VoIP Deregulation In South Africa: Implications for Underserviced Areas

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Abstract

Several statutory restrictions have recently been lifted on the use of Voice over Internet Protocol (VoIP) in South Africa. Previously, VoIP could only be utilised by the incumbent telecommunications operator, Telkom, the Second National Operator (SNO) and Under Serviced Area Licensees (USALs). This means new opportunities and cost savings for both network service providers and consumers. However, in rural and remote regions, further liberalisation is required so that service providers can take advantage of wireless technologies to provide connectivity in these areas. This paper discusses the legislative environment in South Africa and around the world with respect to VoIP and Wireless Fidelity (WiFi). In addition, examples are provided of how these technologies have been combined to provide last mile solutions around the world and particularly in South Africa. The paper concludes that further liberalisation in the telecommunications environment in South Africa is required if the goal of providing affordable access in rural areas is to be attained. Specifically, it is recommended that wireless technologies be deregulated since the combination of VoIP and WiFi may benefit rural areas. Also, the paper finds that USALs may not be the right model for underserviced areas in South Africa. Lastly, it is apparent that applications drive development and dictate which technologies are relevant for rural areas.

Key words: VoIP, WiFi, South Africa

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1 Introduction

Around the globe, Voice over Internet Protocol (VoIP) is increasingly being used to provide telephony. In many African countries VoIP is prohibited, even though it provides advantages by providing telephony access at lower cost to providers and consumers alike (Cohen and Southwood, 2004). Until recently in South Africa, VoIP was prohibited except if provided by the incumbent telecommunications operator, Telkom, and several other exceptions. An announcement by the Minister of Communications revoked this ban so that as of 1 February 2005, VoIP could be provided by Value Added Networks (VANS) as well. The lifting of the restrictions on VoIP opens up a vast number of opportunities and will reduce the costs of voice transmission for both network service providers and consumers. However, in South Africa, where the government is still trying to achieve universal access, the removal of the prohibitions on VoIP is only one step needed to reform telecommunications policy so that it supports the goals of achieving this access.

This paper proposes that VoIP deregulation alone is not sufficient for the provision of viable last mile solutions for South African rural areas. The last mile refers to the telecommunication links required, whether telephony or value added services, from a telecommunications provider to the homes of those living in the more remote and isolated regions of South Africa. In this paper, the concentration is specifically on the combination of Wireless Fidelity (WiFi) and VoIP for providing a telecommunications infrastructure to underdeveloped areas. Firstly, definitions of both VoIP and WiFi are provided as background information. A discussion of the present legislation and upcoming changes in legislation affecting both technologies in South Africa follows. Section 3 then provides an overview of how these technologies have been regulated and used elsewhere in the world. Next, a case study undertaken in South Africa is described to illustrate how these two technologies have been used to provide service to a rural community. A discussion of the pros and cons of VoIP deregulation follows. The paper concludes by suggesting that South Africa is heading in the right direction by deregulating VoIP. However, this is not useful in itself without the simultaneous deregulation of wireless technologies such as WiFi, particularly for rural and underserviced urban areas.

2 The Telecommunications Legislative Environment In South Africa

For this discussion background information on technologies under consideration is required, therefore a brief definition of VoIP and WiFi follows.

VoIP refers to a range of protocols designed to send voice over packet switched networks, traditionally the domain of internet traffic. Voice is sampled, digitized and broken down into packets before being sent to its destination (Sherburne and Fitzgerald, 2004; Goode, 2002; Varshney et al., 2002; Ahuja and Ensor, 2004).

This is achieved by a signalling protocol for call setup and teardown as well as a transport protocol for transmitting the voice packets. The two most common signalling protocols are the International Telecommunication Union's (ITU) H.323 and the Internet Engineers Task Force's (IETF) Session Initiation Protocol (SIP). The transport protocol used in both implementations is RealTime Transport Protocol (RTP) which has been optimised for the transmission of realtime data.

VoIP offers several advantages over the Public Switched Telephone Network (PSTN). It makes more efficient use of bandwidth by only transmitting when there is useful data to be sent - for example, through the use of silence compression which takes advantage of the pauses in natural speech. In the PSTN, each call requires a dedicated virtual end to end channel for the duration of the call. Using VoIP, there is no need for a dedicated channel for voice traffic. Packets can be sent via any route to their destination which is another bandwidth saver. VoIP also obviates the need for a separate data and voice network. In other words, users can use the same line for browsing the internet and phone calls. Moreover, the encoding and decoding algorithms used to digitise the voice, generally work at lower rates than the PSTN. For instance, one of these algorithms produces voice at a rate of 11.8kbps as opposed to the unvarying 64kbps rate produced by a call on the PSTN (Goode, 2002). Since the intelligence in the network is provided by smart terminals, adding more features to a VoIP network is easier than adding features to the PSTN network. Overall, this means that a VoIP network is generally cheaper to set up than traditional telephone networks.

VoIP does suffer from several disadvantages. Unlike the PSTN, where the quality of service is very high, voice quality using VoIP varies with the codec used. Factors such as latency, packet loss and jitter may also degrade the overall voice quality. In addition, if the same network is used for voice and data, voice traffic should be given priority over data traffic. If voice data competes with data traffic, the quality of service may deteriorate significantly particularly if a network is congested. In the next section, a definition of WiFi is provided.

