Viability of 4G Mobile Network Deployment in Botswana

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Abstract—This paper discusses aspects of 4G wireless technologies which include architecture, features, comparison between 2G, 3G, 4G technology, and future growth of 4G in Botswana. There have been rapid strides in communication technologies, but the latest developments have been restricted to the first world countries. For example, the 4G technology has been rolled out largely, part of countries such as South Korea, Japan, and the United States that the third world still has to understand the benefits of these systems. It would therefore make an interesting exercise to understand the benefits of technology such as 4G in countries like Botswana, which is discussed in this paper.

Keywords— 4G, 3G, 2G Wireless Communications, Internet Bandwidth.

I. INTRODUCTION

The fourth generation technology (4G) which will assist improved data transfers with wireless service which has been introduced in the United States, Scandinavia and countries in the Far East, from 2001. The United Kingdom [2] is planning to use the mobile services that will use 4G to give fast downloads of high definition movies and songs in the year 2012. The service is expected to be seven times faster than the 3G. However problem consumers will have to use handsets that will accommodate 4G as they will be different from the 3G specifications.

The requirements for the 4G spectrum [6] were specified by the International Telecommunications Union-Radio Communications Sector (ITU-R) to the International Mobile Telecommunications Advanced (IMT-Advanced). The specifications included the requirements for the 4G which was setting 1Gbps for low mobile communication, for ordinary people and a high mobile communication 100 Mbps for trains, cars etc. Although the earlier released versions of Long term Evolution (LTE) and Mobile WiMAX did not provide peak bit rates of 1 Gbps, and therefore not IMT-Advanced compliant they are still branded as 4G by providers. However the ITU-R in December 6, 2010 took cognizant of the fact that the mentioned technologies and other technologies did not meet the IMT advanced requirements, could still be considered 4G as they provide substantial improvement in performance to the earlier third generation (3G) versions.

Mobile telephones were introduced in mid 1980’s which formed the first generation (1G), and the use of this service has only increase over the years. There is an estimated 2 Billion users in the work and about 80% of the users have access of mobile facilities within their vicinity.

Initially mobile networks were used for voice communication, but currently the usage in terms of data and video had increased which with the advent 3G technologies.

4G unlike the earlier generations does not implement circuit switched telephony, but uses the Internet telephony which is an Internet Protocol Based communication. The 4G also does not use the spread spectrum radio technology which is used in the 3G, and instead uses the orthogonal frequency-division multiple access (OFDMA) multi-carrier transmission and the frequency-domain equalization which gives it faster transmission rates. The bit rates are further made faster by the application smarter antenna arrays which are used in Multiple Input Multiple Output communication (MIMO).

Some of characteristics of 4g can be given as follows:

• The support for various radio interfaces such as 3G, Wireless LAN (WLAN), Lmax, Bluetooth (BT).
• Ability to allow multiple radio accesses.
• The ability to provide better spectral efficiency, i.e. user per volume, and fast data rates, 1 Gbps and 100 Mbps in stationary and mobile connections respectively.
• An IP core network will provide the system to work on.

This paper is explains the above theory of 4G with looking at the relevance to the developing world, using Botswana, Africa as the basis for the discussion.

II. 4G NETWORK ARCHITECTURE

Fig. 1: Generic 4G network Architecture [1]

2.1 Characteristics Of 4G

The European commission estimates that the 4G will provide seamless service, through various wireless systems in Figure 1, [1] and the delivery will be optimal, among the network systems available. There are often operational challenges attached to shifting between generations, as implementation of new technologies often leads more investment and incompatible technology to the previous generations.
Some of the key aspects of the 4G networks are given as follows:

2.1 The ABC Vision

4G provides GAN (Generic Network Access) formerly known as Universal Mobile Access, which provides seamless communication between various networks, local and cellular. There is suggestion that 4G will be a “network of networks” which will provide interoperable and uninterrupted communication between various networks. 4G debates in the European Union have been taking in the context of IST networks. The system’s vision is “ABC” which stands “Always Be Connected”. The idea is to have endless and efficient connection over heterogeneous networks which comprise of various wireless systems such as Global System for Mobile communication/General packet radio service(GSM/GPRS), Universal Mobile Telecommunication System(UMTS), Digital Video Broadcasting – Terrestrial(DVB-T), High Altitude Platforms(HAPS), Wireless local Area Network(WLAN). The wireless access networks will however have the following aspects in common

i. A dynamic addressing mechanism such as the Dynamic Host Configuration Protocol(DHCP), Internet Protocol version 6(IPv6) that will assist in providing short and long term addresses at wireless mobile interface.

