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5G Network Architecture and Emerging Technologies and its Economic Implication to the Nigerian Post Covid-19 Economy

Raphael Ilofe Olong, Emmanuel Tashiwa Ibrahim, Muhammad Uthman*

Faculty of Engineering, University of Abuja
olongraphael@yahoo.com, emmanueltashiwa@yahoo.com, *m.uthman@yahoo.com

Abstract Fifth Generation (5G) mobile technology wireless communications and its economic implication in Nigeria present diverse prospects. An enormous increase in data speed; up to 100 times faster than current 4G LTE; is expected with 5G technology in addition to lower latency and an increase in the number of connected devices amongst others. This substantial improvement would enable numerous new technologies such as autonomous vehicles, industrial Internet of Things, and telemedicine. With the emergence of the global pandemic as a result of the novel Coronavirus (COVID-19), this is even more pertinent for the Nigerian economy to harmonize with the rest of the world. For the Nigerian economy to profit from these technological developments, some challenges towards its adoption need to be addressed especially with regards to infrastructure and consumer attitude. Telephone and Internet density has experienced a quantum growth over the last decade since the deregulation of telecommunications, but the contribution to Gross Domestic Product (GDP) has not been proportionate as a result of uneven distribution in the teledensity between urban and rural and general lack of awareness and education. Based on this research, it was discovered there is poor service delivery on the part of the Internet Service Providers (ISPs), very expensive data plans for the consumers, and unsatisfactory customer experience. It is projected that 5G technology would be able to eliminate some of these deficiencies creating thousands of new jobs especially in the areas of trade and e-commerce, manufacturing, healthcare, transportation amongst others, and this is made more urgent with the presence of COVID-19.

Keywords 5G, Emerging Technology, Pandemic, COVID-19

Introduction

Our economic and professional activities have now largely shifted online with video teleconferencing becoming more popular as a result of the global pandemic caused by the novel Coronavirus (COVID-19), which was first discovered in Wuhan, Hubei Province, China towards the end of the year 2019 [1] which has forced businesses, teachers, students, etc. to all work from home over the internet. This has also lead to the enhanced use of other wireless communications services such as voice messaging, internet, and video, these have become a critical constituent of most economic activity and even more vital to our personal and professional lives. This reputation has been attained through considerable advances in mobile communications abilities and service quality with each successive generation of network technology; from the analog First Generation (1G) service in the 1980s through the current Fourth Generation Long Term Evolution (4G LTE) generation of technology [2] of providing high-quality mobile broadband services with end-user data rates of quite a lot of megabits per second over wide areas and tens, or even hundreds, of megabits per second locally [3].

The far-reaching potentials in terms of the improvements of mobile communication networks, along with the origination of new types of mobile devices such as smartphones and tablets, have produced an upsurge of new applications which will be used in cases for mobile connectivity and consequential exponential growth in network traffic [3] as nations are today galvanized by Information Technology (IT), its sociology, business and technology and how people live and work which the advent of COVID-19 has accelerated this growth and galvanization.

5G refers to the 5th generation of mobile telecommunications technology. The main difference between 5G and its predecessor, 4G, is that 5G will have higher data rates, lower latency [4], and higher connection density [5]. For these reasons, it is expected to be the most critical element of the digital society in the next decade [6]. With the advent of COVID-19, this has become even more significant. 5G can turn mobile technology into a General Purpose Technology (GPT) that is one adopted across numerous industries and with the transformative potential to redefine work processes and the rules of competitive economic advantage [7] which Nigeria needs to key into to remain competitive with the rest of the world. 5G wireless networks promise significant improvement in data speeds (up to 100 times faster than current LTE), single-digit (millisecond) latency, and a significant increase in the number of wirelessly-connected devices (capacity), compared to current 4G LTE networks [8]. These enhancements are expected to enable several new cases, such as autonomous vehicles, the industrial Internet of Things (IoT), and telemedicine [9]. 5G will support these improvements because it is designed to exploit not only the low-band spectrum, which historically has been used for mobile voice and data services, but also mid- and high-band spectrum while exploiting the propagation characteristics of the different spectrum bands [10].

