

Towards a Sustainable Business Model for Rural Telephony

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Abstract

This paper presents the work done thus far towards designing a sustainable business model for rural telephony in the community of Mankosi, located in the Eastern Cape province of South Africa. The pillars of the model are sustainability and community ownership to design both the wireless mesh network providing the telephony service and its business model. Given the airtime consumption pattern in the community, the model is based only on the provision of calls inside the community and for using solar power to charge mobile phones. Some scenarios with different usage of the telephony services and different pricing rates are explored in order to find the break even point of the network, or in case the CAPEX was provided externally, to calculate the revenues expected. These revenues could be used for projects that benefit the community at large. Although the project is in its initial phase and the community has some particularities that make it unique, the sustainable business model presented here is intended to showcase innovative ideas that could serve similar projects in other parts of the world.

Introduction

Mobile data networks are reaching coverage close to 80–90% of the population in many developing countries in the world [ITU 2010]. This fact, together with the widespread availability and affordability of easy-to-use mobile phones, is driving many researchers to the conclusion that the digital divide in terms of access is about to be closed. Although this data is undeniable given that penetration rates of mobile phones are reaching 100% in many countries (considering that in some places phones are shared), the price of communications makes their daily use unaffordable for large segments of the population [Hausman 2010], especially those in rural and isolated places where new communication methods using mobile phones have been created to avoid such costs [Bidwell et al. 2011].

In this context, several initiatives around the world have spread to provide data communication using technologies that operate in unlicensed bands (those not requiring a license to transmit on them). [Rendón et al. 2005]. This reduces to zero the price of the communication among the devices forming the network. By network, we mean a series of communications hardware devices interconnected by communication channels, in our case electromagnetic waves, that allow sharing of resources and

information. In most of these initiatives, the cost of paying for Internet access in isolated places is the biggest barrier to its financial sustainability [Johnson 2007; Matthee et al. 2007] leading some to stop providing the services due to lack of funds [Rey 2008] or relying on external funding [Best & Kumar 2008]. However, other projects that might have been financial sustainable in the long run have been trapped by other factors, such as the lack of institutional support [Best & Kumar 2008] or the lack of capacity of local technicians to maintain the network [Brewer et al. 2005].

Some projects in South Africa, like Dabba¹, have attempted to leave Internet access aside (understood as web surfing, social networking, etc.) and base their revenue on rates charged for providing telephony using voice over Internet Protocol (VoIP). Most of them are located in peripheral and urban areas, and are run by individual entrepreneurs who base their business model on using VoIP providers over the Internet to offer cheaper rates than incumbent operators for calls to the PSTN and mobile phones, while providing free calls to other members on the network. Telecommunication networks like this can be considered as inverse infrastructure [Westerveld 2011]. Frequently, such networks consist of wireless mesh networks where every wireless router, or node, can establish connectivity and exchange information with any other peer without central management of any kind.

Although a more detailed study is being carried out (by us), observation in the field and informal interviews have shown that such a business model could not work in rural areas in South Africa given that most communication happens between members of the same community, i.e. within the potential members of the network. In addition, Internet access (for connecting to VoIP providers) is scarce and very expensive in these areas, being only available in many cases by satellite connection. For this connection to be financially sustainable the prices of calls to the PSTN and mobile phones would not be competitive with the prices offered by incumbent operators, not to mention the delays inherent in satellite connectivity.

This paper presents the main ideas behind a business model based on a community owned and designed wireless mesh network for providing internal voice communications within the community of Mankosi located in the Eastern Cape province of South Africa. We believe that the model described herein is unique, and is thus the main contribution of this paper. The rest of the paper is organized as follows. A Context section provides contextual information on the Mankosi community. A Methodology section describes a business model that lays the grounds for *financial* sustainability and given its participatory nature, the basis for influencing the *social* sustainability of the network. These are the main modifications to the model introduced by Bebea et al.

1 http://en.wikipedia.org/wiki/South_African_wireless_community_networks Last accessed May 25th 2012.

(2010) that has been used as a reference for designing the sustainability framework of the project. A Network Design section provides technical details on the mesh network and how it is powered. A Business Model section shows calculations to achieve a break even point. A Conclusion and Future Work section closes the paper.

