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In Memoriam

In memory of Adrian Tumwebaze Baryamujura, Kachwekano FM Community Multi-Media Centre, Kabale, Uganda, who passed away in July 2007.

We had the pleasure of meeting Adrian through the Community Wireless Resource Centre. It was a true privilege to have the chance to get to know this enthusiastic and energetic young person, dedicated to his work and the Kabale community. With his wonderful personality, Adrian did not leave anyone untouched.

His time on Earth was too short, but we are certain that he left many footprints in Kabale. It is our duty to make sure that all his work is remembered and continued within the community.

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PART 1

“There is no delight in owning anything unshared.”

(Seneca, Roman philosopher, mid-1st century AD)

1. About this book

During 2005 and 2006 we were involved in an ambitious wireless training project in Africa¹. The project not only delivered four training workshops but created the very first open-licence modular training materials in the field of Community Wireless Networking. The effort was conducted by a human network composed by an international team of wireless enthusiasts², coordinated by APC³ and funded by the Canadian research organization IDRC⁴. More than 150 representatives from civil society, universities, private companies, and regulators were invited to participate and learn about wireless technologies for “civil society.”

Shortly after these workshops, IDRC received funding proposals from the Makerere University in Uganda and Fantsuam Foundation in Nigeria. The proposals requested financial support for building wireless networks with communities in their respective countries.

The two projects arose out of two needs: 1) to reduce the high cost of Internet connectivity, and 2) to explore optimal connectivity models such as sharing existing bandwidth with neighbouring institutions via outdoor wireless networks. We anticipated that more institutions could get access to Internet by managing the costs of connectivity collectively at each Telecentre, without heavy initial investments in satellite hardware and subscriptions.

¹ Zanzibar, Tanzania (March 2005), Cape Town, South Africa (September 2005), Senegal (January 2006) and Ifrane, Morocco (July 2006).

² Sebastian Büttrich, Alberto Escudero Pascual, Kyle Johnston, Thomas Krag, Bruno Rogers, and Anas Tawileh, among others.

³ APC, Association for Progressive Communication, www.apc.org

⁴ IDRC, The International Development Research Centre, www.idrc.ca

The aim of both projects was to make connectivity more affordable for existing Telecentres by implementing a communications infrastructure that is shared and managed by the community. This general concept, known as a “Community Wireless Network”, is based on the possibility for groups or communities to build self-owned and operated internet networks.

The organizations behind the proposals have quite different backgrounds. The Ugandans, located in the capital city of Kampala, came from one of the largest universities in East Africa. with a long tradition of research projects with international development agencies.

The Nigerians represented their civil society, coming from a small rural not-for-profit organization that started as a micro-finance institute for smallholding farmers in the early nineties. They had limited experience with “donor funds,” as they had mostly managed their activities with their own bare hands thus far.

One thing the two organizations had in common was the vision of bringing affordable internet connectivity to rural communities. Both organizations were aware of the opportunities that low-cost wireless communications bring to establish new community-based business models.

Thanks to the support of IDRC and the hard work of the project actors, *the first rural wireless ISP in Nigeria – ZittNet* - was established by Fantsuam Foundation in September 2007.

The same year in Uganda, Makerere's Community Wireless Resource Centre⁵, in close cooperation with existing Telecentres, established *three rural Community Wireless Networks* across the country that serve a cluster of partners with internet connectivity by wireless communication.

The two projects are unique in that they are built bottom-up by local people and serve the needs of local communities in support of rural development. Both projects have undergone intensive internal

⁵ The Community Wireless Resource Centre was established within the Department of Electrical Engineering at Makerere University to manage the project, act as an intermediary and provide technical support to project actors, and conduct research in issues related to community wireless networking.

processes of planning, designing, procuring imported equipment, implementing, testing and finally deploying ICT⁶ services to rural clientèle.

The purpose of this book is to share with you the important lessons learned from these experiences. We are now (2008) writing the book we would have wished to read five years ago, before starting the projects. This book will tell you the story of these initiatives from the inside, focusing on the processes of establishing the “networks”, and the outcomes achieved, challenges encountered, and insights gained.

2. Information technologies in developing regions

After visiting numerous African countries during the last decade, we have seen that many of the challenges are the same throughout the continent. What we thought at the beginning of our journey was unique to a specific town or village, has unfortunately turned out to be present all over Africa. The typical conditions that are common to many countries can be summarised in five areas:

- 1. Lack of a stable source of electricity*
- 2. Lack of voice and data infrastructure*
- 3. Low level of ICT education*
- 4. Limited and unfair market rules*
- 5. Costly and unfair access to the Internet*

Each one of these five areas is a great obstacle for any ICT project, including the establishment of a Community Wireless Network. They all very much depend on external factors that the grassroots organizations or we as facilitators can do little or nothing to change.

⁶ Information and Communication Technology.

At the heart of the problem, the thing that most hinders the onset of development in many other regards, is the lack of reliable electricity. Without electricity, there is no market for voice and data services, there is no place for computer-related education, and the market for ICT products remains highly limited.

3. What is a Community Wireless Network?

A *Community Wireless Network* is a *concept* that has become increasingly popular in the last couple of years within *ICT for Development (ICT4D)*. Although there is no single formal definition, the root of the concept can be found in the convergence of the amateur radio (packet radio) and free software movements. In this book we describe a Community Wireless Network as one that is ***built*** by the community, ***owned*** by the community, ***maintained*** by the local community and ***serves*** the community in their collective interest.

Sometimes only a few of these conditions are met, opening up lots of space for discussion of what is or should be considered a community network. In any case, all Community Wireless Networks share the mission of finding alternative models to extend internet connectivity for the common good.

The main purpose of community wireless networks are to:

1. Share the *Internet connectivity* (the bits and bytes) obtained by any mean of wired or wireless infrastructure
2. Share the *cost* for Internet connectivity (such as installation costs and monthly running fees)
3. Share the *risk* of investment in equipment, infrastructure and human resources to make the network operate successfully.

3.1 What are the driving forces behind Community Wireless Networks?

The main driving forces behind the establishment of Community Wireless Networks can be summarized as *increased Internet penetration* among the public and a *reduced investment risk* in terms of costly hardware and high subscription fees.

In the ideal case, the physical network should also create a playground for a community (the human “network”) where *ideas and knowledge are exchanged* without costs.

By sharing an upstream connection to the public Internet, more people can get access to the Internet in their offices, homes or at public places.

Accessing the Internet at public cybercafés normally implies a busy and noisy environment and a near-100% risk of using a virus-infected computer (from which the virus will inevitably transfer to any disk, memory stick, drive, or dongle belonging to the user), and for those not living down town, public access will likely imply a long walk or ride from home. Experience around the world demonstrates that users who have the opportunity to access the Internet at work or at home have a much greater opportunity to learn from it, discover new ways of communicating, search for information, and benefit from useful services.

Having access to the Internet on a regular basis also greatly increases the productivity of the users. This is no news to anyone. The Internet is good!

Several ways exist to reducing the risks associated with hardware investments in a Community Wireless Network. The most important thing to remember here is that it is up to the partners of the network to set up the rules for such shared responsibility.

One common solution is to agree that it is each partner's responsibility to protect equipment installed on his or her premises with a setup jointly defined by the community members in advance, including a UPS (uninterruptible power supply), grounding and thunder

protection. Damages caused to the unit will be the responsibility of the community only if the agreed procedure is followed.

For backbone infrastructure that all community members depend on, it is wise to share responsibility in case of failure or theft.

4. What are the obstacles?

Over the years that we have worked and supported Community Wireless Networks, we have seen many obstacles to their existence. Many of these obstacles, if not all, are common throughout sub-Saharan Africa in the establishment of any reliable business where quality of service and reliability matter.

4.1 Electricity: the absence of a reliable power grid

With the Magreb region and South Africa being the exceptions, the African continent suffers from badly-developed, poorly-designed and ill-managed power grids, shortages of energy production, and a low proportion of the population connected to the grid.

A stable and reliable power grid is something that we take for granted in the “North”, but is something far from reality in most parts of the world. When it comes to electricity, there are several factors that are important to understand.

Generation of electricity

Many Africa countries depend largely on hydro power, so frequent and unavoidable shortages of electricity occur in times of drought. Other countries are heavily dependent on diesel generators to produce power. Rwanda, for example, uses diesel generators to produce no less than 42%ⁱ of its electricity; the diesel is trucked more than 1500 km from the coast of Kenya via Uganda and finally to landlocked Rwanda.

When the demand for energy is greater than the supply, the load in the power network must be reduced, which is done by mean of load shedding. During load shedding, a certain geographical area is disconnected from the grid, and the end-users need to provide their

own power backup to obtain electricity. The load shedding can be scheduled or random, or can be perceived as random by end-users who do not have access to the master schedule. As of this writing, South Africa is experiencing scheduled load shedding in great swaths of the country due to lack of energy, as they are dependent on water supplies in Mozambique⁷. If scheduled, load-shedding at least give people the opportunity to plan their electricity-demanding activities like cooking and cleaning. Un-scheduled load shedding, a frequent practice in Tanzania or Nigeria for example, always strikes you by surprise!

The transmission backbone

The quality of Africa's transmission infrastructure is generally poor, and often suffers from the theft of transformers, transformer oil and copper cabling. In Nigeria, whole transformers get stolen from some rural communities and the city of Cape Town, South Africa, reports having lost 22,000 litres of transformer oil over a three-week period in August, 2008ⁱⁱ. The oil is used in transformers for its insulation and cooling properties; without the oil, the transformer burns out. The thieves drains the transformers and oil is used to fuel vehicles. As a result of the theft, load needs to be removed from the grid while the transformers are refilled with oil, causing power cuts in the surrounding areas. When copper cables are stolen, the load reduction is usually even greater, and the missing sections can take a long time to find and fix.

⁷ In June 2008, Cape Town experienced load shedding twice per week, 2h each time.

The Local Loop

The final connection of end-users to the transmission backbone is often missing, and households pay high fees to get connected. According to the *African Wind Energy Association*⁸, only 5% of Uganda's 24 million inhabitants receive electricity. Around 20% of the urban and less than 1% of the rural population are connected to the grid.

Nigeria, the largest oil producer in Africa and the eleventh largest producer of crude oil in the world, scores much higher with no less than 40% of its 140 million inhabitants connected to the grid. Unfortunately, those approximately 56 million people, have only around 4000 megawattsⁱⁱⁱ to share, the equivalent of 70W (two light bulbs!) per person assuming no factories and other power drains are connected to the grid.



Image 1: Poor electrical installations in premises are unfortunately commonly found. This image is taken at the Muhimbili Hospital in Dar es Salaam, Tanzania.

Operation and maintenance: Running a national power grid is not an easy task. Improper operation of a power grid leads to *power outages* due to poor load balancing, fluctuating voltage and surges in the grid. Surges frequently damage electrical appliances. In the last five years, we have seen dozen of power supplies, Ethernet and VGA ports, PoE injectors, and wireless access points destroyed as a result of plugging them into the grid without protection. Nowadays, we are wiser and we always bring a power bar with surge arrestor and built-in fuses to protect our equipment from spikes.

⁸ AFRIWEA, <http://www.afriwea.org>

An unstable power grid can not provide reliable service to its customers. As a result, none of its customers that depend on electricity from the grid can operate a reliable business. If non-interruptible electricity is needed, an expensive power backup system such as a diesel generator, solar panels or deep-cycle batteries is needed as a complement. In comparison with grid power, electricity from a generator can be from 10 to 30 times more expensive, excluding the initial investment cost. Solar and battery solutions are expensive to obtain, and have a limited life time as well.

4.2 Lack of data and voice infrastructure

Many developing regions lack high-capacity ICT infrastructure. Local fibre networks might occasionally be present as a result of GSM or CDMA rollouts but are not accessible to community initiatives. This leaves no possibilities for local actors to hook their own ICT infrastructure onto a national backbone, so they must rely on expensive satellite connections to the Internet. The high connection costs not only limit their investment capacity and possibilities to expand, but also impose high connectivity fees to end-users. The cost of Internet access in most areas in Africa is on average 1000 times higher than same service in North Europe.

Large fibre networks are in place in some instances, but they are not in use as the owner of the infrastructure is waiting for the right time or occasion to give access to the fibre. Rwanda, which probably has the most advanced installed fibre network, provides an example of current limitations. First, the Rwandan network leads to a few central access points in major towns, rather than being available for community expansion. Second, the two fibre trunk lines end at the borders of Tanzania and Uganda, where as of 2008 they were awaiting other parties to actually connect the fibre to the world. Most broadband business models are based on the principle of making lots of money with a few large customers, rather than making little bits of money from many.

The development of voice infrastructure in large parts of the developing world took off much later than in the North. In fact, most African rural communities never got access to the plain public

switched telephone network (PSTN), and the GSM network is just being expanded to these areas.

When the GSM boom hit Africa a few years ago, it did not take long until the GSM networks had superseded the PSTN networks in coverage area and number of subscribers. GSM networks are cheaper than PSTN networks to deploy as they are based on wireless cell-based technology. An abundance of flexible and inventive business models are in place, which is a great part of the success behind the GSM expansion in developing countries. Still, a GSM phone call is expensive for a common person, and a handset of 30 USD is quite an investment for many.

4.3 Access to Equipment

4.3.1 *Lack of quality control on local markets*

In many African countries, especially those that are land-locked, it is difficult to get access to quality hardware. Yes, we know that when we use the expression “quality hardware” we are providing a fuzzy requirement, but this is absolutely intentional in this book. The lack of quality in goods ranges not only from basic network equipment such as network cards, Ethernet cables, or RJ45 connectors, but extends to items such as power plugs, extenders and cables as well. Our bitter experiences tell us that a power strip bought in Africa never lasts more than a few months. If you are lucky, it just stops working. If you run out of luck, the power-bar will burst into flames and will cause a fire that will burn down your house. Although our experiences do not provide a scientific measure of this problem, we can tell you that in the last four years we have experienced three fires due to short-circuited power-bars. None of the fires burned down a house, but a university computer laboratory and a newly renovated server room were in danger.

The majority of the technical equipment (if not all) that is found in African markets comes from China. But since much technical equipment in the North also comes from China, why are industrialized

countries not facing this problem?

The European electronic market provides a good example. Europe has very strict import rules for what can be shipped into the Union. All equipment must comply with extensive European quality control. We are certainly no experts in export regulations for the African continent, but we have not become aware of any quality controls on the goods that are imported to most African countries from any part of the world. One can not avoid thinking that perhaps it is in Africa where all the goods that do not meet European or American standards are dumped. Sure, the equipment is far cheaper than the corresponding equipment in Europe, but when the lifetime for a power-bar is less than 6 months, the recurring cost becomes far more expensive than purchasing any standard power-supply from Europe that will last for 10 years or longer!

4.3.2 Limited access to hardware supply chains

Something as simple as buying equipment, which in Europe involves just a quick trip to a local computer superstore is a challenging task in Africa. Local markets seldom give access to radio or other more sophisticated equipment. In the major cities along the coast and a few other large cities with international exposure, the equipment might be found in the local markets, but a general rule-of-thumb is that you can not assume that anything will be available. Local businesses struggle with similar problems as those of end-users: lack of access to markets and supplies. Private import requires private connections to resellers or a good Internet connection and a topped up credit card. Markets are small and overheads huge. Imagine the hassle for a local business owner in Kampala to contact the Netgear office for the Middle East and East Africa in Dubai in order to apply for a RMA⁹ for one broken switch. The general assumption is that to obtain a replacement from vendors will probably cost more than buying a new unit. In most of the countries that we have worked, the import of equipment from a neighbouring country is as difficult as bringing the item from 20,000 kms away. We learned to assume that any appliance will cost 200-250% more locally than those we manage to squeeze into our

⁹ A Return Materials Authorization or RMA, gives the customer or supplier the right to return a good or product to the vendor for replacement or repair.

checked luggage.

If we take the example of Nigeria, wireless equipment can often be found in Lagos. The centre of trading in Nigeria, Lagos is conveniently located near the coast so as to be well connected to the international market. However, Lagos is not convenient to many outlying areas of Nigeria, and our African partners were mugged at gunpoint every time they went there to buy equipment.

In Uganda, we were not able to locate any shop that sold any type of wireless equipment in 2005/2006. Since then, a few shops have appeared in Kampala that offer common wireless access points for home or small enterprise usage.

Still, for more heavy duty wireless equipment, the closest location is a two days' bus ride to Nairobi, Kenya.

4.3.3 The concept of “warranty”

During these years, we have also learned how basic economics produces understandable but infuriating obstacles. We learned in school that price of goods should normally¹⁰ decrease as the quantity of an order increases. This applies to most businesses, including wireless equipment. That is why we can enjoy standard access points at a price of 40-50 USD in the North, as our resellers are able to place large orders for equipment with the knowledge that they have a steady quantity demanded and customers willing to pay for it. In developing regions where the market for wireless equipment is not that hot, the reseller needs to buy smaller quantities, faces a high risk of being stuck with unsold inventory, and of course the unit price increases notably.

It is also a high risk for both the end-user and the local reseller to enter business with expensive equipment. What happens when something breaks? Under what conditions does the warranty apply?

Let us go back to the example of our broken network switch. What happens if the unit breaks in Stockholm? We call or email the seller, who asks us when we bought the unit and politely tells us to return

¹⁰ We say “normally” here, though we will soon see an exception regarding Internet bandwidth.

the broken hardware in exchange for a new one. What happens if the unit breaks in Kampala? The local business owner in Kampala ask us to contact the regional Netgear office to obtain a RMA, and then post the unit to Netgear Middle East in Dubai, UAE.

What happens in Stockholm? We get a new unit in less than 48 hours. What happens in Kampala? We try to find a new unit to buy.

The example might sound simple and obvious, but it was not for us a few years ago.

4.3.4 Import, taxes and restrictions

Import tax is often a means to protect local industry from international competition; for example, the US maintains high tariffs on sugar in order to protect its own farmers. If no local industry produces a product, however, import taxes are just applied for the purpose of creating a revenue stream.

Many African countries have favourable import policies for computers and computer appliances. In fact Tanzania and Uganda have 0% import tax on such equipment in order to boost ICT development in their countries. Unfortunately, the same does not apply for *wireless equipment* intended for home or small-office usage.

In Uganda, we experienced strict import rules of the Ugandan Revenue Authorities¹¹(URA), who applied commercial import tax to all imported equipment.

Although the equipment was intended for a research project within Makerere University for rural development, in collaboration with non-for-profit Telecentres, taxes were applied on all equipment as though it was intended to be used by a major Telecom operator for a pure commercial purpose.

