CHALLENGES OF 5G DEPLOYMENT IN NIGERIA

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ABSTRACT

In Nigeria, there is increase in demand for wireless connectivity due to increase in population/data traffic over the cellular network. Therefore a corresponding support for fixed, mobile wireless and satellite access technology becomes a priority to achieve the present day globalization. Most network operators are challenged to cope with the high traffic demands such that cellular systems can be deployed within few meters to achieve increased mobile broadband services. This is implemented with the advent of 5G technology. In this paper, (1) fundamental challenges inhibiting the deployment of 5G technology in Nigeria is discussed. (2) Probable solutions to these challenges are proffered. (3) Key enabling technological features to compliment 5G applications are also discussed. A scalable and customized technology like 5G will support increased demand for broadband connectivity, create services for massive and critical internet of things application, to bridge the technological gap between Nigeria and other advanced nations.

Keywords: Deployment challenges, ultra low latency, enhanced mobile broadband, massive machine communication, 5G.

I Introduction

The development and deployment of commercial wireless cellular telephony has evolved from one generation to another beginning from the early 80's. This was initiated in the first generation (1G) cellular phones which operated on analogue frequency modulation technique, to convey narrow band voice services. The second generation (2G) was launched in the early 90's to carry voice and data signal using time division multiple access (TDMA) technique. Code division multiple access (CDMA) technique was implemented to convey packet switched data as well as circuit switched voice signal for the third generation cellular system. This was launched in the early 2000 due to the

exponential rise in tele-traffic and increased subscriber. The 3G network operated to simultaneously convey speech and data at high speed rate. Although there are other networks which existed in between (e.g. 2.5G) but are silent in the public domain. Then the 4G LTE network was deployed to use voice over internet protocol (VOIP) and multimedia application with broadband access. Its operation was based on orthogonal frequency division multiple access (OFDMA). The evolution of radio technology is represented in figure 1. Figure 2 shows the advancement in the mobile network of the different generations and the improvement in processing speed of the network. It is important to note that LTE network cannot uphold massive connectivity in uplink. This facilitated the emergence of 5G wireless systems.

The 5G is the fifth technology in the growing generational evolution of global system for mobile (GSM) communication. It is the prevailing mobile telephone technology in the world whose potentials cannot be overemphasized. It has underlying improvement in efficient telecommunication network performance with increased geographical coverage area. 5G network is an advancement of the 4G LTE-A network. The essence is to make up for the limitations and drawback of 4G LTE and other earlier networks. For this reason, 5G is associated with low latency, increased speed, very high reliability and tremendous potentials to improve the well being of man through internet of Things (IoT), Artificial intelligence (AI) and Big data. 5G will promote efficient interconnectivity between humans, things and machine to the internet [1].

