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A REVIEW ON 5G WIRELESS NETWORK IMPLEMENTATION STRATEGIES IN NIGERIA

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ABSTRACT

The 5G networks stand for fifth generation mobile technology and can outperform earlier versions of wireless communication technology. The new technology provides diverse abilities and encourages full networking among countries globally. Fifth Generation (5G) wireless communication network development was an initiative in furtherance to the current Fourth Generation (4G) wireless communication network technology. The 5G networks for future applications in all domains provide prospects for a fully connected society. The proliferation of all connectivity between the devices provides a broader range of new governance, business structures, health care delivery, Economic growth and insecurity reduction which subsequently paves a path towards different industry profiles, such as energy, Communication and manufacturing sectors. This paper discusses the Concept of 5G Network, 5G network implementation strategies and technology requirements, deployment challenges as well as suggestions on the way forward based on Nigerian context.

Keywords: 5G Network, Wireless Communication, 5G Technology, 5G spectrum, Fifth Generation Network

INTRODUCTION

5G technology is the current generation of mobile communications technology, and it is designed to exceed the preceding 4G networks with new capabilities and specifications equipping the technology to support new and innovative solutions and products (Watts, 2020).

The most popular 5G deployments around the globe have been in the (3.3-3.8) GHz band, which is used by other communication technologies. Other bands proposed for the 5G deployment includes frequencies in the sub 6GHz range and above 6GHz, with ranges between 24GHz to 86GHz, known as millimeter wave bands that were studied at the ITU-R. These new frequency bands will in addition to enhancing service delivery, create additional revenue to Government Consultation Document on Plan for 5G Deployment in Nigeria through licensing (NCC, 2020). 5G will leverage existing infrastructure when deployed in Non-standalone architecture and subsequently progress to the Standalone architecture.

One of the most significant advantages of 5G is the higher bandwidths in some of the frequency bands identified for the technology. These high bandwidths will translate to its ability to transfer large volumes of data at extremely high speed and very low latency. These speeds are expected to reach 10Gbps which is ten times faster than the highest rates offered by the fibre to the premises networks. The most significant advantages of 5G are the sheer amount of data it can transfer and the extremely fast response (Guidotti et al. 2019). A unique feature of the 5G which is the low latency will enable the utilization of 5G in critical control and remote health applications which were challenging with the 3G and 4G networks. The response time for 3G is usually rated for 100milliseconds while that of the 4G is rated for 30milliseconds. Comparing this with the 5G response time rated as low as one millisecond, provides an enormous opportunity for the development of real-time control applications. This rapid response time is made possible by the higher available bandwidth and spectrum efficiency of the technology, as applications can complete their data transfer and allow other applications to access the bandwidth. Critical applications which will benefit from these advantages include automation, particularly in the healthcare and mining sectors,

massive Machine Type Communications, and the remote control of industrial processes such as oil and gas, farming and manufacturing. A vital drawback of the high frequency bands is their susceptibility to atmospheric attenuation; thus, the cells must be very small micro or femtocells. While these cell sizes are small, the form factors of the base stations are even much smaller resulting in microcell BTS as small as tiny boxes on streetlight installations which can be powered by solar panels and batteries (Sun et al.,2018).

KEY CHALLENGES OF 5G NETWORK DEPLOYMENT IN NIGERIA

This section discusses some key challenges 5G technology network operators need to look into consideration in order to transform their technology for full 5G implementation. Most of these challenges manifest at the point of deployment, while others were government policy related challenges. According to (Sun et al.,2018) particular focus is given to how appropriate regulation from Nigerian Communications Commission (NCC) and government policy might help wireless operators to deploy small cells, fibre backhaul as well as the use of spectrum. According to Yang, et al. (2019) some of the major challenges are discussed as follows:

1. One of the major key challenges in 5G deployment is interest-based conflict as many parties are interested in the technology. Therefore, the technology may not be able to satisfy needs by the parties at the same time.
2. Spectrum availability and network deployment feasibility.
3. Strategy use cases and business model.
4. Device innovation and technology breakthroughs.
5. Network deployment approach.
6. Architectural and platform innovation.
7. Operational complexity and cost.
8. Accenture 5G Acceleration Services.
   The aforementioned challenges and many others can be reduced or even eliminated entirely through government policies, stakeholders' dialogue, Technology transformation and improvement, needs assessments and proper monitoring and supervision of service providers (Yang, et al. 2019).

