Asian Journal of Science and Applied Technology
ISSN 2249-0698 Vol.10 No.2, 2021, pp.15-21

DOI: https://doi.org/10.51983/ajsat-2021.10.2.3044

A Review on 5G Technology: Evolution, Features and Challenges

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***Abstract* - Everyday living becomes more convenient and joyful as a result of technological advancements. The advancements in telecommunications and networking have changed throughout several decades. The first generation of mobile wireless communication was the 1G (the earliest form of voice-only network), which was followed by 2G, 3G, 4G, and 5G. The 5G network is expected to provide higher connection speeds than earlier networks, being more dependable, faster response time and more capacity. In this paper, we provide an overview of the standards, data rates, capacity, primary service, challenges, and features provided by each generation, as well as how advances have been achieved from one generation to the next. Also, the paper highlights the new emerging technology, 5G, its architecture, features, and applications.**
***Keywords:* 5G, 5G Network Architecture, Features, Challenges**

I. INTRODUCTION

The mobile wireless industry has started its technology creation, revolution and evolution in the early 1970s. In the past few decades, mobile wireless technologies have experienced 4 or 5 generations of technology revolution and evolution. The telecommunication service in World had a great leap within the last few years. 6 billion people own mobile phones, so we are going to analyze the various generations of cellular systems as studied in the evolution of mobile communications from the 1st generation to the 5th generation [1]. The world has seen a lot of changes in the world of communication. Today we no more use landlines. Everyone possesses a mobile phone that functions all day. Our handsets not only keep us connected with the world at large but also serve the purpose of entertainment gadgets. From 1G to 5G this world of telecommunications has seen several improvements along with improved performance with every passing day [2]. Here are some previous generations of mobile network communication.

A. The 1980s: 1G Delivered Analogue Voice

The first generation of mobile networks or 1G was launched by Nippon Telegraph and Telephone (NTT) in Tokyo in 1979. It contains an analogue system and is popularly known as a cell phone. It introduces mobile technologies such as mobile telephone system (MTS), Advanced mobile telephone system (AMTS), Improved mobile telephone system (IMTS) and push to talk (PTT) [3].

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 [2].

B. The Early 1990s: 2G Introduced Digital Voice

2G was launched under the GSM standard in Finland in 1991. It uses digital signals for voice transmission and has a speed of 64 kbps. It provides the facility of SMS (Short Message Service) and uses the bandwidth of 30 to 200 kHz. Next to 2G, 2.5G system uses the packet-switched and circuit-switched domain and provide data rate up to 144 kbps [2]. For the first time, calls could be encrypted and digital voice calls were significantly clearer with less static and background crackling and introduced data service (SMS) [4].

C. In the Early 2000s: 3G Brought Mobile Data (e.g., CDMA 2000)

3G utilizes extensive trademark wireless networks by expanded transmission system support benefits that give a data transmit rate of at any rate 2 Mbps. It was introduced in 2000 including reliability and high-speed data transfer. An association called the 3GPP (3rd Generation Partnership Project) was formed to help with the deployment of the 3G network. The 3G's expanded information transmission abilities multiple times quicker than 2G. The features increased are bandwidth and data transfer rate to fit a web-based application, audio, video file and ended IP (for example Skype). The peak data rates of 100-300 Mbps [5].

D. The 2010s: 4G LTE Ushered in the Era of Mobile Broad Band

4G was first deployed in Stockholm, Sweden and Oslo, Norway in 2009. 4G wireless technology is also referred to by "MAGIC" which stands for Mobile multimedia, Any-where, Global mobility solutions over, integrated wireless and Customized services.4G is all about convergence; convergence of wired and wireless networks, wireless technologies including GSM, wireless LAN, and Bluetooth as well as computers, consumer electronics, communication technology and several others. By using Orthogonal Frequency Division Multiple Access (OFDMA), LTE will

be able to provide download rates of 150 Mbps for multi-antenna (2x2) multiple-input multiple-output (MIMO) for the highest category terminals [6].

E. April 2019: 5G ERA Started

5G (fifth generation) mobile network is a progressive version of the present 4G /IMT-Advanced standards [1]. The capacity of this fifth generation is aimed to be much higher than the current fourth generation [1]. Higher capacity would allow a 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 [7].