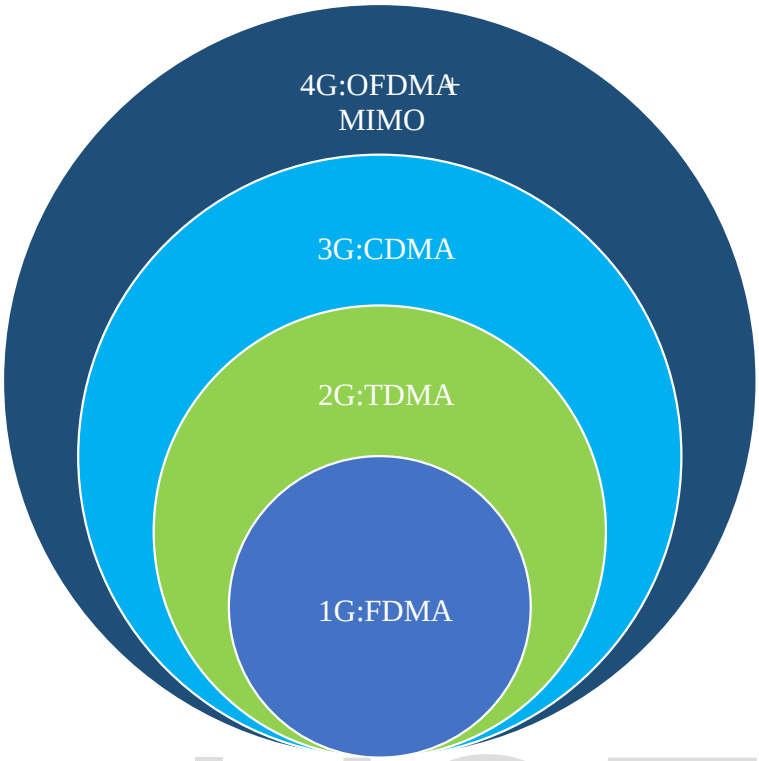

Figure 1 Radio Technology Evolution

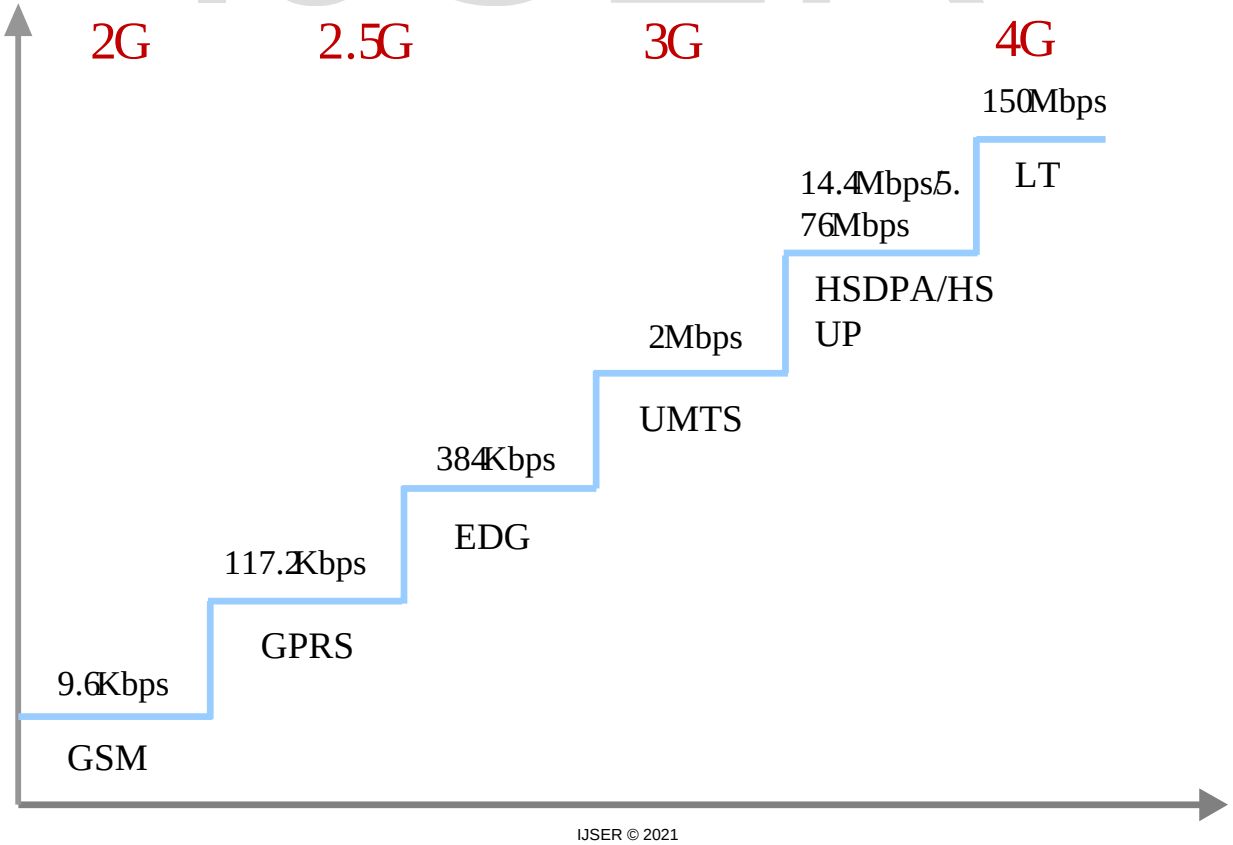

Figure 2 Mobile Network Evolution

It can handle the issues of insecurity, job creation, improved economy and governance. 5G can be described as a smart technology which is the advent of a smart city, with smart transportation system, remote surgery, self driving cars, internet connection for drones and virtual reality. Figure 3 shows that 5G cuts across all facets of life. However, 5G network gained tremendous awareness in recent time due to the conspiracy theory linking the global covid-19 pandemic with the 5G networks. Five international bodies with reputable expertise has categorically debunked any link between the novel covid-19 pandemic and the 5G network. These bodies include; the World Health Organization (WHO), International Commission on Non-ionizing radiation protection (ICNIRP), Institute of Electrical/Electronic Engineers (IEEE), GSM Association (GSMA) and the International Telecommunication Union (ITU). 5G though a new technology, has been deployed in countries like South Korea, US, United Kingdom and Germany. In Nigeria at the time of this research, there is no 5G deployment, however a prototype was tested in November 2019 which has been concluded but not implemented. The Nigerian communication commission has not licensed any 5G spectrum to telecommunication operators. The essence of the prototype test which is a non commercial proof of concept (PoC) was to study and observe any health or security implications of 5G network. The International Commission for non-ionizing radiation protection (ICNIRP) is a body which set the radiation emission limits of devices while the Nigerian telecommunication commission test to ascertain compliance ensuring service providers conform to set limits of radiation from their base stations and other operating device.

