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5G Wireless Technology Review

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*Abstract— The latest networking design is used by 5G technology, a breakthrough advancement in wireless telecommunications that offers high-quality services. In this essay, an effort is made to examine the development of the many generations of mobile wireless technology as well as to compare their characteristics and abilities. There are efforts to clarify the architecture that has been put forth so far for the deployment of a 5G network. The terms "5G" and "World Wide Wireless Web" (WWW) alternately refer to a platform that enables us to connect to any type of device, anytime, everywhere***.**

Keywords—5G, 5G architecture, Evolution of 5G, 5G design.

I. Introduction

Radio technology has shown rapid and highly evolving nature through the introduction of analogue cellular systems in the 1980s.Digital wireless communication systems continue to work toward meeting the expanding human requirement after then. Because there was such a high demand for new connections around the world, mobile communication standards progressed quickly to accommodate more users[1].

First generation in 1980s used analogue data communication i.e mode of communication (pagers). The second generation of mobile communication systems made use of the Global System for Mobile Communication (GSM). It was a cutting-edge form of wireless digital transmission. UMTS (Universal Mobile Terrestrial/Telecommunication Systems) marked the start of the third generation of mobile communication[2].

Technology advancement both supports and pushes the limits of flexible usage regulations, allowing for a wide range of uses and users. This is likely the case with 5G technologies, which open up higher-spectrum bands for quality than was previously anticipated. South Korea and the US became the first nations to commercialize 5G wireless technology in April 2019. China also wants to deploy 5G by giving major carriers access to 5G trade licenses[3].

The commercial debut of 5G wireless technologies in India has a target date of 2020, which is extremely timely in comparison to other nations. In March 2018, the government already unveiled a three-year strategy to advance 5G research. Additionally, Ericsson built a 5G testing infrastructure at IIT Delhi to generate applications for the Indian state[3]

II Evolution

A **First Generation (1G)**

The 1980s saw the development of 1G. It has an analogue system that can support cell phones from the first generation at speeds of up to 2.4kbps shown in fig1.1. It introduces mobile technologies

such push to talk, the improved mobile telephone the advanced mobile telephone system, and the mobile telephone system (MTS) (PTT). It makes use of analogue radio signals with a 150 MHz frequency. The method used for voice call modulation is known as frequency division multiple access (FDMA). Users can use it to make voice calls within a single nation. However, it had a low capacity, erratic handoff, poor voice connectivity, and no security at all because voice calls were replayed in radio towers, making them vulnerable to uninvited third party eavesdropping [4].

Figur ... es

In ... red. released comm ... GSM protocol (199 ... nd transmits voice ... 1.2. The 2G netw ... xt messages, image messages, and Multimedia Messaging Service (MMS), which uses the bandwidth of 30 to 200 KHz, and allows for significantly larger penetration intensity. Text communications are encrypted digitally. In comparison to 2G, the 2.5G system offers a data rate of up to 144 kbps while using a packet switched and circuit switched domain.Consider GPRS, CDMA, and EDGE[2].

Figure 2: 2G Technology and devices

C Third Generation(3G)

The third generation of smart phones saw the introduction of web surfing, email, video downloads, photo sharing, and other services, as shown in figure 1.3.Third-generation mobile communications, which went on sale in 2001, was designed to cut costs while increasing data capacity and simplifying voice and data traffic[5].

Figure 3: 3G Technology and devices

D Fourth Generation (4G)

Technology developments over the past ten years have only made it possible for 4G, which is a fundamentally different technology than 3G. Its goal is to offer users high-speed, high-quality, and high-capacity voice and data, multimedia, and Internet services via IP with improved security and lower costs. Alterations to IP addresses, game resources, HD mobile TV, video conferencing, 3D television, and cloud computing are a few examples of the potential changes. shown in figure 1.4.The success of this has been largely attributed to MIMO (Multiple Input Multiple Output) and OFDM technology[6].

OFDM is a type of digital dynamic signal that is divided into numerous sub-channel channels with different frequencies. Due to the rotation of voice calls to GSM, UMTS, and CDMA2000, carriers will need to redesign their voice network with the deployment of LTE[7].

Figure.4: 4G Technology and devices

E 5G - Fifth Generation

The benefits of 5G include increased data throughput, improved connectivity, and decreased latency. Some advantages of 5G include device-to-device communication, improved energy efficiency, and expanded cellular coverage.In comparison to 4G, the maximum predicted 5G high speeds is 35.46 Gbps, which is more than 35 times faster. Massive MIMO, Millimeter Wave Mobile Communications, and other vital technologies were developed over the previous ten

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years and can be used to give consumers 10Gb/s of data at an unbeatable low latency and allow them to connect to at least 100 billion devices, as shown in figure 1.5. Table 1.1 is showing the comparison between the various generation that is 1G,2G,3G,4G and 5G networks. On the day of the commercial introduction of 5G networks, various ratings were given[7].