Samplings of these new technology components are different ways of accessing spectrum and considerably higher frequency ranges, the prompting of massive antenna configurations, direct device-to-device communication, and ultra-dense deployments [11].

5G´s standard, International Mobile Telecommunications-2020 (IMT-2020) which will define how the network operates and interworks, is planned to be agreed upon in the year 2020. It will allow the implementation of the following three key technologies:

- Enhanced mobile broadband (eMBB): can handle more devices and higher data volume, decreasing the cost per gigabyte (by 10 times compared to a basic 4G site [12]. At the same time, the lower prices would increase the demand for mobile services, fostering its deployment [13].
- Ultra-reliable and low-latency communications (URLLC): enables low-latency monitoring and real-time control. It would support applications such as autonomous vehicles, by improving the cooperative automatic driving through the real-time exchanged among cars connected in the same area, and the deployment of the Industry 4.0 [14], by the implementation of time-critical process control, intra/inter-enterprise communication and connected goods [15].
- Massive machine-type communications (mMTC): allows the connectivity to tens of billions of machine-type terminals [16], boosting, for example, the development of smart cities through the efficient allocation of resources, the better provision of public services and a decreased environmental impact [13].

In this research, the future of wireless communications is presented looking at some of the vital challenges the Nigerian economy may face adopting this technology. This is with a comparison of what was experienced with previous mobile communications like 2G, 3G, and 4G. With the surfacing of COVID-19, which has indirectly accelerated the adoption of more teleconferencing for business, there is a need for Nigeria to reposition itself for full adoption to remain competitive with the rest of the world.

Research Background

Although in Nigeria, internet and telephone density has experienced substantial growth in the last ten years since the telecommunication deregulation policy and with recent studies displaying the percentage contribution of the telecommunication industry to the GDP to be at 10.11% in 1st quarter of 2019 from the 9.85% of the last quarter of 2018 with internet subscription increasing from 115,938,225 of March 2019 to 119,506,430 of April 2019 [17], it's still unable to achieve the 40% broadband penetration set by the international telecommunication union (ITU) for developing countries [18], [19] due to the persistent failure of local Internet Service Providers (ISPs) and Mobile Network Operators (MNOs), inadequate power supply, poor telephone infrastructure, insufficient fiber optics ring, scarcity of data workers and digital skills, high cost of bandwidth and poor satellite capabilities. These bottlenecks have dwarfed the anticipations of the citizens to fully participate in the new world economic order; the engines of world economic and social development galvanized by e-commerce and

world trade which is expected to contribute about $23 trillion by 2025 to world GDP [20], [21]. This would significantly be altered because of the COVID-19 pandemic the world is going through.
Implementation of the 5G network will allow the full deployment of the digital economy, which in Nigeria could create thousands of jobs and revenue increase per year in ten key sectors: communication, manufacturing, public safety, media and entertainment, healthcare, automotive, health, public transport, energy, and utilities. The implementation of 5G technology is expected to increase mobile data traffic at a compound annual growth rate although the global COVID-19 pandemic could revise this growth forecast. For this reason, the need for the 5G network becomes essential for the capitalization of these data assets with high speed and low-latency. Therefore bridging the existing gap in the labor market and the launch of the in industry 4.0[22]; the fourth industrial revolution which strive for a transformative technology to transform the industry through cyber-physical systems networked collectively like smart factories, smart machines, intelligent robots and interconnected machines in a supply chain [23]. Examples of such technology are the Internet of Things (IoT) and Artificial Intelligence (AI). Post COVID-19, the Nigerian economy would be required to be harmonized with the rest of the interconnected world economy to ensure maximum profit for the country.

