Draft Report on Rural Connectivity Planning And Related Locally Sustainable Technologies

by

Mr. Samudra E. Haque

Short Term International Consultant

ICT – Assisted Development Project/ World Bank P078458

Ministry of Capacity Building

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Synopsis

This consultancy report describes the outcome of a specialized mission authorized by the Ministry of Capacity Building, Gov't of Ethiopia to undertake a short survey of the existing, vibrant and progressive ICT industry in Ethiopia in February/March 2004 and to report on two innovative technical demonstrations organized in conjunction with the public and the private sector. These technical demonstrations were designed to introduce low-cost, flexible use, ICTs for deployment in "zero-infrastructure" areas to policy makers and engineers in the ICT industry in order to address their needs to expand ICT services into areas where traditional telecommunications infrastructure and planning has been estimated to be unprofitable.

The particular technology practice chosen for this short mission, "Broadband Multi-Service Switching Transmission and Distribution Architecture", or *BMSTDA,* originated from public demands by the Internet user community in South-Asia in 1999 and is one of a family of recognized related low-cost technologies used by ICT practitioners around the world. In this report, a considerable amount of detail is presented on the 'how' and 'why' of the technology as well as estimates of the cost of implementing large scale deployments as well as an estimate of the benefits that can be achieved if wide spread deployment is undertaken.

Apart from the technical demonstration, the deliverables of the mission included extra educational materials and software materials which are in a format suitable for distribution (CD-ROM) that could help in transferring of know-how to build small scale Internet Service Providers or Application Service Providers, and contained public domain source code and ready-built operating system and applications. In fact, these materials were collected from the same sources that Asia-Pacific ICT industry typically collect their software from and use it to build their own services.

During the technical demonstration, these software applications were used to create *in-situ*, ad-hoc Internet Service Provider facility for use by the attendees of the demonstration, independent of any national or private telecommunications infrastructure and able to be used just like any global provider of content and applications.

Objectives and Challenges

The Consultant for this mission was tasked to introduce low-cost broadband communications technology to the engineers and administrators currently involved in ICTs programs and projects in Ethiopia. Prior to the mission, before the actual visit to Ethiopia could be organized, preliminary research on the available country data[1,2,] showed that it seemed to have limited communications infrastructure, inadequate policies to utilize existing capacity through the telecommunications backbone, unwillingness to allow private sector participation in the deployment of telecommunications services and lack of a suitable mix of satellite and terrestrial technologies to deliver services to the end user. The Infostate of Ethiopia in 2001 was reported to be 138 out of 139 countries surveyed while the Infodensity rank was 137 and the Info-Use rank was 138[3].

A visit was arranged from 12-25 February 2004, with a very specific agenda (see Terms of Reference) requested by the Ministry of Capacity Building, ICTAD which could certainly be considered ambitious in its goals. It was created with a specific target of providing proof-of-concept demonstration to as many stakeholders as available within the shortest time. The reason for this quite specific plan to demonstrate "low-cost" technology in a "learn-by-doing" approach was intended to avoid the traditional pitfall of discussion, evaluation, research, pilot, assessment and recommendation process which would have taken perhaps several months at a large expense and would have resulted in an understanding most probably of "it is possible". Since the ICTs chosen for the proof-of-concept demonstration had already been in commercial use in countries over several years such as Bangladesh, India, Indonesia, Laos it was felt that a real, live demonstration would be useful to dispel any preliminary doubts and special attention was given to having the opportunity to address relevant questions by stakeholders which might be asked, such as "What if..", "How..", "Why.." etc.

A large part of the conceptual challenge revolved around the global work-in-progress idea that this "new", low-cost *Broadband Multi-Service Switching, Transmission and Distribution* Architecture based technology should be easy to implement by technicians and engineers of all skill levels and that it should be easily repaired in the field if things go wrong. It is understood through discussion with the stakeholders that there had been no prior introduction of this type of technology prior to the arrival of a specialized consultant to Ethiopia in either of the sectors of Research/Education, Private/Commercial or Gov't/Telecommunications industry.

In order to fulfill the objectives of the mission therefore it was necessary to organize a mini-development strategy to work out the precise practical engineering details to build the system, test it and make sure it works well *in-situ*. It had to be designed and implemented at short notice and the test network setup as well as the test servers and workstations programmed in the shortest possible time. A hard deadline that had to be set

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[1] See http://www.cia.gov/cia/publications/factbook/geos/et.html (2003)
[2] Various ITU indicators
[3] "Monitoring the Digital Divide … and beyond", Sciadas, George, Editor, Orbicom, 2003

was the fixed departure date of this Consultant from Addis Ababa on the 25th, and it was necessary to organize two demonstrations which were at the Ethiopian Telecommunications Corporation headquarters building to all senior operational staff and Addis Ababa Chamber of Commerce to all interested private sector and gov't sector attendees.

By establishing an artificial deadline (and a quite difficult one to uphold even in the most developed countries,) for preparation of a local team to develop a live network suitable for proof-of-concept demonstration, volunteers were inducted from both the ETC and the private sector and in certain cases each group helped out one another in organizing amazing amount of resources that could not have otherwise been ordered in time. The technical skills of the engineers and technicians was found to be of *world-class* quality enough to be considered "*Expert"* by any measures in many distinct disciplines of Software Programming, Electronics, Radio Engineering, Mechanical and team-work really was the key to the success despite each volunteer doing work after their regular office hours and official duties. During the preparation of the 2nd proof-of-concept demonstration a significant hardware failure happened that was unexpected and would have caused the entire project to be rendered useless, yet the knowledge transferred during the preparation allowed the local Ethiopian engineers to rebuild from scratch and to implement a standby solution – this is exactly the sort of flexible thinking required to implement versatile ICT projects in the vast regions of Ethiopia and to ensure success in every respect, and is an enviable skill to possess world-wide.

The biggest challenge facing this consultant was of course to consider how to assess the needs of providing for rural connectivity in Ethiopia. Located in the Horn of Africa, it is a literal vast rugged country encompassing over 1.1 million sq. km of land, and home to over 64 million people of more than 70 ethnic and linguistic groups. The topology of the land ranges from desert areas gradually extending to fertile plateaus higher elevation around the central high plateau dotted with high mountains and deep valleys. The history of the country remarkable continuity through the ages as an independent state and its achievements and recorded progress in economic growth and development objectives should certainly be considered a role model for many developing countries faced with constrained resources and limited access to world markets for export of goods and products.

Reviewing Existing ETC Infrastructure and Services

Legacy Services

Ethiopian Telecommunications Corporation (ETC) is still the incumbent national operator which operates a modern digital telecommunications network that providing efficient nationwide fixed and mobile telephone service. The network capacity on most of the long-haul transmission routes are what you would expect from a typical hybrid fiber and microwave network, where possible STM-1 (155Mbps) or E3 (34 Mbps) for wireless routes and for fiber circuits, 622 Mbps and 2.5 Gbps interfaces are available for use as needed. It can be said that the transmission network is satisfactory for a multitude of services as long as the services utilize the SDH hierarchy of E1 (2 Mbps), E2 (8 Mbps), E3 (34 Mbps), STM-1 (155 Mbps), STM-4 (622 Mbps), STM-16 (2.5Gbps) for the required interfaces.

The political divisions of Ethiopia are numerous and diverse in size and population demographics, and in the short time available for the mission it was not possible to tabulate in detail the full telecommunication network diagram/resources and Points-of-Presence. However from interviews with senior management of ETC it was evident that there is well trained manpower within the organization available to manage a mix of Fixed Satellite, Fixed Cellular, Fixed Microwave Transmission, Switching (PSTN, Data/IP, Frame Relay/ATM, GSM, Multi-media/Optical, Wireless Local Loop, Wireless Data/IP) equipment spread around distant corners of the country. There are existing expansion plans to provide advanced networking capacity including DSLAM available in the 28 *woredas* of Addis-Ababa but throughout the rest of the country, standard SDH transmission network is deployed that can typically provide one E3 (34 Mbps) or sixteen individual E1 (2 Mbps) interfaces at each of the Points of Presence.

It is expected that future generations of subscribers in the main rural towns will also be provided with advanced connectivity should there be sufficient demand. The real issue of service deployment revolves around the problem of lack of local network (i.e., copper, fiber or wireless to the customer premise) at the various regional, zonal, *woreda* or local town/village level. Only in the last six-months to nine months prior to this mission, has ETC provided direct E1 digital trunk telephone service to private customers installing their own EPABX switches.

Of particular note are the ongoing ETC efforts to commission and deploy in excess of 600 sets of Satellite Earth Stations along with a VSAT Hub Earth Station at Sululta Earth Station to serve multi-purpose data communication service network. The first two networks are called *Woreda-Net* and *School-Net*. The satellite equipment has been purchased from a US manufacturer of TDM/TDMA VSAT equipment and designed to provide on-demand services including video-conferencing, VOIP telephone connections, internet content streaming and regular internet access to all parts of Ethiopia using C-band transponders on the Intelsat 901 satellite in service over the Atlantic Ocean Region. Technical designs and plans are being developed in conjunction with the contractor/systems integrator of South African origin but the overall installation and implementation of the Satellite part of the network are being executed by regular ETC engineers. The terminal equipment to be used in conjunction with the satellite network are being installed also by ETC engineers which include Routers, Video Conferencing equipment, Plasma large screen TV, servers, IP telephones etc..

Generally speaking, core Ethiopian telecommunications network infrastructure was observed to be modern, well designed and uses latest standards. The presence of Frame Relay services, TDM/Leased services, IP Services, IPLC Services, GSM services, Wireless local loop services (for fixed telephony, and soon for wireless IP service) indicate that given adequate need for local content and applications using that content, such applications can be delivered anywhere that ETC has a operational Point-of-Presence.

An anecdotal proof of the quality of the ETC network is that it has contributed so well to the civil society as a reliable means of communicating such that in most of the commercial advertisements published in the newspapers, the only means of communicating that are printed are the telephone numbers to call for information. While it is a well known fact that street addresses are rarely used in Ethiopian cities and directions to a particular meeting place are always available on request, the complete absence of any physical location information often surprises the unwary international visitor until realization sinks in that the best way is to make a quick phone call and ask for the directions. It is obvious that only a very good public switched telephone network can provide this quality of service and the managers and planners of ETC have done a very good job so far in the provision of services.

Some minor inconsistencies were observed that can be assumed to be teething problems for a developing country and not a reflection or comment of any particular department:

- There is almost universal opinion in Addis Ababa that the Internet service provided by ETC was at the time of study, inadequately managed and ultimately unreliable. This consultant was provided with proof by customers who were falsely billed for duplicate logon despite the fact that the records of ETC cleared showed such duplicates.

- Technical support for telephone problems or internet access problems are not adequately provided or are not provided in time.

- The entire current bandwidth consumed for distribution by the ETC Internet service is estimated from sources to be a total of 4 Mbps (outbound) and 10 Mbps (inbound) to two destinations. However the access to this bandwidth is not universally an enjoyable experience, in surveying the number of cyber-cafes providing internet service or corporate users having leased connections in Addis Ababa, some can enjoy fast access, others suffer from slow access despite similar equipment and service agreements. The most glaring example of this phenomenon is the experience of this consultant in accessing the internet through the ETC head-quarters network. It is not logical that inside of the ETC headquarters a shared internet connection for the senior managers on the 6th and 7th floor should not be able to provide a connection to hotmail.com for basic message retrieval or MSN Instant Messenger from the dates of 14-17 February inclusive.

- According to sources, blocking of websites, or arbitrary filtering of traffic to manage the demand of services this is not an isolated event and may be due to a large variety of factors (paucity of gateway bandwidth, lack of adequate bandwidth control, lack of proper operations monitoring and management system, lack of real-time data on network performance etc) and may indicate the need of further exposure of technical staff to globally managed networks in operation elsewhere.

- There are annoying problems with calls being dropped on the GSM network, looped subscriber calls (caller hears his own voice), and wrong numbers as well as certain problems in roaming between cells. The GSM network is composed of equipment from at least two major vendors and there are reports of difficulty in integration between the two sets of equipment. However GSM network interconnections to the PSTN is typically very good with caller-ID being utilized and is available. It is understood that GSM network will continue to be upgraded.

- It is a known fact that dialing into the ETC controlled and managed internet service is a long wait at best, despite their being hundreds of dial-in ports[4] in service. When connections are made finally, often the subscriber is prevented from logging on as the system rejects the attempt showing incorrect or illogical reasons. Many such examples have been demonstrated by customers.

- Leased line subscribers are able to enjoy “always-on” service most of the times, but the two most common complaints reported are that the bandwidth provided is rarely as advertised and technical problems are not addressed promptly.

- E-mail access through the ETC internet service is available to all subscribers but most users have shifted to use global free E-mail services such as Yahoo or Hotmail, for better reliability and lower cost.

- Very few establishments had proper LAN infrastructure to distribute internet service, but it was observed that both the Solutions Group within the ETC and selected private IT companies have the requisite expertise to design customer LAN and WAN networks in order to build enterprise-wide data communication networks. According to consensus, it is observed that the bottleneck is administrative permission to build private networks, and is not considered to be a technical issue.

VOIP or similar low-cost IP Telephony services for the general subscriber were not observed, and the high profile arrests of illegal satellite earth station operators in 2003 who attempted to bypass the national telecommunications gateway to make alternative phone calls was found to be high on the do-not-ever-do list in the minds of the

[4] Estimated from sources to be over 700 dial-in ports supporting V.90

stakeholders surveyed. However the very high average cost of telephone calls to/from international destinations for general Ethiopians has encouraged private alternative operators to find innovative ways to continue to make calls. This consultant observed on his own during this mission that in many places in the open market or reputable places of business various types of active, smart devices were being used that intercepted international calls from the establishment and automatically routed/directed them to a different, hidden number somewhere within Ethiopian telecommunication networks to connect to a private, unauthorized international gateway and such low-cost, low-quality telephone calls were being charged to the customer at a maximum of 20 Birr for a 5-minute telephone call to almost all destinations.

The phenomenon of attempts to bypass national incumbent operators is not an isolated incident only happening in Ethiopia, it is a worldwide pandemic for all fixed line operators and typically has been seen to act as a prologue to an extended period where the national policy makers consider how to legalise VOIP and other low-cost telephone transmission services and ultimately it is seen that the national authorities allow such services to be provided on a commercial scale with some sort of royalty provision for lost-revenue recovery.

In any case, such subterfuge is rarely required for internet users who can easily make a free phone call through almost any method on their computer, as long as they download some software from a compatible provider who wants to promote global telephone calls as part of their advertising or commercial strategy. This type of service is almost impossible to control as the nature of the Internet means that resources can be easily shared, and if any of those resources were to be a VOIP switch, any user operating a compatible program would be able to access and connect to that switch for voice and/or video and/or data services[5,6]. Such services can be found out by simply entering a few appropriate keywords into a search engine such as Google. The data traffic that is exchanged between calling parties can be masked very easily by the software that makes it look as a normal interactive connection to a WWW server, hence it is difficult to detect using normal methods.

