A REVIEW ON TRANSITION FROM 1G TO 5G

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***Abstract*—In last 40 years mobile network generation has been showed huge progress. Many of them changed the technology idea's bases with the time. There is no doubt cellular communication is maintaining its acceleration and give direction to the scientific studies. This paper summarizes the briefly historical progress of all generation of mobile network.**

***Index Terms*—Cellular network first generation, second generation, third generation, fourth generation and fifth generation.**

I. Introduction

In Section II, we summarize earlier generation of mobile network systems by mentioning in detail. With the rapidly increasing needs of more bandwidth, speed and many different things mobile network keep progress. In Section III, we explain all basic techniques and methods those are used in mobile networks. Finally, in Section IV, we conclude the report by comparison all generation feature.

II. GENERATION OF THE MOBILE COMMUNICATION SYSTEM

A. 1G (FIRST GENERATION)

The first generation of mobile network be implemented by Japanese Nippon Telephone and Telegraph company (NTT) based in Tokyo between 1979-1980s. After it gained popularity in United State of America and the European country follows it like Finland and United Kingdom. This technology existed in the first wireless phones. The 1G mobile phones used a single , universal network standard known as the Advanced Mobile Phone System (AMPS) . This system designed as analogue, and it brings with itself many limitations.In analog communication, the voice and data carrier is carried by changing the amplitude or frequency of a signal and converted into an electrical signal at the receiver.Analog signals are heavily influenced by noise, have a high error probability, are low-budget, but use higher energy and have a lower bandwidth. Compared to digital communication, it has many weak points. AMPS (Advanced Mobile Phone Service) was invented in the Bell lab[11]. England and Japan also had different names for it[11].The main logic of 1G was to divide the coverage area into cells, and the coverage was created by cells separated by 10-25 km intervals and the base stations in the center of them[4].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.1G was of course extraordinary, but not sufficient. Therefore, users faced some disadvantages. 1G is a system with a bandwidth of approximately 2MHz, using the range of 800 Mhz-900 MHz. Wide bandwidth means more data transfer at the same time. There is only voice communication in 1G and the technology used is FM (Frequency Modulation). FM is the processing of information in a carrier wave by changing the real time frequency of the wave. It also uses FDMA (Frequency Division Multiple Access) as its access technique. FDMA is a technique of channel access used in several multiple-access protocols. FDMA allows distinct customers to transmit data across a single communication channel, such as a transmission line or microwave beam, by partitioning the channel's bandwidth into independent non-overlapping frequency sub-channels and delegating each sub-channel to a particular user[3, 5].Besides, it has some disadvantages like poor sound quality due to high interference. Interference can be defined as the addition or effect of unwanted signals to the signal we want to transmit in a communication channel. Also other disadvantages are poor battery life, large phone size, low security (with FM demodulator, signals can be decoded)[1], limited number of users and cell coverage area, and last about roaming. Roaming is not possible in 1G. When a mobile subscriber moves just outside of the physical coverage area of their home network, they can surely make and receive phone calls, transmit and receive data, or access other services by joining a visiting network. Despite the fact that the first telephone was manufactured in 1973, the first commercial telephone was introduced in 1983.

Parameter	Analog	Digital
Noise immunity	Poor	Better
Long distance Communication	Not Possible	Possible
Storage and Retrieval	Not possible	Easily Possible
Flexibility	Not possible	Easily Possible
Coding	Not Possible	Possible
Band Width required	Low	High
Nature of Transmitted Signal	Analog	Digital
Modulation Type	AM,FM,PM, PAM PWM	ASK,FSK,PSK , PCM,DM,ADM

