Design for Sustainability

Rural Connectivity with Village Operators

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Abstract—**South Africa has approximately 26500 primary and secondary schools, of which at least 17000 are in remote rural villages. None of these rural schools have any form of Internet connectivity. The same rural villages may have one health facility for every 20 schools and very few other public or community service centres. This paper presents a model that is being developed and tested in South Africa to establish rural connectivity by way of Village Operators as rural micro enterprises that build, operate and support localised network infrastructure using wireless mesh network technology. The design of the intervention focuses on sustainability and resilience in providing the connectivity service, keeping in mind the adverse conditions, limited resources, and the cultural and political contexts in which these networks have to survive. In the space where the market does not normally operate, the creation of a new ecosystem with an associated business model is being explored. The findings and learning from the first phase, in which 200 schools were connected and 15 Village Operators established, is presented.**

Keywords - Wireless Mesh Networks; Village Operators; Sustainable Design

I. INTRODUCTION

To thrive in today's world, it is important for societies to have ubiquitous access to broadband. Recent econometric studies have quantified the direct impact on productivity and economic growth suggesting that an increase in broadband penetration of 10% could result in an increase in GDP of 1 to 2% [1].

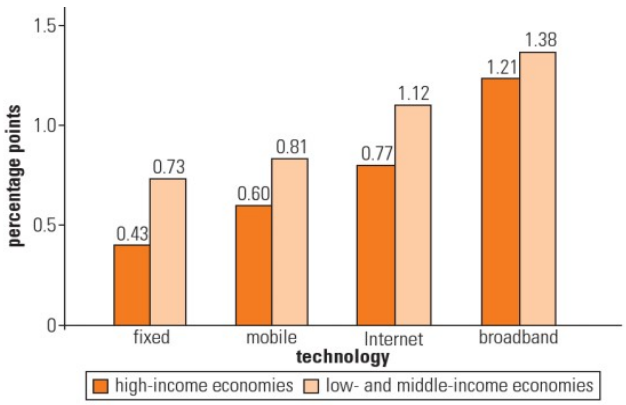


Figure 1. Growth effects of 10% increase in ICT penetration [1]

The Broadband for All (BB4All) initiative by the CSIR Meraka Institute aims to provide affordable broadband connectivity to under-serviced, rural communities. It uses low-cost infrastructure that is owned and supported by the local community, to create socio-economic and commercial opportunities. The BB4All initiative is sponsored by the South African Department of Science and Technology (DST) with European Union sector budget support funding.

At the heart of the BB4All initiative is the Wireless Mesh Network (WMN) project. The large scale demonstrator of the WMN project started in 2009 with initial deployment targeted at a rural area of South Africa, previously called KwaNdebele. This area represents a typical South African rural area characterised by a significant lack of public infrastructure and economic opportunities, and a large population of people who were relocated there during the apartheid era.

The BB4All initiative is designed as a collaborative effort between researchers, government, NGOs and industry with the aim to create an enabling ecosystem of players that will survive beyond the project phase. This ecosystem is depicted in the illustration below.

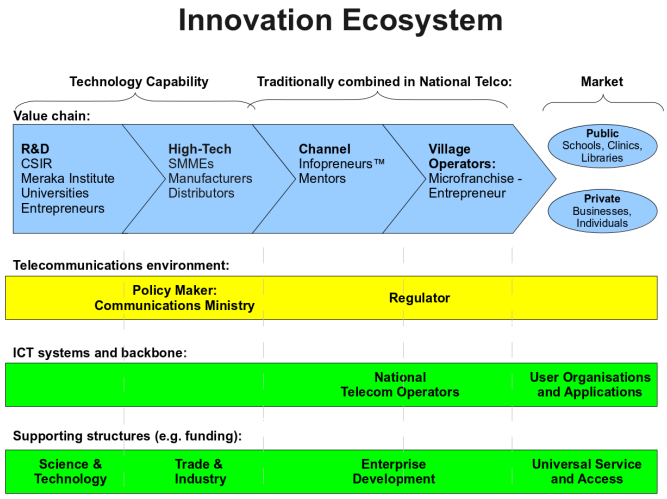


Figure 2. Players in the rural access ecosystem

This paper presents how this model was developed to establish rural connectivity by way of Village Operators (VOs) as rural micro enterprises that build, operate and support localized network infrastructure. The design of the intervention focuses on sustainability and resilience in providing the connectivity service, keeping in mind the adverse conditions, limited resources, and the cultural and political contexts in which these networks have to survive.

