

Challenges of deploying broadband in rural Uganda and smart technical Solutions to address these challenges

Anthony Mile, Susan Serumaga, Patrick Kizito

mileanthony@yahoo.com, leahsz@yahoo.co.uk, patrickmusazi@yahoo.com

School of Computing and Informatics, Makerere University

Abstract

Since the liberalization of the telecommunication sector in Uganda in 1998, the key services have been voice, data and low rate Internet. The backbone link to the rest of the world has been via satellite which is characterized by low bandwidth limiting broadband usage in Uganda. With the arrival of undersea cables at the East African coast, Uganda is now linked to the rest of the world via optic fiber which offers high bandwidth rendering access to broadband services. Internally, wired, Optic fiber and wireless technologies such as 3G mobile and WiMAX infrastructure have brought broadband services within reach of the urban population. These improvements have revolutionized telecommunication by making broadband access more affordable and enabling converged voice, data and video/entertainment services to the urban population. Rural areas with low level or absent grid power and telecommunication infrastructure to deliver such services are still in a broadband blackout. In this paper, we discuss the challenges to rural broadband deployment in Uganda and propose possible technical solutions to address these challenges.

Keywords: Broadband, Wi-Fi, WiMax

I. Introduction

Broadband [1] is a high data rate, low-latency connection to the Internet that allows for instant access to a range of services that require a combination of high data rate, unmetered usage, low latency, high reliability and are predictable. Broadband penetration is now treated as a key economic indicator [2] and a basic telecommunication service. While experience has shown that the arrival of basic telephony service (public pay phones, fixed residential or

mobile lines) and broadband Internet constitute a critical take off point in a community's path to economic and social development, [3], in Uganda, access to broadband services is generally restricted to major cities and towns. Broadband penetration is driven by infrastructure development, accessibility to communication devices and availability of appropriate content to aggregate demand and supply of telecommunication services. Rural areas, characterized by varying geographical diversity, low population density, poverty, and lack of grid power, are often underserved or lack coverage all together. Given these rural characteristics it has been difficult to deploy telecommunication infrastructure to support voice and low rate data, later alone broadband services.

This paper is organized as follows. Section II reviews the status of broadband connectivity in Uganda, section III presents the challenges to rural broadband connectivity in Uganda, section IV highlights related work in the area, while section V presents the possible technical solutions.

II. Status of broadband in Uganda

Internet services are a nascent market in Uganda provided via; Dial-up narrowband, Digital Subscriber Lines (ADSL), Private VSAT satellite, WiMAX, and Mobile services via 3G, GPRS and EDGE offered by the five major Telecommunication companies in Uganda (UTL, MTN, Warid, Airtel and Orange), [4]. This infrastructure is used to provide broadband services on a low scale in the urban areas and a few economic towns but not rural areas. In the past, service providers relied entirely on satellite to link Uganda to the rest of the world. In light of the low bandwidth offered by satellite, access to broadband services was a problem. With the arrival of the undersea cables(Kenyan-led

TEAMS, SEACOM, the East African Submarine System (EASSy) at the East African coast, international backbone bandwidth has greatly improved rendering access to broadband services to a greater population in the urban areas than was the case in the past. Broadband connectivity within the country and the rural areas is however still a challenge.

The National Information Technology Authority – Uganda (NITA-U) is implementing the National Data Transmission Backbone Infrastructure and e-Government Infrastructure Project (NBI/EGI) whose major aims are to connect all major towns within the country onto an Optical Fiber Cable based Network and to connect Ministries and Government Departments onto the e-Government Network, [4]. It is anticipated that broadband services such as videoconferencing, Voice over Internet Protocol (VoIP), Data exchange and internet will be accessed over the e-Government Infrastructure. Currently 27 ministries and departments that form the e-government have been connected. Additionally, 168Kms of fiber optic cable to link five towns Jinja, Mukono, Bombo, and Entebbe to Kampala has been laid, [4].

III. Challenges to Rural Broadband deployment in Uganda.

Rural areas present a difficult environment for deployment of telecommunication infrastructure to provide voice, data, Internet and broadband services. The high energy constraints, poverty, illiteracy, sparse population, topological and geographical environment, limit infrastructure development in rural areas.

