Towards a Viable Broadband Solution in South Africa: the Potential of WiMAX Technology

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Abstract: It is widely accepted that ICT is a tool with the potential to empower individuals, offering innumerable prospects for socio-economic development in a society. E-commerce, e-learning, e-health and e-governance provide opportunities for citizens to participate in socio-economic activities as never before. However, many societies and particularly in developing countries cannot benefit from these ICT’s, due to a lack of access, limited bandwidth capacities and the high cost of services. Limited access means that these societies are cut off from much needed socio-economic development the technologies provide. This study analysed the existing literature and governments’ policy reports to investigate the potential of WiMAX technology to offer a viable broadband solution in South Africa, by comparison to existing solutions. Existing solutions according to the findings, do not meet all the commercial and socio-developmental necessities for a cost-effective, reliable, faster, and broader capacity connectivity needed by South Africa (SA). With WiMAX technology, deployment costs are low. Data rates and capacity are high, and has a potential to transmit over longer distances than the ordinary WiFi. It can transmit data within and outside the line of sight. It is easy to operate and does not require massive gadgets by the user, and inconvenient line networks to use. When wisely implemented, it can also be used to connect populations in hard to reach areas to the mainstream networked world. WiMAX technology therefore is a positive development towards finding broadband to address the commercial competitive needs, and universal access objectives in SA.

Keywords: Universal Connectivity, Digital Opportunity, WiMAX, Rural connectivity, broadband.

1. Introduction

Information and Communication Technologies (ICTs) are an important part of modern society. They provide opportunities for individuals to participate in the economic mainstream [1], thereby enhancing economic development and growth [2,3]. Networked ICT is a valuable tool for e-government [4]; e-commerce [5], e-learning [6] and e-health [7] innovations.

In e-government for example, the Internet, telephone, community centres and wireless devices are used by state departments to improve communication with, and service delivery, for the public. It gives “…citizens the opportunity to access knowledge and a number of government services with minimum investment” [8]. In e-commerce, the business sector sells commodities to customers in unlimited destinations over the Internet whilst customers benefit from the convenience of shopping, buying, and paying for the commodities online - without leaving their living room or their office desk [9]. Through e-
learning, learning experiences are improved as students interact with the learning content through the use of a learning management system such as WebCT (www.webct.com/webct/), anytime and anywhere [6]. In health services ICT is used to innovate the effective administration of health service delivery [7]. The European Union for example, is advocating the use of ICT to improve “… healthcare through the use of "smart" identification cards; cost-efficient healthcare (both medical and administrative)... clearinghouses for medical and financial information flows, access to quality emergency medical data; and support of health authorities in assessing health needs and planning capacity” [10].

1.1 Research Problem

Studies indicate that the majority of poor people in developing countries (including many rural South Africans) do not have access, and therefore cannot benefit from the advantages offered by ICT [11]. According to the Department of Communications (South Africa), access to the Internet is restricted to geographic locations and segments of society, with 7.1 per cent of Internet users per 100 people in South Africa [29].

Even where Internet connectivity exists, bandwidth remains scarce, costly and therefore not affordable for the majority of the population. ITU studies indicate that, ‘a broadband connection in a high-income economy costs, on average, around US$16 per 100 kbit/s of data transmission capacity per month. The average price in low-income economies is over US$186 per month, almost twelve times more’ [1]. ‘Furthermore, in terms of affordability (or price relative to monthly income), the gap between high and low-income economies is a staggering ratio of 432. Consumers in high income economies spend only 2 per cent of their average monthly income on broadband connectivity, whereas in a low-income economy, even the cheapest broadband offering costs more than 900 times the average income’ [1]. Ability to afford exorbitant fees however is not a guarantee to adequate access as users are often subjected to limited capacity (and poor quality) in existing networks and telecommunications infrastructure, with bandwidth limitations as the common denominator in developing countries such as South Africa and many parts of Europe.