[5] For an example of software-only phones, see http://www.xten.com/
[6] For an example of free phone call service, *globally*, see http://www.freeworlddialup.com/

VSAT Network

The establishment of a dedicated satellite network for servicing the district administrations (611 in *Woreda-Net*), and leading Ethiopian Secondary High Schools (*School-Net*) and a network for Agricultural stations have breathed new life into Ethiopian civil society as well as private ICT industry and the entire distributed organization of the ETC. While the number of active VSAT earth stations is likely be over 1100 when the project is commissioned in its final form, a far greater number of users will be connected to each node on the *Woreda-net* or *School-net* through terrestrial data network which is expected to be constructed in the future.

How those future terrestrial data networks will be designed, built, implemented and utilized has been under active discussion for some time now in Ethiopia. For now, the bulk of the focus of the relevant authorities are to ensure startup of services to as many locations as possible, despite some initial configuration and interoperatability that were expected in a project of this complexity.

Some obvious issues have come to light that need to be mentioned and discussed as a lesson for future telecommunications project planners:

- A test-bed of the equipment being selected must be setup and put into place and demonstrated as far as possible before vendor selection and contract is awarded.

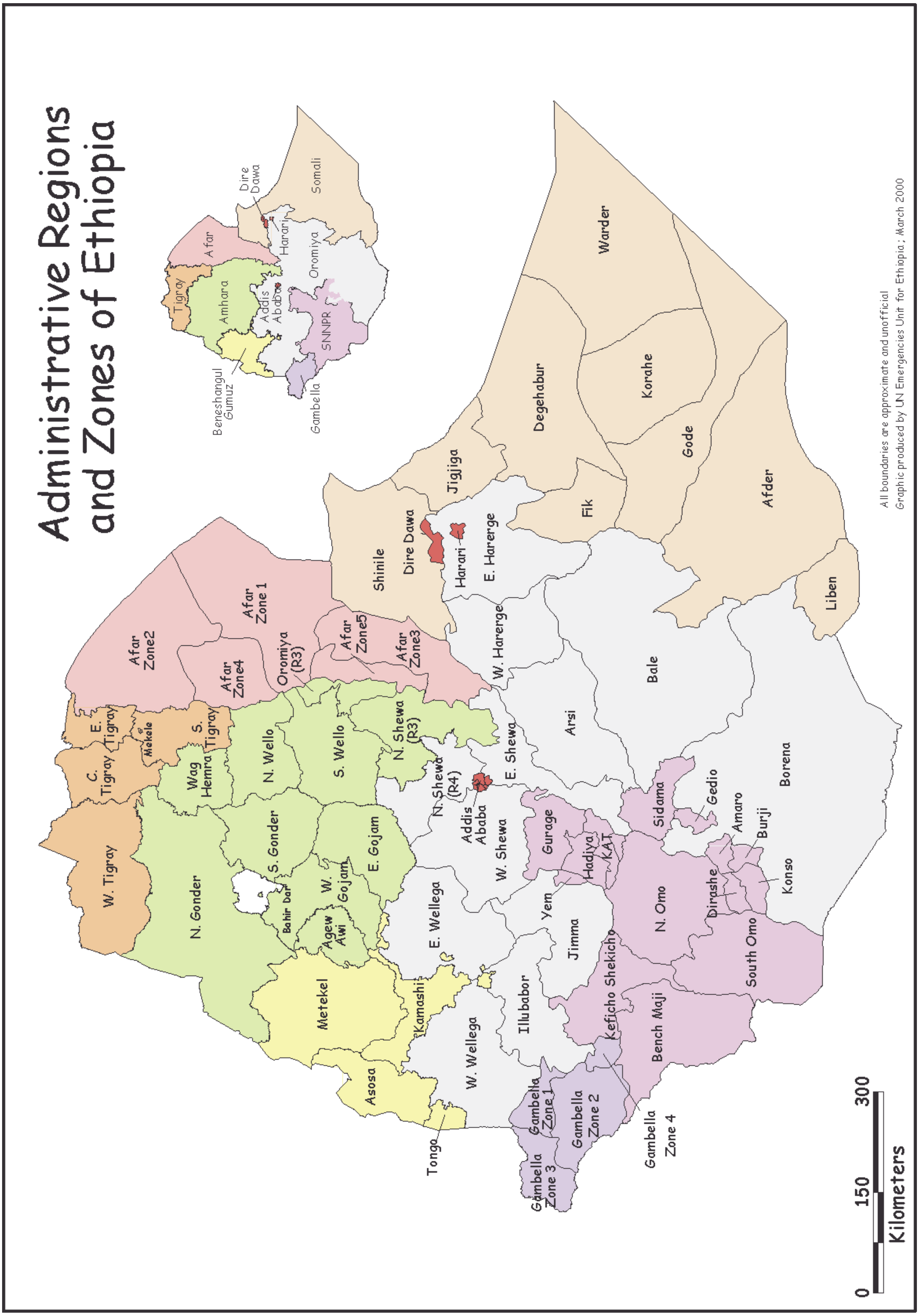
- The satellite network architecture so far demonstrated to this Consultant assumes distinct equipment for each and every separate service (voice, video, multimedia content, and internet), generating separate one-way or two-way satellite carriers to access the same transponder that serves the network. However the earth station antenna size is limited to only 2.4m and transmits/receives on the C-band with a very low power transmitter which limits the total uplink capability to a maximum of 128kbps + 128kbps in two carriers. Therefore it can be said that satellite network architecture has been designed to save on bandwidth at the expense of costly earth station terminal equipment and this concept is quite acceptable if the network were only used lightly and occasionally.

- Since this is also the first major initiative to deploy communications on a mass-scale for a country that is the size of Ethiopia (see picture) and where a substantial number of *woreda* are not currently served by regular communication network, the utilization of this network may be safely estimated to be higher than anticipated. In a typical high demand situation, rather than TDM/TDMA satellite access which ultimately imposes limits on growth, SCPC access to a satellite transponder is typically adopted where each station can obtain their desired amount of bandwidth on a permanent basis, depending upon their actual needs and projected utilization. Such comparison or trial was apparently overlooked for this phase of the project but can be considered for inclusion in the future plans.

Duplicate resources were observed in the choice of equipment for the satellite network, which raises questions about expanding the network architecture or unnecessary complexity in management, configuring and provision for spares.

For example, the integrated earth station provides routing features and an Ethernet port. A separate commercial router is also used to divide up the local network into two or more Ethernet networks for service delivery, but these two functions could have been amalgamated into a single device; in addition the choice of ISP grade routers to handle LAN traffic that would hardly exceed 20% of the rated capacity of an Ethernet interface is puzzling.

It is understood that the VSAT network is actually undergoing test and turnup at the time of writing this report, so any conclusions about the success of the network is premature. Since the infrastructure is going to be a permanent addition to the capability of the Gov't of Ethiopia, some thought needs to be done to try to use it more effectively and for a long time, to make the most out of it. If possible, other than the vendor specified configurations, some tests may be conducted on the network to see whether it can be used for higher network capacity and fixed service access, or whether the equipment can be re-organised into functional networks to multiply its capacity for providing service.


Administrative Regions
and Zones of Ethiopia
Tigray
Afar
Amhara
Beneshangul Gumuz
Addis Ababa
Dire Dawa
Harari
Oromiya
Somali
SNNPR
Gambella
W. Tigray
C. Tigray
E. Tigray
Mekele
S. Tigray
Afar Zone2
Afar Zone 1
Afar Zone4
Oromiya (R3)
Afar Zone5
Afar Zone3
Wag Hemra
N. Wello
S. Wello
N. Shewa (R3)
N. Gonder
S. Gonder
Bahir Dar
W. Gojam
E. Gojam
Agew Awi
Metekel
Kamashi
Asosa
Tongo
N. Shewa (R4)
Addis Ababa
W. Shewa
E. Shewa
E. Wellega
W. Wellega
Illubabor
Jimma
Yem
Gurage
Hadiya
KAT
Arsi
W. Harerge
E. Harerge
Harari
Dire Dawa
Shinile
Jijiga
Degehabur
Warder
Korahe
Fik
Gode
Afder
Liben
Bale
Borena
Sidama
Gedio
Amaro
Burji
Konso
Dirashe
N. Omo
South Omo
Bench Maji
Kaficho Shekicho
Gambella Zone 1
Gambella Zone 2
Gambella Zone 3
Gambella Zone 4
0
150
300
Kilometers
All boundaries are approximate and unofficial
Graphic produced by UN Emergencies Unit for Ethiopia; March 2000

With regard to network topology that has been chosen to be used in transmitting data, content from the Internet would have to travel first over satellite/fiber optic gateway from Europe, America, Asia to the ETC gateway and then travel back up to a satellite (perhaps different from the first) to then be retransmitted down to the destination at a distant *woreda* and the user would get their desired Internet content with an extreme amount of delay. Typical round trip times for a single satellite hop are over 550 mS with no traffic, so a double-hop path would make interactive applications very difficult to use and websites very hard to navigate through.

- The network is designed for use with an Intelsat satellite (IS-901 at 342 degrees East orbital position). There are other satellite operators with quite a large number of powerful satellites[7] in orbit over Ethiopia that could potentially be used with the same equipment and at more competitive rates for lease of transponder. (See sample picture below of APSTAR-IIR, which is a very actively used multi-national satellite at 76.5E orbital position. It can be used for Australia/Ethiopia or England/Ethiopia or Singapore/Hong Kong to Ethiopia service everyday.

- However in case that TDM/TDMA earth stations cannot for any technical reason be used with such satellites are not able to be used, new SCPC VSAT services can be easily setup to connect high bandwidth, fixed locations with domestic and international gateways.
- The proposed network of VSAT Earth Stations has been configured to provide voice, video, multi-media content, and internet service assuming the satellite link works well and remains functional. However in most networks 100% uptime of all the required service hardware cannot be guaranteed and backup facilities are

[7] Please see http://www.satcodx.com/ which is frequently updated with satellite payload data

needed in many cases. This consultant was unable to verify through discussion whether in fact alternative arrangements were in incorporated into the master plan to allow for field level replacement from locally available stores, or whether off-network communication facilities were available at all remote VSAT Earth Station locations to facilitate in remote diagnostics of problems. For example, if a remote VSAT Earth Station in *Korahe* zone were to be reported off-line, they could be contacted through either a GSM phone (if GSM network extended to their area), or through telephone (if PSTN service extended to their area), or through HF radio (if they had a radio transceiver base station/mobile station), or they could be provided with assistance from any nearby *woreda* having similar equipment either by a technician traveling from the nearby *woreda* to the non-functioning site, or vice-versa personnel traveling by road to the next nearest active network node for technical assistance.

This Consultant is legitimately concerned about the experience and ability of technical personnel who will run the primary and backup communication facilities of the Government departments entrusted with implementing complex communications engineering tasks, in the case of the *woreda-net*, it is the Ministry of Capacity Building which presently does not have a HF Radio network, and depends upon the standard telephone communications network. Ultimately the required backup support may not be able to be done and the overall service will suffer as the far away remote locations will be unable to contact smoothly with the network operations center, unless the local telephone network is sufficiently able to handle long distance calls easily and affordably. But here is the logical conundrum, if there is a local telephone exchange able to serve long distance telephone calls, and likely to be *all-digital communications capable*, what then would the need be for a *satellite network* which is expensive to operate; the two concepts are typically mutually exclusive.

So far as observed, very few engineers in service today in Gov't of Ethiopia are actually familiar with basic radio communication skills, practices and methods. This may become a thorny problem when remote troubleshooting and diagnosis is to be conducted and the only way to communicate is through rudimentary voice communication prior to the satellite or terrestrial network being setup and commissioned.

As discussed, the health of the Gov't owned and operated telecommunications sector is quite active and impressive, but private operators of telecommunication services are also permitted upon application. This consultant noted individual Satellite Earth Stations for exclusive use of foreign missions (including International Organisations such as the World Bank, ECA etc.) and from discussions with the Ethiopian Telecommunications Agency has learnt that subject to application, permission may be granted to non-ETC organizations with sufficient and demonstratable justification for a direct connection between two location domestically or between a domestic location and an international gateway. The process is not open for everybody however, and it is difficult to obtain according to discussions held with various stakeholders. One such example is the Ethiopian Airlines which requires connection to foreign airline ticketing and reservation networks and such services cannot be easily provided by ETC internationally as well as domestically.

The use of telecommunication (or "communication") facilities by the general subscribers in Ethiopia is broadly limited to either accessing the Internet, or to make phone calls domestically and internationally. There are a large number of Cyber Café, Cyber-shop, Business Center in and around Addis Ababa that we seen to be quite heavily used. However the frustration of the users at the low quality of service was evident, as most of the connections were using the dialup services of ETC. Contrary to the global trend, satellite based reception (i.e., signal is received only, not transmitted) of DVB/IP multicast IP data through the use of TVRO dish antenna was found to be absent, which is unfortunate as that would ultimately reduce immensely the wait time and cost of browsing the Internet.

There did not seem to be a visible capacity constraint in provisioning of fixed telephone lines as observed by this consultant. Subscribers were happy at contemplating ordering of new fixed telephone services and being connected in due course. But standard dialup facilities and a few leased line facilities are not enough obviously to ensure equitable access to the greater subscriber base. Access networks need to be deployed so that more users at a time can log-on to the networks to access content and applications. Since the cost of building traditional telecommunications networks are considered to be expensive, alternative ways could and should be considered which may follow trends[8] used by other developing countries such as:

- Licensed ISPs (Internet Service Providers) can be authorized to connect customers in their own localities directly from their data center or Points-of-Presence and they will aggregate all traffic and pass it through either the nearest commercial, licensed Internet gateway or such a gateway is not available, they will typically receive permission to install transmission equipment (satellite, fiber) to become their own Internet gateway.

- Broadband cable Internet – using CATV / SMATV cable infrastructure to deliver TVRO signals from satellites as well as Internet data services through a broadband hybrid fiber-coaxial network and use of Cable Modem Terminal System (CMTS) and DOCSIS subscriber management system. Speeds in excess of 10 Mbps can be delivered in the forward direction to customer premises.

- Broadband wireless internet through access point – ETC is already investing in this a medium sized rollout using Aironet Wireless Access Points, but on a smaller scale, small neighbourhoods and commercial buildings can share a single high speed internet connection and distribute the signal through common wireless infrastructure in a particular area. Typical speeds are on average 150-200 kbps per user

- Broadband DSL – In many parts of the world, new *wired* networks are being setup with very high speed delivery to the customer premises through DSL connections.

[8] See "Digital Review of Asia-Pacific 2003/2004", P.51 'Peoples Access to Technology'

A variety of technologies exist depending upon the type of service required. Business users will need SDSL (typically 2Mbps duplex), Residential Customers will need ADSL (typically 2x4 Mbps) and small shops may need SHDSL (typically from 128kbps to 4 Mbps).

