The expansion of the Siyakhula Living Lab: a holistic perspective

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In this paper we discuss the recent expansion of network connectivity within the Siyakhula Living Lab. This is part of an ICT-for-development project located in a rural area on the Wild Coast of South Africa. Thus far, five schools in the area have been the primary points of access to the network for the surrounding communities. Thanks to external funding, eleven more schools will be connected. Consistent with the Living Lab approach, the expansion needs to take into account technical as well as social aspects. Technical challenges relate mainly to the constraints of working in a rugged, mountainous terrain with poor road and electricity infrastructure and harsh environmental conditions such as dust and temperature variances. Social challenges relate to obtaining the buy-in of the local community and to reaching consensus on the criteria for the expansion. In this paper we account for the preliminary work which led to the implementation plan. We hope our experience will inform similar interventions in other parts of Africa.

Keywords: Living Labs, ICT-for-development, wireless networks, WiMAX, social aspects, community involvement.

1 Introduction

Internet penetration in Africa is low compared to other parts of the World. Despite its strong economy and first-World infrastructure in metropolitan areas, South Africa only averages an Internet penetration of 10% [1]. This is largely due to poor ICT infrastructure in rural areas where a vast portion of the population (approximately 42.5% according to the 2001 census [2]) lives. The fixed-line teledensity in rural areas is less than 5% [3] and the high cost of deploying and maintaining copper and fibre plants make it risky for telecommunication operators to roll out traditional wired technology into these rural areas [4]. For these reasons wireless technologies appear to be a more viable solution [5].

Access to the Internet has recently been recognised by the UN as a human right [6]. Information and knowledge are key strategic resources for social and economic development. Rural communities could be empowered by participating in the

knowledge society through the use of ICTs. In order for ICT interventions to be effective and sustainable, the local community of prospective users needs to be involved in shaping and supporting the intervention [7].

In this paper we discuss the current (Aug – Nov 2011) expansion of an existing ICT-for-development (ICT4D) project with a strong telecommunication focus. The expansion is funded by a company who specialise as a telecommunications solution provider [8] as an exploration of possible technical and social challenges in network provision in rural communities. We couple the use of wireless technologies like WiMAX, WiFi with a focus on social integration within the framework of the Siyakhula Living Lab (SLL) based in Dwesa/Cwebe, a rural area of South Africa.

The work covered in this paper is part of an overarching project, the SLL. For more information on the project as a whole, or for specifics on the wireless technologies that are used, refer to [7] and [4] (respectively). This paper differs from past publications as it focuses on the planning of and expansion of the infrastructure in the SLL as well as the integral participation from local community within the SLL, while still covering some necessary background information from our previous interventions. The paper starts by providing background on the SLL, describing the location and a brief history of the project. It then details the expansion of the footprint of the SLL, including discussions on technical, logistical and social considerations. The paper then finishes with some concluding remarks.

2 The Siyakhula Living Lab

2.1 Dwesa/Cwebe

The SLL includes several villages in the Mbashe municipality adjacent to the Dwesa-Cwebe nature reserve. The natural environment, consisting of the nature reserve and the adjacent coastline are assets for the communities. The unspoiled natural beauty and wild beaches have the potential to significantly promote eco-tourism in the region. Furthermore, the high levels of rainfall and rich soil in a typically dry area of the country, has potential for controlled agricultural intensification and commercial forestry [9].

Despite the distinctive features mentioned above, the Mbashe municipality is representative of many rural realities in South Africa and in other parts of Africa. It is characterised by a lack of electricity, telecommunication infrastructure and poor road conditions. Dwesa/Cwebe can be reached only via gravel roads (which vary between 40 and 50km in length and quality) and becomes inaccessible after heavy rain as a result of flooding in the Mbashe and Nqabara rivers. In many villages, schools and clinics are the only buildings connected to the electricity grid, although electrification efforts are underway to connect community members' homes (having begun in mid 2010). Fixed-line telecommunications are non-existent and members of the local communities rely mainly on mobile phones.