AIM AND OBJECTIVES

The plan implementation of 5G focuses on creating an enabling environment for operators to plan and deploy 5G infrastructure and roll out services as efficiently as possible. The aim of this study is to review 5G implementation strategies in Nigeria with following plans objectives:

1. To ensure efficient assignment of spectrum for deployment of 5G technology
2. To create an enabling environment for additional investment in the industry
3. To collaborate with relevant stakeholders to ensure nationwide availability of fiber and other backhaul infrastructure.
4. To ensure effective deployment of 5G to cover major urban areas by 2025.
5. To ensure the security of the 5G ecosystem and the protection of data.
6. To ensure that international best practices and globally accepted standards and specifications are entrenched in Nigeria's 5G eco system.
7. To create an enabling environment for innovation, digital entrepreneurship, and the proliferation of impactful 5G use cases.

SIGNIFICANCE OF THE STUDY

5G's characteristics will enable the implementation of innovative new technologies and services that can bring radical changes to industry, business, and everyday life. These benefits according to (Sethi and Sarangi, 2017) include the following:

1. Enhanced Mobile Broadband (eMBB)

Mobile broadband is the obvious primary application of 5G. It is expected that operators will deploy 5G across the country over time, providing subscribers with much faster broadband speeds and enhanced reliability.

2. Internet of Things (IoT)

The Internet of Things (IoT) refers to a network of devices equipped with sensors, actuators, and processors communicating with each other in real time to serve a meaningful purpose (Da Xu, and Zhao 2018). 5G makes this feasible due to its low latency (faster responsiveness) and high capacity (the ability to support the connection of huge numbers of devices at once).

IoT technology can be applied to innovations in various sectors such as:

i. Healthcare: IoT can enable remote monitoring of patients, the collection of medical data through multiple sensors, and the potential automation of initial responses to changes in patients' condition.
ii. Agriculture: Sensors can monitor soil and plant conditions and deploy unmanned agricultural equipment, water sprinklers, or drones carrying seeds, fertilizer, or insecticide as required.
iii. Transportation: IoT can be used for traffic control, fleet management, remote vehicle diagnostics, and even remote control of vehicles. Autonomous vehicles will

rely on 5G and IoT to gather, process, and respond to information rapidly in real time.

iv. Manufacturing: The automation and real-time monitoring of manufacturing processes including production floor, troubleshooting, and quality control will be enhanced by IoT.

v. Business: Business Intelligence, Big Data Analytics, Supply Chain Management, Process Automation, and many more business-critical concepts will benefit from 5G and IoT.

vi. Retail: In retail, IoT can augment inventory management, customer tracking and engagement, consumer data gathering, and customer self-service. vii. Energy: Energy companies are increasingly turning to IoT technologies to enhance their grid optimization, energy distribution, predictive maintenance, and remote asset management and monitoring.

3. Mission Critical Services (MCS)

Mission Critical Services (MCS) are digital services requiring an extremely high level of reliability and ultra-low latency, with very little room for error or loss of connectivity, such as telemedicine, autonomous vehicles, autonomous drones, smart power grids, and manufacturing processes. 5G's characteristics will enable and enhance the deployment and operation of MCS.

4. Virtual and Augmented Reality (VAR)

Virtual (VR) and Augmented (AR) Reality applications can be used for various purposes including education, training, design, marketing, engineering, troubleshooting, maintenance, simulation, healthcare, and much more.