It must be said that the URA is not the main cause to this problem, as they are simply implementers of the rules set up by the Ministry of Finance. It is the task of the Ministry of Finance to revise and update the import rules of today's wireless equipment, if they want Ugandan small and medium enterprises, not only major operators, to participate in the aggressive ICT development that is taken place in Africa at the

¹¹ Ugandan Revenue Authorities (URA), www.ugrevenue.com

moment.

However, the URA has also a fair deal of responsibility to improve the import conditions in Uganda. As implementers there is not always one single option to choose, as an item can be fit several descriptions in the rule book. One can ask oneself weather the authorities sometimes rather look after its own short-term revenue stream, than does the greater good of its people.

An example of a “doubtful” classification, is the case of a simple 9 dBi sectoral antenna, typically used for client's premises due to its short range. This small antenna was classified as “*Aerials and aerial reflectors of all kinds; parts suitable for use therewith*” and applied with a 49% total tax. One can argue this tax could be reasonable for a high-gain micro-link antenna used in the national backbone by a large operator, but we have difficulty understanding the benefits of applying this tax to an end-user low range device.

Wireless access points with small internal antennas were classified as aerials (25% import duty + 18% VAT), instead of a “*Transmission apparatus incorporating reception apparatus*” that would imply a 0% import duty.

The story ended with a tax bill of 24%¹² of the total value. The CWRC did not have the resources to undertake a struggle against the authorities, with the high risk of losing the battle, as the bill for storing the equipment in customs grew to a value comparable to the taxes applied.

Another example of how import tax can have unexpected consequences can be found in heavy goods such as the project's deep-cycle batteries. In the case of Nigeria, locally produced deep-cycle batteries of *doubtful quality* and with *low life-time* are charge low taxes to promote the local industry. High-quality batteries with a much longer life expectancy that are better for the environment are charged with sky-high import taxes in order to encourage local businesses and individuals to buy the locally produced batteries.

From these stories, we can see that there is a great need to sensitize policy makers on community activities in general and their special needs. The authorities need to be informed how these initiatives differ

¹² VAT was 18% in Uganda in 2007.

from typical commercial wireless networks, of which the authorities are familiar with and on which they base the current import system on.

4.3.5 *The sellers' market*

All these components together – lack of quality control, long supply chains, ineffective warranties – contribute to a harsh climate for the end-user to do business. This does not only apply for technical equipment, but also for tomatoes and rice! John Dada, founder of Zittnet Community Wireless Network summarizes his market reality better than us: “The market in Africa is a *Sellers' Market*, while in Europe, it is rather the opposite! In Africa, the end-users have very little influence on *what, when and for how much*. Customers are many times forced into an unfavourable deal due to lack of alternatives.”

4.4 Business Skills

A great obstacle that we experience in every project we work with is the lack of business skills. A few years ago, we were tempted to believe that some people are born to be business savvy and some are not. Why are so many people with Indian or Lebanese backgrounds so successful in any business area they go out for? How come that the Chinese have managed to gain a dominant market position for domestic products all over the African continent within only a few years' time?

Of course, examples abound of highly successful African entrepreneurs. Entire ethnic groups – the Kikuyu of Kenya, the Igbo of Nigeria, the Chagga of Tanzania – are considered the “business people” of their respective countries. Little more than a decade after Rwanda's horrific genocide, Kigali is sprouting subdivisions with 250,000 USD homes to house the business elite newly returned from the diaspora. Whether a young Bena woman in southern Tanzania starting her own door-to-door used-clothing business, or a young Ghanaian starting his own computer programming shop with an international clientèle, we have seen that *innovation can thrive everywhere*, leaving the question of why it so often does not.

One inhibition is probably the educational system. The British and

French colonial systems that dominate throughout the continent do not encourage students to take initiatives and try their own wings. Students are trained to stand to attention and deliver set answers, rather than experiment and innovate.

Bureaucracy is another important factor. Starting a business demands jumping through any number of hoops, paying numerous fees, and buying “tea” for the “gatekeepers”, in addition to establishing a market, arranging credit, maintaining a supply chain, and securing the merchandise. When faced with such barriers, many people would rather stick to the *tried-and-true*.

We are not alone in noticing the relative lack of entrepreneurship in Africa. As a result of that, the newly started Africa-wide research initiative *Wireless Africa*¹³, which is a follow-up on the projects “Capacity building for community wireless connectivity in Africa” and “First Mile First Inch”¹⁴, pays great attention to entrepreneurship, business models and sustainability around Community Wireless Networks.

4.5 Opportunity to invest

A common obstacle, difficult to avoid, is the lack of investment capital for a community member with a bright idea. There are few places to turn for a young entrepreneur with a solid business plan but empty pockets. That is sometimes where the “development agencies” come in.

Development projects often come with an *initial hardware investment* that covers the deployment of a first stage *pilot project*. When the project money runs out, no more resources are available to invest in the project. After all, the first stage of the project was a “pilot” that did not focus on a positive cash flow, but rather sought to test the concept. Does this sound familiar to you?

If concepts such as “revenue” and “turnover” are not a part of the initial project plan of the “pilot”, the project will never be sustainable. This ought to be, honestly speaking, a responsibility of the funders of the project, not the receivers of the funds.

¹³ Wireless Africa: www.wireless-africa.org

¹⁴ All three projects are sponsored by IDRC.

4.6 Basic IT skills

4.6.1 Lack of IT skilled resources

It should come as no surprise that, in countries where less than 5%¹⁵ iv of the population have the chance to obtain post-secondary education, a person with advanced networking skills is hard to find.

In countries where less than 1%¹⁶ v of the population owns a computer (representing the middle and high class) *basic IT skills* are also difficult to find.

Even at major technical universities such as the *University of Dar es Salaam* (Tanzania) or *Makerere University* (Uganda), finding a person with experience in Linux or networking is quite a task, as the students, even Masters students in Computer Science, get limited access to computers. Lack of access implies no means to obtain the necessary knowledge and gain a deeper understanding about computers and networking. Much of the computer science education is still done on paper instead of computers, as the resources are not enough.

With this background, it is not difficult to understand that a person with more advanced IT skills than managing Microsoft's basic PC applications is hard to find in any rural setting in Africa.

It also makes sense that when a person gains new knowledge in an area with great potential but scarce human resources, a door is open to that person. Knowledge opens new possibilities and hence opportunities. In combination with the fact that universities and civil society offer far lower salaries than private companies, many of the students that we have educated over the years have left the organization that provided them the training and gained more advanced positions with higher salaries elsewhere (mainly GSM operators or Internet Service Providers).

¹⁵ 4% of the population in Uganda attended higher education, 2002/2003

¹⁶ 7 out of 1000 people in Nigeria have access to a computer, 2005.

4.6.2 *How do we improve the available skill sets?*

I¹⁷ earned my computer skills by actively working with a computer and trying new things since I was 15 years old. I went to school eight hours per day for 17 years. Today I work 10 hours per day with computers and I have access to an amazing library of ICT resources through my 12 Mbps¹⁸ broadband Internet connection.

How can we replace that investment with a one week practical workshop on Wireless Communications or any other ICT topic? The simple answer is that we cannot. One week's training can not replace the thousands of hours I have spent behind the screen. But still, the attempt is better than nothing. A workshop can give the basic skills to get started, to awaken an interest and visualize opportunities, but it must be followed by more practical *training on a personal level* and a *long-term support* from a dedicated mentor.

Without any post-workshop follow-up, the learning curve will unfortunately run flat once the trainee has returned home after the workshop.

One idea that has been dancing around recently is the possibility of building up a network of mentors, consisting of a group of ICT “geeks” who need a meaningful task to accompany their routine day jobs. There is so much knowledge out there, brain cycles waiting to be released and focused on a good cause (instead of playing computer games, playing Second Life or drowning in Facebook).

If you are the owner of one of those brains, just let us know!

Finally, to raise the overall level of ICT skills in Africa, there is only one way to go: formal education as in primary schools, secondary schools, and higher studies. This applies to all fields and specialities – education is crucial. India has become a global ICT hub as a direct result of a focus on educating her people with skills that are valuable in the modern economy. Why should Africa be any different?

¹⁷ Example based on the author (Berthilson L.), but would apply to most ICT people in the North.

¹⁸ In Sweden we pay 40 USD/month for a 12 Mbps connection in our office. A similar connection in Africa would cost not less than 35000 USD/month

4.6.3 What are the results?

A problem that we are facing in all Community Wireless Networks that we have supported is the lack of knowledge when something goes wrong. When an access point fails to respond, or when a client can no longer be reached, what do we do? There is no local support team available and travelling to the capital city for technical help is both time-consuming and unlikely to solve the problem.

It is relatively easy to train someone to get systems up and running (for example, to configure a wireless access point according to an instruction manual) and very complicated to explain how to troubleshoot when they fail!

4.7 Civil engineering

The challenges of working in Africa are often exacerbated by problems introduced through civil engineering. Those of us from the North tend to take many things for granted, such as that concrete lasts forever¹⁹ vi and that a new building is properly grounded.

4.7.1 Buildings, material, design and structure

You should be aware of several things related to civil engineering when doing wireless installations in Africa:

Bad concrete

Concrete works are often of bad quality, no matter if it is a wall or a floor, and drilling equipment through it will create huge craters that will obstruct your work. Bad concrete can be caused by impure water, bad aggregates, wrong mixing technique or bad hydration or curing.

If you need to mount several small items to a concrete wall, consider mounting an inch-thick wooden mounting board to the wall first, and attach your appliances to the mounting board instead.

¹⁹ The reader will enjoy knowing that in Sweden, the 6320-meter-long multi span bridge that links the Swedish mainland at Kalmar with the Baltic islands of Svinö and Öland needed to be repaired due to lack of quality of the concrete. Yes, the owner approved the use of brackish water in the original concrete mix instead of more expensive fresh water.

Weak roofs

Most rural buildings have a tin shed roof that cannot handle any load whatsoever. You will therefore need to mount the equipment on a side wall or erect a small mast in the ground.

Lack of ladders

If you need to visit a lot of rooftops, it is wise to bring your own portable light-weight aluminium ladder. In the country side, it is difficult to find anything other than home-made spindly wooden ladders made out of broken branches.

A 5m ladder takes you far, as most buildings are just one storey.

Low buildings but high trees

A typical rural community hosts a few two or three storey buildings, which normally belong to the church and the bank. The rest of the buildings are one storey buildings with a mounting level of 3-4m.

This makes it hard to build any wireless network without the use of towers and masts, as achieving line of sight between two sites is fairly complex.

Non-grounded buildings

Buildings, private or public, are normally not grounded or lightening protected in a proper manner. If you install any technical devices in a building, you should always consider (1) grounding of the building and (2) lightening protection of the building.

A proper grounding should always include *measurement of the electrical resistance between the ground and your installation.*

5. Community Network Business Models

A good business model is crucial for any profit-making or non-profit venture. The same applies, of course, for a Community Wireless Network. In order to operate, maintain, support and expand a not-for-profit Community Wireless Network, a certain surplus (profit) is always needed.

There is certainly no business model that fits all community networks. The model you choose depends on the actors involved and the purpose of the network. The business model must primarily fit the *end-users* of the network in terms of financial capacity and technology demand. When those requirements are sorted out, you need to match the result with what the upstream providers are willing to offer you.

5.1 What do the end-users want?

A common desire for all end-users is to know what they are paying for and being able to track their usage, just like they do with their GSM mobile subscriptions.

Individual users mainly prefer *pre-paid* scratch card systems based on consumption of volume (downloaded data), not depending on time, while small and medium size organizations more often prefer a monthly flat-fee system with a guaranteed bandwidth and no volume restriction.

Common for all users is that everyone wants a low-risk model with no surprises by the end of the month. The initial *cost of hardware and installation* must be low for the end-user, or there will be a shortage of clients. One alternative is to lease the client equipment to the end-user for a fixed fee per month. When the total cost of the equipment is covered by the fee (purchase cost and supplement for service, repairs and maintenance), the client should have the option to take over the ownership of the equipment at no cost and assume full responsibility for it. A client who does not accept the offer could still rent the equipment at a reduced price (covering service, repairs and maintenance). If a client stops purchasing the service for a

considerable time (let us say 6 months), the steering body of the Community Network should be able to reallocate the equipment to another site.

Furthermore, our experience tells us that clients would rather pay a little extra for a higher speed, than pay a lower price for a slow connection. The youth are restless and do not like to sit around and wait!

For clients using the “flat-fee” model, the concept of “guaranteed bandwidth” per client is important. Without proper management of the bandwidth, the distribution of upstream connectivity between the clients of the network will easily be unfair. We have seen in all networks that bandwidth management is crucial for the fair allocation of upstream bandwidth between the clients. This can be done locally on each wireless link (in the access points) or centrally using Bandwidth Manager software.

5.2 What are the ISPs offering?

The business of Internet connectivity in Africa is still in the hands of a few powerful companies^{vii}. It is an unfair market where the end-users have little power to affect their destiny. Ignoring the fact that bandwidth is extremely expensive all across Africa, which is not (only) the fault of the ISPs, many other things could be done to strengthen the position of the end-users. Today, end-users are signing fuzzy contracts with blurry service level agreements and vague promises of quality-of-service. Concepts like *contention ratio* and *international bandwidth* are often not mentioned, and tag lines such as *free phone calls*, and *broadband service* are often used to attract customers. “All around service” can be offered free-of-charge and “annual preventive maintenance fees” are often added to VSAT installations without ever being explained.

Seldom does a contract include specific details about what technology is being used, or which hardware will be installed.

To give examples of bad contracts, we have selected a few quotes²⁰

²⁰ The quotes were given to telecentres in September 2007.

from two ISPs in Uganda.

Example 1: Africa Online

Africa Online offers a broadband wireless solution to Nabweru Telecentre in Kampala, with a dedicated bandwidth of 128kbps for 120 USD/month. The wireless link connects the client with the NOC which has a VSAT upstream connection.

Wait a second, does not that sound too good to be true? What Africa Online really means is that you get 128 kbps dedicated bandwidth to their Network Operation Centre (NOC), not to the Internet!. There is no information about how much upstream connectivity you are guaranteed, and hence, there is no quality of service granted for information that is not stored on their premises.

From their quote, we can find the following statements:

“The local link guarantees 1% packet loss and a response of between 20-40ms to the NOC”

How can they guarantee 1% packet loss? Ok, let us assume that they mean that the link has a maximum of 1% packet loss. Do you know that 1% packet loss can be quite a lot for a voice over IP conversation to avoid audible errors?

And, do their users understand that most of the content that they want to access is on the Internet and not in their NOC?

“A bandwidth capacity will be allocated on the link respectively as shown in the topology [128kbps]. This capacity will enable users at all your offices to run online applications.”

What online applications and for how many users simultaneously?

Under “Advantages of a Broadband Wireless solution” the following statement can be found:

“No telephone bills”

Great! I can call for free to all of my friends! Surely that must apply to my GSM phone as well!

Example 2: iWay Africa (Afsat)

iWay Africa offers a VSAT Broadband Internet Solution to Kachwekano CMC in Kabale. The solution offered is a single hop solution to the NOC in Germany with a broadband terrestrial link to the Internet. The equipment including installation costs is 3300 USD.

The quote does not mention if the solution is based on C-band or Ku-band²¹, but judging from the size of the antenna promised (1.2 m) it must be a Ku-band solution.

The quote is not free from marketing pitches, as the service is described as:

“Is low cost”

“It is fast because it is single hop and because of the unique way in which we designed our network”

“Speeds promised to you will be experienced at least 99% of the time because of the unique way in which we manage our network”

“It costs 1/5 of what it would cost for a dedicated circuit but performs just as well”

We will like to know what low cost, unique design, unique management and “just as well” means. However, the spectacular part of *iWay Africa* is not their marketing pitches, it is their *pricing model*.

If I go to the market and buy one banana for 5 Shilling, I would assume I would get a discount if I decided to buy 10 bananas the following day. In the case of *iWay Africa*, I would pay more per unit the more units I buy! Can you make any sense on this?

²¹ The uptime of satellite connections in Ku-band is known to be smaller than the C-band alternative. Ku-band, especially at frequencies higher than 10 GHz, experiences noticeable degradation in heavy-rainfall areas.

Let us have a look at their pricing model [September 2007]

GB/month	Downlink (kbps)	Uplink (kbps)	USD/month	USD/GB	USD/kbps downlink
1	64	40	150	150	2.34
1.5	100	40	250	166.67	2.5
3	175	50	531	177	3.03
4.5	220	50	802.4	178.31	3.65
6	300	50	1003	167.17	3.34
7.5	375	50	1298	173.07	3.46
9	450	50	1534	170.44	3.41
10.5	525	50	1770	168.57	3.37
12	600	75	2006	167.17	3.34
13.5	675	75	2242	166.07	3.32
15	750	75	2537	169.13	3.38
18	825	75	2950	163.89	3.58
21	900	75	3894	185.43	4.33
25	975	75	4248	169.92	4.36
30	1050	75	4720	157.33	4.5
36	1125	75	5723	158.97	5.09

Table 1: Pricing model for iWay Africa's one-hop VSAT solution.

The green figures shows the lowest prices per *Gigabyte downloaded* data and per *kbps downlink*, while the red figures show the highest prices.

We can see that the price for 1 Gigabyte downloaded data follows no predictable pattern whatsoever. The best offer can be found for the lowest service level (64/40kbps, 1GB/month).

Looking at the price for the bandwidth (USD/kbps) we can see a surprising **increase** of the price per kbps as the service level rises. iWay Africa are raising the price per banana the more we buy from them!

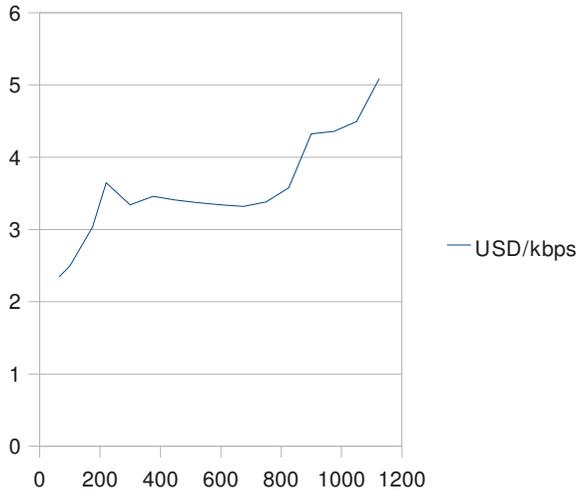


Table 2: Price per kbps (USD/kbps) versus downlink capacity (kbps) for iWay Africa.

We had the opportunity to meet with one of iWay Africa's salesmen in Kampala²² in September 2007, and he could not explain these odd figures when we plotted them for him. The mystery remains.