A system known to emit electromagnetic radiations need to be analyzed and tested to ascertain the exposure limit for the safety of the user and the public. It is not impossible to achieve unsafe exposure limit mostly from high power transmitters and antennas with very high gain. The radiations from 5G networks are non-ionizing. This implies that there are practically no underlying health hazard when exposed to such network device. It has no adverse effect on man. The non-ionizing radiations are generally applied to

electromagnetic radiations between the radio frequency and the visible light in the frequency spectrum. The ionization radiation include the gamma rays, x-rays and cosmic rays. These radiations has the possibility of striping electrons from its molecules thereby leading to mutating effects. It can alter the structure of the human cell and damage the DNA in them. They are liable to producing cancerous effect on the human body.

II Operation

Electromagnetic radiations spread geometrically as they emanate from the transmitting source, with the strongest fields and highest exposure levels occurring very close to the source and decreases as the signals travels far away. However, the specific absorption rate and the average time of whole body exposure are two important parameters necessary to determine exposure limit. There is no evidence of 5G deployment in Nigeria as at the time of this research. But 5G will produce massive enhancement to the existing 4G networks. The high frequency signal of 5G network will travel at faster speed over very short distances. This process will necessitate the utmost deployment of many micro-cell site to effectively connect human, machine and objects accordingly. By this, 5G channels will depend on 4G LTE infrastructure such that it is said to operate on a non-standalone (NSA) mode. While 4G towers transmits in all direction covering a wide geographical area, 5G towers ought to be distinct with directional signal which do not travel more than a mile. For this reason, the 5G towers ought to be smaller and closely spaced for efficient communication process to be established and availability to end users.

