Rural Access: Options and Challenges for Connectivity and Energy in Tanzania

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Findings of a study carried out for the International Institute for Communication and Development (IICD) by Suhail Sheriff, Information and Communication Technology Resource Centre (ICT-RC), Tanzania.

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Purpose of this report

This report was commissioned by the International Institute for Communication and Development (IICD); an international, not-for-profit, non-governmental organisation (NGO) that promotes Information and Communication Technology (ICT) in developing countries to alleviate poverty and achieve sustainable development. It is part of a wider initiative by IICD to prepare a series of reports on connectivity and Internet access in rural areas with its partners in Zambia, Tanzania, Ghana, Uganda, Burkina Faso, Mali, Ecuador, Bolivia and Jamaica.

The purpose of this report is to enable organisations engaged in rural development to make informed decisions on rural connectivity and Internet access in Tanzania. It also aims to demystify the technical issues associated with obtaining connectivity and Internet access, which often confuse lay-persons. The report also provides a general inventory of connectivity options and costs. As energy is a major concern for rural connectivity, the second part examines this issue and outlines the potential use and cost of alternative energy sources such as solar power, wind, hydropower and bio-mass.

Providing this overview is by no means a one-off exercise. Rather, it is a work in progress as connectivity options and costs change rapidly. The report is a revised and updated edition of an earlier study into connectivity options and costs in Tanzania, the results of which were first published in May 2006. Future follow-up studies are planned. Their findings will be published on a bi-annual basis.

If, after reading this report, individuals or organisations can critically and analytically study the options available to them and achieve Internet connectivity that is efficient and cost-effective in remote and rural areas, then the report will have fulfilled its purpose.

Executive Summary

Establishing Internet access in rural areas is more complex than one would expect. It requires individuals or organisations to analyse their connectivity requirements and examine what is available on the market. A crucial factor is the availability and reliability of the power supply. Therefore, this report also deals with issues such as power backup systems and alternative sources of energy. The report aims to clarify all the issues involved, thereby empowering the reader to make more informed decisions.

Making a thorough analysis of an organisation's connectivity requirements is essential to obtain the required service at an affordable price and thereby ensure the sustainability of the rural access service. It forces an organisation to assess why and how connectivity is required and how it will be used. Secondly, it will help to assess the type of technology and mediums of service required. Thirdly, it will help to review available options and costs in relation to the needs of the organisation in question. Finally, it will help an organisation to plan for a scalable solution so that new demands for connectivity can be catered for by the selected system and entirely new equipment and hardware will not have to be purchased.

A simple example would be the case of a rural non-governmental organisation (NGO) with a tight budget that only needs an efficient email system. All that is required is a mail-server that could act as a store-and-forward system. The server can dial-in to an Internet Service Provider (ISP) once or twice a day to pick up and drop any waiting e-mails. This is much cheaper than a live satellite connection in terms of investment and recurrent costs.

Similarly, if a costly satellite connection were to be selected, the available bandwidth would need to be utilised most effectively. If, for example, an organisation connects all its computers to the network, this is bound to result in congested Internet traffic. Critical services such as video-conferencing may suffer because a user on the network is downloading music or has a virus which slows down the entire network operation.

When a satellite link is chosen, the organisation needs to consider the type of traffic it requires and where it will be routed. For example, if the organisation primarily offers tele-medicine with a partner institution in Dar es Salaam, then a satellite service with a hub in Europe may not be favourable as the route that the traffic would follow between the two points would be very long. It would be ideal, in this example, if the satellite hub was located within Tanzania. Likewise, if the organisation has a large network and sends a lot of inter-office e-mails but the mail server is not located on their premises, then every e-mail between two neighbouring offices is routed via the global Internet. This will become very slow and will use up a lot of costly bandwidth unnecessarily.

To sum up, as far as obtaining connectivity is concerned there is no such thing as 'one size fits all': it is necessary to find solutions based on pre-determined connectivity needs.

This report also deals with the issue of energy and power. Any form of connectivity is rendered useless without an adequate power supply. If the Internet is used mainly for non-critical or leisure purposes, then a power cut is just an inconvenience. However, the consequences are more severe if the power cut affects core operations such as systems in large hospitals where patient healthcare depends on a well-functioning Health Management Information System (HMIS). Power cuts in situations where advanced software and hardware has been installed to manage key operations will shake confidence in any new system. An effective power backup system is therefore required to ensure that systems continue operating during critical periods, despite power failures.

In addition to using the electricity grid as a power supply it would be useful to consider alternative energy sources as well. Although still fairly new in Tanzania, many vendors and users have installed solar systems to run their facilities. Alternative energy sources such as hydro, wind and bio-mass power are discussed later in this report, although more specific research and piloting needs to be done to optimise the use of the various systems. This can be done in areas where people can use both solar and grid power or in remote areas where solar is the only power source.

1. Major Developments

This study aims to provide organisations with information and advice on the different issues relevant for planning activities to achieve rural Internet access. The various options currently available are highlighted in this report.

The study also intends to signal new developments relating to connectivity and Internet access in rural areas on a regular basis. The main developments since the last report of 2006[1] are the following:

The deployment of the 3G network by Vodacom

The deployment of CDMA 800 networks by the Tanzania Telecommunication Company Ltd. (TTCL) and Zanzibar Telecommunication Ltd (Zantel)

The deployment of CDMA 450 network by Benson Informatics (BOL)

The official launch of the Tanzania Internet Exchange (TIX) in April 2007

The official launch of the Arusha Internet Exchange Point (AIXP) in July 2007

The launch of a local Ku-Band and C-Band satellite hub by SimbaNet

These developments are discussed in more detail elsewhere in this report.

[1] *See http://www.iicd.org/files/RuralConnectivityTz_TR_FINAL_online.pdf*

2. An Historical Perspective on Connectivity

Internet use first started in Tanzania with a ‘store-and forwarding’ system for e-mail. This initiative began approximately in 1989 between the Muhimbili University College of Health Sciences (MUCHS) and FidoNet. Users dialled into the MUCHS servers and sent and received their e-mails. These e-mails would reside on the MUCHS server until a Low Earth Orbiting satellite was overhead. At that point, it picked up all e-mails waiting to be delivered and dropped e-mails destined for anyone connected to MUCHS. The same satellite eventually passed over the United Kingdom where it dumped all the e-mails it had collected from various locations. In the United Kingdom, the e-mails where received by GreenNet and subsequently channelled to their respective destinations through the Internet.

In 1995, a company called Star Telecoms Ltd. attempted to build a ‘Tanzanian Internet’ which was a network of many users and servers within Tanzania but without a link to the global Internet.

The first ‘live’ Internet experience was pioneered by a company called CyberTwiga in 1996. Their connection to the Internet was via the SITA network which was used predominantly for ’live’ flight-booking systems around the world. At that time, SITA and the telecoms incumbent were the only licensed providers of international data connections.

As regulations eased, more data providers were licensed; namely, Afsat and Datel. After this, many more ISPs connected to the global Internet. The cost of connectivity was extremely high with a mere 32kbps link costing an ISP about US$16,000 (1 MB = 1,024kbps) in 1999.

Five years later, more licenses were issued for data operators and the prices began to fall. Today, many operators are active and the regulations have been relaxed considerably. As a result, the bandwidth prices have also dropped to about US$3,000 per MB (based on quantity purchase), a major difference with US$ 512,000 for 1MB in 1999.

However, although the price of International Bandwidth has dropped dramatically, it must be compared with the cost of connectivity in the ‘developed’ world, where 1 MB bandwidth costs only US$300. The price of bandwidth is expected to drop further as technology becomes more efficient and the connectivity infrastructure grows. For example, the East African Sub-Marine System (EASSy) is a fibre optic cable network that will link all countries on the East Coast of Africa to the global networks via South Africa and Djibouti. This development and other international fibre deployments can lead to a further reduction in prices for international bandwidth.

All in all, Tanzania has developed tremendously in terms of Internet access and has made great strides forward compared to its humble beginnings in 1992. Economic growth, a favourable regulatory environment, and the increase of users and services requiring Internet have fuelled rapid advancements in connectivity in Tanzania, especially in the rural areas.

3. Rural Connectivity: The Challenges

Although it is possible to establish rural connectivity in all areas of Tanzania, organisations that are about to embark upon this journey should be aware of a number of critical aspects.

Last Mile Infrastructure

Rural areas in Tanzania usually lack adequate 'last-mile' infrastructure. This is considered to be the final link between a major Point of Presence (POP) of the Internet access provider and the user.

Because this last mile infrastructure often does not exist, it is necessary to deploy expensive and sometimes innovative ways to gain access to the Internet. One way is through a satellite dish, which overrides any need for infrastructure on the ground. This is often very reliable but the price tends to be much higher than if connectivity infrastructure on the ground would be available.

Another option is for the provider to build a wireless network that extends from the POP to the user. Although usually cheaper than a satellite link, this option is also comparatively expensive. In most areas in Tanzania, this is the medium of choice for many Internet Service Providers (ISPs).

Cost of Service

For a service other than that provided through a satellite dish, the cost of service in a rural location is comparatively higher than that in an urban location. This is due to the following main reasons:

The Cost of Bandwidth: In Tanzania, the cost of bandwidth is generally more expensive than in developed countries. This is due, in part, to the fact that Tanzania is not connected onto any fibre-optic system (which offers substantial savings) as well as the fact that the demand, although growing, remains relatively small.

(Lack of) Infrastructure: Because terrestrial infrastructure is lacking or inadequate, users have to use a satellite connection which increases the cost of Internet access. Likewise, if a local ISP invests in solutions – such as wireless – to bridge the last mile, then the costs will have to be recovered from the users. In essence, the users are paying for the infrastructure costs.

Lack of 'economies of scale' ISPs: Most ISPs in Tanzania are relatively small, especially those operating in the rural areas. The largest ISP in Tanzania has less than 10,000 customers, while most rural ISPs have less than 500 users. As each ISP buys bandwidth independently and, because of the small amount of bandwidth, no use is made of economy of scale when purchasing bandwidth.

At the user-end, economies of scale are also lacking. Rural populations are generally dispersed over a large geographical area. The low population density implies that services reach fewer clients than in areas where customers are concentrated. This relative additional cost is borne by the customer.

Inappropriate technology: Many of the smaller rural ISPs lack the necessary technical know-how and experience to deploy the most appropriate technologies. For example, a simple billing solution is of paramount importance. An ISP with technical capabilities could deploy Open Source Software (OSS) that would perform this function satisfactorily. An ISP without these skills has to go for more expensive proprietary software which increases investments and operational costs. Some ISPs do not deploy technologies to optimise the use of their resources, such as a bandwidth management systems. As a result, network congestion occurs and the ISP has to purchase more bandwidth. Again, the extra costs are borne by customers instead of simply managing the limited resources more effectively.

'Appropriateness' of the Service

The Internet service purchased from various ISPs hardly differs at all. They basically sell the same type of service: mere connectivity to the global Internet.

There are, however, some uses of connectivity that do not require Internet access *per se*. One example would be a point-to-point voice conversation or a video-conference between a location in a rural area and a location in Dar es Salaam. However, most ISPs have a fixed charging system that does not take into account the different types of access needed. For example, if a video-conferencing session needs 512kbps of bandwidth, they will charge for a 512kbps link to the Internet which is extremely expensive. However, if the ISP were to offer a 512kbps LOCAL link with no access to the Internet, the cost would be substantially lower. Likewise, if a link were used for only Voice over Internet Protocol (VoIP) then it could be charged at a lower rate than full Internet access.

This mismatch between the service provided and the service required is due, in part, because end-users are not yet aware of the services they can demand from their providers. If the number of customers demanding a local link (at a fraction of the price of an international link) would increase, ISPs would soon specify how much local and international bandwidth is allocated to each service plan.