Service delivery in the area is poor and limited to basic education and health care. People have to travel to the nearest urban centre (approximately 40km away) to buy groceries and electricity, withdraw money at the ATM and reach the police station,

hospital and local administrative offices. The cost of travelling to and from town adds to the burden of communities, which are characterised by endemic poverty and heavily reliant on government grants, subsistence farming and cattle-raising. The Mbashe municipality has recently been the site of various developmental projects. ICT can support rural development initiatives by enabling communication and access to relevant information and services over the Internet.

2.2 Project history

The Dwesa/Cwebe area has been the site of ethnographic research by the Anthropology Department at Rhodes University for a number of years [9]. Together with its potential for economic and social development and its representativeness of many African rural realities, this is one of the reasons why it was chosen for an ICT-for-development intervention. What is now known as the Siyakhula Living lab started as a joint venture of the Telkom Centres of Excellence (CoE) at Rhodes University and the University of Fort Hare to explore the potential of marginalised areas through the introduction of ICT. The collaboration provides the level of resources necessary to run an ICT project in a remote rural area. Other academic departments such as Anthropology, Education, Information Systems, Communication and African Languages have also joined the project.

Since 2005, a multi-disciplinary team of young researchers from the two universities has been visiting the Dwesa/Cwebe area for approximately one week of every month. The initial deployment of infrastructure was preceded by extensive consultation with the communities and the local power structures (e.g. headman, nature reserve trust etc.). Schools were chosen as the points of presence because of their role as centres of knowledge in community life, as well as for the availability of electricity and secure building infrastructure. The development of the project was based on the premise that the local communities would take responsibility for the safety and use of the equipment, and that the schools would become centres that provide access to computers and the Internet. Educators with an interest in the project identified themselves as ICT-champions [10], i.e. as the primary drivers of the implementation at the local level.

Informed by the principles of social informatics [11], our intervention has always coupled technological development with skills development and social integration. Following this holistic approach, the project has grown into the Siyakhula Living Lab, which currently connects five schools in the area and provides access and training for the respective communities. The living lab approach is defined as "an approach that deals with user driven innovation of products and services that are introduced, tested and validated in real life environments" [12. p8]. The community is an active participant in the project, and the impact of ICT in the area has been documented by a number of publications [7, 13] focusing on different (multidisciplinary), changing aspects within the project that has now been running for almost 6 years (November 2005 to November 2011). The SLL has attracted considerable interest by the media and by government officials at the local, provincial and national levels. An excellent collaboration with the local offices of the Department of Education resulted in the funding of an Advanced Certificate in Education (ACE) specialising in ICT. This is a

part-time qualification for educators in the area and, as shown below, is instrumental to the expansion project. A wide array of Industry and Government parties are participating in funding the SLL. Funding by one such industry partner spear-headed the expansion described in this paper.

2.3 Current network configuration

From a technical point of view, the primary objective of the SLL is to develop and field-test a distributed, multifunctional community communication platform, using localization through innovation, to deploy in marginalized rural communities in South Africa. These communities, by sheer size and because of current political dynamics, represent a strategic emergent market. A reliable local loop access network was required; we decided to make use of wireless technologies as there was no fixed line infrastructure in the region onto which we could piggy-back. WiMAX technologies were chosen to build a wireless local access loop and more specifically the Alvarion BreezeMAX technology.