Context

Mankosi is an impoverished rural community located in the so-called ‘Wild Coast’ of South Africa’s Eastern Cape. Mankosi is situated in the Nyandeni Local Municipality, “where over 50% of households have no income, other than remittances from family members living elsewhere, pensions and child allowances; and, 80% of families survive on less than 10% of South Africa’s national, median income for a working white man” (Bidwell 2009).

Mankosi is divided into twelve villages that are geographically spread across 30km² of very hilly land (see Figure 1). Mankosi has a population of about 11,000 inhabitants that with the exception of a few white people are Xhosa, grouped into families of up to five adults and seven children. Housing in the community is mainly traditional thatched roof mud-brick ‘rondavels’, with rectangular tin-roofed houses slowly becoming more common. Income is mainly from land-use and animal farming; horses, pigs, cows, goats and chickens can be seen everywhere in the community, although there are some local businesses, too.



Figure 1 The community of Mankosi is located between the Mthatha (left) and Mdumbi rivers (right), up until the landmark for a total of about 30 km².

As with many other rural settlements in South Africa, Mankosi is governed by a Tribal Authority (TA), which is a traditional political institution inherited patrilineally and is

different from the democratic and more modern legislative and political institutions existing in more urbanized areas. The TA comprises a Headman and Sub-headmen (one from each village), each of whose homesteads are also sites for administration.

There are communal goods that belong to the entire community, like sand to build bricks for the rondavels and houses, that are regulated to benefit not only the people making business out of it, but the whole community. To do that, the people that want the sand buy it and that money is kept to carry out projects for the community in the future. For collecting that money and manipulating it, the TA has created a legally recognized institution called Mankosi Trust.

According to a survey by Bidwell et al. (2011), the mobile phone penetration accounts for 56% of females and 76% of males in the community; 5% of people use another person's phone and 2% own more than one phone. Coverage in the area according to the two biggest stakeholders' websites, cover the whole community². However, according to Bidwell et al. (2011), most people subscribe to MTN given that they consider it to have good signal where they live. People buy airtime 'pay-as-you-go' and none have a contract or mentioned any data plans. People spend R13.5 per week (around R60, or US\$7.30, a month), although not all of that money is usable for communication. There is business in re-selling: people buy airtime in Mthatha, the closest city 80km away, and then resell it locally with a R2 surcharge on R5 top-ups.

Most community members do not have grid electricity domestically, so they have to pay to charge their phone in the few nearby places that have electricity, like the spaza (small shop), shebeen (bar-like meeting place), a neighbour's solar panel or generator, or at TransCape's premises (see below for more about TransCape). People pay on average R5.50 for charging a phone [Bidwell et al. 2011].

TransCape³ is a not-for-profit collaboration between staff at Mdumbi Backpackers located in the community⁴, the nearest rural hospital in Canzibe, and community members of Mankosi. TransCape aims to tackle the significant health, social, educational and economic needs in the community.

Apart from Transcape interventions in the community, action research, ethnographic and participative methods in technology initiatives have been carried out in the area since 2004 [Chetty et al. 2004; Tucker & Blake 2008; Tucker & Blake 2010; 2009; Bidwell 2010; Bidwell et al. 2010; Bidwell et al. 2011; Reitmaier et al. 2011; Reitmaier et

2 <http://www.vodacom.co.za/personal/main/coveragemaps> & <http://www.mtn.co.za/MTNServices/broadband/Pages/CoverageMap.aspx> Last accessed May 25th 2012.

3 www.transcape.org/ Last accessed May 25th 2012.

4 <http://www.mdumbi.co.za/> Last accessed May 25th 2012.

al. 2012]. These include deploying Wi-Fi to connect a clinic to a hospital, exploring communication practices and technology use, and localizing media design. One of these projects laid the groundwork for our proposed business model by charging money to charge mobile phones with a solar solution. On average, each solar unit charged 5 to 8 phones a day, at a cost of R3 per mobile phone⁵.

Methodology

The methodology used in the project is based primarily on the sustainability model described by Bebea et al. (2010). However, we made subtle changes given the big differences between their project aimed at providing telemedicine services for improving health care provision in isolated places operated by a regional health administration and the one described here, a community designed and owned wireless mesh network for the provision of telephony services. The approach defines a Sustainability Action Plan around five categories: technological, financial, socio-institutional, human and content. These factors are operationalized through three different plans: Operative Maintenance Plan, Institutional and Financial Plan and Continuous learning plan, as shown in Figure 2.