Support and Sustainability of the Service

Finally, the last major challenge for connectivity in the rural areas is sustaining the quality of service. Tanzania has a big shortfall in Information Technology (IT) personnel. The few IT professionals that are available tend to be concentrated in the urban areas. Because supply is short and demand high, the cost of hiring IT professionals is fairly high. All these factors conspire against rural consumers. Maintaining a centre with connectivity requires high-cost input: firstly the IT personnel are not available and secondly, when they are available they are quite expensive.

4. Applications and Uses of Connectivity

Connectivity generally refers to the physical medium of linking you to the global Internet. It can be used for various purposes the most common of which are e-mail and surfing the web, but these are not the only uses of connectivity. They are explained below as well as some other types of uses and applications.

Surfing the World Wide Web

This is the most common and conventional type of access: 'Surfing' for websites that reside elsewhere in the world, known as the Global Internet.

Surfing a Local Website

It is possible to have access to, and surf for, local websites with local content. This requires a link to the server where the information is stored but does not need a link to the global Internet.

Data exchange for software applications

This is in cases where a software application, such as a Health Management Information System (HMIS), can interact with a central server to exchange information and data. Depending on where the server is hosted, a point-to-point link without Global Internet could suffice. Most software applications exchange pure text, which requires very little bandwidth. If this is the only use of connectivity, a simple 16kbps local link would suffice.

Video-conferencing for distance learning or telemedicine

As discussed above, if one of the two users for a video-conference are located in the same place as the satellite hub, or is connected to the location of the satellite hub, then a local link would suffice. If, however, the other point is elsewhere on the Internet, then a global internet link would be needed.

Voice-Over Internet Protocol (VoIP)

This is a fast-growing application for making telephone calls at much cheaper rates than through conventional mediums. If voice communication is needed within a private network, then an exchange could be set up at the same location as the communication hub (such as a satellite hub). This would allow 'internal' voice communications at no cost, only the cost of bandwidth. If, however, telephone calls need to be made to other 'outside' users, then a link to a global provider is needed as well as a VoIP service provider. There will usually be a monthly fixed charge as well as a per minute charge, but it is still much lower then conventional mediums. This service is very attractive and can bring down the operating costs of a remote location in terms of communication expenditure. In other words, obtaining connectivity would be justified if you can prove that the main use would be VoIP which would cut down part or all of the communications expenditures. However, it is worth mentioning that VoIP is very dependant on the quality of the link, especially with relation to 'latency' which is discussed in more detail below.

E-Mail Communication

This remains the oldest and most critical use of connectivity. If a link is needed for e-mail only, the cost of service can also be drastically lower than a full-service link.

5. Main Types of Connectivity Available

When approaching a provider for services, it is useful to know which types of connectivity mediums are available, at what cost, as well as the quality of service available and its reliability.

Dial-up

This is a simple medium that requires either a stand-alone PC or a network server calling an ISP using regular telephone lines. The cost of the service from an ISP would be the cheapest and is in the range of US$30-US$50 per month. However, there are three other factors. The first is the cost of the telephone call. This could easily mount up and become a major expense depending on how often you call, how long you stay online, and the location of your ISP. If you are calling from a remote location and your ISP is in Dar es Salaam, then the call would be billed as a toll-call. The second factor is the 'convenience' aspect. That means that whenever you want to check mail, or to do some surfing, then you first have to log-in to your ISP. The third factor is the connection speed. Although most computer modems are rated at 56kbps, you would be lucky to get 36.6kbps and often less based on the quality of your copper wire connection to the telecoms operator. In some cities in Tanzania, the Tanzania Telecommunication Company Ltd. (TTCL) has deployed Wireless Local Loop (WLL) instead of copper wire. These are in essence wireless telephones. It is not possible to use a dial-up connection over a WLL telephone.

Cable Connection (UTP)

Some ISPs have built up a cable network through a city or town using UTP cable, which is standard Ethernet cable having 8 wires. UTP stands for Un-Twisted Pair. Traditionally, UTP cable is meant for indoor use only. However, due to the lack of infrastructure, ISPs have had to get creative and extend this technology to the outdoors. UTP cable is not supposed to exceed 100 metres. Inadvertently, this limit is sometimes crossed leading to a rapid deterioration in service. Some rural ISPs have pushed this limitation in extremely innovative ways. One such way is to pair the 8 wires in a UTP. This extends the reach to 200-300 metres but with varied outcomes. In addition, due to the limit of distance, the ISP needs to install a switch or hub every 100 metres so as to 'daisy-chain' in order to reach further. A daisy-chain of more than 4 switches starts to have an effect on the quality of service. In addition, each of these switches needs a power source. Therefore, at times, the ISP may have power and the client may have power, but because the intermediary switch may not have power, the link goes down.

This method is the most widely-used medium of connectivity. It is cheap and relatively easy to install. It is, however, limited in reach to a maximum of about 500 metres from the ISP head-end, unless used in conjunction with other mediums such as fibre optic and wireless. If your ISP will sell you a service through this method, make sure you are clear on how many switches you transit before getting to the ISP, where the intermediary switches receive their power from, and any compensation for downtimes. This medium is not the best there is, but it is the best that a rural ISP can offer. A well-maintained UTP network can work fantastically with higher throughput speeds (between you and the ISP) than any other feasible medium including wireless, dial-up and even ADSL (Asymmetric Digital Subscriber Line - a common connectivity medium that uses the existing copper wire used for telephone lines from the telecom company).

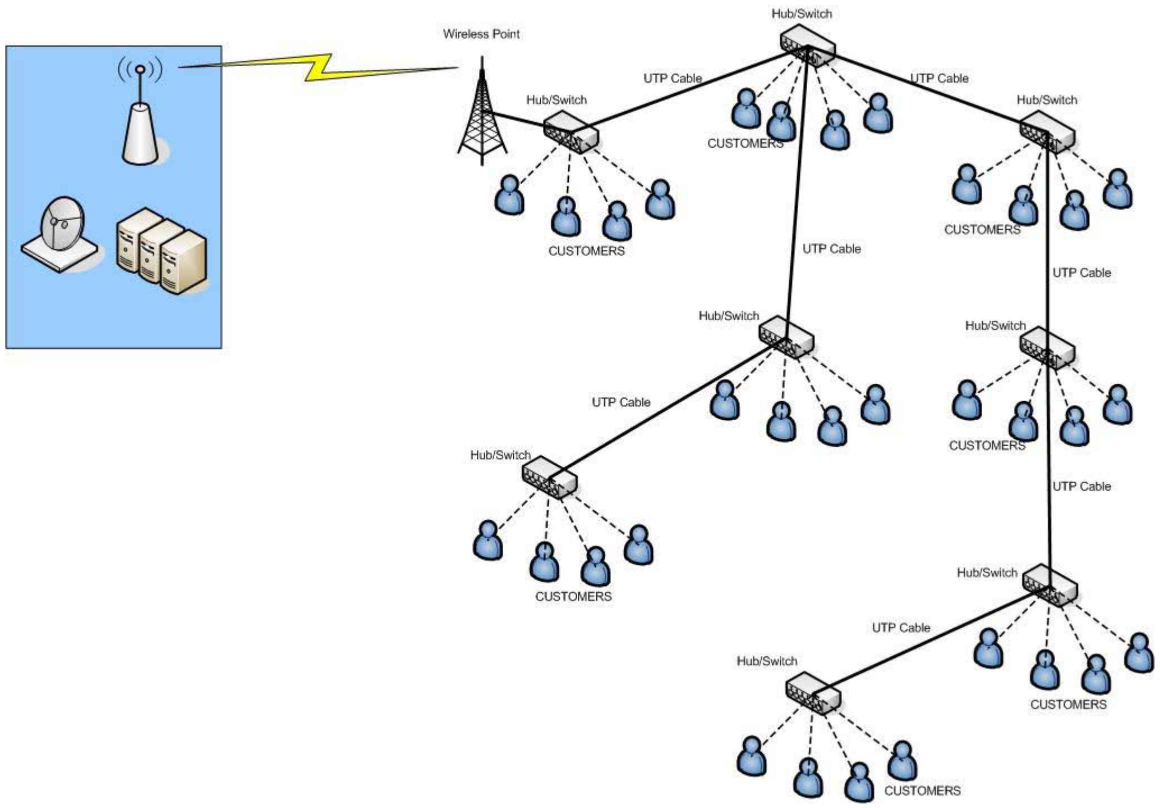


Figure 1: Typical Network Topology of an ISP using UTP & Wireless

In addition, ISPs usually use a combination of UTP and wireless (discussed below) mediums to extend their range. For example, if they determine that they will get a large concentration of customers 1 km from the ISP head-end, then they may deploy a wireless link to that point and distribute access through UTP, hence sharing the cost of the wireless unit among many subscribers. This is why some users say they have a wireless connection even though it is actually a UTP cable that enters their premises.

Lease Line Point-to-Point over copper wire

This is a point-to-point connection using 2 or 4 copper wire connections with 'modems' on each side. There are many types of protocols that can run on copper wire and they will have an effect on the throughput capacity of the wire as well as the distance it can run. The most common point-to-point protocol over copper is SHDSL (Symmetric High-Speed Digital Subscriber Line – this is one of the standard protocols used by the 'modems' that are connected at both ends of the link so that they can communicate with each other). This type of a link can reach much further than a UTP cable, even beyond 10 kilometres!

This type of point-to-point connectivity through copper cable can be deployed via private copper wire pulled by an ISP or through the telecoms operator. The Tanzania Telecommunication Company Ltd. (TTCL) has 'Leased Line' available in most, if not all, districts in Tanzania. However, their reach is limited to within the city/town limits and is usually dependant on the quality of copper wire between the exchange and the client. The TTCL now have a different type of access (ADSL) discussed below.

ADSL through the telecom provider

ADSL is more or less the same concept as discussed above as it is a point-to-point connection over copper wire. However, ADSL is a much more efficient method because it uses the same copper wire that delivers voice services to your home or office. At the exchange side, they 'input' both voice and data services onto the same copper wire that is routed to the user's premises, but they are inputted at different frequencies. When the copper wire reaches the user's premises, it first enters a splitter. This splitter then separates the two types of signals and sends the voice service to the telephone while sending the data service to a computer or router. You can therefore use both services simultaneously. Furthermore, using the data service does not constitute a telephone call or any telephone expenses. This is the most common type of service available in most of the 'developed' countries. The only limitation is the reach of the copper wire network of the TTCL in Tanzania.

ADSL through private copper

Although not very common, an ISP can deploy a city-wide network of copper cables to its clients. At the ISP head-end or Point of Presence, they would install a DSLAM (Digital Subscriber Line Access Multiplexer). This is a device that is a point-to-multipoint connection. Each DSLAM will support many customers who connect individually through the copper cable to their locations where they would use a regular DSL modem. This has only been done in Arusha city with Arusha Node Marie.

Wireless (License-free Frequency Bands)

This is the most common 'wireless' service used in Tanzania. Because it is license free, anyone can deploy a wireless network. The service can differ in quality from excellent to terrible, depending on several factors. The first is how well the wireless network is designed. If an ISP has a huge wireless network but there is no 'routing' it means that the whole network is one big mesh of 'bridged' traffic. This usually causes congestion and reduces network security of the users as all users can 'see' other users on the network. It is rare that a wireless network is designed with routers as this requires the additional investment of routers as well as the administration hassles of maintaining a routed network.

The second consideration is the issue of radio interference. If there are many providers in the same city and they all happen to use exactly the same frequency, then there is a likelihood of interference. Moreover, when a signal does face deterioration or interference, an ISP usually installs a 'booster' that amplifies the signal. This helps the signal but creates more interference for other providers. Because ISPs rarely discuss and coordinate their activities this can sometimes be a problem.

Thirdly, there is the power backup component. Since an extensive wireless network would need 'repeater' stations, these repeaters must have a power backup component. This repeater station becomes a potential point of failure between the ISP and the client. Therefore, when the power goes off at the repeater station, many clients and perhaps other repeater stations may be affected.