Although Europe seems free from the bandwidth problems that developing regions are experiencing, studies indicate that there is variation in the European broadband landscape with many EU states having limited access to benefits of fast and mobile broadband [12].

This is particularly evident in the rural and remote areas of Europe, the Eastern European countries [12] and regions such as Greece and Cyprus [34]. Currently, 10% of the EU population, which amounts to 50 million individuals, do not have access to broadband [14] and one third of European schools do not have broadband Internet access [15]. The Eastern European region, which accounts for one fifth of Europe's population, has only 7% of Europe's broadband subscribers [12].

These middle and low ranking regions experience problems of weak telecommunication infrastructures, difficulty in deploying broadband services and are struggling with high costs of broadband services [34].

The paper takes on the following format; the objective of the research is discussed next in section 2; this is followed by the methodology in section 3. Section 4 contains a short background to the universal connectivity challenge in the developing world (i.e. South Africa) followed by strides that have been made to redress this challenge. This leads to an investigation into the limitation of these (section 4.1). Section 4.2 introduces WiMAX technology. The viability factors for an effective broadband solution are covered up section 4.3. WiMAX technology as a potential connectivity solution in South Africa is discussed in comparison with existing technologies in section 5. Section 6 contains the results and closes with a conclusion in section 7.
2. Objectives

This research is informed by several briefings on the objectives of the ICT Element of the EU FP7 initiative. This initiative highlights the need for advances in ICT research to promote innovations that enhance economic competitiveness, tackling social challenges, improving the quality of life, and meeting the challenge of the ageing society in Europe. The commonality of these challenges between Europe and South Africa is prevalent in the discussion above. On this basis, the aim of this study is to investigate the potential of WiMAX wireless technology as a viable broadband option to connect remote and hard to reach communities in South Africa and in similar conditions (as highlighted above) in Europe. The objective is to find a cost effective, but fast and strong connectivity solution to improve the quality of both the private, social and economic life. A research process, method of investigation and research question/s are discussed under the methodology section below.

3. Methodology

This is an exploratory and descriptive study that is largely based on secondary data that includes academic literature, policy documents, reported institutional practices, and media reports. It is an academic article that targeted at the academic community, service providers, and policy makers within Southern Africa and Europe.

As the main question, the study investigates the potential of WiMAX technology to address broadband needs in terms of its (1) signal strength; (2) distance of transmission; (3) types of data that can be transmitted through it; (4) capital infrastructure required to implement it (by the service provider); (5) capital infrastructure required to implement it (by the user); (6) availability in the market; (7) regulatory limitations, (8) the cost of its use, and (9) evidence of success cases elsewhere. For a research tool, a table incorporating characteristics for each of the above 9 factors is drawn to compare WiMAX technology with existing alternatives.

4. The Universal Connectivity Challenge

While ICT is accepted as a tool with a potential to empower individuals to access life improving opportunities, it remains inaccessible by many of those who need it most in developing countries.

In 2000 the ITU reported that there were 14 million phone lines in the entire continent of Africa, fewer than in either Manhattan or Tokyo. Wealthy nations comprised 16 per cent of the world's population, but commanded 90 per cent of Internet host computers then. Not much has changed today (in 2007). Out of all the Internet users worldwide for example, 21 per cent are in North America where a mere five per cent of the world's population reside compared with 3 per cent in Africa where fourteen per cent of the world's population reside. Two in 3 Americans are online, compared with only one in 28 Africans. North America, Australia and Europe, boast high Internet usage patterns while the Middle East, Latin America and Africa reflect low usage patterns [16].