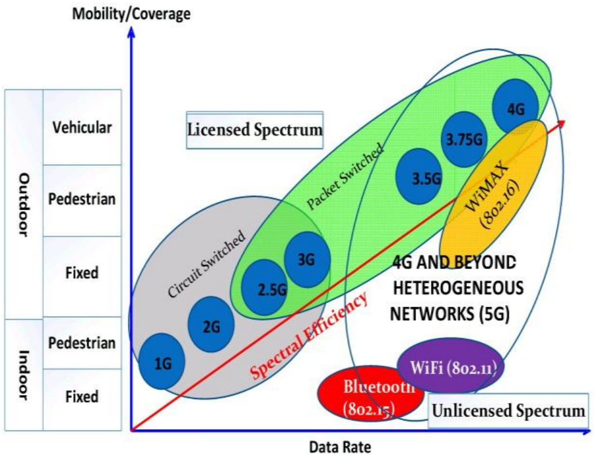

Figure 1: Evolution of Wireless Technology [3]

3. Evolution from 1G to 5G Technology

The first generation was announced originally in the 1980s. It has a data rate of up to 2.4kbps. Major subscribers were the Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS). It has a lot of drawbacks like below par capacity, reckless handoff, inferior voice associations, and with no security, since voice calls were stored and played in radio towers due to which vulnerability of these calls from unwanted eavesdropping by third party increases [7].
The second generation was introduced in the late 1990s. Digital technology is used in second-generation mobile telephones. Global Systems for Mobile communications (GSM) was the first second-generation system, chiefly used for voice communication and having a data rate of up to 64kbps. 2G mobile handset battery lasts longer because of the radio signals having low power. It also provides services like Short Message Service (SMS) and e-mail. Vital eminent technologies were GSM, Code Division Multiple Access (CDMA), and IS-95 [3] - [7].
The 2.5G generally subscribes to a second-generation cellular system merged with General Packet Radio Services (GPRS). A 2.5G system generally uses 2G system frameworks, but it applies packet switching along with circuit switching. It can assist data rates up to 144kbps. The chief2.5G technologies were GPRS, Enhanced Data Rate for GSM Evolution (EDGE), and Code Division Multiple Access (CDMA) 2000 [3] - [7].
The third-generation (3G) was established in late 2000. It imparts the transmission rate up to 2Mbps [3]. 3G systems merge high-speed mobile access to services based on Internet Protocol (IP). Aside from the transmission rate, an unconventional improvement was made for maintaining Quality of Service (QoS). Additional facilities like global roaming and improved voice quality made 3G as a remarkable generation. The major disadvantage of 3G handsets is that they require more power than most 2G models. Along with this, 3G

network plans are more expensive than 2G [3] - [7]. Since 3G involves the introduction and utilization of Wideband Code Division Multiple Access (WCDMA), Universal Mobile Telecommunications Systems (UMTS) and Code Division Multiple Access (CDMA) 2000 technologies, the evolving technologies like High-Speed Uplink/Downlink Packet Access (HSUPA/HSDPA) and Evolution-Data Optimized (EVDO) has made an intermediate wireless generation between 3G and 4G named as 3.5G with an improved data rate of 5-30 Mbps [3].

Long-Term Evolution technology (LTE) and Fixed Worldwide Interoperability for Microwave Access (WiMAX) is the future of mobile data services. LTE and Fixed WiMAX has the potential to supplement the capacity of the network and provides a substantial number of users the facility to access a broad range of high-speed services like on-demand video, peer to peer file sharing and composite Web services. Along with this, a supplementary spectrum is accessible which accredit operators manage their network very compliantly and offers better coverage with improved performance for less cost [4] - [7].

4G is commonly referred to as the descendant of the 3G and 2G standards. A 4G system improves the predominant communication networks by conveying a comprehensive and dependable solution based on IP [3]. Amenities like voice, data, and multimedia will be transmitted to subscribers anytime, anywhere and at quite higher data rates as related to earlier generations. Applications that are being made to use a 4G network are Multimedia Messaging Service (MMS), Digital Video Broadcasting (DVB), and video chat, High Definition TV content, and mobile TV [11], [4] - [7].