There are many things that can be improved in regards to contracts between upstream providers and end-users. Service agreements for Internet connectivity are rarely flexible for the end-users in terms of termination or temporary “freezing” of a contract if the client has problems making payments.

We have seen many cases where telecentres have outstanding bills with upstream/satellite providers for several thousand dollars! Instead of cutting off the non-paying clients the upstream providers let them run into debt for months. It is common to see telecentres with debts for services that they have never used and upstream providers claiming large amounts to reconnect them. In most cases, the overdue bill will be paid by an external funding agency or donor organization.

²² 2007, September 6, Makerere University.

5.3 Satellite-based ISP Business Models

When selecting an upstream provider (Internet provider) for your Community Wireless Network, it is good to know the various business models they normally have. This section gives an overview of common business models among satellite based Internet providers.

In satellite Internet connectivity, common parameters to define a service are:

- Uplink vs Downlink (Ratio)
- Bandwidth [kbps]
- Max. Download Volume [GB]
- Dedicated vs shared bandwidth [contention ratio, 1:x]
- C-band vs Ku-band
- Flat fee vs Time and/or Volume based fee

To illustrate the various satellite based models and their *pro and cons* for the buyer, we will present offers from five providers offering Internet access in Africa through VSAT. The information has been collected from services offered either to Fantsuam Foundation in Nigeria or the CWRC in Uganda.

A: One-hop satellite, Flat fee, shared bandwidth

Provider	Kansas Broadband Internet, US
Bandwidth	1024/256 kbps
Contention ratio	10:1
Volume restriction	No
Bandwidth cost	870 USD/month
Hardware and installation	8000 USD
Annual maintenance cost	700 USD
Type	C-band
Year	2008

This C-band setup provides a robust solution for an environment with

heavy rain and a lot of dust.

A fixed monthly cost of 870 USD implies a high risk for any African community organization. In a Wireless Community Network, you would need at least 8-10 solid clients to share that monthly cost.

Remember that a non-dedicated bandwidth makes it impossible to resell dedicated bandwidth to clients as you never know what bandwidth you actually will obtain. In a non-dedicated scenario, you can guarantee bandwidth within the local network. It is a good idea to try to find out which other organizations are connected to the same segment space that you are. If you share connectivity with banks or companies, you can expect better connectivity during non-office hours. Our experience is that satellite providers will always hesitate to tell you who you share bandwidth with. Over-subscription is a normal practice, as it is very difficult to check a contention ratio.

Another disadvantage of this solution is that the provider of the solution is based outside of Africa. That means that all support must be channelled through the US, which can be both costly and time consuming.

B: One-hop satellite, Flat fee, dedicated bandwidth

Provider	Emperion, Denmark
Bandwidth	128/64 kbps
Contention ratio	1:1
Volume restriction	No
Bandwidth cost	1000 USD/month
Hardware and installation	3000 USD
Annual maintenance cost	700 USD
Type	C-band
Year	2006

Again, a C-band solution provides a robust satellite connection with little interference from rain.

The effective bandwidth is comparable with Alternative A, but the monthly cost is higher as the bandwidth is dedicated.

This solution gives you a better ground to start a business offering QoS, since it can offer a guaranteed bandwidth per client. However, a monthly cost of 1000 USD again requires a number of solid clients with long-term agreements. This solution is appropriate for international voice services as you can control the bandwidth resources during calls. This type of configuration is less congested and you can expect a predictable and more constant latency in the link (never less than 500 ms, though).

C: One-hop satellite, Flat fee, volume restriction, dedicated bandwidth

Provider	Afsat Communications, Uganda
Bandwidth	220/50kbps
Contention ratio	1:1
Volume restriction	4.5 GB
Bandwidth cost	800 USD
Hardware and installation	3000 USD
Annual maintenance cost	400 USD
Type	Ku-band
Year	2007

This “volume based” solution forces you to implement a volume based bandwidth management solution in the system, so that each client has a quota to spend according to their subscription fee. The concept of limiting the amount of transfer of data over a period of time is known as “bandwidth cap” or “bit cap”.

Although implementing a volume based system is technically possible, end-users tend not to like the model as the volume of downloaded data is a concept difficult to measure while doing your daily routines on the Internet. Users will wonder why they have to pay for Windows

updates or the bandwidth generated by a virus.

This alternative implies training the end-users in how to work on the internet in a “volume-effective” way, i.e. how to minimize the use of international bandwidth when browsing and checking email. It will also benefit from the installation of appropriate browser plug-ins to block unsolicited images such as advertisements in websites.

Furthermore, the network needs to be equipped with a web cache that can store commonly requested information locally.

D: Wireless metropolitan network, dedicated bandwidth in local loop

Provider	Africa Online, Uganda
Bandwidth	128/128 kbps (local loop)
Contention ratio	N/A
Volume restriction	No
Bandwidth cost	100 USD/month
Hardware and installation	200 USD
Annual maintenance cost	N/A
Type	Wifi (local loop)
Year	2007

With the information that was offered, we would advise anyone against signing up. Without knowing the actual bandwidth for international traffic and its contention ratio, this offer has great chances to fit under the category of “scam”.

However, if that data were available and acceptable, it would be a good start-up solution for many Community Networks due to the low setup fee and monthly cost for bandwidth.

Something to take into consideration is that good satellite bandwidth is by definition expensive. How expensive? Very. It is difficult to get prices but during 2008, 1 dedicated Mbps cost something between 6500-7000 USD/month^{23 viii}.

²³ Using QPSK modulation, $\frac{3}{4}$ rate FEC, Ku-band.

E: Satellite, dedicated, pre-paid time/volume based

Provider	Knoochi Communications, UK
Bandwidth	512/256 kbps
Contention ratio	1:1
Volume restriction	8.7 GB/year
Bandwidth cost	562 USD/year
Hardware and installation	3200 USD
Annual maintenance cost	N/A
Type	Ku-band
Year	2007

The *pay-as-you-go* service is a voucher based system with a centralized captive portal (in the UK) that handles authorization and keeps track of time and volume spent per client.

All access is time and volume restricted, and whatever resource runs out first will activate a termination.

A strong advantage of this system is that the *start-up fee* for opening a wireless hot-spot is low. Additionally, the overall risk for the re-seller is also low since, with each end-user paying for what s/he uses, no fixed monthly fees are involved for the bandwidth. The only fixed fees involved are the installation and hardware costs and a yearly fee of 562 USD that gives an annual downloaded volume of 8.7 GB.

The main disadvantages of the system are the *weak user feedback* that the system provides in terms of volume of data spent, and the fact that the system is restricted both in terms of time and volume, which has shown not to be popular among end-users.

The table below shows a quick overview of the five solutions presented.

- A: One-hop satellite, flat fee, shared bandwidth
- B: One-hop satellite, flat fee, dedicated bandwidth
- C: One-hop satellite, flat fee, volume restriction, dedicated bandwidth
- D: Wireless metropolitan network, dedicated bandwidth in local loop
- E: One-hop satellite, dedicated, pre-paid time and volume restricted.

Type of connection	A	B	C	D	E
Bandwidth [kbps]	1024/256	128/64	220/50	128/128	512/256
Contention ratio	10:1	1:1	1:1	N/A	N/A
Bandwidth cost [USD/month]	870	1000	800	100	-
Volume restriction [GB/month]	∞	∞	4.5	∞	-
Hardware and Installation [USD]	8000	3000	3000	200	3200
Annual maintenance cost [USD]	700	700	400	N/A	N/A
Type	C-band	C-band	Ku-band	WiFi	Ku-band

5.4 Having all the facts, can this really work?

International bandwidth through satellite will always be expensive. The satellite market is controlled by a few large companies, and it is not a simple market that just anyone can enter.

Most of the transponders of the satellites covering Africa are congested already. A large part of their capacity is dedicated to GSM operators, governments and satellite TV. When it comes to satellite TV, entertainment like sports and “adult services” consumes most of the bandwidth.

When all transponders of a satellite are occupied, the only way to increase capacity is to launch another satellite. Launching a satellite into the space is a costly project that takes years to pull off. There have been some recent attempts to launch satellites with the intention of improving the connectivity situation in Africa. Unfortunately, several of them have failed. Let us have a look at a few trials.

In January 2007, the *NSS-8^{ix}*, a high powered state-of-the-art Dutch telecommunications satellite that would have provided coverage to two-thirds of the planet, was destroyed during launch.

The satellite was equipped with 56 C-band and 36 Ku-band

transponders. NSS-8 was designed to support a wide range of services including broadband Internet services.

For Africa, the NSS-8 was long seen as a great opportunity to increase the upstream connectivity for the continent, and lower the cost of international bandwidth. Instead, the result was rather the opposite, as prices increased^x when the news of the failed launch reached the world.

Another recent satellite failure that affected Africa was Nigeria's 240 million dollar communication satellite *NIGCOMSAT-1^{xi}* that experienced severe power failures short after its launch in May 2007. To prevent the satellite from damaging other satellites, it had to be sent to a "graveyard orbit^{24b}" in November 2008 just 18 months after being launched, as it became apparent that the satellite could not be recovered.

The satellite was produced by Chinese manufacturers, and there are now allegations that the satellite was built with poor-quality materials that resulted in the loss of the satellite.

The satellite was expected to have a life-time of 15 years, and to provide broadband Internet and communications for government agencies in Africa.

On the other hand, good news for Africa might come from Intelsat. In December 2008, Intelsat, a privately-owned satellite firm, reported that they will launch a 250 million USD satellite solely for Africa^{xii}. Two and a half years before the satellite is slated for service (2011), more than half of its capacity has already been booked. The pre-orders, worth more than 350 million USD, come from cellular connections to Vodacom, video to Gilat Satcom and corporate network support to Gateway Communications Africa.

Let us be clear, although new satellites will be launched to the sky, and more capacity will be offered to Africa, space-based Internet capacity will never be affordable for the masses and broadband Internet will never be a reality. There is no way to reach a high broadband penetration to the masses without fibre networks.

There are many undersea cable projects underway that will connect

²⁴ An orbit where spacecraft are intentionally placed at the end of their operational life as a way to lower the probability of collisions with operational spacecraft.

the African continent with Europe and Asia. It is quite likely that we will see changes within the near future, but until then, we need to live with expensive satellite connections.

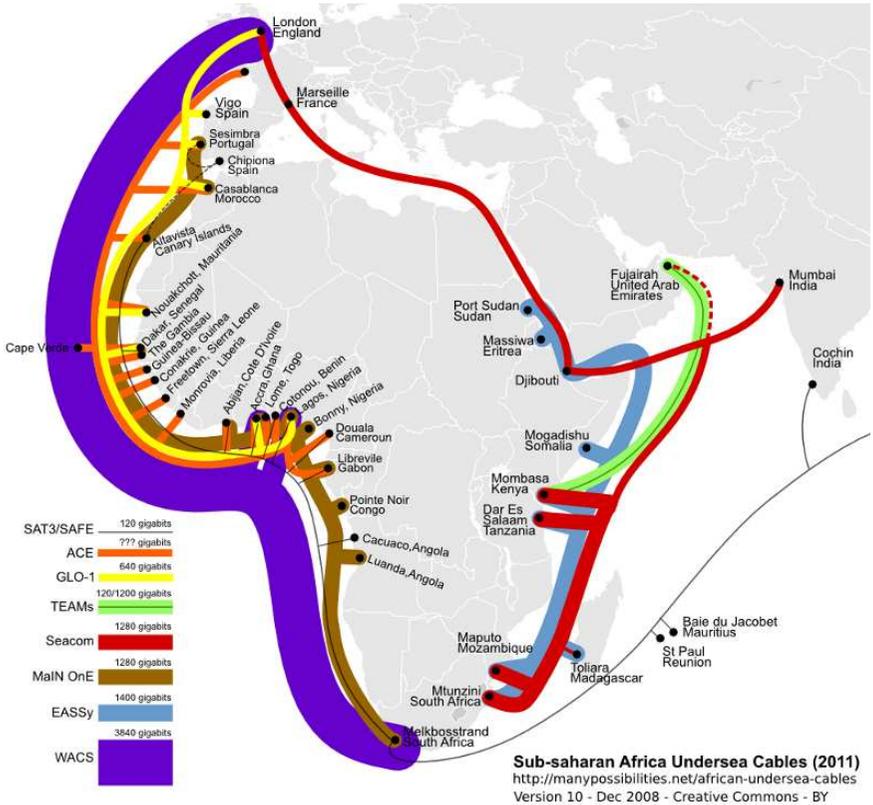


Image 2: An illustration of the current under-sea cable initiatives connecting Africa with Europe and Asia. Last updated: December 2008

Source: <http://manypossibilities.net> by Steve Song.

So what does all this mean for our Community Wireless Networks? Is there even a chance to establish a sustainable network based on satellite bandwidth?

It is sad to conclude that the initial assumption of a *volume discount* for bulk Internet capacity is often not correct. More often, the price for connectivity is constant (USD/kbps).

Having that said, we still believe that there are many advantages and great possibilities involved in building community networks, but one should not be fooled into thinking that it is a “piece of cake.” One of the great advantages is still the reduced risk of investment for people who approach a satellite provider as a group rather than individually. Installation of a satellite connection is never cheaper than 3000 USD, which is a large investment for anyone. Splitting the monthly fee of hundreds of USD is also a great advantage, as the minimum fee for satellite bandwidth rarely goes below 500 USD.

So what does it take to make a Community Wireless Network “sustainable”?

The most important component for success, is actually *the people*. *particularly* the people on the ground handling the daily operations. Without the right personalities, skill sets, minds and ideas, a Community Wireless Network has no future.

Having that important building block in place, you will always need initial funding for the physical infrastructure of the network. It must be clear that this funding can hardly be considered as “venture capital,” as any eventual profit from the network will be needed to cover expenses for support, maintenance, and possible expansion of the network and not to recover the initial infrastructure investment.

This initial funding for infrastructure should include central tower(s), power backup systems, wireless backbone, wireless access network and spare parts for at least one year.

So, the answer to the question “Can this really work?”, is **Yes**. With the right people on the ground and initial seed funding in place, you can establish a Community Wireless Network in Africa.

Let us have a look at *two major initiatives* in Africa for building Community Networks, the Community Wireless Resource Centre (Makerere University) in Uganda and Zittnet (Fantsuam Foundation) in Nigeria.

6. Methodology

Although we would love to provide a step-by-step guide in how to build a successful Community Wireless Network, it is not possible. No environment provides the same conditions, no grassroots organization works the same way, and no community has the same needs. However, we would like to share with you the methodology we have developed over the years and used for these Community Networks.

6.1 Philosophy

The basic philosophy behind the methodology is

“learn by theory and practice, repeat what you learnt, teach a friend, and document your work”

We humans do not learn new skills in one single way. While some people prefer to read and study a topic thoroughly before trying it in practice, others prefer to learn by “trial and error” or watching someone else demonstrating the work. Having that in mind, we try to meet the needs of different types of learning styles. To do that, our training includes both *theory* (oral presentations and handouts for self-studies), *practical exercises* (both joint and individual exercises), and provide large amounts of *visuals* (images, illustrations, sample equipment etc.).

As the trainees of a workshop are people with varying ICT skills, different levels of formal studies, religion, ethnicity, age and gender, we need to be aware of how *social rules* impact the way we learn. In some cultures women are not expected (nor encouraged) to deal with technical appliances or climb roof tops, while men are not supposed to get their hands dirty sweeping a dusty floor. In other cultures, the eldest in a group naturally becomes a self-appointed leader, on the simple basis of his or her age. In our trainings, we try to overcome these social and cultural rules, as we are convinced that they hinder the learning. We do so by simply ignoring factors such as gender, age, religion and social status. What really matters during a training is *how badly a trainee wants to learn?*

An example of how this philosophy is applied in our training is *not to*

treat women any different than men. Assume that women have the same qualifications as the men, let their voice be heard, and demand the same results from them as from the men. During our first workshop with Fantsuam for example, we let the men clean out the server room, while the women prepared the network cables connecting the NOC with the central tower. This exercise resulted in a clean server room, and a fully functional backbone link.

Another example of breaking social boundaries is the example of a Muslim young woman, interviewing a Catholic bishop about his use and needs of ICTs.

An important part of our philosophy is that *learning takes time!* We can not expect wonders from a workshop. It is important to distinguish between *teaching* and *learning*. During a workshop, the trainer teaches the trainee a certain topic. For the trainee to learn the topic, individual training with post-training support is required. To learn a topic, repetition is needed. There is no better way to learn something than to try to teach it to someone else and document what you learnt. These are routines that we encourage trainees to undertake.

6.2 The building blocks

The methodology can be divided in six building blocks.

6.2.1 Studies and preparations

As any other project that implies implementation, a thorough background study and good preparations are crucial for success. In our case, the partner organizations (Fantsuam Foundation and the CWRC) started by conducting a set of surveys and studies to get a clear picture of the clients' needs, the telecentre's ability, and the services offered by existing ISPs.

A *partner survey*, targeting potential clients, was carried out by both teams. This survey focused on the clients' need of ICT services, and their ability to pay for them. This survey did also facilitate the development of the Business Model and Service Level Agreement used in the different networks.

This phase of preparations did also include some research on how import procedures were handled in each country, and how to procure, transport the equipment needed in a feasible way.

6.2.2 Basic Training

A two-weeks' on-site workshop in building Community Wireless Networks. The training normally includes 10-15 trainees handled by two trainers. The training focuses on building up a *basic skills' level* in the field of wireless communications within the group. Typically, 25% of the training is pure theoretical, 25% is practical (in a computer lab) and 50% is field work (site visits and temporary installations). By the end of this training, the group should be able to make their own wireless installations and avoiding the major and most common mistakes.

The Basic Training Workshop includes the following sessions:

Theoretical sessions

- Introduction to Wireless Communications
- Network Topologies
- Wireless standards
- Access point configuration
- Basic Radio Physics
- Radio Link Calculations
- Antennas and Cables
- Outdoor Radio Simulations

Practical sessions

- Ethernet cabling
- Access point Configuration I (basic configuration)
- Access point Configuration II (advanced configuration)
- Access point Configuration III (PtP wireless link)
- Outdoor radio simulation

Field work

- Site surveys (1-2 days)
- Implementation of temporary wireless links (1-2 days)

6.2.3 Implementation Plan

Based on the site surveys carried out during the Basic Training Workshop (Step 2), implementation plans were developed for each network. Each implementation plan includes network architecture, network topology, wireless configuration, hardware requirement, budget, activity plan and time plan. The plans are developed by the trainers with feedback given from the local partners.

6.2.4 Procurement of equipment

As soon as the implementation plan is completed and agreed on by all partners, the procurement process can start. While bulky and heavy equipment was procured locally, most technical equipment was imported from abroad.