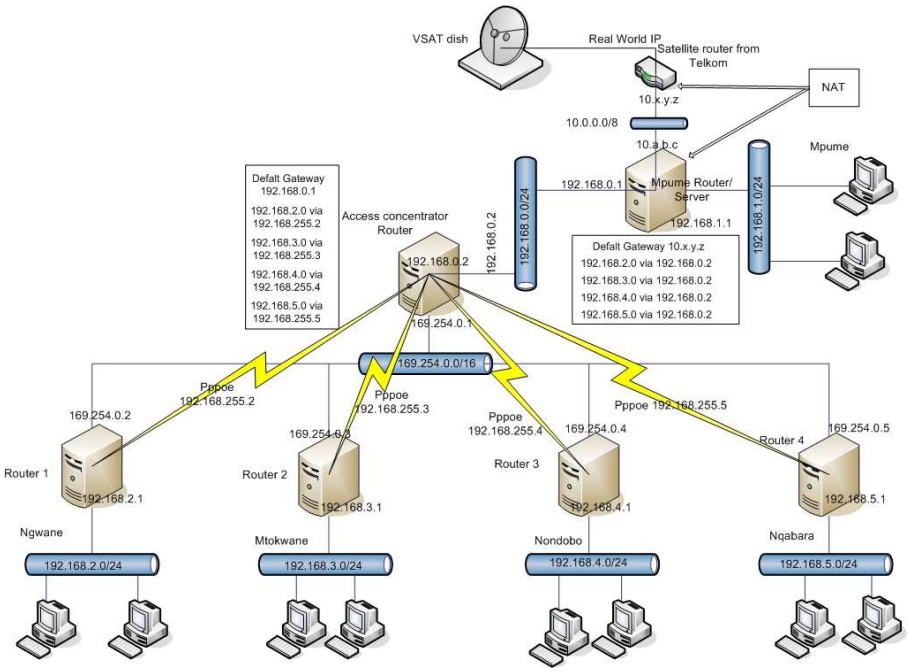

Figure 1: Network diagram of the SLL

The communities access the SLL infrastructure and communications platform via the distributed access nodes (DANs) at the schools where the DANs are hosted. Currently five schools house DANs, namely, Mpume JSS, Ngwane School (both a primary and a secondary school), Mthokwane JSS, Nondobo JSS and Nqabara SS [see Figure 1]. Each DAN is equipped with a thin client computer lab running

Edubuntu Linux and approximately 5 to 20 thin clients, depending on the size of the classroom made available and the level of security. At each DAN there is a community access point (CAP) which provides access to the local loop WiMAX network for all the clients at each site. The CAP is a FreeBSD router that is configured to manage and monitor the DAN through a number of services such as SMTP and Netflow to name a few.

The CAP acts as a gateway between the local area networks (LAN) within each school and the bigger local loop network. The CAP runs a Point-to-Point Protocol (PPP) client, specifically PPP over Ethernet (PPPoE), which contains the school's username and password for authenticating with the access concentrator housed at Mpume. Once authenticated and the link has been established the router will route all outgoing traffic, intended for one of the other schools (such as local VoIP traffic) or the Internet, onto the next hop which is the access concentrator.

The WiMAX micro base station is housed at the Ngwane School because of the schools currently involved it is situated at the highest point within the geographical area. WiMAX technologies do not require a clear line of sight (LOS) like WiFi, however large obstructions will still affect the signal path and either disrupt or prevent communication. Thus a high site is still required so that the best possible path is available for wireless communication between the micro base station and the customer premises equipment (CPE) at the various DANs. At Mpume, Mthokwane, Nondobo and Nqabara there is a CPE unit that connects back to the micro base station at Ngwane to allow network traffic to flow between the schools.

The local loop access network connects to the Internet via a Telkom VSAT connection. This equipment is however not housed at the Ngwane School (where the micro base station is installed). The VSAT unit was installed at the Mpume School. The reasons for this are both historical and strategic. The Mpume School was the first school to join the SLL project and so was the logical location (at the time) for VSAT installation. The Ngwane School only joined the project a year after the VSAT link had been installed and so its status as the geographically highest school in the SLL was only determined post VSAT installation. However, it was decided that the VSAT unit should not be moved retrospectively to the Ngwane School in order to ensure that no one school was responsible for all the network facilities. Rather, the schools and communities need to work together, pooling their resources and collective capacities to jointly run and operate the network for the benefit of all.

Mpume thus houses the Access Concentrator (AC) which terminates all incoming PPPoE connections from the DANs (school sites) in the SLL local loop network. Traffic from the other schools is switched at the micro base station and sent to the Mpume School where the AC terminates the PPPoE sessions; each router at each of the other schools runs a PPPoE client and authenticates with a PPPoE service running on the AC. These four schools (Ngwane, Mthokwane, Nondobo and Nqabara) are reliant on the AC in order to reach the Internet, while Mpume is reliant on access to the base station in order to make use of other local services such as VoIP and access to shared resources (off-line content) that are housed at the other schools. In the interest of collaboration and organic development, the principles informing the initial deployment will be maintained as far as possible during the expansion phase.

