A SURVEY OF 3G TECHNOLOGIES; VITAL TOOL IN NATIONAL MOBILE TELECOMMUNICATION (NMT) DEVELOPMENT

Agbaraji C. Emmanuel and Aririguzo I. Marvis
Department of Electronic and Computer Engineering,
Nnamdi Azikiwe University Awka, Nigeria

ABSTRACT
Today, almost all fields of human activities rely on the high-speed broadband technologies for their day-to-day activities. The banks for example, are making plans to implement better and more sophisticated services such as cashless banking and other e-transactions as part of the NMT development goals. The 3G network coverage has become a problem in most rural and parts of the urban cities in Nigeria. However, the national mobile telecommunication development goals cannot be achieved without addressing the issue of 3G coverage in the country. The objective of this paper is to investigate the 3G technologies, their applications and the situation in developing nations especially Nigeria. The NMT development was reported to lag behind in the global telecommunication development and 2G networks are still more prevalent in most areas than 3G networks. It was concluded that the full deployment and coverage of 3G network will enhance the success of the NMT goals.

KEYWORDS: *3G, Broadband, CDMA, EDGE, GSM, HSPA, ICT, LTE, Mobile Telecommunication, UMTS.*

I. INTRODUCTION

Information and Communication Technology uptake has continued to grow worldwide [1], with 3G technology [2] as the key or the major driving force towards this achievement and growth. Mobile Broadband is an exciting new technology that allows connection to the Internet without the usual ADSL router and telephone line setup. Using the connection is not limited in the house - as the name suggests it allows connection while mobile as it uses wireless technology, so that the Internet and e-mail can be accessed anywhere (as long as the 3G signal is available). Therefore the usage of the 3G service depends on the availability of the 3G signal in an area.

3G is a term used to represent the third generation of mobile telecommunications technology [2; 3]. This is a set of standards used for mobile devices and mobile telecommunication services and networks that comply with the International Mobile Telecommunications-2000 (IMT-2000) specifications by the International Telecommunication Union [3]. 3G finds application in wireless voice telephony, mobile Internet access, fixed wireless Internet access, video calls and mobile TV [4]. Several telecommunication companies market wireless mobile Internet services as 3G, indicating that the advertised service is provided over a 3G wireless network. Services advertised as 3G are required to meet IMT-2000 technical standards, including standards for reliability and speed (data transfer rates). To meet the IMT-2000 standards, a system is required to provide peak data rates of at least 200 kbit/s (about 0.2 Mbit/s) [4]. Recent 3G releases often denoted 3.5G and 3.75G, also provide mobile broadband access of several Mbit/s to smartphones and mobile modems in laptop computers. There are standards that are typically branded 3G which will be extensively used in this work which include UMTS (Universal Mobile Telecommunication System) and CDMA2000 (Code Division Multiple Access-2000).

The UMTS system, first offered in 2001, standardized by 3GPP, used primarily in Europe, Japan, China (however with a different radio interface) and other regions predominated by Global System for Mobile Communication (GSM) 2G system infrastructure. The cell phones are typically UMTS and GSM hybrids. The CDMA2000 system, first offered in 2002, standardized by 3GPP2, used especially in North America and South Korea, sharing infrastructure with the IS-95 2G standard. The cell phones are typically CDMA2000 and IS-95 hybrids. The latest release EVDO Rev B offers peak rates of 14.7 Mbit/s downstream [2].