II. LITERATURE SURVEY

Shukurillaevich, Sattorivich *et al.,* [8] have tried to explain various terms related to 5G technology. In the past few decades, mobile wireless technologies have experienced 4 or 5 generations of technology revolution and evolution, namely from 1G to 4G. In 5G, research is underway on the development of Wireless World Wide Web, Dynamic Adhoc Wireless Network (DAWN) and Real Wireless World. The 5th wireless mobile internet networks are truly wireless.

Patrick Kwadwo Agyapong *et al.,* [9] give a structure imaginative and prescient to deal with the demanding situations located on 5G cell networks. A two-layer structure is proposed, including a radio community and a community cloud, integrating diverse enablers inclusive of small cells, big MIMO, control/person aircraft break up, NFV, and SDN. This article proposes a unique 5G cellular community structure that incorporates the evolution of conversation types, end-consumer conduct, and era.

Ketanpreet Kaur *et al.,* [10] has mentioned the crucial additives of 5G consist of the spectrum, beam forming, massive MIMO, network slicing, and cloud implementation. 5G is the approaching platform as a way to be supplying speeds up to 20 Gbps and extremely low latency. To achieve a very high data rate it requires bandwidth up to 1-2 GHz. That means 5G must use a millimetre wave spectrum above 20 GHz for high data rates and capacity.

According to Maryam Fizza *et al.,* [11], 5G becomes a fundamental necessity nowadays due to better boom in video grabbing, limit the power requirements, high data speed, real-time connectivity, greater safety, etc. One of them is the high operational cost because the cost is directly related to energy consumed for transmission. But the 5G generation will overcome these problems and presents a brand-new possibility to approaching generations.

According to Arun Kumar Tripathi *et al.,* [12] due to innovative improvements in electronics and communication, cellular and hand-held gadgets turn out to be the element of our day-by-day life. 5G community can offer better Quality of Service (QoS) together with better statistics prices than 4G community and features. It can also provide services to fixed host communication, cloud infrastructure, etc.

In this article, the author Enas Selem *et al.,* [13] tried to explain different terms related to 5G technology. Today, the development of 5G technology is having a great influence on real-time healthcare applications. Wireless Body Network (WBAN) is considered the main technology used for healthcare systems, noise reduction and wireless power transmission. All these features improve the health monitoring system continuously.

According to Ijaz Ahmad *et al.,* [14], 5G will offer broadband access everywhere, entertain better consumer mobility, and permit connectivity of a massive variety of devices in an ultra reliable and inexpensive way. The major technological enablers such as cloud computing, Software Defined Networking (SDN), and Network Function Virtualization (NFV) are maturing towards their use in 5G.

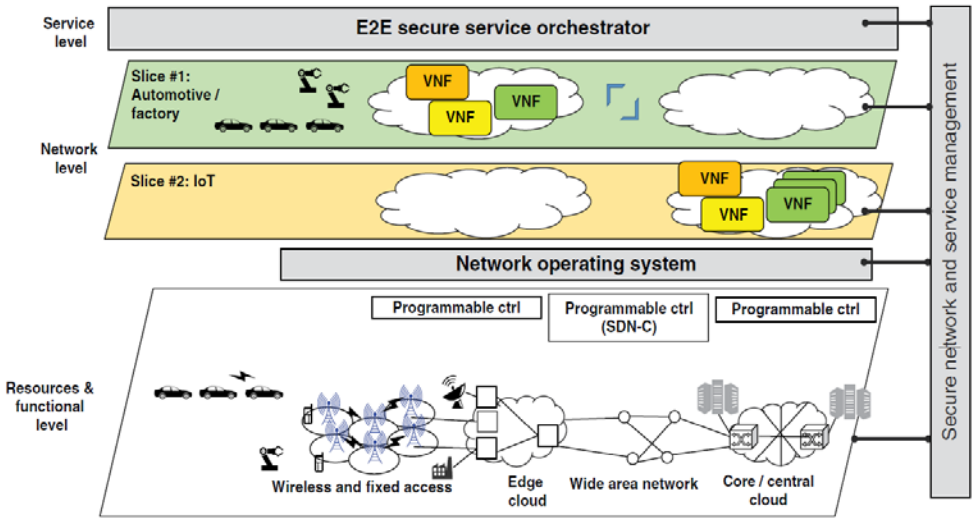

Fig. 1 Architecture of E2E in 5G [23]