ii. An IP forwarding service that is accessible at the IP layer of the mobile terminal and one and more gateways, e.g. Gateway GPRS support Node (GGSN), Mobile Internet Protocol (IP), and Foreign Agent (FA).

2.2 COMPARISON OF 2G, 3G AND 4G

Figure 2 shows the comparison of the three generation, 2G, 3G and 4G and the process of evolution of the different networks. 2G which was operational in the 1990’s, employed the Code Division Multiple Access (CDMA)and Global System for Mobile communication (GSM) which were two digital voice standards. GSM used the Time Division Multiple Access (TDMA) where in a 900 and 1800 MHz bands, and multiplexing would take place for eight calls per channel. Unlike 2G, the 3G would provide better, faster services and the GSM would use the circuit switched data which would give speeds upto 14.4 Kbps, apart from the voice communications. 3G technology will be discussed in detail in the next section.

In the case of 4G, the key to success is the uninterrupted communication between the heterogeneous nature of platforms and the service providers. There are multitudes of networks that provide different services, and the parameter to judge the performance of the services Quality of Service (QoS) varies between these services. In order to have the customer to deal with the various services without frustrating them is the key success of using the 4G network. It is important to provide maximum traffic flows between the various networks with minimizing the costs, but keeping in mind the QoS for the various traffic flows is different. Therefore across such heterogeneous systems it is important to maintain with an intelligent mediation between the various services. There is also a need to provide the customer with a universal roaming with a good service keeping in mind their preference irrespective of the network infrastructure provided. It can be observed from the picture Figure 2 given below, unlike earlier technologies like 2G and 3G, 4G uses an “intelligent” mediator to assist in providing better and faster connectivity.

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![Fig. 2: Evolution of Mobile Value Chain toward 4G [1]](image)

2.3 4G ARCHITECTURE FEATURES AND SERVICE PROVIDER REQUIREMENTS

Some of the features of 4G architecture are as follows

- It is not organized as monolithic structures rather have multiple service providers that work together to provide a cooperative and competitive environment.
- There is a heterogeneous service access for a variety of devices, networks and services, applications service and network providers. The key here is the mediation between the various service architectures.
- Various topologies which use cent raised approaches such as High speed circuit switched data (HSCSD), GPRS, Enhanced Data for Global evolution (EDGE), and Universal Mobile Telecommunication (UMTS), and Laos peer-to peer options such as Wi-Fi and Bluetooth technologies.
- Branding the services that will assist the businesses to identify the various service providers available, while providing the best service possible.

Some of the requirements of the end- to end service characteristics in 4G are as follows:

- The key aspect for end-to end frameworks in 4G network [3] is a provision for overlapping, independent connections looking at the domains the
There is also a need for better understanding of the business demands considering unlike conventional telephone approaches the 4G uses a heterogeneous environment which give difficulties while pricing and other business demands.

There must be no trust deficit between the various stakeholders, the clients, the different service providers considering the heterogeneous nature of these services. There has to be methodology of indentifying reliable and unreliable service providers by a mechanism of audit by a third party that will ensure quality service is provided.

A mechanism of providing a collaborative approaches that will consider some of the aspects mentioned above which will identify the frameworks to establish trust relationships. A collaboration of this nature will also provide the service providers to better access to different bandwidths which will ensure that quality service is provide to the customer.

Fault notification, service and recovery are some of the key aspects while working with end-to-end service providers.