3 The expansion

3.1 Technical/logistic aspects

There are three aspects to the network expansion project. These include: upgrading the existing networking infrastructure from the 802.16d (fixed WiMAX) technology to the 802.16e (mobile WiMAX) technology; adding five new clients to the new mobile WiMAX base station at Ngwane; and creating a new second "cell" (using the old 802.16d base station equipment) that peers with Ngwane. The upgrade of the WiMAX technology at Ngwane from a fixed wireless WiMAX base station to the mobile 802.16e WiMAX base station allows the SLL to experiment with the use of nomadic stations through the use of USB WiMAX dongles together with laptop computers or WiMAX enable mobile handsets that community members can use from their homes. Badi SSS is a secondary school which is approximately 10km from Ngwane. It was chosen as the host of the second cell because the school infrastructure has recently been renovated as part of the Dinaledi imitative to create centres of excellence in mathematics and Science Education and has a secure and fully furnished 30-seater computer lab. The school also has a water tower, which can be used to mount antennas onto in order to ensure links with remote schools. The second cell allows the network to expand to more sites.

In order to identify potential schools for inclusion in the expansion of the network, two methods were employed: a desktop survey and a site visit. The desktop survey produced visual representation of potential schools on a topographical map, using Radio Mobile and Google Earth, based on a comprehensive list of the possible schools in the area and their GPS coordinates. The set of potential schools had to be narrowed down to ten due to limitations in funding and prospective technical support.

Numerous factors played a role in selecting schools to be included in the newly expanded SLL. One of the key technical considerations was the location of the schools; we needed to connect schools that were within a 20km radius of Ngwane to firstly ensure that the Ngwane and the new base station host school would peer and secondly, because of logical constraints of moving around and supporting the numerous schools. Furthermore, the area around the Dwesa-Cwebe nature reserve is mountainous and there are many zones hidden in the shadows of higher mountain tops. We were able to make use of Radio Mobile to determine the likelihood of connecting schools to either Ngwane or Badi.

Even when considering schools within a 20km radius and not located in dead zones, we still needed to shorten the list further. At this point we considered the schools with at least one educator enrolled in the ACE ICT course mentioned in section 2.2. This yielded a list of nine schools: Badi Senior Secondary School (SSS); Lurwayizo SSS; Zwelidumile SSS; Lurwayizo Junior Secondary School (JSS); Ngoma JSS; Ntubeni JSS; Ngqeza JSS; Lower Nduku JSS; and Kunene Senior Primary School (SPS). While the desktop survey has its merits in narrowing down the list of possible schools, we still needed to conduct a physical site survey in order to confirm that the schools could in fact connect to the base stations at either of the

two schools (Badi or Ngwane) and to ensure that the school had no physical constraints, such as a lack of power, preventing their inclusion in the expansion.

Our site survey revealed that one of the nine schools had no electricity with no time frame for connection. A further three schools (Lurwayizo SS, Lurwayizo JSS and Ngoma, JSS) were soon to be connected to the power grid (end of July 2011). In addition, the school principal of Ngwane, a key driver within the adoption of ICTs in the community, suggested a further three new schools (Mevana JSS, Nquba JSS and Hlabizulu JSS) all of which are connected to the power grid.

Another significant finding during the site survey was the need for a 12m mast at Ngwane in order to connect some of the new school sites and in order to peer with Badi. Furthermore, in order to support the link between Badi and Ngwane, we will need to make use of the water tower on the Badi school property to achieve enough ground clearance to facilitate the link between the two schools.

Combining the findings from the desktop and site surveys we found that the following five new schools could be connected to Ngwane: Lurwayizo JSS, Lurwayizo SS, Ngoma JSS, Ntubeni JSS and Ngqeza JSS. While, the following five schools can be connected to Badi: Kunene SPS, Zwelidumile SS, Nquba JSS, Hlabizulu JSS and Mevana JSS (see Figure 2 for a graphical representation of the expansion network, created using Radio Mobile). Within the group of new schools we have a combination of schools that are closer by to the original communities (expanding the facilities there) as well as some schools much further away, such as Zwelidumile and Lurwayizo, allowing new communities to have access to technologies. In addition, the schools that are further away allow the project to test to the capabilities of the equipment of greater distances (up to 16km hops).