These applications require the real-time processing of massive amounts of data to render intricate graphical scenes, recognize real world objects, superimpose relevant information, and make sense of the complex input mechanisms for interacting with the virtual or augmented environment. The low latency and elevated data capacity of 5G will help to eliminate the lag, stutter, and stalls typically experienced by users when using sophisticated VR and AR applications over current (4G) networks, providing a smooth and seamless user experience.

SCOPE OF THE STUDY

The scope of the study is to review the implementation strategic plans for the deployment of 5G technology in Nigeria. This Plan takes into account the expectations of all the stakeholders in the communications industry in Nigeria. In line with the strategy of the Federal Government of Nigeria for the acceleration of the National Digital Economy for a Digital Nigeria and the positioning of Nigeria as an early adopter of digital technology and a major participant in the growing global digital economy, the successful and timely deployment of 5G is crucial. It is expected to facilitate several emerging technologies, generate innovative new use cases, spur significant socio-economic growth, and job creation.

BACKGROUND

5G network infrastructures are made up of macro- and micro base stations with edge computing capabilities. In a 5G network, network functions that typically run on hardware become virtualized, running as software (https://www.ntia.doc.gov/files/ntia/, 2020). In this section, related literatures are reviewed; the conceptualization of 5G technology, a critical theoretical review of implementation across the world and discussion on the issues are addressed.

CONCEPTUALIZATION OF 5G TECHNOLOGY

Wireless communication technology is one of the rapidly changing developments nowadays (Tugbiyele, 2019). As part of its rapid changing, International Mobile Telecommunications (IMT)-Advanced Specifications of Fourth Generation (4G) Terrestrial Mobile Telecommunication was approved by the International Telecommunication Union Radio Standards Sector (ITU-R) in January 2012 (Kelechi,et al., 2018), (Mgbodille, 2018). However, there are a lot of debate that surrounded the implementation of new generations' Wireless network technology and its devices currently referred as 5G wireless network. In the last fifteen years, mobile and wireless networks made significant growth which impacted peoples' life positively. In the present days, mobile phones are equipped with WLAN and WiMAX adapters in addition to 3G and 4G technologies (Hoffman, 2018). The 5G network architecture was designed to support present and future infrastructure implementation modules (Marzal, S., et al). and was aimed at achieving high data rate, low latency, low power consumption, improved system capacity and the most important thing; more device connectivity (Galadanci,and Abdullahi, 2018).

EMPIRICAL REVIEW

Mobile and Wireless communication technology experienced progressive evolution during the last few decades, it progressed from Zero Generation (0G) to First Generation (1G), Second Generation (2G), Third Generation (3G), Fourth Generation (4G) and now the entire world is moving towards Fifth Generation (5G) as shown in figure 1 (Idowu-Bismark, et al.2019). This progressive change was aimed at improving Quality of Service (QoS), efficiency, reliability, scalability,

performance and trustworthiness (Kotulski, et. al., 2018), (Shi, et al. 2019).

1G is the first generation wireless telephone technology, Cell phones. They were analog cell phones and were introduced in 1980 (Reka and Dragicevic, 2018). 2G is the Second-