An idea to shift towards 5G is based on recent themes, it is commonly anticipated that 5G cellular networks must address six challenges that are not effectively addressed by 4G i.e. higher capacity, higher data rate, lower End to End latency, massive device connectivity, reduced cost and consistent Quality of Experience provisioning [24], [25]. These challenges are succinctly considered along with some potential facilitators to address them. An overview of the challenges, facilitators, and corresponding design fundamentals for 5G [26] was recently introduced in IEEE 802.11ac, 802.11ad, and 802.11af standards and are very helpful and act as building blocks in the road towards 5G [27] -[28].

4. 5G Cellular Network Architecture

To envision the 5G network in the market now, it is manifest that the multiple access techniques in the network require swift improvement. Current technologies like Orthogonal Frequency Division Multiple Access (OFDMA) will work at least for the next 50 years [29]. Moreover, there is no need to have a change in the wireless setup which had come about from 1G to 4G. Alternatively, there could be only the addition of an application or amelioration done at the fundamental network to satisfy user requirements. This might entice service providers to drift to a 5G network as early as 4G is commercially set up [12]. To meet the demands of the user and to overcome the challenges that have been put forward in the 5G system, a drastic change in the strategy of designing the 5G wireless cellular architecture is required. An overall observation of the researchers has shown in [30] that most of the wireless users stay inside for approximately 80 percent of the time and outside for approximately 20 percent of the time [31]. In contemporary wireless cellular architecture, for a mobile user to communicate whether inside or outside, an outside base station present in the middle of a cell helps in communication. So for inside users to communicate with the outside base station, the signals will have to travel through the walls of the indoors, and this will result in very high penetration loss, with corresponding costs will reduce spectral efficiency, data rate, and energy efficiency of wireless communications [3]. To overcome this challenge, a new idea or designing technique that has come into existence for scheming the 5G cellular architecture is to the distinct outside and inside setups [32]. This idea will be supported with the help of massive Multiple Input Multiple Output (MIMO) technology [33], in which geographically dispersed array of antennas are deployed which have tens or hundreds of antenna units. Since present MIMO systems are using either two or four antennas, but the idea of massive MIMO systems has come up with the idea of utilizing the advantages of large array antenna elements in terms of huge capacity gains [34].

To build or construct a large massive MIMO network, firstly the outside base stations will be fitted with large antenna arrays and among them, some are dispersed around the hexagonal cell and linked to the base station through optical fiber cables, aided with massive MIMO technologies [35]. The mobile users present outside are usually fitted with a certain number of antenna units but with cooperation, a large virtual antenna array can be constructed, which together with antenna arrays of base station form virtual massive MIMO links. Secondly, every building will be installed with large antenna arrays from outside, to communicate with outdoor base stations with the help of a line of sight components [3]. The wireless access points inside the building are connected with the large antenna arrays through cables especially optical fiber for communicating with indoor users. This will significantly improve the energy efficiency, cell average throughput, data rate, and spectral efficiency of the cellular system but at the expense of increased infrastructure cost [37]. With the introduction of such an architecture, the inside users will only have to connect or communicate with inside wireless access points while larger antenna arrays remained installed outside the buildings [32]. For indoor communication, certain technologies like WiFi, Small cell, ultra-wideband, millimeter-wave communications [38], and visible light communications [39] are useful for small range communications having large data rates. But technologies like millimeter-wave and visible light communication are utilizing higher frequencies which are not conventionally used for cellular communications [3]. But it is not an efficient idea to use these high-frequency waves for outside and long-distance applications because these waves will not infiltrate dense materials efficiently and can easily be dispersed by rain droplets, gases, and flora [3].