The above systems and radio interfaces are based on spread spectrum radio transmission technology. While the GSM EDGE standard ("2.9G"), DECT cordless phones and Mobile WiMAX standards [2] formally also fulfill the IMT-2000 requirements and are approved as 3G standards by ITU, these are typically not branded 3G, and are based on completely different technologies. A new generation of cellular standards has appeared approximately every tenth year since 1G systems were introduced in 1981/1982. Each generation is characterized by new frequency bands, higher data rates and non backwards compatible transmission technology. The first release of the 3GPP (Third Generation Partnership Project) Long Term Evolution (LTE) standard does not completely fulfill the ITU 4G (Forth Generation) requirements called IMT-Advanced. First released LTE is not backwards compatible with 3G, but is a pre-4G or 3.9G technology, however sometimes branded "4G" by the service providers. Its evolution LTE Advanced is a 4G technology. WiMAX (Global Interoperability for Microwave Access) is another technology verging on or marketed as 4G. Conversely in this work, the 3G technologies represent the various flavors of 3G and beyond 3G technologies.

While the mobile broadband network development has been on the rise and has recorded great impact in most developed nations. The mobile telecommunication industry in the developing nations such as Nigeria had generally suffered from lack of high speed mobile broadband facility development, rather growing gradually with high market attraction and recording a little impact in most sectors. Despite the high market attraction of the mobile broadband in Nigeria and other developing nations, it has been suggested that they should invest more in the adoption of 3G technologies. Different sectors of work in the government and the society are planning or have started to bring in facilities that are totally dependent on high speed mobile network service for full functionality. Recently, the Joint and Matriculation Board in Nigeria announced that by 2015 all JAMB examinations will be computer-based and students will have their scores instantly [5]. The banking industry had already introduced the e-banking and cashless banking and planning for full implementation. GSM operators MTN and Zain have also applied to the Central Bank of Nigeria (CBN) for m-banking licenses, with the aim being to expand into mobile banking services [6]. Both operators believe that the service will add value to their subscribers and plan to target both the banked and unbanked populations. These and many other services are the goals of the NMT development in the country.

However, with the 2G networks (GSM, GPRS and EDGE) having more coverage in the rural areas and some parts of the urban areas, the 3G network coverage currently available in some areas will not be enough to support the electronic and internet based services proposed or already implemented by almost all the sectors such as education, banking, health, security, and other social establishments.

Section two presents the review of the previous works, overview of the 3G technologies evolution and a brief history of the technologies. Section three provides the adoption of 3G technologies which was narrowed down to Nigeria, and the applications. Section four presents the results of the investigation and section five provides the conclusion and future work.

II. LITERATURE REVIEW

This section presents the previous works on 3G technologies, overview of the 3G developments and the standards guiding the development and implementation of the technology. The detailed breakdown of the technology and its history were also presented.

2.1 Previous Work

Alam, [7] worked on future prospects of 3G network in Bangladesh. He also presented an analysis of the ICT infrastructure status, available 3G services, key challenges and recent successes recorded indicating 3G to be the next step of the ICT development. Sangwon et al [8] presented the deployment of 3G service network and a multinational analysis of contributing factor in which they stated that

successful diffusion of 3G mobile is necessary for the provision of many advanced applications via the mobile platform such as mobile broadband Internet and video. Simba et al [9] carried out surveys on the available connectivity technologies with potentials to offer broadband access network to rural areas where they discussed on the deployment of WiMAX and 3G technologies in Africa. Jarmo [10] carried out investigations on the impact of 3G and beyond technology development and pricing by carrying out analyzes on the incumbent mobile operator business prospects in a large Western-European country.