The procurement phase takes normally around 1-2 months including order, payment, shipping and clearing of customs.

6.2.5 Implementation

Once the equipment is delivered to the partner, implementation can take place. Based on the skill set the local team have gained from the first workshop (Step 2), and the Implementation Plan (Step 3), the local team begins the deployment. The team uses the Implementation plan as primary guideline, the wireless training material as supplementary help, and contact the trainers if additional help or consultancy is needed.

The implementation phase runs for around 2-4 months depending on the size of the network.

6.2.6 Quality Control and Advanced Training

When the network has been up (at least partly) and has been running for a few months with a small set of clients connected, the second (Advanced) training workshop takes place.

This workshop has two main objectives; to (1) ensure quality of service in the network and (2) to teach the local team advance topics in the field of Community Wireless Networks.

The quality assurance is done by studying the network topology and its configurations (routing tables, SSID:s, channels, NATs, DHCP servers, IP allocations), measure the performance (round-trip times, availability, packet drops), and by physically visiting the majority of the client sites (including all backbone infrastructure) to inspect the installation (antenna location, connectors, cables, PoE, civil works, etc.). If there is not time for visiting all sites, the local team should understand by now which sites need a second round of installation work. The Advanced Training covers the following areas:

Theoretical

- How to reduce the use of international bandwidth?
- Traffic management with *MasterShaper*
- Troubleshooting a wireless network
- Point of failure in wireless installations
- Critical reading of ISP contracts

Practical

- How to reduce the use of international bandwidth?
- Traffic management with *MasterShaper*
- How to set up a fully routable wireless network with repeaters

6.2.7 Running and maintaining the network

As more clients are connected and the traffic increases in network, problems will occur sooner or later. Viruses will be spreading, equipment will be plugged into non-stable power and be damaged, antennas will shift direction by the wind, and so on. It is naive to think that a wireless network needs no maintainable once it is up and running. Rather the opposite, now is when the real work starts, *to provide a stable and affordable service to the clients.*

This last part of the methodology was the weakest in our project plans. We focused on starting Community Networks, and did not take into consideration how the network should be managed and maintained. To fill this gap in the project, IT46 still continues to provide remote support to the networks after the project time on a volunteer basis.

PART 2

One generation plants the trees; another gets the shade.

Chinese Proverb

7. The Community Wireless Resource Centre, Uganda

By Dorothy Okello

7.1 Project background

The Community Wireless Resource Centre (CWRC) was set up in 2006 as a centre within the Department of Electrical Engineering at Makerere University in Kampala, Uganda. The aim of the centre was to act as a bridge between the University and telecentres across the country with an interest in wireless communication. The Centre (CWRC) received funding from IDRC to *train* students and telecentre representatives in Community Wireless Networks and together *implement* a number of such networks in Uganda. After the implementation phase, continuous support has been given from the CWRC to the telecentres to ensure sustainability of the initiatives.

The centre has since September 2006 been lead by Dr Dorothy Okello, lecturer at the Electrical Engineering Department, together with bachelors students in electrical engineering. The Centre activities have become an embedded part of the university curriculum, as CWRC can offer both industrial training (3 months practical work in the field of ICT) and a MSc. Project. Students taking their MSc. Degree within the department of Electrical Engineering, are offered the possibility to specialise in wireless communications and carry out their research with the CWRC.

7.2 Results and outcomes

A substantial and tangible result of the CWRC work can be found in the three Community Wireless Networks established by CWRC across Uganda in 2007. All three networks are unique in their own way, depending on their geographical location, staff, partners and access to Internet Service Providers. For detailed information about each network, please see Section 8-9.

In addition to the establishment of Community Wireless Networks, there have been three primary results and outputs of the project:

Information sharing and dissemination

A variety of reports are available from the project, including industrial training reports by the students, telecentre and partner survey reports, continuous status reports, and meeting notes illustrating the ongoing work during preparation and implementation of the project.

All reports are available at <http://cwrc.it46.se>

Training of Electrical Engineering students

Industrial training opportunities were provided to eight students of the Department of Electrical Engineering. This training is a key element towards fulfilment of the degree for a Bachelor of Science in Electrical Engineering. In addition, two workshops were conducted targeting the telecentre managers together with the CWRC staff and students. In addition, components from the community wireless project have been incorporated into existing courses within the Department of Electrical Engineering. For example, students have been introduced to Radio Mobile software for designing wireless networks.

The CWRC has also sought to make a particular contribution to the capacity-building of women. The CWRC project director is a woman and in 2007 a deliberate decision was made to have a 50:50 gender representation among the industrial training students.

The female students were able to fully engage in all aspects of the project just as their male colleagues. However, in general, the CWRC has not been successful in attracting women into the program and more needs to be done in this area to increase the participation of women from 25% to 50%.



Image 3: Sanyu Lutaya-Kamya (right), demonstrates for her colleague how to configure a routing table.

Increased research opportunities

The IDRC-funded project is the nucleus upon which we are positioning ourselves for increased research opportunities. This is because we have results to show! To-date, the CWRC has been selected as one of three projects to serve as pilots in the Wireless Africa initiative that seeks a holistic approach to the sustainability of Community Wireless Networks, including technical, social and economic aspects.

The CWRC has also been selected as one of five projects that will participate in the pilot MP/Scientists shadowing scheme being implemented by the Uganda National Academy of Science. Through this scheme it is expected that scientists will expose Members of Parliament (MPs) to current trends in science and technology. On the other hand, it is hoped that scientists will learn to appreciate policy and law-making processes. This is particularly important for the CWRC if we are to have the Community Wireless Networks approach

formally taken up as one of the solutions to address last mile connectivity in Uganda nationwide.

Furthermore, the CWRC has been selected under the Millennium Science Initiative (MSI) research grants initiative of the Uganda National Council for Science and Technology. The focus of this research is on issues to do with bandwidth management, in particular with flexible ways of managing the bandwidth you have available through the telecentre. The grant, effective 2009, will be primarily used to support at least three graduate students and to purchase spectrum and network analyser equipment.

Finally, the initial successes of the CWRC have interested more students to consider taking up projects and research with the CWRC. We expect to continue having fourth year projects based on issues of concern to the CWRC. So far, we have also taken on one MSc student to do further research on issues of concern.

“In my view, the CWRC has had great achievements in its few years of existence. It has settled down in the University setup and has made a name for itself because of its achievements. Three wireless networks were established in different parts of Uganda, but it was not easy especially on the technical part. The technical team had never been involved in this kind of work, and therefore it was a great achievement for them to install these networks without major problems.

CWRC has made a network of partners interested in its activities both in the university, nationally and abroad. CWRC is always in contact with Uganda’s Ministry of ICT nationally, and globally there is support from IT46 in Sweden, and a good relationship with a string of partners connected to the Wireless Africa initiative at the Meraka Institute in South Africa. These relationships will be vital if CWRC is to continue on a forward path of spearheading the drive for usage of ICTs to foster development in local communities.

CWRC has also had major achievements in availing students with good training opportunities and confirming itself as a

major research institution at the university. Today, there are three working community networks and whoever thought it was impossible in Uganda has his/her answer. As a pioneer, CWRC will continue to be remembered for this, and will continue to be a hub of knowledge and expertise for people and organizations seeking to venture into such an area.”

Edwin Mugume, Project Officer [2008]

7.3 Organizational structure

The Community Wireless Resource Centre, taking the leading role during the implementation phase in 2007, is currently acting as a supporting organization for the established Community Networks and other organizations that aim to walk the same path.

The Centre has three permanent staff, namely Dr Dorothy Okello, Director, Dr. Julius Butime, Researcher, and Mr Peterson Mwesiga, Project Officer.

7.3.1 Students behind the daily operations

The engine of the CWRC has always been students from the Electrical Engineering programme. This is an odd phenomenon in Africa, where students normally do not reach positions related to practical implementation, financial responsibility and decision making.

Each year, the centre has access to four third-year students from the Electrical Engineering programme, which play an active part in the daily operations of the centre. The selection of the students is a competitive process, based on a call for students from the CWRC. The applications are reviewed, rated and finally selected by the Department in collaboration with the CWRC.

Since 2006, the students have joined the centre in June each year, to conduct the three month mandatory Industrial Training with the CWRC. The Industrial Training is a requirement of the Bachelors programme at Makerere, with the aim of building appreciation for the practical aspects of the theoretical lectures taught in class.

“During training, we had a golden opportunity to tinker with equipment like antennas and RF cables which was a rare thing in the private sector where industrial training students are onlookers.”

Peterson Mwesiga, Project Officer [2008]

“In a field where there are a lot of restrictions that companies put on students they take on for training, CWRC allowed her students full access to equipment, books and other resources, and full time availability of staff to help the students learn. For two years (2006 and 2007), CWRC gave students the best training in terms of theoretical knowledge backed by hands-on training with equipment.

While companies have restricted areas and systems, CWRC does not. CWRC also offers her students an opportunity to continue learning even after the training period, an opportunity that you never get from companies.

The students who did industrial training during the implementation phase between July-September 2007 gained such knowledge and experience that each one of them could install an entire network on his/her own. That is the level of knowledge and experience you get from CWRC, which you never get anywhere else.”



Image 4: Edwin and his team is making a wireless client installation in Kabale, 2007.

Edwin Mugume, Project Officer [2007]

7.3.2 Further research within the field is attractive

Most of the past CWRC students have remained associated with the CWRC during their fourth and final year of study, and even upon their graduation remain engaged with the CWRC.

The field of Wireless Networking is attracting more and more students at Makerere, as wireless networks are becoming increasingly popular in Uganda, and rumours of resourceful training at CWRC is spreading around the university.

Several CWRC students have chosen further studies in Wireless Technologies, which has resulted in a number of research projects and reports.

The topics include “Investigation of low-cost data and voice networks based on 802.11b/g technology” [Okwany R.], “Wireless VoIP Networks, case study on Nabweru Telecentre” and “Bandwidth Management and An Investigation On ISP Business Models In Uganda”.

7.4 CWRC member network

One of the aims of the CWRC is to build local capacity, both within the university and within the community at large. As a result, the CWRC is carefully building a network of members that include telecentre managers from the established networks as well as current and past students involved with the CWRC. This network will continue to grow as the CWRC continues to attract not only students but also lecturers from within the Department of Electrical Engineering.

The CWRC also aims to attract a wider range of stakeholders into its network. This includes both technical experts and policy makers. Currently on the CWRC mailing list, which is the primary means of communication, we have representatives from the Ministry of ICT and the Parliamentary committee on ICT.

7.5 Integration of wireless curriculum in university curricula

It had been anticipated that the CWRC would integrate the Wireless Community Networking Curricula in Makerere University by including components of the curriculum in already existing courses in the 2006/2007 academic year, and then offering a fully fledged course in Community Wireless Networks within the second semester of the 2007/2008 academic year. The courses would be offered through the Department of Electrical Engineering.

The courses targeted for integration of the topics from the wireless curriculum and that are already available to both Electrical Engineering and Telecommunication students at the Department of Electrical Engineering were:

- *Introduction to Information and Communication Technologies (ICTs)*, where students are expected to gain an appreciation of the need to select appropriate ICT systems for the various tasks and deal with issues of sustainability of ICT systems in the context of Uganda and given the high rate of change in ICTs.
- *Propagation*, where students are expected to gain an understanding of wireless propagation characteristics in order to aid the design of sustainable wireless networks.

Indeed, components from the CWRC work have been included in these courses, ranging from modules to discuss the basic setup of Community Wireless Networks, to group projects that involve the design and simulation of simple Community Wireless Networks with a few partners each.

The element yet to be implemented is that for a fully-fledged course in Community Wireless Networks. Even then, this may be overtaken by events in the sense that there are now plans to include a course on Wireless Networks – of which Community Wireless Networks could be a component.

7.6 Funding situation

The CWRC was established with initial funding from IDRC from inception in June 2006 to the close of the Uganda Community Wireless Project in September 2007. The CWRC is hosted by the Department of Electrical Engineering, which provides the office space that also doubles as the office of the CWRC Director. The CWRC is also well received at faculty level and enjoys support from the top management including the Dean of the Faculty.

The CWRC has continuously sought out further opportunities for funding to support and enhance our operations. Some of these efforts are beginning to bear fruit as the CWRC in May 2008 was selected as one of three pilot projects under the Wireless Africa²⁵ initiative that will provide technical and business-oriented training to the team, and support implementation of Voice over IP (VoIP) systems and advanced wireless services such as bandwidth management, monitoring and billing.

As previously mentioned, the CWRC has also been selected to participate in a pilot MP/Scientists Pairing Scheme. In September 2008, the CWRC Director together with four other scientists spent a week at the Parliament of Uganda where they shadowed a corresponding Member of Parliament (MP) and met with the parliamentary researcher who deals with legislators' science queries. In December 2008, the CWRC had the honour to introduce the *Nabweru Community Network* to Hon. Gordon Sematiko, representing Mityana North Constituency.

²⁵ Wireless Africa, Alliance and Supporters of Community Wireless Networks across Africa, www.wireless-africa.org

8. The Kabale Network

Based on an interview with Mr. Nkurunungi Peter Rugarafu

8.1 Kabale and its local reality

Kabale town is located in south-western Uganda, close to the Rwandan border. It is known as “*the Switzerland of Uganda*”, considering the landscape and the climate, but that is where all similarities end²⁶ ^{xiii}. Although Kabale is stunningly beautiful with its green hills and magical Lake Bunyonyi, it is a poor community that often is neglected by the central government. Signs of that are the roads of Kabale, mainly dirt except for a few main roads in the centre, all equipped with countless wide and deep potholes. Dirt roads and potholes are a part of daily life all across the continent, playing a particular role when for those who need to travel up and down along kilometres of steep hill tracks every day to reach work, the market or just to visit a family member, knowing that one little mistake would send them to the bottom of a ravine.

When we visited Kabale in September 2007, just two months before the upcoming CHOGM²⁷ meeting, people told us that the roads were worse than ever because the annual patching of the roads never took place due to a reallocation of funding for road construction in Kampala for the CHOGM event. Most likely, it was not only Kabale's infrastructure budget that was pulled that year, as every paved road in Kampala visited by any of the CHOGM representatives was improved to European standards during a few months time. Inevitably, the new roads, built in a hurry without proper materials, only lasted a few months before they started to break down. How many accidents did this “reallocation of budgets” lead to, just to show a shiny surface to

²⁶ It seems that there is one Switzerland in every country we work: *Lushoto* “The *Switzerland of Africa*” (Tanzania), *Kabale* “smaller version of Switzerland” (Uganda), *Ifrane*, “Little Switzerland” (Morocco). The biggest claim is the declaration that the entire nation of Guinea is “the Switzerland of Africa”. This phenomenon has been documented on the linguistics blog “Language Log” (see endnote).

²⁷ The Commonwealth Heads of Government Meeting, held in Uganda, November 2008.

the CHOGM guests? At least every second person that we got to know in Kabale has been involved in at least one accident on those hilly, holey roads.

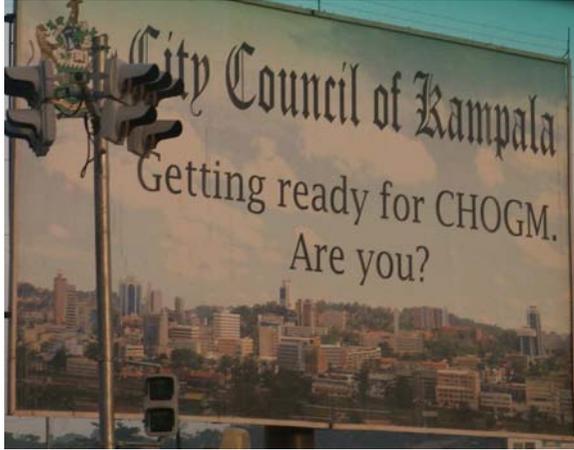


Image 5: A billboard promoting CHOGM in Kampala, 2007

Most of Kabale's inhabitants are small-hold farmers. For the last couple of years, most farmers have been occupied growing Irish potatoes. A bit odd one might think, as the Ugandan diet does not include much potato, but everything has a reason. Irish potatoes are large and oval, perfect for French fries (or chips, as they are called in East Africa). The South African fast-food chain *Nandos* found out that the Kabale climate is excellent for potato farming, and made the local farmers an offer to grow potatoes for export that they could not refuse.

8.2 Network topology and client distributions

The Kabale district hosts two Telecentres, the *Kabale Telecentre* (in Kabale centre) and the *Kachwekano Community Multimedia Centre* (CMC) located an 18km drive from Kabale (6km as the crow flies). The initial project idea was to establish two separate networks, as there were two different organizations willing to take on the challenge. The organizations are separated 45 minutes by car (yes, 18 km!) which limits their possibilities of working closely together.

While Kabale Telecentre is located in a flat but heavily-populated area without any nearby mast or tower owned by the community, the Kachwekano CMC is located at the top of a hill (300m higher than Kabale town) and owns a 45m communication mast donated by UNESCO. Kachwekano's mast is used for community radio and space is leased for a commercial mobile operator's radio equipment. With these facts in mind, it was necessary to reassess our first assumptions and consider the establishment of one single network with Kachwekano CMC as the central hub of a typical star topology.

In order to expand the network in Kabale town, we needed access to a high point around town. Unfortunately, communication masts are expensive to procure²⁸, and it is difficult to gain access to existing ones already hosting commercial equipment. The existing masts in Kabale are owned by MTN²⁹, Zain³⁰, Mango (UTL)³¹ and Warid Telecom³², all commercial GSM operators. The only non-commercial mast available in the area is the one established by UNESCO at Kachwekano CMC.

The network topology built in Kabale is a fully routable network where all the access points of the core network act as routers. The

²⁸ As a reference, a 45m self-standing mast in Nigeria costs about 10,000 USD for material and installation.

²⁹ MTN, a South African-based multinational mobile telecommunications company, operating in many African and Middle Eastern countries.

³⁰ Zain Group, a Kuwait-based Mobile Telecommunications Company providing mobile and data services in the Middle East, Africa and Europe.

³¹ Uganda Telecom

³² Warid Telecom, a joint venture between Abu Dhabi Group & SingTel Group.

backbone and the access network are logically separated from each other using different IP ranges. The network includes three repeaters (October 2008), two in the central tower and one hosted on a two storey building above Kabale centre.

Each client unit is configured as a router. The use of routers, instead of bridges, was deliberate so as to have full control over traffic at the far reaches of the network. Transparent bridges are easy to deploy but introduce several security threats and seriously jeopardize the stability of the network.

