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Communication generations: 1G to 5G

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Abstract

Ever since mobile technology standards were first laid down in the 1980s (the First Generation or 1G), there has been a continuous effort to increase the data rates available to the end users. Higher levels of data rates are achieved by the industry by the Mobile Communication Technologies with the increasing demand of the users. While connecting to internet, the speed of internet is depends upon the signal strength that has been shown by the alphabets like G, E, 2G, 3G, H, H+ and 4G right next to the signal bar on the home screen of mobile. The key technologies that have made it possible are MIMO (Multiple Input Multiple Output) and OFDM (Orthogonal Frequency Division Multiplexing). The two important 4G standards are WiMAX (has now fizzled out) and LTE (has seen widespread deployment). It is the generation on which academia and the industry both are working and expected to arrive in 2020. In addition, the main purpose of the fifth generation wireless networks (5G Wireless networks) is planned to design the best wireless world that is free from limitations and hindrance of the previous generations.

Keywords: Communication, technology, connecting to internet, wireless

1. Introduction

Today wireless services are the most preferred services of the world. The rapid increase in the service is due to the advancement of technology. As a subscriber becomes more aware of the mobile phone technology, will seek for an appropriate package with all the advanced features of a Mobile phone. Thus, the search for new technology is always the main intention of the prime mobile phone manufacturing players of this industry towards the innovations. Realizing that people wanted phones to access both the voice and the data and for this intermediate standards were introduced. Until 2G, only circuit switched networks were in use, which were not suitable for internet applications. Packet switching was introduced with the advent of GPRS which was more suited for internet. They now want to offer broadband-like data rates on mobile devices ~ 100-200 Mbps. The telecommunication services in World has seen a quantum jump within a few decades. At present about 8 billion people own mobile phones. Here we are going to analyze the various generations of cellular systems as the evolution of mobile communications from 1st Generation to 5th Generation. Now almost all the service providers as well as the customers look for availing either 3G or 4G services. It has been observed that the telecom customers are increasing at exponential rate day by day. At present, there are four generations in the mobile industry. These are respectively 1G the first generation, 2G the second generation, 3G the third generation, and then the 4G the fourth generation. The U.S. Federal Communication Commission (FCC) approved the spectrum for 5G, including the 28 GHz, 37 GHz and 39 GHz bands, on July 14, 2016. We can analyze that this could be due to increase in the telecom customers day by day. At present different wireless and mobile technologies are present such as third generation mobile networks (UMTS- Universal Mobile Telecommunication System, CDMA2000), LTE (Long Term Evolution), Wi-Fi (IEEE 802.11 wireless networks), WiMAX (IEEE 802.16 wireless and mobile networks), as well as sensor networks, personal area networks (e.g. Bluetooth, Zig Bee) etc.

The Next Generation Mobile Network defines the requirements that a 5G standard should have:

- For tens of thousands of users data rates of tens of megabits per second and 100 megabits per second for metropolitan areas.
- 1 Giga bit per second to many workers on the same office floor at the same time.

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- Several hundreds of thousands of simultaneous connections for wireless sensors.
- Spectral efficiency significantly enhanced compared to 4G with improved Coverage.
- Enhanced signaling efficiency.

Various mobile generations assigned frequency bands and wider spectral bandwidth per frequency channel (1G up to 30 kHz, 2G up to 200 kHz, 3G up to 5 MHz, and 4G up to 20 MHz, fig. 1 and fig 2), but there is little space for larger channel bandwidths and new frequency bands suitable for land-mobile radio. The higher frequencies would overlap with K-band transmissions.

2. Pre-Cellular Generation (0G)

0G is also called "Mobile Radio Telephone" technology considered as the dawn of wireless connectivity. MTS (Mobile Telephone System) was the first commercially used mobile telephone service started in 1946. Such mobile phones were installed in different vehicles with bulky transceiver placed in the trunk of vehicle like car and a headset and a dialler positioned near the driver seat. Both headset and transceiver were connected through a wire. Some models are designed with briefcase used for extreme connectivity by the specialists. 0G systems provide half duplex communication in which only one person can speak at a time and the other has to listen. These systems were expensive, heavy weight, big size and provide limited connectivity. In 1962, IMTS (Improved mobile Telephone System) fully automatic mobile telephone system was introduced. No operator is required to connect the calls [2, 8]. Atlay introduced by Russia, PTT (Push to Talk), AMTS (Advanced MTS), MTD are other technologies used in 0G.