In the first year of the project, 19 Village Operators were recruited and trained, wireless mesh equipment installed in 200 facilities, backbone networks built, and many stakeholder discussions held. The project still has many challenges with most of these Village Operators still being fledgling businesses, training found to be inadequate, schools not ready to fully utilise the available broadband capacity and the overarching operational and support organisation still in its infancy.

II. BACKGROUND

Research and development on the use of information and communication technologies (ICTs) for deep rural development started in the late 1990s [2]. At that stage tele-centers and other rural ICT projects showed more failures than successes, as the projects were technology driven and the environment was not very conducive to new innovations. At the time, the use of WiFi and Voice over IP (VoIP) was still illegal in South Africa. Nevertheless, the research highlighted the potential of these technologies for development. The use of VoIP was legalised only in 2005 [3], whereas use of WiFi beyond the confines of a single premise was limited to national telecommunication licence holders until some exemptions were allowed in 2008 [4]. The main challenges identified were with regard to local ownership, security (of equipment), and sustainability.

After taking cognisance of the work on minimally invasive education with the Hole-in-the-Wall project [5], the CSIR developed the Digital Doorway [6] for application and use in the rural areas of South Africa. The Digital Doorway proved to be a successful intervention with little need for maintenance and support, and the technology continues to function usefully for many years after deployment. One of the key lessons from the Digital Doorway initiative was the importance of having the communities apply for installation of the Digital Doorway in their communities, instead of the sponsor or donor deciding where the technology should be deployed. This addressed the challenges of local ownership, which in turn also remedied a lot of the security of equipment issues.

Work on software and systems to give business and information support to small enterprises in rural areas led to the development of the Infopreneurs™ concept [7]. The lack of higher level organisational support and ongoing mentorship was identified as key to the failure of many rural ICT-based enterprises. This was addressed by building a network based organisation to connect players involved in local economic development at three layers of national, regional and local organisations.

The final area of work that influenced the design of the BB4All initiative came from the imperative to stimulate innovation at local level in rural areas. This lead to researching the application of Living Lab methodologies in rural development [8]. The importance of including members of the local community in the actual technology development and innovations became clear; some of the rural development challenges were best addressed by the market-facing participants in the project instead of the researchers and technologists who are often far removed from rural realities. This is also reflected in the concept of human scale development, as conceptualised by Max-Neef and collaborators [9].

III. PROJECT DESIGN

A. Context

The BB4All initiative is positioned as a "smart intervention" in the area that is defined by Sabater as the "smart subsidy zone" [10]. The aim of the BB4All initiative is to address universal access in this area where the market has limitations and we reach what we have termed the "affordability frontier". Beyond this frontier, there may be areas or groups that cannot be reached commercially, even in the most efficient of markets, without some form of intervention. The aim is to intervene in such a way to make the area more attractive and to ensure that it eventually becomes market driven.

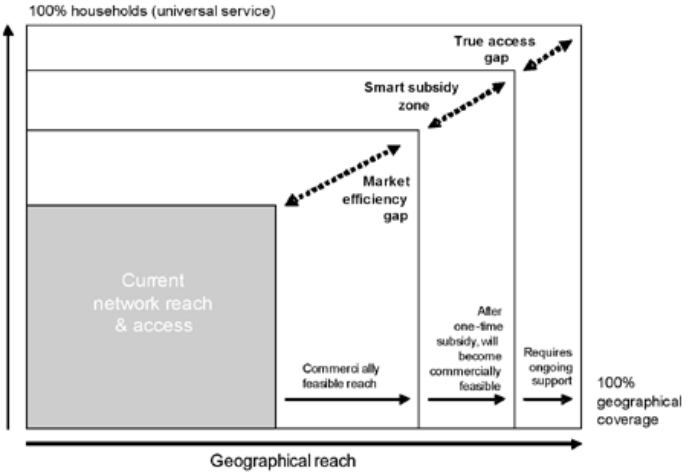


Figure 3. Affordability frontier and access [9]

South Africa has approximately 26500 primary and secondary schools, of which at least 17000 are in remote rural villages, according to statistics from the national department of education. None of these rural schools have any form of Internet connectivity. In most of the rural areas of South Africa, these schools represent the majority of government owned infrastructure. Schools were therefore chosen as the starting point for establishing this model. The same rural villages may have one health facility for every 20 schools and very few other public or community service centres.