When using transparent bridges across a wireless network, all hosts on the network are logically connected to the same LAN within the same subnet. When one host gets infected with a virus or Trojan, an administrator has no simple way to stop the problem by isolating the infected hosts. On the other hand, a router provides the possibility of isolating problems and blocking undesired traffic. This is an important aspect, as most of the networks that we have seen implemented are flat and poorly managed. In a flat network (transparent bridged), any host can accidentally bring down the whole network by assigning itself a fixed IP address that belongs to the core network. With a duplicate IP in the core network, things just stop working!

In terms of hardware, the core network is running *SmartBridges AirPoint Nexus Pro Total*³³ equipment while the clients are equipped with a cost-efficient radio from Complex³⁴.

³³ SmartBridges equipment, badly grounded, will eventually get the network ports blown up by lightening

³⁴ Complex WPP45AG-C (outdoor) or Complex WP54G (indoor) with external antenna.

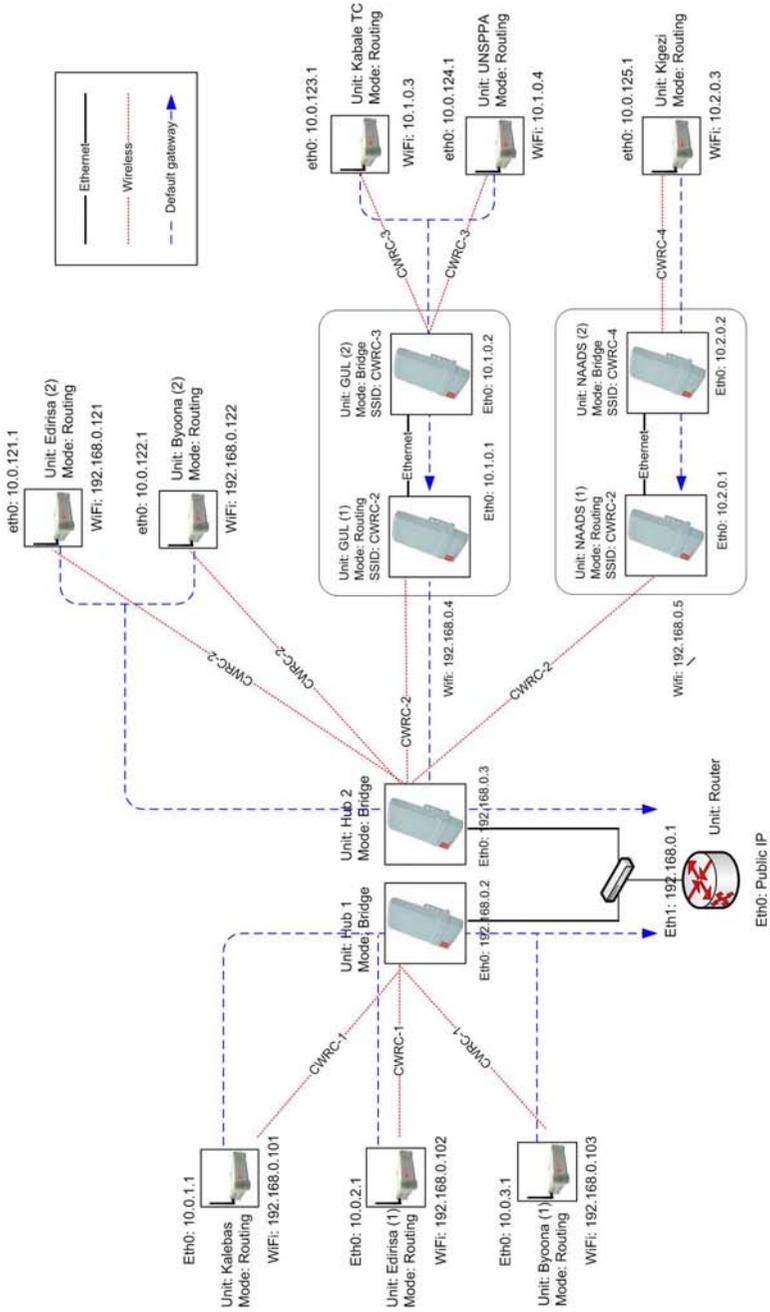


Image 6: Network diagram for the Kabale Community Network.

8.3 Organizational model

The members of the Kabale Network have created an organization lead by the director of the Kachwekano CMC, Dr Imelda Kasheija. The organization holds quarterly meetings to discuss investments and financial issues, but additional meetings can be arranged whenever there is an urgent matter that needs attention. Although Dr Imelda has executive power, most decisions are taken by the group during the meetings.

All technical problems or other network related issues are reported to the Network Manager, Mr. Nkurunungi Peter Rugarafu.

8.3.1 *Communication flow*

Apart from the quarterly meetings, the partners communicate by email or phone whenever needed. The directors of the two Telecentres and the Network Manager are all members of the CWRC mailing list to keep in contact with the Centre and seek advice when necessary.

8.4 Business Model

The Kabale Community Network has a C-band VSAT installation from iWay Africa. For 530 USD/month, they get a dedicated international bandwidth of 175/50 Kbps with a volume restriction of 3 GB/month.

The monthly fee is split equally between the ten partners. Each of them pays 65 USD/month to the Kachwekano CMC, which later pays iWay Africa.

Additionally, all partners contribute 10 USD/month to cover the costs of support and maintenance of the network.

If the network fails to deliver the service to a client, due to network failure or broken client equipment, the client is free from responsibility to pay the fee. During the last year, several clients experienced problems with broken equipment, and hence, monthly fees were outstanding. So far, the Kachwekano CMC have covered for those losses, and the monthly fees for each partner have not been raised. Dr

Imelda has chosen this strategy to avoid losing clients or in any way discourage their participation in the network.

From the positive perspective, all partners who have received the service without interruption have paid the monthly fee on time.

The Kabale Network has yet not found a working business model to cover the operational costs for the ongoing maintenance done by Mr. Nkurunungi. The plan was for his services to be covered by the partners' maintenance fees, but he has still not been reimbursed for the work he carried out during the last year. The reason for the shortfall is that the Kabale Network is still struggling to meet the monthly cost for iWay Africa, while the shortage of wireless equipment in the country has led to fewer member fees when equipment has failed. For the same reason, the expected network growth has not taken place.

Although the compensation for his work would be welcomed, and he expects to get paid once the organization is on its feet, Peter looks back at this year of volunteer work with joy since it has been an exciting year when he has gained a lot of valuable knowledge.

8.5 The clients

After the installation phase in August 2007, there were no fewer than 10 clients connected to the network. Two of them are currently not paying members, as parts of their wireless equipment have failed, while one client has moved away from Kabale. However, finding new clients for the network does not seem to be a problem. A few months ago, Peter carried out a survey among potential clients. He found out that more than 40 people in Kabale and its surroundings were willing to join the network and had the financial capacity to do so. The clients were educational institutions (universities and colleges), religious institutions, public and private health care organizations and private businesses (hotels and Internet cafés). While larger organisations and schools were willing to pay up USD 60 per month, most private people, who only have one computer, were willing to pay up to USD 30 per month.

8.6 Challenges faced

Over the year Peter has faced numerous technical problems, most of which he has managed to fix by himself. Common problems have been access points that suddenly do not associate to the backbone or access points that reset to default settings for unknown reasons. When such problems have been reported, Peter has visited the client and reset and reconfigured the access point.

Another common problem has been faulty RJ45 connectors. The locally procured connectors are of poor quality and can easily fail to provide contact to one or more strands after some time in use. Once, Peter recalls, all clients in Kabale town went off-line, as the RJ45 connector of one of the central access points suddenly failed.

Access points have lost signal to the backbone a few times due to heavy wind. In those cases, Peter simply re-aligned the radios and improved their mounting points.

Although Peter has managed to solve many issues by himself, there are a few areas where he and his team need assistance and guidance from outside. Peter summarized his needs as:

1. Bandwidth management

The network is in need of volume-based bandwidth management because their ISP, AFSAT, provides a volume-based Internet connection. At the moment, there is no mechanism in place that controls each user's traffic, neither in speed nor in volume, and hence there is no way to charge each client according to his or her usage.

2. Access to equipment

Several clients have experienced equipment breakdowns. Both access points and PoE injectors have failed. The CWRC and IT46 are working on troubleshooting and/or replacing the faulty units, but distance between the network in Kabale, the CWRC team in Kampala, IT46 in Sweden and hardware suppliers in Europe is a delaying factor.

The CWRC is trying to find sources within the country to procure similar radio equipment at reasonable prices, but their efforts have so far been fruitless.

3. Access to masts or towers

Many potential clients do not have line-of-sight to any repeater and hence no wireless connection can be established. There is a need to equip Kabale Town with a non-commercial mast, so that the Kabale network can serve its population in terms of data and voice communication.

8.7 Access to technology

There is of course no wireless equipment available in Kabale town, but even if you travel to Kampala, which is a day's ride away, components are difficult to find. And if you are lucky enough to find a reseller, the prices can be stratospheric!

The CWRC has been aware of this fact for some time now, and is trying to find a solution. An alternative would be for the CWRC to open up a small shop in Kampala to provide wireless equipment to Community Networks for reasonable prices. By importing equipment in bulk, they hope to be able to reduce the prices.

The lack of access to wireless equipment does not only hinder the expansion of the network, but also causes trouble when equipment breaks down. As there are no spare parts within the country, broken units have been disconnected from the clients for months. Peter has sometimes managed to cannibalize spare parts to repair broken equipment from another failed unit, but that is of course not a sustainable way of doing business.

8.8 Future plans

“The future of the Kabale Network? - We will expand it and ensure sustainability by finding the right business model for us”, says Peter.

The timing for Peter and his partners in Kabale could not be better, as the Kabale Network, represented by the CWRC recently was selected as the country representative of Uganda in the Wireless Africa initiative. The Wireless Africa Initiative is a research project funded by IDRC that aims to support community-based operators as they roll out their networks in ways that are financially sustainable and technically appropriate. In terms of technology, the Wireless Africa initiative will focus on low-cost wireless devices, easily set up Voice-over-IP systems, and management systems for bandwidth and billing.

Apart from representing Uganda in the initiative, the CWRC and the Kabale network have been nominated to be one of the three pilot networks, based on their readiness in terms of technical knowledge, practical experience and openness in sharing research results..

Peter explains that the partners of the network have discussed the possibility of creating a separate body for the network, not attached to the Telecentre in Kachwekano, namely the Kabale Community Wireless Network (KCWN).

By creating the KCWN, the Kabale network would become a project on its own that could seek funding from the government or other sources for its future expansion. The creation of a new organization should help to make it sustainable and would help the project to remain independent of the Telecentres' funding issues.

9. The Lira Network

Based on an interview with Juma Okee, IT Officer at CPAR Telecentre, Lira

Lira district, located in the northern part of Uganda, is – tragically – mainly known for the long lasting violence of the Lord's Resistance Army (LRA). Since 1987, the LRA has abducted around thirty thousand children in the area, using them as sex slaves or as expendable child soldiers in their infinite war against the Ugandan Government.

It is estimated that no fewer than 12,000 people have been killed in the battles between LRA and the civilian population, and far more have died of sicknesses and malnutrition as a direct result of the conflict^{xiv}.

A sudden increase in violence in 2002 resulted in a massive displacement of the district's population. Since then, no fewer than two million people have been forced to flee from their homes. The refugees, known in UN jargon as internally displaced persons (IDPs) ³⁵ have been living in government protected camps within the Lira district since 2002 to avoid further abductions and killings.

In 2006-2007, most IDPs could return to their homes as a result of the Cessation of Hostilities Agreement (CHA) that was signed by the government of Uganda and the Lord's Resistance Army (LRA) in August 2006^{xv}. This agreement, which was not subsequently renewed and has now expired, led to significant improvements in the security situation in northern Uganda.

The district of Lira experienced a massive return of IDPs when more than 310,000 people of the estimated 350,000 IDPs left the camps and returned to their villages during a period of 14 months^{xvi}.

“Today, Lira has become a little more peaceful, as almost all people

³⁵ Internally displaced persons (IDPs) are people forced to flee their homes but who, unlike refugees, remain within their country's borders.

have gone back to their original homes,” says Mr Juma Okee, IT officer at CPAR Lira. Mr Okee explains that most of them are engaged in agriculture, but most households are experiencing extraordinary poverty, having lost most of what they owned during the time they were in the camps. Houses were destroyed, personal items were stolen, cattle were taken or killed, and fields were left untended for many years. Men who survived could often reclaim their land, but women who had lost their husbands had no land rights and thus face even harsher obstacles to re-establishing their lives. Today, many NGOs and international organizations such as MSF, WHO and the World Food Programme are present in Lira, working together to improve conditions for the population.

Since 1992, the Canadian non-governmental organization CPAR (Canadian Physicians for Aid and Relief) has been present in Lira to support the population with water, sanitation, health care, natural resource management, food security and landmine victim assistance. CPAR also operates a Telecentre³⁶ and recently began running a Community Wireless Network. The Community Wireless Network was implemented in July 2007 by the CWRC implementation team.

The Lira network comprises the CPAR Lira Telecentre as the owner of the network, and three clients located nearby. The network is based on a simple business model: each client pays 100 USD per month for a “best effort” bandwidth equally divided between the three clients and the Telecentre. To ensure liquidity to the ISP, each client needs to pay the fee three months in advance. Although this is a lot of money for most people in Uganda, the model has proven to work well in Lira, and Mr Okee has not experienced any problem with delayed payments.

Since January 2007, the upstream connectivity has been delivered by Iway Africa (AFSAT), via a Ku-band VSAT. For 250 USD/month, the Telecentre enjoys 64/32kbps connection. A quick head count shows that CPAR Lira makes a surplus of 150 USD, assuming the CPAR Lira puts 100 USD into the pool as well.

³⁶ CPAR Lira is funded by IDRC.

The Internet connection is shared equally among the four clients, as the traffic is not shaped by any bandwidth management tool. This setup has worked well so far, as there are only four clients, all of them located closely to the main hub, and each client is equipped with more or less the same number of computers³⁷.

The Lira network has been spared from any major incidents so far – no unaccounted equipment failures or strokes of lightning. However, recently Mr Okee experienced a network failure due to water leakage in the outdoor network cables.

“One day my clients reported lack of connectivity. When I started to troubleshoot the network operations centre, I noticed a blackish substance around the PoE injector feeding the central access point with power and data. It looked like the result of a short circuit spark! In an effort to replace the RJ45 connector I cut the old one off, just to discover that water was dripping through the cable!”

Mr Okee notified the CWRC about the damage through the mailing list. It did not take long until CWRC members were sending advice to Mr Okee on how to fix the damage. Despite the advice, Mr Okee could not get the network back on its feet, so arrangements were eventually made to put Peterson Mwesiga, Project Officer at CWRC, on a bus from Kampala to Lira for a site inspection. The trip was sponsored by CPAR Lira as the Centre did not have funding for this kind of support work in the field.

As expected, it turned out the the outdoor cable that fed the central access point with data and power was not properly watertight. Fortunately, the PoE injector was not damaged and the cable just needed to be replaced with a new one from Kampala. The entire process of diagnosing the problem and completing the repairs knocked the network offline for 52 days.

³⁷ In total, the Internet connection of 64/32kbps serves 15 computers.

Other than the incident with the water leakage, the network in Lira has been running quite smoothly since it was installed in July 2007, with a steady cash surplus every month. Still Mr Okee has visions for a larger network in the future.

“In the future I wish to see a network that serves greater parts of the community at a greater speed than today. I also wish that the community would gain a deeper understanding of the potential of these “cyber resources”. Finally, I wish to be a local market for the hardware and software needed to run and support these networks, something that apparently is missing today.”

When asked about how the reactions from the community been since the network was put in operation, he says

“Very positive, if their reactions were electric shocks, our Telecentre would have caught fire by now! “

10. Experiences from the Project Officer

By Edwin Mugume, Project Officer [2007]

Edwin Mugume joined the CWRC in June 2006, just after the Centre's establishment. After completing his third year of the BSc. Electrical Engineering programme, he conducted his industrial training at the Centre. At the end of his studies, he was retained by the CWRC as Project Officer and led the implementation phase of the project during July-September 2007. After handing over the flag to Peterson Mwesiga in May 2008, Edwin Mugume now works as an RF Planning Engineer for Zain Uganda (Celtel Uganda Ltd).

10.1 Challenges faced

As in any other project, this project faced a wide range of challenges and therefore credit goes to all those involved who ensured that the project met its goals.

First of all, there were many technical challenges faced by the CWRC technical team. The team was introduced to the equipment for the very first time by IT46 during the November 2006 workshop. Most especially for the least experienced CWRC staff and students, this was a great challenge as they had never had hands-on experience with WiFi equipment, let alone using such equipment to set up networks. Overcoming this challenge was necessary for the networks to be set up, since this was the team supposed to carry out this exercise. After all the pain in learning the equipment and its configurations, personally I consider this knowledge and experience to be a great lifetime experience and very priceless.

The project faced logistics-related problems. In most cases, the equipment was not enough for everyone during trainings and workshops which meant that several people had to share one set of equipment, a situation that hinders learning. Lack of enough equipment has also hit the networks directly in that some of the pieces of equipment installed do not have spares. When a spare is needed, either CWRC gets it from its own laboratory equipment, which is meant for classroom instruction, or the entire setup is replaced. Note that specific pieces (especially power adapters and PoE injectors) are prone to damage.

Another area where the project faced a challenge was human resources. While all other posts were stable, it was hard for the project to hold down an employee in the post of Project Officer for a long time. At the time I took over this post in May 2007, the project had already had two people in this post over a period of eight months. The reason was a salary structure that was less competitive as compared to that of the other competitors such as the multi-national mobile telecommunications companies. It was always easy to get a better opportunity somewhere else and people had to move on. When I took

the post, it was very difficult but I stayed on because of my history with the project and my desire to be part of its successes. I enjoyed working with everyone, from my fellow CWRC staff, the students, IT46 to the telecentre staff and their partners. I had confidence of a better future for CWRC, and the continuity of my career. Other than the salary, I enjoyed my job and I am glad that I stayed on up to the very end.

10.2 What could have been done differently?

In my opinion, the CWRC could have optimized its achievements if several things had been done differently. First and foremost, more funding was necessary in all areas, let it be logistics, human resource, training, or any other area. More equipment was necessary for the technical workshops so that people did not have to share the same set of equipment. Furthermore, each telecentre should have been provided with a full set of tools (crimping tools, safety gear, etc.) so that they could have been able take care of more problems on their own.

More resources were also needed to set up local training workshops at the telecentres for their staff and partners. This would have solved some problems the Centre struggles with today. For example, when a partner has issues with faulty cable that which needs to be re crimped, he needs to call an “expert” who is located 20 miles away.