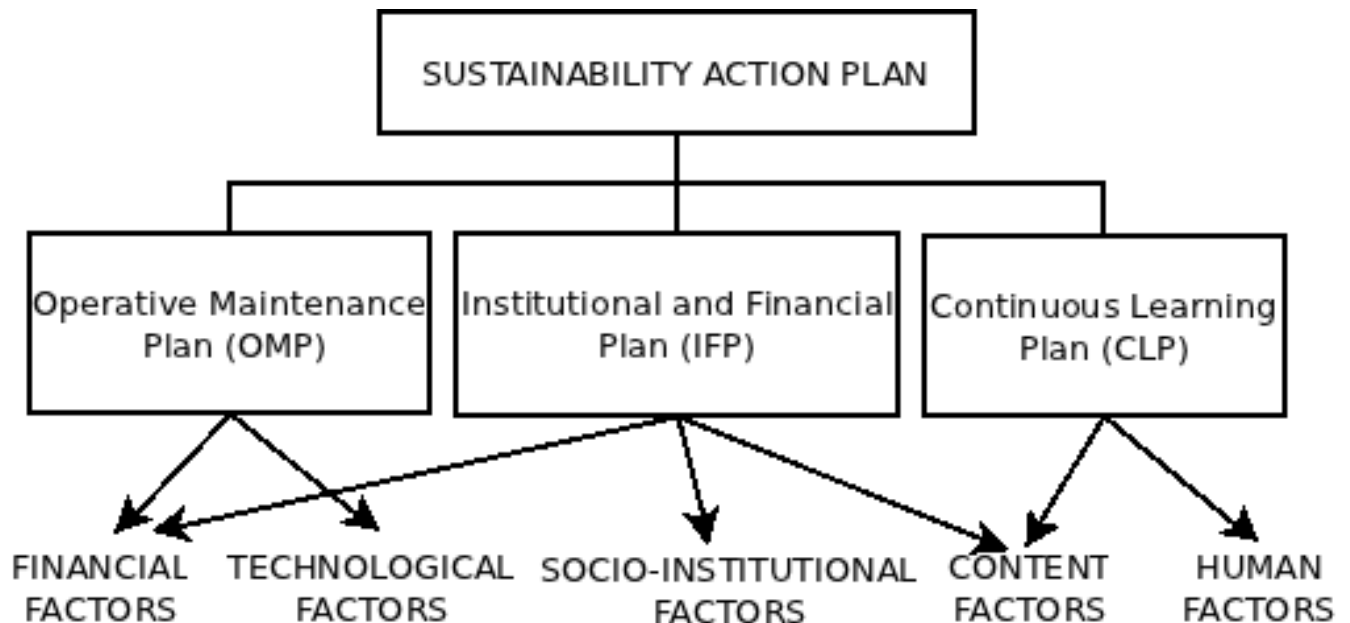


Figure 2 Sustainability Action Plan from Bebea et al. (2010).

Given that we are working directly with the community members and not through governmental institutions, our Institutional and Financial plan differs. Where Bebea

⁵ Data based on information from interviews with the project's manager.

et al. (2011) focus on creating the structures necessary within the regional and health administration to support and maintain the network, we focus on building a sense of ownership in the community concerning the network and business model, and base our effort on existing institutions, as discussed below. This is intended to improve the social sustainability of the network, meanwhile strengthening the existing institutional one.

One way of doing this is to adhere to the existing local protocol that people coming from outside the community should follow when wanting to carry out an initiative in Mankosi. This consists of first having a private meeting with the Headman and his closest advisers to describe the idea, its pros and cons, and if they like it, to ask for permission to work in the community. If the project is considered positive for the community, then the Headman calls a bigger meeting with all of his advisers, including subheadmen and other people interested in the development of the community, and the project is presented again with the pros and cons discussed yet again. This may not suffice for granting that the project will benefit the whole community, e.g. perhaps only the ruling institutions, and extra care will be given to this issue in future steps of the project.