Despite the above, service on the ISM bands is improving dramatically. This is due to the fact that the technologies have become more efficient in using limited bands of radio frequencies, identifying interferences and migrating to a different channel with no interference. These types of technological advancements carry huge potential for connectivity in rural areas.

Wi-Fi

WiFi is a type of wireless service. WiFi is basically an internationally agreed-upon set of standards or protocol. This protocol is used so that many different vendors can produce equipment that can be compatible with each other. For example, a Linksys Access Point can communicate perfectly well with a D-Link wireless PCMCIA (a type of 'add-on' accessory to laptop computers) card for a laptop because they are both certified to be WiFi devices. This is in contrast to some proprietary wireless equipment that is often used, such as Breezecom.

WiFi was traditionally an indoor technology that allowed users to roam within a building and remain connected. Impressive developments have now made it possible for WiFi to be used outdoors and across whole cities! This has great potential for rural ISPs because the cost of deployment is usually much less than that of proprietary technologies. Ask your ISP if they offer a WiFi service. A regular wireless card for the laptop costs around $120, while a more powerful desk-mounted wireless unit may cost $150. The latter may have a detachable antenna and you could instead connect an outdoor antenna for an additional $300 to $400 for extended coverage and reach.

WiMax

This is yet another protocol developed on the same principle as above but operating on a different frequency range. This protocol has been presented as a major advance in rural connectivity. Although the equipment is still much more expensive than that of WiFi, it is set to grow more and more feasible as it becomes an accepted standard. We have yet to see whether that will actually happen because advances in WiFi protocol are occurring much faster. To coin a phrase recently used by *Southern African Wireless* magazine: "WiMax is a solution looking for a problem". Vodacom are in the process of deploying this solution nationwide. With their type of coverage, this could mean that many rural areas may have access to good connectivity. It is definitely something to consider and inquire about when you are ready to seek the best solution.

Wireless (Licensed Frequency Bands)

Service on these frequencies are more reliable due to the fact that they are regulated. However, services offered on these frequencies are also usually more expensive. Additionally, just because they are licensed does not necessarily mean that they are policed adequately. In other words, if a user decides to start using that frequency, then it is usually hard to identify who it is and take appropriate action. More often than not, this is a rare occurrence but it has proved to be quite a menace to ISPs at times.

Mobile Technologies (3G, GPRS, CDMA)

These different types of connectivity mediums use the infrastructure of mobile telephone networks. They allow for voice and data communication via small hand-held devices or larger mounted devices, both of which can be connected to a computer or a computer network. There has been a boom in the development of these technologies in the last year. Celtel and Vodacom are already offering a GPRS service in many parts of Tanzania, while TIGO has said that it will expand its present platform of offering a WAP service to mobile devices only to include GPRS. The Tanzania Telecommunication Company Ltd. (TTCL) and ZANTEL have also deployed their CDMA 800 services, but these are mostly concentrated in Dar es Salaam and Zanzibar. Vodacom also officially launched their 3G platform which is also confined to Dar es Salaam for now. While BOL have stated that they will soon launch their CDMA 450 Internet solution very soon. All these technologies will charge the customers based on a transfer rate. That means that you pay as you go for what you use.

Mobile Technologies (proprietary)

Apart from standardised protocols such as those mentioned above, there are many other technologies that are proprietary in nature. There are three major deployments of this type of connectivity, but unfortunately they are all exclusively based in Dar es Salaam. They are: IP-Wireless by Cats-Net, Navini by BOL, and Aperto by SimbaNet. Africa Online will soon release its iBurst solution as well. Although they have the potential to serve rural areas well, their initial investments are very high so unless there are some government incentives, they will tend to remain in urban concentrations where there will be a faster return on investments.

Satellite (V-SAT)

Satellite communication is by far the easiest to deploy and the most reliable, precisely because it does not depend on any terrestrial infrastructure. There are many satellite companies now in Tanzania. Some are local and some are international. One major difference between satellite companies is if their satellite hub is in Tanzania or housed elsewhere in the world, probably in Europe or North America. This only becomes an issue when we talk of a 'local link'. For example, if we want to link a rural hospital to the National Hospital in Dar es Salaam for a live video-conference for the purpose of offering telemedicine, then we need to make sure that the link is the shortest possible one. This is because we need to make sure that 'latency' is kept low.

Latency is a measurement of the time it takes for a small amount of data (usually only 32bits) to travel a complete round-trip between the 2 points. Just to give you an idea, latency between two computers on a perfect network within an office should be less than 1 millisecond, whereas the latency from Dar es Salaam to a point in North America through a international fibre-optic connection (which does not exist in Tanzania at present) would be between 2,080 milliseconds. The latency between the same two points but through a single satellite hop would be between 600-800 milliseconds.

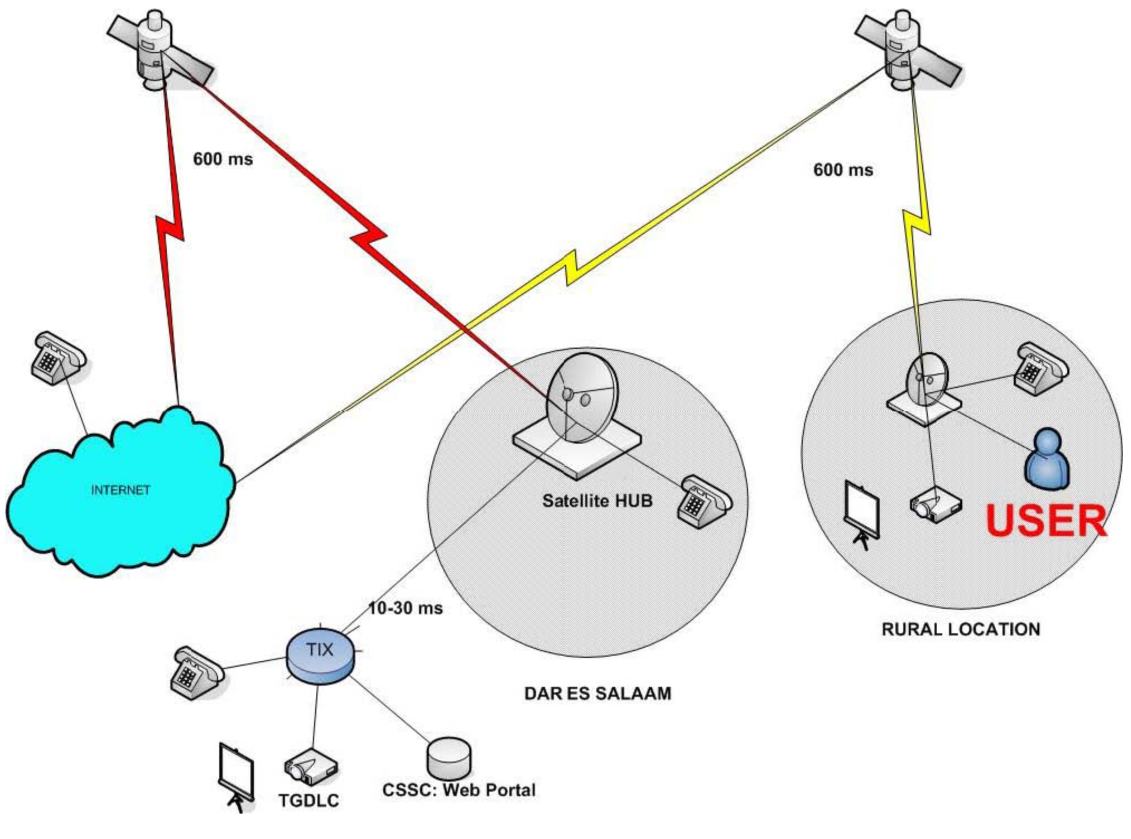


Figure 2: Standard Topology of a Satellite provider having an INTERNATIONAL Satellite Hub

This latency of a single satellite hop is still adequate for most video-conferencing purposes and voice communication. However, if the link had to pass through two satellite hops, then latency would increase and the quality of service would decrease. This would occur if the two points were themselves connected to the Internet via a satellite link to the global Internet. For example, if a hospital in Dar es Salaam has a satellite link via a provider in Norway and a rural hospital in Mwanza has a satellite link to a provider in Canada, then the two hospitals would link via a satellite hop on each side – therefore making a double jump. Video-conferencing would not be practical under normal conditions.

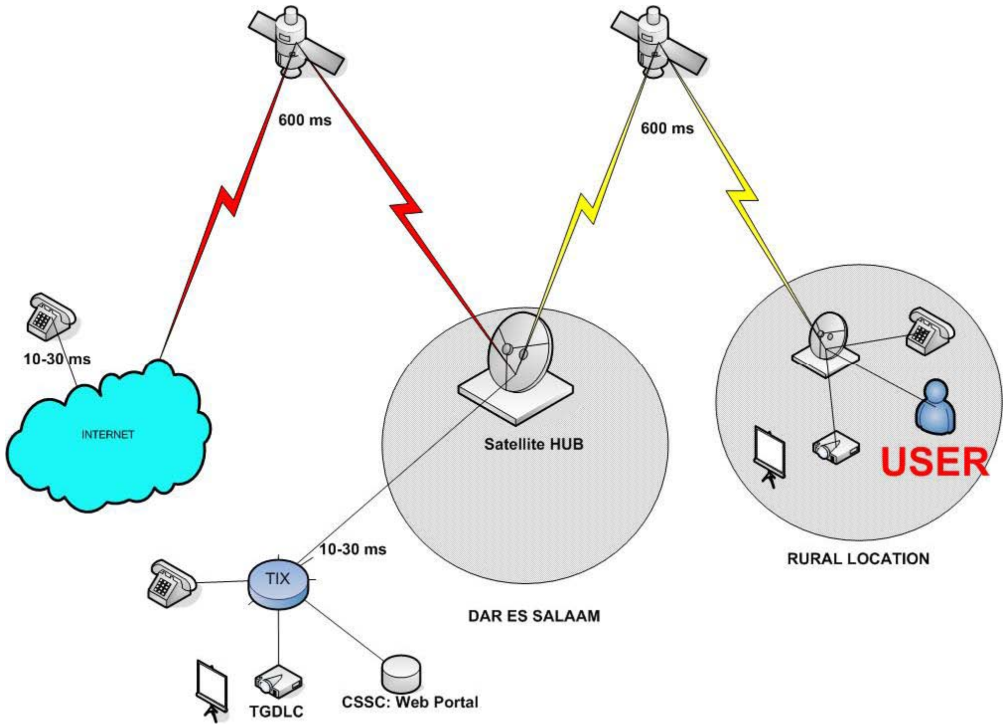


Figure 3: Standard Topology of a Satellite provider having a LOCAL Satellite Hub

However, if the Hospital in Dar es Salaam was connected to a satellite hub that was located in Dar es Salaam via a wireless connection, and the rural hospital in Mwanza was the customer of the same satellite company, then the link between the two would be a single satellite hop, making video-conferencing feasible. Furthermore, the rural Hospital in Mwanza could negotiate a broadband LOCAL link separately from an International link to the Internet, hence reducing its operating costs.

Types of Satellite technology used

There are two main types of satellite technology used. One is C-Band and the other is Ku-Band. C-Band is said to be much more reliable and advisable for 'mission-critical' applications such as banking and real-time transactions. However, technological developments have improved the reliability of Ku-Band devices to a point that it is almost (but not quite) comparable to that of C-Band. For most practical purposes, Ku-Band does suffice. The difference is the cost. Traditionally, a C-Band Antenna (dish) and modem comes to about US$10,000 to US$12,000 while that of Ku-Band ranges from US$1,800 to US$3,000.