It is well established and can be seen in figure 3 that speed, capacity and latency are the driving force for 5G network [2]. The reason been that 5G is associated with a new frequency band which is the millimeter wave (30 – 300GHZ) band for large bandwidth channels. It is important to also note that the millimeter wave spectrum is free from interference from other devices, thus the reason for its fast speed and low latency. The 5G technology will utilize the already deployed optical fiber cable which serves as a backbone for the 4G LTE internet connectivity in Nigeria. Most base transceiver stations use optical fibers to link one base transmitter station to another. This implies that 5G will

be integrated into the existing infrastructure of 4G network for extensive boost for wireless communication.

5G is developed under three categories which include; ultra low latency enhanced mobile broadband (eMBB) and machine type communication using millimeter wave in a MIMO full duplex beam forming network with numerous small micro cells. The eMBB is designed for mobile telephony and media transfer for large volume of data at extreme data rates. The ultra-low latency feature is centered on real time human machine collaboration with reliability defined as a probability of successful data delivery within a specific time frame. Massive machine type communication provides connectivity to massive number of low complexity narrow band devices. 5G design is aimed at expanding the spectral available band into the millimeter wave (1 to 10mm) that has not been deployed for mobile services. Although a major draw back of millimeter wave is that they can be absorbed by foliage and rain but they can't easily travel through buildings or obstacles. The small cells are base stations which require minimal power to operate and can be placed 250 meters away from each other in a given region. Thousands of small cells are created to form a dense network, to transmit and receive signals from base station to end user respectively in a multiple input multiple output system. The MIMO system operates with multiple antennas in an array which is used by the corresponding number of transmitters and receivers for increased capacity of mobile network.

Beam forming is applied by the antennas on the transmitting device to identify the most efficient service delivery route to a particular user, this helps to reduce interference from other device by channeling the side lobe radiation to interference signal and the main beam to the user. This can be achieved with a full duplex transmission where 5G transceivers are able to transmit and receive data at the same time on a frequency band.

The core network and access radio of any cellular network technology is standardized by the 3rd generation partnership project (3GPP). 3GPP considered 5G operation on three stages; as a non-standalone new radio (NSA) NR, standalone new radio (SA) NR and advanced architecture network. In the NSA network, LTE serve as a prerequisite for initial access and mobility while the SA network can operate independent of the LTE.

The advanced architecture network considered options of the possibility to connect 5G nodes B's to an evolved packet core (EPC), by connecting new radio and LTE in multi connectivity mode, where NR, serves as the driver node and LTE is secondary node. Figure 4 shows the core aspects of 5G network with the corresponding uplink modulation schemes for licensed and unlicensed access. In [3], sparse code division multiple access was proposed for 5G radio access to contend traffic over the cellular network.