Fig. 1. Analog Vs Digital Communication

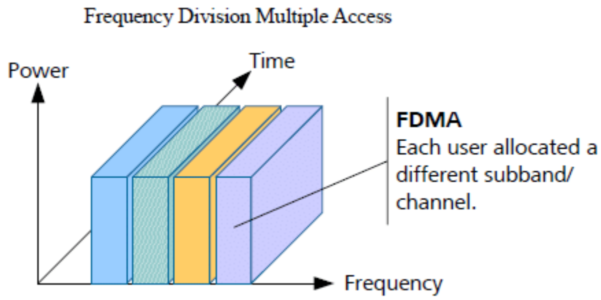

Fig. 2. FDMA

B. 2G (SECOND GENERATION)

The 2nd generation wireless communication system was launched in Finland in 1991 in accordance with Global System Communication (GSM) standards. 2G has moved us from analog signal transmission to the digital signal transmission era. Since in 2G sounds are converted to digital data and error correction is possible in digital bits, most noise in 1G is improved and a high quality sound is obtained. In addition, audio data could be compressed with CODEC (compression-decompression) algorithms, so it was possible to compress more users into the same radio spectrum, and bandwidth was provided for other services. ITU (International Telecommunication Union) tried to standardize the radio frequencies to be used in different parts of the world. Yet there was more than one 2G technology. GSM in large parts of Europe and Asia, D-AMPS (aka TDMA) and CDMA in the US. Then again there was overlap in the spectrums used, so there were GSM operators in the USA and CDMA operators in Asia. This was not good for people traveling because the frequencies could be different even if the technology used was the same. Since 2G technology is digital, the idea of sending data (not voice) over air waves emerged. In 1990, mobile data, mobile internet access, was provided. Of course, this brought with it the need for broadband. In addition, the internet was quite slow, although some improvements were made in internet speed later on.In essence, we had two core networks, one for voice calls and one for data transfer. Two technologies are used in 2G. GSM is a time division multiple access (TDMA) protocol that is routinely used throughout the world. Due to GSM, both other 2G slice is code division multiple access (CDMA), which is presently less ubiquitous than TDMA. IS-95, often known as cdmaOne, is such a well CDMA technology, and it is implemented in portions of Asia and the Americas. With this technology it was possible to encrypt digital voice calls. For the first time, people could send text messages (SMS), picture messages and multimedia messages (MMS) from their phones. Data transfer rates, which were 9.6 kbit/s in the beginning, reached 40 kbit/s with the development of hardware such as mobile base stations. In other words, the download speeds of 2G also improved. It was 0.2 Mbps on average over its lifetime. 2G also allowed data sharing between phones. Using digital audio compression, TDMA (Time Division Multiple Access) standards supported three times as many devices at the same time as older analog systems at the same bandwidth. Over time, the existing technology proven to be capable of meeting the escalating data and spectrum demand. 2.5G was released as GPRS's upgraded data services. GPRS may be thought of as an enhanced data service for GSM clients that use packet switching and multiplexing methods. The highest transfer rate via GPRS is around 170 Kbps. EDGE (Advanced Data Rates for GSM Evolution) technology was launched at 2.75G. The data transmission rate improved fourfold, from 170 kbps to 500 kbps (practical application). It was theoretically stated to be 1 mbps. EDGE transferred the data in a shorter time if we compare it with GPRS Technology. For GSM customers, GPRS provides video conferencing, streaming audio, and continuous internet access. EDGE offers multimedia applications for mobile devices as well as third-generation GSM services. Satellites are currently employed in place of cells. GPS primarily supplies the user with information such as time, location, and velocity at every place on the earth's surface, in any climatic condition, at any instant of time. Also, digital signals consumed less power. With the use of digital signals, more cells were required to cover the area, but the cost was reduced. 2G was also better in terms of health as it had lower emissions. In areas where the coverage area is weak, the digital signals become very weak or even do not reach the base station.With 2G, it is now possible to transfer data between phones. With encryption, our conversations gained security. Time-division multiple access (TDMA) is a shared-