2.2 *Wireless Fidelity*

WiFi stands for Wireless Fidelity, which is the popular name for the IEEE 802.11b standard (Kapp, 2002; Stallings, 2001, 2004; Varshney, 2003). It is the protocol behind "hot-spots", areas where wireless internet access is provided to the public. Essentially, the protocol defines how devices can connect to each other or to a central access point in order to access another network; both wirelessly. 802.11b has a maximum channel bit rate of 11 Mbps (shared) and operates in the ISM (Industrial, Scientific and Medical) band at 2.4 GHz. This band is considered licence exempt by the ITU and many American and European countries follow this recommendation. The WiFi protocol describes 2 layers of communication, a physical layer and a MAC (media access control) layer. The physical layer defines how the data is encoded and transmitted and the MAC layer specifies how devices can use the transmission medium in an orderly and efficient manner.

WiFi is a short range protocol providing coverage of up to 100 metres (Kurose and Ross, 2005). Multiple hops or repeaters can be used to spread this coverage over a wider area (up to 20 kilometres) but the further one is from the main access point in terms of hops, the more one experiences reduction in signal strength and data rates (Best, 2003). Another limitation on WiFi is that to connect sites that are far apart a clear line of site must exist from one site to the other. If no such line of sight exists, repeaters may have to be used to connect areas up by configuring the network so that each site can 'see' either a repeater or the final site. WiFi can also suffer from degraded quality due to interference with other devices that operate in the same frequency band. More recent wireless standards include 802.11g, 802.11a and 806.11. The first two standards improve on security flaws in the WiFi standard and have a higher data rate of 54 Mbps. The third standard defines a wider range point to point wireless protocol. A discussion on the current South African legislation on VoIP and WiFi follows.

2.3 *South African Legislation on VoIP and WiFi*

Until recently, legislation in South Africa restricted the use of both VoIP and WiFi. Specifically, according to the Telecommunications Act of 1996, *as amended* (RSA, 1996), and the Telecommunications Amendment Bill of 2001 (RSA, 2001), VoIP could only be provided by Telkom (the incumbent telecommunications operator in South Africa), the Second National Operator (SNO) and the Under Serviced Area Licensees (USALs) (RSA, 2002). USALs are licences designed for small, medium and micro enterprises (SMMEs) and are geared to achieve connectivity in areas where less than 5 percent of the population have access to a telephone. The initial call for USAL applications was released in December 2002. Yet, at the end of 2004, only 4 out of 27 USALs had been granted; none of which were operational at the time of writing this paper (ICASA, 2004). This is due to the high entry costs associated with setting up an infrastructure in the areas covered by the USAL and the fact that these USALs were only recently granted in late 2004, leaving little time to set up operations before this paper was written.

In September 2004, the Minister of Communications announced that from 1 February 2005, use of VoIP by specified bodies other than Telkom, the SNO and the USALs would be permitted (RSA, 2004). In terms of these ministerial determinations, VANS, the term used to include Internet Service Providers (ISPs), will be allowed to carry voice using any protocol. ISPs are organisations which provide internet access and related services to corporations and individuals. For this service, ISPs charge a monthly or annual fee and provide the user with software and access codes to access the internet.

In the initial announcement, VANS were also told that they would be allowed to use telecommunications facilities other than those provided by Telkom. The ministerial determinations conflict with the Telecommunications Act of 1996, *as amended*, which states that only licensed telecommunications operators are allowed to provide telecommunications infrastructure. Thus, according to Gillwald and Esselaar (2004), in order for these determinations to come into effect legally, a new licensing regime for VANS needs to be provided, which will also cover the use of voice over any protocol. The Independent Communications Authority of South Africa (ICASA), the South African telecommunications regulatory body, must also define interconnection and numbering rules for VoIP use before the determinations declared in September 2004 come into effect legally.

Already, several concerns have been raised over the new proposed VANS licence by the Internet Service Providers Association (ISPA). Specifically, the proposed new VANS licence does not outline the definition of a VANS clearly and the license fee has increased significantly without justification (ITWeb a, 2005). Thus, although several statutory restrictions have been lifted on VoIP, the effects of this change will not come into place for some time. Additionally, the network service providers and the end-consumers will have to wait to reap the benefits.

South African telecommunications legislation also constrains the use of WiFi. Currently, WiFi can be used for hot-spots within the confines of the same premises or buildings but once it crosses beyond the border of their premises it becomes local access telecommunication service. This means connecting wireless local area networks (LANs) between premises is illegal unless the provider has a telecommunications service licence (RSA, 2003). Similarly, in rural areas, communities can not be linked up or linked to public networks legally with WiFi. This effectively rules out WiFi as a last mile solution for these areas except for provision by telecommunications operators until the legislation becomes more permissive.

In terms of WiFi regulation, ICASA has largely focused on opportunities for the private sector, by allowing WiFi to be legal for wireless LANs within the confines of one's own premises. This benefits businesses because it allows them to have wireless infrastructures within a premises. However, even in this case the legislation is still very restrictive. For instance, hot-spots require a VANS licence and the VANS licensee is bound to using Telkom's facilities for the wireless link between the hot-spot and the user. For rural areas, this means one could set up local hot-spots for WiFi within buildings but that connecting up hot-spots would be illegal. This hampers the infrastructure that one could use to provide services to remoter regions.

Thus restrictions still exist on the provision of VoIP and wireless technologies and unless these are removed, achieving the goals of universal access will be more difficult. The following section examines how the rest of the world legislates on VoIP and wireless technologies.

3 A Global Outlook on VoIP and WiFi

This section examines where South Africa fits into the global context in terms of telecommunications legislation on VoIP and WiFi. In addition, several examples of how VoIP and WiFi have been used to provide rural connectivity are discussed.

