

EVOLUTION OF MOBILE GENERATION TECHNOLOGY: 1G TO 5G AND REVIEW OF UPCOMING WIRELESS TECHNOLOGY 5G

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Abstract—There has been a vast advancement in mobile wireless communication since the last few decades. This innovation consists of a number of generations and is still going on. The journey of mobile wireless communication began with 1G followed by 2G,3G,4G, and under research upcoming generations 5G. In this paper an attempt has been made to provide an overview of evolution of mobile generations by comparing the standards, data rates, capacity, primary service, challenges and features provided by each generation and explaining how improvements have been made from earlier generation to the next one. Also the light thrown on the new emerging technology 5G, its concept, requirements, features, benefits and hardware and software requirements.

Keywords --1G, 2G, 3G, 4G, 5G, WWW, UMTS, WCDMA, MIMO

I. INTRODUCTION

In the last few decades, Mobile Wireless Communication networks have experienced a remarkable change. The mobile wireless Generation (G) generally refers to a change in the nature of the system, speed, technology, frequency, data capacity, latency etc. Each generation have some standards, different capacities, new techniques and new features which differentiate it from the previous one. The first generation (1G) mobile wireless communication network was analog used for voice calls only. The second generation (2G) is a digital technology and supports text messaging. The third generation (3G) mobile technology provided higher data transmission rate, increased capacity and provide multimedia support. The fourth generation (4G) integrates 3G with fixed internet to support wireless mobile internet, which is an evolution to mobile technology and it overcome the limitations of 3G. It also increases the bandwidth and reduces the cost of resources. [1]. 5G stands for 5th Generation Mobile technology and is going to be a new revolution in mobile market which has changed the means to use cell phones within very high bandwidth. User never experienced ever before such high value technology which includes all type of advance features and 5G technology will be most powerful and in huge demand in near future.

II. EVOLUTION

Mobile communication has become more popular in last few years due to fast reform from 1G to 5G in mobile technology. This reform is due to requirement of service compatible transmission technology and very high increase in telecoms customers. Generation refers change in nature of service compatible transmission technology and new frequency bands. In 1980 the mobile cellular era had started, and since then mobile communications have undergone considerable changes and experienced massive growth.

A. First Generation, 1G

These phones were the first mobile phones to be used, which was introduced in 1982 and completed in early 1990. It was used for voice services and was based on technology called as Advanced Mobile Phone System (AMPS). The AMPS system was frequency modulated and used frequency

division multiple access (FDMA) with a channel capacity of 30 KHz and frequency band of 824-894MHz. [5]. Its basic features are:

- Speed-2.4 kbps
- Allows voice calls in 1 country
- Use analog signal.
- Poor voice quality
- Poor battery life
- Large phone size
- Limited capacity
- Poor handoff reliability
- Poor security
- Offered very low level of spectrum efficiency

It introduces mobile technologies such as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT). It has low capacity, unreliable handoff, poor voice links, and no security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties [1]

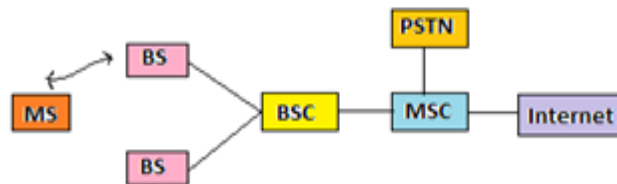


Figure 1. Architecture of Advance Mobile Phone System

B. Second Generation (2G)

2G refers to the second generation based on GSM and was emerged in late 1980s. It uses digital signals for voice transmission. Main focus of this technology was on digital signals and provides services to deliver text and picture message at low speed (in kbps). It use the bandwidth of 30 to 200 KHz. Next to 2G, 2.5G system uses packet switched and circuit switched domain and provide data rate up to 144 kbps. e.g. GPRS, CDMA and EDGE. [5]. The main features of 2G and 2.5G are :

Second generation, 2G:

- Data speed was upto 64kbps
- Use digital signals
- Enables services such as text messages, picture messages and MMS(Multimedia message)
- Provides better quality and capacity
- Unable to handle complex data such as videos.
- Required strong digital signals to help mobile phones work. If there is no network coverage in any specific area, digital signals would weak.

2.5 G :

The GSM technology was continuously improved to provide better services which led to development of advanced Technology between 2g and 3g

- Provides phone calls
- Send/receive e-mail messages
- Web browsing
- Speed : 64-144 kbps
- Camera phones
- Take a time of 6-9 mins. to download a 3 mins. MP3 song.