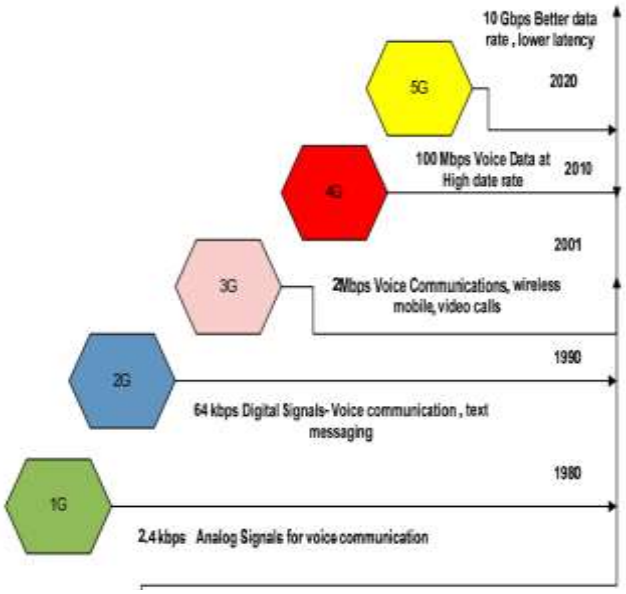

Figure 1: Wireless communications technology and its evolution over the years.
Source: Dragicevic et. al. (2019)

Generation wireless cell phones, based on digital technologies and in early 1990's. 3G is the third generation of mobile phone standards and technology, superseding 2G, and preceding 4G (Lee et al. 2018). 5G technology is not yet deployed by many countries; including Nigeria. When this becomes available in Nigeria, it will provide very high speeds to the consumers. It would also provide efficient use of available bandwidth (Chen et al. 2018).

In March 2020, the Nigerian National Broadband Plan 2020 – 2025 was released, updating and building upon the previous Plan (2013 – 2018). The new Broadband Plan unveiled a detailed strategy for rapid rollout of broadband services across the nation and sets goals for effective coverage, minimum data download speeds in both urban and rural areas, and data pricing, but does not fully or directly address 5G deployment (NCC, 2020).

The success of 5G deployment and commercial operation in Nigeria will be highly reliant on a defined strategy. The priority is therefore to create a Plan that ensures the advancement of 5G while also addressing the challenges and issues that are specific to 5G deployment.

THEORETICAL REVIEW

Many countries across the world have taken different approaches to participate in 5G technology implementation. Some of them focused on the development of 5G infrastructure, while others focused on the development of associated applications of technologies and services which either enhance the 5G experience or advances the 5G capabilities. According to Colin and Simon (2019), the summary of the current ongoing or just recently concluded trials of 5G and the associated technologies is briefly reviewed as follows:

EARLY 5G DEPLOYMENT TRIALS GLOBALLY

Some of the early 5G deployment trials as in (https://www.theguardian.com, 2019) include the following:

1) **Japan**: The trial in Japan was planned for selected areas in Tokyo, and the aim was to evaluate the performance of prospective 5G technologies in a live environment. The country had scheduled to launch a 5G network in Tokyo on time for the summer 2020 Olympics.
2) **South Korea:** Samsung and KT Corporation had completed early connectivity trials. The next phase upon the completion of these trials was the setting up of the first Mobile 5G trial at the Pyeongchang Winter Olympics for 2018. All three Korean mobile operators are expected to launch commercial 5G service before the end of the year 2020.
3) **United States**: Verizon and AT&T approached the US Government for multi-year licences to run 5G tests.
4) **China**: China Mobile, China Unicom and China Telecom all announced 5G testing with telecommunications vendors Huawei and ZTE.
5) **Australia:** Telstra, in partnership with Ericsson, tested one of the world's first 5G Radio testbeds in Melbourne.
6) **Sweden**: Telia worked with Ericsson to conduct trials in Kista, Sweden, over a live 5G network.

5G COMMERCIAL LAUNCHES ACROSS THE WORLD

There are about ninety-two (92) commercial launches of 5G networks in Thirty-Eight (38) countries across the world spread across all regions of the world as at July 2020. There are currently 92 commercial deployments of 5G in 38 countries (David et al. 2018).