- Millimeter radio bands, which range from 30 GHz to 300 GHz, are only used in a small number of 5G networks. About 500 meters from the tower, a 5G spectrum test at mm Wave gave results. 5G deployments based on millimeter waves could improve the overall integration space by deploying smaller cells. When combined with beam shaping, small cells can offer speedy coverage and minimal latency..
- Low latency is one of the most important characteristics of 5G. Scalable orthogonal frequency-division multiplexing is the foundation of the 5G network (OFDM). With real measurements spanning from one to 10 seconds, this aids 5G in achieving low latency as low as one millisecond. It's projected that 4G would typically have a 60–120 times faster delay than 5G.
- A functional 5G antenna integrated with a large 5G MIMO is used to provide better connectivity and advanced user experience.
- Large 5G antennas are used to obtain additional light-emitting information and to transmit broadcasting challenges found in the mm Wave frequency range

Additionally, 5G networks with network cut-off structures enable telecommunications providers to provide consumers with much-needed connectivity while upholding SLAs (SLA). Delays, data speed, dependability, quality, services, and security are a few examples of specialized network skills.

Figure.5: 5G Technology and devices

Limitations of 5G networks

- Due to the limited wavelength travel, as well as the fact that 5G is frequently impeded by visible obstructions like trees, towers, walls, and buildings, the range of 5G connectivity is not good.
- The costs associated with upgrading 5G infrastructures or upgrading existing mobile infrastructure will be higher. This amount will also be included in the ongoing repair costs required to ensure high- speed connections, and customers may bear the brunt of these high-value tags.
- While 5G may bring real connectivity too many urban areas, those living in rural areas will not benefit from connectivity. As it stands, most remote locations across the country do not have access to any type of cellular connection. 5G carriers will target large, densely populated cities, eventually operating in outdoor environments, but it is unlikely that this will happen anytime soon. As a result, only some people will benefit from 5G connectivity.
- When it comes to 5G mobile devices, it appears that batteries are not capable of lasting a long time. Battery technology needs to be upgraded to allow for this advanced connection, where single charging will enable the phone to charge full day.
  The 5G technology's download speed is unexpectedly fast, reaching up to 1.9 Gbps in some circumstances. However, as was previously demonstrated, the download speed hardly ever goes above 100Mbps, which is absurd. However, compared to 4G LTE, the upload speed on the current mobile connection is faster.
- It seems to reduce the feel and look of the universe, and many civilizations find it unpleasant when new cell phone towers are built, or existing ones are extended. More infrastructure construction will be required for 5G, which will not appear to be beneficial to locals.

Advantages of 5G networks

- Bi-directional shaping with high resolution and huge bandwidth.

- The ability to unify all networks onto a single platform.

- More successful and efficient.
- Subscriber oversight tools made easier by technology for swift response.
- Most likely, will offer a significant amount of broadcasting data (in Gigabit), supporting over 60,000 connections.
- Simple to handle with the older generations.
- Sound technological foundation to support diverse services (including private network).
- It is feasible to offer persistent, uninterrupted, and universal connectivity.
- More artificial intelligence (AI) applications will be developed as artificial sensors that could communicate with mobile phones surround human life.

Salient features of 5G technology

The 5G technology offers consumers well-shaped and quick Internet connection while providing high resolution for sharp, passionate cell phones every day.

The 5G technology offers billing caps in advance, which is the more attractive and prosperous of the present day.

The 5G technology enables for big volume data delivery in Gigabit, which also maintains close relationships to over 65,000 users of mobile phones, cell phone records for printing operations.

The data from the 5G data transfer technology is used to organise more precise and trustworthy outcomes.

By having higher speed and clarity in less time alone, using remote control technology, the user may also experience 5G comfort and relaxation. The 5G technology also supports virtual private networks.

5G Design

Complex design factors must be taken into account while developing a 5G network architecture that can serve demanding applications. There isn't a one-size-fits-all solution, for instance, because different applications need data to travel long distances or in big volumes, or a combination of both. To achieve the complete 5G goal, 5G architecture must handle low, mid, and high-band spectrum from licensed, shared, and private sources[8].

This is why the radio frequencies used by 5G, known as "millimeter waves," range from below one GHz to exceedingly high frequencies (or mmWave). The signal can travel further the lower the frequency. The more data that can be carried, the higher the frequency.

Figure 6: 5G Technology frequency bands

At the heart of 5G networks are three frequency bands:

The highest frequencies of 5G are delivered through 5G high band (mmWave). These have a frequency range of about 24 GHz to 100 GHz. High band 5G is inevitably limited in range because to the difficulty of passing through obstructions at high frequencies. In addition, mmwave coverage is constrained and necessitates additional cellular infrastructure.