As a corrective measure, the international community is making ambitious efforts to connect most of the world’s disadvantaged communities with ICTs. In the World Summit on Information Society (WSIS) Geneva [3] and Tunis [2] for example, world countries committed to efforts that ensures the provision and application of ICT, “not only as a medium of communication, but also as a development enabler, and a tool for the achievement of the internationally agreed development goals and objectives, including the Millennium Development Goals” [2]. As such, countries committed through this international forum to promote the availability and use of ICT, to achieve the eight UN Millenium Developement Goals; poverty reduction, improved health and literacy rate for
all, as well as advance gender equity and empowerment at levels all by 2015 [17]. At national level, governments have made several policy, and practical remedial efforts over the past few years - to address this challenge. In South Africa, the government started telecommunications sector reforms by proposing the universal service fund (USF) in 1996 to finance telecommunications connectivity in priority areas [18].

Establishing telecentres to bring telecommunications connectivity to remote areas was seen as a useful option, leading to 100’s of such centres mushrooming in many remote areas in South Africa [19]. The gradual managed liberalisation of the sector was also seen by the government (through pressure from the private sector) as a useful mechanism in which the telecoms sector could become competitive and therefore efficient in bringing ICT to needy areas. Reforms began in 2001, with licensing conditions attached to the incumbent and new telecoms operators, including cellular phone companies [11]. In line with these reforms, a new cellular phone company, CellC was licenced and began operations in November 2001, along with firm efforts to establish a second national operator (SNO) [33]. In 1996, there were 10 telephones per 100 people [11]; this number has steadily increased since then. The second national operator, Neotel, has been established with a license obligation to increase connectivity. They began operating in 2007. The growth in cellular technologies has been on the increase since 1996, “cellular market development in South Africa has far exceeded expectations and now extends to roughly 92% of the population” [11]. Four cellular phone service providers service a total of 30 million subscribers nationally [32]. New technologies such as VoIP, WiFi, HSDPA and Satellite technologies have emerged as a viable solution to connecting all South Africans to basic ICT infrastructure.

4.1 Limitations to Existing Initiatives

While a lot has been achieved through policy reforms and further innovations, there is still a large number of people in remote and rural areas in South Africa without connections to networked computers.

Current fixed line and wireless solutions in rural areas have ‘largely been limited to the operation and maintenance of telecentres and phoneshops’ [11] and ‘although Telkom has met its national rollout obligations during its five-year exclusivity period, the trend of increasing access to fixed line telephones is being reversed by rates of disconnection as high as 50-70%’ [35]. The main cause of these disconnections has been the issue of affordability and while attempts have been made to ensuring affordable access through some form of subsidy (examples governments USF) people in rural areas still cannot afford the costs of connectivity [11] . High costs coupled with bandwidth limitations remain the main cause of slow and breaking transmissions, not only in rural and remote areas but also in many business and academic circles.

In light of this, researchers are looking into alternative solutions to connectivity and wireless technologies have been identified as having the potential to extend the reaches (of existing networks) and provide alternative services to hard to reach areas [11]. The South African government has allocated the national signal distributor Sentech R500 million to enable it to provide wireless Internet connectivity, especially to health clinics, schools, libraries, post offices and other services in outlying areas [30].

This study investigates one of these alternative innovations, WiMAX technology; and its potential to offer wide range, low cost, fast and effective broadband solution across urban and rural areas in South Africa.

4.2 WiMAX

WiMAX, which stands for World Interoperability for Microwave Access is a broadband wireless technology that supports fixed, nomadic, portable and mobile access [20]. It is
based on the IEEE 802.16 standard on Wireless Broadband Access (WBA), which aims to
deploy Wireless Metropolitan Area Networks [21].
The “IEEE Standard 802.16-2001 [1], completed in October 2001 and published on 8
April 2002, defines the WirelessMAN™ air interface specification for wireless
metropolitan area networks (MANs) … a wireless MAN provides network access to
buildings through exterior antennas communicating with central radio base stations (BSs).
The wireless MAN offers an alternative to cabled access networks, such as fiber optic links,
coaxial systems using cable modems, and digital subscriber line (DSL) links” [21].
WiMAX is engineered to deliver ubiquitous fixed and mobile services such as VoIP, and
Video at very low cost and it is are able to cover a large geographical area, up to 50 km and
to deliver significant bandwidth to end-users up to 72 Mbps [22].