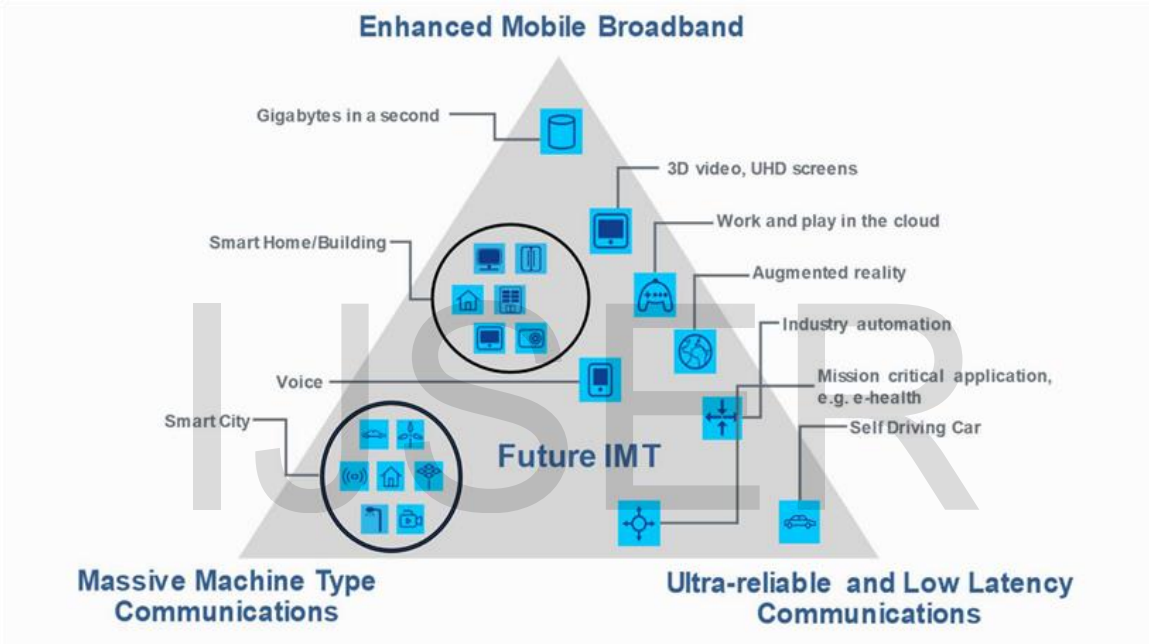

Figure 3. The three driving force of 5G Network and its components [4].

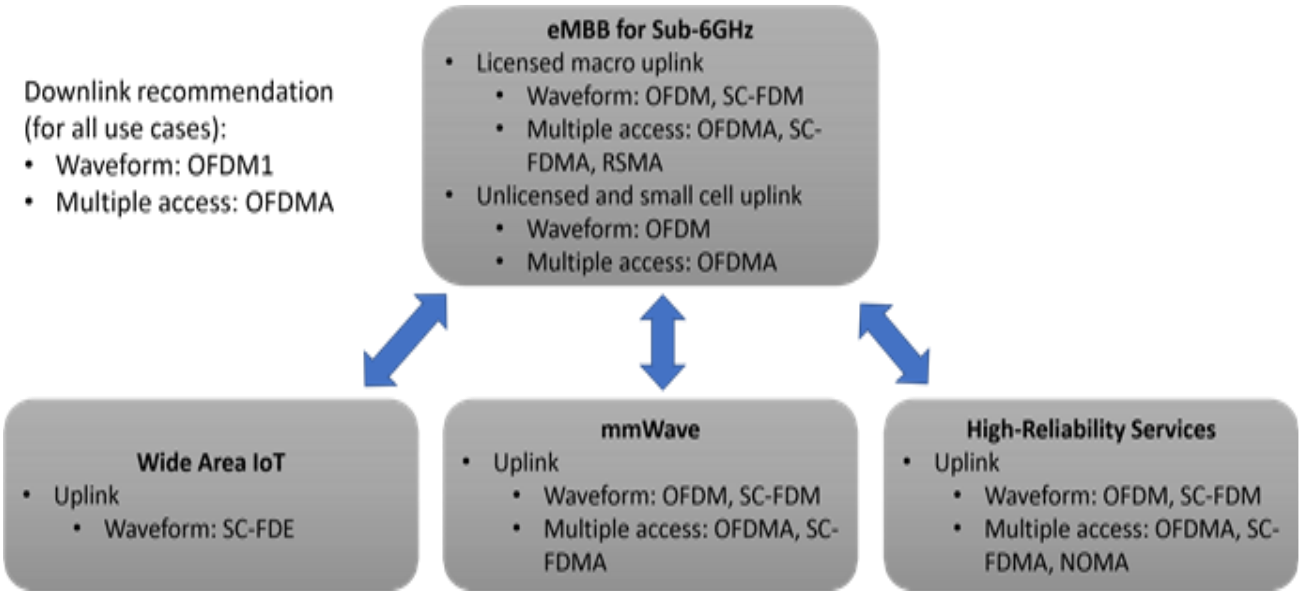

Figure 4: 5G Requirement [4].

