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Virtual Mobile Networks For Affordable Mobile Broadband: Towards A Working Model

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Abstract**—***Broadband access and the broadband network infrastructure on which it is based is a key enabler for economic and social growth. Broadband changes everything. It enables the delivery of essential services from e-health, e-education, e-commerce to e-government. A survey of the Zambian telecommunications industry reveals that broadband connection is expensive. The factors that contribute to the cost of broadband are operational costs, such as backhaul transport; which must be shared between voice and mobile broadband, site rental, network maintenance and electricity. This paper explored how all IP networks can be used to deploy virtual mobile networks considering architectures like the 3GPP's Evolved Packet Core.*

Virtual mobile networks do not need to own licensed frequency allocation of radio spectrum nor do they necessarily have to own all the infrastructure required to provide mobile telephone services, these can be leased from Mobile Network Operators, leading to a considerable reduction in capital expenditure as well as operating expenditure which in turn leads to cost reduction in the provision of mobile broadband services. Ultimately the paper concluded that a Virtual Mobile Network based on Evolved Packet Core, have the potential to provide sustainable and affordable access to Mobile Broadband.

Keywords*—mobile broadband; evolved packet core; mobile network operator; virtual mobile network;*

I. Introduction

It is commonly accepted that in many ways the liberalization of telecommunications industry has generally increased efficiency, increased the number of people who receive services, lowered prices, and improved the choice and quality of services provided. However, even in open competition environments which are properly regulated, ensuring universal access and service remains a challenge [1]. Mobile broadband penetration remains at below 20% in Africa [2] and developing nations like Zambia lag behind in the implementation of high speed mobile broadband. According to the Zambia Information and communications Authority (ZICTA) statistics, only 32.15% of mobile subscribers have access to mobile broadband. Significant technological, service and competitive changes taking place in telecommunications require significant capital expenditure. This coupled with need to secure appropriate spectrum are some of the challenges the telecommunications industry is facing in providing wide spread high speed mobile broadband access. There is need for industry and regulators to establish systems and policies that will encourage technical and service innovation. Virtual Mobile Networks (VMNs) are an example of innovative service providers that can spur universal access and service in the context of mobile broadband. This paper attempts to create a model of VMN with an evolved packet core, however, interfaces and protocols are not discussed in detail.

A. The current state of mobile broadband service

It was necessary to have a synopsis of the current state of mobile broadband service provided by

Mobile Network Operators (MNO) and to determine whether there was a need for an alternative mobile broadband model. A survey research was carried out, the approach used consisted of getting information from responses to a survey that was distributed to mobile broadband users and information from secondary sources such as the MNOs websites as well as the website of the national regulating authority's website (ZICTA). From a sample frame of 250, a sample of 50 participants was chosen using simple random sampling. The closed ended survey questions were grouped the following way; factors that influence choice of provider, availability of broadband connection, cost of mobile broadband connection per month. Analysis of the issues highlighted revealed that;

- End - users based the choice of a mobile broadband service provider based on coverage, speed and price.
- Majority users had 3G connection, with few connecting to 4G. Network peed varied regularly and connection dropped regularly and the cost of connection was very high and prohibitive.
- Mobile broadband was preferred over fixed broadband; most users consumed more than 3GB of data per month for business, educational and entertainment purposes.

A survey of the ZICTA website revealed the network coverage of each MNO. The MNOs website provided the pre-paid prices of mobile data bundles. Table 1 below shows mobile network coverage, table 2, 3 4 and 5 show the prices of data bundles per month by operator.

TABLE1. NETWORK COVERAGE BY OPERATOR

Network Coverage	
Operator	***Coverage %***
Airtel	42.1
MTN	44.1
Vodafone	-
Zamtel	27.0

Source: www.zicta.zm

TABLE2. DATA BUNDLES PRICES - AIRTEL

Airtel	
Bundle	***Price Per Month (K)***
1GB	134
2GB	190
5GB	415
10GB	700

Source: www.africa.airtel.com

TABLE3.DATA BUNDLES PRICES - MTN

Data Bundles Prices MTN	
Bundle	***Price Per Month (K)***
75MB	20
150MB	35
300MB	60
500MB	100
1GB	130
2GB	185
3GB	265.50

Source: www.mtnzambia.com

TABLE4. DATA BUNDLES PRICES - VODAFONE

Data Bundles Prices Vodafone	
Bundle	***Price Per Month (K)***
500MB	102.18
2GB	189.03
5GB	235.00
10GB	255.44
25GB	561.96
50GB	1020.72
100GB	1890.22

Source: www.vodafone.zm

TABLE5. DATA BUNDLES PRICES – ZAMTEL

Data Bundles Prices Zamtel	
Bundle	***Price Per Month (K)***
10MB	7.81
25MB	10.68
50MB	19.23
100MB	32.05
250MB	69.43
300MB	76.91
500MB	102.55
1GB	122.84
1.5GB	181.59

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Source: www.zamtel.zm

From the results obtained, it was clear that currently end-users considered mobile broadband to be expensive even though it was their preferred mode of internet access. The network coverage affected the availability of the broadband connection. End users would move to a provider with wider network coverage and cheaper services. There was need for alternative mobile broadband networks.