VoIP is legal in most developed countries such as the United States of America (USA), Canada, the United Kingdom (UK) and in much of Europe. However, according to Cohen and Southwood (2004), most countries in Africa still restrict competition in both fixed line and mobile markets and VoIP usage is usually limited. In fact, Mauritius and Nigeria are two of the only countries in Africa to have legalised the use of VoIP and WiFi. For these countries, the long term benefits these technologies will bring offsets the short term losses in revenue by the incumbent telecommunications operators. However, other countries in Africa are slowly waking up to the usefulness of VoIP and its potential for lowering costs for network providers and consumers. Algeria has experimented by allowing ISPs to utilise VoIP for Personal Computer (PC) to phone traffic and Kenya is investigating using VoIP services in cybercafes. Thus South Africa is not unique in realising the potential of liberalising VoIP usage.

In terms of WiFi legislation globally, the ISM bands including 2.4 GHz and 5 GHz are licence exempt in the USA and much of Europe (Neto et al., 2004). In fact, 41 percent of all developing countries worldwide allow unlicensed use of internet devices and/or spectra while 96 percent of developed countries have licence exempt wireless (Wireless Internet Institute et al., 2003). However, in Africa, wireless spectrums are largely restricted. For use of these bands, Neto et al. (2004) have drawn up several categories into which each African country falls. In parts of Africa such as Rwanda, Lesotho and Tunisia, the bands are considered unlicensed with no registration. Other countries, like Kenya and Ethiopia, consider the bands unlicensed but require registration for use.

In some cases, the unlicensed bands are still restricted in terms of the amount of power the wireless points are allowed to operate and signal range is limited. In other parts of Africa, like South Africa and Botswana, a licence is required for these bands; conditional upon payment of licence fees and fulfilling criteria specific to that country's regulations. In the last category of licensing of wireless technologies in Africa, use of the ISM bands is simply barred as in Zimbabwe. Even though licensing regimes differ across the continent, it was found that 37 percent of all African countries are using wireless technologies for providing backhaul connectivity in rural areas (Neto et al., 2004). Backhaul connectivity refers to connecting links up to the main network backbone.

Thus VoIP and WiFi in general are more restricted in Africa than in Europe and America. In most cases, this is because Africa has more countries with state owned incumbent telecommunication operators lacking liberalisation and there is reluctance to cut into the revenue streams of these monopolies (Cohen and Southwood, 2004). However, there are many examples around the globe illustrating how wireless technologies combined with VoIP can help to provide connectivity in rural and remote regions. While much of the developed world is already reaping the benefits of both VoIP and WiFi, Africa is falling behind. The desire to protect telecommunications monopolies by delaying liberalisation, typical of African countries, only widens the digital divide between the developed and the developing world. The following section presents several examples of how VoIP and WiFi have been used in conjunction to provide rural connectivity.

3.1 Examples of Using VoIP and WiFi to Achieve Rural Connectivity

VoIP and WiFi are not without limitations. However, there are many examples around the globe illustrating how wireless technologies combined with VoIP can help to provide connectivity in rural and remote regions. For instance, Best (2003) describes a village area network which provides services and capabilities that enhance the economic development of rural communities. One particular village area network was implemented in the rural community of Behechio in the Dominican Republic in March 2001. This area is home to some 7000 people and comprises one of the least developed communities in the country. The village area network covers an area of one square kilometer and took a mere 3 days to install. It makes use of radio antennae and routers operating on the 802.11b standard at 11Mbps. The village area network extends the facilities of the Multipurpose Community Centre (MPCC) to the rest of the village and via mobile and fixed wireless devices and services. In addition, the MPCC has a satellite or Very Small Aperture Terminal (VSAT) internet connection. It also runs a VoIP telephone service accessed by the IP phones in villages. VoIP services have also been tested on hand held devices. This illustrates how innovative solutions can be developed for rural communities using a variety of technologies including VoIP.

Another example of using wireless technologies to connect up rural areas is discussed by Bhagwat et al. (2004). They describe the Digital Gangetic Plains (DGP) project in India which has investigated the use of 802.11 as a long distance access technology. Their aim was to find a solution that provides both rapid and low cost deployment of voice and data communications services in rural areas. Using 802.11 links, the DGP has built a multi-hop testbed spanning up to 80 kilometers on the longest link. They conclude that using wireless links to provide voice and data services in rural areas is cost effective and speedily deployed.

Zhang and Wolff (2004) also argue that WiFi is a cost effective way for providing broadband access to sparsely populated rural areas. In the USA, they modelled a network from realistic demographics based on information from an American rural area (Gallatin County) and concluded that providing wireless internet access to rural areas can be cost effective. The model is more limited when applied to rural areas in developing countries where subscribers often cannot afford to pay individual subscription costs. However, if the subscription costs are shared by a group or paid by an organisation and access is provided for community centres, schools and businesses, this model does indicate that WiFi is a viable last mile solution for rural areas in developing countries. Combined with VoIP, it can be a cost effective solution for providing value added services as well as telephony.

By following the example of the developed world, it seems that Africa should follow suit in liberalising VoIP and wireless technologies. Moreover, as the case studies above illustrate, the combination of VoIP and wireless technologies can help provide connectivity to rural areas efficiently and at low cost. In the next section, a local case study using VoIP and WiFi to provide a telemedicine solution for a rural village in South Africa is described.

4 An Example of VoIP and WiFi Usage To Support Telemedicine

South Africa is a mixture of both a developing and developed country and there is a huge disparity in infrastructure between rural and urban areas. According to the ITU c (2003), 77.7 percent of the total telephone subscribers in South Africa are cellular subscribers. There are 10.4 telephones per 100 inhabitants and 7.26 personal computers per 100 inhabitants (ITU b, 2003; ITU a, 2003). These figures are deceptive since most of the fixed lines and computers are concentrated in urban areas. The lack of an adequate telecommunications infrastructure is particularly evident in the Eastern Cape province. Statistics South Africa (2003) found that this province is the second largest province in terms of the total proportion of land in South Africa and approximately, 14.4 percent of all South African's live here as shown in Figure 1. The unemployment rate in the province is 54.6 percent and only 29 percent have a landline or cellular telephone in their place of dwelling (Statistics South Africa, 2003).