5G DEPLOYMENT INFRASTRUCTURE

5G requires new infrastructure, including cell towers and antenna – known as small cells and Distributed Antenna Systems (DAS). The cells could be any of the following according to Watts, (2020):

- Macrocell - that covers a wide area
- Microcell - that covers a small urban or rural area
- Picocell - that covers a business-size premise and
- Femtocell - that covers a home or small business

DRIVING TECHNOLOGIES

Many new technologies have driven the development of 5G. However, according to (Watts, 2020), the main ones are:

1) **Virtualization**: The network element architecture is distributed internally onto specific types of blades that perform specific tasks.
2) **Cloud Native:** This technology allows service providers to accelerate both the development and deployment of new services by enabling practices such as DevOps, while the ability to rapidly scale up or scale down services allows for resource utilization to be optimized in real-time, in response to traffic spikes and one-time events.
3) **Containers**: This technology is used to optimize hardware resources to run multiple applications, and to improve flexibility and productivity. They are also used where low-latency, resilience and portability are key requirements; for example, in Edge computing environments.
4) **Microservices**: these are an architectural and organizational approach to software development where rather than be developed in a monolithic fashion, software is composed of small independent services that communicate over well-defined APIs. It is often considered a variant of the service-oriented architecture approach. The overall aim with microservices architectures is to make applications easier to scale and faster to develop, enabling innovation and accelerating time-to-market for new features. They also, however, come with some increased complexity including management, orchestration and create new data management methods.
5) **Automation**: One of the main drivers for the evolution of the core network is the vision to deliver networks that take advantage of automation technologies. Across the wider ICT domain, Machine Learning, Artificial Intelligence and Automation are driving greater efficiencies in how systems are built and operated. Within the 3GPP domains, automation within Release 15 and Release 16 refer mainly to Self-Organizing Networks (SON), which provide Self-Configuration, Self-Optimization and Self-Healing. These three concepts hold the promise of greater reliability for end-users and less downtime for service providers. These technologies minimize lifecycle costs of mobile networks through eliminating manual configuration of network elements as well as dynamic optimization and troubleshooting.

DEPLOYMENT PLAN IN NIGERIA

The Federal Government will provide an enabling environment for 5G deployment, but the Mobile Network Operators (MNOs) will determine their own deployment Strategies subject to alignment to the approved polices and other regulatory instruments in force. However, the obvious strategy at this time would involve a phased approach (www.ncc.gov.ng/documents/918, 2020).

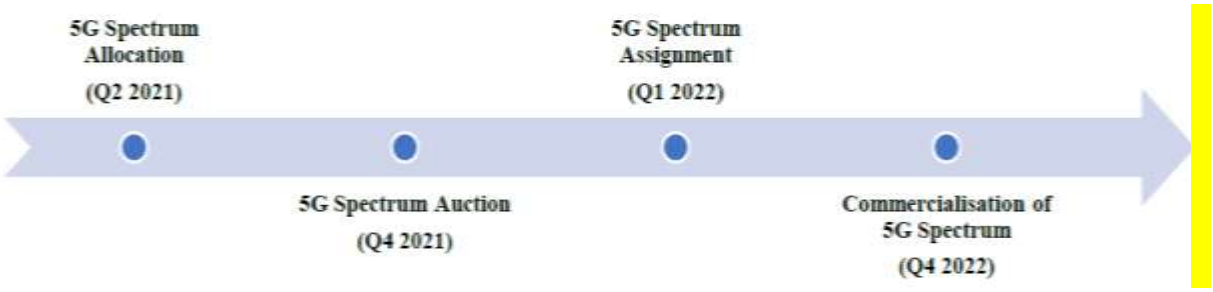

Figure 2: 5G Spectrum Release Timeline. Source: www.ncc.gov.ng/documents/918, (2020).

Indications suggest that majority of operators in different markets will opt for a phased strategy, involving a Non-Stand Alone (NSA) approach for the early stage, a hybrid approach mid-term, and a Stand-Alone approach long term. This phase approach will accommodate device availability.

For the early stage of Nigerian 5G deployment strategy (2020 – 2021), a Non Stand-Alone approach will involve deployment of 5G equipment on some existing sites, supported by densified networks of small cells.

The mid-term stage (2021 – 2025) will involve a hybrid approach with new-build 5G sites added to the small cell networks. Depending on demand and Return On Investment (ROI), this hybrid scenario may be seen by some as a long-term solution.