B. Innovation Ecosystem

The value-chain approach as illustrated earlier (Figure 2) highlights the following stakeholders as potential key contributors to the initiative:

1) Research component: Department of Science and Technology, CSIR Meraka Institute, universities and high-tech SMMEs.

2) Technology development component: Department of Trade and Industry, manufacturers, high-tech SMMEs, distributors.

3) Implementation and distribution ("channel") component: Small Enterprise Development Agency, training and support partners, national network operators.

4) Business operations & community component: Department of Communications, National Regulator (ICASA), Village Operators (local entrepreneurs), and civil society organisations.

5) User/usage component: Department of Education, Universal Access and Services Agency, State IT Agency.

The necessary elements to make this ecosystem work, include:

An anchor client – some organisation or entity that makes it viable to establish the business. We have chosen to approach schools and with a minimum number of schools have to be connected in an area to make it viable.

A young person (based locally) who has the right attitude, interest and approach to become a Village Operator. A carefully designed process has been followed to recruit potential Village Operators (via school and NGO references) and filter candidates (testing, interviews and practicals) to a handful who are then given the Village Operator training.

Each Village Operator is linked to an exclusive 'service area'. The Village Operator is responsible for the clients from this area and know where boundaries to adjacent service areas are. The service area should be reasonably small to allow for support logistics, e.g. travel by foot or motorcycle to clients. Typical areas range from 5 to 15 km in diameter.

A minimum number of Village Operators have to be in the greater service area to make peer-to-peer learning and mentoring viable. The mentor assists in the business and personal growth of the Village Operators.

A back-office supporting service is essential to deal with national/political level negotiations, developing the 'offerings', vetting the Village Operators, conducting monitoring and evaluation, etc.

C. Outcome mapping for design, monitoring and evaluation

Using the innovation ecosystem perspective as basis, an 'outcome mapping' methodology [11] was used to design the monitoring and evaluation effort of the project. In the outcome mapping design, three clusters of 'boundary partners' or stakeholders were identified as critical to the success of the initiative. For each of the clusters, the desired 'outcome' was identified as follows:

1) National "Information Society" cluster (Education, Health, Communications, Public Service, etc):

- Endorse BB4All initiative (promoted by Department of Science and Technology in the cluster)
- Facilitate inputs to be provided by provincial stakeholders
- Facilitate directives to stakeholders in support of BB4All objectives
- Fund the roll out of backbone infrastructure and bandwidth provision

2) Provincial stakeholders (Premier's office, Provincial IT, Education, Health, and Provincial Public Service and Administration):

- Identify and select target areas for implementation of BB4All.
- Provide letters of approval to allow VOs to engage officials at government facilities.
- Information sharing and alignment with provincial ICT initiatives.
- Where applicable, provincial level contracting of VOs.

3) Local government facilities

- Enthusiastic support and use of broadband connectivity for administration and service delivery.
- Commit to provide electricity and access to facilities
- Where applicable, contract VOs for broadband access and support and value added services

A detailed monitoring and evaluation programme was then implemented to measure whether the desired behavioural changes took place, and/or whether any unexpected effects could be identified.

D. The local heroes – Village Operators

Asset-based community development (ABCD) is a methodology that seeks to uncover and utilise the strengths within communities as a means for sustainable development. The basic tenet is that a capacities-focused approach is more likely to empower the community and therefore mobilise citizens to create positive and meaningful change from within. Instead of focusing on a community's needs, deficiencies and problems, the ABCD approach helps them become stronger and more self-reliant by discovering, mapping and mobilising all their local assets.

The Village Operator models aim to leverage the social capital that exists in and between local school leavers, local

schools and other government facilities and the local community. By approaching the service as a community based enterprise development effort, the local infrastructures and local 'gatekeepers' are more easily accessed by the Village Operators. Trust is built between local players, without the need to create additional dependencies on external supply of resources or skills.

The key success factor therefore in the initiative is the Village Operators (VOs), who work within the communities to provide and manage the BB4All network. There are currently 18 VOs working in 15 communities in the Nkangala region. VOs are young local entrepreneurs with a keen interest in ICTs and who want to be self-employed. They are sourced from the targeted communities and will service their own communities.

The VOs are encouraged through training and mentoring to build and maintain their own businesses. They receive business and basic technical training, which is augmented by training on WMN technology and experiential learning. All these aspects support and encourage self-learning, a key skill for the VOs and communities to be self-sustainable.