3. First Generation (1G)

Martin Copper who is known as father of cell phone had given the concept of cellular network structure. The first generation mobile phones are based on cellular network structure, in which one frequency is divided into different cells so that each cell could support a decent number of users for placing calls independently on same frequency channel. These cellular networks facilitate voice transmission using analog signals, by simply modulating analog voice signal to a very high frequency of 150MHz. The very first commercial 1G network was AMPS (Advanced Mobile Phone System) introduced in US in 1980s. NMT (Nordic Mobile Telephony) is another 1G cell phone technology developed by European countries. It was a free and open standard which led to lower price and high accessibility. Total Access Communication System (TACS), C-NETZ, Radio Telephone Mobile System (RTMS), Nippon Telephone and Telegraph (NTT) and later NTACS (Narrow band Total Access Communications System) and JTACS (Japanese Total Access Communication System) were some other technologies of 1G. This mobile system provides full duplex communication. The limitations of 1G system were unsecure communication, which led to eavesdropping and theft of airtime [6], [8]. 1G mobile phone provided less mobility and less number of subscribers covered because it requires a significant amount of wireless spectrum support. The maximum speed of 1G network is about 2 kilobits per sec (kbps)

4. Second Generation (2G)

2G was a period of very rapid expansion for mobile communication technology introduced in 1990s. They were the first digital cellular networks; instead of analog. This technology was based on binary codes like a series of zeros and ones. At the receiver's end, it was converted back to voice through switch on and switch off of the inbuilt circuit. The two major standards of 2G were named - GSM (created in Europe) and CDMA (created in the US). 2G brought many new opportunities in mobile technology. The very first smartphone-IBM Simon, having many features from phone to calendar, notepad and even email also emerged in 2G. This was the beginning of smaller, sleeker and more attractive phones. 2G networks introduced a feature that all of us are using every day - SMS. Picture messages, access to media content on mobile phones and extra storage (memory cards) are other facilities given by 2G networks. One of the best things about this generation is that as carriers continued to install more and more cell sites, their networks became denser, requiring cell phones to use less battery in order to maintain a normal signal level. This technology allowed manufacturers to leave the brick-phones in the past and start producing much more compact and lighter handsets at lower cost. This generation also started the trend of prepaid mobile phones and brought many benefits like faster connections, better service and support for new features [5]. 2G introduced internet access in mobile phones in 2000 using GPRS (General Packet Radio Service) and it was called as 2.5G. It was a packet switching technology used in GSM mobile phones. It provided data rates from 56 kbps up to 115 kbps. CDMA also introduced 1xRTT. They facilitated WAP (Wireless Application Protocol) access, MMS (Multimedia Messaging Service) services. Then GPRS1 networks evolved provide higher data rates than GPRS and termed as 2.75G. It was also called as EDGE (Enhanced Data rates for GSM Evolution) networks. It provided three-fold increase in capacity of GSM/GPRS networks.

5. Third Generation (3G)

The first commercial 3G network was launched on 1st October, 2001 in Tokyo region by NTT DoCoMo. It was powered by WCDMA (Wideband Code Division Multiple Access) technology or UMTS (Universal Mobile Telecommunication Systems). It was a generation of rapid growth and improvement for wireless technology. With its focus on faster speeds and reliability, it brought us stuff like streaming audio and video, VoIP capabilities and usable internet access among many others. This generation has made mobile phones work just like a mini computer with large number of mobile applications. User can now surf internet, upload or download data, make video call, audio and video streaming, use GPS (Global Positioning System) at the blink of eye using 3G technology. The main aim of 3G services is to provide user with highest speed of data and voice transfers, GPS and other applications in secure manner. In 3G services the transmitted data is in encrypted format only the end user can decrypt the data. 3G provides a maximum data rate of 1Mbps to 2Mbps. Other technologies that are being used in 3G are HSPA (High Speed Packet Access), HSPA⁺ provides much higher speeds 7.2 Mbps to 14.0 Mbps and 21 Mbps to 42 Mbps respectively. These technologies are called as 3.5G. High Speed Uplink Packet Access (HSUPA) is named as 3.75G. This technology is used in compliance with 2G technology [1], [3]. The