2.2 Overview

The following common standards comply with the IMT2000/3G standard [4]:
Enhanced Data Rates for Global Evolution (EDGE), a revision by the 3GPP organization to the older 2G GSM based transmission methods, utilizing the same switching nodes, base station sites and frequencies as GPRS, but new base station and cellphone RF circuits. It is based on the three times as efficient 8PSK modulation scheme as supplement to the original GMSK modulation scheme. EDGE is still used extensively due to its ease of upgrade from existing 2G GSM infrastructure and cell-phones.
EDGE combined with the General Packet Radio Service (GPRS) 2.5G technology is called EGPRS, and allows peak data rates in the order of 200 kbit/s, just as the original UMTS WCDMA versions, and thus formally fulfills the IMT2000 requirements on 3G systems. However, in practice EDGE is seldom marketed as a 3G system, but a 2.9G system. EDGE shows slightly better system spectral efficiency than the original UMTS and CDMA2000 systems, but it is difficult to reach much higher peak data rates due to the limited GSM spectral bandwidth of 200 kHz, and it is thus a dead end. EDGE was also a mode in the IS-135 TDMA system, today ceased. Evolved EDGE, the latest revision, has peaks of 1 Mbit/s downstream and 400kbit/s upstream, but is not commercially used [4].
The Universal Mobile Telecommunications System (UMTS) created and revised by the 3GPP. The family is a full revision from GSM in terms of encoding methods and hardware, although some GSM sites can be retrofitted to broadcast in the UMTS/W-CDMA format. Wideband Code Division Multiple Access (W-CDMA) is the most common deployment, commonly operated on the 2,100 MHz band. A few others use the 850, 900 and 1,900 MHz bands. High-Speed Packet Access (HSPA) is an amalgamation of several upgrades to the original W-CDMA standard and offers speeds of 14.4 Mbit/s down and 5.76 MBit/s up. HSPA is backwards compatible with and uses the same frequencies as W-CDMA. HSPA+, a further revision and upgrade of HSPA, can provide theoretical peak data rates up to 168 Mbit/s in the downlink and 22 Mbit/s in the uplink, using a combination of air interface improvements as well as multi-carrier HSPA and MIMO. Technically though, MIMO and DC-HSPA can be used without the "+" enhancements of HSPA+ [4].
The CDMA2000 system, or IS-2000, including CDMA2000 1x and CDMA2000 High Rate Packet Data (or EVDO), standardized by 3GPP2 (differing from the 3GPP), evolving from the original IS-95 CDMA system, is used especially in North America, China, India, Japan, South Korea, Southeast Asia, Europe and Africa [31]. CDMA2000 1x Rev. E has an increased voice capacity (in excess of three times) compared to Rev. 0 EVDO Rev. B offers downstream peak rates of 14.7 Mbit/s while Rev. C enhanced existing and new terminal user experience. While DECT cordless phones and Mobile WiMAX standards formally also fulfill the IMT-2000 requirements, they are not usually considered due to their rarity and unsuitability for usage with mobile phones [4].

2.3 Detailed Breakdown of 3G Systems

The 3G (UMTS and CDMA2000) research and development projects started in 1992. In 1999, ITU approved five radio interfaces for IMT-2000 as a part of the ITU-R M.1457 Recommendation; WiMAX was added in 2007 [11]. There are evolutionary standards (EDGE and CDMA) that are backwards-compatible extensions to pre-existing 2G networks as well as revolutionary standards that require all-new network hardware and frequency allocations. The cell phones used utilize UMTS in combination with 2G GSM standards and bandwidths, but do not support EDGE [12]. The latter group is the UMTS family, which consists of standards developed for IMT-2000, as well as the independently developed standards DECT and WiMAX, which were included because they fit the IMT-2000 definition. EDGE fulfills the 3G specifications, most GSM/UMTS phones report EDGE ("2.75G") and UMTS ("3G") functionality [4].

2.4 Brief History

3G technology is the result of ground-breaking research and development work carried out by the International Telecommunication Union (ITU) in the early 1980s. 3G specifications and standards were developed after fifteen years of persistence and hard work. The technical specifications were made available to the public under the name IMT-2000. The communication spectrum between 400 MHz to 3 GHz was allocated for 3G. Both the government and communication companies unanimously approved the 3G standard [4]. The first pre-commercial 3G network was launched by NTT DoCoMo in Japan in 1998, branded as FOMA. It was first available in May 2001 as a pre-release (test) of W-CDMA technology. The first commercial launch of 3G was also by NTT DoCoMo in Japan on 1 October 2001, although it was initially somewhat limited in scope; broader availability of the system was delayed by apparent concerns over its reliability.