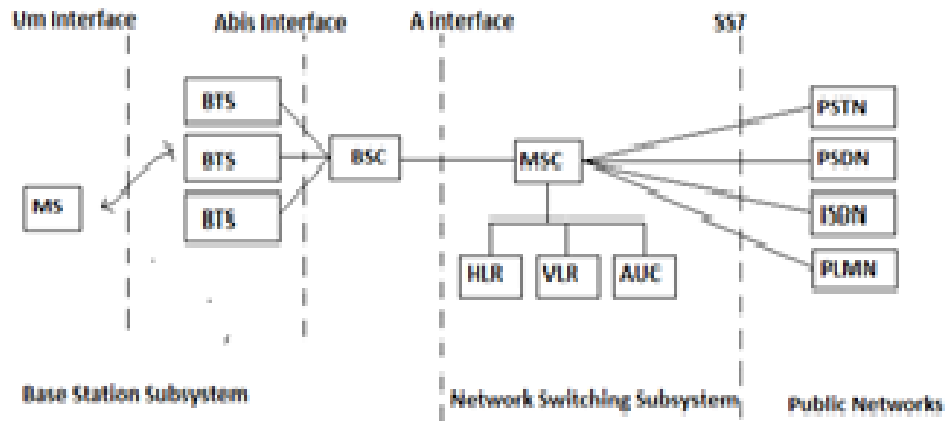


Figure 2. GSM System Architecture

C. Third Generation (3G)

3G is based on GSM and was launched in 2000. The aim of this technology was to offer high speed data. The original technology was improved to allow data up to 14 Mbps and more using packet switching. It uses Wide Band Wireless Network with which clarity is increased. It also offers data services, access to television/video, new services like Global Roaming. It operates at a range of 2100MHz and has a bandwidth of 15-20MHz used for High-speed internet service, video chatting. [5]. The main features of 3G are:

- Speed 2 Mbps
- Typically called smart phones
- Increased bandwidth and data transfer rates to accommodate web-based applications and audio and video files.
- Provides faster communication
- Send/receive large email messages
- High speed web/more security/video conferencing/3D gaming
- Large capacities and broadband capabilities
- TV streaming/mobile TV/Phone calls
- To download a 3 minute MP3 song only 11 sec-1.5 mins time required.
- Expensive fees for 3G licenses services
- It was challenge to build the infrastructure for 3G
- High bandwidth requirement
- Expensive 3G phones
- Large cell phones

3G mobile system was called as UMTS(Universal Mobile Telecommunication System) in Europe, while CDMA2000 is the name of American 3G variant. Also the IMT2000 has accepted a new 3G standard from China, i.e TD-SCDMA. WCDMA is the air-interface technology for UMTS. [1]

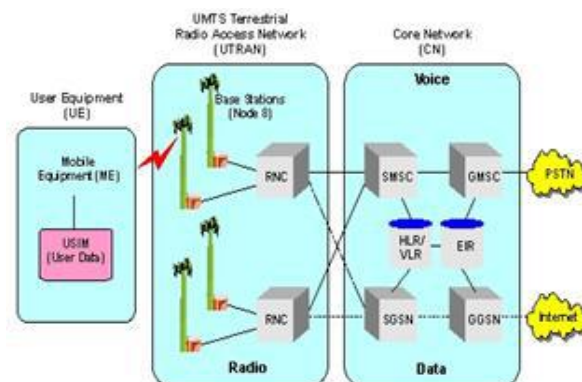


Figure.3 WCDMA Network Diagram

D. Fourth Generation (4G)

4G offers a downloading speed of 100Mbps. 4G provides same feature as 3G and additional services like Multi-Media Newspapers, to watch T.V programs with more clarity and send Data much faster than previous generations [3]. LTE (Long Term Evolution) is considered as 4G technology. 4G is being developed to accommodate the QoS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and other services that utilize bandwidth. [2]. The main features of 4G are :

- Capable of provide 10Mbps-1Gbps speed
- High quality streaming video
- Combination of Wi-Fi and Wi-Max
- High security
- Provide any kind of service at any time as per user requirements anywhere
- Expanded multimedia services
- Low cost per-bit
- Battery uses is more
- Hard to implement
- Need complicated hardware
- Expensive equipment required to implement next generation network