The Nabweru network has still failed to get Internet access since the telecentre has failed to pay for a previous Internet subscription. Had CWRC had funding to get them off the ground, all three networks would be fully operational as initially planned .

CWRC also faced high employee turnover, especially for the post of Project Officer, before I took over. This was principally because of a salary structure that was much less competitive as compared to that of major telecommunication companies in Uganda. When employees keep leaving from such a sensitive post, it takes time for the new employee to get up to speed which disrupts smooth progress. In future, salaries

must be determined on a market-based strategy to optimize results.

Two major training workshops were carried out by IT46. However, this training only involved at most two representatives from each telecentre. This meant that most partners did not get a chance to have training, even in the most basic of concepts. This means that each problem or issue at a partner's side must be handled by telecentre staff, even if it is as simple as crimping a cable or allocating a new IP address. While IT46 could not have trained everyone, a mechanism should have been put in place where those who got trained could pass on the knowledge to the others.

The CWRC funds passed through the university account. I do not know whether this could have been done differently, but during my tenure I observed a lot of bureaucracy and lack of urgency on the side of the university in meeting requisitions. Several times, deadlines could not be met because of lack of liquidity. I am not criticizing the university's involvement because the university has been helpful to CWRC in many other major ways, but the CWRC would not have needed more time to complete the project if getting money for buying equipment and implementing had been faster.

In short, in future, in such a project with a small time in which to deliver, several factors must be given more attention. The issue of training is the most major. People must be given the skills and knowledge to get the work done fast. Secondly, the flow of funds should be quick. Somebody who understands the kind of deadlines to meet should be tasked to handle the funds. Thirdly, a good investment should be made in the best human resources. It is vital to have the best people, and to keep them motivated. Fourth but not last, communities must be made to have ownership of the networks. With this kind of feeling, they will embrace the network and make an effort to make it sustainable.

10.3 My dream

My personal dream of these networks is simple. After all the effort, I would like to see these networks become self-sustaining over a very long time. I believe that this will happen but it is my dream nonetheless. I would like to see communities being more involved with telecentres so that they can use the services offered, including Internet. I would like to see community members using the Internet to find out market prices, agricultural information, health information, national and global news, communicating with loved ones, and all the other good information. It is also my dream to see so many other services such as VoIP provided over these networks. This will help to optimize their potential. I would like to see communities that are empowered to embrace these networks and use them to better their lives and the status of their communities.

In the long run, I believe that I will see most of these things happen; however, it will take considerable effort on the side of CWRC and its partners.

10.4 Why it is so hard to build sustainable networks in Africa

Through my experience with the Community Wireless Networks in Uganda, the long term sustainability of such networks is not guaranteed and a lot of effort is still needed on a day to day basis to make them work. In fact, in my opinion, installing the network is the easy part. Making it sustainable in the long term is the biggest challenge facing such networks in Africa. There are several factors and these might vary with respect to the general income of the population, the cultures, attitude, etc.

Computer literacy in African communities is quite low especially among the older generations who make up the most part of these communities. Most people do not know how to use computers which hinders them from making use of the networks. If the networks cannot directly affect them positively, then there is no reason why they should make an effort to make them sustainable. A lot of training and empowerment of local communities is necessary before such projects

are launched so that they can contribute more to make the livelihoods of such people better.

Another factor is lack of expertise on the side of the local community members to keep maintaining these networks. In an entire network, you find only one person who is responsible for maintaining and solving all people's problems. Considering that this is not a job that pays him well (or is full time), he is always busy doing his own things as well. This means that complaints go unattended to for long periods which makes the complainants get disillusioned, hence they start despising the networks in terms of service delivery. A strategy should be put in place where telecentre officials and partners alike are given comprehensive training so that they can solve most of the problems. This means that they will only seek help on the major issues that need greater expertise.

The power of information has not yet been revealed to everyone. Many people still wonder what they can gain from being connected to the Internet or any other kind of network. People need to be made aware of the potential of such networks and the kind of information they can access, and how to access it. Because of a lack of training in this area, such networks have been left to those who are quite elite, and have better incomes. It must be made clear that these networks are meant for everyone, poor or rich. The community must maintain a sense of ownership of these networks. CWRC has done this and it has worked wonders, with telecentres and their partners proudly calling the network their own. They acknowledge that it would be a failure on their part if the networks failed. The local government should also be involved in the running of these networks, perhaps at a managerial level, so that they can help with mobilizing the community. Local governments can also inject some money in such community initiatives if need be. A massive community effort is vital for such networks to remain self-sustainable over a long time.

10.5 Way forward

There is still work to be done with respect to the project that I am writing about. While the networks are up and running, there are still many other services, other than Internet provision, that can be provided to the beneficiaries. Such services include Content Management Systems, VoIP, etc. CWRC can also help in designing a better business model that can optimize output and continued self-sustainability of these networks. Bandwidth management is another critical area that CWRC will work on, in terms of good bandwidth usage and techniques that can help save bandwidth. A SQUID Proxy is a good example of this.

It should be noted that CWRC has already carried out projects in these two areas of bandwidth management and provision of VoIP over these networks. These projects were carried out by the four industrial trainees that CWRC took on in June 2007, as their final year projects for 2008. Both these projects were carried out with help from CWRC staff, and were both very successful and helpful. A VoIP service was provided across a wireless link from Nabweru Telecentre to one of the partners. The voice quality was very good, and it proved that this service can be provided locally on the networks, and it can also be linked to the PSTN for a cheaper commercial service.

As mentioned, CWRC has already reached many milestones. The only challenge now will be to keep the ball rolling. In my opinion, CWRC will continue to do well because it has made a good network of partners. IT46 is always at hand to help, and it also has links with Meraka Institute (Wireless Africa Project). The wireless networks that CWRC installed on its maiden project will still require her assistance and intervention with respect to technical help and support. CWRC will also look to install such networks in other areas that richly deserve them. As part of the research, CWRC will look at these networks for a longer time, and perhaps put up others with a different technology so as to compare their performance.

I also believe that CWRC will become a big research institution within

the department of Electrical Engineering at Makerere University. It has a very capable director and support team that will take it to the next level. Projects that provide financial help for further studies for its employees usually attract the best people, and CWRC should, and has already started looking to get such projects. As it is based in a university, such opportunities would further enhance its position in the university system and nationally.

For three years in a row, CWRC has attracted some of the best students that finish BSc. Electrical Engineering to work on its projects. CWRC will continue to do that because the opportunities that it can provide such students in terms of career development and study opportunities are increasing each year. With such a team, CWRC will continue to grow unbounded.

The way forward is for CWRC to continue to look for projects in the area of ICTs and telecommunications because it has shown great ability in handling them successfully with the Uganda Community Wireless Project. The more projects CWRC has, the better the team it will manage to put together and the better the results.

As I write this, CWRC has already submitted a proposal to compete with other research teams in Uganda for an opportunity for projects funded by the Uganda Government in its Millennium Science Initiative (MSI) for the year 2008. CWRC has already been selected for the final stage of the competition, and hopefully it will get the funding. This continues to show that CWRC has the credentials and capacity to compete at the highest level. Whether it gets this opportunity or not, CWRC will continue to look for funding of such nature for a continuation of its good work.

11. Lessons learned by the Director

By Dorothy Okello

One key lesson is for *continued support* of the CWRC. In particular, such support should address *capacity building of students and technical staff* in wireless networking as well as provision of *follow-up support and maintenance* of the Community Wireless Networks that have been established. As already mentioned, the CWRC has the opportunity to serve even beyond Uganda as a sub-regional hub – and factors that would allow for this should be taken into consideration. Already, in the CWRC training held in November 2006, a telecentre from Tanzania – FADECO – had a participant join the training. In addition, there is need to develop a strategy on how to address requests by additional partners seeking to join the Community Wireless Networks.

It should be noted that the IDRC-funded project provided some equipment solely for the CWRC. This equipment has been used for training and for the pre-implementation network testing, thereby giving the Electrical Engineering department an opportunity to offer quality education by way of both theory and hands-on training. It is however proposed that, to maintain this type of training opportunity, a laboratory be established with equipment that is used solely for training and testing of various network layouts.

Secondly, there is need to plan adequately for contingencies or the unexpected. For example, there is urgent need to provide efficient grounding of all the wireless installations – particularly in Kabale – as most of the grounding/earthing work was found to be inadequate. This poor grounding has the potential to greatly reduce the lifetime of the various equipment that has been installed.

Still on the technical front, in order to ensure minimum down time, it is also recommended that each site have at least one other hub established. Currently all the networks have been established with only one hub, which makes them vulnerable to the status of this single hub. Where feasible, it would also be good to consider the cost-benefit

trade-offs involved in constructing a mast in every region with a Community Wireless Network. For situations such as Kabale, a well-constructed mast could have simplified the network setup required. However, a full cost-benefit analysis would be necessary to weigh the technical ease of network implementation versus the cost and administrative requirements for constructing a mast.

Thirdly, there is a need to address the administrative handling of the project. This can be done by recruiting a full-time project officer, or alternatively pursuing the preferred approach of facilitating more students or recent graduates to come on board as CWRC staff. It should be noted that the CWRC project has experienced a very high turnover with this position – since inception in 2006, this position has been held by five people to date.

Fourthly, there is need for the CWRC to widen its scope to address a number of emerging issues from the installations to date. For example, what is the likely impact on the quality of service as the number of new partners grows, what is the impact on the ‘co-operative’ model of meeting the costs of the bandwidth, and what are appropriate models for billing for services utilized that should be considered. In addressing some of the issues, the CWRC will need to be supported to engage in inter-disciplinary research undertakings. These questions are already being raised by the telecentres – and we need to have the answers.

In addition, the CWRC should pay attention to value-added services that would enrich and optimize the functionality and performance of the Community Wireless Networks. For example, services such as VoIP, local data storage and retrieval, etc., are some of the opportunities that should be investigated. Lessons learned from the wireless VoIP project tested at the Nabweru Telecentre should be used to roll out this application to the networks.

Lastly, it is important too that the CWRC is supported to participate in regional and international fora on issues pertinent to Community

Wireless Networking. In a bid to strengthen both the research and administrative capacity, the CWRC could also be supported to host visiting researchers and/or exchange students. At a local level, the CWRC needs to continue engaging in capacity-building initiatives including training workshops for technical staff at the telecentres, CWRC staff and students within the Department of Electrical Engineering. There is also a role to play in advocacy for issues related to Community Wireless Networks, such as regulations affecting community-owned networks and/or 'first mile' connectivity.

In a nutshell, the major lesson learnt is that *wireless networks can facilitate the rapid deployment of last mile internet connectivity in rural and/or under served areas* although there should be a clear model of *sharing the resource especially with regard to demand-based utilisation and the payments of such utilisation.*

PART 3

I shall make electricity so cheap that only the rich can afford to burn candles

Thomas Alva Edison

First light bulb, October 22, 1879

12. Zittnet, Nigeria's first rural wireless ISP

Zittnet is a not-for-profit wireless Internet Service Provider that emerged from a local initiative in a rural community.

Before you get to know Zittnet further, we would like to introduce you to this local community in the town of Kafanchan.

12.1 Welcome to Kafanchan

Kafanchan, located 200 km north-east of Abuja in central Nigeria, is a community of approximately 83,000 people. Kafanchan used to be known as a busy and thriving town as the site of one of the main junctions of the national railway. When the railway industry was booming, almost 80% of Kafanchan's population relied on it in one way or another. Since the complete breakdown of the Nigerian railway system, the population has been forced to go back to its original source of income, agriculture.

Kafanchan is a poorly connected area in terms of fixed telephony and Internet connectivity. Today, fixed telephony (PSTN) is no longer available³⁸ in the area and GSM just arrived in 2005. However, the GSM coverage is just as poor as the quality of the service. At the moment, SMS services are the most reliable communication service. Voice conversations tend to cut off in the middle and suffer heavy

³⁸ As long as the railway was functioning in Kafanchan, the PSTN network was operating, but since the breakdown of the railway, the PSTN network was no longer maintained and was finally shut down.

noise. GSM subscribers in Kafanchan move around with two phones for the two mobile networks as a way of maintaining constant connection. One terminal uses the MTN network and the other connects to Zain, an operator that has changed names three times (Econet, Vmobile, Celtel). The quality of the GSM network is so terrible that the Nigerian Communications Commission (NCC) has been trying to impose multimillion dollar sanctions on MTN and Zain for their poor service.

Further challenging the people of Kafanchan is the access to electricity. Nigerians commonly refer to the electrical company, NEPA (National Electric Power Authority)³⁹ as *Never Expect Power Always*. Kafanchan receives an average of 3 hours per day of power from NEPA. It is joked that the first word a child learn is “NEPA!”, as everyone announces when power is lost or eventually has been restored.

Most of the day, the population needs to rely on expensive diesel generators or kerosene for illumination and cooking. When NEPA is available in the grid, it provides an unregulated voltage in the range of 100-120 V in a system designed for 240 V.

As the voltage must be regulated to 240 V before any “advanced” load can be connected, only incandescent light bulbs can be fed straight from the grid.

12.2 Welcome to Fantsuam Foundation

Given this challenging background, how could anyone come up with the idea of establishing a rural wireless ISP in this area? Fantsuam Foundation got the idea and they made it happen!

Fantsuam Foundation is a local non-governmental organization that has been working together with the community of Kafanchan since 1996 to fight poverty and disadvantage through integrated development programs. Fantsuam's focus lies on micro finance, ICT services and social development in rural communities in Nigeria. To become the first rural wireless ISP in Nigeria was just another step towards their mission, to be a recognized leader in the provision of

³⁹ NEPA was recently renamed the *Power Holding Company of Nigeria (PHCN)*, which resulted in the new nickname "*Problem Has Changed Name*".

rural development initiatives and the foremost and thriving rural knowledge economy driver in Nigeria.

The Foundation is named after its host community, the Fantsuam people, which is an ethnic and linguistic group comprised of a few thousand members.

The wireless ISP of Fantsuam Foundation is called as *Zittnet*, meaning “our network” in the Fantsuam language.

12.3 Objectives of the project

The main objective of Zittnet was to improve access to communications in the area of Kafanchan by implementing a Community Wireless Network to share the existing Internet infrastructure of Fantsuam Foundation. At the inception of the project, there was only one satellite Internet connection in Kafanchan, which belonged to Fantsuam Foundation and had a monthly bandwidth subscription cost of 1,250 USD.

But is there really a demand for Internet services in a place like Kafanchan, one might ask? Well, despite its size, Kafanchan hosts no fewer than five tertiary educational institutions and a campus of Kaduna State University. Additionally, there are several small and medium sized businesses in the area, as well as a Government hospital and a secondary-level referral hospital. Kafanchan is a well-known trading center, which means that communication is important to enable people to be at the right place at the right time. On top of that, the now compulsory online registration for secondary school WAEC and NECO exams has also increased the demand of Internet access among the population.

12.4 Results and outcomes

The result of the last three years of hard work can not easily be summarized. Many important lessons have been taught and much knowledge has been gained. Let us start with the pure practical outcomes that are physically tangible.

In pure practical terms, the Zittnet project has resulted in a

Community Wireless Network providing coverage to substantial parts of Kafanchan, currently with 6 permanent clients.

The network is managed from the Network Operations Centre (NOC) that was built by local youths attending Fantsuam's program in brick laying, using local low-cost, hand-made building material.

A robust power backup system has been designed to fit the unique needs and conditions of Fantsuam Foundation in terms of electricity and reliability demands and access to energy resources. The network provides electricity to the Fantsuam Foundation and Zittnet 24/7, based on solar energy, occasional access to the power grid, and a stand-by diesel generator as a last option.

In addition to all the technology and infrastructure in place, large efforts have been put into building local capacity to run and maintain the systems. More than 25 local youths, originally from Kafanchan and its surroundings, have attended three training workshops in wireless technologies, solar energy, bandwidth management and VoIP.

12.4.1 Behavioral changes

The large investments in hardware, infrastructure and training have also lead to many “soft” result and outcomes. These results are often left unreported, as we traditionally are used to measuring success with “hard evidence”, such as *number of wireless links established*, *number of dollars surplus*, or *number of people trained*. We often tend to neglect the more “human associated” results, such as

- *In what way did those wireless links change the daily life of the local people?*
- *What did that training result in for the trainees?*
- *Could the trainees advance within their current organization after the training or could they apply for a more qualified job?*
- *What was the surplus of the project in terms of human capacity?*

These types of changes, commonly known as *Behavioural Changes*, are given more and more space in development projects, as most development work is not purely business oriented but instead driven by the community needs and wants.

Looking back at the human changes that Zittnet caused within the the Fantsuam Foundation and with its host community, John Dada, director of Fantsuam Foundation, summarizes:

“The power backup system has brought about significant improvements in the provision of services to Fantsuam Foundation as an organization as well as extending the period of gainful activities for the host community. The access to electricity has resulted in improved revenue earnings for the Fantsuam Academy since the school is now able to run in full scale. Another major advantage for us has been the access to a reliable Internet connection, which has helped us to improve contacts with our project partners and Fantsuam’s global network.

In term of changes in the community, I would like to mention the Fantsuam Internet Café which provides the most reliable Internet Café in town where young people for example can access online career applications, register and pay for courses or just browse for information.

Another benefit to the community, not anticipated or planned, is the new “night life” of Bayan Loco⁴⁰. As a part of the Power Backup System, two street lights, the very first ones ever in Kafanchan, were installed at our premises to improve the security at night. However, the street lights illuminate not only our own premises but they are also giving light to the surrounding streets, which normally lie in pitch dark from dusk to dawn. The street lights have provided an enhanced night-life for the community given that some students use the location to do school work in the evening, while the local hairdressers are able to attend to more clients while sitting under the street light after normal business hours.”

⁴⁰ Bayan Loco (“behind the train”) is the suburb of Kafanchan where Fantsuam's premises are located.

12.5 Wireless, infrastructure and design

12.5.1 *Mesh or star?*

Kafanchan is a typical African rural town, densely populated by one-story buildings with flat tin roofs. Quite a few communications masts are present, the new ones belong to GSM operators that arrived recently, and the old decaying ones, no longer in use, belonging to various state institutions. Apart from the towers of a number of wealthy new-generation Pentecostal churches, there is no tall infrastructure in town. Instead there are plenty of heavy obstacles blocking radio signals, in the shape of mango trees.

One might think that with these conditions, the ideal wireless topology would be to build a mesh network. The mesh would allow every node to communicate with any other node, and not be dependent on a costly central point in the form of a tower. That solution would work if it were not for the low *density of clients* in Kafanchan and *their geographical distribution*.