- Broadband Wireless Router – this technology is described in detail within the parameters of this mission.

- Direct LAN connection – Where possible ISPs can connect customers using low cost Local Area Network peripherals (Ethernet cards, Hubs, Switches) directly from their nearby Points-of-Presence.

- Mobile Phones GPRS or WAP – GSM operators often provide limited Internet service through their existing transmission network for use by mobile telephone/PDA devices.

- DVB/IP and DVB-RCS – For bulk internet data transfer, Digital Video Broadcast/Internet Protocol is used, which is a one-way service. However in recent years a new concept of two-way Digital Video Broadcast/IP has been introduced, Digital Video Broadcast/Return Channel over Satellite.

Reviewing ICT Human resources within Ethiopia

ICT man-power is an important part of the raw materials required to build and effective wide area rural communications network. Several types of skill-sets will be required for long term sustainable management of a low-cost, broadband communications network. During the period of the mission, several significant stakeholders were interviewed to ascertain the capability to produce technicians and engineers in the categories listed below:

- Hardware/Electronics Engineers
- Software Engineers
- Radio Engineers
- Civil Engineers
- Network Architects
- Telecommunications Switch Engineers
- Satellite Engineers
- Mechanical Engineers
- Electrical Engineers

Addis Ababa University remains the major source of new undergraduate and graduate student resource pool, and according to the published plans has recently decided to re-organise its ICT related departments under a common Faculty of Information and Communications Technology. This faculty will have three departments, Computer Science, Information Science and Computer and Communications Engineering. Students enrolled in the departments of Electrical Engineering, Mechanical Engineering and Civil Engineering will continue to study under the Faculty of Technology. The university capacity has been strengthened by the installation of fiber optic networking to connect its campus into a high speed digital network, and it has its own special-permit very high speed connection to the Internet through the ETC infrastructure. Also, separately, a VSAT Earth Station has been setup to cater for the African Virtual University. A related example of modern training facility is the World Bank/Global Development Learning Network center at the Ethiopian Civil Service College, also connected through satellite linkup. However it was not evident that Amateur Radio club station was present on campus or that the students of the technical faculty had been introduced to the concept of Amateur Radio Service (Ham Radio service).

Technical jobs were observed to be a much sought after commodity in the current state of Ethiopian economy, and it is learnt that the salary structure in general is quite low for public sector jobs. The private ICT sector is quite large, in one list of companies compiled by the ICT Focus and published in Vol #2, Issue #3 the list shows there are:

- Higher Learning Institutions providing ICT education (22)
- ICT Companies (132)
    - Computer Training Centre (96)
    - Computer Sales (61)
    - Web Design (32)
    - Networking (65)
    - Software Development (53)
    - Maintenance (7)

On the other hand, Gov't backed organizations such as the incumbent operator ETC enjoys the reputation of being a large scale employer of technical graduates and it is often the first choice to be selected when graduates apply for the jobs. Here the lower wage structure is traded for the guaranteed benefits and long term stability of a public sector position. In order to test the quality of available technical manpower a field-level investigation was done by this consultant by visiting the repair and service facilities of several resellers of GSM telephones and reprogrammed SIM modules. It was found that EE graduates of Addis Ababa University were conversant in Surface Mount Technology and had no problem in reverse-engineering and trouble-shooting board level problems and literally re-manufacturing GSM cellular phones.

During the installation phase of the proof-of-concept demonstrations, several difficult programming problems were easily solved including TCP/IP configuration, HTTP, FTP, DNS servicing provisioning and SQL-based GIS server configuration and development problems were handled with ease from regular engineers with only a basic work experience portfolio. This ad-hoc assessment of available skill-set is in the opinion of this consultant most probably only a small portion of the aggregate skill set available for use by ICT industry in Ethiopia.

In addition, non-formal and volunteer organizations such as Amateur Radio Club of Ethiopia have been granted permission to operate a club radio station in Addis Ababa for licensed Amateur Radio Operators. The Club station has been issued an international *call-sign,* **ET3AA** (See picture in this section) and is permitted to use the Radio spectrum normally reserved by the ITU for all amateur radio services and all permitted modes of communication which include Voice, Packet Data, Facsimile, Slow Scan Television, Satellite, TCP/IP etc. Group members conducts training through volunteers at their club station for any interested technical person with a minimum of knowledge but the benefits of being able to communicate using a radio signal and an antenna to any part of the world without assistance remain with the student forever. In fact, Amateur Radio Service is a recognized service by the ITU. The International Amateur Radio Union has summed it up nicely

Radio technology offers a wide array of tools for teachers to use as they integrate technology into the curriculum. In schools without an Internet connection, Amateur Radio can fill that void through interactive communications and shortwave reception. Elementary school teachers, using AM radios, can interject fun while helping students learn basic electricity and regional geography. Social Studies teachers can use Amateur Radio and shortwave receivers to teach about different cultures the world over, as well as advancing deeper into geopolitics and geography. Earth science and physics teachers can use radio to teach electricity and electronics, radio wave propagation, weather and atmospheric science. Language arts teachers may use radio to supplement writing, speaking and listening skills while providing access to numerous foreign languages from the lips of native speakers

IARU Press Release, 18 April 2003

Introducing BMSTDA Concept

Genesis of BMSTDA requirements

In April 1999, several brainstorming sessions were held at the "Workshop on Internet: South Asian Realities and Opportunities"[9], in Dhaka, Bangladesh during which discussants from South-Asian countries created a set of recommendations which included two significant recommendations:

- Newly emerging communication technologies and their convergence should be explored for enabling rapid growth of Internet service and infrastructure.
- Explore and create new markets for Internet services, particularly in the rural areas (which are conventionally supposed to be non-profitable sectors), to make the establishment of telecom facilities viable and profitable in these areas.

In 1999, Wireless LAN technology (later to be known as IEEE802.11x standards) was in its infancy and was showing promise, but the prevailing method of establishing telecommunications services to any areas in countries such as Pakistan, India, Nepal and Bangladesh was to follow the "traditional" telecommunications architecture of centralized, switching, transmission and distribution facilities. This "top-down" methodology of network made it possible to provide services in quantity for those areas that had dense population demographics. It did not make it easy to spread communication services to sparsely populated, rural areas where heavily centralized services could not be rolled out economically. The common "standard" transmission technologies in use at that time were fixed microwave, fixed satellites, fixed optical over cable, fixed free space optics. The common "standard" switching techniques in 1999 did not consider IP as the primary method of either switching of transmission, yet it was obvious that the demand for Internet services was expected to increase rapidly at over 30% per year growth.

At the time the workshop was held, Pakistan had 40 ISPs in operation serving 250,000 users; Nepal had 4 ISPs with 8,000 users; Bangladesh had 18 ISPs and 40,000 users with India having a staggering 1,000,000 users with a dozen ISPs. Each of these countries was connected to the Internet in 1993, first by electronic mail through UUCP, then gradually by on-line satellite or fiber connectivity. The 1999 usage statistics were calculated by experts in the respective ICT industry who monitored growth and there was a clear consensus that this number represented only a small fraction of those who had access to (a) Computer Technology (ICTs) and (b) public switched telephone network (PSTN). Wherever PSTN and ICTs were available people were "connected", otherwise there was no chance they would be until a Point-of-Presence of the PSTN would be established nearby.

The challenge was therefore to consider a technical solution that could possibly satisfy the needs of the "lower-income" population which would be typically found in rural areas

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[9] The workshop was sponsored by the International Center for Integrated Mountain Development (ICIMOD), Kathmandu, in cooperation with the Local Government Engineering Department (LGED) of the Ministry of Local Government, Rural Development and Cooperatives, Gov't of Bangladesh. 5-8 April 1999. (Please see http://www.icimod.org.np/focus/ict/ict_bang/tel6.htm and related for full text reference)

and consequently deemed "unprofitable" by the established telecommunication companies. In addition, a low-cost, *low-technology* solution was not desired, through the brainstorming sessions it was made clear that there is always a technical solution to make products work more efficiently and at lower-cost providing innovation is rewarded for clever design and workarounds. Another issue that came up frequently was the requirement that the equipment be serviceable in the field, and that it be able to be repaired with the minimum of spare parts – a very demanding and difficult issue. Most of the practitioners in the field of ICTs were frustrated at deploying communication networks and having to cater for the frequent breakdowns and repairs having had to been sent back to the factory. Network service quality and time to repair were very important attributes of any new technical solution as opined by the workshop participants. In fact the additional challenge was given to develop a class of technology that could be fixed in the field where there would be usually no developed infrastructure, a place that we would call "zero-infrastructure" area.

Throughout 1999 this idea was discussed after the workshop in several other venues by the various participants and this consultant decided to formulate a set of specifications for a new telecommunications network architecture that would fit all the requirements of the 1999 ICIMOD workshop. This specification was titled "Broadband Multi-Service Switching, Transmission and Distribution Architecture" which was abbreviated as BMSTDA and in its simplest form could be stated as:

- BMSTDA communications technology solution must be quick to implement
- BMSTDA communications technology must cost less than existing switching, transmission and distribution solutions[10]
- BMSTDA communications technology must be broadband in performance[11]
- BMSTDA must be independent of any particular transmission method in use
- BMSTDA must be able to use hybrid communications technologies
- BMSTDA must use a distributed, fault-tolerant, partial-mesh network topology
- BMSTDA communications technology must make use of common-of-the-shelf parts and components as much as possible and should be interchangeable.
- BMSTDA technology must be able to repaired in the field
- BMSTDA technology should be built and designed taking note of the needs suitable for "zero-infrastructure" regions where it is likely that BMSTDA will be the first such communications technology to be introduced.

Prior to 1999 this Consultant had been involved in Research and Development of various types of data communications services for use in Bangladesh through the facilities of PraDeshta Limited. Amongst these projects one innovative requirement of a potential NGO was to use the video/audio output capability of a standard computer to playback recorded digital content for distribution of educational/entertainment material in the villages, through reception of satellite signals. The computer would have had a satellite receiver card installed to receive multicast data. This idea actually made technical sense, but the idea had to be modified to allow broadcasting over open airwaves on VHF

[10] Concept originated by *Arun Mehta*
[11] Concept originated *Bhoop Raj Pandey*

channels in order to reach a wide audience of several villages who would tune their television sets to a miniature broadcasting terminal connected to the PC. The total cost of this setup was actually less than US$100 for an effective range of about 4 miles in diameter over open ground and the tests were demonstrated in PAL-B colour TV transmission broadcast standard. An important feature that had to be figured out was the minimum RF signal strength that would be required to broadcast a signal, yet be within the minimum legal parameters that are commonly allowed for any transmitter in use in Bangladesh. This "minimum legal power limit" is an item that is regulated on an individual basis by each country telecommunications industry regulator. It refers to the smallest signal power that the regulator will permit before considering it to be a broadcast and therefore would need a license. For example, the signal strength for cordless telephones is rarely above 1/20th of a Watt (or 50mW) while that of a cellular phone barely ½ of a Watt signal output at its maximum. By clever use of antennas and shortening the distance from the transmitter to the antenna even low power signals can be sent farther away than expected. Since BMSTDA architecture was being formulated at this time, the two technology tracks were combined and therefore two additional attributes of BMSTDA was defined thus:

- BMSTDA networks must support multiple services
- In case of radio links used in a BMSTDA network, the least amount of signal must be used in order to be legal as per local regulatory guidelines.

A model network to provide "proof-of-concept" of BMSTDA was created by this Consultant for commercial use by PraDeshta Limited[12] in 1999 and the results of that experimental network was reported as a work-in-progress paper presented by invitation at COMMSPHERE2000[13,14], Indian Institute of Technology, Chennai.

Some international news reports reviewed the technology and provided their comments in various articles such as:

- "Call for a Hybrid, Radical Approach in Telecom", *Venkatachari Jagannathan*, http://www.domain-b.com/infotech/itnews/20000309hybrid_radicalapproach.html

- "IDEAS APLENTY ON HOW SOFTWARE CAN HELP THE MILLIONS", *Frederick Noronha*, http://www.nettime.org/Lists-Archives/nettime-l-0003/msg00028.html

The longest distance that was achieved using those early terminals was 16 kilometers line-of-sight at speeds of 3.5 Mbps. This network was replaced with a commercial service network connecting three points in Dhaka city which was operated until 2001, with another two distinct network of two and three nodes respectively operating from 2000-2002. There were at least four generations of devices that were experimented with:

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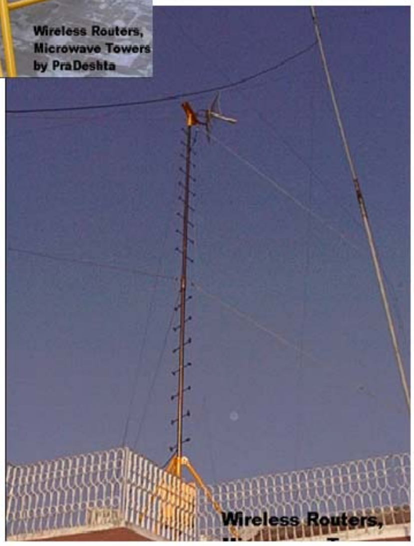
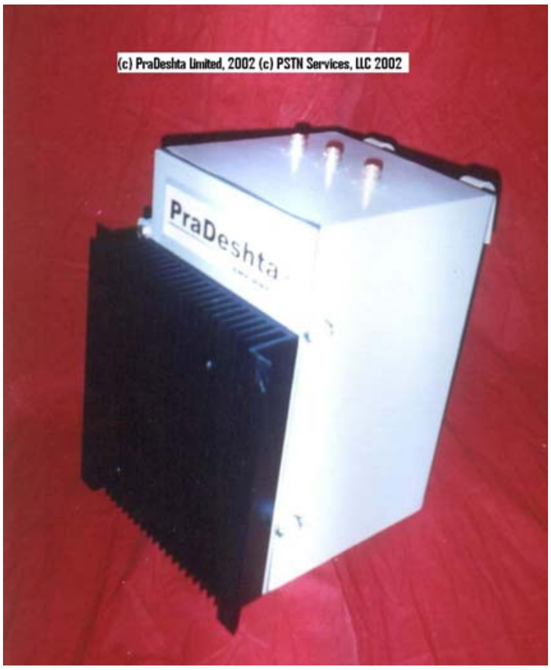
[12] http://www.pradeshta.net
[13] http://www.bytesforall.org/4th/samudra.htm
[14] http://www.tenet.res.in/commsphere/s7.2.pdf



Model 1: Initial 1999 developmental version, simple bare bones computer in conventional cabinet with expensive microwave low-loss feeder cable. For indoor/short-range use only; not for commercial service; Failed in outdoor tests. Antenna was simple indoor type. Commonly called “Broadband Wireless Router”.