The long-term stage (post 2025) should see Stand Alone networks deployed and will require the largest infrastructure investment.

PHASE 1 5G SPECTRUM RELEASE TIMELINE

Securing spectrum for 5G is an antecedent for any operator to commit serious investment to 5G infrastructure. This makes it imperative for the spectrum allocation and assignment process to be concluded as early as possible. The following timeline in figure 2 is therefore proposed as optimal (www.ncc.gov.ng/documents/918, 2020)

PLANNING REGULATIONS

Many existing policies, regulations, and processes pertaining to the deployment of wireless networks were designed for previous generation networks (Dalibor, 2020).

With 5G, however, MNO network planning has become much more complex, with heavy reliance on small cells as opposed to large cell towers. Some of these cells may be located on street furniture or on buildings. Flexible and fit-for-purpose regulations will be required. Sitting regulations and permits will need to be updated urgently to take this into consideration and help accelerate 5G deployments by easing previous restrictions that are no longer valid. Completion of the updates should be timed to coincide with the assignment of 5G spectrum.

The relevant building regulators and urban and town planning agencies should collaborate and ensure that buildings are designed to ensure ICT services are included in the building codes. The Commission will also engage in strategic collaboration with relevant agencies to explore lower deployment costs and encourage long term investments in communications infrastructure (Brown et. al., 2020).

NIGERIAN 5G DEPLOYMENT PLAN AND TIMELINES

The deployment plans and timelines for the Nigerian 5G deployment is shown in figure 3.

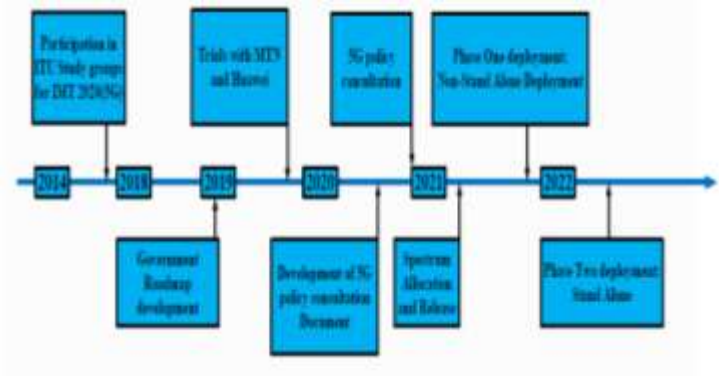

Figure 3: 5G Deployment Plan in Nigeria.
Source: www.ncc.gov.ng/documents/918 ,(2020)

The deployment plans for Nigeria is shown in figure 3. Nigeria envisages a two-stage deployment approach with the phase one deployment based on the Non-Standalone approach and the Phase two based on the Stand-alone approach. Phase one is planned to commence in 2021 and the phase Two deployment which rely on new spectrum allocations is planned to commence in 2022.

The deployment plans and timelines in figure 3 shows that the adopted strategy, funding and technology trials are critical in planning the launch of the 5G technology.

There are commercial 5G networks already launched in several countries across the world. Several other countries have also moved on to deploy 5G technology.

DISCUSSION

The mobile data traffic in Nigeria is on an upward trajectory, increasing exponentially year on year. There is thus the need for an effective and cost-efficient network expansion to ensure optimal support for this traffic growth. Cisco predicted that by 2020, global mobile data traffic would have grown eightfold from 2015 to 2020, a compound annual growth rate of 53%. This assertion is based on the higher flow rate of data, the advent of new systems and technologies such as the IoT and smart cities. A recent World Economic Forum report concluded that 5G networks would contribute $13.2 trillion in economic value globally and generate 22.3 million jobs from direct network investments and residual services (Arias et. al. 2020). Accenture in a 2017 study concluded that 5G could create USD500 billion in additional GDP and 3million jobs in the US through a USD275 billion investment by telecom operators. A similar study by the European Commission estimated that the benefit of 5G in Europe would reach EUR 113 billion per annum in four key sectors namely automotive, healthcare, transport and energy, creating 2.3 million jobs. A global study commissioned by Qualcomm also concluded that 5G would enable USD12.3 trillion of economic output by 2035 with the