It is a fact that Internet access is still a luxury in this part of the world. In Kafanchan, there might be a handful of individuals who can afford Internet access in their homes for personal use. If we include small and medium-sized organizations, we can probably gather around 20-30 potential clients.

The typical geographical distribution of housing in traditional towns also creates a disadvantage for a mesh. There are normally no “residential” areas or “business centres” in a small town. Most petty businesses are gathered nicely along the main road leading through the town, but unfortunately, they are not potential clients for a wireless network. Larger businesses are few and spread around the town.

Private houses are mixed, rich and poor together, as people tend to stay in the same place that they grew up or where their family has land. If you get wealthy despite all odds you either move to a larger city or you upgrade your current house.

In the actual “centre” of a town, where the density of houses is highest, you will mainly find homes belonging to people with low incomes, which makes the city centre again a non prioritized area for wireless coverage.

In the case of Kafanchan, potential clients are spread out in all directions, 360 degrees around Fantsuam's premises and at a distance between 0-20 km.

Although a mesh network is a technologically attractive way to build wireless networks, both in terms of low complexity (the access points can have a default pre-configuration) and low cost (no towers should ideally be needed), many environments, like Kafanchan, require a more centralized wireless network that uses one or more communication masts or other high points to interconnect the different network segments.

12.5.2 Network architecture and hardware

The wireless backbone was initially designed to use SmartBridges multi-band access point and client units from the Nexus PRO Total series. The units are designed for service providers and enterprises to establish high performance Point-to-Multipoint outdoor wireless links. The units come with an integrated multi-band sectoral antenna that can operate both in 2.4GHz and 5.x GHz frequencies. The Nexus PRO Total series offers QoS in terms of traffic prioritization and bandwidth management per client using the IEEE 802.11e compliant WMM (WiFi Multimedia) extensions.

Currently, the network topology is a typical star topology with two access points in the central mast. One access point hosts a 90 degree sectoral antenna and the other access point provides an omnidirectional coverage to the surrounding clients.

Plans are underway to expand the wireless backbone by setting up two wireless repeaters. One repeater would be located in Kafanchan city using an existing Nitel⁴¹ tower to enhance the wireless coverage in the city centre. The second repeater would be established in the Kagoro Hills, a small mountain group with a relative altitude to Kafanchan of about 500m, located 7 km away. This repeater would provide coverage to many surrounding towns and even enable a multi-hop long-distance link to Abuja.

⁴¹ Nigeria Telecommunications Ltd

12.6 The NOC, dust-free and cool

When we started to draw up the plans for Zittnet, Fantsuam was using a henhouse as server room. The room was tiny, far from waterproof and hot as a Finnish sauna. It was clearly not suitable to host either the NOC or the power backup system.

In collaboration with Linus Nok⁴², a local architect from Jos, a new Network Operating Center was designed and constructed in 2007⁴³. The building was designed with the purpose of creating a dust-safe space, made of locally available materials, with good cooling capabilities for batteries and inverters using natural methods. Another requirement was to host the solar panels on the rooftop, in order to save valuable space on the compound premises.

In August 2007, the week of the inauguration of Zittnet, the NOC stood ready. This time, it was the goats that had to move out from their comfortable tin shed⁴⁴, to give space to the new NOC.

The building accommodates four rooms: a battery storage room, a server room, a working space and an equipment storage area.

The battery storage room hosts 70 (200 Ah) deep cycle batteries together with 5 charge inverters (one of them pure sine wave), two solar regulators, power stabilizers and DC and AC disconnects. The batteries are stacked vertically on a metal-based shelf structure for better cooling. To improve cooling, an extractor was installed to push out warm air.

The server space accommodates a rack unit for low power Inveneo servers. To avoid dust and over heating, the room has no regular big windows. Instead, the room is being cool through the use of small rectangular windows located by the floor and by the ceiling. The small windows provide a natural circulation of air from bottom to top which cools down the room. With this zero-power cooling technology in place, no power thirsty AC is needed.

⁴² Life is full of surprises The Network Operation Center (NOC) was going to host Linux servers and the name of the local architect was Linus Nok!

⁴³ Concepts of permaculture were integrated into the NOC design. As a matter of fact, Alberto wrote his Masters Thesis in alternative energies and permaculture back in 1998.

⁴⁴ Do not worry, a new tin shed was built for the goats, they were not kicked out on the street!

To further improve the cooling of the NOC, the server room and the battery storage room has been equipped with thick walls of bricks (double width). By having thicker walls in the server room and the battery storage room, we avoid direct sun heat and improve the natural cooling effects. The server room and the battery space require effective low cost/low energy cooling as they need to operate 24/7.

The work space is equipped with four Inveneo low-power computers, managed by the Zittnet team.



Image 7: The small windows provides a natural cooling effect to the server room.

The south side of the building hosts 24 solar panels in a shadow-free area at the top its metal roof. The roof was designed with an inclination of 20 degrees to support the panels and limit the corrosion and dust.

Extra efforts were made to keep the panels easily reachable for cleaning and maintenance. The roof has also been strengthened in order to carry the extra load of 150-200 kg that the panels weigh.



Image 8: The inclination of the roof (20°) optimizes the performance of the solar panels. The roof has been enforced to handle the heavy load of the solar panels.



Image 9: The machine used to manufacture laterite bricks.

The NOC building is constructed of locally produced *laterite* compressed mud bricks. The material is cheap as it is locally available and comes from the top layer of the soil. The bricks have been fabricated locally using a manual press machine. This low cost, high-local-tech building is unique in Kaduna State.

12.7 A hybrid power backup system, providing electricity 24/7

The unreliable power grid of Nigeria delivers around 3h of unserviceable power to Kafanchan. The rest of the time, it delivers nothing. The power voltage normally moves around 100-120 V and can only feed incandescent light bulbs and some TVs, not advanced technical devices.

With these limitations, it is difficult to provide any reliable service, no matter what sector you work in. After a few visits to Kafanchan, we had no doubt that a power backup system was needed in order to provide any reliable around-the-clock service.

In 2007, a hybrid power backup system consisting of a deep-cycle battery bank and solar panels was designed and installed at Fantsuam⁴⁵. The hybrid system can be charged from three different sources: from NEPA when electricity is available, from solar panels during the day, and from the generator when no other source of power is available. It uses a bank of 24 V, 70 deep cycle batteries to store the electricity.

To ensure maximal reliability to the critical infrastructure of Zittnet, the Network Operations Centre (NOC) has been separated from the rest of the loads at the compound, including Fantsuam's own computers. In that way, the system can guarantee a certain amount of electricity to the NOC, and the NOC can guarantee service to all its clients, even though other battery banks are running low on power.

Additionally, a separation in terms of power sources has been made to further ensure reliability to the NOC. The NOC runs solely from solar energy, while the remaining loads are fed from NEPA and the generator. This has proven to work well, as the power consumption of the NOC is fairly constant and the lowest amount of solar energy per day is predictable as well. The solar arrays are dimensioned according to the worst-case sunlight scenario for Kaduna, which is 4 sun peak hours during the worst months, the June-August rainy season.

⁴⁵ The system was designed by Yves Gattepaille and David Dung from *Solar and Renewable Energy Systems Nigeria Ltd*, based on system and dimensioning requirements from IT46.

Each of the solar panels (Suntech 80 Wp) that are used provides a maximum current of 5A (when the solar radiation is at its highest during the day). In the worst months of the year, the 24 V installation, is expected to produce no less than 6 Kwh/day.

The 6 KWh/day that feeds the NOC is used to power the following equipment:

Unit	Hours/day	Units	Power [W]	Wh
Access points	24	2	15	720
Low power servers	24	2	10	480
LCD screens	2	1	20	40
Laptops	8	2	75	1200
Low power light bulbs	8	4	15	480
Satellite VSAT modem	24	1	60	1440
Low power PC	8	1	22	176
24port switch	24	2	20	960
TOTAL				5496

During good conditions (not the rainy period), the power obtained from the grid (NEPA) is enough to power the 25 low power workstations at Fantsuam, the indoor and outdoor low power lights, fans and ACs, the kitchen and the two street lights. When the heavy rains comes in April, the performance of the national grid drops drastically, and support from the diesel generator is needed.

12.7.1 Financial benefits

The total estimated power consumption of the NOC is 5.5 KWh/day which is less than the daily power generated from the solar panels in the worst month.

Since the installation of the power backup system in February 2008, the Zittnet team has kept statistics on the use of the generator in order to be able to measure the *financial benefits* of the system.

Based on the data collected during March – June 2008, Fantsuam has reduced the fuel costs from 106,000 Naira/month (USD 830) to 42,000 Naira/month (USD 330), which is a reduction of no less than 60%.

Since the installation, they have (on average) used the generator *1/2h per day* to complement the national grid. In comparison, the generator used to run 5-6 hours every day before the system was installed.

1. GENERATOR USAGE

Date			Time Start	Time Stop
DD	MM	YY	HH:MM	HH:MM
14	03	08	10:15AM	10:30am
17	03	08	12:45PM	12:55PM
17	03	08	1:22PM	2:55PM
24	04	08	4:02PM	4:17PM
25	04	08	1:54PM	2:51PM
02	05	08	10:35am	3:00pm
05	05	08	9:35am	12:43pm
07	05	08	8:25am	9:55am
09	05	08	2:PM	4 PM
13	05	08	3:PM	4:30pm
14	05	08	8:30am	9:20am
15	05	08	11:05Am	12:55am
16	05	08	10:00	1pm
17	05	08	9:01am	11:58am
19	05	08	10:24am	10:24am
20	05	08	4:00PM	5:00PM
21	05	08	9:8am	12:21PM
28	05	08	11:20am	2:00pm
30	05	08	10:00	1:40pm
03	06	08	11:55am	3:31pm
04	06	08	11:30	2:30pm
5	06	08	2:23	3:41pm
08	06	08	8:20	9:30am
09	06	08	12:40	1:27pm
11	06	08	8:45	9:29AM
11	06	08	1:20pm	16:15pm
13	06	08	09:16PM	3:50pm
17	06	08	1:15PM	4:01pm
19	06	08	11:12am	2:00PM
18	06	08	15:45pm	

Image 10: Logs of generator usage March-June 2008.

From the log you can clearly see that the rain was late in 2008 and did not arrive until May. As soon as the heavy rains start (May-June), the national grid collapses.

12.7.2 Human benefits

It is not fair to measure the impact of the the power backup system in purely quantitative aspects. Financial savings do not take into account

the more human-oriented benefits.

Some of the benefits that Zittnet experiences as an organization by having access to reliable and clean electricity are:

- *Knowing that there is electricity available during office hours allows you to plan your work, and stick to the plan*
- *Power cuts used to stop parts of the organization's work, and negatively affect the working morale*
- *Zittnet's clients can access the Internet service around the clock, and plan their work as long as they can ensure power on their side*
- *Clean, regulated power does not destroy sensitive electronics, which used to be a costly problem*
- *Reduced use of the diesel generator reduces the NOC's daily carbon footprint by more than 90%.*

12.7.3 Changing your mindset

In order to stay within the limits of what the power backup system can provide, Fantsuam Foundation has made major changes in their own organization. The first measure was to get rid of all old computers donated from various sources. These computers were sold to community members for a symbolic price. The old computers were replaced with 20 low-power PCs with screens from Inveneo, consuming a fraction of what the old ones used to.

Another measure taken by Fantsuam was the introduction of the “power guardians”. Staff from the Zittnet team responsible for the maintenance of the power backup system took on the responsibility of educating the rest of the team how to reduce the use of power in their daily work. Behavioural changes, such as always switching off screens and computers when not in use, or shutting off the fan when



Image 11: Changing the mindset of an organization takes time and efforts.

leaving the room, or just closing the doors when the AC is running, were explained and monitored by the power guardians. Reminder notes were put up by the entrances to each building, to catch people's attention.

12.8 The business model

Fantsuam Foundation was novice regarding business models a couple of years ago, but today they have quite some experience in the area. They know the importance of finding a business model that fits both *their clients* and *themselves*, and which still can be offered by an ISP!

Their current ISP, Kansas Broadband Internet, is the third ISP they have engaged with. They have tried both dedicated bandwidth (C band), pre-paid vouchers (Ku-band) and ultimately a shared bandwidth (C-band) system. Although no alternative has been optimal, they are pleased with their current setup.

Kansas Broadband Internet, provides shared bandwidth (10:1) with a capacity of 1024/256 Kbps for 870 USD/month.

The bandwidth is shared between Fantsuam (offices, computer labs, NOC, etc.) and external clients.

Each department within Fantsuam is charged according to its usage (based on the number of computers connected). For the external clients, a fixed monthly fee is being charged based on the same principle.

Each client pays a monthly fee between 10,000-30,000 Naira based on their agreement with Fantsuam. The total income from the five clients is 100,000 Naira (680 USD) per month, which covers almost 80% of the total Internet bandwidth costs. The fees from the various projects within Fantsuam account for 90,000 Naira (620 USD)/month, which together with the income from the clients results in a surplus of 430 USD/month. This margin covers the Zittnet staff and spare parts.

The wireless equipment installed at each client's premises is owned and maintained by Zittnet. Each client pays a small monthly fee for the rental of the equipment.

12.9 The Zittnet clients

Currently⁴⁶ Zittnet has five fixed clients with wireless installations on their premises. Each client pays a monthly fee to Zittnet for the bandwidth and the equipment they rent.

The clients are the Isaiah Balat Cyber Café (Isaiah Balat), the Jagindi Street Clinic, the General Hospital, the New World Motel), and Zenith Bank.

Each client is free to use the Internet access in the way they prefer, according to individual agreements with Fantsuam Foundation that encourage new types of “client models”. For example, the *Isaiah Balat Cyber Café* is reselling bandwidth to their clients. In this way, individuals who do not have access to a private computer, or can not afford a fixed connection to Zittnet, can still access Zittnet through the PCs at Isaiah Balat's.

The *New World Motel* is another client that aims to create a similar business model but on a larger scale. They will provide wireless Internet access to all of their rooms and offer access to Zittnet's uplink by reselling vouchers.

The other clients are using the Internet access for professional and private use without reselling the access to downstream clients.

During our last visit to Kafanchan in February 2008, we visited the Cyber Café and the health clinic to hear about their experiences with Zittnet.

⁴⁶ December 2008

12.9.1 *Isaiah Balat Cyber Café*

Isaiah Balat, a cybercafé run by two local young men, is located on the outskirts of Kafanchan. It is one of the two cybercafés in town, running about 10 computers that are frequently occupied by people of all ages. The killer-applications among their clients are web-based university registration processes, and downloading of ring tones and mp3 files.

They are happy to conclude that Zittnet is “faster” than the competing cybercafé in town, as “speed” is an important factor for their clients.

“The customers choose the cybercafé with the greatest speed as they prefer to pay a bit extra but to get things done, than to pay less and don't get anything done.”

Isaiah Balat struggles with the lack of electricity, as do so many others in Kafanchan . Since they do not have an independent power backup system, there is no business when the grid power is gone. As you remember, power cuts are both frequent and long in Kafanchan, which results in few and unpredictable business hours.

Before Zittnet was established, Isaiah Balat used to have its own VSAT connection but they had problems to affording the monthly fee to the provider – a constant stress and struggle for the owners. Since Zittnet started in August 2007, they have been using both the pay-as-you-go system and now the flat-fee model.



Image 12: The owners Sunday Oubu Otokpa, and Barnabas Nduwak Suku outside the Cyber Café.

They agree that it has been a relief not to have to meet high monthly fees for connectivity. Now only the rented equipment needs to be paid on a monthly basis. When the pay-as-you-go system was in place, the owners used to buy a batch of vouchers and resells them to their clients, adding a small mark-up. They took little risk, but they had small margins, the owners complains.

They are now pleased that Zittnet has changed its business model to a flat fee per month for a guaranteed bandwidth. Although this implies a larger risk for the owners, they still prefer this model, as the voucher system did not really fit them nor their clients.

12.9.2 Jagindi Street Clinic

Another client of Zittnet is medical doctor Chris Azukaeme, who introduces himself as a man in his fifties, with roots from the south western part of Nigeria, belonging to the Igbo people. Dr Chris has been running his own health clinic for more than a decade in Kafanchan. The health clinic has a special focus on nutrition and supplements. Not long ago, computers and the Internet were unknown areas to Dr Chris, who, like most people in his generation, did not get the opportunity to work with computers during his studies. Despite his limited practical experience with computers, Dr Chris understood their powers and what access to the Internet could do for him. He tells us how he started using the Internet a few years ago at local Internet cafés. In fact, they were not quite local; he needed to go to Jos, at least an hour drive away, until the first Internet café opened up in Kafanchan in 2003.



Image 13: The use of Internet has changed MD. Chris Azukaeme's life and the way he performs his work.

He remembers how he had to ask the young boys working in the Internet café for help, since he did not quite know how to log in and read his Hotmail. Dr Chris found this experience both frustrating and humiliating, and he felt powerless. He would never ask any stranger to open his personal post, so why would he do that with his email! He decided to take the matter into his own hands, and contacted Fantsuam Foundation for help. During the next few months, he took private lectures at Fantsuam to learn how to use a computer, how to browse the Internet and how to communicate with email. He has never regretted the decision he took, and he is now even considering joining the Cisco course that Fantsuam is offering!

Now Dr Chris is one of the most frequent clients that Zittnet has. He is using the Internet to search for medical information and new drugs that can be useful for his clinic. He is also active in an international network of medical doctors where ideas are exchanged and new trends are discussed.

To have Internet in your own house makes you so efficient, Dr Chris says. "I can wake up at 3 in the morning with an idea, and in a few minutes I am online and can look for the information I need".

When we ask him a common provocative question that we received, "Why should we bring Internet to the rural areas, when the people do not even have clean water and access to education?", his eyes shine. "But of course, we need Internet here in Kafanchan! Naturally, the basic needs must be covered, but then we need to catch up with the rest of the world. Access to Internet is access to information, and that is the key to prosperity and development."

12.10 Always bad things happen.

During the last 12 months, Zittnet has been affected by two major catastrophes caused by natural forces.

In July 2008, ZittNet experienced extensive damage on electrical equipment caused by a heavy thunderstorm. It is believed that the communication tower suffered a strong indirect hit, which the current lightening protection could not handle. The lightening resulted in an immediate loss of power in the entire wireless facility. The inverters controlling the solar power and electrical systems of the Foundation were blown out by the lightning, along with a server and the Internet satellite modem. Laptops, desktops and indoor wireless devices connected to the power system were also affected. The wireless backbone radios serving the clients were also damaged.

The monetary costs of repairing the damage from the lightening strike so far are as follows.