Molumaela, one of the VOs attest, "*For me, the BB4All initiative brought a lot of knowledge. I didn't know about broadband and wireless technology, I am now informed and will in turn share this knowledge with my community. In this way I will be adding value to my community just as the initiative has added value to my life*."

Another VO, Sibusiso Mazibuko adds, "*We (the VOs) wake up every morning to go to the office. You should see Michael Mabena and Innocent Nene going to their office; you would be convinced they are working on Wall Street! Such is the pride we have in this project.*"

E. Village Operator feasibility and sustainability

Taking the context and aim into consideration, the first step is to do an evaluation of potential sustainability. A framework for Village Operator feasibility was developed and is summarised in the figure below. [12]

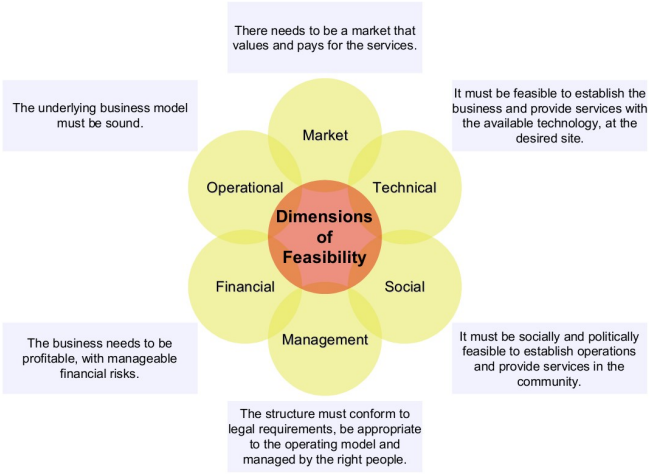


Figure 5. Village Operator feasiblity framework [12]

F. Partnerships, support network and sustainability

Further to the local sustainability, the sustainability at the different levels in the ecosystem also have be addressed.

Local manufacturers are used to manufacture some of the wireless mesh equipment. A South African company manufactures the high performance nodes (HPNs), a key component in WMN technology. This stimulates the use of local products and local labour. Ingwapele Technologies, headed by Louis Bapela, employs 10 permanent staff members, who are trained to install the nodes and other equipment unique to WMN, thus broadening the local skills base in the use of wireless mesh technology.

The initiative was designed with many levels of mentorship and support built in. A regional (district) level technical and business mentor provides the coordination and support of Village Operators within a particular district. A national support structure sets the standards for Village Operator selection, training and qualification, handles the legal and regulatory aspects, develop relations with national organisations, and do the national planning and coordination of Village Operator roll-out.

Through training and development, the BB4All initiative aims to leave a legacy in this community, a business model powerful enough for the community to sustain and develop further. The VOs will be well-equipped with resources, knowledge and the contacts to grow their own businesses, support their community and be the real advocates of ICT.

G. The network and associated technology

Putting the pieces together in the broadband network design and identifying the most appropriate technology led to the architecture illustrated in Figure 6 below.

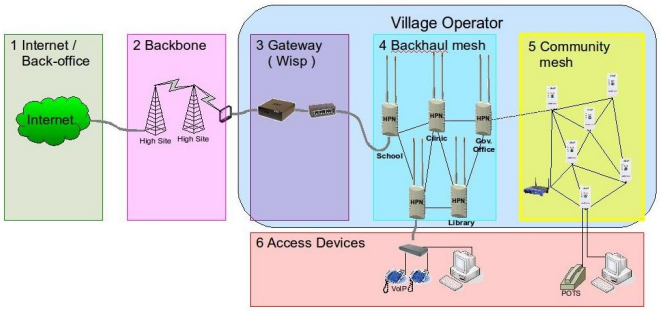
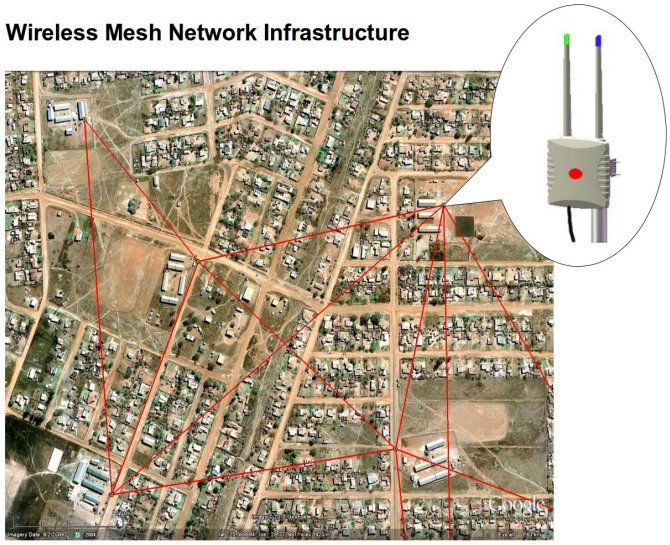