The capacity layer for urban and suburban areas is provided by 5G mid-band, which runs in the 2–6 GHz frequency range. Peak rates in this frequency band are in the thousands of Mbps.

III Core Network

The 5G System, also known as 5GS, has three main components. One of these is the 5G core network, which provides the additional functionality of 5G networks (source). User Equipment and the 5G Access Network (5G-AN) make up the remaining two elements (UE). As demonstrated in the 5G core diagram, the 5G core uses a cloud-aligned service-based architecture (SBA) to enable authentication, security, session management, and traffic aggregation from linked devices, all of which call for the intricate integration of network operations[9].

The following elements make up the 5G core architecture:

• User-plane Activity (UPF)

• Data network (DN), including third-party services, Internet access, and operator services

• Fundamental Access and Mobility Management Task (AMF)

• Server Function for Authentication (AUSF)

• Function for Session Management (SMF)

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• Function for Network Slice Selection (NSSF)

• Network Exposure Performance (NEF)

• Repository Function for NF (NRF)

• Function of Policy Control (PCF)

• Data Management, unified (UDM)

• Application Purpose (AF)

IV 5G Network Architecture

Network functions are divided up by service in 5G, which was built from the ground up. This architecture is also known as the 5G core Service-Based Architecture for this reason (SBA). The main elements of a 5G core network are displayed in the following 5G network topology diagram.

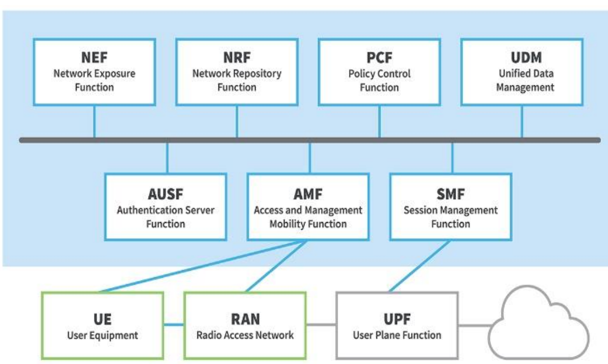

Figure 7: 5G Architecture

User Equipment (UE), such as 5G smartphones or 5G cellular devices, connects to the 5G core and then to Data Networks (DN), such as the Internet, via the 5G New Radio Access Network[6].

The UE connection uses the Access and Mobility Management Function (AMF) as a single point of entry.

The AMF chooses the appropriate Session Management Function (SMF) for managing the user session based on the service the UE has requested.

The User Equipment (UE) and the external networks are connected through the User Plane Function (UPF), which transmits IP data traffic (user plane).

The AMF can authenticate the UE and access 5G core services thanks to the Authentication Server Function (AUSF).

The policy control framework, which applies policy decisions and accesses subscription information, is provided by other functions such as the Session Management Function (SMF), the Policy Control Function (PCF), the Application Function (AF), and the Unified Data Management (UDM) function[10].

V 5G Architecture and the Cloud and the Edge

One more idea that sets 5G network architecture apart from its 4G predecessor is edge computing, often known as mobile edge computing. In this case, it is possible to place mini data centers near the cell towers at the network's edge. For applications requiring large bandwidth and extremely low latency and conveying the same content, this is crucial. Consider video streaming services as a high bandwidth example[11].

A server in the cloud houses the content's original source. It is more effective to have that material as close to the user as possible, right there on the edge, ideally on the cell tower, if, for example, 100 people are using a cell tower to stream a popular TV show[12].
Instead of having to stream, transfer, and backhaul this information for 100 users from the central location on the cloud, the user streams it from an edge storage medium. Instead, you can bring content to the tower simply once utilising the 5G structure, then distribute it to your 100 subscribers.

The same idea holds true for applications that require two-way communication and low latency. Because the data doesn't have to travel via the network, turnaround time is substantially faster if a user has an application running at the edge [13].

These edge networks can be utilised for services offered at the edge in the 5G network architecture. These 5G core tasks can be virtualized, so you could run them on regular server or data centre hardware with fibre running to the radio that broadcasts the signal. Thus, just the radio is specialised while the rest is rather normal[2].

Figure 8: 5G Technology architecture cloud and Edge

VI Conclusion

A significantly more difficult development approach will be required for 5G. The 5G network is incredibly quick and dependable. The fourth generation uses 4G technology. The security of 5G will increase with the deployment of IP version 6. Higher data rates and the all-IP principle are on the horizon for wireless and mobile networks. For the same applications, mobile terminals get better every year in terms of processing power, onboard memory, and battery life. The newest technologies used in 5G include cloud computing, cognitive radio, software defined radio (SDR), nanotechnology, and All IP Platform[14].

In the upcoming generation of mobile networks, referred to as 5G, it is anticipated that the original Internet philosophy of keeping the network as simple as possible and offering additional features to the end nodes will become reality. In this research, we examine the features of 1G and 5G networks.

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