Given the rolling hills and uneven terrain in the province, fixed line phone services are not viable for connecting rural and isolated communities. This area also has a low population density and low telephone density.

A better solution is to use wireless solutions coupled with VoIP among other protocols. This section illustrates the combined use of WiFi and VoIP in a rural area in the Eastern Cape through the description of a case study conducted from August 2003 to October 2004.

4.1 Project Setting

The case study was conducted in Tsilitwa village in the a rural area in the Eastern Cape province. The project built on a previous undertaking in Tsilitwa village by the Council for Scientific and Industry Research (CSIR) a national semi-private research organisation. The CSIR built a wireless network connecting up several structures in Tsilitwa village with the neighboring village of Sulenkama. ICASA granted special permission to build this wide area wireless network using 802.11b. The WiFi network connects five facilities together: the school, community centre and clinic in Tsilitwa and the police station and hospital in Sulenkama. A schematic of the network is shown in Figure 2.

Each facility has an antenna and there is a repeater site in the middle of the two villages due to obstruction presented by an intermediate hill. Each facility was furnished with a VoIP phone and a personal computer and the network has been operational from late 2003.

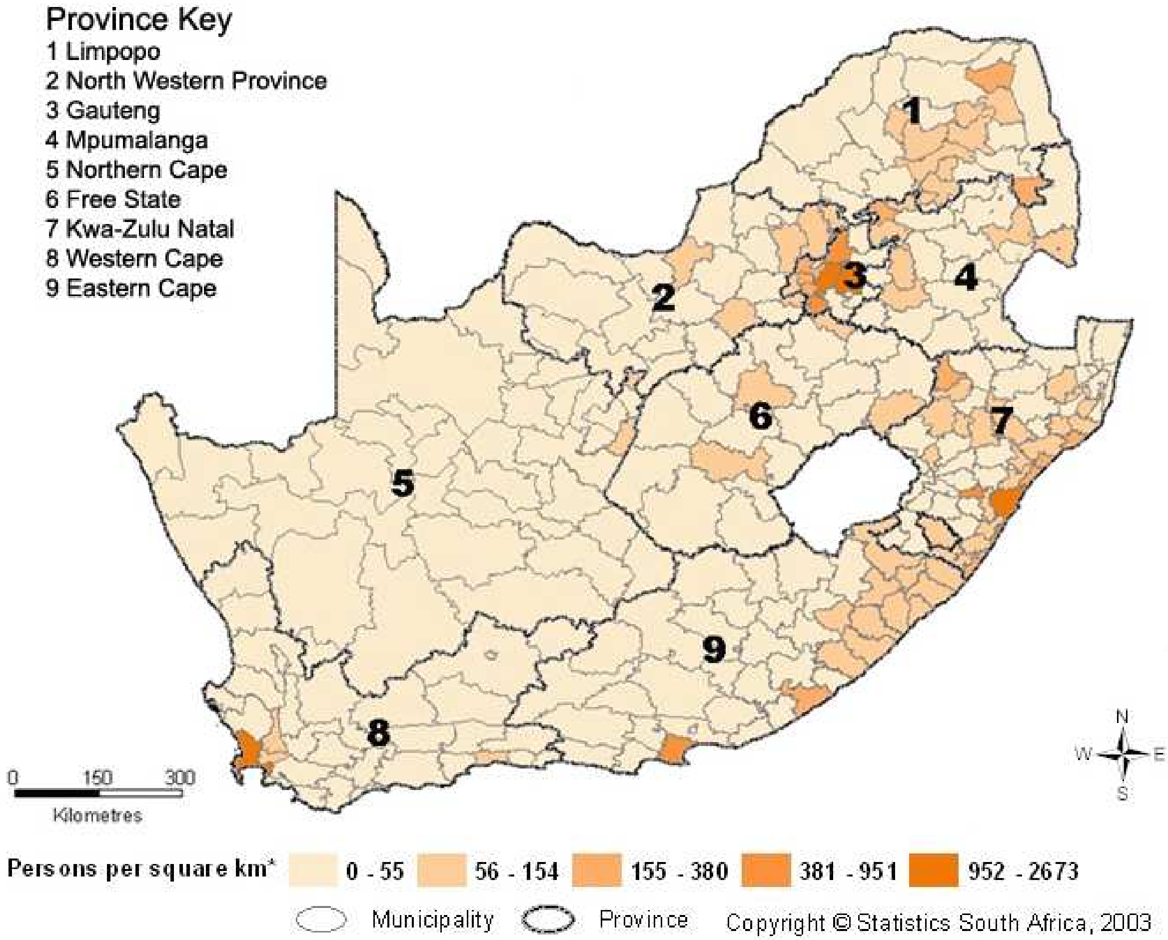

Fig. 1. The map shows the population distribution for South Africa. The Eastern Cape is the second largest province where approximately 14.4% of all South Africans live. Source of original map: Census 2001 Digital Census Atlas, Statistics South Africa, www.statssa.gov.za.

The area has full cellular coverage provided by two of the three national cellular operators (MTN and Vodacom) but has no fixed line phones. Previous attempts made by Telkom to set up Digitally Enhanced Cordless Telephones (DECT) phones in the area have not been successful for a number of reasons. Phones are often vandalised and the power supply to these phones is often unreliable. Also, DECT only offers 70kbps and although this is dedicated bandwidth, it is not adequate to provide VoIP applications or a broadband value added service. Additionally, fixed line services have not been successfully deployed in these areas due to theft and vandalism concerns as well as the geography and remoteness of the region which makes maintenance difficult.