Model 2: 1999-2000 “Yellow Box”, custom outdoor cabinet for mounting at Base of tower with expensive microwave low-loss feeder cable. For medium-range distance commercial service. Failed due to heat/cold problems. Range: 16+ Km @3.5Mbps duplex data rate with RF power output of 100mW. Electronics payload used conventional PC motherboard. Antenna was 24 dBi grid parabolic. Commonly called “Mast-Mounted Microwave Router Unit”.

Model 3: 2000-2002 “White Box”, custom outdoor cabinet with double insulated wall, fireproof, very heavy (25 Kg+ weight). It proved to be unwieldy for installation on top of tower. Range: 38+ Km @3.5Mbps duplex with RF power output of 100mW. The design was rejected due to extremely heavy weight problems at top of tower and lack of adequate cooling. Electronics payload was conventional PC motherboard. Needed no expensive microwave feeder cable. Antenna was 24 dBi grid parabolic. Commonly called “Mast-Mounted Microwave Router Unit”.



Model 4: 2002-2003 “Grey Box”, custom small outdoor cabinet with anodized aluminum heatsink and internal convection fan as well as sophisticated industrial strength Single-Board Computer and Passive Backplane. Reliability very good, distances achieved 22 Km at 5.5Mbps @100mW RF power output and 4 Km very good quality links at 30 mW RF power output.. For maintenance purposes, keyboard and monitor was attached directly to the router which was placed at the top of the tower, and the system did not need expensive microwave feeder cable. Antenna was 24 dBi grid parabolic. Commonly called

"Mast-Mounted Microwave Router Unit".

Model 4B: 2003-present. Similar to Model 4, but all connections to Keyboard and Monitors input/output were installed on the OUTSIDE of the cabinet, not the INSIDE of the cabinet thereby making it possible to seal the unit after construction, assembly, integration and testing and also to prevent water seepage. An additional benefit was that on certain units, we used low-cost DC power supplies instead of expensive Switched Mode Power Supplies to reduce weight and manufacturing cost further. "Commonly called "Mast-Mounted Microwave Router Unit" abbreviated as "MMRU".

Along with the Mast-Mounted Microwave Router Units that were produced in an effort to validate the BMSTDA approach, a set of Antenna Tower Masts or Communication Towers were also designed and fabricated which allowed the build up of cheap telecommunications infrastructure including Antenna mounting kits for accurate AZ-EL pointing of microwave antennas.

Common Off-the-Shelf (COTS) peripherals for BMSTDA use

Choosing hardware that fits the requirements of BMSTDA network technology turned out to be easier than expected despite the ambitious list:

- BMSTDA communications technology solution must be quick to implement
- BMSTDA communications technology must cost less than existing switching, transmission and distribution solutions
- BMSTDA communications technology must be broadband in performance
- BMSTDA must be independent of any particular transmission method in use
- BMSTDA must be able to use hybrid communications technologies
- BMSTDA must use a distributed, fault-tolerant, partial-mesh network topology
- BMSTDA communications technology must make use of common-of-the-shelf parts and components as much as possible and should be interchangeable.
- BMSTDA technology must be able to repaired in the field
- BMSTDA technology should be built and designed taking note of the needs suitable for "zero-infrastructure" regions where it is likely that BMSTDA will be the first such communications technology to be introduced.
- BMSTDA networks must support multiple services
- In case of radio links used in a BMSTDA network, the least amount of signal must be used in order to be legal as per local regulatory guidelines.

In the marketplace, dedicated Wireless Access Point hardware and commercial broadband microwave distribution networks were not considered for adoption, as they proved to be (at that time) simply too expensive, and they could not be manufactured or repaired in developing countries. In their place, software based routers such as Linux operating system based hosts with multiple network interface cards were considered and since the hardware foundation would remain a standard PC in all respects, almost any application could be adapted to run on it, in the manner that suited the particular application.

Therefore the following basic components were chosen for inclusion in BMSTDA component list:

<u>Motherboard</u>: Almost any computer motherboard will work, whether based on Intel's chipset, AMD's chipset or any other manufacturer of a motherboard as long as it supports PCI network interface cards, ISA cards (if desired), video/audio interface cards and is compatible with any version of a *open-source* operating system such as Linux. Integrated Motherboards are not preferred despite their absolutely rock-bottom prices since their failure rate is much higher in grueling environment. Therefore a choice was made to use Industrial-rated Single Board Computers and Passive Backplanes since that allowed for two major advantages:

- Ability to withstand huge variations in temperature
- Modular design and not integrated allowed for faster repairs/replacement.

<u>Power Supply</u>: Almost any power supply will work, as most Motherboards or Single Board Computers require only +/- 12Volts and +/-5 Volts and therefore these power supplies can be made by any competent EE student or graduate on a commercial scale. However there is a growing trend for adapting devices for use of Power-over-Ethernet connections (where the device obtains power from the Ethernet cable) so their may be a

potential for further optimizing the power requirements by investigating just how little a device can be provided power for it to work. In the future, it is expected that custom hardware can be designed and manufactured that will have much simpler power requirements.

Software: Each BMSTDA device will have to perform functions in at least one of the following categories:

- Dynamic Routing between local and wide area network interfaces
- Switching of data between its local area network interfaces
- Fault Tolerance Management
- Operation and Maintenance functions
- Alarm Management and Reporting
- Event Management and Logging
- Multi-media Services
- IP Telephony Services
- Video Broadcast Services
- Audio Broadcast Services
- Network Discovery and Negotiation Services
- Proxy Services
- Authentication Services
- Firewall Services

So far to date, a recommended software application that provides some, but not all, of the desired functions above has been used successfully in the field, authored by *Mikrotik* of Latvia[15]. There are now renewed efforts to build custom-Linux operating system that would provide a rich feature set but these are not at a point where they are significant or can be recommended. Some of these development efforts are noteworthy but ill-fated (such as http://www.linuxrouter.org/) and which have failed in the USA due to lack of interest by *commercial* companies who did not want a cheap, mass-produced router. *In fact the software capability already exists with source code within that project*, but ultimately it was abandoned because it was created in a market that was already developed and did not want to investigate low-cost solutions at that time. *Perhaps a further study would be useful to see what other good efforts are available out there*. Such an effort to "acquire" technology would pay off in a short time as the "time to market" would be reduced by much less. See also http://doggerdog.bravepages.com/freesco/, where similar collaborative initiatives are reported to build routers and devices. A very popular implementation of a routing module for Linux operating system is the http://www.zebra.org repository of GNU routing software provided free of charge.

We assume that in the future the capability of computing hardware will be such that many other services can be performed simultaneously at the same time and this will need *Research and Development* support, but for now the objective is to make use of our limited skills and hardware capabilities *at present.*

Network Interface: The following types of network interface cards have been tested and are known to work with a variety of Operating Systems (including, non-Linux Operating Systems): Ethernet devices, IEEE 802.x spread spectrum devices, Fiber Optic devices, Free-space Optic devices, HF/VHF Radio devices, Dialup Modems, xDSL devices,

[15] http://www.mikrotik.com

Telephony Servers etc. As long as there is a compatible driver to interface the hardware with the software operating system, a BMSTDA device can make use of the data transmission capability of the device and “connect” to any other node with a similar networking arrangement. This proves the versatility of the BMSTDA in that it doesn’t care what device is connected to it, as long as it is able to *communicate* through that device and run networking protocols to manage traffic.

Memory: In order to run the Operating System, the BMSTDA device needs Read-Write Memory, and it must match the particular type of hardware used. With a custom-developed Operating System it should be able to be installed and made to work in a device with a minimum of 32 MB of RAM for basic routing functions but if more advanced services are required then 64MB of RAM upto 256MB of RAM may be required for the current generation of service applications.

Processor: Any kind of processor that matches the Single Board Computer, mainboard or motherboard and supports an *open-source* operating system can be used. The speed of a Processor will dictate the total aggregate data communication traffic that can be passed through each of its interfaces, and the higher the speed the better obviously. However careful measurement and planning of the (a) heat generated by the processor and its cooling requirements (b) the amount of processing power needed at present and in reserve for the future (c) calculation on the amount of dynamic memory consumed (d) crash recovery process if a processor exception causes total hardware failure. There are both professional and amateur ways to make sure a device stays operational even when hardware inside of its cabinet has failed; this is an important issue as a BMSTDA network is likely to be used for broad-based service to far-flung communities.

Flash Media: The storage device for the Router Operating System. Early on in the development phase of the MMRU hard drive technology was found to be notoriously unreliable for continuous service in varying weather and environmental conditions. Also, proper operation of a moving, mechanical device was subject to stringent safety and environmental guidelines that could not be guaranteed in the field. Therefore a decision was made to invest in the (more expensive but reliable) solid-state flash memory modules which interacted to the Processor and Operating System as standard hard-drive, but was actually a non-volatile device, and would retain its information for long time, *without power*.

Hard Drive: For Multi-media applications such as storage of digital content, application service, broadcast from stored files, Flash Media will be an inefficient storage device and will be ultimately slow in performance if repeated read/write attempts are done to it. In addition, the data storage requirements of multi-media will be often in the Gigabyte sizes which will result in cost-prohibitive Flash Media modules. Therefore for some of the BMSTDA configurations (see later section) normal Hard Drive installation is recommended, but only if the unit is kept indoors and in a controlled environment.

Internet Support Equipment: The local distribution of the network is achieved by a combination of any type of interface possible, and typically may include Ethernet Hubs, Ethernet Switches, Plain copper wire, fiber optic cable, Wireless Access Point etc. and the network can be expanded as much as required by duplicating the technology for each layer.

Mix-and-Match to make BMSTDA network devices

As stated earlier, devices of BMSTDA had to use common components as much as possible. Some configurations of the same type/class of function, hardware and software were frequently used and these were called:

- Broadband Router (BR)
- Broadband Wireless Router (BWR)
- Mast-Mounted Wireless Router (MMRU)
- Multi-Media Terminal Server (MMTS)
- Micro-Community Broadcast Station (MCBS)
- IP Telephony Gateway (IPTG)
- Micro-Community Node (MCN)

In most cases the difference of configuration is not strictly in the basic hardware but rather in the controlling operating system and choice of installed peripherals and components. Readers are advised to note that the "Architecture" should not and cannot care about what is installed, but rather the Architecture employed should facilitate the services required of it. Therefore it is accurate to say that BMSTDA is hardware independent in nature.

Obviously no single software application for BMSTDA devices exists today and there is an excellent opportunity for Ethiopian software developers to show their skills and develop complex, time-critical/mission-critical management software that provides:

- Voice Switching
- Packet Data Switching and Routing
- Alarm Management and Disaster Mitigation
- Remote Configuration and Troubleshooting
- Automated Tasks
- Video/Audio Conference and Broadcast Services
- Content Caching and Application Service Hosting
- And many more….

Configuration for BMSTDA:BR

A Broadband Router is a simple device that is an essential foundation of any BMSTDA network. It is basically a combination of:

- Motherboard with several slots (or Passive Backplane with Industrial grade Single-Board Computer)
- Memory
- Processor
- Flash Media
- Power Supply
- Interface Cards including any combination of:
    - 10/100/1000 Ethernet LAN Adapter
    - 10/100/1000 Fiber Optic LAN Adapter
    - xDSL Network Adapter and/or Baseband Modem for copper wires
    - Dialup Modem Adapter and/or RS-232 serial link to external Modem
    - Free Space Optics Transmitter/Receiver

- Indoor Cabinet
- Keyboard connection to monitor (optional)
- VGA Display connection to monitor (optional)
- Router Operating System with remote management
- SNMP Management System for remote management

Configuration for BMSTDA:BWR

A Broadband Wireless Router is a BMSTDA:Broadband Router device with the addition of a suitable Radio interface of some type. It is a fact that IEEE 802.11 family and related standards allow very easy, cheap use of Wireless LAN adapters that can extend the range of a Broadband Router to metropolitan areas, which is very cost-effective and practical. However there are many kinds of radio devices that can and should be used in a BMSTDA network. Note the use of Satellite technology here; there is nothing that will prevent a BMSTDA network along side a Satellite network such the Government of Ethiopia's *Woreda-Net.* These devices are intended to be installed within a building's radio room and a RF feeder cable is to connect this device to an external antenna. Typically for short range, an OMNI antenna is used, long range, an UNI-directional antenna is used.

Typical wireless links are designed on a 1:1, exclusive point-to-point basis and are not shared. If a shared system is required where many clients stations will access the network node BWR, then the BWR Router Operating System will have to work as an "Access Point" or "HotSpot" and then the device is defined as "BWR-A".

The component list for the BMSTDA:BWR is therefore:

- Motherboard with several slots (or Passive Backplane with Industrial grade Single-Board Computer)
- Memory
- Processor
- Flash Media
- Power Supply
- Interface Cards including any combination of:
  - 10/100/1000 Ethernet LAN Adapter
  - 10/100/1000 Fiber Optic LAN Adapter
  - xDSL Network Adapter and/or Baseband Modem for copper wires
  - Dialup Modem Adapter and/or RS-232 serial link to external Modem
  - Free Space Optics Transmitter/Receiver
  - Wireless LAN Adapters (Spread Spectrum, any frequency band)
  - HF/VHF/SHF Radio Modem Interfaces
  - Satellite Modems and Personal Earth Stations with Synchronous or Asynchronous or Ethernet Interfaces
- Indoor Cabinet
- Keyboard connection to monitor (optional)
- VGA Display connection to monitor (optional)
- Router Operating System with remote management
- SNMP Management System for remote management
- Low-Loss Microwave or VHF/UHF RF coaxial feeder cable

Configuration for BMSTDA:MMRU

The range of a BMSTDA:BWR is limited due to the power loss of the RF signal from the interface output point to the antenna. This may be as much as 6 dB[16] loss (75% power loss) at 2.45 GHz using LMR-400 Microwave cable from the Manufacturer Times Microwave, which results in a lot of unnecessary wastage of valuable transmission capability. It also requires cost; LMR cable is quite costly but thankfully not as costly as Microwave HARDLINE from a reputed manufacturer such as Andrew which offers slightly better performance (approximately 4 dB loss per 100 ft). What this type of discussion indicates that it would be better if we could eliminate totally the requirement for RF microwave feeder cable and therefore the concept of the Mast-Mounted Microwave Router Unit was to construct a BMSTDA:BWR and put it in a hermetically sealed outdoor weatherproof cabinet so that it would operate without any regard for its environment, install it on the rooftop and *connect the antenna directly to the radio interface output port*. The resultant savings in signal lost (6 dB) allows the MMRU to outperform the BWR by many tens of kilometers of line-of-sight performance, using exactly the same type of antenna in both configurations.