III. 5G NETWORK ARCHITECTURE

A. E2E Architecture

Figure 1 shows the 5G E2E network architecture, which outlines the 5G E2E network. The end to end (E2E) 5G network architecture is composed of a next-generation radio access network (NG-RAN), multi-access edge computing (MEC), virtual evolved packet core (vEPC), a data network (DN) and a cloud service.

B. Network Slicing Architecture

Network slicing is a paradigm that permits the sharing of the identical infrastructure for providing differentiated 5G services. A network slice example is an end-to-end logical network custom described to fulfil required networking traits and offer particular services to serve specific use cases (e.g., voice communication, video streaming, e-health, vehicular communication).

The 5G architecture consists of various community domains, consisting of the Core Network (CN) and the Radio Access Network (RAN). Chaining a RAN sub-slice and a CN sub-slice is an instance of sub-slice chaining. Figure 2 below shows the 3GPP diagram of the slicing network [15].

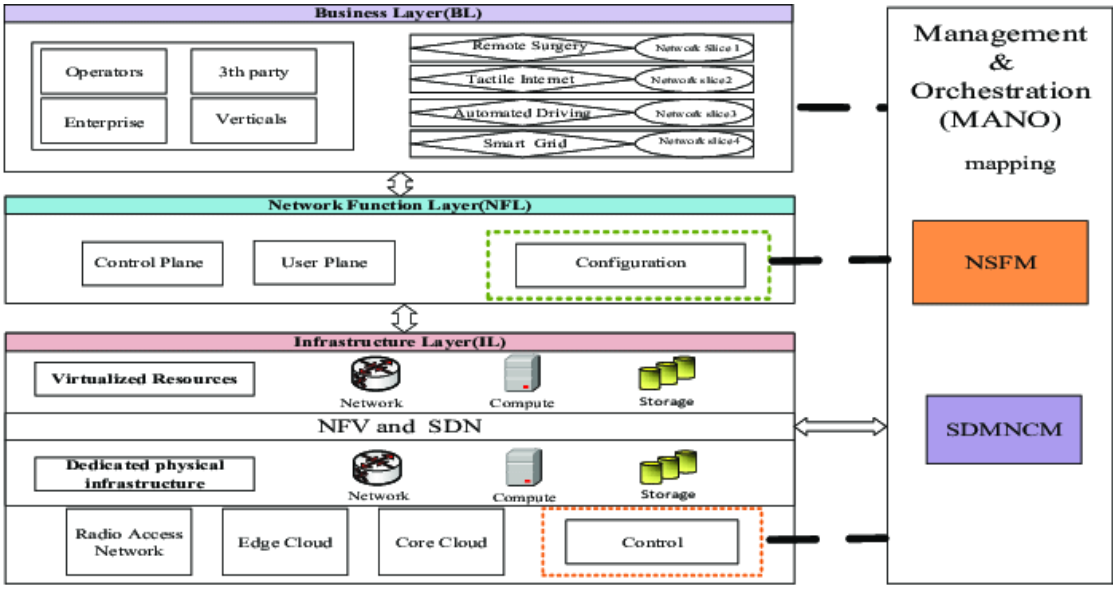

Fig. 2 Network Slicing Architecture

C. vEPC Network Function

VEPC is a network and stands for virtual evolved packet core. Virtual Evolved Packet Core (vEPC) is an outline for switching and processing information for mobile networks. Multiple virtual network features (VNFs) virtualize the features of LTE evolved packet core (EPC). The discounts in the construction cost and the capacity to quickly set up service environments are supplied through virtualization. The features of LTE evolved packet core (EPC) areas compared with the components of evolved packet core vEPCare in Figure 3 below [16].