limitations of 3G technology is the requirement high bandwidth, high spectrum licensing fees and huge capital investment. Thus, with the help of 3G, one can access many new services too. One such service is the GLOBAL ROAMING. Another thing to be noted in case of 3G is that Wide Band Voice Channel by which the world has been converted into a little village because a person can contact with other person located in any part of the world and can even send messages. 3G not only provides clarity of voice, but one can talk without any disturbance. Not only this but also can have Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming, Multi-Gaming etc. are also possible with 3G phones.

6. Fourth Generation (4G)

4G is the next step into wireless and cellular technologies. It is the result of human hunger to get more and more. This hunger is the constant force behind every development. This technology is associated with high speed and remote connectivity anywhere in the world. 4G provides speed of 100 Mbps for moving users and 1Gbps for stationary users. It is fully IP- based integration of several wireless broadband access communication systems. The two main standards competing for 4G are Wimax (Worldwide Interoperability for Microwave Access) and GSM's LTE (Long Term Evolution) introduced in 21st century. WiMAX is also called Broadband Wireless Access because it does not require any cabled infrastructure.

This technology is based on OFDM (Orthogonal Frequency Division Multiplexing). The basic principle of OFDM is to split a high rate data-stream into multiple lower rate data-streams that are transmitted simultaneously over a number of sub carriers. MC-CDMA, a combination of CDMA and OFDM is being used in 4G for providing high speed communication. MC-CDMA in combination with adaptive modulation may give more speed with lower error rate to 4G. MIMO (Multiple Input Multiple Output), Smart Antenna are other key technologies used in 4G [4], [5]. It uses signal multiplexing between multiple transmitting antennas and time or frequency. 4G technology will allow users to download full-length feature film within five minutes and users will also be able to stream high-definition television and radio to hand-held devices. This has increased the demand for more data rates/speed and bandwidth in video applications. It has come up with solution to higher data rates and more bandwidth. It is completely wireless technology based on VoIP i.e. wireless technology of telephony. 4G offer divergent levels of data transfer from sources to a device with a speed of 100 Mbit/s [2], [3]. The first two commercially available 4G technologies are named as the WiMAX standard and the LTE standard. Now, scientist and researchers already working on a completely wireless scenario denoted as WWW (World Wide Wireless Web). This will be the future generation of mobile communication technology and termed as 5G.

7. Fifth Generation (5G)

5G is a proposed, but the not-yet-implemented wireless technology that's intended to improve on 4G. Some of the plans for 5G include device-to-device communication, better battery consumption, and improved overall wireless coverage. The max speed of 5G is aimed at being as fast as 35.46 Gbps, which is over 35 times faster than 4G. However, data rates of tens of Mbps might be expected for thousands of users, and around 100 Mbps for metropolitan areas. 5G network is very fast and reliable. The concept of hand held devices is going to be revolutionized with the advent of 5G. Now all the services and applications are going to be accessed by single IP as telephony, gaming and many other multimedia applications. As it is not a new thing in market and there are millions of users all over the world who have experienced the wireless services wireless technology. It is not easy for them to shrink from using this new 5G network technology. There is only need to make it accessible so that a common man can easily afford the profitable packs offered by the companies so that 5G network could hold the authentic place. There is need to win the customer trust to build fair long term relation to make a reliable position in the telecommunication field. To complete with the preceding wireless technologies in the market 5G network has to tender something reliable something more pioneering. All the features like telephony, camera, mp3 player, are coming in new mobile phone models. 4G is providing all these utility in mobile phone. By seeing the features of 4G one can gets a rough idea about what 5G Networks could offer. There is messenger, photo gallery, and multimedia applications that are also going to be the part of 5G. There would be no difference between a PC and a mobile phone rather both would act vice versa.

8. Charactericts of 5G Technologies

- 5G presents the high resolution to cell phone every day and give consumers fast Internet access.
- This technology provides billing limits in advance which is beauty and success of the modern era.
- The 5G technology allows users of mobile phones, cell phone records for printing operations. The 5G technology for large volume data distribution in Gigabit, which is close to almost 65,000.
- It gives you 5G carrier distribution gateways to unprecedented maximum stability without delay.
- This technology also support virtual private network.
- The uploading and downloading speed of 5G technology is very high.
- The 5G technology network offers enhanced connectivity around the world.
- This network is very fast and reliable.

