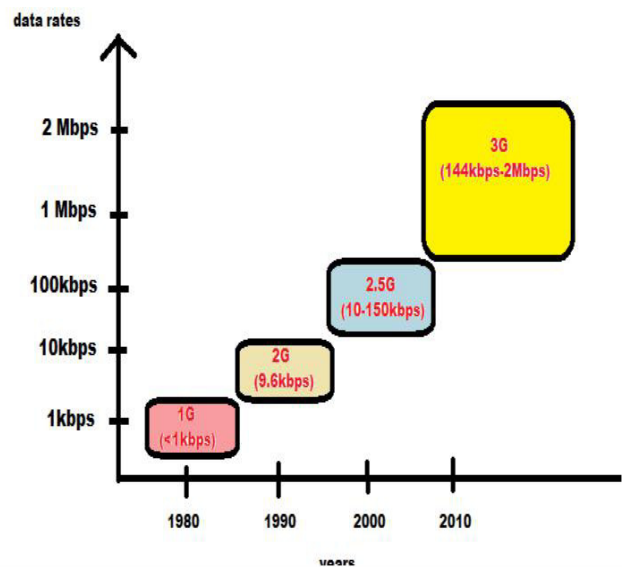


Fig.1.Evolution from 1G to 3G [4]

## 2.FIRST GENERATION(1G)–ANALOG SYSTEM

1G means first generation which was launched in the 1980s [5]. It was continually used until being substituted by 2G. The basic difference between 1G and 2G is that 1G is analog based whereas 2G is digitally based. User has to enable a transmission button and disable reception and hence it became ‘press to transmit’ system. Simultaneous listening and talking is not allowed by this system, therefore, IMTS (Improved Mobile Telephone System) was launched in 1960s [4]. This system constitutes two channels in which one channel was used for sending and the other one was used for receiving thus, ‘press

to transmit' system was eliminated. There were 23 channels ranged from 150Mhz to 450Mhz used by IMTS [3]. Bell labs invented AMPS (Advanced Mobile Phone Service) and hence introduced first generation (1G) cellular networks in 1980[11]. AMPS was known as MCS-LI in Japan and in England it was called as TACS [11]. Main concept of first generation cellular networks is that geographical area is distributed into cells. The cell is of length 10-25kms and each cell has its base station [4]. Length of cell in AMPS is smaller as compared to the cells in IMTS and hence can support other nearby cells. Also, cells in AMPS require less power, cells are cheaper. There are two 25Mhz bands allotted to AMPS bands [11]. One is for transmission from base to mobile unit and the other one is from mobile to the base unit. 32-bit number is consisted by each phone and a ten digit phone number is allocated to the phone in PROM (Programmable Read-Only Memory) [4].

### Security Issues (1G)

Since 1G is an analog cellular phone hence is very insecure because an unknown receiver with all-band radio can listen into the conversation. There are many incidents that have had occurred. Thefts of airtime is also a major issue that has been reported in this area.

### Paging networks

This is one of the oldest technology which includes caller and a pager. What happens is that a caller calls a pager and leaves a short message. **Fig.2** shows the paging network. Example of paging networks - BellSouth Clamshell Pager with keyboard[4].

### There are various advantages of paging networks-

- > It is very easy to operate.
- > Penetrates efficiently through the building.
- > Users have an open option to use it numerically, alphanumericly, two-way and message storage.
- > Not at all expensive.

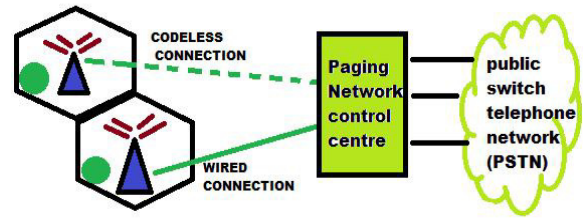


Fig.2. Conceptual view of paging network [4]

### LIMITATIONS OF PAGING NETWORKS ARE AS FOLLOWS-

- > There is an extra cost of two-way paging.
- > Data transfer rate is 1200bps i.e. very slow.
- > Overloading and delay is also caused.