Figure 6. Network architecture

Wireless mesh network technology was selected due to its good fit with the low capital layout requirements and the potential to leverage the social capital between local facilities and the Village Operator. The wireless mesh technology developed at the CSIR is called high performance nodes (HPNs) due to the differentiation with respect to single channel mesh used in other community networks. The HPNs establish peer-to-peer communication within the network of schools and other government facilities. These nodes do not necessarily use one route, if one node goes down; the nodes are able to relay the

message using another route. This technology enables self-healing of the network via the ability to find these alternate routes automatically.

Figure 7. Wireless Mesh Network Technology



IV. RESULTS

In the first year of the project, 19 Village Operators were recruited and trained, wireless mesh equipment installed in 200 facilities, backbone networks built, and many stakeholder discussions held to get buy-in and alignment. As it is too early to report on sustainability at this stage, only some anecdotal results can be presented.

The following lists some of the field notes that reflect the results to date.

1) VOs are learning valuable business lessons

Customer use of Internet or email costs more than they are being charged! R5 for 30 minutes of access is the going rate at Internet Cafes. With their current 3G modems a few large downloads or file attachments exhausts their pre-paid bandwidth allocation. They are innovating to solve these issues, e.g. "use your phone to find the website and download the file and I will print it for you".

2) VOs are creating employment already

One VO is employing 2 people, "his little sister" and a young man, while another VO asks somebody to be in the office when she is away.

3) VOs are making a difference in communities

A VO is running a "job market". The mentor reports that several people have found repeat temporary employment through his efforts in connecting people to job offers. He checks people's email for them and informs them when they have a job offer. The VO has also posted instructions on an office wall as to how to use the Internet to get jobs.

4) VO Offices are becoming "Community Offices".

VOs keep copies of job related and other forms (govt Z83 job application form, SAPS, ESKOM, Dept of Social Services, etc.) which they had obtained from customers. These forms are put on a wall for all to see. This advertises jobs to a wider community and they get more business as people ask for copies of forms and assistance in emailing forms.

Small business customers are being helped too. Nombulelo has a hotel and funeral parlours as customers. She helped one customer, who wanted a catalogue, to get an email address and to load the mobile gmail client on his cellphone. Now he does his own email.

Two teachers have come with learners to do research. Customers come from as far as10km away.

5) VOs are supporting each other

Abel and Timothy share office premises and report that: Abel is better at video editing, while Timothy is better at numbers if you are writing a report. Abel bought a printer, while Timothy bought lights for use in video filming.Abel also prints pictures on DVDs for another VO.

The VOs from the Kwa-Mhlanga area come to the Moutse area VOs for support. An example is helping each other with laptop "rebooting" problems. According to Timothy, "Mpho comes every week to check consumables".

6) VOs are proud of their skills

VOs compared themselves to their local Internet Cafe's who cannot open .pdf files, do not provide a personal service and cannot assist people with Internet searches. They also provide additional services such as scanning, binding and receiving faxes.

7) VOs are already using social media

One VO stated that they are "all on Facebook". Her customers also use Facebook to place orders.

8) VOs are investing in their businesses.

As mentioned above:

- Abel bought a printer
- Timothy bought lights
- Mpho bought a laptop
- Nombulelo: brought a PC from home (for her customers to type on) and wants to buy a second hand fast high volume printer.

9) VOs are collaborating with Internet Cafes

Nombulelo's nearest cafe (400m away) sends people to her for printing if they have run out of ink.

10) VOs want to offer more services

VOS want to offer training that is accredited, the examples mentioned include: MS Office and "rebooting computer".

V. CONCLUSION

The Broadband-for-All initiative uses wireless mesh network technology and asset based community development theory to transform the project from a technology intervention into an innovative approach to real-life situations. Through this intervention, the improvement of the quality of life of rural or under-serviced areas of South Africa has become a possibility.

The early results of the project have shown signs that this approach can be scalable and sustainable.

This project also provides the opportunity for multidisciplinary research where social and business aspects are integrated with technological research to develop a sustainable business model.

ACKNOWLEDGMENT

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