III Challenges of 5G Deployment in Nigeria

In Nigeria, 5G may not operate on a standalone basis hence it will deploy the facilities of 4G LTE networks. However, 5G may still be faced with challenges of the existing 4G. Although very rigorous real time testing ought to be carried out on 5G network to ascertain its real time challenges. Notwithstanding, the following are the challenges to be associated with 5G network based on Nigeria's peculiarities.

1) Inconsistent Power Supply

Power supply is an essential aspect of any communication system. Inconsistent power supply in Nigeria will to a great extent inhibit the commercialization of 5G networks. Nigeria's installed capacity is about 12500Mwatts but she is only able to generate 7000Mwatts while less than 4000Mwatts is distributed among over 180 million people in the nation. This will give epileptic power supply which cannot sustain most base transmitting stations meant to run 24 hours. This has constantly posed severe operational cost for the 3G and 4G networks which runs on diesel engines and other form of alternative power supply.

2) Infrastructural Cost

With additional 5G network, there is bound to be increase in operational/infrastructural cost due to expensive devices. This include devices that will allow ultra low latency in communication, 5G antennas and RAN hardware to create a denser network for 5G operation. Building a 5G network will require a large initial/overhead cost which will bring about a corresponding increase in the cost of subscription by the subscribers. The infrastructure to keep such high speed data network up and running is a major concern.

3 Deployment and Coverage

Since 5G transmits over shorter range of distances, directional antennas are required to achieve effective communication. This means that fewer base transceiver stations will be required with large installed devices on buildings, homes and larger towers including extra repeater stations to boost signal strength of 5G connections while maintaining consistent speed in densely populated areas. This becomes a major challenge when installing 5G in rural areas due to the sparse settlement. However additional devices are needed to achieve very efficient network coverage. The limited range of 5G network calls for more infrastructure to allow for directional wave propagation.

4) Limited Presence of 4G Network

Currently in Nigeria, there is limited presence of 4G network mostly in rural and sparsely populated areas. This will pose a serious challenge since the 5G will exist on a non-standalone form at its initial stage. It will rely on the infrastructure of 4G network. This limitation will continually pose challenges for 5G deployment. The limited quality of internet speed with require 5G enabled devices to overcome this challenge.

5) Security/Privacy of Communication Facility

Like other networks, 5G technology will also be faced with sophisticated cyber security threats [5]. It is essential that digital safety is provided for subscribers. Also, most of the telecommunication facility should be heavily secured to avoid been stolen, damaged or vandalized. Information of any sort for 5G network need be highly secured because there are some 5G protocol that has the ability to track calls, expose user location and down

grade subscriber services. These will pose massive challenge for deploying 5G network if not well tackled.

6) Frequency Band

The 5G network needs a higher spectrum band of about 300GHz, therefore bidding still needs to be done to establish the frequency band just like the 4G LTE network. The allocation which will be done by the National frequency management council along side other relevant professional bodies will require large amount of resources. This will invariably affect the running cost for 5G deployment.

Although Nigeria as a nation has been using the 5G carrier spectrum but has not deployed it for wireless communication. It has used the mm wave band for satellite communication at the 24GHz frequency which is the best promising band for 5G.

7) 4G and 5G Synergy

It is important to mention another likely challenge which has to do with integrating 5G networks with existing 4G network to provide continuous connection. This is necessary since 5G cannot operate in a standalone at the very initial stage. The infrastructure should support the synergy to provide efficient communication process. 3G and 4G infrastructure should serve as a building block for efficient existence of 5G networks.

IV Complimenting Features of 5G Application.

1) Network Function Virtualization

Network function virtualization aims at transforming standard IT virtualization technology to consolidate many network equipment type onto industry standard high volume servers, switches and storage located in data centers, network nodes and end user premises. It implements network functions in software that can run on a range of industry standard server hardware and can be moved to various locations in the network as required without the need for installation of new equipment.