The component list for the BMSTDA:MMRU is therefore:

- Motherboard with several slots (or Passive Backplane with Industrial grade Single-Board Computer)
- Memory
- Processor
- Flash Media
- Power Supply
- Interface Cards including any combination of:
    - 10/100/1000 Ethernet LAN Adapter
    - 10/100/1000 Fiber Optic LAN Adapter
    - xDSL Network Adapter and/or Baseband Modem for copper wires
    - Dialup Modem Adapter and/or RS-232 serial link to external Modem
    - Free Space Optics Transmitter/Receiver
    - Wireless LAN Adapters (Spread Spectrum, any frequency band)
    - HF/VHF/SHF Radio Modem Interfaces
    - Satellite Modems and Personal Earth Stations with Synchronous or Asynchronous or Ethernet Interfaces
- ~~Indoor Cabinet~~ replaced by Weatherproof Outdoor Cabinet
- Keyboard connection to monitor (optional)
- VGA Display connection to monitor (optional)
- Router Operating System with remote management
- SNMP Management System for remote management
- ~~Low-Loss Microwave or VHF/UHF RF coaxial feeder cable,~~ replaced by Pigtail Adapter for Radio interface output port to Antenna converter

Configuration for BMSTDA:MCBS and MMTS

Each and every BR, BWR or MMRU is essentially at heart a personal computer, and in most cases motherboards or mainboards or singleboard computers have the ability to play Sound and in some cases with software help, to play Video digital content. In fact, there

[16] Please use the online calculator at http://www.timesmicrowave.com/cgi-bin/calculate.pl

are a huge number of “multi-media” applications that allow programmers to design streaming audio/video playback of digital content either locally stored (in a Hard Drive) or remotely stored (through the World Wide-Web). The objective is to take the video output (traditionally VGA output specification) and to convert it a regular broadcast standard signal specification. This can be easily done with a VGA-to-TV converter, almost any device can be used in this family. The resultant VIDEO stream is either PAL or NSTC (or rarely, SECAM) and is in the format of Video signal but does not have audio signal accompanying it.

The VIDEO signal and the AUDIO signal (from a suitable sound card or multi-channel sound system) can be combined into a single TV Channel for reception by a TV receiver through the use of a very low cost Cable TV video channel RF modulator which is commonly available in Addis Ababa market it was found, the resultant PAL or NTSC signal is actually a powerful (relatively speaking) but low-power TV transmission signal that should normally be fed into a cable TV network for delivery to a building occupants such as a TV in a hotel room in Ghion Hotel. In case that the audience for such a TV signal is not located within a nearby area, the small signal of the CATV modulator can be attached directly to a suitable antenna and the signal allowed to propagate through free space as far as possible. This allows the MMRU device to act as a miniature broadcasting station and since we want to serve only a small sized community (if not, our power transmission requirements will be larger and we may be considered to be exceeding the legal limit of transmission) the device is referred to as a *Micro-Community Broadcast Station*. However if the function of the MCBS is to deliver just video/audio to a close by classroom or building, then it could be considered as a *Multi-Media Terminal Server*. This change of nomenclature allows us to introduce a two-way aspect to our plans; the MMTS is typically prepared for two-way video-conferencing features with the addition of a camera and a TV screen.

The component list for the BMSTDA:MCBS is therefore:

- Motherboard with several slots (or Passive Backplane with Industrial grade Single-Board Computer)
- Memory
- Processor
- Flash Media
- Power Supply
- Interface Cards including any combination of:
    - 10/100/1000 Ethernet LAN Adapter
    - 10/100/1000 Fiber Optic LAN Adapter
    - xDSL Network Adapter and/or Baseband Modem for copper wires
    - Dialup Modem Adapter and/or RS-232 serial link to external Modem
    - Free Space Optics Transmitter/Receiver
    - Wireless LAN Adapters (Spread Spectrum, any frequency band)
    - HF/VHF/SHF Radio Modem Interfaces
    - Satellite Modems and Personal Earth Stations with Synchronous or Asynchronous or Ethernet Interfaces
- ~~Indoor Cabinet~~ replaced by Weatherproof Outdoor Cabinet
- Keyboard connection to monitor (optional)
- VGA Display connection to monitor (optional)

- ~~Router Operating System with remote management~~, replaced by custom Multi-Media aware Operating System with remote management
- SNMP Management System for remote management
- ~~Low-Loss Microwave or VHF/UHF RF coaxial feeder cable,~~ replaced by Pigtail Adapter for Radio interface output port to Antenna converter
- TV modulator for A/V signal processing
- Omni-Directional Antenna for QRP[17] broadcast of A/V programs.

Obviously the MMTS configuration is simpler than the MCBS configuration and is very much like the BWR configuration as most of the functionality can be indoors or outdoors.

- Motherboard with several slots (or Passive Backplane with Industrial grade Single-Board Computer)
- Memory
- Processor
- Flash Media
- Power Supply
- Interface Cards including any combination of:
  - 10/100/1000 Ethernet LAN Adapter
  - 10/100/1000 Fiber Optic LAN Adapter
  - xDSL Network Adapter and/or Baseband Modem for copper wires
  - Dialup Modem Adapter and/or RS-232 serial link to external Modem
  - Free Space Optics Transmitter/Receiver
  - Wireless LAN Adapters (Spread Spectrum, any frequency band)
  - HF/VHF/SHF Radio Modem Interfaces
  - Satellite Modems and Personal Earth Stations with Synchronous or Asynchronous or Ethernet Interfaces
- ~~Indoor Cabinet~~ replaced by Weatherproof Outdoor Cabinet OPTIONAL
- Keyboard connection to monitor (optional)
- VGA Display connection to monitor (optional)
- ~~Router Operating System with remote management~~, replaced by custom Multi-Media aware Operating System with remote management
- SNMP Management System for remote management
- ~~Low-Loss Microwave or VHF/UHF RF coaxial feeder cable,~~ replaced by Pigtail Adapter for Radio interface output port to Antenna converter
- TV modulator for A/V signal processing
- Omni-Directional Antenna for QRP broadcast of A/V programs.
- Video Camera and Video Camera interface or Video Conferencing equipment with network interface.
- Large Television for presentation or Projection Television for larger audience participation
- Sound Recording equipment and mixing panel

Configuration for BMSTDA:IPTG

An obvious requirement of any new digital communications network is whether it will have the ability to provide basic voice communications service in addition to value-added

[17] QRP – Ham Radio abbreviation, meaning *Very Low Power*

services such as Internet and E-commerce applications. It is certainly possible to consider purchasing and deploying commercial grade IP telephony devices that would do a certain amount of processing and would do it well, but repair, maintenance, troubleshooting problems would always be an impediment to smooth operation. Also, the planners of future BMSTDA networks would have to deal with different hardware and software configuration of the various devices depending upon the manufacturer's specifications. In certain cases they may not be able to get an economic configuration of commercial IP telephony gateways enough to satisfy the very poor purchasing power available in "zero-infrastructure" gateways.

Therefore the challenge here is to build BMSTDA equipment that could possibly include all the hardware that a regular BMSTDA:BWR has, or a BMSTDA:MMRU has and include some low-cost audio interfacing hardware (or pre-owned, software-hardware telephony devices such as Intel Dialogic and other manufacturer hardware) in order to construct flexible, affordable telephone gateways.

The component list for BMSTDA:IPTG is:

- Motherboard with several slots (or Passive Backplane with Industrial grade Single-Board Computer)
- Memory
- Processor
- Flash Media
- Power Supply
- Interface Cards including any combination of:
    - 10/100/1000 Ethernet LAN Adapter
    - 10/100/1000 Fiber Optic LAN Adapter
    - xDSL Network Adapter and/or Baseband Modem for copper wires
    - Dialup Modem Adapter and/or RS-232 serial link to external Modem
    - Free Space Optics Transmitter/Receiver
    - Wireless LAN Adapters (Spread Spectrum, any frequency band)
    - HF/VHF/SHF Radio Modem Interfaces
    - Satellite Modems and Personal Earth Stations with Synchronous or Asynchronous or Ethernet Interfaces
    - Voice Telephony or Voice Processing Interface Cards
- Indoor Cabinet
- Keyboard connection to monitor (optional)
- VGA Display connection to monitor (optional)
- Router Operating System with remote management with IP Telephony Module
- SNMP Management System for remote management
- Low-Loss Microwave or VHF/UHF RF coaxial feeder cable
- Main Distribution Frame for outside plant access
- Wireless Access Point (optional)

In case local distribution is done through Wireless Access Point, IP Telephones can be utilized directly. But if regular Plain-old-telephone set is required then a Voice telephony and Voice Processing system is required to interface old-style technology with new style networks.

Configuration for BMSTDA:MCN

The Micro-Community Communication Node is not a single device, and does not refer a collection of technology, but rather it is a moniker for a service network that provides applications and connectivity for an entire "small" area. The idea of Micro-Community Communications Node is a reference to the concept of "Community Communications Node" that acts as a tele-center in some villages in rural areas worldwide. It is assumed that a MCN would be setup in a small area serving several house-holds or established schools or medical facilities which would be entrusted with its safe-keeping and guardianship. In fact, that family or nearby families or nearby schools/hospitals can be provided with support so that they in turn can "own" their infrastructure after a period of time. This is called Community Ownership of BMSTDA network infrastructure. By adopting local ownership practices:

- Local youths can be employed to service and maintain this equipment
- Typically there will be 2 (two) persons per MCN who will be responsible for it
- Equipment pilferage is drastically reduced

A single MCN must be connected to at least one other MCN for it to be part of a "network". But since one of the major objectives of BMSTDA is to provide "fault-tolerant, partial-mesh" service each MCN that is connected should be connected at the earliest opportunity to another MCN somewhere nearby.

A single MCN therefore can consist of any number of:

- BMSTDA:BR
- BMSTDA:BWR
- BMSTDA:MMRU
- BMSTDA:MCBS
- BMSTDA:MMTS
- BMSTDA:IPTG
- Internet Support Equipment: in order to distribute the *connectivity*, the network on the ground or in the air has to be spread out.

A "small BMSTDA service area" is defined as 100 sq. km of coverage which may include many MCN in a network.

A "medium BMSTDA service area" is defined as 500 sq. km of coverage which will include many MCN in a network.

A "large BMSTDA service area" is defined as 1000 sq. km of coverage which will include many MCN in a network.

BMSTDA: Why does it work so efficiently at low-cost?

BMSTDA concept is new, but its technology components are not. There has been no attempt to "discover" new product technology, new methods of sending data transmission, new ways to manufacture cheaper, faster, better. What is new is however the idea of using existing technical products in an innovative way, by deciding to define a set of parameters that will satisfy the average requirements of the poor region and then attempting to choose compatible products to fit them into the picture puzzle.

There are common sense formulas that have to be taken into account that actually makes the BMSTDA concept work, but those formulas are related to old, established scientific disciplines such as Radio Engineering, Mechanical Engineering and Computer Science. For example the idea that a small power signal can be sent large distances away is embodied in the concept of all communications theories and is calculated generally as a "link budget", which can be used to mathematically prove or disprove a given communications link will work. Given that a typical Wireless LAN adapter puts out a maximum of 200 mW (this is special order, normal WLAN cards are 30 mW) it can be calculated from various standard formulas that the signal of that WLAN card if connected WITHOUT LOSS to a 24 dBi grid parabolic antenna then the signal will go as far as 30,000 meters if the antenna is fixed at 60 feet above ground level on both sides.

What data rate can be achieved in this type of ad-hoc point-to-point network depends upon the various Wireless LAN or Radio Adapters being used, and that specification can be calculated from the Link Budget formula which is a complex equation of:

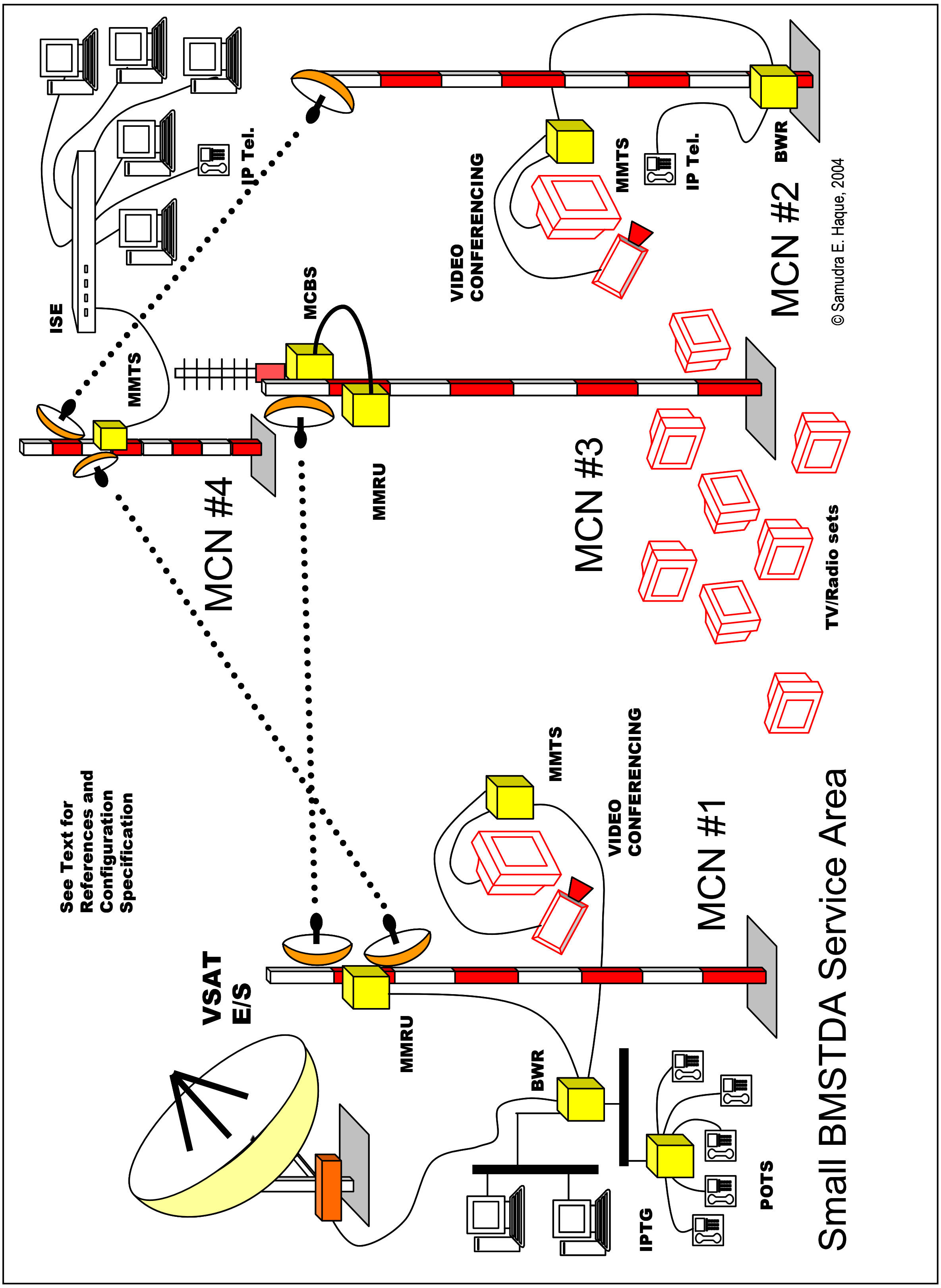
- Power at Transmitter Output Port in dBm units *less*
- RF Feeder Cable Loss in dB units *plus*
- Transmit Antenna Gain in dB units *less*
- Free Space Loss in dB units *less*
- Signal Loss due to atmospheric factors in dB units *plus*
- Receive Antenna Gain in dB units *less*
- RF Feeder Cable Loss in dB units *less*
- Misc. coupling losses in dB units = Received Signal Strength (in dBm).