II. THE VIRTUAL MOBILE NETWORK MODEL

The proposed model consists of the access network, the core network, and the external networks. The core network is based on the 3rd Generation Partnership Project (3GPP) Evolved Packet Core (EPC) standard. All services within the network are transported using IP .It is a flat architecture divided into data and signaling planes to make scaling independent. It is made up of the Mobile Management Entity (MME) which is the control node. The MME manages attach states, detach states, idle states and radio access network (RAN) mobility. It also handles authentication, paging, mobility with Serving GPRS Support Node (SGSN), roaming and other bearer management functions. The Serving Gateway (SGW) serves as the local mobility anchor for inter eNodeB handover and roaming between 2G and 3G networks. It sits in the user plane and forwards and routes packets to and from eNodeB and the Packet Data Network Gateway (PDN-GW). The PDN-GW acts as the interface between the Long Term Evolution (LTE) network and packet data networks such as internet and IP Multimedia Subsystem (IMS). It is the mobility anchor point for intra 3GPP and non-3GPP access networks. The Home Subscriber Server (HSS) the database store for information about each and every user on the network. It handles authentication and authorization of users and the services provide to them. The Policy Charging Rules Function (PCRF) manages quality of service (QoS), online and offline flow-based, deep packet inspection and lawful intercept.

The access network can be Long-Term Evolution (LTE), Global System for Mobile communications(GSM), Wide-Band Code-Division Multiple Access (WCDMA), Worldwide Interoperability for Microwave Access (WiMAX), Wireless Local area network) WLAN. The external network could be made up of the IP Multimedia Subsystem (IMS) or the Internet. The VMN model is graphically depicted in fig 1.

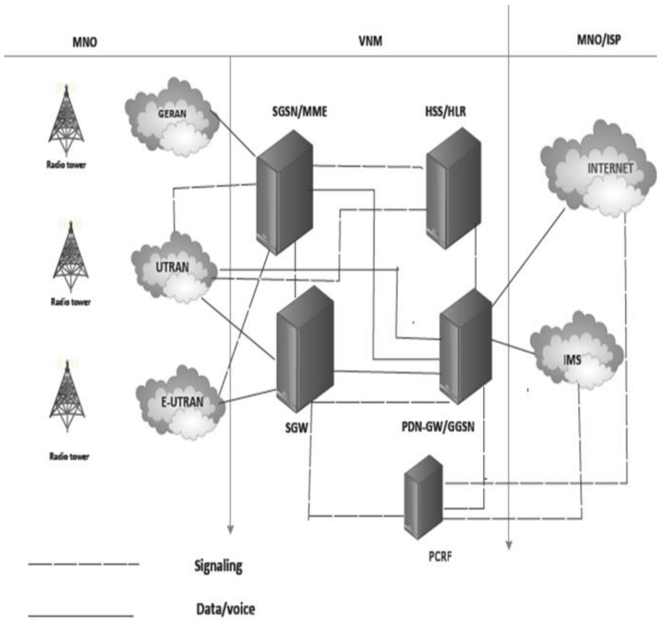

Figure 1: MVN model

A. *Inter-System Mobility Support*

EPC provides support for multiple access technologies and provides mobility between them. This allows end-users to move between 3GPP and other non-3GPP accesses.

Figure 2 shows the interworking between LTE and GSM or WCDMA.

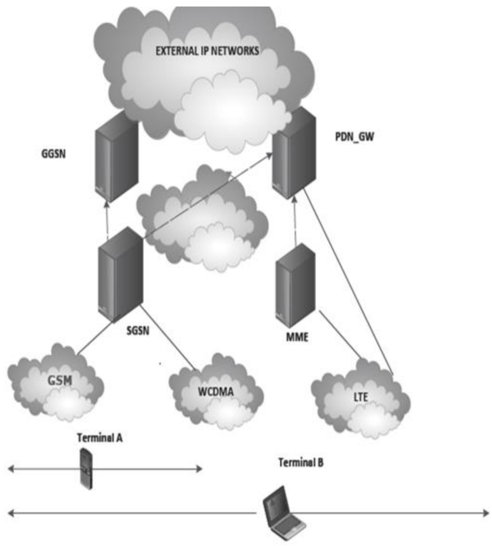

Figure 2: Interworking between LTE, GSM or WCDMA

In GSM and WCDMA networks the SGSN handles packet switched data, mobility management and authentication of users. The Gateway GPRS Support Node (GGSN) is responsible for interworking between the GPRS network and external packet switched networks. In EPC, MME and PDN-GW function in the same way as SGSN and GGSN. In multiple access networks MME and PDN-GW interface the SGSN. In fig 2 terminal A has GSM and WCDMA support but is unable to attach to LTE, terminal B is able to attach to all access networks. When either of the terminals attach over GSM or WCDMA it is served by SGSN. When terminal B attaches over LTE, it is served by MME which will select a PDN-GW and SGW. In the first case the SGSN provides an IP anchor point to either the GGN or PDN-GW depending on the terminals subscription data and the preferred external network to which it is pointing. This means that Home Location Register (HLR) of GSM and WCDMA networks and HSS must provide a single subscription point or have close interaction between the two.