2) Mobile Edge Computing (MEC)

MEC is a fundamental technology for 5G to drive demand for its services and accelerate 5G coverage. It provides low latency, high bandwidth, device processing, data offload, computing and storage. It serves two major purpose;

a. Network performance and QoE (Quality of Experience) improvement. This is achieved since MEC serves as an interface between cloud servers and the device. It brings about low latency, improved performance and does not call for the use of expensive devices.

b. The user experience is generally improved with video optimization, performance optimization and content caching.

3) Network Slicing

Network slicing requires the splitting of a single physical network into multiple isolated logical network within which the configurations and activities do not interfere with each other. Network slicing improves and enhances the reliability and security of each slice. Each network slice is an isolated end-to-end network narrowed down to fulfill diverse requirement for a particular application. This implies that traffic and security issues from one slice cannot interfere with another slice. Network slicing has the ability to bring network resource utilization efficiency, deployment flexibility and support fast growing applications and services. 3GPP which defines standards for mobile broadband is considering network slicing as one of the key features of 5G with the aim of spending significant effort to develop comprehensive network slice related standards in various working groups.

Typical slice type include; (1) EMBB enhanced mobile broadband slice suitable for handling 5G enhanced mobile broadband, useful but not limited to the general consumer space. Mobile broadband applications including streaming high quality video, fast large file transfers etc. (2) URLLC ultra-reliable low latency communications and (3) MIoT massive internet of things.

4) Massive MIMO Concept

The application of multiple input multiple output technology for 5G networks is a key concept which enables increased throuput in 5G wireless technology, increase in signal to noise ratio, support for millimeter communication and energy transfer. MIMO has the potentials to meet the growing demand for high data rate transmission for wireless communication. Massive MIMO requires a system architecture with large number of antennas, each generating a specified radiated power to a direction of interest (DOI) with minimum radiation in unwanted direction. This will reduce interference to a great extent [6]. Bandwidth requirement, electrical/physical size of the antenna and frequency reconfigurable property for massive MIMO are parameters of great importance [7].

Massive MIMO deploys key concept which include; spatial diversity, spatial multiplexing and beam forming. It is aimed at improving the reliability of the system with improved performance. The benefit of massive MIMO include; increased network capacity, improved coverage and very improved user experience [8].

5) Multiple Access in MIMO

5G wireless technology is faced with numerous challenges to overcome large scale heterogeneous traffic. To achieve this, new modulation and multiple access schemes are considered and development. This include; the orthogonal multiple access (OMA) and non-orthogonal multiple access (NOMA) [9]. The schemes are used to overcome out-of-band leakages, bit error rate problems and achieve good spectral efficiency associated with OFDM. Pulse shaping and filtering process is also employed in OMA for improved 5G networks. The NOMA can accommodate several users in the network within the same orthogonal resource block to achieve significant bandwidth efficiency [10]. In NOMA each user operates in the same band and at the same time but are distinguished by their power levels with successive interference cancellation algorithms. Superposition coding at the transmitter and successive interference cancellations is adopted at the receiver.

6) Cloud/Open RAN (Radio Access Network)

Open RAN describes open interface between network elements. It implements an open interface between components while cloud RAN virtualizes baseband and targets the separation of baseband hardware and software.

5G RANS can support multiple input multiple output (MIMO) antennas, wide spectrum bandwidths, multiband carrier aggregation etc. The evolution of RAN for 5G networks will have huge impact on wireless technologies including enabling mobile edge computing (MEC) and network slicing. The RANS contributes to the high reliability of 5G networks due to low latency.

V Conclusion

In this paper detailed discussion on the challenges of rolling out 5G network in Nigeria based on her peculiarities has been discussed. It has also given the benefits of 5G and the basic characterization for effective deployment. Although the spectrum for 5G is already in use in Nigeria for satellite communication but has not be deployed for wireless broadband communication. High data rate, low latency and efficient signaling for augmented reality, artificial intelligence and virtual reality are key benefits of 5G technology.

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