In order to deliver the maximum amount of power from one side of a network to other side, the signal needs to be sent with as much as "less" loss as possible; hence the idea of directly attaching Wireless LAN adapters and Radio Modems to antenna is of significant merit and importance to the concept of BMSTDA implementation.

By eliminating the need to have hundreds of feet of RF Coaxial cable from (perhaps) a BWR to an antenna expense is saved in implementation as well as gaining signal strength for longer range applications.

By adopting software-based approach to designing routing and multi-media systems and not adopting hardware based approach where product is custom designed for high reliability situations, flexibility of implementation is achieved. In case new features are required, or different configuration is required just a software upgrade can be implemented. In case that equipment has returned from service and needs to be retired, instead of retirement they can be recycled into other configurations. For example, MCBS and MMTS share hardware, but they also can be used in emergency as BWR, BR, MMRU and vice-versa. That way, a BMSTDA network manager can rest assured that at least the network will remain functional until repairs are made. Also, older generation of personal computers can be utilized by recycling their parts into custom-designed BWR, BR, MMRU, MCBS and MMTS with no limits. There are obviously many sources of recycled and obsolete parts of computers and peripherals and the items can be purchased at throw-away prices.

The elegance of the BMSTDA concept comes apparent if we look at a sample network diagram.



This *top-level* network diagram shows an imaginary area of 4 Micro-Community Communication Nodes connected to each other. The mode of connection in this network is primarily through wireless links (could be Free-space Optics, pt-to-pt Microwave of either Spread Spectrum or Clean Carrier). A VSAT Earth Station is connected to a BWR in service area MCN#1, which can be treated as a gateway for the entire network. The functionality achieved in each MCN is listed as follows:

MCN#1: Satellite Connectivity, IP Telephony Services, Internet/Intranet Services, Video-Conferencing services and connections to MCN#3, MNC#4

MCN#2: IP Telephony Services, Video Conferencing Services, IP Telephone Service, and connection to MCN#4

MCN#3: Connectivity to MCN#1 and Micro-community Broadcast Station Service for TV/Radio transmission to surrounding community. In this node, there is no provision for computer connections locally.

MCN#4: Connectivity to MCN#2, MCN#1 with Internet Support Equipment serving a collection of PC users and IP Telephone Service.

The use of common equipment allows the designers of BMSTDA networks to make hybrid network topology possible, and the roll-out of the network can be implemented in stages as and when practical.

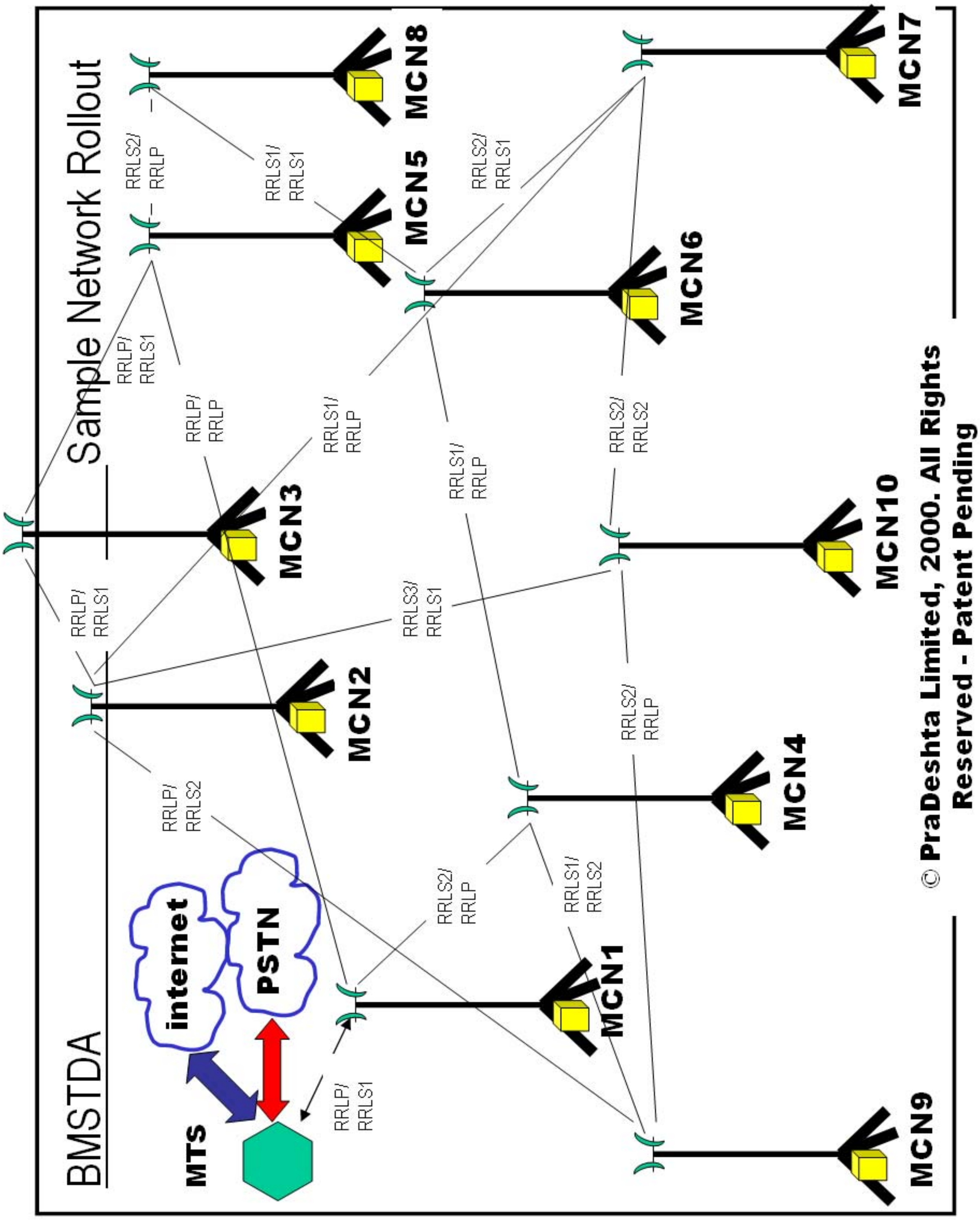
Each MCN has to be designed to be independent in makeup and function, and should be provided with adequate power (typically << 50 Watts, 250Volts AC) and the required supply could be provided adequately by Lead-Acid deep-discharge storage battery which would be charged by Mains supply, Solar Panels or AC/DC Generators if available. Otherwise if a *battery-plant* were to be setup and fully charged through an AC/DC generator, then the MCN could potentially be operating continuously for several weeks without additional charge.

As can be seen in the diagram, some nodes are connected only to another node, whereas there are nodes which are multiply connected. Typical network configuration for small-size networks will result in 1-4 connections per node. For long-distance networks 1-3 connections per node can be expected. If for some reason more than 3-4 connections are desired at any one particular MCN location, it is recommended to connect two or more MMRU or BWR back-to-back as can be seen has been done for the case of MCN#2 in the diagram.

For the first link for a MCN to connect to other MCN the designation of that link is "Redundant Radio Link – Primary" or RRLP. There is only one RRLP per MCN. Other links that emanate from that same MCN in any direction are called secondary links, so they would be designated as RRLS1, RRLS2 and so on.

It is very important to note that the links RRL*n* actually refer in most cases to IP subnetworks and the total number RRL*n* will be reflected in the number of active routes in the routing tables of the various BMSTDA devices. Since some form of dynamic routing protocol will be active at all times, any link that will be disconnected will be also deleted from the routing table, and any new link or MCN that comes on line will cause a change in the routing map – new routes can be added or subtracted or changed according to the network status at any time.

This dynamic routing feature is a strong benefit of BMSTDA networks and this can be amply demonstrated in the next diagram which was presented as early as 2000 calendar year.



Each MCN node is depicted here in this diagram as a BWR but in reality they can be any type, BWR, MMRU, BR, MCBS, MMTS etc. Since there are multiple paths between the various nodes, it is practical to consider whether and how the network will survive a catastrophic disaster that perhaps would disable or destroy (due to natural disaster) any number of nodes, such as (for example): MCN#3 and MCN#7.

As the reader can see, by tracking the remaining possible paths the network connectivity is left intact even missing the two nodes:

- MCN1 is still connected to Nodes 4, 5
- MCN2 is still connected to Nodes 9,10
- MCN3 is inactive
- MCN4 is still connected to Nodes 1,9,6
- MCN5 is still connected to Nodes 8,1
- MCN6 is still connected to Nodes 4,8
- MCN7 is inactive
- MCN8 is still connected to Nodes 6, 5
- MCN9 is still connected to Nodes 10,4,2
- MCN10 is still connected to Node 9,2

Note that "MTS" refers to *Main Telecommunication Switch* similar to a VSAT Earth Station or a regular Point-of-Presence of an established fixed public switched telephone network.

Sample 5-year Project Costing for a BMSTDA network

- Assumption: 100 MCN with at least:
  - 1xBR
  - 1xBWR or 1xMMRU
  - 1xIPTG with 30 analog telephone channels and cables
  - 1xMCBS
  - 30xPOTS
  - 10xISE to cater to 50 personal computers (if required)

- Assumption: each MCN connected to other MCN by at least 15-20 km of line of sight so total area covered approximately 1000 sq. km.
- Assumption based upon current costs adapted from Bangladesh installations of BMSTDA networks.
- Industrial data from Ethiopian manufacturers not consistent at time of report but estimate given below falls within higher range of expectations.

Phase I: Estimated Manufacturing Costs

Item	Unit Cost	Qty	Sub-Total
Sectional Communication Towers (avg. 100 feet)	$2,000	100	$200,000
BR	$500	100	$50,000
BWR/MMRU with 2 x RRL, 2 x Antenna	$1,200	100	$120,000
IPTG (30 FXS POTS capability)	$2,500	100	$250,000
MCBS (1 TV Channel capability)	$800	100	$80,000
POTS (DTMF Telephone)	$10	3000	$30,000
ISE (Ethernet switches)	$70	1000	$70,000
Outside cable plant (UTP Cat 5 and POTS 2-wire)	$7,000	100	$700,000
Generator	$2,000	100	$200,000
UPS/Battery Plant/Battery Charger	$1,000	100	$100,000
Operating System(s) Licenses	$250	100	$25,000
100xMCN SUB-TOTAL			**$1,825,000**

Phase II: Site Preparation

Communication Tower Foundation	$750	100	$75,000
Communication Tower Guy Wires	$150	100	$15,000
100xMCN SUB-TOTAL			**$90,000**

Phase III: Deployment (6 months lump sum contract, 100 nodes)

Manpower (Network Managers, Full-Time)	$6,000	5	$30,000
Manpower (Network Engineers, Full-Time)	$4,500	10	$45,000
Manpower (Network Technicians, Full-Time)	$3,000	20	$60,000
Deployment Manpower Costs			**$135,000**

Phase IVa: 5-year Manpower cost (61 months contract)

Manpower (Network Managers, Full-Time)	$800	61	$48,800
Manpower (Network Engineers, Full-Time)	$600	61	$36,600
Manpower (Network Technicians, Full-Time)	$400	61	$24,400
Manpower (On-site Technician, Contract)	$250	61	$15,250
5-year Manpower SUB-TOTAL			**$125,050**

Phase IVb: Spares and Maintenance

Assume 20% spares required $490,050

Assume use of electricity @25kW for 100 MCN[18] 219,000 KWH/year

Assume avg. 10 miles travel required per day 3,650 miles/year

Phase V: Independent Satellite Link from Tier-1 Asian Teleport/Gateway (example only[19])

- Assume C-band partial transponder leased for 5-years 8Mbps/8Mbps duplex
- Assume full use of space segment for IP purposes @$2.5/kbps
- Cost of satellite bandwidth (8Mbps/8Mbps) international service to public IP gateway is estimated at $2.5/kbps * 8000 kbps * 2 = $40,000 per month.
- Cost of Satellite Earth Station: Approximately $75,000 for large scale VSAT Earth station (4.5m with redundant high power RFT/ODU)

So, in summary:

Domestic Service:

- Phase I: $1,825,000
- Phase II: $90,000
- Phase III: $135,000
- Phase IVa: $125,050
- Phase IVb: $490,050 + Electricity expenses for 219,000 KWH/year + travel
- Estimated cost is therefore: $2.66 million able to serve for 5-years 3,000 rural POTS connections and 5,000 rural personal computer connections.
- This network can be connected to nearby ETC infrastructure if any.
- The recovery rate of the network is (assuming non-profit mode of business):
  - $2.66 million cost / (3000 POTS services x 60 months x 30 days x 0.5 hours per day average utilization) = $2.66 million / (2.7 million hours) = $0.99 per hour minimum recovery rate, or 0.14 Ethiopian Birr per minute. (Assuming 1USD=8.5 Ethiopian Birr).

International Service:

If direct internet service, or international IP telephony service is required, then a direct satellite service has to be implemented.

Domestic Service + Phase V: $2.66 million + $75,000 one-time cost + $40,000/m

Over 5-years the total additional cost will be $75,000 + ($40,000 x 60) = $2.475 million
The cost of IP service *per minute* will therefore be $2.475 million divided by 8 Mbps over 5 years: $2.475 million / (365 x 5 x 24 x 60)
= US $0.94 full duplex, Tier-1 IP service *per minute* for the entire network

The tariff rate per minute per 64kbps full duplex, Tier-1 service is US$0.0074
The tariff rate per minute per 128kbps full duplex, Tier-1 service is US$0.015
The tariff rate per minute per 256kbps full duplex, Tier-1 service is US$0.03

[18] Assumed to be HIGH estimate, not based upon actual measurement
[19] Source: APT Telecom, Hong Kong/Singapore Telecom, Singapore

The tariff rate per minute per 512kbps full duplex, Tier-1 service is US$0.06
The tariff rate per minute per 1Mbps full duplex, Tier-1 service is US$0.12

Note that for each 64kbps duplex service, 5 (five) voice channels can be serviced simultaneously if VOIP service is used. So the cost of an international phone call through the BMSTDA/VSAT Network is as follows:

Per minute cost for 1 single VOIP/IP Telephony call from Ethiopia to Hong Kong (e.g.) gateway will be US$0.00148 or Ethiopian Birr 0.01 per minute.