The potential of the WiMAX technology to offer the cost effective, fast, efficient, wide
range broadband solution is investigated by comparing this technology to existing solutions,
using the viability indicators outlined in section 2.3 below.

4.3 Viability Indicators
The study is concerned with two main inhibitors; that of high cost and bandwidth
limitation. Indicators were considered that may overcome these inhibitors. They are listed
and discussed below.

Table 1: Technology Viability Indicators

<table>
<thead>
<tr>
<th>Viability Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal strength</td>
<td>The performance of a wireless network connection depends in part on the signal strength between a computer and the access point. Measured in terms of consistency (degree to which its able to maintain performance) and reliability (ability of a system to perform and maintain its functions in routine circumstance). The signal strength in each direction determines the total amount of network bandwidth available along that connection. [22].Signal strength has been used to determine bandwidth capacity.</td>
</tr>
<tr>
<td>Distance of transmission</td>
<td>Refers to the technologies capability to reach any potential customer within the coverage area.</td>
</tr>
<tr>
<td>Type of data that can be transmitted through it</td>
<td>Text, pictures, audio, video, and a variety of these combinations.</td>
</tr>
<tr>
<td>Deployment costs</td>
<td>The overall cost of deploying the technology is considered through considering the capital infrastructure required to implement it.</td>
</tr>
<tr>
<td>Device required to implement by user</td>
<td>The device required is being considered to determine ease of use and deployment cost on the side of the user.</td>
</tr>
<tr>
<td>Market availability</td>
<td>Whether leading service providers are advertising to offer it retail-wide.</td>
</tr>
<tr>
<td>Regulatory limitations</td>
<td>Refers to issues of regulation which may affect availability.</td>
</tr>
<tr>
<td>Cost of use</td>
<td>Refers to the relative cost of use of the technology to the customer.</td>
</tr>
<tr>
<td>Success cases elsewhere</td>
<td>Case studies are referred to in this section to determine if and how the desired technology has been successfully implemented.</td>
</tr>
</tbody>
</table>
5. Developments

5.1 The Potential of WiMAX technology

Table 2: Comparison of the Potential of WiMAX as a Viable Broadband Solution in South Africa

<table>
<thead>
<tr>
<th>Viability Indicators</th>
<th>Comparison of Technology*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fixed Line Technologies</td>
</tr>
<tr>
<td>Signal Strength</td>
<td>Reliability and consistency limited by the nature of the transmission medium</td>
</tr>
<tr>
<td>Range</td>
<td>Requires direct physical connection</td>
</tr>
<tr>
<td>Types of data that can be transmitted through it</td>
<td>Voice, Data, Video - Depending on distance and nature of the transmission medium</td>
</tr>
<tr>
<td>Capital infrastructure required to implement it by service provider</td>
<td>High, requires deploying cable links to individual sites</td>
</tr>
<tr>
<td>Devices required to implement it by user</td>
<td>Dialup/ADSL/Cable Modems</td>
</tr>
<tr>
<td>Market availability</td>
<td>Existing infrastructure limited. Capital layout for expansion of market high</td>
</tr>
<tr>
<td>Regulatory issues</td>
<td>Market liberalised (and competitive?)</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Cost of use**</td>
<td>High</td>
</tr>
<tr>
<td>Success cases elsewhere</td>
<td>Fully operation globally</td>
</tr>
</tbody>
</table>

References: [38], [39]

**Explanatory Notes:**

*Approaching 4 Generation technologies

** In South Africa, the cost of dialup is measured at cost per minute (Telkom rates average at R0.57 p/minute) + service charge (R69/p month), this varies according to monthly usage; average cost to the user for 40hrs per month would amount to R1368 p/month. The average price for the ADSL modem with wireless router and 4port switch (802.11g) costs R1000 (USD166). Telkom offers 3GB of ADSL Usage at speeds of 4Mbps for a monthly cost of R665.90. In addition to this, line rental from Telkom varies from R111.90 to R413.00. 3G services in South Africa average at R599 p/month for a total of 3GB data usage [31], with Vodacom’s HSDPA services costing R689 for 3GB data usage at speeds of 1.8 Mbps. Telkom offers WiMAX services at R479 p/month for a 3GB cap at speeds of 0.5 Mbps [37]. The final cost for WiMAX CPE’s is not clear, however, according to the WiMAX Forum, the production of high volumes of CPE’s will ensure that the cost of WiMAX CPE remain low - ‘under $100’ [22]. When compared with current broadband services, WiMAX pricing is lower.