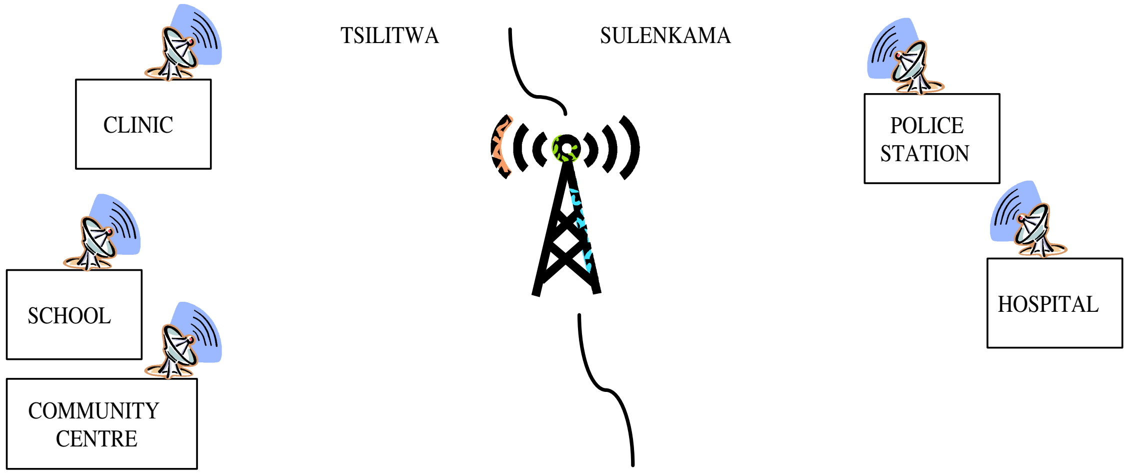

Fig. 2. This is the schematic of the WiFi network connecting several facilities in two neighbouring villages: Tsilitwa and Sulenkama. Each facility has an antenna and there is also a repeater site between the two villages due to the line of sight obstruction presented by an intermediate hill. Each facility has a VoIP phone and a personal computer connected to the network.

4.2 Multi-modal Telemedicine Intercommunicator

The project was a collaboration between the University of Cape Town (UCT), the CSIR and community members of Tsilitwa village with the goal of building a telemedicine solution to run on the WiFi network in Tsilitwa. The application was designated Multi-modal Telemedicine Intercommunicator (MuTI) and allowed for communication between the clinic in Tsilitwa and the hospital in Sulenkama village which are about 20 kilometers apart (Chetty et al., 2004). Nurses at Tsilitwa clinic are trained in primary health care. If a patient has a problem going beyond the extent of their training, the patient is referred to the hospital in the Sulenkama village. The hospital is a fair distance away and travel is costly, particularly since most of the patients in the area are unemployed. Also, at the time of the study, the hospital was only staffed by one full time doctor and several nurses.

This situation is common in the remoter regions of the Eastern Cape where the harsh conditions deter local doctors from working in these areas. Doctors are usually overworked and have to see to all the ailments patients present. Basically they are expected to act as the gynaecologist, dentist, cardiologist and general practitioner among other specialities. Patients usually have to wait for hours to see the doctor and if the patient had a relatively simple problem that could have been attended at the clinic, the travel and wait time have been wasted.

A simple telephone call from the clinic to the hospital makes this process more efficient for the patient. If the nurse can consult with the doctor about the patient, she can discern whether treatment for the patient can be administered locally or whether it is strictly necessary for the patient to travel to the hospital.

MuTI was developed as the tool to be used for gathering this kind of advice. It consists of two main components: a VoIP component and a store and forward component. The VoIP component handles calls over the WiFi network and maintains the information necessary to display presence information for contacts on the contact list. In the MuTI project, all doctors and nurses using the system were denoted as contacts on a list similar to contact lists in instant messaging tools. Presence information indicates the availability of a contact to take a call i.e. whether the contact is "online" or "offline" (Sherburne and Fitzgerald, 2004). The store and forward component is responsible for the creation, storage and forwarding of patient records. Store and forward technology basically refers to the fact that records are stored locally until a time when they can be forwarded to their destination (Petersen and Davie, 2000). In the case of MuTI, records are forwarded when a network connection is available. Since MuTI was tested in a rural environment, frequent power failures led to network failure which is why a store and forward approach was deemed suitable.

MuTI records consist of images, text and voicemail. If a doctor is busy and unable to take a MuTI voice call, nurses can send through a MuTI message with digital images of patients, physiological values in text and/or a voicemail message to indicate the patient's problem. Doctors using MuTI usually respond with text and voicemail messages only or use MuTI to call the nurses. MuTI was deployed on laptops so that in the event of a power failure, several hours of battery power ensured that patient records could still be created. These records would be forwarded when the power returned and the network connection resumed.

MuTI is innovative for several reasons. To the authors' knowledge, the combination of VoIP and a store and forward approach in telemedicine has not been used in the Eastern Cape environment before. Furthermore, MuTI is multimodal and allows both synchronous voice calls and asynchronous message passing. Most telemedicine applications for developing countries only allow one mode of communication - usually a store and forward approach such as email. Also, the use of presence information, which indicates whether people are available to take calls or respond to messages, is novel in a rural telemedicine application. MuTI is also unique in that it ran over a WiFi network in a rural and underserviced area. Prior to this research, this combination had not been utilised for telemedicine in the Eastern Cape.