### 3. SECOND GENERATION (2G –DIGITAL SYSTEM)

Based on digital transmission, 2G cellular network was introduced in the late 1980s [10]. There are various advantages of digital system over analog system as shown in **Fig.3**. USA and Europe had different approaches towards development of 2G [4]. Second generation cellular network was commercially launched on the GSM standard in 1991[13].

Benefits of 2G over its predecessor

- > 2G allows far greater phone penetration hence has more efficient spectrum.
- > 2G cellular network is digitally encrypted.
- > SMS text messaging and other services were started with 2G cellular network.

2.5G, 2.75G, 3G and 4G are the successors of 2G but 2G is still widely used in most part of the world.

### 3.1 Capacity

- ❖ Radio power from the handsets is very less emitted in the digital systems therefore the size of the handsets had to be smaller and hence more number of handsets can be packed in the same amount of space [4].

Compression and multiplexing of digital voice data can efficiently be done as compared to the analog voice encodings.

Table 2[4]: Advantages and Disadvantages of 2G system

Advantages of 2G	Disadvantages of 2G
<p>a. Cloning problem was omitted as it was very easy with the analog systems to use same phone numbers with different headsets.</p> <p>b. Eavesdropping – 2G cell phones based on digital system are more secured as compared to 1G that was based on the analog system.</p> <p>c. SMS and email services were allowed on 2G cellular telecoms.</p> <p>d. Digital system reduced power emissions that Helped health concerns.</p>	<p>a. 2G digital system sometimes have dropouts under slightly worse conditions whereas analog system is static.</p> <p>b. Particular problem on 2G cellular system is that sometimes weaker digital system may not reach the cell tower.</p> <p>c. Digital has a jagged steppy curve whereas analog has a smooth decay curve.</p>

GSM is the most popular 2G technique used and is dominating the world today [5]. Delivery rate of GSM is up to 9.6kbps and is designed from scratch. 124 channels per cell is used by data rate of 9.6kbps[4]. GSM can be used as a wireless system also as it can be connected to PC and hence acts as a modem for email, fax internet browsing and etc. There are two types of techniques on which GSM's interface is base -

- TDMA

Division of frequency bands is done. Frequency bands are divided into time slots. Each user has its time slot. On a single radio multiplexer which is designed to support 16 half rate channels.

- CDMA

If TDMA is used by GSM, then by whom is CDMA is used in 2G ?

Best example of 2G with CDMA is IS 95[4].

In CDMA, each user has a unique code whereas in TDMA each user is assigned with a time slot[13]. As compared to TDMA, in CDMA many users can be supported.

### 3.2 GPRS (2.5G)

GPRS is carried by most GSM users. Theoretically, speed of 160kbps can be provided by GPRS.

Table 3 Configurations [4]

Downlink	Uplink
80kbps maximum	20kbps maximum

IP and X.25 networking both are supported by GPRS. Existing GSM and TDMA networks with packet-switched capabilities is provided by GPRS[7].

High data rates are offered by GPRS and also internet services and packet-based services are very suitable

### 3.3 EDGE (2.75G)

EDGE refers to Enhanced Data Rates for GSM Evolution and is a next phase after GPRS. Data rates up to 500 kbps could be delivered by EDGE [6]. To overcome the limitations of GPRS, EDGE has been designed.

Data rates in GPRS are much lower than they actually display or advertise however to achieve data transmission of 172.2kbps, a single user would require all the 8 timeslots [4].

GPRS is based on GMSK (Gaussian Modulation Shift Keying) whereas EDGE is based on 8PSK (Eight-Phase Shift Keying). 3G also uses 8PSK as it allows higher data rates [4].

## 4. THIRD GENERATION (3G)

Third generation or 3G telecommunications fulfills IMT-2000 i.e. International Mobile telecommunication-2000[7]. Services associated with 3G provides users with mobile TV, internet access, video calls and all in the environment of mobile.

NTT DoCoMo from Japan was the first to launch pre-commercial 3G however its scope was limited at that time and it was not widely reliable [4].

In India MTNL was the first service provider of 3G. latter on 3G was also launched by BSNL. On 1 September 2010, private operators were allotted with

the 3G spectrum and hence it started developing its market nationwide [9].

3G services were provided by all the operators on 2100 Mhz band [4]. 3G provide wireless services with data rates of 144kbps to 384kbps [4]. There are various services that allow us to access through 3G such as e-mail, video teleconferencing and multimedia services.