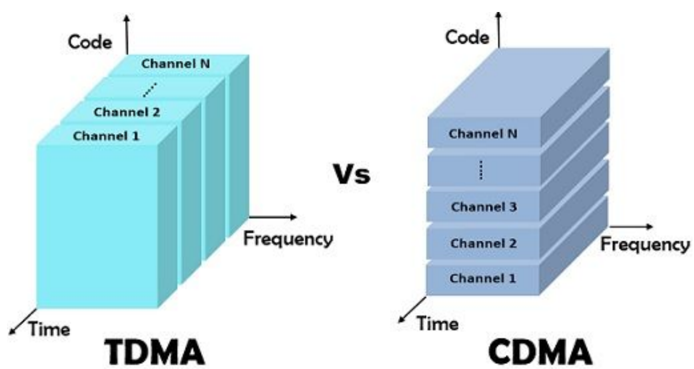

Fig. 3. TDMA and CDMA

medium network channel access mechanism. By separating the signal into distinct time slots, it allows several users to share the same frequency channel. [1] The users broadcast one after the other in fast succession, each utilizing its own time slot. This permits numerous stations to utilize the same transmission medium (e.g., radio frequency channel) while only consuming a portion of its capacity.CDMA (code-division multiple access) is a channel access technology utilized by several radio communication systems. CDMA is an example of multiple access, in which many transmitters can transfer data over a single communication channel at the same time. This permits many users to share a frequency band. CDMA uses spread spectrum technology and an unique coding technique to do this without causing excessive interference between users (where each transmitter is assigned a code).

C. 3G (THIRD GENERATION)

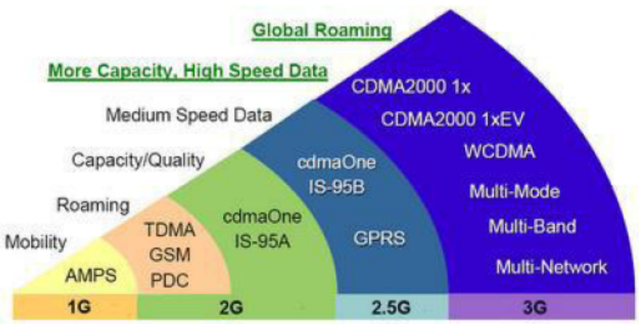

Fig. 4. Journey from 1G to 3G [13]

Third generation mobile communication began with the introduction of UMTS – Universal Mobile Terrestrial/Telecommunication Systems. UMTS has a data rate of 384kbps and, for the first time on mobile devices, video calling is supported.It employs a Large Band Mobile Network, which improves clarity.Following the introduction of the 3G mobile communication system, smart phones became popular all over the world.Smartphone applications have been developed for multimedia chat, email, video calling, games, social media, and healthcare. 3G offered us new things and these were high speed communication, advanced multimedia support and global roaming support. Making audio and video calls with 3G, downloading and uploading data, and connecting to different IP networks on the internet were important developments. Compared to its predecessors, it has a higher data rate, increased audio and video transmission rate, video chat support, faster web calls, and IPTV support. 3G transfer rates were slower for users moving at constant speed than those at stationary, and 2 Mbps in LAN networks. 3G included standards like W-CDMA, WLAN(Wireless Local Area Network), and cellular radio, among others. Essentially, it is the third generation of access technology that lets mobile phones to connect with the internet. Each iteration introduces additional frequency bands and faster data transmission speeds. Thanks to 3G, the internet was now widely used in mobile phones and smart phones were paved the way. According to several estimations, 3G has a meaningful top download speed of 7.2 Mbps and an upload speed of 2 Mbps. Another two technological advancements are introduced into the network to improve data rate in existing 3G networks. On 3G networks, HSDPA (High Speed Downlink Packet Access) and HSUPA (High Speed Uplink Packet Access) have been developed and deployed. Data rates of up to 2mbps are possible on the 3.5G network. The 3.75 system is a 3G network upgrade that includes HSPA+ High Speed Packet Access plus. This system will eventually evolve into the more powerful 3.9G LTE system (Long Term Evolution). However, 3G spectrums are expensive, infrastructure and equipment costs are high.