6. Technical Considerations on Connectivity

Bandwidth Allocation – shared vs. dedicated

When an ISP sells a service based on bandwidth it usually gives two options. The first is shared. This implies that, as a customer, you are 'sharing' that bandwidth with other users. So a 128kbps shared link theoretically means that there are several users sharing the same 128kbps link. Some customers then demand to know the ratio according to which this bandwidth is shared and an ISP can rarely give a definitive answer to this question although they may offer a range of different answers. The reason is that in practical terms it is not feasible to break down a larger pool of bandwidth into little segments that can be shared. For example, if an ISP has 10 customers who are buying 128kbps shared, but their 'over-sell' ration is 5:1, then it is not practical for the ISP to have a 512kbps pool broken down to 2,128kbps pools and put 5 customers in each pool. Instead, they put all 10 customers in a pool of 512kbps. They then limit the maximum bandwidth per customer to 128kbps. Therefore, in the best case scenario you will get 128kbps if there are only two active users and only 51.2kbps if all ten customers were pulling as much bandwidth as possible; a situation that is quite rare. To add to the above intricacies of Bandwidth Sharing, an ISP may have a general over-sell ration but very few have dynamic bandwidth control mechanisms that auto-regulate the size of the overall pool. Most ISPs, if they do any form of bandwidth control, do it manually through rules and policies.

Dedicated Bandwidth on the other hand is as simple as it sounds. A customer is sold a segment that is fixed and will not be used by anyone else, even if is not used by the customer. Bandwidth is expensive, so this option has a substantially higher cost for the end user.

Service Monitoring Tools

Users usually get embroiled in arguments and disagreements with the ISP when they are not receiving good service. There are usually two main reasons for this: either the customer is genuinely getting a bad service but cannot prove it, or the ISP is actually delivering the right service but the customer is using it inefficiently or it is being wasted without the customer knowing how. In such circumstances it is useful to ask the ISP for access to the user's interactive MRTG graph. This is a very common tool that monitors and graphs the customer's bandwidth usage and this will provide a qualitative measurement that could help in the discussions and resolve any problems. Alternatively, there are many tools available to monitor the total bandwidth, transfer rate, and even determine the type of use of the service that the customer is receiving. This helps to determine the Quality of Service delivered, the up-time calculation, and helps the customer detect any leakage or abuse of bandwidth such as viruses and worms on the network, or excessive downloads like movies and songs during office hours and so forth. Likewise, there are simple devices that can help an organisation or company to monitor and actually control the type of uses on the network. For example, a simple bandwidth control hardware (or software) can easily allow certain users to access e-mail only and others to access the web, while blocking other services like P2P (often used to download songs and movies) or chatting. It can even regulate these policies according to the time of day – such as chatting allowed only after 5:30pm. These types of control mechanisms are highly advisable for users as they will ensure that this expensive resource is used and maintained as efficiently as possible.

Some Useful Sites and Tools for Better Network Management

In general, network monitoring is a specialised task. It is usually recommended to hire a professional to adequately monitor your traffic and send you an analysis. Although this is an additional cost, you may find that ensuring that your bandwidth is monitored and controlled well in this way could save you more money than it actually costs to hire such a professional vendor.

However, there are many simple sites and tools available that you could use even if you are not very technically savvy. A simple search on Google will reveal hundreds, but here are a few that could be very useful:

To test your download speed: You can use this free tool to test your maximum bandwidth speed at the time of doing the test. If you are on a network, it is useful to do this test with only one virus-free PC connected. This way you can find out what speed limits your ISP has in place. Go to: http://www.bandwidthplace.com/speedtest/

Download Utility: This utility helps you download files even if your connection is slow or intermittent. If, during a download, the connection is lost, the download will pause and resume automatically when connection is restored. There are many such utilities, and this is one of them:
http://www.tensons.com/products/downloadacceleratormanager/freeedition/

To monitor your 'up-time': You can use a 'ping' program that simply records when a certain site is accessible. You can use this to test certain equipment in your network (such as your network printer), and equipment at your ISP (such as your gateway) as well as to monitor an international site to determine if you have connectivity. Therefore, if you cannot get onto the Internet, you may find that the link to the ISP is fine, but that the problem lies in the onward route.

Some up-time monitoring tools are:

1) IPCheck Server Monitor by PAESSLER. A free version allows you to monitor up to 5 IP addresses at intervals of 15 minutes. The commercial version allows you to monitor more IP addresses at more frequent intervals. See: http://www.paessler.com/ipcheck
2) FREEping by tools4ever. Similar to the above. See http://www.tools4ever.com/products/free/freeping/
3) Graph-a-ping by Mata Luis. Similar to above with a nice graph. See: http://www.mataluis.com/index.php?option=com_content&task=view&id=37&Itemid=36
4) Visual Ping by IT Lights Software. Similar to above. See: http://www.mataluis.com/index.php?option=com_content&task=view&id=37&Itemid=36

To monitor your bandwidth use:

This becomes a little tricky because the PC you use to load the monitoring software should either be:

a) in between the external network and internal network – this means that the PC used to monitor should be the 'gateway' or 'firewall' of your network. All traffic between your ISP and your internal network must pass through this PC.

OR

b) be able to monitor a network interface that is SNMP-enabled. This means that the port that is being monitored should be able to relay needed data to your application. This is usually possible in mid-range and higher range routers and firewalls such as Cisco, Multi-Tech and so forth.

Some softwares that are useful are:

1) PRTG Traffic Grapher by PAESSLER. This is similar to MRTG but can run on a Windows PC and is a little easier to set up for people with little technical experience. There is a free version that is limited but helpful and a more commercial version. See: http://www.paessler.com/prtg
2) BMExtreme by LP23.com. This is a simple and cheap software ($25 for home use and $50 for Professional use) that can monitor bandwidth. See: http://www.lp23.com/bmextreme/
3) MING Bandwidth Monitor by MING Software. This is an affordable ($15 with a 14day free trial) software that allows you to monitor overall traffic as well as traffic from each connected PC. In this way it is also useful in finding the PCs with un-usually high traffic, such as those misusing the service or those that may be infected with a virus. See http://bandwidth.mingsoft.com/
4) Bandwidth Meter Pro. This is a $20 software that shows you impressive graphs of bandwidth usage. See: http://www.bandwidth-meter.net/index.htm

Tools to control bandwidth use in your network:

Apart from the above tools that merely 'monitor' bandwidth usage, there are others that allow you to control bandwidth usage within your network. With these tools you should be able to allocate bandwidth to each user as per their requirement, allocate certain priority allocations for 'mission-critical' applications such as video-conferencing as well as limit or regulate types of usage, such as music downloading, chatting and so forth. All of these tools will only work if installed on the gateway computer. Here are a few:

1) Routix NetCom. This is a free software. See: http://www.routix.net/netcom/
2) SoftPerfect Bandwidth Manager. This is a user-friendly utility. It costs $35 or $100 depending on enabled features. See: http://www.softperfect.com/products/bandwidth/
3) JDSoft Bandwidth Manager. This software costs about $60 for a home edition version and $230 for enterprise edition, although the home edition should suffice for most small networks. See: http://www.easyfp.com/bandwidth-manager/index.html
4) Traffic Shaper XP is a free utility for Windows OS. See: http://bandwidthcontroller.com/trafficShaperXp.html

SLA (Service Level Agreement)

This is an agreement that outlines issues relating to the quality of service that will be delivered by the ISP as well as its reliability and other factors. It may also contain a clause about a refund formula in the event of the ISP failing to meet the minimum acceptable terms of the SLA. This SLA is also highly advisable for customers. However, many ISPs only offer this option to customers who pay for higher levels of service as this is a liability for the ISP. If you are able to get an SLA, there are a few fundamental issues that are particularly important, such as:

Up-time guarantee. This is a percentage of the time they guarantee the service provided. For example, an ISP could guarantee an uptime of 99.5%. This means that in a month of 30 days they guarantee that downtime, if any, would not exceed 3hours and 36 minutes. Be careful to notice the definition of 'up-time' in other words, uptime to where. Uptime to ISP or uptime to the global Internet.

Compensation for downtime. This is a formula with which the ISP will be penalised for not meeting the minimum up-time guarantee. This is the penalty for the amount of down-time beyond the stated minimum. For example, if the up-time is guaranteed at 99.5% or 3 hours and 36 minutes, then anything above that must be compensated for.

Latency. This is the time it takes for a small amount of data (usually 32bits) to travel a complete round trip. This has been discussed previously, but a normal satellite connection would give about 600 milliseconds latency at best. This is very easily tested by running a 'ping test'. A ping test is a utility that is available on all computers and it tests the amount of time (in milli-seconds) that it would take for a 'packet' of data to be sent and a response to be received. Be careful that the SLA does not have a hidden clause of offering a one-way reading. It must include the complete reading of send and receive time.

7. Rural Energy: General Issues

Introduction

Any information or communication technology is rendered useless without adequate power. The availability of reliable power is crucial for any connectivity option, not only for rural communities but also for urban centres. Although an area might be connected to the grid, the power supply may be unreliable and subject to lengthy black-outs. It might also be unstable leading to power fluctuations that damage sensitive electronic equipment. So measures are needed to stabilise and control the energy supply as much as possible.

The issue of power is not only a rural issue. In Tanzania, power rationing periods occur of 12 hours at a time in the main city! These, however, are not predictable, so it is necessary to have backup options in place. In terms of protection, many incidences occur of various types of PC, modems, UPSs and other sensitive equipment burning out because of a power surge or spike.

If you are located away from the power grid or do not have a stable power supply, it is necessary to think through your solution methodically and practically. Examples for this phenomenon are as follows:

The Chief Medical Officer of a rural dispensary gets a nice satellite dish and fancy video-conferencing equipment for live telemedicine sessions with the Muhimbili University College of Health Sciences (MUCHS). Since there is no power at the centre, a top-of-the-line solar system is bought, capable of powering the whole connectivity set-up. Everything works well and the telemedicine sessions are very successful. However, it becomes harder to operate the centre on candle light, whilst the computers are running comfortably on solar power. So the CMO connects one tube-light for the reception area from the same source. Slowly, more lights and a fan are added to the solar system. As a result, the power stored in the batteries is not adequate to run the communication equipment and its hours of operation are limited. In a worse case scenario, the drain of power may be too high and may damage electrical equipment, rendering all other equipment useless.

However, if the CMO could have anticipated or planned for additional power, then a more suitable system could have been installed. Alternatively, if he was aware of this issue, he may have planned the clinic in such a way that the telemedicine sessions were only held during the morning hours and used the afternoon to re-charge the batteries completely for use in the evening for lights and fans only. There can be a variety of ways to overcome some potential power problems, but they all stem from a simple understanding of the broader picture of 'power supply'.

Another example is a rural centre that spends a lot of money on wireless equipment and a solar system to power it, but fails to get a connection because the ISP tower they are using is constantly down because the ISP has not invested adequately. Prior understanding might have forced the centre to cross-check the reliability of the ISP power before going ahead.

The other consideration in energy is the energy consumption of equipment. For example, a 15" Flat Screen Monitor may be twice as expensive as a regular monitor. However, its energy consumption is four times lower. So 'cheapness' of equipment should be balanced against other 'costs' of running it. Another angle on the same example is the effect on the environment. If the rural centre is powered by a diesel generator, that means that having flat screen monitors will reduce energy needs, and therefore reduce carbon emissions four-fold! Likewise, if we use proper batteries for power storage, fewer batteries need to be used that last longer. This has an effect on the amount of lead being dumped into the environment after their shelf-life has expired. At present, battery recycling is very rare in Tanzania.

As energy is likely to remain scarce, costly and not easily available in many rural areas, options for alternative energy supply and reduction of energy consumption deserve attention.

8. Power Backup and Protection

Protection from instant power failures is very important. This is usually solved by having an online UPS (Un-interruptible Power Source). This device is fed from the main power source. It has an internal (or external) battery that is charged continuously. When the power goes off or becomes unstable, the UPS takes over and supplies power from the battery. The backup time that a UPS provides depends on the capacity of the UPS and the energy use of equipment that is connected. For example, a 1KVA UPS supplying 2 PCs with flat screens may give 90 minutes of extra power, but if regular monitors are used it may only provide an extra 45 minutes of power.