Uganda suffers acute shortage of power (principally electricity) both in the interconnected grid and to the largely unserved rural areas where the majority population lives, [13]. Through a Statutory Instrument (No. 75 of 2001) Government put in place the Rural Electrification Agency (REA) as the Secretariat of the Rural Electrification Board (REB) with a key responsibility of ensuring management of a Rural Electrification Fund (REF) for promotion of rural electricity access and connectivity in an equitable manner for the

whole of Uganda. The target was to achieve at least 10% electricity access for rural Uganda by 2010 as compared to 1% in 2000. Energy supply in rural Uganda is progressively being provided through grid extensions, independent mini grids, Photo Voltaic (PV) solar based systems and privately owned generators, [15]. A number of these solutions are however still unaffordable to rural population limiting rural socioeconomic and technological transformation among which telecommunication infrastructure development to deliver broadband services.

With 25% of the population living below the poverty line [5], Uganda is one of the countries in the world with the highest poverty levels. Additionally 33.2% of the population is illiterate [6]. Since the liberalization of the telecommunication sector in 1998, Uganda has experienced a 33% growth in the industry. This has been mainly through mobile telephony with voice as the main product and more recently data and financial applications (such as mobile money). While there is need for broadband services in rural areas, the high poverty and low literacy levels, low ICT awareness and scarce population discourage deployment of telecommunication infrastructure to deliver such services. Digital content, customized to the needs of these populations must be sold at affordable prices in order to maintain the infrastructure. There must be sizeable demand for the services in order to meet the costs of deployment and maintenance of this infrastructure. With the rural characteristics described, the balance between the demand and supply required to sustain a broadband market in rural areas is absent, [7]. The prevailing applications are limited to email and web browsing with a limited multimedia content in a few telecenters and Internet points of presence in rural areas.

The private sector is the main driver of the telecommunication industry in Uganda. Being foreign companies, priority is placed on ROI which favors mostly urban and densely populated areas leaving rural areas behind. At liberalization of the sector, one of the new entrants, MTN, as a policy had exclusive rights to cover the entire country with mobile telephone services. While mobile telephony was able to reach a greater part of the country, the

rates were high and unaffordable for majority of the rural population, and further still, only part of the rural areas were covered. The policy excluded new entrants for a period of five years limiting competition and fast development of the industry that we now see. The current policy and regulatory environment in Uganda was established through the telecommunications sector policy of 1996, and operationalised by the Uganda Communications Act, 1997 (Laws of Uganda Cap 106). The main objective in the policy was to increase the penetration of services and increasing private investment in the sector. These goals have since been met; the market has expanded, what was previously seen as value added services are now dominant services with demand for new services such as broadband. There is need for timely review and implementation of new policies and regulations to regulate the changing market. Additionally, as a means to bridge the telecommunication divide between rural and urban Uganda, the Uganda Communications Commission (UCC) formed the Rural Communications Development Fund (RCDF) whose goal is to facilitate the development of the rural telecommunications infrastructure. As policy, each service provider is required to commit one percent of its revenue to the Rural Communication Fund to help finance these developments. With the new demands and other external factors such as energy availability, the funding is not enough to meet the requirements.

Technologies such as optic fiber, xDSL, WiMax, laser optics, 3G have served well in bringing broadband services to densely populated and urban environments. These access/last mile technologies are rather very expensive to deploy and maintain in rural settings where the population is scattered coupled with the different geographical and topological environment.

Additionally, the backhaul to rural areas in Uganda also provides a challenge to broadband deployment. Most of the links to these areas are low bandwidth wireless microwave links and satellites which are relatively good for voice and low data traffic but not broadband services like video conferencing and streaming.

IV. Related Work

Many developing countries have faced a number of challenges in broadband deployment as is the case with Uganda. Various solutions have been proposed and sometimes implemented to solve some of these challenges.

One of the main challenges to broadband deployment is building appropriate content to satisfy the demand and supply requirements to maintain the broadband market. [12] Discusses a Rural/Urban Source Network (RUSN) and associated databases that promotes indigenous mobile content creation. These social network groups build their own local database content share and sell their content to service providers, public and private organizations. This however requires a paradigm shift on the side of operators and the local population. Additionally, there is need for improvement of the literacy levels and human skill to run such services.