Table 1: KPIs for 5G networks [36]

KPI items	KPI for 5G Networks	Definitions
Peak data rate	≥10 Gbps	Maximum achievable data rate by user
Minimum guaranteed user data rate	≥100 Mbps	Minimum experience data rate by user
Connection Density	1 million connections km^{-2}	Number of connected devices per unit area
Traffic density	≥10 Tbps km^{-2}	Total network throughput per unit area
Radio latency	≥1 ms	The duration between a packet is available at the IP layer in a base station and the availability of this packet at the IP layer in a terminal
End-to-end Latency	Millisecond level	The duration between transmitting a data packet from source node and successfully receiving it at the destination node
Mobility	Up to 500 km h^{-1}	The relative velocity between the receiver and transmitter

Table 2: Summary of the main technical requirements for 5G use cases [40]

Use case	Requirements	Desired value
Autonomous vehicle control	Latency	5 ms
	Availability	99.999%
	Reliability	99.999%
Emergency communication	Availability	99.9% victim discovery rate
	Energy efficiency	1week battery life
Factory cell automation	Latency	<1 ms
	Reliability Packet loss	< 10-9
High-speed train Mobility 500 km/h	Traffic volume density	100 Gbps/km^2 in DL, 50 Gbps/km^2 in UL
	Experienced user throughput	50 Mbps DL, 25 Mbps UL
	Latency	10 ms
Large outdoor event	Experienced user throughput	30 Mbps
	Traffic volume density	900 Gbps/km^2
	Connection density	4 subscribers per m^2
	Reliability Outage probability	< 1%
Massive amount of geographically spread devices	Connection density	1,000,000 devices per km^2
	Availability	99.9% coverage
	Energy efficiency	10-year battery life

Media on demand	Experienced user throughput	15 Mbps
	Latency	5 s (start the application), 200 ms (after possible link interruptions)
	Connection density	4000 devices per km^2
	Traffic volume density	60 Gbps/ km^2
	Availability	95% coverage
Remote surgery and Examination	Latency	Down to below 1 ms
	Reliability	99.999%
Shopping mall	Experienced user throughput	300 Mbps in DL, 60 Mbps in UL
	Availability	At least 95% for all applications and 99% for safety-related applications
	Reliability	At least 95% for all applications and 99% for safety-related applications
Smart city	Experienced user throughput	300 Mbps DL, 60 Mbps UL
	Traffic volume density	700 Gbps/km^2
	Connection density	200 00 users per km^2
Stadium	Experienced user throughput	0.3-20 Mbps
	Traffic volume density	0.1-10 Mbps/m^2
Teleprotection in smart grid network	Latency	8 ms
	Reliability	100.00%
Traffic jam	Traffic volume density	480 Gbps/ km^2
	Experienced user throughput	100 Mbps in DL, 20 Mbps in UL
	Availability	95%
Virtual and augmented reality	Experienced user throughput	4-28 Gbps
	Latency	10 ms RTT

5. Research Design/Structure

This research used the qualitative research method to observe feelings, thoughts, behaviors, and the belief of the mass society. Examples of qualitative methods are action research, case study research, and grounded theory. Qualitative data sources include observation and participation observation (fieldwork), interviews and questionnaires, documents and texts, and the researcher's impressions and reactions.

For this research, the method of interviews, industry data collection, and standard global data sources were employed. The interview is a means of gauging the awareness and also the acceptance of internet products and services offered by several ISPs (Internet Service Providers) in Nigeria. Interviewing of selected individuals is a very important method often used by qualitative researchers. The rationale for using the interview methods is to enable the researcher to find out what is on their mind, what they think, and how they feel about something.

This research critically aims at gathering bits of information received from interviewing and data available from various service providers and organizations like the Nigerian Bureau of Statistics (NBS), Nigerian Communications Commission (NCC), the ITU, Global System for Mobile Association (GSMA), etc. to understand internet penetration in Nigeria and its limitations in achieving the global standard.

A. Population, Research sample and Sampling

The population in a study is all units possessing certain characteristics, which are of the interest of researchers' study. From the definition, the population can be understood as the targeted community or group of people who is involved or selected by the researcher for his study.