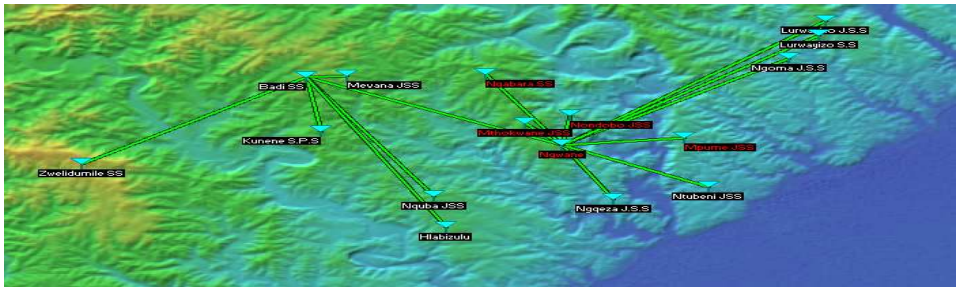

Figure 2: SLL network's physical/geographical layout; original network sites in red and black with new sites in white and black.

After the site visit, a meeting was organised by the researchers involved in the SLL to discuss which schools to prioritise and the nature of the intervention at each school. As mentioned previously there are three aspects to expansion, the network upgrade at the existing network sites, the creation of a new (second) cell within the network and the inclusion of the new distributed access nodes at the identified schools (of which there are 10 in total). Each aspect of the expansion and upgrade will be tackled at different stages:

- **Phase 1**. Upgrade existing network and deploy new cell. Ngwane: Install the mast and replace the base station with the new mobile WiMAX unit. Mpume, Mthokwane, Nondobo and Nqabara: Replace the CPEs for the new mobile

WiMAX units. Badi: Install the old base station; attach a pole to the water tower to house the omni-directional antenna.

- **Phase 2**. Connect seven new schools. Ntubeni and Ngqeza: Mobile WiMAX CPE. Zwelidumile: Old fixed wireless CPE. Kunene, Nquba, Hlabizulu and Mevana: Old fixed wireless CPE
- **Phase 3**. When electricity is available, connect remaining schools. Lurwayizo JSS, Lurwayizo SS and Ngoma: Mobile WiMAX CPE.

3.2 Social aspects

The expansion of the SLL network was the topic of a session of the ACE ICT group (refer to Section 2.2. for details on this certificate). Twenty educators from the area discussed issues of inclusion/exclusion of schools, priority of connection and criteria to use. The purpose of this exercise was to make sure educators in the area are aware of the expansion and have a chance to contribute in shaping it. It was also an opportunity for us to gauge the opinions of informed stakeholders, many of whom work in the schools we intend to connect. The session was structured in three parts. The first part consisted of preparation. Educators were invited to work in groups on a list of schools in the Dwesa/Cwebe area they felt should be connected to the Internet and provide some motivation. No further details were provided, not to influence the educators' responses.

The second part consisted of an explanation of the rationale for expansion and of some of its constraints, such as number of schools, need for electricity and line of sight with either Ngwane or Badi. Educators were then invited to fill in a four-question questionnaire. Question 1 provided them with a list of schools (based on our proposed list, but with no particular order) and asked them to rank them in order of connection priority. The list excluded Badi which, as was explained, had to be connected as a matter of priority. Question 2 asked them to motivate their ranking. Questions 3 and 4 asked if there were any schools they felt should have been included or excluded from the list (respectively).

The third part consisted of a class discussion. Criteria were summarised, propositions were matched and reconciled with our proposed list and ranking, constraints to the inclusion were reiterated and clarified. This activity highlighted the need to prioritise: schools near the ones already connected; secondary schools; schools with identified ICT champions; new schools serving far-away communities; and schools of good quality and readiness. These are the same criteria which emerged from the analysis of the questionnaire responses and resulted in the following order: 1) Ntubeni, Mevana, Ngqeza (close to schools already connected); Zwelidumile (a faraway secondary school); 3) Lurwayizo (JSS and SSS) and Ngoma (faraway schools with identified ICT champions; and Kunene, Nquba and Hlabizulu (schools with identified ICT champions). The input of local educators also provided us with a list of additional candidates: Ngwane, Nqabara and Luvundu Primary School (close to more senior connected schools); Mpozolo and Dumalisile (secondary schools); and Lower Mbancolo and Lower Nduku (schools with identified ICT champions).