D. 4G (FOURTH GENERATION)

The ITU has also standardized 4G. It offered the same wireless bandwidth and data throughput as previous models. Users of 4G may expect speeds of up to 100 Mbps, whilst 3G only promises a peak speed of 14 Mbps. 4G also offers wireless broadband, which allows users to access the internet without the requirement for a fixed, wired connection from an internet service provider (ISP).

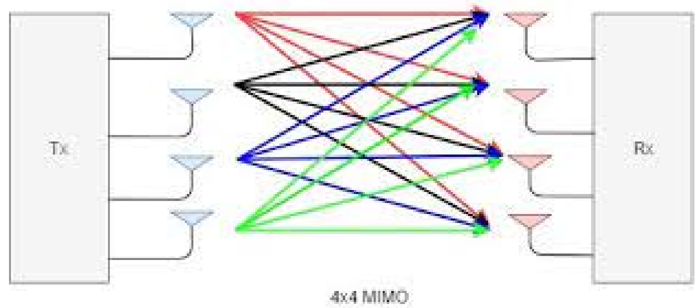

Fig. 5. MIMO

MIMO (Multiple Input Multiple Output) and OFDM (Orthogonal Frequency Division Multiplexing) are used as technology in 4G. MIMO and OFDM enable more capacity and bandwidth in comparison to 3G.