The UPS also provides protection because it controls power fluctuations. It also prevents high voltage 'spikes' as it will usually burn out before the PC does. This is not the best way to protect your PC as each time there is a big spike you blow up a costly UPS! It is therefore advisable to place a 'surge arrestor' which costs around $10 to $20 in between the UPS and the mains supply. The most common is a brand called "Sollatek" and the rating for a regular PC can be 13 Amps.

There are two types of power backup systems: 1) short run and 2) extended.

A short run power backup system consists of small UPSs that can give up to 30 minutes of power: enough time for you to save the work you were doing and safely shut down the computer. An extended system is one that is designed to allow you to work for an extended period of time, usually above 2 hours.

An extended power backup solution can give you anything between 2 hours and 24 hours (or more!) of extra power. These devices are more expensive and usually have external batteries. They are good for 'mission-critical' servers and PCs that should work regardless of the power situation. When you select such a system, be sure to get an 'on-line' UPS. The grid power comes in 'alternating current' or AC. This means that the voltage alternates between the conductors 60 times per second. Contrary to that, 'direct current' or DC, e.g. from a battery, is a constant flow at all times. So when a UPS is charging a battery, it converts AC to DC current and, likewise, when a battery is powering your PC it is again transforming DC to AC current. To do this efficiently it must 'simulate' AC current. The quality of the UPS is determined by how well it can simulate this alternating current. A pure AC is graphically represented by a pure sine wave. On a graph, this looks like a smooth and consistent wave. A simulated AC is usually 'stepped' and on a graph looks like a jagged line, resembling stairs. If the 'steps' are relatively small, they are not felt by the PC and it is therefore safe. If the steps are too large, the PC detects it and may burn out as a result.

Inverters are not to be confused with Extended UPSs. Although they perform exactly the same function, inverters give an output that is not a smooth sine-wave. It is sometimes considered to be 'dirty power'. While this is suitable for most applications, it is detrimental for sensitive electronic equipment such as computers.

The quality of a extended UPS is also determined by its efficiency. Converting AC power to DC power and vice-versa is a costly business since each conversion brings along power losses. For example, converting from AC to DC for charging may be only 60% efficient and the same for converting the other way. This means that you need 100 units of power to give 60 units (60% of 100 units) of charge power in the batteries. Once the batteries are fully charged, they are able to discharge only 36 units (60% of 60 units). This means that you have consumed 100 units to obtain 36 units of backup power which represents a colossal power loss of 64%. Unfortunately, even the best UPSs still have rather low efficiency ratings so this is a kind of inescapable loss.

Any extended power backup solution needs batteries. Some of them need a lot of big batteries and combined they are almost as expensive as the UPS. A quick note about 'Deep-Cycle' batteries. These are batteries specifically designed for extended power backup and solar-based systems. In general, they accept a continuous small current to charge - even when fully charged - to maintain the batteries performance. This is called 'trickle charging'. Deep-cycle batteries are recommended by power experts because the batteries last longer. However, they are usually twice as expensive as regular batteries, thereby increasing total cost of the solution drastically. If budget is not a constraint they are recommended. However, if cost is a consideration, it is advised to buy regular sealed batteries and replace them every three years.

Regular wet batteries - the ones that you need to top up with water and acid - are usually not recommended. In cases of sloppy maintenance they degrade and are not able to hold a charge. In addition, they produce fumes that are extremely detrimental to electronic boards and equipment. If you must use these types of batteries then make sure they are stored away from electronic equipment and in a well-ventilated location.

To give a brief idea of the costs involved, here are a few extended power backup solutions as well as batteries that are available on the market:

1) Su-Kam online UPS, 3KVA ONLINE system, approximately US$1,600. A battery system for this (180VDC): 200AH (12VDC) X 15 pieces approximately US$4,300

2) APC Smart UPS, 3KVA ONLINE system, approximately US$1,900. A battery system for this (230VDC): 6 pieces of 192v packs approximately US$5,500

Both of the above are approximated prices without Value Added Tax (VAT). Actual prices will vary from vendor to vendor.

A note about batteries in general with relation to the environment is that they inevitably end up being thrown away after they have served their purpose. Batteries have some elements in them, such as lead, that is poisonous and bad for the environment. Unfortunately, there is no big re-cycling programme in Tanzania and even if it were there, it may not be feasible to return used batteries to the recycling plant as it might be located very far away. There are batteries which are better designed and have less environmental risks but they are not common and importing them is expensive. This is, however, positive when compared to energy from diesel or petrol generators that produce carbon emissions. In any case, environmental considerations need to be taken into account when making a choice.

9. Alternative Power Options

In the previous section we discussed power backup solutions. This is based on the premise that the organisation or company in question has a mains power supply for most of the time. However, many areas in rural Tanzania do not have grid-power (power from Tanesco). These areas may consider more innovative solutions and alternative power sources. Options for energy supply from solar, wind, pico-hydro and biomass are therefore discussed below.

Solar Panels (Source: Wikipedia)

Photovoltaics (Solar Power)

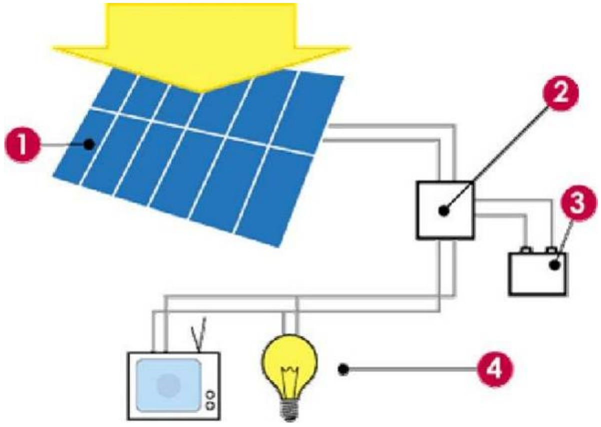
There are many forms of Solar Power, but the one used to convert the sun's rays into electricity is called Photovoltaics, often referred to as 'Solar Power'. These panels are very valuable, so give due consideration to theft or pilferage when choosing a site for installation.

Solar power was discovered as early as 1839 by Edmund Becquerel, a French experimental physicist. Since then, there have been massive developments and a notable reduction in prices. Solar power is also extremely scalable; from a tiny solar panel on a calculator to a 40 Mwh power plant in Germany called the Waldpolenz Solar Park which is expected to be completed in 2009.

Solar Systems can be used completely off-grid, that is in areas with no other source of power. A Solar System usually consists of the following four main components: Solar Panels, Charge Controller, batteries, and a Load (Inverter/On-line Inverter).

Solar Panels are the actual devices used to capture the sun's rays and convert them to electric power. The panels are mounted on the roof or in clear view of the sun.

The **Charge Controller** is the electronic device central to the whole system. It collects energy from the solar panels and directs a charging current to the batteries. At the same time, it supplies the load. In other words, the other four components of the system connect to the charge controller at the centre.



1= Solar Panel; 2= Charge Controller; 3 = Battery; 4 = Connected Load

Figure 4: Complete Solar System (Source: www.mysolar.com)

The **Battery** stores the power which is used at times when there is no sunshine (for example, at night). There are many types of batteries. These are discussed in the previous chapter.

Finally, there is the **Connected Load**. This could be direct appliances running on DC or an online inverter. An online inverter transforms DC power into clean AC power that can be used for powering computers.

If you want to deploy a solar power system, there are many variables that you have to calculate first so that you are informed. You can either buy the components yourself, or have a supplier/contractor give you an estimate. If you have made your own calculation, then you can query an estimate to make sure the equipment offered is correctly priced or to work out whether the supplier is trying to sell you a larger system than you actually need.

To simplify the process, here are the main steps to follow when planning your solar power system:

Calculate your load. To do this you need to know the power consumption of the appliances and the number of hours that the appliances will be used per day. Each appliance should be rated either with Watts or with the Maximum Current Load. You should also know the voltage; it is usually 220V. The watts are calculated as the Amps X Voltage. Therefore, if you have a PC that is rated at 1.2 Amp Maximum Current operating from normal supply power (220 V), then the Wattage is 220 V X 1.2 Amps = 264 Watts. However, it is highly unlikely that it will operate in this 'maximum current' state all the time. Therefore, it may be alright to assume 60%-70% of the maximum current as the regular operating current. This gives approximately 160 watts of power per computer.

An indication of the approximate energy needs of a few common appliances are as follows:

Type of ICT equipment	Power Requirements
Laptop	75 Watts
Desktop PC	300 Watts
15" Monitor (Flat screen)	65 Watts
15" Monitor (old style)	500 Watts
Light bulb (standard – 40 W)	40 Watts
Light bulb (energy-saving – 20 W)	20 Watts
Laser Printer, small	550 Watts
Ink-jet Printer, small	100 Watts
Wireless router	50 Watts
V-SAT satellite Receiver	500 – 1,000 Watts

Now determine how many computers will be connected and how many hours per day they will be used. Let us assume there are 10 computers and the centre is open 8 hours a day. Based on experience, it is possible to judge how many hours, on average, each computer will be used. For example, each computer is used on average for 4 hours a day. This gives a load of 160 watts X 10 computers X 4 hours = 6,400 watt hours per day. Other appliances must be included in the calculation too. To simplify, you can use a table like the one overleaf:

Load Calculation Worksheet

Appliance	Qty (1)	Watts (2) (Amps X Volts)	Hrs/Day (3) Of usage	Watt Hrs per day (= 1 X 2 X 3)
Computers	10	160	4	6,400
Lights	2	40	10	800
Total Watt Hours Per Day (4):				7,200
Total Watt Hours Per Month (4 X 30 days):				216,000
Total Kilowatt Hours per Month (above divided by 1000):				216

Solar Panel Array Sizing. After you have calculated your load, the size and number of solar panels required need to be calculated. This can be done in the following manner: find out the "Peak Sun Hours" for your area. Generally, Tanzania lies within a geographical zone that receives between 4.5 and 6 peak sun hours per day (Source: http://www.science.udsm.ac.tz/physics/Research.htm).

For our example, assume having 5 Peak Sun Hours value. Take this Peak Sun Hours value and multiply it by 30 (days in a month) to give you the total number of peak sun hours in a month. This gives us 150 Peak Sun Hours. In other words, our load will have to run on energy collected during these 150 hours out of the total number of hours in a month, which is 720. Now we divide the Kilowatt hour per month value (216,000 Wh) with our total monthly Peak Sun Hours (150) and we get a value of 1,440 W. We then add a contingent of 30% of power loss and this gives us 1,872 Watts. This is the total power we need to capture during the peak sun hours of the day. Solar Panels come in many sizes, each with a different 'watts' rating. The bigger the wattage, the bigger the panel, but the fewer panels we will need. The bigger panels are also generally more efficient. In other words, it is more beneficial to have two large 250 Watt panels than to have five smaller 100 watt panels. So, for our example, we will assume that we want to purchase 240 watt panels. If you divide 1,872 Watts with 240 Watt panels, you get 7.48, which we round off to 8 solar panels (of 240 Watts each) which we will need to meet our requirements. Alternatively, you could consider using 130 Watt panels. In this case, the calculation would be 1,872 Watts divided by 130 Watt = 14.4 or 15 panels needed. As a formula, this is:

Number of Panels Needed = (a/b * 1.3) / c

Where a = Calculated load in Watt Hours per month, b = Peak Sun Hours per day X 30 days, c = Watt rating of each solar panel that you are considering. Multiplying by 1.3 is the factor of adding 30% to compensate for inherent losses.

Solar Charge Controller Sizing. Once we know the number of panels and their rating, we need a charge controller that can cope with the amount of power that the panels can provide. First we calculate the wattage of the Solar Panel Array. This is the number of panels multiplied by the rating of each panel. In our example above, we have 8 panels, rated at 240 Watts each. That gives us a total wattage of 1,920 Watts. Then you need to decide on the battery bank voltage. Each battery is usually 12VDC. The only difference in this choice is for the size of the charge controller and the associated wiring. If the voltage is 24VDC, the Ampere calculation is halved and therefore you can use a smaller rated charge controller and smaller gauge wires. The solar panels also have to be connected accordingly. For example, if our solar panels are 12VDC panels then we need to connect them in pairs. That is, connect each pair in series to get 24VDC and then parallel to each other in pairs. If we assume this to be the case (choice of 24VDC system), then your charge controller rating should be the solar panel rating divided by the charging voltage, which gives us 80 Amps. This is the rating that we need for the Charge Controller.