For the case of this project, the first meeting was arranged by one of the authors who was born in the community and has lived there ever since. The meeting was carefully prepared by formulating the main ideas of the project, including its benefits and constraints, with regard to both local knowledge and culture. Both meetings discussed the constraints of wireless mesh networks like electromagnetic line of sight among nodes (not just the human line of sight, i.e. if you can see it you can connect to it, but that an extra space, Fresnel zone, is needed), link budget (e.g. the calculations needed to check that the received power over a certain distance is going to be above the receiver sensitivity so that communication is possible – a metaphor with the human auditory system was used), the need to be powered 24/7, the need for a maintenance budget and a maintenance team to solve the problems that certainly will appear, benefits like no cost associated to the calls (or any other traffic inside the network) and independence of node location. It is believed that thanks to the work done by Bidwell et al. (2010), the community is open to work with technology projects like this one, and they can trust the promised benefits.

Apart from making sure that the concepts were understood and obtaining the permission to work in the community, these meetings were of great value in learning about local cultural factors that could be key for the sustainability of the project. Informal meetings and interviews were also held with workers of TransCape, both locals and foreigners, where semi-structured questionnaires were used for further understanding those factors.

In those meetings the commitments that the research group from the University of the

Western Cape (UWC) was willing to accept were also presented, including the maximum number of nodes that could be installed and the empowerment approach that we wanted to apply, regarding participatory decision making in all stages of the project, open training sessions for every activity of the network (mounting solar panels in roofs, building boxes in wood for the batteries, simulating radio links, configuring the wireless routers, etc). Complete transparency is also intended to further the social sustainability of the network.

The commitments to the partnership expected from the community were also discussed. It was agreed that the community choose the places to locate the nodes according to the technical constraints mentioned above. Security issues were also discussed, such as having someone present at each homestead. Also discussed was a commitment to basic rules in those households chosen as nodes, in order to keep the network up and running. If a recipient of one of the nodes does not take care of the devices or misuses the electricity, the node can be moved somewhere else in the community.

Regarding the business model, it was agreed that the community will define the rates and will provide a mechanism for collecting the money from the households, likely through the Mankosi Trust. The rates charged are the basis for the financial sustainability of the network, and they will provide the means for its maintenance and operation. In this sense, they are the beneficiaries providing the financial sustainability of the network, and not a governmental agency like in the project done by Bebea et al. (2011).

We also strongly emphasize training. It is expected that local technicians install the network, which differs from Bebea et al. (2011), where the installation was carried out by those executing the project and not by its beneficiaries. Furthermore, Bebea et al. (2011) identified five levels of maintenance in the Operative Maintenance Plan, in this project only three will be considered. Levels 0 and 1 remain the same, i.e. the users and the local maintenance team, respectively and a revised Level 2 combines the other three levels. The project is based on the use of devices called 'mesh potatoes' which have a very strong support from the Village Telco community (see www.villagetelco.org). The UWC members carrying out the project can carry out the Level 2 role along with the online Village Telco community. It is through this online community that a more on-demand Continuous Learning Plan will take place in our project. This approach is intended to reinforce the technical sustainability of the network, while at the same time reducing maintenance costs.

Network Design

The telecommunication infrastructure is composed of mesh potatoes, each with an analogue telephone (the router includes an embedded ATA) in each house and a

monitoring server. We use mesh potatoes for several reasons: it is available locally (nationally), it has low power consumption (3.6W including wireless router and ATA), it has been designed for easy installation and maintenance in extreme outdoor environments and it comes with the support of the Village Telco online community for problem solving and improving the system. In addition, it is very low-cost at R500 (\$US 60) per unit.

Furthermore, the mesh concept is also very important. As can be seen by the network design in Figure 3 (which shows the locations of the houses chosen by the community), all except one node are connected to more than one other node and so, if a node goes down, there will be no consequences on the rest of the network. At the same time, thanks also to the hilly geography of the area, it will be easy to install nodes that are in line of sight with others already deployed, as many nodes are on hilltops. This will help us expand the network while at the same time reduce installation costs since no high towers are needed.

A monitoring server will store the accounting system (A2Billing), the network management system (Nagios), and the software for incident tracking (Request Tracker for Incident Response). All software was chosen to be open source and will run under an open source operating system (Ubuntu). One thing that remains to be considered is that although Ubuntu is already available in isiXhosa, the rest of the programs are not. Thus a translation will be needed for the local technicians to work with these applications in their mother tongue. Conversations will be held with www.translate.co.za in this regard. The server needs to be installed in a safe place and powered 24/7. As part of the partnership, Transcape has allowed us to install the server at its headquarters at Mdumbi 's Backpackers for free. Note that such an arrangement will not likely be the case for other projects.