However each individual country and operator will add in their own gateway charges, which may be in the range of equivalent costs per minute.

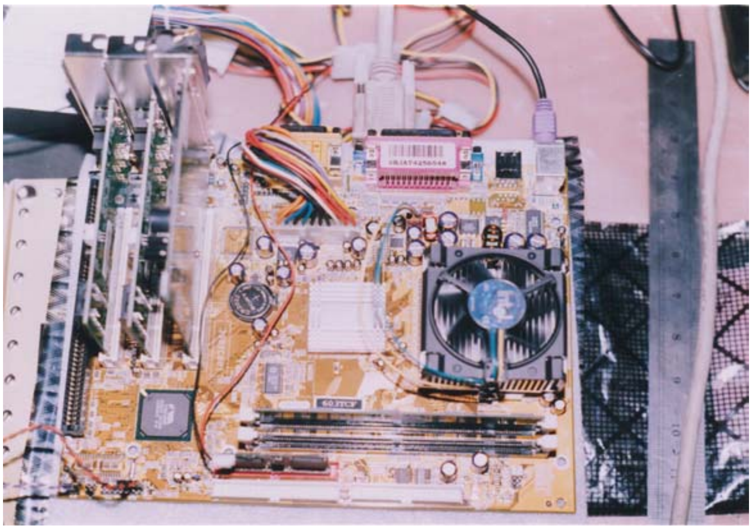
The retail rate for this service should be calculated by dividing the base IP rate into as many customers as possible, through the use of proxy servers and web cache hosts.
The first level ISPs will then take the gateway connection and distribute it at retail rates to the end user according to the market demands.

Hands-on Demonstrations

Proof-of-concept Demonstration I (ETC Headquarters)

Date: February 17, 2004 Time: 3:00 p.m.
Location: ETC Room #710

A network to demonstrate the features and benefits of a Broadband Multi-Service Switching, Transmission and Distribution Architecture was presented to senior managers of ETC which was constructed by a joint effort of this Consultant and the members of the Solutions Group[20]. The short range, high speed radio network using locally assembled Broadband Wireless Routers (Similar in specifications to BMSTDA:BWR Model 1) and a short range omni antenna, was set up between room no. 710 and 719, considering one of the rooms to be "Ketema" and the other end "Geter" respectively to simulate a real ISP network separated by distance and serving customers far away. The Geter side, which is the client point, has IP Telephony Gateway with two handsets for voice services and one multimedia workstation. The Ketema side consisted of a server operating as a virtual ISP, and two telephone handsets for voice services, acts as a Point-of-Presence. The virtual



ISP used LINUX Slackware Distribution operating system with Domain Naming Services (DNS), File Transfer Services (FTP), Web Server (HTTPD), Secure Telnet Shell Daemon (SSHD) activated. Two sets of Broadband Wireless Router were constructed by combining regular PC hardware components and installing a Mikrotik Router Operating System to enable Local Area Network and Wireless Local Area Network interfaces to be utilized for Switching and Routing functions. On the KETEMA side the operating system features were set to "Access Point", and on the GETER side the operating system features were set to "Client" due to the particular nature of the Wireless LAN Adapters used. This is flexible, any side can be an Access Point, Bridge or Client depending upon the particular network topology used (Star, Point-to-Point Bridge, Point-to-point). Please refer to the diagram on the next page for easy reference and further details

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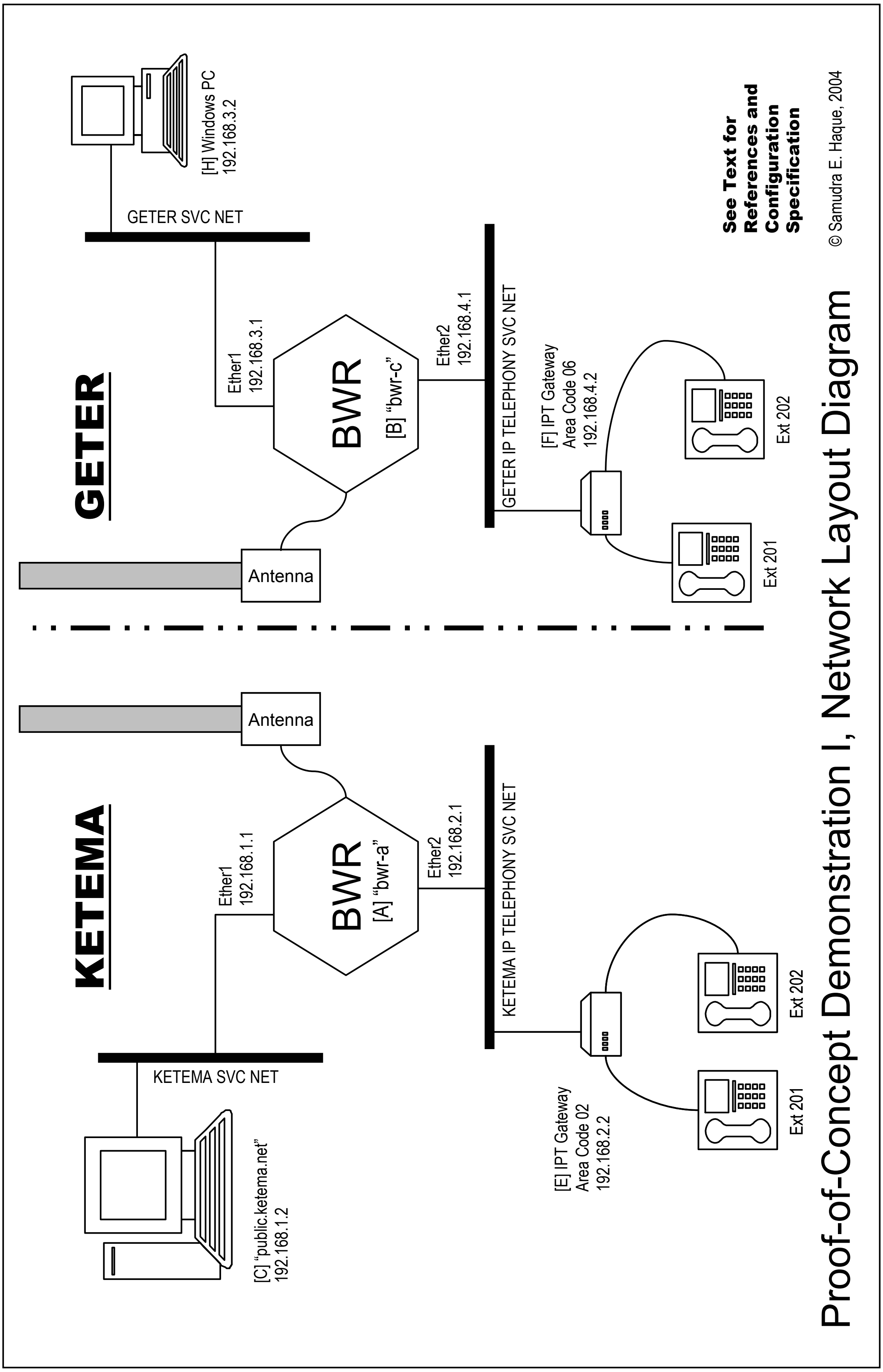
[20] *Anteneh Mekonnen*, D/Division Mgr, *Ayalneh Fikremariam*, *Bewket Abrha*, *Chalew Demlie*, *Gashaw Nigussie* and others



Proof-of-Concept Demonstration I, Network Layout Diagram

A series of example tasks were shown to the audience, these included:

- The files for a power point presentation entitled "Portable and Versatile Broadband Multi-Service Communication Network Architecture for Deployment in Large Geographic Areas at Very Low Cost" were downloaded to the PC Workstation (H) on the GETER side by browsing on the internet and entering http://www.ketema.net into the web browser. The 3.08MB MS-PowerPoint presentation file was located on the account http://www.ketema.net/~haque and once downloaded in a few seconds was able to be shown on the computer workstation attached to a digital video projector. The Power Point Presentation Show can be seen here.
- A very large multi-media file of a professional video program segment was then transferred from the web server to the computer workstation and the time taken to transfer the 58.7MB file was measured. According to stopwatch operated by a volunteer from the audience, the approximate time to transfer this very large file was 1 minute and 39 seconds, which resulted in an effective data transfer rate of 4.74Mb/s.
- For the purposes of voice service between KETEMA and GETER, all four of the telephone sets had been pre-connected to the IP Telephony gateway and the telephone area codes of the respective gateways programmed before the demonstration started. A telephone call was made from the KETEMA side (E) to the GETER side (F) by dialing 06-201 or 06-202 and to call from GETER to KETEMA via this service, 02-201 and 02-202 were used to contact the remote party. The mechanism for contacting other parties was just like a regular phone call using fixed telephone service, but working through wireless high speed connections.
- A collection of documents (HTML, PDF) were installed on the server "public.ketema.net" and the contents of that online-library were displayed to the audience by browsing from the remote workstation over the network through URL http://www.ketema.net/library
- Real-time management of the system in operation on both the Broadband Wireless Routers were demonstrated by using the WinBox GUI application running on the Windows XP Workstation (H) which showed the ability of an operator to effectively manage bandwidth on a dynamic basis and to control all aspects of the network at any time.

Over 20 Senior Managers and mid-level Managers of ETC are reported to have attended the event and at the conclusion the Solutions Group engineers gave a tour of their "wide area network" in detail to anyone interested. For this purpose the equipment had been left in a barebones condition so that the technology could be shown in its original form as being readily available and easy to setup.

Amongst the attendees during the regular presentation the presence of Ato Million Fekadu (Satellite Division Manager), Ato Abdulsemed (Marketing Division Manager), Ato Melak (Switching Division Manager), Ato Melaku Wakjira (Marketing Division D/Manager) was noticeable.

The Network for POCD-I was setup using the following equipment

Component Ref	Part	Specifications	Qty
[A] Broadband Wireless Router (Access Point Configuration) KETEMA SIDE	Motherboard	Mfr: Jetway	1
	CPU	Genuine Intel Celeron 1.3 GHz	1
	Memory	128MB SDRAM	1
	Flash Media	32MB IDE	1
	Router Operating System	Mikrotik 2.7.20 S/N 4HZ4-P4N (key: CCYK-JDC-1LT)	1
	Wireless LAN Adapter	Senao/Generic PRISM chipset IEEE802.11b WLAN card, 200mW output	1
	Antenna	2 dBi Omni antenna with RP-TNC connector	1
	Coax Pigtail Converter	6" MMCX to RP-TNC converter cable	1
	Ethernet LAN Adapter	10/100 Ethernet LAN Adapter	2
	Power Supply	P4 power supply 200W	1
	CONFIGURATION:: NAME: "bwr-a" ETHER1: 192.168.1.1/24 serving SUBNET "KETEMA SVC" ETHER2: 192.168.2.1/24 serving SUBNET "KETEMA IP TELEPHONY SVC" WLAN1/PRISM1: 10.0.0.1/30 serving SUBNET "WIRELESS" OSPF authentication simple, OSPF authentication key "clagn96", networks 192.168.1.0/24, 192.168.2.0/24, 10.0.0.0/30 SSID1="bwr-c" default channel, default power setting for TX output		
[B] Broadband Wireless Router (Client Point Configuration) GETER SIDE	Motherboard	Mfr: Jetway	1
	CPU	Genuine Intel Celeron 1.3 GHz	1
	Memory	128MB SDRAM	1
	Flash Media	32MB IDE	1
	Router Operating System	Mikrotik 2.7.20 S/N LHP7-ZVN (key: 54DC-GWW-WHP)	1
	Wireless LAN Adapter	Senao/Generic PRISM chipset IEEE802.11b WLAN card, 200mW output	1
	Antenna	2 dBi Omni antenna with RP-TNC connector	1
	Coax Pigtail Converter	6" MMCX to RP-TNC converter cable	1
	Ethernet LAN Adapter	10/100 Ethernet LAN Adapter	2
	Power Supply	P4 power supply 200W	1
	CONFIGURATION:: NAME: "bwr-c" ETHER1: 192.168.3.1/24 serving SUBNET "GETER SVC" ETHER2: 192.168.4.1/24 serving SUBNET "GETER IP TELEPHONY SVC" WLAN1/PRISM1: 10.0.0.1/30 serving SUBNET "WIRELESS" GATEWAY: 10.0.0.2 OSPF authentication simple, OSPF authentication key "clagn96", networks 192.168.1.0/24, 192.168.2.0/24, 10.0.0.0/30 SSID1="bwr-c" default channel, default power setting for TX output		
[C] Linux Host for ISP services	Motherboard, CPU, Memory, Case, Power Supply, Monitor, Mouse	Used existing DELL Optiplex computer of ETC	1
	Hard Disk	1 x 1GB IDE, 1 x 2GB IDE	
	Operating System	Linux Slackware Distribution 9.2	
	CONFIGURATION:: NAME: "public" DOMAIN NAME: "ketema.net" IP ADDRESS: 192.168.1.2/24 GATEWAY 192.168.1.1 Applications/Services: DNS, FTP, HTTP, SSHD, BASH		
[D] Ethernet Hub	Generic, on loan from ETC staff	1 Hub for KETEMA SERVICE subnet 1 Hub for GETER SERVICE subnet	2
[E] IP TELEPHONY GATEWAY (KETEMA)	VIP-200	2 xFXS Port IP Telephony gateway for POTS connections, 2-wire. CONFIGURATION:: IP ADDRESS: 192.168.2.2/24 GATEWAY: 192.168.2.1 AREA CODE: 02	1

The Network for POCD-I was setup using the following equipment

[F] IP TELEPHONY GATEWAY (GETER)	VIP-200	2 xFXS Port IP Telephony gateway for POTS connections, 2-wire. CONFIGURATION:: IP ADDRESS: 192.168.2.2/24 GATEWAY: 192.168.2.1 AREA CODE: 06	1
[G] Plain old Telephone Sets, 2 wire	Any telephone	2 Wire, DTMF Touch Tone	4
[H] Windows XP Workstation	Dell Optiplex	Any standard PC with Windows 98/2000/XP Operating System	1

Proof-of-concept Demonstration II (Chamber of Commerce)

Date: February 17, 2004 Time: 10:30 a.m.
Location: Addis Ababa Chamber of Commerce Conference Room

A network to demonstrate the features and benefits of a Broadband Multi-Service Switching, Transmission and Distribution Architecture was presented to members of the IT/ICT industry as well as to invited Senior members of several Gov't Departments (see list). The equipment had been prepared with the assistance of the World Bank Ethiopia Office[21] and volunteers from several local IT and Engineering firms[22]. The short range, high speed radio network using locally assembled Broadband Wireless Routers and a short range omni antenna, was set up in the same room on two sides of a conference table. One of the sides was considered to be "Ketema", a network known on the (pseudo) Internet as "Ketema.net" and the other end "Geter" respectively to simulate a real ISP network separated by distance and serving customers far away. The Geter side, which is the client point, has IP Telephony Gateway with two handsets for voice services and one multimedia workstation. The Ketema side consisted of a server operating as a virtual ISP, and two telephone handsets for voice services, acts as a Point-of-Presence. The virtual ISP used LINUX Slackware Distribution operating system with Domain Naming Services (DNS), File Transfer Services (FTP), Web Server (HTTPD), Secure Telnet Shell Daemon (SSHD) activated.