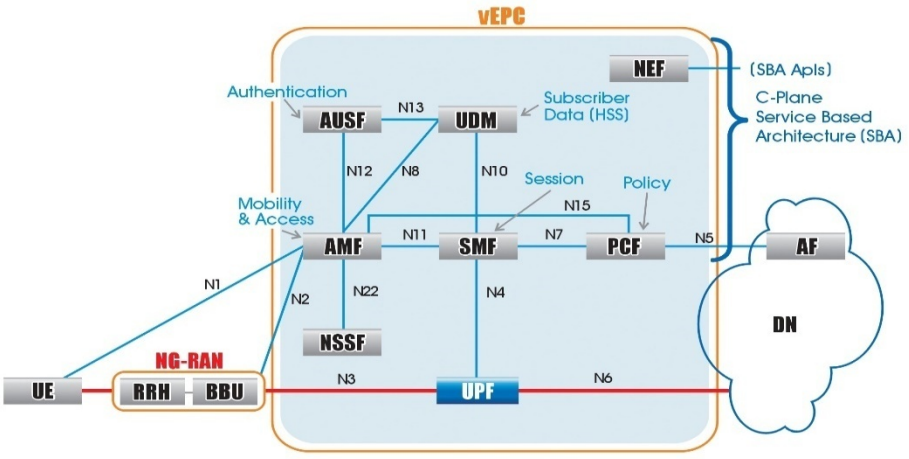

Fig. 3 vEPC Architecture [16]

D. NFV MANO (Management and Orchestration)

The European Telecommunications Standards Institute (ETSI) evolved Network Functions Virtualization (NFV) Management and Orchestration (MANO) framework. Within that framework, NFV orchestrator (NFVO) and Virtualized Network Function (VNF) Manager (VNFM) purposeful blocks are responsible for dealing with the lifecycle of network services and their related VNFs. In Figure 4 from [17] based on the ETSI framework, many open supply organizations have evolved their personal NFV MANO frameworks.

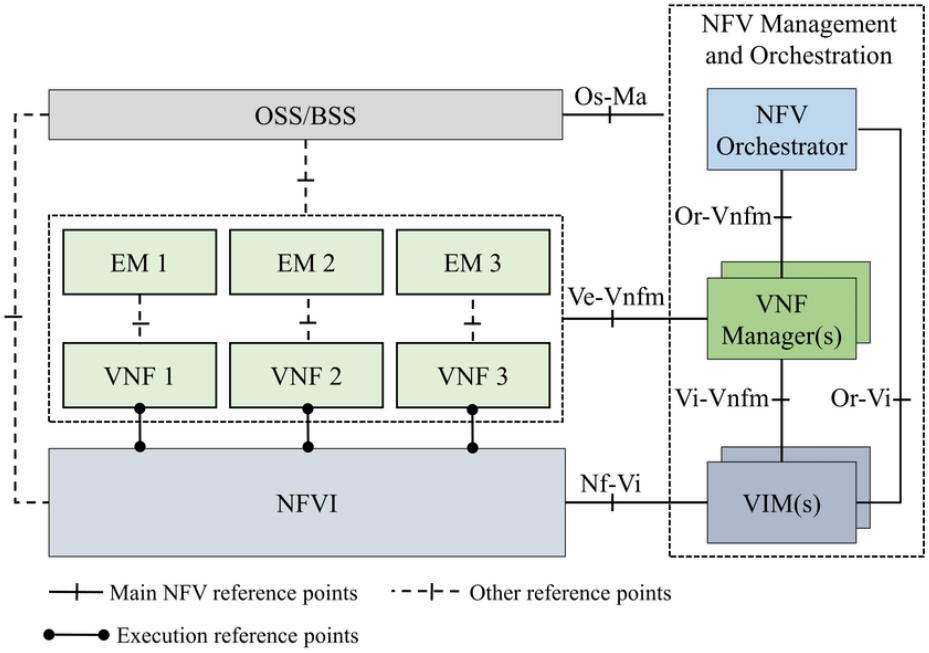

Fig. 4 ESTI NFV Architecture [17]

E. 5G Mobile Network Architecture Design

The system model of 5G is the completely all-IP based model designed for wireless and mobile networks interoperability. The system comprising of a major consumer terminal (which has a crucial position in the new architecture) after which some independent and autonomous radio access technology. Each of the radio technology is considered as the IP link for the outdoor internet world. Within each of the terminals, each of the radio access technology is seen as the IP link to the outdoor Internet world. However, there needs to be a different radio interface for each Radio Access Technology (RAT) in the mobile terminal. For example, if we need to have access to four exclusive RATs, we want to have four exclusive accesses - specific interfaces in the mobile terminal, and to have all of them active at the same time, to have this architecture to be functional.