UTMS (Universal Mobile Telecommunication Mobile System) is the best example of 3G. It was originated in Europe and is now used elsewhere.

Main idea of UMTS is that 3G technology will be used all over the world under different banners [9]. UMTS operators can operate their 3G services from all the locations in the world with the help of satellite and land based networks. VHE (Virtual Home Environment) is an environment in which user can use 3G services when in the roaming [9].

2G systems are based on older circuit switching systems whereas 3G systems are based on packet switching i.e. they are connectionless.

Same data path at the same time is used by multiple users as 3G involves splitting of data into packets [4]. For example, splitting a message into 8 packets theoretically increase data rate eight times [4].

#### 4.1 Multimedia message service

In a very simple language MMS is just like SMS but with pictures. Examples of MMS include pushing of messages, cartoon deliver etc.

#### 4.2 Some other features

Instant messaging, SMS, MMS are the applications that are easily accessed on 3G. Journey from 1G to 3G is as shown in

#### Fig.4.

3G can provide speed up to 2mbps in business environment. 802.11 is a network superior to 3G and hence can provide speed up to 11mbps – 54mbps [13].

Shopping malls and Starbucks coffee shops use 802.11WLANs and its hotspot . 802.11 access points has a limitation over 3G as 3G networks can transmit from 5 to 6 miles in diameter where as 802.11 has a range only between 300 to 900 feet [2].

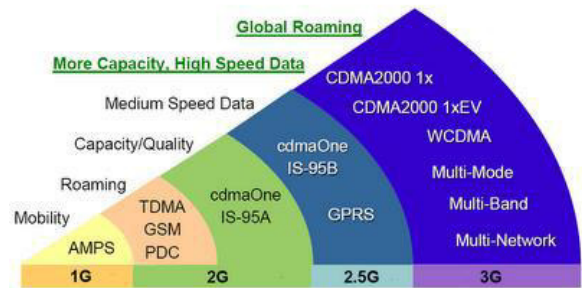


Fig4. Journey from 1G to 3G [13]

### 5. FOURTH GENERATION (4G CELLULAR NETWORKS)

4G generation is successor of 2G and 3G families of standards. Mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, and 3D television are the applications that are used using 4G cellular networks. Highly heterogeneous and time varying quality of service from the underlying protocol layers are required for the emergence of the applications for 3G and 4G wireless systems. Therefore, adaptability will be one of the basics [12]. The first release of LTE (long term evolution) standard has been commercially deployed in Oslo, Norway and Stockholm, Sweden since 2009[2]. 4G does not support circuit-switched networks but it is an IP-based network system. 4G networks are the pillars as it integrates several radio access networks with fixed internet networks [4].

Table 5 Data rates [4]

For high mobility	For low mobility
100 Mbps	1 Gbps

### 6. FIFTH GENERATION (5G CELLULAR NETWORKS)

5G i.e. fifth generation mobile networks are the next major phase of mobile telecommunications standard beyond 4G/IMT– advanced standards effective since 2011. Currently, there are various standards beyond 4G that are in progress by various standard bodies but 5G is not yet officially in use.

5G is designed for WWW (World Wide Wireless Web) and IPv6 is a fundamental protocol used to run 4G and 5G cellular networks but since IPv6 assigns any IP address to any mobile node based on

location management; therefore, this would cause wastage of 5G resources.

According to the resources, 5G would get implemented around the year 2020[4]. It has been noted that a new generation has appeared after every 10<sup>th</sup> year since first generation cellular network was introduced in 1981, second generation cellular network was introduced in 1992, 3G was introduced in 2001 whereas 4G came into the market in 2012-2013.

### 6.1 MIMO concept

MIMO stands for multiple input and multiple output. Since there are multiple inputs and multiple outputs therefore the capacity is increased. More data can be added to the wireless channels as there are multiple antennas at the transmitter and the receiver [3]. From Fig.5 it is seen that there is multipath propagation in which more than one data signal on the same radio signal is sent and received and hence energy efficiency, spectral

efficiency and reliability can be improved.