For this research, the population from which the samples were derived consists of the following groups of participants/interviewees:

i. Nigerian Male and Female internet users

ii. Selected ISPs and Governmental agencies

iii. International Organizations

In this research, the purposive sampling method for the selection of the participants was employed. Purposive sampling refers to intentionally chosen samples according to the needs of the study. This means the researcher selects participants because they have indicated their willingness to participate in the study. Likewise, this strategy enables the researcher to collect relevant and useful information for answering the research question. A face-to-face interview was conducted however several respondents are being interviewed through online survey tools using Google forms.

B. Research methodology

Considerable technical, economic and behavioral uncertainty is present as 5G is yet to be standardized, there are no market available 5G equipment costs, and we do not yet know the rollout strategies of Mobile Network Operators (MNOs) but this would be affected with the emergence of COVID-19. In this research, the incremental delivery of the required capacity as it relates to future demand was considered. The expected traffic demand is calculated based on the required user throughput and population density, assuming a broadband penetration of 100%. The capacity expansion principles used in this analysis focus on integrating a new spectrum (at 700 MHz and 3.4-3.6 GHz) into existing sites to meet traffic demand. If additional infrastructure capacity is required, remaining traffic is met by network densification enabled by small cell deployments operating initially at sub-6 GHz but which over the long-term may be utilizing millimeter-wave spectrum (~26 GHz).

The modeling methodology employed utilizes a top-down approach whereby sectors are segmented into seven geotypes based on population density, as this relates to expected demand.

We then dimension a network for these seven geotypes using site density and extrapolate existing 4G LTE and LTE-Advanced characteristics to 5G. The costs presented in the research are based on hypothetical network operators that may share traffic demand, spectrum, site locations, and network infrastructure, depending on the scenario.

The total cost is also calculated for shared small cell deployments on transport infrastructure, with the results being reported nationally as well as being visualized at the local authority level.

C. Library Research

Library research is a process dealing with the analysis of pieces of evidence such as historical records and documents. Similarly, it means gathering data from library materials which includes textbooks, both published and unpublished academic documents such as journals, conference proceedings, dissertations, and theses. Library research also includes information gathered from an internet search.

The literature review consists of data gathered from numerous journals regarding internet technology and activities all over the world.

6. Results and Discussions

A. Broadband Penetration

Broadband Penetration is a measure for the extent of access to broadband communications within the population of a particular location. According to the UN Sustainable development goals, 40% Broadband Penetration must be attained by developing countries like Nigeria. Industry statistics released by NCC in 2019 has shown that Nigeria is yet to attain the required for Sustainable development of the telecommunication industry and likewise service delivery to the customers. Table 3 shows the corresponding penetration from Nov-18 to Oct-19.

Table 3: Broadband Penetration [41]

Month	No of Subscription	Penetration %
Oct- 19	72,289,389	37.87
Sept- 19	67,580,047	35.40
Aug – 19	67,009,771	35.10
Jul- 19	64,366,778	33.72
Jun- 19	63,593,329	33.31

May- 19	63,244,610	33.13
Apr- 19	64,332,974	33.70
Mar- 19	63,405,089	33.22
Feb-19	63,136,978	33.08
Jan- 19	61,732,130	32.34
Dec-18	60,087,199	31.48
Nov -18	58,965,478	30.90