The first criterion was to connect schools near the ones already connected. This was often mentioned as a first or second criterion, together with the presence of ICT

champions. It was mentioned by roughly half the class in relation to both ranking (10) and inclusion (12). Educators commented both on the technical advantages and on the possibility for collaboration (e.g. “Ntubeni, Ngoma and Lurwayizo are nearer to Mpume so connection may be easier and also ACE ICT teachers can help each other”). The use of proximity as a criterion clearly informed the proposed ranking, with Mevana and Ntubeni (close to Badi and Ngwane respectively in the first and third positions. Nqabara Primary School, which is close to Nqabara Secondary School which is already connected, was suggested by 8 as a strong candidate for inclusion. In similar cases (e.g. Nqabara and Ngwane Primary) schools will be connected in the foreseeable future to a school included in the expansion via WIFI.

The second criterion was the choice of secondary schools as a priority. This was mentioned by an equal number of educators in response to the ranking (7) and inclusion (6) questions. Making space for secondary schools was also mentioned by 2 educators as a reason to exclude some primary schools from the list (e.g. “Nquba and Kunene could be removed to give chance to two high schools”). The fact that some primary schools are feeder schools for secondary schools was mentioned as an explanation for high ranking (e.g. “Ngoma and Lurwayizo JSS are the feeder schools of Lurwayizo SS”). The only two secondary schools in the list (Lurwayizo and Zwelidumile) were in fifth and seventh position. Secondary schools like Mpozolo and Dumalisile were suggested by 4 for inclusion, while only 1 suggested primary schools (in combination with a secondary). These considerations suggest that prioritising secondary schools was more important for inclusion than ranking.

The third criterion was the presence of an ICT champion, often a participant in the ACE ICT course. This was mentioned as a criterion more often in relation to ranking (11, often after proximity to connected schools) than inclusion (4). Most schools in the list had educators who were part of the ACE ICT course. The presence of two educators from Ngoma is consistent with its second position, while the absence of educators from Nquba JSS and Hlabizulu JSS might explain why they were placed in the two lowest positions and were mentioned by two for exclusion. 5 educators mentioned the presence of ICT champions to motivate for the inclusion of schools not originally on the list, such as Lower Mbangcolo JSS and Lower Nduku JSS.

The fourth criteria was providing connectivity for schools and communities far away from the ones already connected in order to promote a sense of sharing of resources and social cohesion (e.g. “Connectivity should be spread evenly in order to sustain the project“). In terms of ranking, this was mentioned by 6 educators, invariably as the first criteria. The idea of forming a cluster with neighbouring schools and providing access for the surrounding community featured very strongly. In terms of inclusion, this criterion was mentioned by 10 educators. An educator indicated that some schools could be excluded because they were close to the ones already connected in order to “give a chance” to faraway schools (e.g. “I feel that Mevana should be excluded as is closer to Badi where it can access Internet easily“). On the one hand, the use of this criterion led to some interesting discoveries, such as Luvundu JSS which already has a computer lab and can be connected via Zwelidumile SSS). On the other hand, two educators also suggested schools which are too far away to be considered because of technical constraints (e.g. Ngxunyana JSS, which is more than 40Km away in Willowvale). These unrealistic expectations had to be managed.

Educators also commented on the perceived quality and readiness of schools. Good performance seemed to have more bearing on inclusion (3) than ranking. Perceived readiness of the school management and neighbouring community were mentioned (e.g. “The principal is so interested for this project” and “There will be motivation in the community members”). Lack of electricity was mentioned by 6 educators as a reason not to connect some of the schools. In all cases, this referred to schools which, according to our site visit, have actually been connected to the electricity grid in recent times. Not surprisingly, the general consensus was that, if possible “All schools should benefit”). The presence of technical and logistic constraints gave some grounding to the exercise and teased out the most relevant criteria. These criteria will be probed at a meeting involving the whole community.

4 Conclusions

In this paper we discussed the framework for the extension of the Siyakhula Living Lab, an ICT4D project based in a rural area in South Africa. Consistent with the Living lab approach, we took both technical and social aspects into consideration. The framework we proposed in this paper relies on general principles, key dimensions and two sets of operational criteria (technical and social). General principles such as interdependence of the schools and system redundancy which had informed the initial deployment were upheld during the expansion.