Battery Bank Sizing. Once we have all that information, we then compute the number of batteries that we need based on the required backup time needed. To protect the batteries and extend their years of service, we assume a calculation that should only discharge them to 50% capacity. Therefore, if our charging rating is 80 Amps, we assume it to be 160 Amps per day. We should factor in a backup period of, say, 4 days to compensate for the rainy and cloudy days. This brings the rating we need to 640 Amps with a 24VDC system. Now that we have a 640 Amps requirement, we choose the battery size. Generally, it is better to get larger batteries so there is less connection work and better operational-efficiency as well as cost-efficiency. But it is perfectly acceptable to choose a smaller battery; we will just need more batteries. For our example, we assumed that we wanted 200Ah batteries. Therefore, we divided 640 by the battery rating of 200 to get 3.2, rounded off to 4 batteries. However, as we are running a 24VDC system and the batteries are 12VDC each, then we must connect them in pairs. We therefore need 8 batteries, connected in pairs. In other words, each pair is connected in series to each other and in parallel to the other pairs. Remember that when you connect in series, you double the voltage but the ampere remains the same, while when you connect in parallel, the voltage remains the same while the amperes double. Consequently, the above connection would look like this:

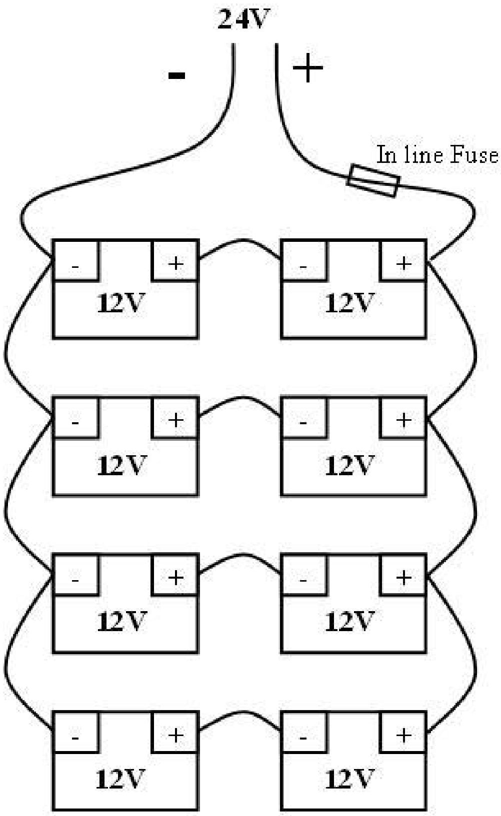


Figure 5: How to connect 12VDC batteries into a 24VDC Battery Bank

When planning your system, do not forget that there are tremendous losses attributed to DC cable. You should therefore try to keep the cable length to an absolute minimum and the gauge should be thick enough to minimise this power loss. Your vendor should be able to look up the losses against distance, but the cable should not be smaller than 15mm in diameter.

Some vendors who may be able to supply you with a solar power system are:

Agro Vision, P.O. Box 38177, Dar es Salaam, Swahili Street, Gerezani Area, Tanzania. Telephone +255-22-2182546 / +255-744-470559; Fax : +255-22-2182577; Hotline : +255-748-723467.

Intertec (Tanzania) Ltd, P.O. Box 40365, Pugu Road, Dar es Salaam, Tanzania. Tel: +255-22-2601749. PV Systems, distributor for Shell Solar, Thinlite.

Mona-Mwanza Electrical & Electronics, Sheikh Amin, Mwanza, Tanzania. Tel: +255-28-2502910 / Fax: +255-28-2502910 / E-mail: totomona@hotmail.com PV Systems installation

Umeme Jua Ltd, P.O. BOX 26, Nyerere Road, Dar Es Salaam, Tanzania. Telephone: +255-22-2866061/2 / FAX: +255-22-2866063 / Website: http://www.umemejua.com. Power Solutions for where and when there is no grid electricity Solar PV Systems / Solar Water heaters / Power Back-Up systems.

Hagi Systems Co. Ltd, Box 34536, Dar Es Salaam, Tanzania. Telephone: +255-22-2772966. Product types: solar water heating systems, solar garden lights, solar electric power systems, water filtering and purification systems, water pumping windmills, water heating systems.

Water Wells Services Ltd, P.O. Box 72671, Kisutu Street, Plot 922/17, Dar es Salaam, Tanzania. Telephone: +255-22-2123619/20 / +255-784-334318 / FAX: +255-22-2123621. Product types: Solar Home Systems, Solar Pumping for Water Supply and Irrigation.

Ensol (T) Ltd., P.O. Box 42227, Dar es Salaam, Tanzania. Telephone/Fax: +255-22-2420176. Product types: PV Systems, Power backup systems.

Rex Investments Limited. Telephone/Fax: +255-22-2180109 / Cell: +255-71-3607533. Product types: PV Systems, Power backup systems.

Wind Power

Wind power is when the movement of wind is converted into electricity using a 'turbine'. Wind power is less commonly used in Tanzania than solar power. However, it is generally cheaper and preferable for areas that have a steady and constant breeze.

Wind Turbine mounted on a guyed mast (Source: www.bergey.com)

Wind turbines usually have two to three blades which spin in the wind. The blades are connected to a rotor which drives an electricity generator. It works on the same principle as a dynamo on a bicycle but on a slightly bigger scale. The blades and rotor are mounted on a movable axis which has a fin connected to it as well. The purpose of this fin is to always direct the rotor and blades directly into the oncoming wind.

Wind turbines come in a large variety of sizes ranging from very small units, usually used in yachts and small ships, to massive 'wind farms' that produce enough power to supply a small city. The biggest known wind turbine is the Enercon E112 which has a rotor diameter of 112 metres and an output capacity of 6MW. (Source: Wikipedia)

A smaller wind power system has many of the same components as a solar system, except the wind turbine replaces the solar panels. It generates and stores power in very much the same way, compensating for periods during which there is little or no wind with periods of high wind. Wind systems are generally cheaper than solar systems but this is only true on the international market. After importation, they seem highly priced. This may be due to shipping costs, the lack of sufficient competition in the market, or as a result of low demand for the product.

Although they are slightly cheaper then solar power (on the international market, that is), they need a little more maintenance than a solar system. This is because the turbine is constantly turning and, every once in a while, it is advisable to make sure that all the moving parts are well lubricated. This can be a daunting task when the rotor is mounted 3040 metres off the ground! Installation is also slightly more difficult because the rotor must be mounted on a mast or tower in order to stay clear of wind turbulence. Wind turbulence occurs closer to the ground and forms uneven and bumpy wind patterns that are not good for either the rotor or the turbine. They are like 'pot-holes in the road'.

However, wind power systems have a lot of potential in areas that are remote and need reliable power. For example in Kenya, Safaricom, a cellular provider, has deployed wind turbines at several remote sites, one of them at Laisamis, with very positive results.

Pico-Hydro (Micro Hydro Dam)

Pico-hydro is defined as a micro version of a hydro electric dam. A pico-hydro power system would have a maximum electrical output of 5 kilowatts (kW); sufficient to power light bulbs, radios, televisions, refrigerators and food processors. Recent innovations in pico-hydro technology have made it an economic and versatile source of power even in some of the world's most resource-poor and inaccessible places. Standard AC electricity can be produced and distributed throughout a village to power electrical appliances, or it can charge large batteries for households.

There is also micro-hydro power which is on a larger scale producing up to 100kW of power while the regular hydro power plant is on a national scale. For our purposes, we will only deal with pico-hydro power.

In theory, a pico-hydro power plant is exactly like a wind system, except it derives energy from the flow of water instead of the wind. The interesting thing about Pico-Hydro is that almost the whole system can be fabricated and built locally with minimum or no importation of specialised equipment.

A standard Pico-Hydro system works in the following manner. First, you have to create a sort of miniature dam; a catchment area of water called a Forebay Tank. Then you can regulate the flow of water through a pipe called a penstock. The greater the height of the Forebay tank from the actual turbine, the greater the force of the water. Likewise, the larger the penstock and supply of water is, the stronger the flow. Both of these elements cause a greater amount of electricity to be produced. At the bottom of the penstock is an adjoining piece of pipe that also creates a narrow nozzle from which water will rush at high speeds. This section is called the Flow Shaping End Nozzle. Finally, the high pressure water hits the blade of the turbine, which turns the generator and, lo and behold: electricity is produced. This is graphically illustrated below.

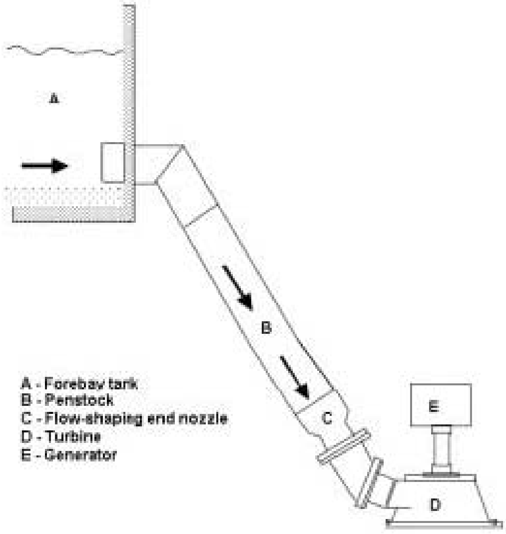


Figure 6: Standard Hydro Power Generation Setup (Source: www.tve.org)

This system may look a little complicated but it is actually very simple. The whole set-up can and has been fabricated out of locally available materials. For example, Kathamba and Thima, in the Kirinyaga District of Kenya, are the recipients of a pico-hydro scheme, with assistance from ITDG East Africa and Nottingham Trent University's Pico-Hydro Unit. In Kathamba during the wet season, the spring produces 8 litres of water per second, generating approximately 1.7 kW to 2 kW of power. This is distributed to more than 30 households, with another 35 homes awaiting connection. The scheme in Thima covers 66 households. Each 'package' consists of light units and a socket for which users pay between US$55 and $75 to be connected to electricity. Fuel costs have been dramatically reduced, with money saved each month on kerosene and dry cell batteries. (source: http://www.tve.org/ho/doc.cfm?aid=871)

There is also a documented case study in Tanzania for a micro-hydro scheme that produces 10 kW in Kinko Village, Tanga Region. The project costs about US$50,000 and supplies reliable power to 100 households and some small business. More information about this project can be downloaded from www.ics.trieste.it/Documents/Downloads/df4338.pdf (Warning: the file is 7.5MB in size).

The only element that may need to be imported is the generator. However, this generator is usually available in specialised stores in Dar es Salaam. One could even convert a regular pump motor into a generator as they run on the same principle. If you want to know how to do that, request the manuals from the Nottingham Trent University website (link given below).

A pico generator using a regular motor (Source: www.tve.org)

The conversion of water flow to electric power actually passes through three energy conversions. It starts off as Hydro Power and as it goes through the penstock it loses as much as 30% of energy while being converted to Mechanical Power. It then loses more power (up to 30%) while going though the turbine and being converted to Electrical Power. There is a further loss of power (again, up to 30%) due to the generator. In general, an efficient pico-hydro system undergoes a 40%-50% power loss from the original hydro power.

To determine whether your local stream or small river can provide sufficient energy, you need to calculate the hydro-power. The hydraulic power in a stream can be calculated when the Head and the Flow have been measured. The head is the vertical distance from the catchment area or Forebay Tank to the location of the turbine. The Flow is the calculation of the amount of water that can flow though the penstock in litres per second. Once you have determined these values, you can use the following formula:

Power = Head (metres) x Flow (litres per second) x 9.81

Example: If the head = 30 m and the flow = 7 l/s then: Hydo Power = 30 x 7 x 9.81 = 2,060 watts or 2 kW

If we assume our pico-hydro system to be 50% efficient, this relates to 1kW of electrical power.