numerous advantages of 5G technology, it is coupled with a

myriad of regulatory challenges that need to be addressed before 5G rollout, such as spectrum allocation and assignment and infrastructure challenges as discussed in section 2.4 as well as coping with the global rejection of Huawei 5G infrastructure (www.ncc.gov.ng/documents/918, 2020).

While the NCC is desirous of deploying the 5G technology, there is a need to focus on the key strengths available in the country. The youth population and the Digital Economy Policy of Government presents an opportunity for Nigeria to focus on the development of innovating products and services which will be significantly enhanced by the deployment of the 5G Technology in Nigeria. Some of such approaches include the setting up of technology hubs and the sponsorship of startup events and research projects for SMEs and academia to stimulate innovation among the youth and the research community in the country.

SUMMARY

Fifth Generation (5G) wireless communication network development was an initiative in furtherance to the current Fourth Generation (4G) wireless communication network technology. The 5G networks for future applications in all domains provide prospects for a fully connected society.

Key Challenges of 5G Network implementation in Nigeria and benefits of deployment such as Enhanced Mobile Broadband (eMBB), Internet of Things (IoT), Mission Critical Services (MCS) and Virtual and Augmented Reality (VAR) which can be used for various purposes including education, training, design, marketing, engineering, troubleshooting, maintenance, simulation, healthcare, and much more are discussed.

The progressive evolution of Mobile and Wireless communication technology experienced during the last few decades from Zero Generation (0G) to Fifth Generation (5G) are discussed.

There are about ninety-two (92) commercial launches of 5G networks in Thirty-Eight (38) countries across the world spread across all regions of the world as at July 2020.

The Federal Government will provide an enabling environment for 5G deployment, but the MNOs will determine their own deployment Strategies subject to alignment to the approved polices and other regulatory instruments in force.

Nigeria like other countries such as Japan, South Korea, China, Australia, United States and Sweden have taken different approaches to participate in 5G technology implementation.

5G deployment implementation plans and timelines for the Nigerian were scheduled to commence from 2014 to 2022. Despite the advantages of 5G technology, there are regulatory challenges that need to be addressed before 5G rollout; such as spectrum allocation and assignment and infrastructure challenges.

CONCLUSION

The new 5G technology provides diverse abilities and encourages full networking among countries globally. It progressed from Zero Generation (0G) to First Generation (1G), Second Generation (2G), Third Generation (3G), Fourth Generation (4G) and now the entire world is moving towards Fifth Generation (5G). 5G deployment implementation plans and timelines for the Nigerian was scheduled to commence from 2014 to 2022. 5G network technology guaranties 90% reduction in network energy usage, Up to ten year battery life for low power, machine-type devices. Most of the challenges identified manifest at the point of deployment, while others were government policy related challenges. These can be reduced or even eliminated entirely through government policies, stakeholders' dialogue, Technology transformation and improvement, needs assessments and prosper monitoring and supervision of service providers. The promise of 5G is coupled with a myriad of regulatory challenges that need to be addressed before 5G rollout, such as spectrum allocation and assignment, infrastructure challenges, right-of-way issues, network security, privacy, health and safety, and so on. However, 5G deployment implementation in Nigeria will in no doubt generate billions of naira as additional GDP and create millions of jobs.

RECOMMENDATIONS

1) There is a need for plan to cater for compatibility of deployments across 3G, 4G and 5G and between different operators
2) Security training is recommended for the operators to develop in-country talent capability
3) There is a need for development of test beds for 5G implementation
4) There is a need for government policies, regulators and stakeholders' dialogue, and proper monitoring and supervision of service providers

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