The expansion presented two dimensions: inclusion and priority. With respect to inclusion, a decision had to be made on which schools it was possible and advisable to connect. The possibility of inclusion was dictated by technical and logistic constraints. The advisability was dictated by more social aspects, such as the presence of a potential ICT champion. A technical/logistic constrain was the creation of a second cell, required by the funder. Once this requirement was satisfied, the priority was dictated by social considerations.

Two sets of criteria emerged relating to technical and social aspects respectively. The criteria relating to technical and logistic aspects were proximity to the Dwesa/Cwebe area, presence of electricity and line of sight with one of the two proposed nodes. The criteria relating to social aspects were proximity and collaboration with schools already connected, level of school (i.e. secondary), presence of an ICT champion and providing access to new clusters of schools and communities. It is important to note that both sets of criteria were considered by both the technical survey team and the group of educators in the ACE ICT course.

The framework presented in this paper is by no means exhaustive and will be revised once the expansion is completed (September 2011). We also realise the limitations of our methodology due to possible bias and lack of knowledge of some of the participants. However, we believe this paper represents a meaningful contribution to modelling ICT penetration in Africa and a possible reference for similar experiences.

References

1. Goldstuck, A., *Internet Access in South Africa 2010: A Comprehensive Study of the Internet*

*Access Market in South Africa*2010: World Wide Worx.
2. Statistics South Africa. *Census 2001: Investigation into appropriate definitions of urban and rural areas for South Africa. Discussion document. Report no. 03-03-20 (2001)*. 2001 [cited 2009 February 26, 2009.]; Available from: http://www.statssa.gov.za/census01/html/UrbanRural.pdf.
3. South African Consulate General. *Communications*. 2004 [cited 2004 May]; Available from: http://www.southafrica-newyork.net/consulate/telecom.htm.
4. Siebörger, I., and Terzoli, A. *WiMAX for rural SA: The experience of the Siyakhula Living Lab*. in *Southern African Telecommunication Networks & Applications Conference: A society enabled by Innovation and Applications*. 2010. Stellenbosch, South Africa.
5. van Reijswoud, V., *Appropriate ICT as a Tool to Increase Effectiveness in ICT4D: Theoretical Considerations and Illustrating Cases.* The Electronic Journal of Information Systems in Developing Countries, 2009. **38**(9): p. 1-18.
6. Wired. *Internet a Human Right*. 2011; Available from: http://www.wired.com/threatlevel/2011/06/internet-a-human-right.
7. Pade, C., Siebörger, I., Thinyane, H., Dalvit, L. *The Siyakhula living lab: a holistic approach to rural development through ICT in rural South Africa*, in *ICTs and Sustainable Solutions for the Digital Divide: Practical Approaches - Development Informatics and Regional Information Technologies: Theory, Practice and the Digital Divide.* 2010, IGI Global.
8. Browne, D. and A. Leitch. *Case Study of Telkom South Africa's Centre of Excellence Postgraduate Research Programme*. In *IST-Africa 2009*. 2009. Uganda.
9. Palmer, R., H. Timmermans, and D. Fay, *From Conflict to Negotiation Nature-based development on the South African Wild Coast*2002, Pretoria: HSRC Press.
10. Brandt, I., A. Terzoli, and C. Hodgkinson-Williams. *Models of Internet Connectivity in Previously Disadvantaged Secondary Schools in the Eastern Cape*. In *Southern African Telecommunication Networks & Applications Conference: A Future Fuelled by Communications, 2004*. 2004.
11. Kling, R., *Learning about information technologies and social change: The contribution of social informatics.* The Information Society, 2000. **16**(3): p. 217-232.
12. Mulder, I., et al., *Real World Innovation in Rural South Africa.* The Electronic Journal for Virtual Organisations and Networks, 2008. **10**: p. 8-20.
13. Kavhai, M., O. Osunkunle, and L. Dalvit, *The impact of rural ICT Projects in South Africa – A Case Study of Dwesa, Transkei, Eastern Cape South Africa*, in *Communication Department*2010, University of Fort Hare: Alice, South Africa.