The following comparison may be useful [37]

<table>
<thead>
<tr>
<th>Service</th>
<th>Cap (GB)</th>
<th>Speed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vodacom HSDPA</td>
<td>3</td>
<td>1800</td>
<td>689</td>
</tr>
<tr>
<td>iBurst</td>
<td>3.5</td>
<td>1024</td>
<td>599</td>
</tr>
<tr>
<td>Telkom Do WiMax</td>
<td>3</td>
<td>512</td>
<td>479</td>
</tr>
<tr>
<td>Telkom ADSL</td>
<td>3</td>
<td>512</td>
<td>611</td>
</tr>
</tbody>
</table>

These findings are discussed in section 6 (results) in the following page
6. Results
This study has sought to investigate the potential of WiMAX technology to offer a viable broadband solution in South Africa. The viability of WiMAX is measured in terms of potential to offer strong signal, wide range, wide data varieties, capital infrastructure burden by vendor, devices required by users, market availability, regulatory issues, cost and success cases, by comparison to fixed line, fibre optic, 1G, 2G & 3G technologies.

Findings indicate that fixed line technologies such as copper, coaxial and power cable networks offers reliable and consistent transmission based on the nature of the medium through which data is being transmitted. The range is dependant on having a direct physical connection to the network. Fixed line technologies have the capacity to carry data, voice and video, depending on the distance and once again the nature of the transmission medium. Capital infrastructure layout is high, requiring the deployment of cable links to individual sites. Users require modems, which is easily accessible. It is easily available in the market, depending on affordability. Existing market availability is limited. The South African telecoms sector has recently liberalised and is transforming into a competitive market. Fixed line technologies are relatively costly and fully operational globally.

Fibre optic technologies offer higher data rates than does fixed copper wire technology, with excellent reliability and consistent of transmission. It is capable of transmitting a wide variety of data, carrying data, voice and video at remarkably high speeds. However, capital infrastructure layout is prohibitively high. Although it is successfully used in most developed countries, fibre optic networks are both costly - and like copper wire lines, lack the mobility capacity.

First Generation wireless technologies (such as analog telephone and radio systems) and Second generation wireless technologies (such as digital telephone, radio and TV systems) have weak signals, that are limited by the amount of users, nature of the transmission and the geography of the area in which the signal is being transmitted. Coverage is within line of sight of the transmitter and is also very limited. It is capable of transmitting data and voice at low data rates. 1G and 2G technologies require limited capital infrastructure, is cost effective and easy to use. It is easily available and easily regulated in the liberalised market. Although it is fully operation globally, it is incapable of providing a viable broadband solution due to its limited capacity.

Third generation (3G) wireless technologies such as High HDPA, W-CDMA, UMTS-DD, GAN and WiFi, operate on a higher frequency than 1G and 2G technologies, therefore the signal strength and range is much better. Although it surpasses rates achieved with 1G and 2G wireless technologies, it’s reliability and consistency is further limited by terrain, amount of users and the nature of the transmission. Coverage is within line of sight and non-light of sight (to a limited extent) for some. 3G technologies offer short-range local area network coverage, which is capable of carrying data, voice and video at limited data rates. It is easy to use, and requires affordable capital infrastructure deployment by the service provider. The market is liberalised in South Africa and the technology is fully operation globally. However, 3G wireless technologies cannot provide connectivity to hard to reach and large geographical areas and due to its inability to address transmissions over multiple frequency ranges is incapable of providing a fast and efficient broadband solution.