The first European pre-commercial network was an UMTS network on the Isle of Man by Manx Telecom, the operator then owned by British Telecom and the first commercial network (also UMTS based W-CDMA) in Europe was opened for business by Telenor in December 2001 with no commercial handsets and thus no paying customers. The first network to go commercially live was by SK Telecom in South Korea on the CDMA-based 1xEV-DO technology in January 2002. By May 2002 the second South Korean 3G network was by KT on EV-DO and thus the Koreans were the first to see competition among 3G operators. The first commercial United States 3G network was by Monet Mobile Networks, on CDMA2000 1x EV-DO technology, but this network provider later shut down operations. The second 3G network operator in the USA was Verizon Wireless in July 2002 also on CDMA2000 1x EV-DO [13]. AT&T Mobility is also a true 3G UMTS network, having completed its upgrade of the 3G network to HSUPA [4].

The first pre-commercial demonstration network in the southern hemisphere was built in Adelaide, South Australia by m.Net Corporation in February 2002 using UMTS on 2,100 MHz. This was a demonstration network for the 2002 IT World Congress. The first commercial 3G network was launched by Hutchison Telecommunications branded as *Three* or "3" in June 2003. Emtel launched the first 3G network in Africa [4].

By June 2007, the 200 millionth 3G subscriber had been connected [4]. This is only 6.7% of the 3 billion mobile phone subscriptions worldwide. In the countries where 3G was launched first – Japan and South Korea – 3G penetration is over 70% [14]. In Europe the leading country for 3G penetrations is Italy with a third of its subscribers migrated to 3G. Other leading countries for 3G uses include UK, Austria, Australia and Singapore at the 20% migration level. A confusing statistic is counting CDMA2000 1x RTT customers as if they were 3G customers. If using this definition, then the total 3G subscriber base would be 475 million at June 2007 and 15.8% of all subscribers worldwide [4].

III. ADOPTION OF 3G TECHNOLOGIES

3G was relatively slow to be adopted globally [4]. In some instances, 3G networks do not use the same radio frequencies as 2G so mobile operators must build entirely new networks and license entirely new frequencies, especially so to achieve high data transmission rates. Other delays were due to the expenses of upgrading transmission hardware, especially for UMTS, whose deployment required the replacement of most broadcast towers. Due to these issues and difficulties with deployment, many carriers were not able to or delayed acquisition of these updated capabilities.

Japan was the first in the world to adopt 3G services in 2001 [15]. The 3G mobile phone diffusion in Japan could be classified in terms of technological innovations, marketing strategies and competition policy of mobile phone operators [16]. In December 2007, 190 3G networks were operating in 40 countries and 154 HSDPA networks were operating in 71 countries, according to the Global Mobile Suppliers Association (GSA). In Asia, Europe, Canada and the USA, telecommunication companies use W-CDMA technology with the support of around 100 terminal designs to operate 3G mobile networks [4].

Base on Pyramid Research [6], GSM technology remains the dominant platform in the mobile market, representing 90% of total subscriptions. Respectively, 2G, 2.5G and 3G technologies accounted for 17%, 75% and 8% of subscriptions at year-end 2009 [6]. Pyramid Research expects 2.5G and 3G+ technology, including CDMA2000, GPRS, EDGE and UMTS/HSPA, to play an increasingly important role in spreading Internet access to the millions of Nigerians who are currently unable to obtain access through fixed-line networks. The lack of a competing fixed-line Internet offering in most regions of

Nigeria has made mobile networks the only Internet option for both business and residential customers. CDMA operators such as Visafone have made a successful business model out of this with CDMA-based technologies, and we expect them to stay strong in this segment given their expansion plans. GSM-based operators such as MTN, Glo Mobile and Zain are also increasingly making inroads in the mobile Internet market with UMTS-based service.