Hardware	Cost [Naira]	Cost [USD]
Inverters and solar systems	599,000	5,056
Inveneo hub server	164,640	1,390
Internet modem and reconnection	714,000	6,026
Backbone radios	424,300	3,581
Lightening Arrestor	547,000	4,617
Compaq computer	55,000	464
Local travels	29,000	245
Electrician	45,000	380
Internet consultant	74,000	625
TOTAL	2,651,940	22,383

To prevent similar accidents in the future, the lightening protection of the tower, the NOC building and the VSAT antenna has since then been reinforced. It took about three weeks to restore the entire facility to its full operational levels.

The insurance company has assessed the damages and has agreed to pay 50 % of the costs from the damages, although they are obliged to pay 100% of the costs according to the contract. What Fantsuam Foundation did not know, is that they were expected to have inflated the request by 100%, in order to receive the fair amount!

The second disaster hit Fantsuam Foundation in April 2009 when the central communication tower was taken down by a heavy rain storm. The wind bent the tower from the top which eventually collapsed. In the course of its fall one of the legs was uprooted from the ground with the foundation. Several buildings including the old network operation center, a Cisco Laboratory and a neighbouring building was seriously damaged. No human casualty or injury was involved. Fantsuam was left with a wireless ISP without a central tower.

The company that constructed the collapsed mast has refused to visit Fantsuam for an inspection of the mast sections. Fantsuam has therefore done an internal investigation of the mast sections to try to find out the cause of its collapse and to learn from previous mistakes. The investigation showed that the damaged mast had two fundamental problems: (1) The galvanised pipes used were of low quality material, and (2) the foundation of the mast was too shallow to withstand the wind speeds experienced.

Immediately after the event, the work to re-establish Zittnet started. The insurance company was contacted for reimbursement, quotes were obtained for a new mast, and the damaged caused to surrounding buildings were fixed by own strength.

The insurance company has been informed both verbally and in writing, and they have also come for a preliminary visit to inspect and document the damages. However, judging from their response to the previous disaster (the lightning strike), Fantsuam is not likely to get much assistance until 2010. Only now (April 2009) the insurance company have sent Fantsuam the 50% compensation towards the cost of the lightning damage they suffered in July 2008.

Fantsuam Foundation is not an organization that sits down and wait for help. In that case, they would never be what they are today. Instead of waiting for the insurance company's reimbursement, they took the matter in their own hands.

No less than six weeks after the accident, Fantsuam Foundation announced that a new mast had been erected, and Zittnet was back up again. The new mast costed around US\$ 11,000. Meanwhile Fantsuam Foundation is waiting for the insurance company to reimbursement then, the tower is financed by a micro-finance loan.

“This unexpected expense is taking a big toll on ZittNet's finances. We had just completed our budget forecast and started a new financial year with expectations that ZittNet will repay all its loans and break even this fiscal year. This disaster has set ZittNet back by at least another year.” says Director John Dada.

Yes, Bad Things Happen Always.

12.11 Project specific challenges

In collaboration with John Dada, Director of Fantsuam Foundation

John Dada looks back at this first year of operation with pride, but he admits that it has given him a few more grey hairs! The challenges have been many, but that is the reality for Fantsuam Foundation in whatever mission they take on. In rural Nigeria, where infrastructure such as water, electricity or roads are not functioning, where poverty is widespread and corruption likewise, nothing is expected to go smoothly. In that sense, Fantsuam Foundation is very well equipped for taking on the challenging mission to build a rural ISP.

There are a few challenges that caused more hassle than others. Among them, John emphasizes 1) access to hardware, 2) difficulties expanding the wireless backbone, 3) maintaining a trained work force and 4) finding a reliable and support-friendly upstream provider.

Procurement and purchases

Sourcing of wireless equipment has not been such a hassle, since Nigeria is a large trading nation, due to its location by the Atlantic coast in the Gulf of Guinea. Several well-known wireless brands can be found in Lagos for a reasonable price.

What was more difficult to source was equipment for the power backup system. The solar panels and the inverters were not locally available and had to be imported from the US. In addition to shipping costs, the Nigerian customs clearance at the entry ports caused delays and introduced demurrage costs and time delays into the project.

Expansion of the backbone

Although there is a ready market and a high demand for the wireless services offered by Zittnet, it has been difficult to expand the client base. Due to the outskirts location of Fantsuam's headquarters and central tower (where the Zittnet's NOC is located), and the lack of robust infrastructure taller than two meters, only a fraction of the potential client base can be covered today. To cover greater areas, the backbone needs to be expanded, which is expensive because communication masts are needed.

As an alternative to procuring costly masts, Fantsuam has tried to arrange agreements with local partners for co-hosting. Kafanchan hosts many old communication towers from its booming days in the eighties that are no longer in use but remain in pretty good shape. Just after the inauguration of Zittnet, Fantsuam made a formal request to host their radio equipment in a tower belonging to Nigerian Telecommunications Limited, for which they still are awaiting a decision.

Attempts to host backbone infrastructure on potential partners' premises has only been investigated. One of the tallest buildings in Kafanchan is the School of Nursing, which is hosted in a three storey building in the central part of Kafanchan. The rooftop is flat, does not host any other equipment and is in very good condition. The School of Nursing, 2 Km in direct line of sight from Fantsuam's central tower, is a perfect location for a central repeater that could provide coverage to a large part of the population in Kafanchan.

Fantsuam Foundation's workforce

Fantsuam Foundation operates an organizational model that relies heavily on national and international volunteers. The national volunteers are typically youths who have completed training at Fantsuam. The subsidized training provided for the volunteers comes with the expectation that they will serve the organization for a period of time after their training. However, the high quality training they are given often makes them eligible for urban-based, better paid jobs. Therefore the reliance of ZittNet on volunteers means that the work force tends to be transient. For example, less than 20% of the original workforce that started this wireless project two years ago, is still working in Fantsuam. The lack of stability and continuity in Zittnet's staff composition adversely affects the daily operations of the project and its future plans.

To address the problem of loss of staff and to allow Fantsuam to grow as a vibrant training hub, we need to ensure that the knowledge gained during the various trainings remains local and is disseminated. This has led Fantsuam to initiate its business incubation program in partnership with Ecoshelter – UK. As a business incubation center, Fantsuam will have a continuous stream of trainers and trainees, provide support services, seed funding, and mentoring, and thereby build and sustain its “train the trainers” model.

In addition, Fantsuam’s volunteering service (aka GAIYA), is now identifying retired professionals who have relevant expertise. Nigeria’s high attrition rate of trained civil servants makes this a viable option because this cadre of volunteers have returned back to their village to stay, and are often people strongly connected to their communities.

This characteristic of retired professionals is making it possible to evolve the ZittNet model into a “social business.” A social business is defined in 'Creating a World Without Poverty', by Muhammad Yunus, as:

- A non-loss, non-dividend business
- A business in every sense except its whole aim is to provide a social benefit, and it repays investors but makes zero profit for them
- Not a charity – it recovers all costs while meeting its social objectives
- The business itself may earn a profit, but not its investors - all profits are reinvested in the business
- Profitability is important – to repay investors, and to support long-term social goals

Bandwidth costs and upstream providers

During the last three years, Fantsuam Foundation has spent lots of time and effort to find an affordable and reliable upstream provider. Since 2006, they have tried three different providers, with three completely different business models. They have finally found one that they are comfortable with.

Each provider has implied different challenges, but one common nominator has been the lack of a suitable business model for a small or medium-sized organization located in a developing nation.

An organization like Fantsuam Foundation does not have easy access to credit cards, they can not make costly international phone calls to get support, and they can not pay thousands of dollars upfront in hardware investments and advance payments for bandwidth. In addition, Nigeria's unfortunately well-deserved reputation as a haven for Internet and banking scams makes many overseas companies hesitant to forge contracts unless they see cash up front. For these reasons, they are not an interesting client for any provider.

12.12 What could be have done differently?

One of the strategic activities we should have undertaken at the start of this project, says John Dada, was the establishment of a close link with the Nigerian regulator.

“However, this is a chicken and egg situation. The regulator would not be interested in a project that was yet to take off. They would rather have seen a proof of concept,” says John. However, the contact that had been missing between Fantsuam and the Nigerian Communications Commission (NCC) was eventually established in 2008. After a series of visits and inspections of Zittnet, NCC has contracted Fantsuam Foundation to replicate Zittnet in a neighbouring community.

Furthermore, applying Outcome Mapping⁴⁷ as a monitoring and evaluation tool from the project's start would have been a good idea, John says. Defining challenges and progress markers for boundary partners is a powerful strategic action that we unfortunately omitted from the start of this project. However Outcome Mapping is such a versatile tool that it can be applied even at this late stage of the project, which we now are doing.

Communications costs in Nigeria are still very high, John explains. “Hardware, technical support, rural community awareness, and the absence of a critical mass of users, all help to keep the prices high”. Therefore, ZittNet is looking at developing a lobbying group that should bring together an Ofcom (UK) type service, which sets standards for communications and imposes fines if these standards are not met. At the moment there is no incentive for communications to improve, especially not in rural Nigeria.

⁴⁷ Outcome mapping is a new approach to planning international development work and measuring its results. The method focuses on measuring changes in the behaviour of the people with whom a development initiative works most closely.

PART 4

*Experience is what you get when you do not get what you want.
Anonymous*

13. Internet in Africa? Abort, Retry, Fail.

IT46 has been an insider and outsider on several Internet development projects in Africa. Being an insider has made us more aware of what the challenges are. Being an outsider has meant that we have not been able to follow the daily work of projects that we have supported on the ground.

Rather than writing about the things that went according to plan, we want to share with you in these final pages the things that did not do so well.

Most of these problematic areas were neglected and overlooked in the original project design, while others were planned for but simply never were given enough priority during the project time.

The ten most important, and often underestimated, areas of building a sustainable Community Wireless Network are:

1. Finding your business model

A business model should not only be about “how much should we charge?” and “how much are we paying?” A good business model needs to be more comprehensive than that and include answers to a number of “*what ifs?*”. It needs to be long-term and include a great deal of entrepreneurship and vision in order to be successful.

The business models we have seen emerging from these networks have been quite basic (total cost divided by number of users) and lacked a future vision of expansion both in terms of clients and services. This is definitely an area that needs careful attention during the *start-up phase* of a project, and *continuous follow-up* during the project time.

2. Define organizational practices

A business needs a sustainable model. The model should include a set of good organizational practices that define how the team will work together.

How will we reach out to new clients?

How should we market the service?

Who will make sure that the clients pay their bills?

Who should the clients contact when they need help?

Who will provide support to clients when things go wrong?

Who will be responsible for new client installations?

Who will procure the hardware needed?

Who will maintain active equipment in the common network?

Who will maintain the passive network?

Who will make sure that the electrical system works properly?

These are questions that needs answers if you want to operate a Community Wireless Network. This type of thinking was never a part of the original plan in either project, but should have been formally included as a part of the basic training.

In February 2008, we did a training session on project organisation at Fantsuam Foundation that resulted in a organizational structure as shown to the right.

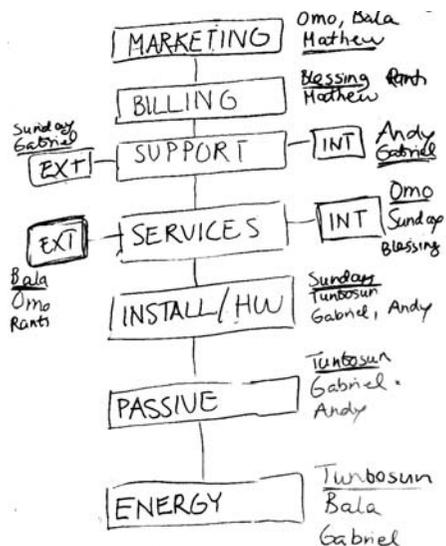


Image 14: The organizational structure developed for Zittnet.

3. Building and keeping local capacity

Capacity building in terms of practical and theoretical training has been an important component in both projects. Intensive training workshops of two weeks each have been carried out 2-3 times per project, with 10-15 people attending each time. What we have noticed in both projects is a fast turnover of trained people. In both cases, 80% of the people we trained during the first workshop had left the organization at the time of the second workshop. To avoid the loss of local skills, more people need to attend the training workshops and there must be a mechanism in place for colleagues and fellow students to replicate the trainings.

Although all of our training materials are free to use and modify⁴⁸, and CDs with the whole course curriculum have been given to trainees, we have seen very few attempts at replication. This is an activity that must get more attention in future initiatives. Each training workshop where external consultants are invited to train, should result in several local replications of the training, where the trainees now train their colleagues or members of the community.

4. Implementing bandwidth saving measures

International bandwidth is currently costly and unaffordable for most Africans, and it will unfortunately continue to be so for quite some time.

Therefore, every measure to save international bandwidth and to use the existing bandwidth wisely must be taken. This applies to national backbones as well as community networks.

Implementing a Web cache to locally store frequently accessed data is a good first step. Additionally, local mirrors of software updates should be set up. OS updates of Microsoft and Linux are useful, as well as low bandwidth mechanisms to keep updated anti-virus software.

If the agreement with the upstream provider (ISP) is not volume based, it is a good idea to implement a local mail server on the

⁴⁸ All training material produced by IT46 is licensed under the Creative Commons attribution share-alike non-commercial license, <http://creativecommons.org/licenses/by-nc-sa/3.0/>

community network. In that way, mail downloads can be scheduled for non-office hours to reduce mail related traffic during office-hours.

End-users should also be educated to browse and use mail in a bandwidth efficient way, by blocking unwanted information such as pop-ups, ads, and flash presentations.

5. Keep a stock of spare parts

Equipment fails. That is reality. In fact, wireless equipment fails quite often due to its outdoor placement in challenging environments. As a rule of the thumb, you should count on a failure of 30%⁴⁹ of your wireless equipment within the first year.

This loss of hardware should be included in the initial plan of the network. It should be customary to earmark funds for spare parts, or even better, procure and stock wireless units (backbone and client) for future use.

6. Comprehensive lightening protection

Both Zittnet and the Kabale Network have been hit by lightening strikes that have caused great damage. In July 2008, Fantsuam's central tower was affected by a close indirect hit that caused enormous damage to both the power backup system and the wireless backbone.

In November 2008, the central tower in Kabale was hit by lightening and blew out both central access points, shutting down the entire network.

The full damage caused by these lightening strikes could never have been avoided but definitely *prevented*. Neither network was properly protected in terms of grounding of *tower, antenna and radio, Power-over-Ethernet injector* and the *NOC building* itself. Ideally, a system would be in place to shut down and disconnect sensitive equipment

⁴⁹ This number was estimated in November 2008, when participants from 10 African Community Wireless Networks met for the Wireless Africa workshop.

when electrical storms loom, but in most cases such a shut down is not simple and requires constant vigilance.

This is an area that needs to be added to any training curriculum in building Wireless Networks.

7. Ensuring stable power

Running a reliable service requires stable power in the backbone. Clients paying substantial fees for Internet access must be able to access the service 24/7, otherwise they will leave your business.

Having a solar power system dedicated to the NOC at Fantsuam has proven to be a costly (initial hardware and installation cost) but yet necessary measure to get clients to sign up for fixed monthly fees of 50-200 USD/month.

8. Documentation and Dissemination

For many people, documentation and dissemination are just two boring words that need to be included in each project proposal.

There are few reasons, but many excuses for not documenting your work. Common excuses are; *"it is time consuming"*, *"I will remember what I did"*, *"there is no value in sharing my work"* and, *"my culture has an oral tradition"*.

None of these excuses is an especially good reason. Some counter-arguments we use to argue against these opinions are:

- Documenting your work as it progresses, takes far less time than documenting it all when it is completed.
- Humans have a limited memory and, without taking any notes, few people actually remember how they solved a specific task a year ago.
- There is a great value in sharing how you solve a problem. Just look at the popularity of online forums for computer software or car mechanics, where people document their

experiences, mistakes, and successes. The lessons you learned could prove useful to someone else later on, whether your neighbour or someone half a world away. Through open documentation, your experiences become part of the general wealth of human knowledge.

- When you document what you have done, other people can offer their insights as well. If you were unsuccessful with something, people might suggest ways that you can succeed the next time. If you succeeded the first time, your readers might build on your success and suggest ways to do things even better in the future.
- Just because things have been done in one way for a long time, does not necessarily mean that is the best way of doing things.

The act of documenting a process, whether it is how to align an antenna in Kabale, or how to develop a business model in Kafanchan, forces you to reflect upon your work, to remember what you actually did and why, and let other people take part of your experience. Documenting is also a way to take pride in your work.

We try to encourage our project partners to document their work in one way or another, whether using personal blogs, project websites, formal reports or just circulating simple notes. The format is less important than the goal: the action of actually writing.

As project partners, we try to set a good example by documenting all our work, publishing it online and licensing it under an open license. Over the years, documentation and dissemination has become a trademark of IT46. During the past five years, we have produced no fewer than 1000 pages of training material and research papers, all licensed under Creative Commons.

9. Building networks of people

The most important aspect of building a physical network is the human network that keeps the project running. Connecting computers together is not as important as making sure that the people behind

them exchange ideas and learn to support each other. Ignoring people when working with computers is a common mistake of those that believe that technology *per se* can solve all problems.

Physical networks should serve as a mechanism to link people and to guarantee that local skills remain local. The process of getting the community engaged is more important than the antennas, cables, masts and computers. The sustainability of the project depends on how quickly the local community takes ownership of the challenges.

Finding ways to make the community proud of their network is fundamental to its success. Participation is the key to empowerment and the development of skills takes time. Unfortunately, most projects underestimate how much time and how many resources are needed to get a community engaged.

We have learned to be patient and the secret of patience is doing something else in the meanwhile. As putting ideas into practice depends on people's confidence, interest and skills, networks need to be created to serve community interests. The ultimate goal is the creation of a generation of curious hackers⁵⁰ with an ethos of social responsibility⁵¹.

10. Trial and error

The last lesson learned is the underestimated process of problem solving, "*trial and error*." Our experiences from these two years in Uganda and Nigeria are that those who have failed have learnt the most. Those that have had misfortune with failing equipment, lightning strikes and key personnel leaving, have been the ones that have survived and become stronger.

We need to allow ourselves to try and fail, as long as we learn from our mistakes and share our knowledge with others. It is impossible to

⁵⁰ Hacker: A person who delights in having a deep understanding of the internal workings of a system. Hackers enjoy adapting, improving and localizing technology.

⁵¹ Social responsibility: A voluntarily assumed obligation toward the good of a larger social unit as opposed to the self alone.

have the magic formula in hand from the beginning. Along the path, however, you will be forced to define one formula, discard it, reformulate, and try again..

Retry

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A compilation of three years
experience working with Community
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