WiMAX technology offers reliable and consistent signals. Coverage is within line of sight and non line of sight, offering long range and wide area coverage. “Unlike other wireless standards that address transmissions over a single frequency range, WiMAX allows data transport over multiple broad frequency ranges. Being able to work in multiple ranges maximizes the technology’s ability to transmit over the frequencies that will avoid interfering with other wireless applications.” [36].
It is capable of transmitting data, voice and video at high data rates, and easy to install. There is no need for deployment of cables and trench digging, thus preventing expensive infrastructure layout. This is particularly ideal for remote and hard to reach areas [22].

WiMAX provides improved range and bandwidth capabilities. It enables connectivity in areas that would otherwise be out of reach of traditional broadband technologies. Rural areas like Dwesa, in the Eastern Cape Province of South Africa, have been connected to broadband networks through trials that introduced ICTs through WiMAX technology [24].

Throughout the developing world, wireless broadband has been identified as a cost effective connectivity solution and as governments continue to invest in local wireless infrastructure, cost effective solutions become significant. In his state of the Nation address of 2008, Thabo Mbeki makes reference to the R500million allocated to the National Signal Carrier, Sentech, to implement a wireless broadband network [25]. Similarly, in the Democratic Republic of Congo, one of the leading ISP’s in the region has chosen wireless broadband for implementing a local broadband infrastructure stating that “wireless broadband is the most cost effective means to provide high speed data to our customers” [26]. Again, in Uganda, wireless technologies such as WiMAX have been identified as a “more cost-effective solution for reaching more subscribers across all market segments” with the government implementing high-speed broadband networks that “bypass legacy communication architectures” and enable greater connectivity, lower tariffs and a more effective broadband service [27]. Deployment costs are also lower since the trench digging and cabling is avoided in the WiMAX capital infrastructure. Instead, what is needed is the purchasing and installation of Customer Premises Equipment (CPE) units and the installation of WiMAX base stations. To illustrate the point of cost efficiency, Intel Corporation also conducted a study on the business case for WiMAX recently. The findings indicate that by offering high-speed network access using WiMAX, the company would be able to save USD 8.1 million to 35.3 million per year [13].

With lower capital and operating costs there is the possibility of an increase in service providers; this could mean an increase in competition and an increase in the customer base, thus allowing for a larger uptake of broadband and greater penetration of ICTs.

7. Conclusions

This study investigated the potential of WiMAX technology to offer a viable broadband solution in urban and remote areas in South Africa and in European countries with similar conditions and needs similar to South Africa - by comparison to existing solutions.

Adequate broadband according to the literature would be that which addresses maximum access across urban and hard to reach rural terrains, offer broader load capacity, high quality transmission, connectivity both within and out of line of sight, at lower costs.

Findings indicate that existing technologies are either too costly to implement and maintain or they do not meet all commercial and socio-developmental necessities for a wider (across various geographical terrains, both within and outside the line of sight), faster, and broader capacity connectivity bandwidth needs. With WiMAX technology, deployment costs are low. Data rates and capacity are high, and has a potential to transmit over longer distances than the ordinary WiFi. It can transmit data within and outside the line of sight. It is easy to operate and does not require a lot of gadgets by the user, and inconvenient networks lines to use. WiMAX technology brings us closer to a realisation of most broadband solutions necessary to function efficiently in the competitive information economy. When wisely implemented, it can also be a viable tool to connect populations in hard to reach areas to the world wide networked world. Whilst the WiMAX technology promises innovative solutions to cost efficient, fast mobile broadband challenges, it remains in early implementation phases globally – with regulatory issues, broad technical limitations, and further innovations for the sustainable benefit of the business sector.
requiring further investigation. A joint study between South Africa and European institutions to investigate technical limitations and ideal regulatory aspects of effective implementations of a WiMAX technology for improved connectivity is recommended.

References