9. Comparative features of 4G and 5G

Following table 1 presents the comparison of 4G and 5G technologies.

Table 1: Difference between 4G and 5G

Specifications	4G	5G
Full form	Fourth Generation	Fifth Generation
Data and width	2Mbps to 1Gbps	1Gbps and higher as per need
Frequency Band	2 to 8 GHz	3 to 300 GHz
Standards	AI access convergence including OFDMA, MC-CDMA, network-LMPS	CDMA and BDMA

Technologies	unified IP, seamless integration of broadband LAN/WAN/PAN and WLAN	Unified IP, seamless integration of broadband LAN/WAN/PAN/WLAN and advanced technologies based on OFDM modulation used in 5G
Service	Dynamic information access, wearable devices, HD streaming, global roaming	Dynamic information access, wearable devices, HD streaming, any demand of users
Multiple Access	CDMA	CDMA, BDMA
Core Network	All IP network	Flatter IP network, 5G network interfacing(5G-NI)
Handoff	Horizontal and vertical	Horizontal and vertical
Initiation Year	year-2010	year-2015

Table 2: Evolution of different Generations in terms of Service & performance

Generation→ Features↓	1G	2G	3G	4G	5G
Deployment	1970 – 1980	1990 - 2001	2001-2010	2011	2015-20 onwards
Data Rates	2kbps	14.4-64kbps	2Mbps	200 Mbps to 1 Gbps	1Gbps and higher
Technology	Analog Cellular Technology	Digital Cellular Technology: Digital narrow band circuit data Packet data	Digital Broadband Packet data: CDMA 2000 EVDO UMTS EDGE	Digital Broadband Packet data: WiMax LTE Wi-Fi	www Unified IP seamless combination of broadband LAN PAN MAN WLAN
Service	Analog voice service No data service	Digital voice with higher clarity SMS, MMS Higher capacity packetized data	Enhanced audio video streaming video conferencing support Web browsing at higher speeds IPTV support	Enhanced audio, video streaming IP telephony HD mobile TV	Dynamic Information access, Wearable devices with AI Capabilities
Multiplexing Switching	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Standards	MTS AMTS IMTS	2G:GSM 2.5:GPRS 2.75:EDGE	IMT-2000 3.5G:HSDPA 3.75G:HSUPA	Single unified standard LTE, WiMAX	Single unified standard
WEB Standard		www	www(IPv4)	www (IPv4)	www (IPv6)
Handoff	Horizontal only	Horizontal only	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical
Shortfalls	Low capacity, Unreliable handoff, Poor voice links, Less secure	Digital signals were reliant on location & proximity, required strong digital signals to help mobile phones	Need to accommodate higher network capacity	Being deployed	Yet to be implemented

10. Conclusion

The coming 5G technology will be available in the market to fulfill user demands at affordable rates and also much reliable with exceptional applications. Fifth generation is based on 4G technologies. This generation technologies offer tremendous data capabilities with unrestricted call volumes. Fifth generation should be more intelligent technology which interconnects the entire world without limits.

Mobile technology has come a long way. In the beginning users were happy just to be able to talk using 1G. 2G improved communication quality and extended the meaning of “long distance calls” with roaming capabilities. 2G also gave text facility to its users. 3G provided the voice calls and introduced high speed internet & video chatting. Now, the most recent 4G technology allows mobile devices to operate at blazing fast speeds. The 4G would completely replace 3G in a long run. Currently 3G and 4G are competing for their growth in the future market and 4G is acquiring 3G’s Customers. There are plenty of opportunities for 4G to meet the needs of consumer demands in the future. A new generation of 5G standards may be introduced approximately in 2020 (Table 2). From a user point of view between 4G and 5G techniques must be something else than

increased maximum throughput. For example lower battery consumption, lower outage probability (better coverage), high bit rates in larger portions of the coverage area, cheaper or no traffic fees due to low infrastructure deployment costs, or higher aggregate capacity for many simultaneous users.

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