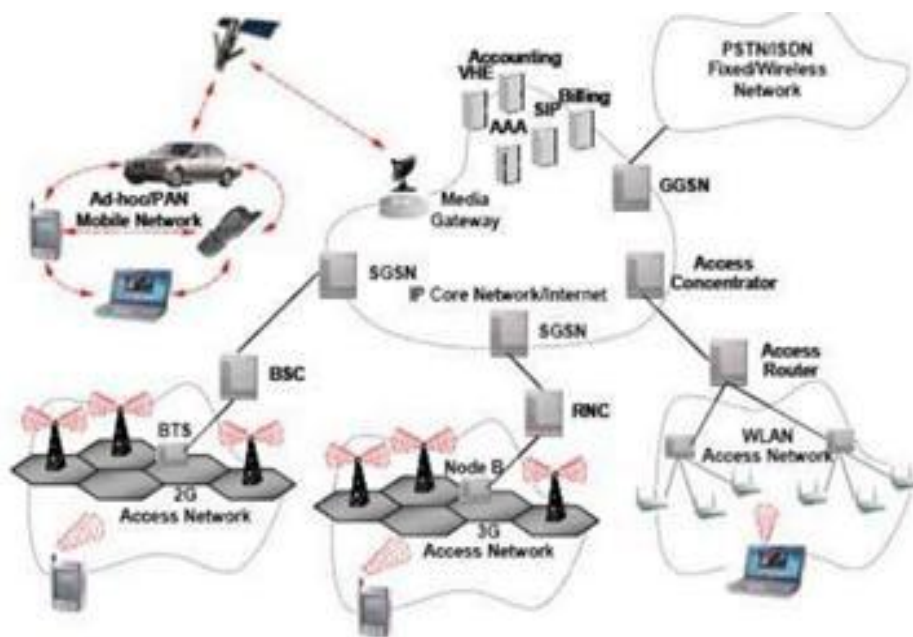


Figure 4. 4G Network Architecture

E. Fifth Generation (5G)

5G refer to Fifth Generation which was started from late 2010s. Facilities that might be seen with 5G technology includes far better levels of connectivity and coverage. The main focus of 5G will be on world-Wireless World Wide Web (WWW). It is a complete wireless communication with no limitations. The main features of 5G are :

- It is highly supportable to WWW (wireless World Wide Web)
- High speed, high capacity
- Provides large broadcasting of data in Gbps.
- Multi-media newspapers, watch TV programs with the clarity(HD Clarity)
- Faster data transmission that of the previous generation
- Large phone memory, dialing speed, clarity in audio/video

- Support interactive multimedia, voice, streaming video, internet and other
- More effective and attractive

III. COMPARISON OF ALL GENERATIONS OF MOBILE TECHNOLOGIES [3]

Table 1. Comparison of Mobile Generation: 1G To 5G

Technology	1G	2G	3G	4G	5G
Start/Deployment	1970-80	1990-2004	2004-10	Now	Soon (probably by 2020)
Data Bandwidth	2Kbps	64 Kbps	2 Mbps	1 Gbps	Higher than 1 Gbps
Technology	Analog	Digital	CDMA 2000, UMTS,EDGE	Wi-Max, Wi-Fi, LTE	WWWW
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit,Packet	Packet	All Packet	All Packet
Primary Service	Analog Phone Calls	Digital Phone Calls and Messaging	Phone calls, Messaging, Data	All-IP Service (including Voice Messages)	High speed, High capacity and provide large broadcasting of data in Gbps
Key differentiator	Mobility	Secure, Mass adoption	Better Internet experience	Faster Broadband Internet, Lower Latency	Better coverage and no dropped calls, much lower latency, Better performance
Weakness	Poor spectral efficiency, major security issue	Limited data rates, difficult to support demand for internet and e-mail	Real performance fail to match type, failure of WAP for internet access	Battery use is more, Required complicated and expensive hardware	?

IV. WHAT IS 5G?

5G Technology stands for 5th Generation Mobile technology. 5G technology has extraordinary data capabilities and has ability to tie together unrestricted call volumes and infinite data broadcast within latest mobile operating system. 5G technology has a bright future because it can handle best technologies and offer priceless handset to their customers. May be in coming days 5G technology takes over the world market. 5G Technologies have an extraordinary capability to support Software and Consultancy. The Router and switch technology used in 5G network providing high connectivity. The 5G technology distributes internet access to nodes within the building and can be deployed with union of wired or wireless network connections. In near

future 5G technology provides a cell phone which is like a PDA and then the whole office will be in our finger tips/in our phone. In a few years, we may be able to download a full-length HD movie in *six seconds*, while 4G require seven minutes and 3G require more than an hour to download the same. Also video chats will be so immersive that it will feel like we can reach out and touch the other person right through the screen. 5G is a packet switched wireless system with wide area coverage and high throughput. 5G wireless uses OFDM and millimeter wireless that enables data rate of 20 mbps and frequency band of 2-8 GHz. The 5G communication system is envisioned as the real wireless network, capable of supporting wireless World Wide Web (www).