Some literature and manuals for building a pico-hydro system are available from http://www.eee.ntu.ac.uk/research/microhydro/picosite/ where you can request certain publications.

Bio-Mass/Bio-fuel

Bio-Mass is defined as substances that are created from biological process and that have an energy value. There are many types of Bio-Mass and one such type is Bio-Fuel. Other forms are gas (biogas) and solid (raw biomass, briquettes, pellets). Together, these three forms are called bioenergy. These different forms can be used for power production, which can be combined with the production of heat or cooling as well. Biomass is highly versatile, can be collected locally, and usually involves the local community or local farmers. Biomass sources, can be agricultural residues, e.g. from coconut, corn, etc; woody biomass from forests or bushes, organic waste/garbage and so on.

Bio-Fuel is either Straight Vegetable Oil (SVO) or Waste Vegetable Oil (WVO). The oil can be used to run a generator that produces electricity. The generator is a diesel generator but is modified to accept either SVO or WVO. Although this is a relatively new for Tanzania, there have already a few case studies. One focuses on a facility run by the Vincentian Sisters in Mbinga. The energy system was designed to run on a hybrid system using both solar power as well as a generator that runs on oil from the Jatropha plant (www.solarserver.de/solarmagazin/anlage-e.html). This plant is said to have a high value for producing energy-rich oil and can grow in any climatic region all year round. The system in Mbiga supplies power to the facility as well as the surrounding areas.

To convert the diesel generator into one that accepts SVO, a 'conversion kit' must be purchased. It is also necessary to have some technical know-how on how to install it too. At the time of writing this report, no known specialised commercial vendors in Tanzania were either selling these kits or offering installation services.

Bio-diesel, on the other hand can be made completely from bio-mass or a combination of bio-mass and diesel. This also requires a little modification by a trained technician, but there are some engines that can now run on this hybrid mixture without any alteration.

The above cases are quite rare and these solutions need more research and piloting to design a system for particular needs. Keep in mind that the above examples continue to produce carbon emissions though on a greatly reduced rate than that of regular diesel. Bio-Mass energy solutions are considered as zero-carbon energies as they produce only the same amount of Carbon Dioxide as they consume in the process, making them highly desirable for the environment.

Some additional reading on Bio-Mass and Bio-Diesel can be found at:

Straight vegetable oil as diesel fuel. http://journeytoforever.org/biodiesel_svo.html

Waste vegetable oil as a diesel replacement fuel. http://www.goodgrease.com / http://www.shortcircuit.com.au/warfa/paper/paper.htm

What is bio-diesel? http://www.biodiesel.org/resources/biodiesel_basics/default.shtm / http://www.eere.energy.gov/afdc/altfuel/biodiesel.html

10. Conclusions and Recommendations

Establishing Internet access in rural areas in an affordable and sustainable manner is clearly not a simple task. The following aspects of connectivity and energy supply and steps can guide organisations engaged in rural access activities.

Connectivity and Internet access

Carry out a bandwidth needs analysis and compare options. Connectivity and Internet access can be achieved in many ways based on technical requirements and costs. The needs for bandwidth may vary. It is therefore recommended that an organisation carries out a thorough assessment of present and future needs and compares the various options before it makes any investment. A realistic evaluation of the actual bandwidth needs can make for considerable costs savings and affects the sustainability directly.

Cost of Internet access. Internet connectivity is relatively costly in Tanzania. In rural areas V-SAT is a common option. These can be expanded by using wireless broadband. Investment costs for a V-SAT connection is US$2,000 to US$4,000 and a monthly fee of US$250 to US$800, depending on the bandwidth. Maintaining the equipment is problematic and costly, which reduces profitability. ICT training in rural areas would be needed. Wireless broadband options are slightly cheaper with investments between US$400 to US$1,300 and a monthly fee ranging widely from US$40 for a shared 16k line to US$2,650 for a 256k dedicated line.

Share costs. As costs for connectivity to the global Internet via V-SAT are high it is recommended to optimise use of the bandwidth and explore options to offset the high monthly costs e.g. by sharing connectivity or generating income via VoIP.

Monitor and control the use of bandwidth. Tools to monitor the provision of bandwidth are useful for claims to providers regarding the bandwidth that is actually delivered compared to the amount that has been contractually agreed. Tools to regulate bandwidth use are crucial to optimise usage during the 24hrs availability of the connection. This can be done using pre-set policies. Finally, if a problem with the network does arise, tools exist that can help to identify the origin of the problem and assist with troubleshooting.

Reduce costs through collective action. Rural organisations could collectively bargain for connectivity. For example, if 20 telecentres buy Internet access individually they would pay much more than if they joined together as a group and then negotiated with an ISP for a larger purchase.

Energy

Rural energy is crucial for rural access. Rural access can be severely undermined by an inadequate or unreliable power supply. This should be factored into all plans to establish connectivity in rural areas. Many options exist for power supply, some of which are listed in this report. A sound energy plan and implementation process will save costs and troubles at a later stage. It also reduces the risk of damage to equipment. The use of renewable energy offers environmental and socio-economic benefits for the local community. A decentralised or local power supply will help to extend the operating hours and services of your telecentres.

Calculate and reduce energy needs. It is necessary for any power supply or backup system to know the power consumption. This report gives guidelines on how to calculate this. Power needs can be reduced by using energy-efficient equipment such as flat screen monitors rather than old screens and laptops over PCs.

Ensure power backup and fluctuation control. If use is made of power from the grid this has to be consolidated with energy backup solutions and probably alternative power supply solutions. It is recommended to install a UPS that absorbs acute power cuts. The capacity of the UPS should match the needs to continue operating the system during grid power-cuts. Simple UPSs that absorb power cuts for a few minutes are rather cheap, around $40-$80. Extended power backup solutions are rather costly and range from US$6,000 to US$8,000. It is advisable to purchase a surge arrestor that eliminates peaks in power which can damage equipment (cost: around US$50).

Use common energy-batteries for energy storage. Most systems need batteries to store the energy generated and release it during other times. Normal energy-storage batteries are cheaper but do not last as long as the deep-cycle batteries which cost twice as much. Car batteries are not recommended because they need regular maintenance and produce corrosive fumes. Sealed maintenance free batteries are recommended and cost around US$300 for a 120AH piece.

Solar panels. These are commonly available in Tanzania. They require little maintenance once installed. The cost of a 240 Watt solar panel that provides 6 hours of use for a 40 Watt bulb is, on average, US$300.

Wind, biomass and pico-hydro energy. These are relative new types of energy in Tanzania. It is recommended that these alternative sources of energy are piloted and closely monitored, documented and shared in order to support connectivity and access in rural areas.

Appendix: Options and Costs of Connectivity

A sample of providers of the various services is given below. This is not meant to be a comprehensive list, nor an inventory of all the providers. It is only intended to give the reader an idea of the types of services available, their characteristics, prices, and an overview of some of the ISPs that provide them.

a) Dial-up

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Africa Online	Dial-in from anywhere. Local POP in Dsm.	33.6kbps where the TTCL copper is of a high grade	Offered	Purchase of modem, service sign-up and configuration on PC. Fairly easy.	$15 + Modem cost	Starting at $10.85 for 'pay as you go' to $57.5/m for unlimited use
Cats-Net	Dial-in from anywhere. Local POP in Dsm, Moshi	As above	As above	As above	Cost of Modem only	$36/m unlimited usage including 1 mailbox (20MB)
Habari Node Marie	Dial-in from anywhere. Local POP in Arusha.	As Above	As Above	As Above	Cost of Modem + $50 for registration in society (ANM is a society)	$24/m for e-mail only and $36/m for unlimited service
Raha.com	Dial-in from anywhere. Local POP in Dsm.	As Above	As Above	As Above	Modem Cost only	$30/m unlimited usage
SimbaNet	Dial-in from anywhere. Local POP in Dsm.	As Above	As Above	As Above	As Above	$20/m unlimited usage
University Computing Centre	Dar Es Salaam, Dodoma, Mwanza	As Above	credit note offered for down time	As Above	As Above	$30/m unlimited usage
Zanlink	Dial-in from anywhere. Local POP in Zanzibar.	As Above	Offered	As Above	As Above	$20/m unlimited usage

b) Cable (UTP)

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Cats-Net	Dsm city only	Throughput range btw 16-128kbps. Fairly reliable.	Offered	Client needs a LAN card in PC. Installation done by staff.	$90 + LAN card	Starts at $60/m going down to $40 based on volume or pre-paid purchase
Zanlink	Zanzibar Stone Town only	Throughput range btw 64-512kbps. Quite reliable, network backed by fibre optic cable and centralised power supply	Offered	As above	$200 including LAN card if needed	Shared Broadband $60/m. Dedicated bandwidth plans start at $250 per month for 64kbps
Habari Node Marie	In selected areas of Arusha town and district	Throughput range btw 64-512kbps. Quite reliable.	Offered	As above	$50-$100 depending on location	Shared home user $60, Shared 64kbps $150, shared 128kbps 450

c) ADSL (via the Tanzania Telecommunication Company Ltd. (TTCL))

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
The Tanzania Telecommunication Company Ltd. (TTCL)	Whole of Tanzania depending on copper quality	Usually very good if copper quality is good. For home user and small business it is 512kbps uplink and 2048kbps downlink	Offered	Customer Request => TTCL Survey => TTCL confirms availability => customer purchase CPE and Pays for the service => Customer connected	*TSh 25,000	Home user and small business is TShs 40/MB download. Business Corporate is TShs 360,000/m unlimited for 1MB up /2MB down link, 1 IP address. Café is TShs 450,000 unlimited for 1MB up /2MB down link, 5 IP addresses
Africa Online	Whole of Tanzania although some areas have poor service. The best service is in Dar, Arusha, Moshi, Zanzibar, Songea, Mbeya, Dodoma	Usually very good if copper quality is good. Throughput between 128kbps and 256kbps	Offered	As above, average 7 day connection period	$100-$250 inclusive of modem and splitter	$100 for 128kbps unlimited download and $250 for 256kbps unlimited download

*TSh = Tanzanian shillings

d) ADSL (via private copper)

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Arusha Node Marie	Most areas of Arusha Municipality	Reliable as independent of power and 3rd party network	Offered	Straight forward	$100 deposit on DSL Modem + $50-100 connection fee	Shared home user $60, Shared 64kbps $150, shared 128kbps 450

e) Wireless (ISM Bands)

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Cats-Net	Most areas of DSM -Gradually being phased out	Throughput ranges from 16k to 128k variable due to shared access. Latency to the Backbone router - Min -20ms and Max - 120 ms	Offered	Currently no new connections accepted on this	N/A	approx 40-60$ a month per computer for unlimited access, inclusive of 1 mail box of 20 Mb
SimbaNet	Morogoro, Tanga, Bukoba, Tabora, Dodoma, Mwanza, Mtwara	Starting Shared bandwidths to dedicated bandwidth allocations of any size.	Offered	Straight forward with installation at clients end with external Antenna	$500 - $750	Starting $150 for Soho. $350.00 Corporate account. 128 Dedicated = $650.00
Raha.com	Dar es salaam, Kibaha, Bagamoyo	from 64k up to 3Mbps and higher if required	Offered	Fairly Easy -depending on sites (average deployment time 2-6 hours)	$750.00 - for Broadband Hardware | Installation: $200.00 | Router (BASIC): $150.00	Shared 64kbps is $300, 128kbps is $450. Dedicated: 64kbps (burst to 128kbps) is $1,000, 128kbps (burst to 256) is $1,750 and 256kbps (burst to 512kbps) is $2,600
University Computing Centre	Dar Es Salaam, Dodoma, Mwanza	<50ms	Credit note offered for downtime	Very Easy	$1300	4.0$/kbps
Zanlink	Covering the whole of Zanzibar as well as the Pemba Islands	Between 64kbps and 516Kbps	Only if the service is down for more than 3 days	Very easy, since we have Repeaters everywhere. Average connection period is about 1 -2 days	Around $800	Shared Broadband $60/m. Dedicated bandwidth plans start at $250 per month for 64kbps
Arusha Node Marie	Kia Airport to Ngaremtomi. Including: KIA Airport, Usa River , Duluti, All Arusha town, up to Ngaremtoni.	As per service plan selected. Generally, latency within network is under 50ms	Offered	Straight forward with installation at clients end with external Antenna	$800 + tower cost ($101,000)	Shared home user $60, Shared 64kbps $150, shared 128kbps 450

f) Wireless (Licensed Frequencies)