Several MuTI prototypes were tested from April 2004 to October 2004 with

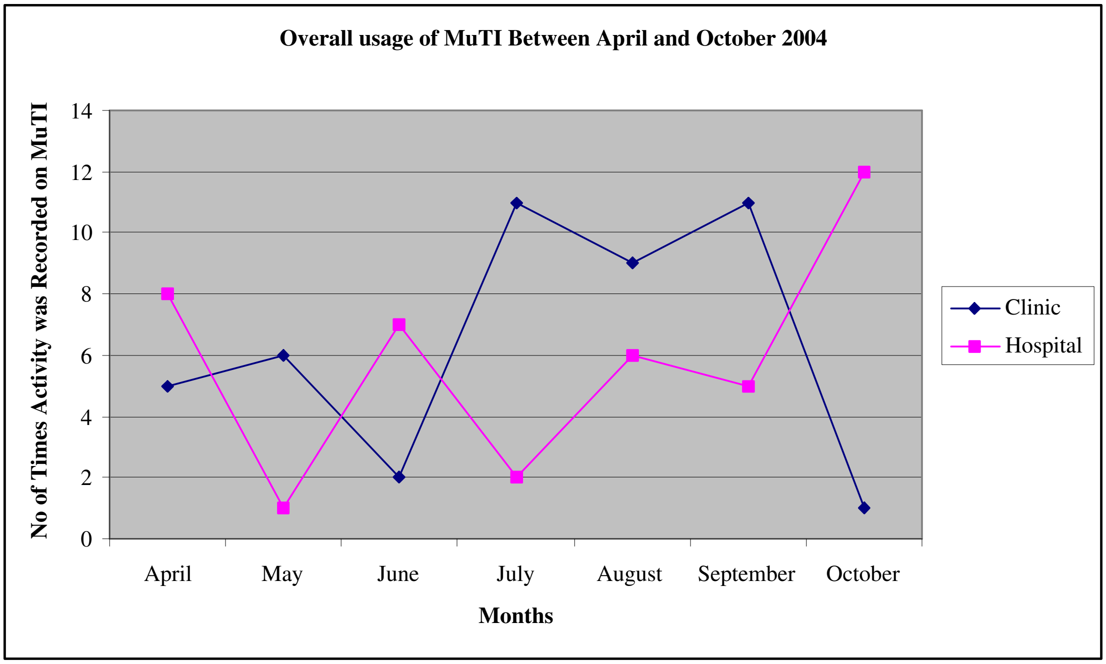

Fig. 3. This graph shows the overall usage of the MuTI system between the time it was first installed in April and the time the project ended in October 2004. Usage was initially low but steadily increased before decreasing again. Patterns of usages differed greatly at the clinic and the hospital. The y-axis shows the number of times activity was recorded on MuTI. Activity was defined as logging on to the system, creating records to send to another party, sending records to another party and making calls to another party.

the only doctor working at Sulenkama hospital at the time, a foreigner, and the head nurse of the clinic in Tsilitwa village. During this time, usage of the system followed the pattern shown in Figure 3. Since the MuTI project was undertaken for research purposes, the system and equipment were provided to the participants for the project duration and all communications undertaken using MuTI by participants were on a voluntary basis.

Initially, system usage was very low but it steadily increased before decreasing towards the end. The usage pattern was affected by a number of factors. In the beginning the doctor and nurse were reluctant to use the system because scheduling time to use MuTI was very difficult. However, once they became more familiar with the system, usage increased. The tail end decrease is due to the doctor preparing to return to his home country and the nurse taking a 2 week period of leave. From interviews and questionnaires with the nurse and doctor using the system, it was evident that this was a much needed solution for the problem. Both parties were positive about the system and felt it was going to directly benefit the patients in the surrounding areas. They also felt MuTI presented a significant improvement on the initial telemedicine solution built by the CSIR. This system allowed voice calls via VoIP handsets.

In addition, a webcam was provided at the clinic so that the nurse could send the doctor at the hospital video footage of patients. To view the video, the doctor had to surf to a web address. However, the video quality was poor due to low resolution and latency.

Overall, MuTI positively impacted Tsilitwa. It also illustrates how VoIP and wireless technologies can be used to provide services and communications for rural areas in South Africa. Next, a discussion follows of why VoIP deregulation is only one step in the liberalisation of telecommunications in South Africa if universal service goals are to be met.

5 Discussion

This section presents several arguments why wireless technologies should also be liberalised and combined with VoIP to speed up universal service goals.

5.1 Using WiFi and VoIP may be an option for rural connectivity in South Africa

From the MuTI case study (Chetty et al., 2004), it became evident that fixed line communications infrastructure may not be the right solution for the rural areas in the EC due to the harsh topological conditions and poor access roads which hampers system maintenance. A better solution might be to utilise a combination of wireless access and VoIP solutions since this would be cost effective and would allow villages to be connected quickly and easily. Wireless access would be used as the last mile technology connecting up rural villages to each other and to the backbone network. The cost of this type of access would then depend on the wireless service provider, the cost of connecting the network to the backbone network and the cost of setting up the wireless infrastructure. (Note, exact costing information for installing a wireless network in a rural area and connecting this up to the backbone public switched telephone network is beyond the scope of this paper [1]).