The uncertainty around 5G is because it's still largely a concept at this point, and the wireless industry hasn't settled on any standards around the new network. But it's looking to achieve some key goals with 5G:

- Significantly faster data speeds: Currently, 4G networks are capable of achieving peak download speeds of one gigabit per second, though in actual practice it is never that fast. With 5G, this would increase to 10Gbps.
- Ultra-low latency: "Latency" refers to the time it takes one device to send a packet of data to another device. In 4G, the latency rate is around 50 milliseconds, but 5G will reduce that to about one millisecond. This will be very much important for industrial applications and driverless cars.
- A more "connected world": The Internet of Things (smart home appliances, connected cars etc.) is expected to grow exponentially over the next 10 years, and it will need a network that can have capacity for billions of connected devices. 5G will provide capacity and bandwidth as per the needs of user.
- The technology is still a *long* way from becoming a reality, but it has the potential to completely change the way we interact with wireless devices, from the Smartphone in our pockets to the cars we drive.

V. FEATURES OF 5G

The current trend of 5G technology has a following feature.

- The 5G technology is providing up to 25 Mbps connectivity speed
- 5G technology offer high resolution for cell phone user and bi- directional large bandwidth sharing.
- 5G technology is providing large broadcasting of data in Gigabit which supporting almost 65,000 connections.
- The uploading and downloading speed of 5G technology touching the peak
- The 5G technology also support virtual private network.
- The 5G terminals will have software defined radios and modulation schemes as well as new error-control schemes that can be downloaded from the Internet.
- The development is seen towards the user terminals as a focus of the 5G mobile networks. E.g. The advanced billing interfaces of 5G technology makes it more attractive and effective,
- The 5G technology network offering enhanced and available connectivity just about the world. The terminals will have access to different wireless technologies at the same time and the terminal should be able to combine different flows from different technologies.
- The vertical handovers should be avoided, because they are not feasible in a case when there are many technologies and many operators and service providers.
- In 5G, each network will be responsible for handling user-mobility, while the terminal will make the final choice among different wireless/mobile access network providers for a given service. Such choice will be based on open intelligent middleware in the mobile phone.
- The remote diagnostic is a great feature offered by 5G, through which a user can get better and fast solution.

VI. CHALLENGES FACING 5G

A. Integration of various standards: One of the big challenges facing 5G is standardization. There are already multiple groups working to come up with standards around interoperability, backward compatibility with older technologies (4G, 3G), and making sure the network will be future-proof.

B. Common Platform: There is no common architecture for interconnecting various engineering practices. One common governing body is required, which creates a common platform for all engineering practices to regularize the interconnectivity issues as well as knowledge sharing. [4]

C. Building the infrastructure: It is a huge task, with issues around spectrum and installing new antennas. 5G is likely going to rely, at least in part, on higher-frequency bands. There is more space in those airwaves available, but at such high frequencies, signals can't travel nearly as far as they can over the frequencies used for 4G, resulting in a poor connection.

D. Obstacles: Like buildings, trees and even bad weather can also cause interference. To offset that, carriers will need to install more base stations to ensure better coverage, and use antenna technologies like MIMO.

VII. 5G SPECIFICATION

Although the standards bodies have not yet defined the parameters needed to meet a 5G performance level yet, other organizations have set their own aims that may eventually influence the final specifications. Typical parameters for a 5G standard may include:

Table 2. 5G Wireless Performance (Suggested)

PARAMETER	PERFORMANCE (SUGGESTED)
Network Capacity	10000 times current Network
Peak Data Rate	10 Gbps
Cell edge Data Rate	100 Mbps
Latency	<1 Mbps

These are some of the ideas being put forwards for a 5G standard, but they are not accepted by any official bodies yet.

VIII. APPLICATIONS OF 5G

Applications of 5G are beyond our imagination. User never experienced ever before such high value technology which includes all type of advance features. Some of the applications of 5G are:

- We can able to charge our mobile using our own heart beat
- We can able to feel our grandmother's sugar level with our mobile
- We can able to know the exact time of our child birth in nano seconds.
- Our mobile rings according to our mood.
- We can vote from our mobile
- We can able to visualize lively all the planets and universe. Also we can able to navigate a train for which we are waiting.
- We can able to view our residence in our mobile when someone enters and also when some once opens our intelligent car.
- We can able pay all our bills in a single payment with our mobile.