### 2.3.1 Forerunner Versions of 4G

The following forerunner versions are provided under the 4G [6]

- **3GPP Long Term Evolution (LTE):** This can also be mentioned also as 4G-LTE, although not compliant to the IMT-Advanced requirements, has a bit rate of 100Mbit/s for the downlink and uplink but rate of 50 Mbit/s, for 20 MHz channel. However for MIMO where there are antenna arrays, the transfers are faster. LTE service was first publicly available in Scandinavian capitals Sweden and Oslo in 14 December 2009. Samsung manufactured the user terminals and the cellular companies that used systems were Ericsson, Nokia Siemens Network Systems for Sweden and Huawei for Norway. South Korea’s LG U+ and SK Telecom goal was to provide access to LTE service from 1 July 2011, and have nationwide transmission from 2012.

- **Mobile WiMax (IEEE 802.16e):** This service which follows the mobile wireless broadband access standard, which is also considered as 4G, provides downlink speeds of 128 Mbit/se and uplink speeds of 56 Mbit/s. The first commercial mobile WiMax was opened on June 2006, in Seoul, South Korea.

- **TD-LTE in the China Market:** The Long term Evolution (LTE) has seen a dramatic rise in the Chinese market. It was also observed according IBM study that LTE has found more favorable response from the market compared to WiMax, as many operators, 67% see this as the future technology. China Mobile, which is the China’s largest telecom company, has undertaken several field tests and the TD-LTE as a commercial entity is expected to roll out in the next two years.

It is important to understand how the 3G network operates as Botswana’s cellular companies such as Orange, Mascom and Be Mobile use this technology.

### 2.4 3G Technology

3G in the mobile environment for example provides transmissions in the wireless voice. Some of the other features of 3G technology are video downloads, e-commerce, services such as location based, audio and gaming (Rouse.M, 2009). It is estimated that there are about 100 million users of the 3G technology. The users in the developed world such as United States with 200 million subscribers showed 10% penetration in year 2006, while Japan showed over 50% users of 3G technology.

According to Internal Telecommunication Standards, 3G network which falls under IMT 2000 standards provides better spectral efficiency compared to the 2G. There has been an improvement of the data transfer rates as result of 3G. Three layers of significance, the top service layer, the middle layer which deals with data transmission control and bottom layer provides the connectivit information. 3G unlike Wi-Fi and IEEE 802.11 deals with cellular telephony and internet access. The companies FOMA in May 2001 and SK telecom in January 2002 of Japan and South Korea respectively were first companies to launch the 3G technology. This was followed by British Telecom and Monet Mobile networks of Britain of the United States respectively.

The network of 3G is different from 2G, as it uses a different bandwidth. There is need for infrastructure requirements and licenses that was the cause of the delay in using these networks in many countries. The cost implications as a result of the licensing and processing were also the cause of the delay in implementation of this technology in many countries. The download for this network is 14.4 Mbps and uploads is 5.8 Mbps.

Some of the characteristics of 3G are given as follows:

- Speeds offered by the General Packet Radio Service(GPRS) up to 114 Kbps.
- Global evolution i.e. EDGE can reach up to 384 Kbps.
- The downlink speeds of TMTS Wideband CDMA can be up to 1.92 Mbps.
- The LTE Evolved UMTS Terrestrial Radio Access (E-UTRA) can go up to 100 Mbps.

The evolution further involved in setting up of a 3rd generation Partnership Project which was meant to assist the transition of CDMA 2000 to 3G in the North American and Asian operations. The technologies under 3GPP2 involved the following:

- 1X RTT which is the one times Radio Transmission Technology to offer speeds up to 144 Kbps.
- The downlink speeds of Evolution Data Optimized (EV-DO) to be increased to 2.4 Mbps.
- An increased downlink speed by the EV-DO Rev A to peak speeds of 3.1 Mbps.
- Downlink speed by the EV-DO Rev B which can use two to fifteen channels to peak speeds of 4.9 Mbps.
- The Ultra Mobile broadband (UMB) to reach downlink speeds of 288 Mbps.

The 1X RTT was considered a transition to EV-DO. UMB and LTE can be considered as 4G but due lack of standardization this process this could be confirmed. The Revision A and B were meant to increase the data rates to through multiple channels. There is a constant drive for innovation for systems that provide mechanism of better data transfers and downloads, which is logical development of these technologies.