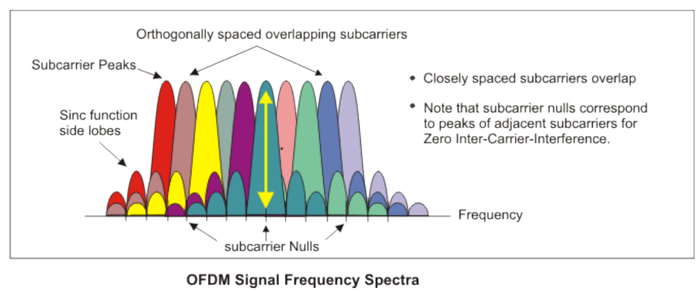

Fig. 6. OFDM

4G is also an internet protocol based standard for both voice and data, as opposed to 3G, which only utilizes IP for data while supporting voice on a circuit-switched network. As an all-IP network, 4G is more efficient to manage and optimize for mobile network operators than managing several network technologies for voice and data.The distinction between 4G and 4G LTE is based entirely on marketing and the evolution of the 4G standard. LTE (Long Term Evolution) was originally designed to help operators shift from 3G to 4G.The International Telecommunication Union (ITU) defined 4G in 2008, however its speeds and technical criteria were not immediately possible for mobile networks or mobile devices. As an interim step up from 3G, LTE provides more bandwidth than 3G, but it does not attain the full bandwidth network speed minimum of 100 Mbps that 4G promises. Although the term LTE is commonly used in marketing presentations, it does not indicate or suggest a specific speed. Depending on the provider, speeds range from 20 Mbps to 100 Mbps. 4G LTE-A (LTE-Advanced) is a specific word that allows for 100 Mbps. It is essentially 4G with no technical differentiation.Despite competing solutions such as LTE and WiMAX (Worldwide Interoperability for Microwave Access), which attempted to bridge the gap between 3G and 4G, no mobile network or cellular carrier could achieve the 100 Mbps speed mandated by 4G in 2008. Sprint was a big fan of WiMAX, whilst Verizon was all about LTE. One notable difference between WiMAX and LTE is that WiMAX did not use OFDM, which subsequently became a standard component of all operational 4G deployments. Sprint had switched course and began to adopt LTE across its network by 2011, while WiMAX had begun to wane. Since 2011, LTE speeds and performance have steadily increased, with 4G LTE-A technology enabling cellular networks to meet the initial IMT-Advanced standard's claimed network capabilities of 100 Mbps. LTE-A, LTE-Advanced, 4G+, and LTE+ are all acronyms for the same 4G service. It's a faster version of LTE. Most 4G and its expansions technologies were unable to provide the theoretical speeds they promised, with some being 2 to 8 times slower in practice. LTE is designed to have lower latency (the time it takes for data to travel via a network) and more capacity, making it perfect for the Internet of Things. Indeed, downlink bandwidth enhancements of up to 100 Mbps and uplink bandwidth improvements of up to 50 Mbps are possible. Faster access to material and applications, notably video apps, which are now only available on fixed systems, is enabled by more bandwidth. Time-sensitive applications such as phone services are viable because to the reduced latency. The all-IP architecture, which is based on the IP Multimedia Subsystem, enables novel convergence services (IMS).VoLTE is an abbreviation for voice-over-LTE. It is a more advanced variant of 4G LTE for voice and video communications.In essence, you get HD audio and video conversations, and it's a terrific overall experience with improved coverage and battery life.Within 4G – which is already widely used to link industrial-grade IoT devices – there are three primary types. The LPWAN, or low powered wide area network, comes in two flavors: category M (Machine to Machine) (Cat-M or LTE-M) and category NB-IoT (Narrowband IoT) (Cat NB-IoT). LTE-1 is the category for mid-range bandwidth (LTE Cat 1). LTE Advanced (LTE-A) or LTE Advanced Pro networks are commonly used for high bandwidth applications. LTE is backwards compatible with existing mobile networks, allowing for maximum flexibility. This feature includes already implemented network technologies such as GSM, cdmaOne, W-CDMA (UMTS), and CDMA2000. The Wi-Fi Alliance developed Wi-Fi in 2000. It is a collection of wireless local area network (LAN) protocols for short-distance communication. The most frequent method of connecting to the Internet is using a wireless router.4G systems are an enhanced version of IEEE's 3G networks, with greater data speeds and the capacity to handle more complex multimedia services. LTE and LTE advanced wireless technologies are utilized in 4th generation systems. Furthermore, it is backwards compatible with prior versions, making LTE and LTE advanced network implementation and upgrading easy.The LTE technology enables the simultaneous transmission of speech and data, dramatically increasing data rate. IP packets may be used to offer any service, including voice services. Complex modulation methods and carrier aggregation are utilized to boost uplink and downlink bandwidth.WiMax and other wireless transmission technologies are being used in 4G systems to boost data throughput and network performance. The following are the features of 4G systems.

E. 5G FOURTH GENERATION

South Korea was the first country to embrace the technology on a broad basis, in April 2019, with 224 operators in 88 nations across the world investing in the technology. Except for one carrier that used Huawei equipment, all 5G carriers in South Korea employed Samsung, Ericsson, and Nokia base stations and equipment.Wireless communications systems transmit data over the air using radio frequencies (also known as spectrum).