A. Pentland et al, [8] present DakNet, an adhoc network that uses wireless technology and existing transport infrastructure to provide asynchronous digital connectivity to outlying villages in rural India and Cambodia. Instead of relaying data over long expensive links, DakNet transmits data over short point-to-point links between kiosks and portable storage devices called Mobile Access Points (MAPs) mounted on and powered by a bus, motorcycle or even a bicycle and a small generator respectively. The data is then relayed to a hub (Internet Access Point) in a non real Internet access scenario. Low-cost WiFi radio transceivers automatically transfer the data stored in the MAP at high bandwidth for each point-to-point connection [8]. While this is a cost effect way of providing content to rural areas in a non real time Internet scenario, it requires a more organized, consistent and perhaps developed transport system which is currently absent in Uganda.

F. Simba et al, [9], discuss wireless access network technologies particularly Cellular 3G at 900MHz and cellular over laid WiMax to provide last mile coverage for rural broadband connectivity. These have an advantage of wide

coverage, provide mobility and are cheaper than the wired/fiber optic access network solutions. GSM 900MHz network already exists in the major towns in Uganda. However, the target population, far away from some of these major towns is still in a blackout. As already discussed, the costs involved in the deployment and maintenance of these technologies which are amortized by dense populations with a good level of economic activity. The cost of end devices required for WiMax clients is also unaffordable for majority of the rural populace. This still leaves a gap in the access network in rural Uganda.

Optic fiber technology though expensive has been proven to deliver the best bandwidth for broadband service delivery. The National Backbone Infrastructure and e-Government Infrastructure project (NBI/EGI), [4] is thus a welcome project in the extension of broadband services to rural areas. The project is however intended to connect the major towns in the country and services still need to be extended to the scattered population. Access network solutions to the populations in the remote locations from the towns need to be devised. The hybrid fiber-wireless technology discussed for the access network in rural areas, [11] is a promising solution.

V. Technical solutions

In this section, we look at the possible technical solutions into the challenges discussed in section II above. As noted, the main challenges are high poverty and low literacy levels, inadequate regulatory framework, under developed access network and lack of appropriate or viable technology for the different topographical environments.

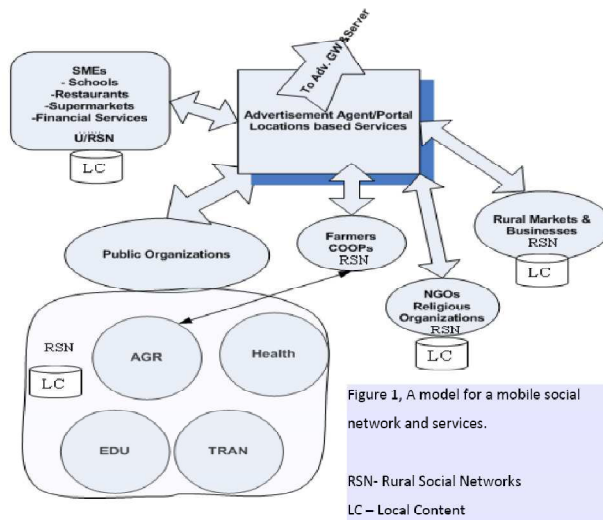
As you may agree technical solutions alone may not lead to a successful rural broadband deployment; other social and political solutions have a play. These may include initiatives towards lifting the literacy levels through the government education initiatives like free universal Primary and Secondary education in affected areas and putting policy and regulatory framework to motivate such areas on education.

Other solutions may include improved infrastructure and rural electrification programs. These would play a key role towards promoting rural development.

We propose three approaches towards technical solutions to the rural broadband deployment, namely 1) Local Content development 2) Policy and Regulation 3) Smart infrastructure technology.

In the first approach, Local Content development, we propose introduction of more innovative mobile broadband services tailored for the local population, preferably in their native languages. These include promotion of the creation of rural/urban social networks (RUSN). By active engagement and support of these social networks, the social networks become producers of indigenous knowledge databases and local content. The local mobile content and service providers can make mobile services more usable, locally relevant and affordable. Furthermore, the move can give an opportunity for poor areas to develop their economies and create the much needed employment opportunities in the mobile content and service provision sector. In a paper “Affordable Mobile Broadband Services” [12], Mekuria et al gives an example of a model which uses a local rural market scenario to describe the usage of the model by social networks that are created as a natural consequence of the interaction in the RUSN members.