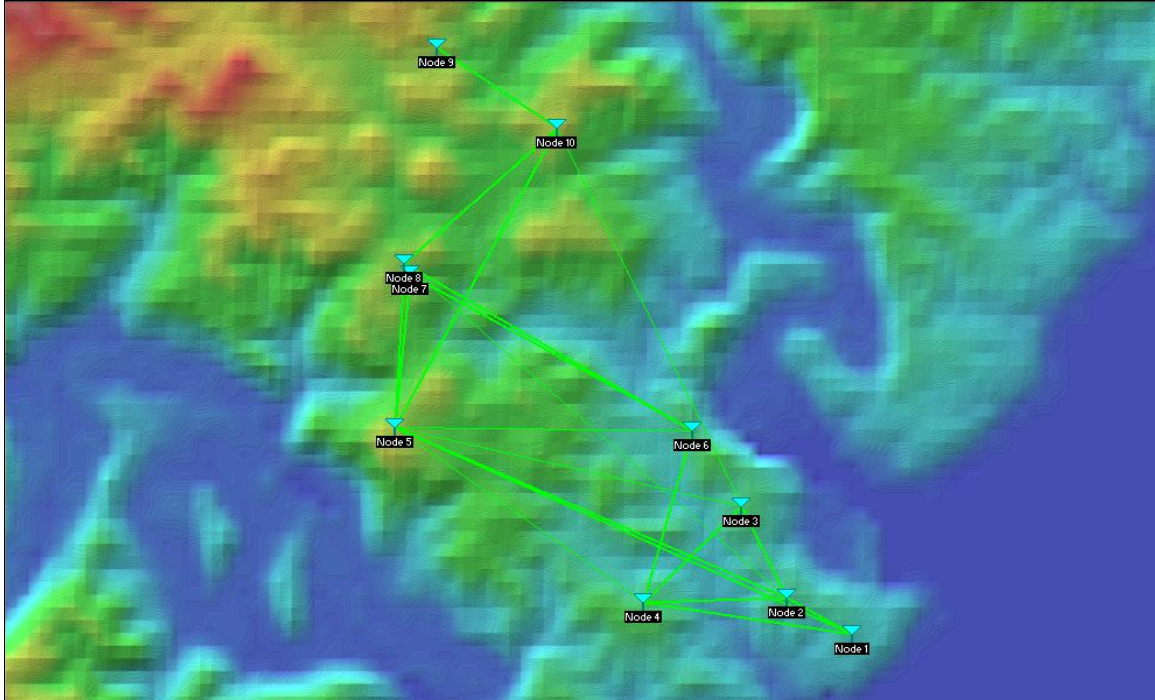


Figure 3 Simulation of the mesh network

An autonomous electrical infrastructure is provided at most nodes comprising one 140W solar panel, two 105 Ah deep cycle maintenance-free batteries, a charge controller (less than 0.5W consumption) and the wiring and fuses necessary to provide DC safely. Both the storage and solar system are over-dimensioned given the load introduced by the router and the regulator. The reason is that the business model includes part of the revenue being generated from charging mobile phones, so the total use of electricity is still uncertain. Two car lighter adapters will be provided to allow for the possibility to charge phones and also plug other devices such as lights and radio to foster a sense of ownership with the project and thus encourage care of the system. A voltage reader (a simple button press activates an LED display) and a logbook will be provided to each household to measure the level of the batteries; for the inhabitants, promoting an understanding of the electricity consumption pattern and for us, information to adjust the dimensioning for future interventions. It is worth noting that the main pieces of the autonomous electrical infrastructure are manufactured and available in the country.

Business model

The description of the business model includes the Capital Expenditure (CAPEX), the Operational Expenditure (OPEX), and the revenue obtained. A section for each follows.

CAPEX

The CAPEX considers the following items: the autonomous electrical infrastructure (solar and storage system), telecommunication infrastructure, civil infrastructure and

tools. Table 1 summarizes the items within the CAPEX. The cost of the autonomous electrical infrastructure per household described above is roughly R6000 (US\$740). The telecommunication infrastructure is composed of a mesh potato and an analogue telephone in each house and a monitoring server. If we divide the cost of the monitoring server by the ten nodes that compose the network, then the cost of the telecommunication infrastructure per household is R1300 (US\$160).