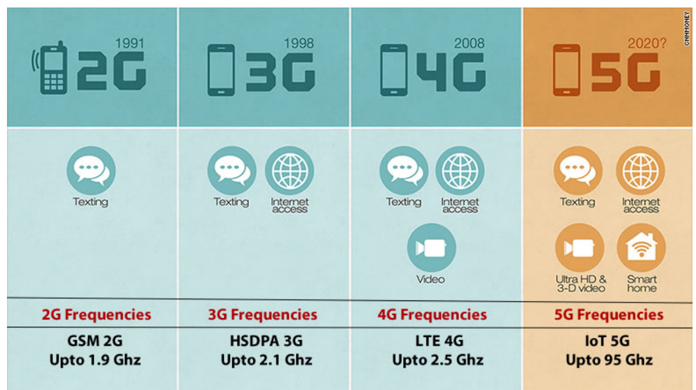

Fig. 7. 2G to 5G

5G works in the same way as 4G, but uses higher radio frequencies that are less crowded. This enables it to carry more data at a much quicker rate. These higher bands are referred to as'millimeter waves' (mmwaves). They were previously unlicensed, but regulators have made them available for licensing. They had mostly gone unnoticed by the general public since the necessary equipment was both unavailable and prohibitively expensive. While higher bands transfer information quicker, there may be issues when sending over long distances. Physical things such as trees and buildings can readily obstruct them. To address this issue, 5G will employ numerous input and output antennae to enhance signal and capacity across the wireless network.Smaller transmitters will also be used in the technology. Rather of employing single stand-alone masts, they are mounted on buildings and street furniture. According to current predictions, 5G will be able to accommodate up to 1,000 more devices per metre than 4G.In addition, 5G technology will be able to'slice' a physical network into many virtual networks. This implies that operators will be able to supply the appropriate network slice based on how it is utilized, allowing them to better manage their networks. This implies that an operator, for example, will be able to employ varied slice capacities based on importance. A single user streaming a film, for example, would utilize a distinct piece of a business's infrastructure, while simpler devices might be segregated from more complicated and demanding applications, such as managing driverless vehicles.

Fig. 8. 5G IOT

There are also proposals to allow enterprises to rent their own isolated and insulated network slice to isolate themselves from rival Internet traffic.You may be asking what makes it so unique.The speed of the network is the most obvious advantage of 5G networks over 4G networks. However, there are advantages related to lower latency, which means faster reaction times and better download rates. Because of the increased operating efficiency, this offers up a plethora of possible applications across industries.Superfast internet without the need for landlines, 5G mobile telecommunications, the development of smart factories, holographic technologies, TVs, remote healthcare, and autonomous automobiles with 5G connectivity as well as car-to-car communication are some of the uses for 5G.Many of these technical advancements will be enabled by lower latency, allowing 5G devices to respond to orders more quickly. The time elapsed between issuing a command and receiving a response is referred to as latency. 3G has a delay of 65 milliseconds, advanced 4G has a latency of roughly 40 milliseconds, and fixed broadband has a latency of 10-20 milliseconds. In comparison, 5G is predicted to have latency as low as 1 millisecond, allowing mission-critical and Internet-of-Things applications to function below the 4 millisecond objective for an enhanced mobile broadband service.The technology will also be more powerful than earlier network technologies. Access to a larger spectrum at higher frequencies will be available, allowing networks to handle more high-demand applications concurrently. This implies that it might give a fibre-like experience for fixed wireless applications, allowing individuals in hard-to-reach places to benefit from much better broadband access.As previously said, the key selling feature of 5G is the network's speed. According to some, peak speeds might someday approach 10Gps.Customers will benefit from ultra-fast internet and multimedia experiences owing to the employment of innovative technology in the 5G network. In the future, existing LTE advanced networks will be supercharged with 5G networks. Earlier 5G network installations will operate in both non-standalone and standalone modes. Both LTE and 5G-NR spectrum will be used concurrently in non-standalone mode. Control signals will be coupled to the LTE core network in non-standalone mode. There will be a specialized 5G core network with greater capacity 5G – NR spectrum for standalone mode. The FR1 sub-6-GHz frequency bands are being used in the first 5G network installations.In order to attain faster data speeds, 5G technology will utilise millimeter waves and unlicensed airwaves for data transmission. The following are the features of 5G systems.

III. CONCLUSION

In this paper, we explored mobile communication technologies from 1G to 5G. We made comparisons between technology and generations while researching the historical development process. Mobile communication in the fifth generation includes more features than the previous generation. This mobile technology will provide fast data speeds, efficient and dependable connectivity, and all at a low cost. It will serve to enhance people's living standards and make our lives simpler, as well as save us time. The fifth generation will undoubtedly alter the course of history.

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