B. Questionnaire Results

How would you rate the quality of internet services by ISPS

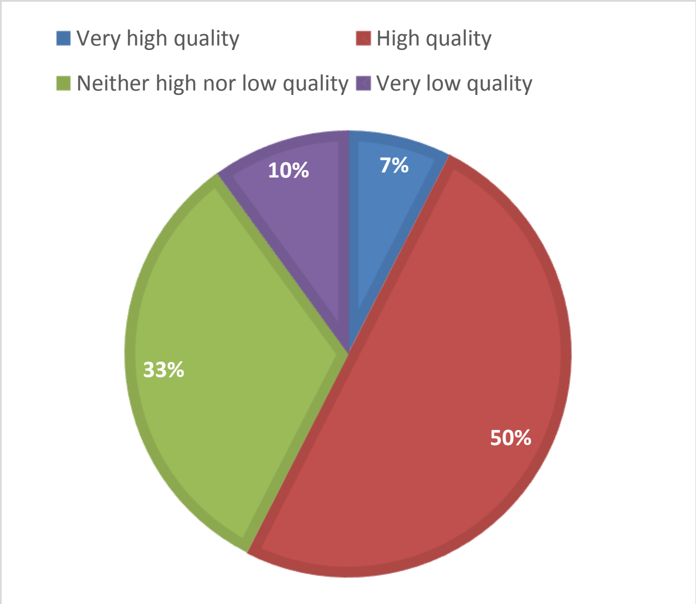

Figure 2: Quality of Internet Services

How would you rate the value for money of the services

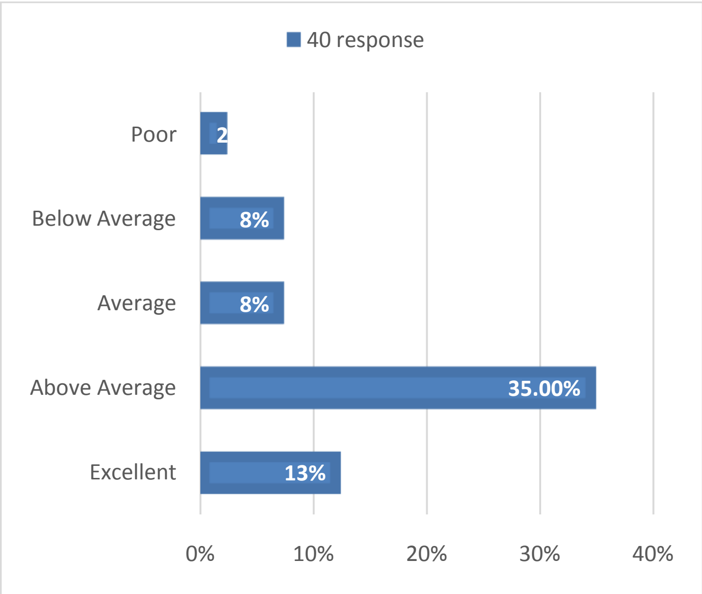

Figure 3: Value of Money for Internet Services

How well do ISPs meet your needs

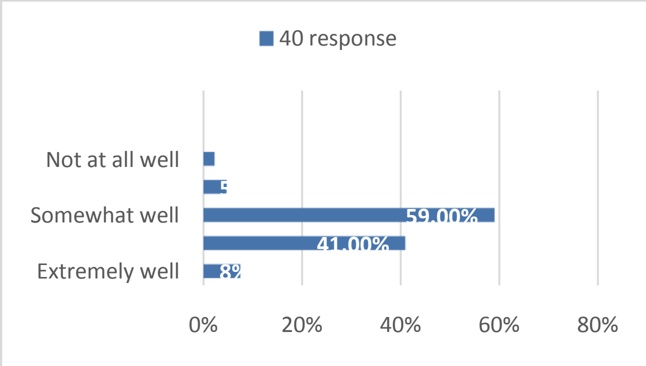

Figure 4: Customer Service

The findings from the tables above reinforce the fact that poor internet services and its high cost are the key factors militating against internet growth and diffusion in Nigeria. These services by the Local ISPs can be attributed to irregular electricity generation and high bandwidth cost from satellite providers. As the global economy is experiencing the COVID-19 pandemic and the massive shift towards teleconferencing for personal, business, and professional uses, the above findings need to be addressed urgently for Nigeria to key into the global economic benefits post COVID-19.