- We can able to sense Tsunami/Earthquake before it occurs.
- We can access our office desktop, Laptop, car, bike using our mobile,
- We can identify our stolen mobile within nanoseconds
- Our mobile can share our workload, identify the best server and also intimate us before the call drops.
- We can able to expand our coverage using mobile phones.
- We can able to fold our mobile as per our desire. [6]

IX. 5G HARDWARE AND SOFTWARE

A. 5G HARDWARE

- **Ultra wideband networks (UWB).**

It is already known that Wi-Fi, Wi-Max and cellular wide area communications are long-range radio technologies. But systems like WPAN need short-range radio technology, which helps in achieving higher bandwidths (around 4000 Mbps) but at low energy levels (UWB network) for relaying data from host devices to devices in the immediate vicinity, i.e., distances of around 10 metres or so. This higher bandwidth (4000 Mbps) level is almost 400 times faster than today's wireless networks. Each network will be responsible for handling user-mobility while the user terminal will make the final choice among different wireless/mobile access network providers for a given service.

- **Smart antennae :** These include the following:

Switched beam antenna: This type of antenna supports radio positioning via angle of arrival (AOA). Information is collected from nearby devices.

Adaptive array antennae: Such antennae promise to improve the capacity of wireless systems by providing improved safety through position-location capabilities. This technique rejects interference through spatial-altering-position location through direction-ending measurements and developing improved channel models through angle-of-arrival channel sounding measurement.

CDMA (code division multiple access) technique: This technique converts audio analogue input signals into digital signals (ADC) in combination with spread spectrum technology. The signal is transmitted using modulation according to some predefined code (pattern), and is demodulated using the same pattern since there can be billions of code patterns which can provide privacy and sufficient security.[8]

B. 5Gsoftware

5G will be a single unified IP standard of different wireless networks and a seamless combination of broadband, including wireless technologies, such as IEEE802.11, LAN, WAN, PAN and WWW. 5G will enable software-defined radio, packet layers, implementation of packets, encryption flexibility, etc. [8]

X. CURRENT RESEARCH

There are several key areas that are being investigated by research organizations. These include:

A. Millimeter-Wave technologies:

Using frequencies much higher in the frequency spectrum opens up more spectrums and also provides the possibility of having much wide channel bandwidth - possibly 1 - 2 GHz. However this poses new challenges for handset development where maximum frequencies of around 2 GHz and bandwidths of 10 - 20 MHz are currently in use. For 5G, frequencies of above 50GHz are being considered and this will present some real challenges in terms of the circuit design, the technology,

and also the way the system is used as these frequencies do not travel as far and are absorbed almost completely by obstacles.

B. Future PHY / MAC:

This area presents many possibilities from the use of new modulation formats including GFDM, Generalized Frequency Division Multiplexing, as well as FBMC, Filter Bank Multi-Carrier, UFMC, Universal Filtered Multicarrier and other schemes to the management of the multiple access schemes. All these need to be developed. Higher levels of processing that will be available by the time 5G is launched mean that multicarrier systems will not require to be orthogonal as in the case of OFDM. This provides considerably more flexibility.

C. Massive MIMO:

In many applications from LTE to Wi-Fi, etc, MIMO is used. Using microwave frequencies opens up the possibility of using many tens of antennas on single equipment becomes a real possibility because of the antenna sizes and spacing in terms of a wavelength.

D. Dense networks reducing the size of cells provide a much more overall effective use of the available spectrum.

XI. KEY CONCEPTS OF 5G

Key concepts of 5G wireless communications are:

- A.** Dynamic Adhoc Wireless Network (DAWN), essentially identical to Mobile adhoc network (MANET), Wireless mesh network (WMN) or Wireless grids, combined with smart antennas and flexible modulation.
- B.** Internet Protocol Version6 (IPv6), where a visiting Care of mobile IP address is assigned according to location and connected network.
- C.** High altitude stratospheric platform station (HAPS) systems.
- D.** Real wireless world with no more limitation with access and zone issues.
- E.** User centric network concept instead of operator-centric (as in 3G) or service-centric (as in 4G) Worldwide wireless web (WWW), i.e. comprehensive wireless based web applications that include full multimedia capability beyond 4G speeds[7]

XII. CONCLUSION

The world of mobile wireless communication is rapidly developing. The last few years have experienced a remarkable growth in wireless industry. 5G technology going to be a new mobile revolution in mobile market. There are many new techniques and technologies that will be used in the new 5G cellular or mobile telecommunications system. These new 5G technologies are still being developed and the overall standards have not yet be defined. However as the required technologies develop, they will be incorporated into the new system which will be defined by the standards bodies over the coming years. Attempts are being made to reduce the number of technologies to a single global standard resulting in 5G. Trials have already started on 5G which may lead to its commercial availability around 2020. The world is trying to become completely wireless, demanding uninterrupted access to information anytime and anywhere with better quality, high speed, increased bandwidth and reduction in cost.

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