Glo Mobile was the first operator in Nigeria to launch mobile access to the Internet, with other 3G licensees replicating the move soon thereafter. MTN launched an HSDPA-enabled 3.5G network in June 2008, while Zain launched its 3G service in early 2009 [6]. Early in the year 2012, Airtel Nigeria finalized arrangements to showcase the latest data and Internet offerings on its newly upgraded 3.75G network at this year's edition of the West African Information and Communication Technology congress [17].

3.1 Applications of 3G Technologies

The bandwidth and location information available to 3G devices gives rise to applications not previously available to mobile phone users. Some of the applications are [4]:

Mobile TV: Mobile television is television watched on a small handheld or mobile device. It includes pay TV service delivered via mobile phone networks or received free-to-air via terrestrial television stations. Regular broadcast standards or special mobile TV transmission formats can be used. Additional features include downloading TV programs and podcasts from the internet and the ability to store programming for later viewing. According to the Harvard Business Review, the growing adoption of smartphones allowed users to watch as much mobile video in just three days of the 2010 Winter Olympics as they watched throughout the entire 2008 Summer Olympics – an increase of 564% [18].

Video on Demand: Video on Demand (VOD) or Audio and Video on Demand (AVOD) are systems which allow users to select and watch/listen to video or audio content on demand. IPTV technology is often used to bring video on demand to televisions and personal computers [19]. Catch up TV is a form of video on demand. Some airlines offer AVOD as in-flight entertainment to passengers through individually controlled video screens embedded in seatbacks or armrests or offered via portable media players. Airline AVOD systems offer passengers the opportunity to select specific stored video or audio content and play it on demand including pause, fast forward, and rewind [20].

Video Conferencing: Videoconferencing is the conduct of a videoconference (also known as a video conference or video teleconference) by a set of telecommunication technologies which allow two or more locations to communicate by simultaneous two-way video and audio transmissions. It has also been called 'visual collaboration' and is a type of groupware. Videoconferencing differs from videophone calls in that it's designed to serve a conference or multiple locations rather than individuals [21]. It is an intermediate form of video telephony, first deployed commercially in the United States by AT&T Corporation during the early 1970s as part of their development of Picture-phone technology.

With the introduction of relatively low cost, high capacity broadband telecommunication services in the late 1990s, coupled with powerful computing processors and video compression techniques, videoconferencing usage has made significant inroads in business, education, medicine and media. Like all long distance communications technologies (such as phone and Internet), by reducing the need to travel to bring people together the technology also contributes to reductions in carbon emissions, thereby helping to reduce global warming [22; 23; 24]. Figure 1, shows a Tandberg T3 high resolution telepresence room in use in 2008.

Figure 1: A high resolution telepresence [25].

Telemedicine: Telemedicine is the use of telecommunication and information technologies in order to provide clinical health care at a distance. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations. Although there were distant precursors to telemedicine, it is essentially a product of 20th century telecommunication and information technologies. These technologies permit communications between patient and medical staff with both convenience and fidelity, as well as the transmission of medical, imaging and health informatics data from one site to another. Early forms of telemedicine achieved with telephone and radio have been supplemented with videotelephony, advanced diagnostic methods supported by distributed client/server applications, and additionally with telemedical devices to support in-home care [26].

Location-based services: Location-based services are a general class of computer program-level services used to include specific controls for location and time data as control features in computer programs. As such (LBS) is an information and has a number of uses in Social Networking today as an entertainment service, which is accessible with mobile devices through the mobile network and which uses information on the geographical position of the mobile device. This has become more and more important with the expansion of the smartphone and tablet markets as well [27; 28; 29]. LBS are used in a variety of contexts, such as health, indoor object search [30], entertainment, work, personal life, etc [32; 32]. LBS include services to identify a location of a person or object, such as discovering the nearest banking cash machine or the whereabouts of a friend or employee. LBS include parcel tracking and vehicle tracking services. LBS can include mobile commerce when taking the form of coupons or advertising directed at customers based on their current location. They include personalized weather services and even location-based games. They are examples of telecommunication convergence. This concept of location based systems is not compliant with the standardized concept of real-time locating systems (RTLS) and related local services [33; 34]

Global Positioning System (GPS): The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver. The GPS program provides critical capabilities to military, civil and commercial users around the world. In addition, GPS is the backbone for modernizing the global air traffic system.