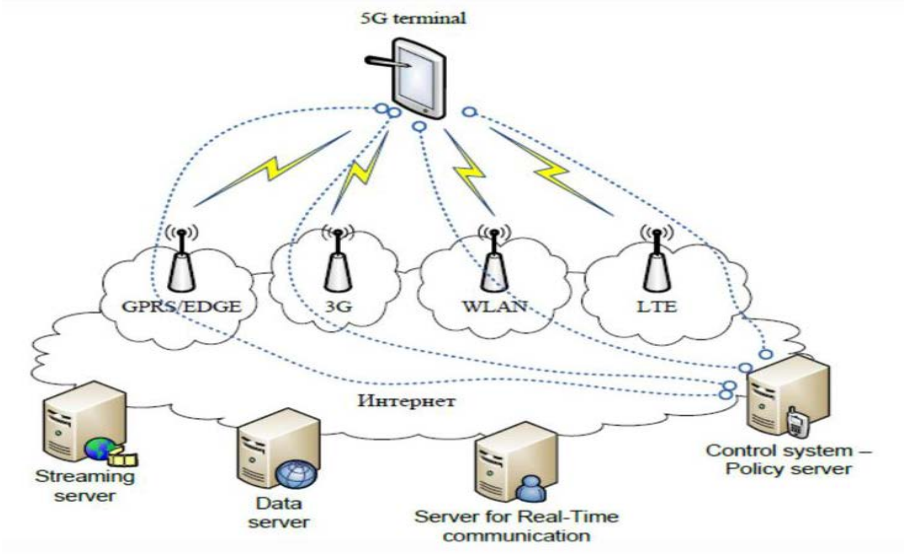

Fig. 5 Functional Architecture for 5g Mobile Networks [24]

The 5G model contains four layers namely the Physical layer, Network layer, Open Transport Protocol layer and Application layer. The function of each layer is mentioned below.

1. Physical Layer

Physical and Medium Access Control layers i.e. OSI layer 1 and OSI layer 2, define the wireless technology. For these two layers, the 5G mobile networks are likely to be based on Open Wireless Architecture [18]. The two layers are supposed to be the foundation of the 5G mobile network.

2. Network Layer

At the network layer, IP (Internet Protocol) is used to route data from a source to a destination IP device. Ipv4 and Ipv6 are the two most common forms of IP. Although IPv4 is extensively used, it does have significant drawbacks, such as limited address space and no support for quality of service (QoS). The problems have been resolved with IPv6 still, mobility remains an issue owing to trading with larger packet headers. As a result, 5G phone manufacturers will adopt IPv6 in their devices.

The multi-wireless network environment will be maintained by the 5G mobile phone. In 5G, the network layer will be divided into two sub-levels, referred to as the Lower network layer and the Upper network layer. The Lower layer network is for each interface and the Upper layer network is for the mobile terminal [19]. Between the upper and lower network layers, the middle layer maintains address translation from upper network IP addresses (Ipv6) to lower network IP addresses (Ipv4 or Ipv6) and vice versa.

3. Open Transport Protocol (OTA) Layer

The OTA layer is a combination of the Transport layer and Session Layer. TCP is used to interconnect network devices on the internet providing end-to-end communications. In terms of the OTA layer, the functionality of the transport layer is different for wireless networks as compared to wired networks. While transporting data, segments are lost and it is presumed that they are lost due to congestion in the network. On the other hand, there will be losses on wireless networks due to a high bit error ratio in the radio interface. Therefore, TCP is used for mobile networks as well as wireless networks, through which the lost or damaged TCP segment can be retransmitted over the wireless link [19]. Because of the quicker download and installation speeds in 5G, this is a significant consideration factor.