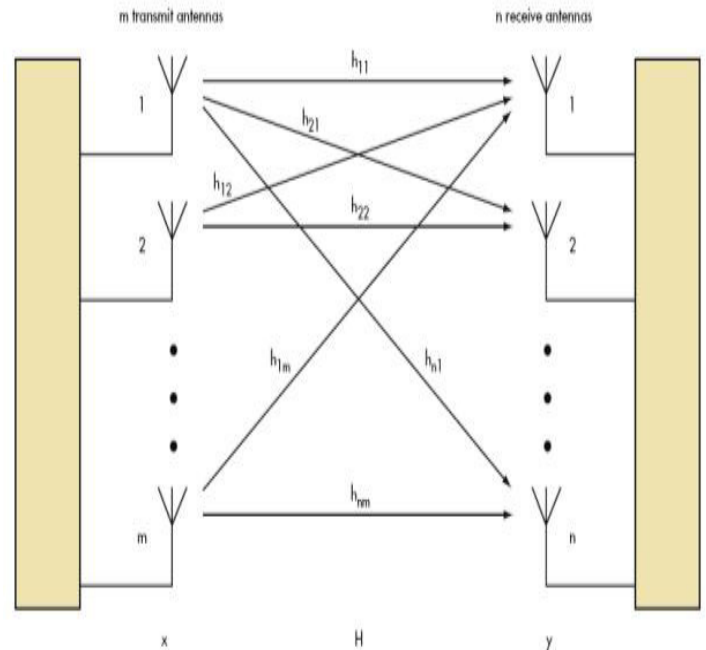


Fig.5. The MIMO concept layout [3]

### 6.2 5G’s core concept

There are mainly three technologies that 5G would possess-

- Nanotechnology
- Cloud computing
- All flat IP platform

## 7. EXPEDITION FROM “G” TO “5G”

Table 6: Comparison of various generations [3] [1] [13]

Parameters	1G	2G	3G	4G	5G
Location of first commercialization	USA	Finland	Japan	South Korea	Not yet
Definition	Analog	Digital narrow Band circular data	Digital broadband packet data	Digital broadband packet all IP very high throughput	Not yet
Time period	1970-1980	1990-2000	2004-2005	Now (transitioning to 4G)	Soon probably by 2020
Data rate	14.4 kbps	9.6/14.4 kbps	3.1 mbps	100-300 mbps	Probably gigabits

Technology	AMPS,NMT,T ACS	TDMA,CDMA	CDMA, EDGE	WiMax, LTE, Wi-Fi	Not yet
Multiple data technique	FDMA	TDMA, CDMA	CDMA	CDMA	-
Switching type	Circuit switching	Circuit switching for voice and packet switching for data	Packet switching except for air interface	Packet switching	IPv6 but advancements are still to be done
Special characteristics	First wireless communication	Digital version of 1G technology	Digital broadband, speed increments	Very high speed, all IP	-
Features	Voice only	Multiple users on single channel	Multimedia features, video call	High speed, real time streaming	-
Internet service	No internet	Narrowband	Broadband	Ultra broadband	Yet to see

Carrier frequency	30 khz	200 khz	50 mhz	15 mhz	Yet to set
Bandwidth	Analog	25 mhz	25 mhz	100 mhz	-
Bandtype (frequency)	Narrow band	Narrow band	Wide band	Ultra wide band	-
Operating frequency	800 mhz	GSM: 900MHZ 1800 MHZ CDMA:800M HZ	2100 MHZ	850 MHZ 1800 MHZ	-
Advantages	Simpler network elements	MMS, internet access and SIM introduced	High security, international roaming	Speed, high speed handoffs, MIMO technology, global technology	Better coverage area, low battery consumption, availability of multiple data transfer path, energy and spectral efficiency is more and has a high security[2].
Disadvantages	Limited capacity, not secure, poor battery life, large phone size, background interference	Low network range, slow data rates	High power consumption, low network coverage, high cost spectrum.	Hard to implement complicated hardware required.	

## 8. CONCLUSION

This paper gives brief on individual cellular generation of mobile wireless technology and its evolution from 1G and emerging up to 5G. The modified versions of these cellular networks enabled users to expand their business and communicate worldwide. As the use of communication has reached from personal level to professional level, the evolution of 4G has provided a time saving and easy access technology to the professionals. Also 5G technologies have high standards that define capabilities beyond those defined in the current 4G standards. User never experienced ever before such a high value technology. 5G will prove to be the reason for India considered to be developed.

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