Subscriber/Teledensity

Table 4: Subscriber/Teledensity [41]

Month	No. of Subscription	Teledensity (%)
Oct- 19	180,386,316	94.50
Sept- 19	179,176,930	93.87
Aug – 19	176,897,879	92.67
Jul- 19	174,950,011	91.65
Jun- 19	174,024,116	91.17
May- 19	173,672,333	90.98
Apr-19	173,641,060	90.97
Mar- 19	173,713,842	91.00
Feb- 19	173,670,035	124.05
Jan- 19	174,012,136	124.29
Dec- 18	172,871,094	123.48
Nov- 18	169,104,830	120.79

Percentage (%) contribution of the Telecoms industry to GDP

Table 5: Percentage (%) Market share by technology [41]

Quarter	Percentage
Q3 2019	9.20%
Q2 2019	11.39%
Q1 2019	10.11%
Q4 2018	9.85%

7. The 5G Challenge both from the Technological and Economic Point of View

Nigeria is faced with economic and societal challenges such as aging of populations, societal cohesion, and sustainable development. The introduction of digital technologies in economic and societal processes is key to addressing these challenges. 5G network infrastructures will be a key asset to support this societal transformation, leading to the fourth industrial revolution impacting multiple sectors. In the next decade, it is expected that the manufacturing industry will evolve towards a distributed organization of production, with connected goods, low energy processes, collaborative robots, integrated manufacturing, and logistics. The COVID-19 crises have further brought forward these requirements which Nigeria needs to get on board quickly since businesses have been forced to work from home or remotely over the internet. These concepts are notably embodied under the Industry 4.0. The automotive and transportation sector will bring to market autonomous and cooperative vehicles before end of year 2020 with significantly improved safety and security standards, as well as new multimodal transportation solutions which is very much required in the fight against COVID-19.

5G will open the field to new business value propositions and cross-vertical collaboration as well as benefit Small and Medium Enterprises' (SMEs) engagement and entrepreneurs. However, these opportunities depend on our ability to leverage 5G over previous investments and on a regulatory framework that the Nigerian government needs to work quickly on in the face of the global COVID-19 pandemic.

8. Causes of Low Teledensity in Nigeria

i. Literacy and telecommunication technology awareness

The gap between the information-rich developed countries and Africa, concerning information availability, continues to increase every day and Nigeria is not an exception to this negative statistic.

Although information technology as grown in Nigeria in the past ten years. However, there is a wide gap between telecommunication subscriptions and penetration. For example, Table 5 and Table 6 show more increase in subscription in Nigeria but reality, the penetration is very low since most subscriptions are concentrated in the urban areas. Inadequate data skills due to poor education also play a role in the low broadband penetration as many Nigeria do not possess adequate skills in computer languages.

ii. Poor energy supply

This implies that most of the times, generating sets are used to power IT systems. This increases the cost of application as much as twice the cost of the public electricity supply. This is one of the factors responsible for the collapse of most ISPs and Internet Cafes**.**

iii. Poor Service Delivery

Most internet access facilities are very slow and download speeds take much time. More time implies an additional cost of application. This performance de-motivates users who need information for research but are not able to have them when they need them**.**

iv. Low Bandwidth

National Bandwidth capacity needs to be increased via expansion of broadband access such as WiMax and Free Space Optics Technology (FSO), deployment of Fibre optics ring backbone, the launch of additional communications satellites in orbit and expansion of submarine cables.

9. Conclusion

In conclusion, 5G promises to be a solution facilitator for industries, providing an integrated communication platform desired for novel production models, and overcoming the limitations of the existing ways of delivering goods and services. With the advent of COVID-19 towards the end of the year 2019, this has accelerated the migration of business towards video teleconferencing and other internet related operations. The challenges associated with infrastructure and awareness among the populace when properly addressed will ensure a seamless transition to 5G. Nigeria would expect to see an increase in GDP within the next 5 years because there is going to be a quantum increase in e-commerce, industrialization, healthcare, transportation amongst others. Going by the research this adoption would be very beneficial to the country.

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