Table 1 CAPEX of the project

Item	Cost per unit (R)	Number of items	Total (R)	Total US\$
Telecommunication Infrastructure	1300	10	13000	1602
Autonomous Electrical Infrastructure	6000	8	48000	5914
Civil Infrastructure	500	8	4000	493
Tools	3000	1	3000	370
		Total	68000	8377

There is no need for a large expenditure on civil infrastructure, and the materials needed (mounting poles for the routers, wooden frames for the solar panels, wooden boxes inside the houses for the batteries, and the rest of appliances needed) for installing the telecommunication infrastructure and autonomous electrical infrastructure will be purchased in the local market in Mthatha to minimize costs. The cost per system is not expected to be higher than R500 (US\$61) per house.

Tools will be provided by UWC during installation and by Transcape during the rest of the operation of the network. When needed, the maintenance team will have to use network revenues to purchase something. However, for the sake of completeness, we can quantify the cost of tools as R3000 (US\$370).

It is worth noting that electromagnetic protection has not been considered as part of the CAPEX because it is believed that the system installed falls into the category of a floating system. Furthermore, given the existence of grid electricity carrying the electricity to some individuals, and other premises in the community, it is expected that the nodes deployed will not attract lightning. In any case, given that installation is going to be carried out during the dry season, a deeper study on this topic will be carried out in the field, and solutions will be provided if considered necessary.

Note that for the autonomous electrical infrastructure and the civil infrastructure, only 8 of the 10 households are provided given that the two additional nodes belong to Transcape (or Transcape's members) who provide the infrastructure for free. The conversion rate used between US\$ and South African Rands is R8.117 per dollar, noted July 3, 2012.

OPEX

The OPEX considers the following items: transportation, maintenance costs, operation costs, depreciation of devices and training. Table 2 summarizes the items within the OPEX. The value after the first month is in concordance with other projects where it was accounted as 5% of the project cost.

Table 2 OPEX of the project

Item	Total (R)	Total (US\$)
Transportation	8100	998
Maintenance	4075	502
Operation	0	0
Deprecation	675	83
Training	15000	1848
Total first month	27850	3431
Total rest of the months	4750	585

The cost of transporting the materials from Cape Town (where routers and the main components of the autonomous electrical infrastructure can be purchased) to Mankosi can be valued at R8100 calculated at R3/km compensation for travel of 2700km, twice the distance that separates the two places.

Maintenance costs include the salary of the maintenance team, the spares needed when solving network failures and the petrol for the maintenance person. A monthly salary of R1500 is considered for the person that is expected to carry out the maintenance tasks. Spares are difficult to quantify until an historical knowledge of the network and its failures is created. However it is expected to be no more than two whole new stations per year. Including the transportation costs for bringing them from Cape Town, that total cost will be R23700, or R1975 monthly. Petrol for the mobility of the maintenance person, given the a medium distance of 10km (round trip) for intervention and an estimated 20 interventions per month (not only for problem solving but for monitoring operator performance) and considering the R3/km used before, will account for R600 monthly. It is worth noting that as part of the partnership, Transcape allows us access to its vehicles if we pay the aforementioned mileage.

Operation costs are to be decided by the community, although they could be considered depreciable. In the informal interviews carried in the community, some were expecting a salary to be provided to those owning the nodes given that they need to open everyday within certain hours, let people go into their houses to make calls and take care of the devices; while others suggested that by having the possibility to use electricity in the house and not to walk for using the phone would suffice as payment for the operators. Until more information is discussed with the community regarding this point, we are not going to consider it in the OPEX.

It is expected that each installation last ten years, excluding routers, so given the CAPEX costs in Table 1, if the whole installation is to be substituted every ten years, and the routers every five years, each month R675 should be set aside to substitute them when the time comes (training cost has been excluded). Considering training, then, salaries of the trainers should be considered. A salary of R500 per day plus R250 per diem is being considered. Assuming 20 working days for the training and the installation, an additional R15,000 should be included in the OPEX.