The GPS project was developed in 1973 to overcome the limitations of previous navigation systems [35], integrating ideas from several predecessors, including a number of classified engineering design studies from the 1960s. GPS was created and realized by the U.S. Department of Defense (DoD) and was originally run with 24 satellites. It became fully operational in 1994. Advances in technology and new demands on the existing system have now led to efforts to modernize the GPS system and implement the next generation of GPS III satellites and Next Generation Operational Control System (OCX) [36].

IV. FINDINGS AND DISCUSSIONS

In Nigeria and other developing countries 2G networks (2G, 2.5G, and 2.9G) are still prevalent in the rural areas and in some towns in the urban areas making most broadband services unusable in such areas. 3G network is increasingly gaining coverage in the urban areas especially in the cities and towns. Pyramid forecasts in 2010 that over 55% of mobile subscriptions in the world will be using 3G+ in the next three years [6]. Figure 2 shows a global line by type of telecommunication service. According to Pyramid's estimates, the annual revenue from mobile services represents between 2% and 7% of African countries' Nominal GDP; in Nigeria this ratio is close to 4% [6].

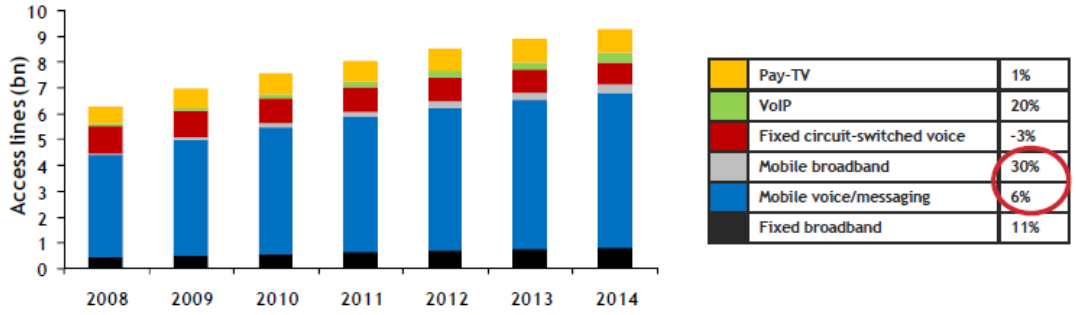

Figure 2: Global access lines by type, 2008-2014 [6].

The areas where mobile services can have an important impact include rural connectivity projects, education, health, finance, agriculture, transport and entertainment applications as shown in table 1. These connectivity projects and many more will only achieve full success when the 3G technology network becomes strongly available in the rural and urban areas in the countries.

The report released on Thursday October 11, 2012 by the International Telecommunications Union shows that Nigeria and other countries in Africa need to do more to gain top ranking in Information and Communications Technologies [1]. The situation is coming despite the advances in mobile telecommunication penetration in the region. This is because of the suspected low level of 3G technology adoption in the national mobile telecommunication network. Hence, the 3G technology has become a key player and a technical catalyst towards the national mobile telecommunications development to meet the contemporary ICT development in other countries in Asia, Europe and America.

The ITU report [1; 37] also shows that the ICT sector has become a major contributor to economic growth [38]. At the same time, ITU research and data suggest that developing countries need a relatively higher level of investment in advanced ICT services to fuel growth, mainly because ICT infrastructure levels are still limited. The new data, released in ITU's flagship annual report, measuring the Information Society 2012, ranked the Republic of Korea as the world's most advanced ICT economy, followed by Sweden, Denmark, Iceland and Finland [1].