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Afsat	Dsm city only	High quality links	Offered	Installations within 2 days from date of order. Payment upfront depending on the given terms and conditions. A service contract is also recommended but not necessary.	$2500 installed	Vary from $300 and above depending on type of service and bandwidth used.
SimbaNet	Dsm city only	High quality links	Offered	To install Wireless equipment at customer place.	$500 - $1250.00	128 Dedicated = $650.00 256kbps = $1100, 512 kbps= $2200.00
Africa Online	Dar, Mwanza, Moshi, Zanzibar, Arusha	High quality links for Dedicated Bandwidths only	Company has compensation policy. Company has SLA 99.5%.	To install wireless equipment at customer location.	$1000+wireless equipment and router	Dedicated 32k-$600, 64K-$1000 128k-$1850 WAN: 64k-$150, 128k-$300, 256K$500
University Computing Centre	Dar Es Salaam, Dodoma, Mwanza	<50ms	Credit note offered for down time	Very Easy	$1300	4.0$/kbps
TTCL	Arusha, Kilimanjaro, Morogoro, Mara, Dodoma	Mostly 64kbps though the channels can be combined to provide up to 256kbps though not encouraged	Company has a policy to compensate for non-delivery of service	Customer Request => TTCL Survey => TTCL confirms availability Customer purchase CPE and Pays for the service => Customer connected	US$ 800-1500.00	Home user and small business is TShs 40/MB download. Business Corporate is TShs 360,000/m unlimited for 1MB up/2MB down link, 1 IP address. Café is TShs 450,000 unlimited for 1MB up / 2MB down link, 5 IP addresses.

g) Mobile Technologies (3G, GPRS, CDMA)

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Celtel – GPRS	Most of Tanzania: Dar, Arusha, Dodoma, Iringa, Kagera, Kigoma, Kiliminjaro, Lindi, Manyara, Mara, Mbeya, Morogoro , Mtwara, Mwanza, Pemba, Pwani, Rukwa, Ruvuma, Shiyaga, Singida, Tabora, Tanga, Zanzibar and the surrounding areas of the aforementioned towns.	Shared Bandwidth	N/A – pay as you go. No service, no payments.	Same day once GPRS modem and Celtel Sim card is obtained.	GPRS Modem costs Tsh250,000	Bundled access-Tsh 25,000 p/m for 100mb, Tsh 250 per mb thereafter. Unbundled -Tsh 0.47 per KB
Vodacom – GPRS	Whole of Tanzania as per Vodacom coverage	Up to 1.8Mbs	No - you only pay for what you use.	Same day once data card or modem is purchased and appropriate paperwork filled out.	USB Modem for laptop or PC cost Tsh 370,000 Datacard for Laptop only costs Tsh 345,000	Unbundled: Tsh 360 / MB Bundle based on 24-month contract: MyMeg 500 is Tsh 60,000/month for 512MB -Tsh120 per additional Mb, MyMeg ONE is Tsh 92,000/month for 1GB - Tsh90 per additional Mb, MyMeg TWO is Tsh 163,000 /month for 2GB - Tsh80 per additional Mb No Contract: same as above except for cost of additional MB usage; MyMEG 500-Tsh250 per additional Mb, MyMeg ONE/TWO Tsh200 per additional Mb.
Vodacom – 3G	Dsm City only	Up to 3.6mbs	No - you only pay for what you use	As Above	As Above	As Above

Zantel – CDMA 800	Dar and surrounding areas, Pemba and Zanzibar. Further roll out by late 2007 to larger towns including Mwanza and Arusha	Throughput up to 2mbs	No - it is Pre-paid based on usage	Same day once customer has purchased a Z-connect starter pack and data access device	From Tsh190,000 to Tsh370,000 depending on type of device purchased	Tsh450 per MB
BOL – CDMA 450	Dar. Plans to increase coverage in the next 2 years	256kbps throughput	Pay as you use	Same day, after approval and hardware purchase	CDMA phone handsets from Tsh75000. Connecting cable between phone and computer Tsh25,000	Prepaid- Tsh75 per Mb
TIGO	As per Tigo Coverage-all major towns and several regional areas, plans to add 300 new towers in the near future	up to 115kbs	Refund policy in place	Same day after application is approved. (The service is only postpaid.)	$150 for GPRS enabled phone or modem	Tsh30,000+vat per month inclusive of 300mb of downloading. Tsh100 per 1mb thereafter

h) Mobile Technologies (Proprietary)

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Cats-Net – UMTS-TDD (IPWireless)	Most areas of Dsm city	Throughput based on subscription plan can range from 64k to 1 Meg. Latency from 50 -200ms	Offered	Very Easy - Desktop Modem with USB/Ethernet Cable to connect to PC or Router	$500	50$ for 64k shared, 84$ for 128k shared per month unlimited access
BOL Navini	Dar and Arusha. Plans to increase coverage in the next 2 years	Up to 2 Mbs	Compensation for Downtime for customers with dedicated bandwidth	Same day after approval of application	$400 for wireless modem	$40 per month for unlimited usage with shared bandwidth. $600-$900 for dedicated bandwidth of 128k

i) Satellite, C-Band with LOCAL hub

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
SimbaNet	Whole of Africa	Dedicated bandwidths starting 64kbps to few mbps	Offered	To install dish antenna, outdoor unit and modem.	Starting $4000.00	Starting 64kbps = $450.00, 128kbps = $800.00

j) Satellite, Ku-Band with LOCAL hub

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
SimbaNet	East Africa including Tanzania, Kenya, Uganda, Rwanda, Burundi and South Sudan.	Dedicated bandwidths starting shared 64kbps to few mbps	Offered	To Install Dish Antenna, Outdoor unit and modem.	Starting $1500.00	Starting Shared 128kbps = $250.00, 64kbps dedicated = 450.00, Dedicated 128kbps = $800.00

k) Satellite, C-Band with FOREIGN hub

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
SimbaNet	Whole of Africa	Dedicated bandwidths starting 64kbps to few mbps	Offered	To install dish antenna, outdoor unit and modem.	Starting $4000.00	Starting 64kbps = $450.00, 128kbps = $800.00
University Computing Centre	The whole of Tanzania	700ms	Credit note offered for downtime	Easy	$8,500	4.0$/kbps

I) Satellite, Ku-Band with FOREIGN hub

ISP	Geographic Coverage	Quality of Service	Downtime Compensation	Ease of Deployment	Initial / Equipment Cost	Bandwidth & Recurrent Cost
Afsat	Across sub-Saharan Africa including the whole of Tanzania	99.5% availability with 800ms latency to the backbone	Yes. We have a 'buy back' scheme for customers who are not satisfied with our services. We also have a clause in our service agreement on credit refunds on non-delivery of service.	Installations within 2 days from date of order. Payment upfront depending on the given terms and conditions. A service contract is also recommended but not necessary.	$2,500 Installed	Vary from $175 to 3,500 per month depending on type of service plan/bandwidth configurations
SimbaNet	East Africa including Tanzania, Kenya, Uganda, Rwanda, Burundi and South Sudan.	Dedicated bandwidths starting shared 64kbps to few mbps	Offered	To install dish, antenna, outdoor unit and modem.	Starting $1500	Starting Shared 128kbps = $250, 64kbps dedicated = 450.00, Dedicated 128kbps = $800
University Computing Centre	The whole of Tanzania	700ms	credit note offered for down time	Very Easy	$1,500	4.0$/kbps

Acronyms and Abbreviations

AIXP (Arusha Internet Exchange Point)

ASDL (Asymmetric Digital Subscriber Line)

BOL (Benson Informatics)

DSLAM (Digital Subscriber Line Access Multiplexer)

EASSy (East African Sub-Marine System)

HMIS (Health Management Information System)

ICT (Information and Communication Technology)

ICT-RC (ICT-Resource Centre)

IICD (International Institute for Communication and Development)

ISP (Internet Service Provider)

IT (Information Technology)

MUCHS (Muhimbili University College of Health Sciences)

NGO (non-governmental organisation)

OSS (Open Source Software)

POP (Point of Presence)

SHDSL (Systematic High-Speed Digital Subscriber Line)

SLA (Service Level Agreement)

SVD (Straight Vegetable Oil)

TIX (Tanzania Internet Exchange)

TTCL (Tanzania Telecommunication Company Ltd.)

tzNIC (Tanzania Country Domain Register)

UPS (Un-interruptible Power Source)

UTP (Un-Twisted Pair)

VAT (Value Added Tax)

VoIP (Voice Over Internet Protocol)

WVO (Waste Vegetable Oil)

WLL (Wireless Local Loop)

Zantel (Zanzibar Telecommunications Ltd.)

About Suhail Sheriff

Suhail Sheriff is a free-lance consultant working specifically on IT setups and information systems. He is particularly interested in areas of using ICTs for national development. He is also the Chairperson of the Tanzania Internet Service Providers Association (TISPA) who, among other activities, setup and run the Tanzania Internet Exchange (TIX) and the Arusha Internet Exchange Point (AIXP). Suhail also serves on various committees and task forces such as the Tanzania Country Domain Registrar (tzNIC) and the independent think-tank for the Ministry of Infrastructure Development (MoID).

About ICT-Resource Centre

The ICT-Resource Centre is a not-for-profit organisation that promotes the use of ICT for development. The ICT-RC aims at being a focal point for the testing, innovating, implementing and support for new and 'appropriate' technologies in the field of IT. Its aim is to assist other organisations to meet their individual objectives much better by using IT in the most cost-effective, productive and sustainable way possible.

About SWOPnet

The report of this study is disseminated via SWOPnet (www.swopnet.org) to ensure wide distribution to the various stakeholder groups in Tanzania. SWOPnet is the national ICT for Development network in Tanzania. Activities undertaken by SWOPnet embrace both Dar es Salaam and the Mwanza region with ICT for Development as their core theme. They focus on exchanging experiences, thus learning from partners and counterparts in other countries, supported by the motto: "Knowledge is power, but only if shared!"

About IICD

The International Institute for Communication and Development (IICD) assists developing countries to realise sustainable development by harnessing the potential of information and communication technologies (ICTs). The driving force behind IICD's activities is that local 'change agents' themselves identify and develop proposals for realistic ICT applications - local ownership forms the essential basis for sustainable socio-economic development. Acting as a catalyst, IICD's three-pronged strategy is mainly delivered through a series of integrated Country Programmes. First, IICD facilitates ICT Roundtable Processes in selected developing countries, where local stakeholders identify and formulate ICT-supported policies and projects based on local needs. Second, working with training partners in each country, Capacity Development activities are organised to develop the skills and other capacities identified by the local partners. Third, IICD draws on its global network to provide information and advice to its local partners, also fostering local information exchange networks on the use of ICTs for development. The best practices and lessons learned are documented and disseminated internationally through a Knowledge Sharing programme. In support of these activities, IICD invests in the development of concrete partnerships with public, private and non profit organisations, thus mobilising knowledge and resources needed by IICD and its local partners. Country Programmes are currently being implemented in Bolivia, Burkina Faso, Ecuador, Ghana, Jamaica, Mali, Tanzania, Uganda and Zambia. More info www.iicd.org

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