Figure 1, below shows an RUSN system based on mobile services, involving both rural and urban social networks, with a further public and private organizations contributing to the system.



Adopted from [12]

The second approach in the technical solutions is the long term planning and regulatory intervention by government and relevant government institutions to consolidate and promote sharing of network resources by competing network operators. Since Broadband services require new costly access and core network investment, this approach proposes a network consolidation model. The network sharing can give substantial reduction in network capital & operational expenses, and reduced power requirement which should be directly translated onto a significant reduction in service costs.

The third approach is the introduction of smart, cost effective and easy to maintain technology in the infrastructure deployment, both in last mile access and backhaul infrastructure. As discussed in the challenges, rural areas are characterized by large areas with sparse population. In these rural areas, where the spectrum is hardly used, in addition to practical and cost-related reasons, Wi-Fi is an attractive option hence we choose to examine the possibility of using Wi-Fi based Long Distance links. Wi-Fi cards are cheap and highly available, enjoying economies of scale. Since full coverage of the rural areas is not feasible.

We cover only those few places where connectivity is required. In low density environments people are usually clustered around small localities (e.g. villages), with large distances among these clusters. Even within villages the user density is low compared to

urban areas. In addition, the typically lower incomes lead users to share access devices to amortize the relatively high cost of the devices. Advances in wireless computer networking particularly the IEEE 802.11 standards have led to huge commercial success and low pricing for broadband networks. Features of such networks such as ease of setup, use, and maintenance; relatively high bandwidth; and, most important, relatively low cost for both users and providers can provide for broadband deployment in rural areas.

We thus propose access network based on low cost Wi-Fi Omni directional or sector technology. In the areas where the population is not in small clusters e.g. villages but sparsely distributed over large geographical areas, we propose the low cost smart antenna WiMax technology. This is a technology which has been tailored for rural broadband. The smart antenna offer stronger signal, less wasted RF energy, and less intercell interference through their beamforming technology. This makes it possible to extend the signal to a wider coverage, hence reducing the number of cells needed. Figure 2 below shows the smart antenna technology.

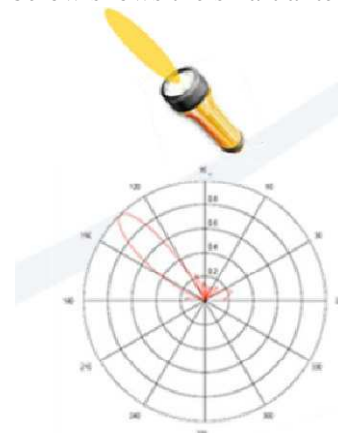


Figure 2: Smart Antenna technology. Like torchlight, it focuses the radio beam in the needed direction [13]

In the backhaul connectivity, we propose wireless point-to-point. Due to the high directional nature of transmission for the point-to-point, we employ the directional antenna technology.

Since Wi-Fi Point-to-Point (backhaul) for long distance links traverse long distances, they require line of sight for operation and this

usually implies towers at each end. As the towers take a substantial part of the total cost of the network, the challenge is to select the locations of sites and the links so that the overall cost of the towers is minimized (determined by the heights of the towers). The site selection is influenced by the topography of the area of deployment.

VI. Conclusion

In this research study, we have analysed challenges in rural broadband and proposed smart technical solutions to address those challenges.

We have proposed technical solutions in three approaches; Firstly, local content development which most importantly must be relevant to the community of deployment. Secondly, policy and regulation where we have proposed policies and regulations towards sharing of infrastructure in between the different service providers and as well as policies towards government subsidies towards promoting investments in those areas which include subsidies in grid power supply. Last and most important, we have proposed smart WiMax antennas and long distance Wi-Fi as solutions towards cost effective and sustainable infrastructure deployment in the areas of last mile access and backbone infrastructure so as to achieve ROI on such investments. While these solutions can extend broadband services to rural areas, we need a basis for a progressive, market-driven migration from government services to universal broadband connectivity that rural local users will pay for.

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