Revenue

The revenue generated from the project will come from two sources: the rate per minute to call within the system and the rate for charging a mobile phone. As the phone charging revenue has been already discounted from the operational costs, it will not be considered. For accounting for the revenues of the system, the following assumptions are made:

- The timetable for making calls (the time that the houses will be open for people to make calls) is from 9:00 to 17:00 and will be open 7 days a week in a standard month of 30 days. So, considering that 5 simultaneous calls can occur, the system could hold 1200 hours monthly, or 7200 minutes.
- A rate of R20 per hour of calls in the system will be considered. This means a cost of 0.33 per minute. Given the rates from Vodacom and MTN for the sake of comparison at R1.20 per minute (R1.68, if we account for the R2 surcharge for each R5 top-up), this means a 80% reduction on the price per minute. Making reverse maths, a monthly expenditure of R60 would allow those with a mobile phone to speak around 35 minutes, and within this network, they could speak for 180.
- The population in Mankosi is 11,000 people.

The proposal to be carried to the community will be that the households keep the money from the phone charging, plus benefiting from having light and the possibility to plug other appliances. Given the data from the field regarding solar charging, five phones per place everyday at R3 each, will account for R450 monthly per household, and so the operation costs for the network will be 0, given the revenues match the costs.

That means that if the system was to be full of calls, a raw revenue of R24000 would be generated monthly. If we shared evenly the use of the system across the community (of 11,000), each inhabitant would spend R2.20 for talking 6.5 minutes. However a 100% utilization scenario is not realistic, and others are considered in Table 3.

Table 3 Network revenue for different percentages of use of the system.

	% of use of the system	Raw Revenue
Scenario 1	100	24000
Scenario 2	50	12000
Scenario 3	25	6000
Scenario 4	20	4800
Scenario 5	10	2400

So, 20% utilization will be needed (1.6 hours at each telephone at each station being used a day) at the rate per minute proposed for maintaining the network operator. This model could be valid for where an external donor is funding the project. One straightforward option for obtaining more revenue would be to increase the rate charged per minute. Keeping 20% use of the system, Table 4 compares the impact of using different rates.

Table 4 Revenue for the project considering different rates.

	Price per minute (R)	% of use of the system	Raw Revenue
Scenario 1	0,33	20	4752
Scenario 2	0,5	20	7200
Scenario 3	0,66	20	9504
Scenario 4	1	20	14400
Scenario 5	1,68	20	24192

For example, if we consider charging R0.66 per minute, the network will generate more revenue and been able to give the money back to the donors. In case that money was interest free, the network can generate revenue from the 19th month, as can be seen in Figure 4. If, on the contrary, we choose to charge R1.00 per minute, the break even point can arrive after month 10, as shown in Figure 5.

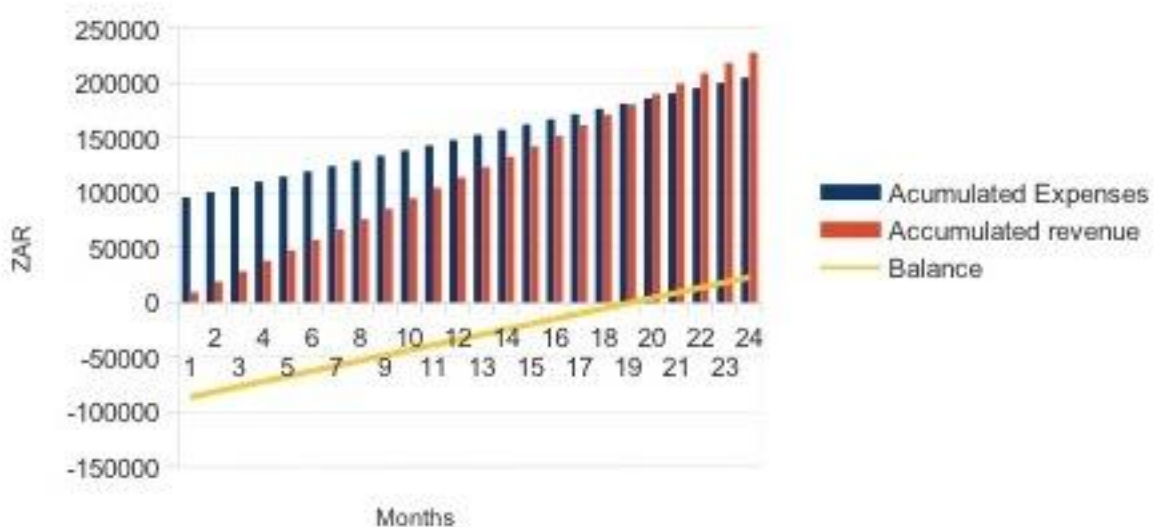


Figure 4 Balance analysis considering R0.66 per minute: break even at month 19.