[1] *Personal Communication with William Tucker (btucker@cs.uct.ac.za):* Setting up a rural WiFi network costs approximately $730 per each site in the network. This cost includes the cost of a waterproof antenna enclosure, an antenna, a router board, radio cards, batteries and either a battery charger or a solar panel. Only router sites require router cards and sites with solar panels may be slightly more expensive. This cost excludes the once off cost of purchasing power tools, cabling and mounting hardware — all of which are reusable. Minimal additional cost may also be incurred for consumables such a cable ties and power wires as well as providing power to sites without solar panels. This information was gathered during an extension of

In the proposed solution, VoIP would be utilised over the wireless network to provide voice services. Until the technologies are improved, using VoIP would only make sense for relatively few subscribers. This is because WiFi shares bandwidth amongst users and the quality of service for VoIP calls may deteriorate with a congested network. In the MuTI project, the CSIR VoIP phones and the MuTI VoIP calls were functioning well over the WiFi network. This illustrates that a working telephone service can be provided to rural villages without the need for extensive cabling, utilising WiFi and VoIP. The network set up by the CSIR presented almost no running costs and it was provided free of charge to the villages in the project since it was part of a research initiative. In a commercial situation, this would obviously be different.

WiFi may be more appropriate than fixed line services for the last mile in rural areas for several reasons. First, as mentioned in Liew et al. (2004), in rural areas with a sparse population, using wireless networks can be less expensive than a wired alternative which requires cabling. Also, wireless networks are easier to install in areas where it is difficult to lay cables, for example, over large hills, roads and valleys. Additionally, installing a wireless network can be less time consuming than installing a wired alternative where laying cables can take substantial amounts of time.

Moreover, at present, most of the rural areas in the Eastern Cape do not have any wired line telephones even though Telkom, the incumbent telecommunications operator, had a mandate to provide a telephony service to these areas. The reason for this might be that these rural areas do not have the economic activity or buying power to justify rolling out wired lines, i.e., these areas are not seen as profitable. However, there was a wide usage of the cellular network in the villages described in the case study which indicates that people in these areas, despite having a low disposable income, are willing to spend money on telephony. Thus, there is a market in these areas for telephony and for cheaper alternative forms of telephony to the cellular network.

Some may argue that with the limited range and line of sight restrictions of WiFi, wireless networks may not be appropriate for rural areas. These restrictions can be overcome. In the MuTI project, Tsilitwa village and Sulenkama village are separated by a large hill so there is no line of sight between the Tsilitwa clinic and the hospital in Sulenkama. The obstruction presented by the intermediate hill was overcome using a repeater site which was installed on the top of the hill. The repeater site also helped extend the somewhat short range of WiFi to connect the two villages which are approximately 20 kilometers apart.

Another point against using WiFi is that the spectrum is limited and interfer-

the MuTI project into another area of the Eastern Cape in May 2005.

ence may be a problem. In rural areas, interference is unlikely to be a major problem as there are no competing signals in these areas at present and it is only as more service providers build up wireless networks that are overlapping, that this aspect of using WiFi will become apparent. For the short term, therefore, interference is less of an issue than in urban areas. If one wished to provide value added services to rural and isolated regions which used WiFi as a last mile technology, one could use a Very Small Aperture Terminal (VSAT) or satellite internet connection. This would extend the range of services available to the people living in these areas. This kind of network also lends itself to many other applications for schools and government amongst others.

These suggestions are supported and advocated by Cohen and Southwood (2004) as well as Gillwald and Kane (2003) who feel that VoIP can be combined with WiFi or other wireless technologies to provide last mile solutions for remoter locations. Furthermore, they recommend that WiFi and VSAT should be opened up to further this cause.

Neto et al. (2004) and Best (2003) also propose that the unlicensed spectrum and low cost wireless technologies that operate in these bands could benefit developing countries with underdeveloped telecommunications and internet infrastructures. They propose that licence exempt regulations provide an environment for entrepreneurship which will lead to a reduction in barriers to entry for network service providers.This will help to achieve more widespread internet access. Setting up wireless LANS is cost effective since equipment using these protocols is now widely available commercially and relatively inexpensive. They also require little technical expertise to install. If there are no licence fees, this makes it even easier to quickly establish wireless data networks without having to depend on telecommunications operators for the use of their services.

Small enterprises could then easily become internet service providers and voice service providers in their local communities. Collections of these local operators could then connect to larger internet and basic service providers. This will enhance competition in these areas which ultimately benefits consumers who can then choose from a variety of connection options for their telephony and internet needs. This will help to achieve rural connectivity and universal access. It will also spur development, which in turn will create employment and further development.

The Wireless Internet Institute et al. (2003) concur and suggest that wireless internet technologies can enable deployment of low cost broadband internet infrastructure and last mile solutions. Using wireless, it is possible to leapfrog traditional infrastructures to the latest most advanced technologies. The Wireless Internet Institute et al. (2003) feel that the demand for connectivity and applications will drive further development in underserved areas. This is elaborated on in the next point.

5.2 Applications drive development and dictate which technologies we use for rural connectivity

Additionally, from the MuTI case study, it has become apparent that applications drive development and dictate which technologies should be used to supply local demands. Basic telephony alone is not sufficient for bridging the digital divide in underserviced areas. The provisions of value added services such as internet access are necessary if universal access goals are to be met.

An example of how applications drive development is illustrated in the following anecdote. During the case study, the authors discovered that in many of the so-called underserviced areas in the Eastern Cape such as Tsilitwa and Sulenkama, there is widespread cellular coverage. A substantial amount of people in these areas have prepaid phone packages and cellular phones. Since the electricity supply in these regions is sporadic and many households do not have electricity, many small businesses have developed around the cellular industry. Specifically, shops have sprung where one can pay a small fee to have one's cellular phone recharged. This example shows how where there is a need, businesses and development follows. It is therefore imperative that the needs and services required in rural and remote regions be fully assessed before deciding what technologies are appropriate to fulfill those needs. The methodology used in the MuTI project centred around this premise of finding the needs of a rural community and developing applications around these needs (Chetty et al., 2004).