Table 1: Areas where mobile telecommunication services have impacts [6]

Vertical	Nigeria	International
Rural Connectivity	Millennium Village Pampaida-extend telephony services to hard to reach rural areas	India: Gramjioti Pilot Program- provide mobile broadband connectivity to villages and towns around Chennai in India
Rural Connectivity	Rural Telephony Program- train and support local villagers to provide mobile based pay-phone services	Uganda: Village Phone train and support local villagers to provide mobile based payphone services
Education	Ladybird Mobile Reading Program- support classroom activities through mobile based educational exercises	South Africa: Dr. Mathleverage the MXit mobile social platform to provide tutoring services
Health	My Question, My Answer- SMS and phone operator based educational and counseling program covering the HIV/AIDS topic	Uganda: Text to Change- SMS based interactive quiz and educational tool covering the HIV/AIDS topic
Finance	Moneybox Africa- mobile commerce application to virtually store and move money, make payments and enable other mobile based financial transactions	Kenya: Safaricom M-Pesa- SMS based mobile payment and virtually store and move money, make payments and enable other mobile based financial transactions money transfer platform
Agriculture	Cassava Growers Project- disseminates market information in conjunction with information points and trade agents	Uganda: Grameen Market Information- disseminates market information through

		SMS, supported by Community Knowledge Workers
Transport	Hot FM Abuja Traffic Monitoring- Collects traffic information sent by listeners through SMS and mobile calls.	United States: OnStar- GSM based in-vehicle security and information service
Entertainment	DSTV and MTN Mobile TV Service- broadcasts content over a mobile network	South Africa: Mxit: WAP based instant messaging and social networking program

The positions of these countries at the top ranking can easily be attributed to their higher investment and commitment in ICT infrastructural development through production and technical contributions. Countries such as China, Japan, USA etc., have contributed technically towards ICT development and they are also into production and marketing of the ICT products. Some other countries in Europe, Asia and America such as Finland, India etc have most of the ICT facilities produced in their countries by some known companies such as Nokia, Samsung etc, which facilitates technological development. However, almost all the countries in Africa and few countries in other continents depend fully on consumption of mobile technology products whereby all the ICT facilities used are manufactured elsewhere and sold in these countries, making development to be stunted.

V. CONCLUSION

2G networks are still more prevalent in the rural areas and parts of urban areas in most developing nations such as Nigeria with 3G network increasingly gaining coverage in the urban cities. Annual revenue from mobile services was estimated to represent between 2% and 7% of African countries' Nominal GDP, therefore, full deployment and coverage of 3G network will boost the Nominal GDP significantly. It was concluded that full coverage of 3G networks will impact more in rural community projects, education, health, finance etc, consequently enhance the success of the NMT development goals.

We recommend that the developing nations should invest more in ICT development most especially in the areas of infrastructural production and technological research programs which will help to expedite the coverage of 3G network and its services.

VI. FUTURE WORK

Since smart mobile devices are increasingly taking over the market and the success of the potential mobile services prospect in the national telecommunication development is dependent on high speed data rate broadband networks, further research should be carried out on the 4G (Fourth Generation) [39, 40] technology network provisioning and diffusion alongside the 3G Technology [41] deployment especially in the rural areas.

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AUTHORS

Agbaraji C. Emmanuel - He obtained his B. Eng. and M. Eng. degrees in Electrical and Electronic Engineering from Federal University of Technology Owerri. Emmanuel is currently pursuing his Ph.D. in Nnamdi Azikiwe University Awka, Nigeria. His research areas include Communication, Software development, Robotics, and Artificial Intelligence.

Aririguzo I. Marvis - She obtained her B. Eng. and M. Eng. degrees in Electrical and Electronics Engineering from Federal University of Technology Owerri. Presently Marvis is pursuing her Ph.D. in Nnamdi Azikiwe University Awka, Nigeria. Her research areas include Data Communication, Robotics, Computing and Computer Networking.