Some factors that lead to the growth of 3G adoption are as follows:

- Consumer demands has changed from a simple usage of the mobile telephones for voice communication to able look at features that 3G provides which is better video and music downloads, internet services with provision for email. IN Japan for example the 50% penetration of the 3G market has given a demand of almost 30% for data services and the remaining 70% for the voice communication.

- The cost plays a major role in upgrading the technology. For example in the United States it cost about $10 Billion to build the 3G networks

- The licensing agreement for buying the 3G spectrums costly, this in turn has an effect on the carriers that can use the network.

- There is a certain level of maturity while handling the 3G technologies as the cost implications, infrastructure setup will have to be evaluated before investment can be made. The various carriers such as UMTS, CDMA, or EV-Do will have to be fully understood while using this technology.

- Highly populated countries such as India and China will even 10-20% mobile subscribers can have significant impact in the usage of the 3G systems.

There are some companies such as Ericsson, Nokia, Samsung and AT & T that stand to gain from the 3G technology, while Research in Motion, Earth Link and Nortel networks that will use because of the technology.

### III. Practical problem of 3G in Botswana

In Botswana, the 3G networks that are used allow end users to stream video, download music and files, and surf the web at average download speeds of 600Kb/s to 1.4Mb/s. With 4G LTE end users will be able to do the same but at much faster rates, while the extra bandwidth opens the door for newer applications.

Internet Bandwidth is the major concern in the efficient use of 3G technology in Botswana. Unlike other countries Botswana is unable to use the benefits of 3G due to poor bandwidth. Although there are high end mobile handsets equivalent to other developed countries used in Botswana, the technology usage remains a challenge. The architecture however, cannot be blamed for inefficient use of the technology.

The Bandwidth concern should be handled separately with the Botswana Telecommunication Corporation. The research on Network Bandwidth issues in Botswana is beyond the scope of this paper.

### IV. 4G – Botswana Context

Mascom (one of the largest telecommunication companies in Botswana) has launched a pilot project for a new 4G LTE technology in Botswana. This makes the country among the few in the world to have the technology, and the third in Africa after Namibia and South Africa. The 4G network efficiency and effectiveness are comparatively better than 3G, which will ensure that the communications sector in Botswana will be better equipped to compete on a global stage.

Mascom will ensure that indeed Botswana achieves her goal of using ICT’s to drive the economy and maximize the economic and social benefits for Batswana. Mascom made an application for non-commercial LTE technical trials in mid-December last year to investigate technical matters such as compatibility with their existing systems, coverage, cell handover etc. Subsequently technical trials were allocated for Mascom spectrum in the 2.5G band, for four months period. The target is to provide the fastest mobile broadband in Botswana which currently is at 21 Mbps. Botswana also wishes to have the lowest internet tariffs and be able to sustain Mascom’s innovative drive.

4.5 LTE Mascom would be the first to pilot that in the country and will be one of the first in the region. MTC of Namibia was the first operator in Africa to commercially roll-out 4G LTE in the African continent.

The 4G rollout will set Mascom as a market leader and market pioneer in the industry. It was also the first to start mobile operations in the country in 1998, first to have a 100% EDGE data network in 2005/2006 and they have also become the first to deploy a 3.5 data network in 2008. Recently they were also the first to complete the Neleletsa II project[4]. Mascom views the rolling out the 4G technology in Botswana, as a successful and profitable venture which will ensure growth of the communications, e-commerce sectors.

### V. Conclusion

In this paper, the history of 4G technology was discussed. The following conclusions were drawn regarding 4G technologies:

i. A comparison of the architectures of 2G, 3G, and 4G assisted in better understanding the growth of technologies and communication systems, and showed how 4G systems have better advantage to the end user as they make use intelligent mediators, faster and more efficient wireless system.

ii. The developed countries such as South Korea, Japan, the United States have taken a lead in using the technologies which is largely due to investment in the research, technology and infrastructure by the telecommunications sector in those countries.

iii. There are some challenges to currently used 3G systems in Botswana, which can be attributed to bandwidth problems.

iv. In Botswana, Mascom a leading mobile company has been taking trials and test runs for rolling out 4G LTE in Botswana. However Mascom Botswana, views the 4G systems as a future profitable venture which would revolutionize the communications and e-commerce sectors in Botswana.
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REFERENCES