4. Application Layer

The topmost layer of the 5G network stack is responsible for providing the best services directly for the application processes across different networks. Today's mobile internet users manually select the wireless port for different Internet services without having the possibility to use QoS history to select the best wireless connection for a given service. The 5G phone will allow for service quality testing as well as the storage of measurement data in mobile terminal information databases. The QoS parameters, such as delay, jitter, losses, bandwidth, reliability, will be stored in a database in the 5G mobile phone to be used by intelligent algorithms running in the mobile terminal as system processes, which at the end shall provide the best wireless connection upon required QoS and personal cost constraints [18]. The application layer also encrypts and decrypts data to ensure that communication is accurately received and handled.

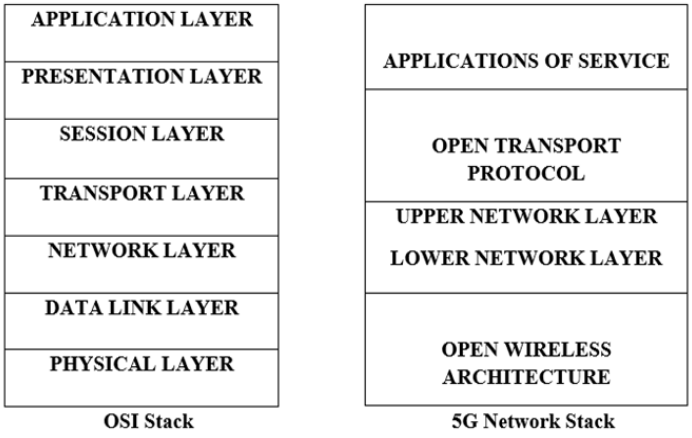

Fig. 6 5G Protocol Stack [18]

IV. 5G WIRELESS NETWORK CHALLENGES

A. High Operational Cost

To meet the demand for higher data speeds 5G requires higher operating costs. There are several causes for this, including increased capacity, high infrastructure, high-energy network devices, etc. The cost is directly proportional to the energy consumed for transmission. 5G wireless technology can decrease the transmit energy per bit, but it cannot reduce the operating energy [20]. To conquer the cost of 5G network is to make the wireless communication technology must be energy efficient [11].

B. Critical Challenges

E-communications face some critical challenges like a battery lifetime, restricted computation capability, and strict latency [21].

C. Security and Privacy

Wireless networks are relatively less secure than wired networks because of easier access of unauthorized persons [11]. In handling data from multiple users accounts several security issues may arise. A lot of data is being conveyed per unit time so there is a possibility of several criminal attacks. Because of the large bandwidth hacker may try to enter the network. Due to high power consumption heating issues may arise. So the data privacy is a key feature of the 5G network.

D. Massive Connectivity

Connectivity has become a real challenge for M2M communication as mobile broadband has grown more widely available. However, the massive traffic growth expected from machine-type communication as a result of billions of connected devices will cause the network to become congested. So, several orders of magnitude increase in network connectivity and capacity are required, which can be met with network densification, dense small cell deployment [22].

E. Challenges of WBAN Health Care System Enabled by a 5G Network

WBAN health care system is composed of lightweight sensors (in-body or on-body) in addition to an IoT device connected to the medical server via a 5G link. Those lightweight sensors detect vital signs of the human body and wirelessly transmit this data to the IoT device which in turn transmits it to the medical server through the 5G link. On the WBAN side, the consumed energy of sensors is the main challenge as the replacement of any sensor when it consumes its energy can cause the patient great annoyance if the node is on-body or tough pain if it is in the body. Moreover, the extended number of various lightweight sensors can raise the amount of data transmitted that can cause congestion on the radio network [22].

V. CONCLUSION

In this paper, we have reviewed different aspects and features of upcoming 5G technology by evaluating them with previous generations of technology. In the meantime, 5G trials have begun in several countries. We have discussed the 5G architecture, which makes use of different platforms and different layers. The challenges of transitioning from 4G to 5G must also be considered for the deployment of a 5G network. The main aim of 5G was to provide a real wireless world free from present obstacles and this is only possible if all the existed radio technologies and future technologies were integrated with 5G. We also emphasised the 5G network's applications, which will expand in the new era. In the future, 5G technology will transform the history of entire telecommunications with its speeds and low latency.

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