A fundamental function for allowing efficient interworking between two access technologies is to enable a common set of subscription data to be used – both for authentication purposes as well as for keeping track of which network the user is currently attached to. The core of the solution is to allow for the HSS to act as the common data base for all subscription data [3].

B. *Inteconnection and Charging*

The VMNs have to interconnect with Mobile Network Operators (MNO) to lease towers and other aspects of MNOs radio access networks, as well connect to external networks such as IMS and internet. This is facilitated by infrastructure sharing regulatory mechanism (Telecommunications Regulations Handbook 2010) where MNOs are mandated to share passive or active elements of their networks to other operators. The terms of infrastructure sharing are approved by a regulator in this case (ZICTA). In determining interconnection charges, ZICTA also follows international benchmarks. Cost based pricing models are the ones mainly used in developing countries. In the case of IP Interconnection regulatory trends, it is mainly agreed that interconnection charges should be based on the necessary cost incurred by the receiving party of the additional traffic it has to carry – that is, the requesting party (VMNs) pays the providing party (MNOs) the relevant costs caused by the request. However, regulators sometimes pursue market based solutions to determine interconnection charges. ITU has set in place guidelines that interconnecting parties can follow in negotiating charges. These are;

- Each party should ensure that all the information to be given to the other party should be credible in order to lead the negotiations in the right direction.
- The parties should negotiate freely and make agreements voluntarily any kind of cohesion should be avoided.
- Each party should act constructively, any offer, proposal, or action should be directed towards reaching an agreement.
- Complex concepts should be simplified as much as possible.
- Each party should act in a time-saving manner and delays should be avoided.
- Regular renegotiations and future amendments should be possible
- Until such a time as an appropriate dispute settlement arrangement may be approved by the ITU with respect to accounting rates, both parties should have the possibility to consult a person or institution for mediation.

C. *Licensing*

A new responsive licensing framework is required for Virtual Mobile Networks (VMNs). VMNs are not full-fledged networks therefore cannot be licensed in the same way the full-fledged Mobile Network are licensed. Under the new Convergence Licensing Framework proposed by ZICTA, VMNs fall under the Service License category, which includes licenses for operators without networks. The service license costs less than network license.

III. DISCUSSION

For the average end - user, mobile broadband is expensive. MNOs set their prices competitively to get a return on their investment and to recoup operational costs. To enhance network performance and quality of service MNOs need to increase capital expenditure [4]; this translates in higher prices of services. Capital expenditure (CAPEX) and operational expenditure (OPEX) also limits an operator's network coverage. Network coverage affects the speed and reliability of a network. The survey revealed that end-users often experience variations in network access speed as well regular network connection drops. End-users would like data plans that enabled them to have mobile broadband access for business, education and entertainment purposes at half the price they were currently paying. Increased access to broadband leads to increased innovation and productivity in business. Better access to services and improved healthcare, as well as efficient energy consumption [5]. A 10% increase in broadband penetration yields an additional 1.38% in GDP growth [6].

To make the growth in mobile technology and services sustainable stakeholders of the mobile value chain need address the cost and reliability issues for mobile services. Service affordability models need to emerge that include radio access network sharing concepts [7]. VMNs based on EPC are an example of affordability models referred to by (Mekuria2007). EPC represents one of the smallest percentages in overall wireless infrastructure spending; it provides the greatest potential in overall network profitability through enablement of new services combined with cost savings from operational efficiencies [8]. EPC was developed with bandwidth services in mind; it combines the best of IP infrastructure with Mobility. It is designed to truly enable mobile broadband services for both operators and end-user. EPC offers;

- Support for multiple network types 2G, 2.5G, 3G, 3.5G, 4G, deployment flexibility and network optimization.
- Smooth and flexible evolution from 2G to 3G and 4G.
- Massive increase in signaling.
- Increased user plane performance
- Session state and subscriber management.
- Integration of intelligence and policy control at the mobility anchor point.
- Security.
- Roaming
- Support for multimedia services over the IP infrastructure.
- Reporting monitoring accounting and charging.

The VMN model depends on interconnection with existing MNOs. However IP interconnection charging rates have not yet been defined by ZICTA in the same way that voice and SMS charges have been defined. ZICTA has however provided guidelines; it is up to the VMNO and MNO to negotiate the interconnection charges. VMNOs and MNOs need to agree on number portability for access to a user's subscription data.

IV. CONCLUSION

The intention of this paper was to come up with a model for virtual mobile works that would contribute to the provision of affordable and consequently reliable mobile broadband services. All IP core networks provide an affordable option for deploying mobile networks. EPC is just one example of IP core networks; further research is needed to determine how other IP core networks would be better suited to create virtual mobile networks.

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