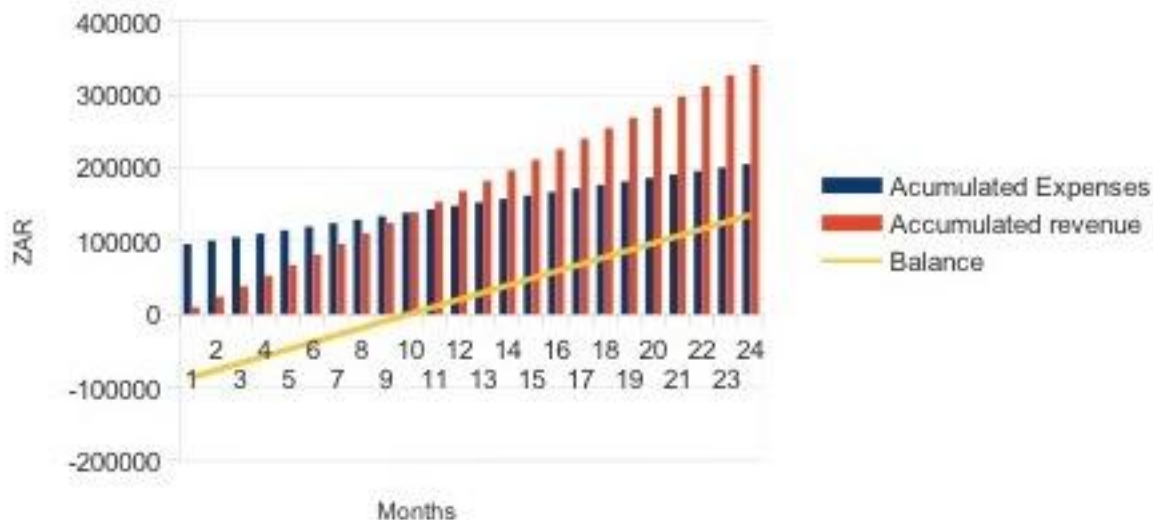


Figure 5 Balance analysis considering R1.00 per minute: break even at month 10.

Another solution for increasing the revenue without increasing the rate would be to provide more simultaneous calls on the system. One way of doing so would be by increasing the number of sites, yet given the price of around R7000 per node, this might be considered at a later stage when the consumption model of the houses has been worked out, and hopefully by then, that the price of station is considerably reduced. Another way would be to allow more telephones per node. Given that there is only one single ATA in the router, only one analogue phone can be connected. Yet other VoIP phones, including mobile phones, could be connected wired or wirelessly. Providing two phones per site, and so doubling the number of simultaneous calls, the break even points shown above could be reduced nearly by a half (the price of the phones and extra wiring should be considered), if there were enough demand. This could become a solution once the system gets to be known and accepted by the community.

In case revenue is generated, it is still to be decided what to do with it. One solution would be using it to upgrade the network and its services: increasing the number of points of presence, providing access to the Internet, and breaking out cheap calls beyond the network. Another idea is to use the revenue for other community projects. A combination of any of the above should also be considered.

Conclusion and Future Work

This paper has presented the work done thus far in designing a sustainable business model for the provision of telephony in a rural and impoverished community in the Eastern Cape province of South Africa. The pillars of the model are sustainability and community ownership to design both the network and the business model.

Results showed that if funds are provided for the installation of ten wireless mesh nodes in a community like Mankosi, charging a price 80% lower than the rates charged by incumbent mobile operators in South Africa (R0.33 per minute) can make the network sustainable providing the network is used 20% of the expected time. We also showed that by maintaining 20% usage of the system, by increasing the rates that are 60% (R0.66 per minute) and 40% (R1.00 per minute) lower than the rates charged by incumbent operators in South Africa, the network can reach a break even point at 19 and 10 months, respectively. We also conclude that if the number of concurrent calls is increased with additional VoIP phones, such that the CAPEX does not vary substantially, the revenues on the network grows linearly if there is enough demand.

Although the system appears financially sustainable on paper, much work needs to be done for this model to become a reality. Questions that remain open include how to promote the use of the system for obtaining the minimum usage desired, how to implement an accounting system that provides transparency and trust within the community, how gender and age influence the ability to operate a station, and how to measure the social impact of the system introduced. Our future work concerns finding answers to these questions.

Acknowledgements

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