Aside from the telemedicine application described in the case study, people in these regions could benefit from applications to improve the delivery of social services, interaction with government and information provisions services. Thus technologies should be used in these areas according to the services and applications required. Also, free reign should be given over the combination of technologies one can use for achieving connectivity and value added services in these areas.

5.3 WiFi and VoIP can help entry barriers for USALs but ultimately USALs may not be the solution for underserviced areas

Another reason why wireless technologies should be opened up is that it will benefit the Under Serviced Areas Licensees (USALs). At present, USALs have to compete with MTN and Vodacom, who due to universal service obligations already have a large market and widespread coverage of remote areas, attracting people with prepaid packages. Also, USALS are for small businesses only which means it is expensive to set up operations in these areas, as they do not have access to large amounts of capital and traditional telephony infrastructure is costly. Wireless last mile solutions could be combined with VoIP to lower the entrance costs for USALs.

However, USALs may not be the answer for deploying telecommunications in underserviced areas. At the time of writing, no USAL was operational due to the drawn out application process for USALs and the fact that only 4 USALs have been awarded and only as recently as late 2004. Furthermore, Gillwald and Esselaar (2004) point out how the ministerial determinations announced in 2004 (RSA, 2004), while good for industry and the general public, have weakened the business case for USALs in several ways. First, the determinations allow VANS and private telecommunications networks to self-provide their infrastructure. This means USALs can no longer count on bringing in revenue from offering alternative telecommunications infrastructure to VANS and mobile operators in underserviced areas.

Secondly, the determinations stated that the Department of Communications will allow anyone to apply for licences to provide pay phones. Again, pay phones in rural areas have a high calling rate per phone since there are not many communication options in these areas. Allowing anyone to provide pay phones cuts down an advantage USALs may have had to provide these kind of services in rural and remote regions. Thirdly, the determinations state that all schools must receive a 50 percent discount for internet access. Again, this removes a potential revenue stream for USALs in remote regions. Fourthly, USALs were part of the original triad allowed to use VoIP (SNO, USALs, Telkom) — this advantage has been removed.

Allowing any company to be a telecommunications service provider using WiFi, VoIP and other technologies without having to apply for licences may be a better solution. This would spur competition and development and allow companies to quickly set up operations without having to deal with cumbersome and expensive licensing procedures. It would also enable the provision of telephony and value added services at affordable rates.

5.4 Wireless technologies are less susceptible to vandalism and theft

Another reason to use wireless solutions coupled with VoIP in rural areas is that they are less exposed to acts of vandalism and there is no risk of cable theft and network loss. In fact, during the MuTI project, we found that the DECT phones in the Tsilitwa and Sulenkama area were often unavailable due to vandalism and theft. Also, in these remote areas, a wired solution is not practical given the topology and harsh environmental conditions.

5.5 WiFi is more cost effective than cellular technologies in rural areas

In the South African case, given the extent of the coverage of cellular networks in rural areas, one might argue that we should utilise cellular technologies, such as third generation wireless (3G) or and General Packet Radio Service (GPRS), to provide value added services as opposed to WiFi. Using 3G, one can access multimedia content and internet services from one's cell phone (Kurose and Ross, 2005). Similarly, GPRS also enables internet connectivity through a cellular telephone at a data rate of up to 114kps (Kurose and Ross, 2005). However, the low population density of rural areas and the fact that rural populations generally have a lower disposable income, make the pricing schemes for these technologies too costly for these areas.

Bhagwat et al. (2004) support this statement, claiming that cellular services are value-priced for markets where users are willing to pay a high price. In rural areas, this type of pricing is not apt. Furthermore, at present, only the mobile operators in South Africa are licensed to provide 3G and GPRS. Again, this means there is less scope for competition amongst the service providers and thus, the end users may not be provided with prices that are suited to the rural environment.

Thus VoIP is not a panacea by itself for last mile solutions to remote areas. However, if it is combined with wireless technologies such as WiFi it will lower the cost barriers for both network service providers and consumers in rural and remote areas.

6 Conclusion

To conclude, South Africa is moving forward in terms of deregulating telecommunications and opening up markets to competition. This will have a positive impact on operators and consumers alike. In particular, the deregulation of VoIP will lead to many new opportunities for commercial enterprises but VoIP will not be useful by itself in the underserviced areas. Instead, to bridge the digital divide and unlock the full benefits of VoIP, wireless technologies should also be deregulated. This paper argues that a combination of VoIP and wireless technologies like 802.11 may help provide the much needed last mile access. Also, since the business case for USALs has been weakened by the ministerial determinations announced in 2004, USALs may no longer be a viable solution for achieving universal access (Gillwald and Esselaar, 2004). A better solution might be to allow any companies or service providers to set up operations in underserviced areas using WiFi and VoIP without having to apply for a licence. This would enable any providers to quickly deploy telecommunications facilities at affordable rates without having to deal with cumbersome licensing procedures.

This is warranted in a country where the sole mandate granted to the incumbent telecommunications operator has not resulted in the goal of 6 million fixed lines (Gillwald and Esselaar, 2004). Also, since the Second National Operator has yet to be licensed before it can set up operations (ITWeb b, 2005), there is a need to speed up the process of providing universal access by whatever means possible. South Africa needs to discover the applications required in its rural regions and then roll out technologies to fulfill those needs. This will spur development and help bring the country closer to the goal of achieving universal access.

Elsewhere, more developed nations are pressing ahead with VoIP and WiFi solutions. In Africa, governments need to follow suit if they are to bridge the digital divide effectively. This paper has provided examples of how VoIP can be combined with WiFi to provide locally relevant applications to underserviced areas around the world and locally. For these reasons, further telecommunications liberalisation is required in South Africa, with an emphasis on technology neutral policies. These will allow more service providers to meet universal service goals with whatever technologies are necessary.

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