In addition, a custom developed Geographic Information System (running on a Windows 2000 Professional Server) which has been programmed to handle several hundred on-demand requests for maps of a particular local area was put into service on the Ketema Service Network and assigned its own Domain Name of "cis.ketema.net" with its own IP address. The function of the "cis.ketema.net" was to serve the various graphics and database information required for a "Cadastral Information System" which is developed by Cybersoft a local firm. According the developer, Tweldemedhin who was on hand to help in the presentation the CIS is "*a software for managing tax collection related with house holds. It integrates Geographic Information System with is entirely locally produced saving expensive ArcView GIS software that had to be used for the same purpose. More over the system integrates Amharic typing.*

Currently the software is deployed in client/server mode with the server at the municipality building and clients in each of the sub-cities connected using a dial-up network. This system will be the first to benefit from the role-out of the BWR technology in Addis. Currently the low-bandwidth of the dial-up network restricts the use of the advanced features of the software to only clients in the municipality building".

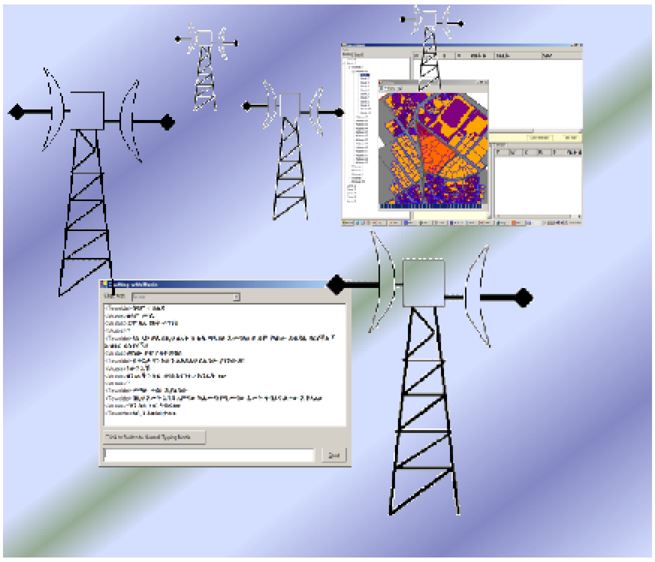
A custom Web based introduction screen was created and put upon the "public.ketema.net" server, which was made accessible as www.ketema.net just like a regular ISP would do in order to serve its customers.

[21] *Ato Menbere Taye Tesfa, Ato Abebaw Alemayehu*
[22] (Cybersoft) *Teweldemedhin Aberra*, (Vision Computer) *Alem Haile*, (USI), (Ebba Engg. PLC) *S.T. May*

Proof of Concept Demonstration II

Ministry of Capacity Building

World bank project: ETHIOPIA - ICT - Assisted Development Project



A bold initiative by Asian countries to **do more with less** using locally available knowledge and minimum of expensive imported equipments.

We think that there is enough expertise available in the country to

- write commercial grade software
- manufacture mechanical parts
- integrate cheap off-the-shelf software and hardware to create useful systems

The demo has two components that demonstrate most of the ideas behind this namely a practical demonstration namely

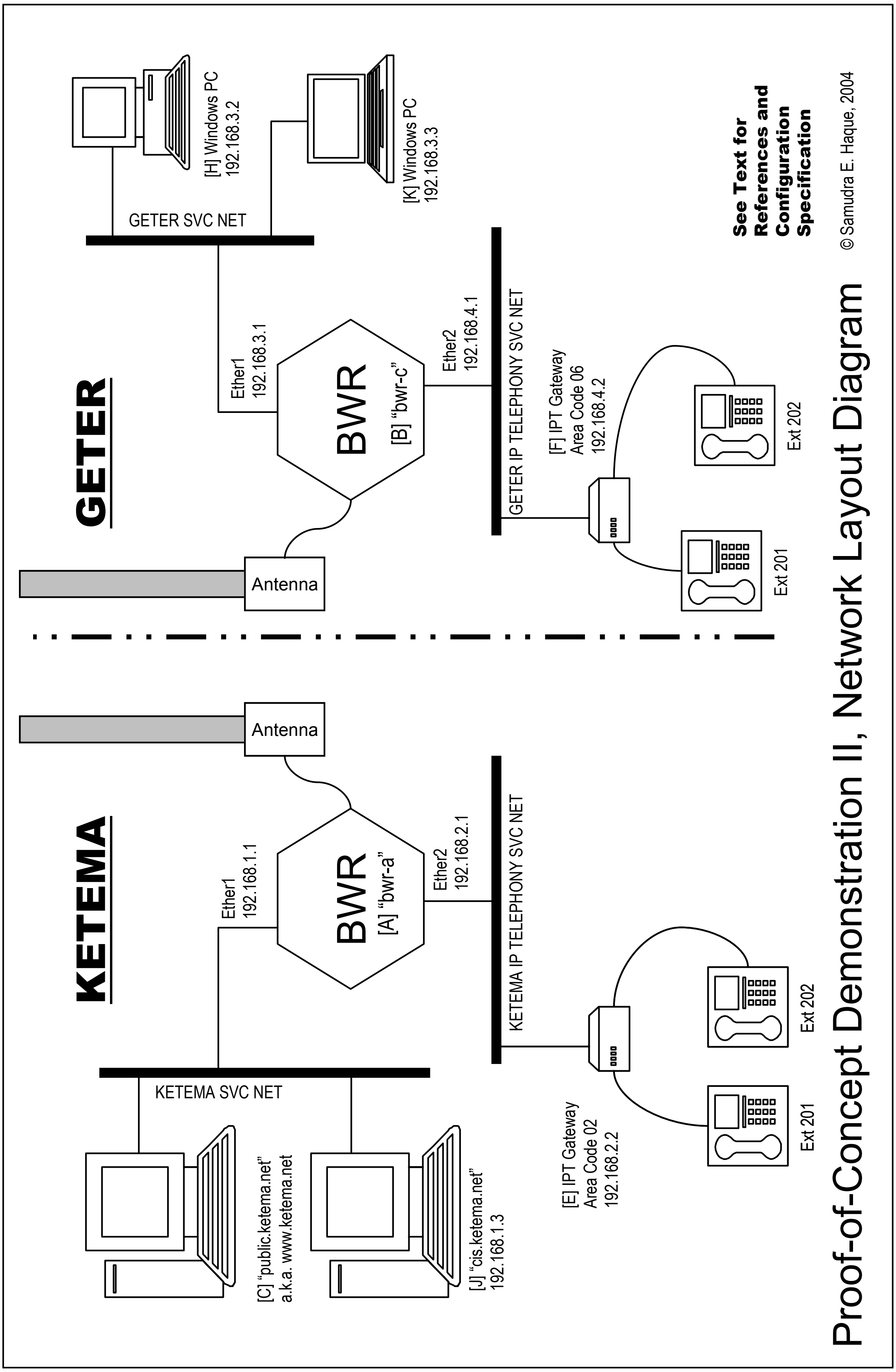
- BWR
- Two example software that are developed locally by Ethiopian private sector

To add an interactive flavor to the use of a high speed, broadband network an innovative custom application was programmed to run on the Windows 2000 Server, which allowed two parties to be involved in an *Instant Messaging* conference where each would be able to type short messages to each other, in English and Amharic. In this test application, the laptop computer on the GETER side was used as one of the terminals through which a remote user was able to chat with Tweldemedhin who was "on the KETEMA network".

The two sets of Broadband Wireless Router were constructed by combining regular PC hardware (please see the list) and installing a Mikrotik Router Operating System version 2.7.20 to enable Local Area Network and Wireless Local Area Network interfaces to be utilized for Switching and Routing functions. On the KETEMA side the operating system features were set to "Access Point", and on the GETER side the operating system features were set to "Client" due to the particular nature of the Wireless LAN Adapters used. This is flexible, any side can be an Access Point, Bridge or Client depending upon the particular network topology used (Star, Point-to-Point Bridge, Point-to-point).

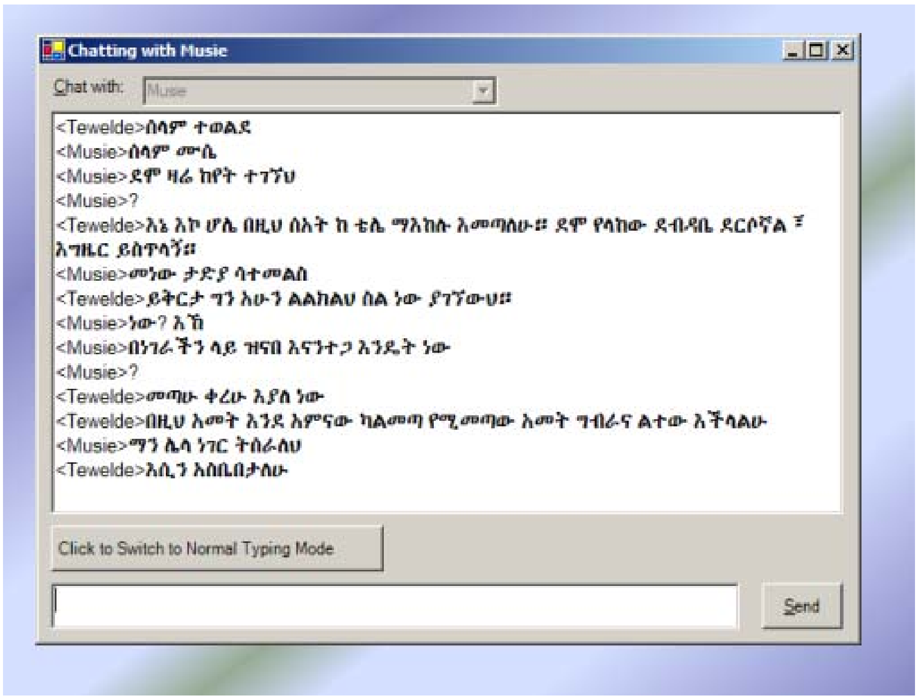
A diagram of this network is presented on the next page, and for quick reference a table of components used is also presented. A series of example tasks were shown to the audience, these included:

- The files for a power point presentation entitled "Portable and Versatile Broadband Multi-Service Communication Network Architecture for Deployment in Large Geographic Areas at Very Low Cost" were downloaded to the PC Workstation (H) on the GETER side by browsing on the internet and entering http://www.ketema.net into the web browser. The 3.08MB MS-PowerPoint presentation file was located on the account http://www.ketema.net/~haque and



once downloaded in a few seconds was able to be shown on the computer workstation attached to a digital video projector. The Power Point Presentation Show can be seen here.

- A very large multi-media file of a professional video program segment was then transferred from the web server to the computer workstation and the time taken to transfer the 58.7MB file was measured. According to stopwatch operated by a volunteer from the audience, the approximate time to transfer this very large file was 45 seconds, which resulted in an effective data transfer rate of 11Mb/s.
- Real-time management of the system in operation on both the Broadband Wireless Routers were demonstrated by using the WinBox GUI application running on the Windows XP Workstation (H) which showed the ability of an operator to effectively manage bandwidth on a dynamic basis and to control all aspects of the network at any time.
- For the purposes of voice service between KETEMA and GETER, all four of the telephone sets had been pre-connected to the IP Telephony gateway and the telephone area codes of the respective gateways programmed before the demonstration started. A telephone call was made from the KETEMA side (E) to the GETER side (F) by dialing 06-201 or 06-202 and to call from GETER to KETEMA via this service, 02-201 and 02-202 were used to contact the remote party. The mechanism for contacting other parties was just like a regular phone call using fixed telephone service, but working through wireless high speed connections.
- A collection of documents (HTML, PDF) were installed on the server "public.ketema.net" and the contents of that online-library were displayed to the audience by browsing from the remote workstation over the network through URL http://www.ketema.net/library
- A volunteer was asked to establish an online chat session from the GETER side to the KETEMA side, and a demonstration (such as a sample screen shot below) was provided where native Amharic speakers would be able to converse with anyone who has the same type of software through this broadband wireless network.



The Network for POCD-II was setup using the following equipment

Component Ref	Part	Specifications	Qty
[A] Broadband Wireless Router (Access Point Configuration) KETEMA SIDE	Motherboard	Dell Optiplex/loan from Cybersoft	1
	CPU		1
	Memory	128 MB	1
	Storage Media	40GB IDE Hard Drive/loan from Cybersoft	1
	Router Operating System	Mikrotik 2.8 Version	1
	Wireless LAN Adapter	Senao/Generic PRISM chipset IEEE802.11b WLAN card, 200mW output	1
	Antenna	2 dBi Omni antenna with RP-TNC connector	1
	Coax Pigtail Converter	6" MMCX to RP-TNC converter cable	1
	Ethernet LAN Adapter	10/100 Ethernet LAN Adapter	2
	Power Supply	As used	1
	CONFIGURATION:: NAME: "bwr-a" ETHER1: 192.168.1.1/24 serving SUBNET "KETEMA SVC" ETHER2: 192.168.2.1/24 serving SUBNET "KETEMA IP TELEPHONY SVC" WLAN1/PRISM1: 10.0.0.1/30 serving SUBNET "WIRELESS" OSPF authentication simple, OSPF authentication key "clagn96", networks 192.168.1.0/24, 192.168.2.0/24, 10.0.0.0/30 SSID1="bwr-c" default channel, default power setting for TX output		
[B] Broadband Wireless Router (Client Point Configuration) GETER SIDE	Motherboard	Mfr: Jetway	1
	CPU	Genuine Intel Celeron 1.3 GHz	1
	Memory	128MB SDRAM	1
	Flash Media	32MB IDE	1
	Router Operating System	Mikrotik 2.7.20 S/N LHP7-ZVN (key: 54DC-GWW-WHP)	1
	Wireless LAN Adapter	Senao/Generic PRISM chipset IEEE802.11b WLAN card, 200mW output	1
	Antenna	2 dBi Omni antenna with RP-TNC connector	1
	Coax Pigtail Converter	6" MMCX to RP-TNC converter cable	1
	Ethernet LAN Adapter	10/100 Ethernet LAN Adapter	2
	Power Supply	P4 power supply 200W	1
	CONFIGURATION:: NAME: "bwr-c" ETHER1: 192.168.3.1/24 serving SUBNET "GETER SVC" ETHER2: 192.168.4.1/24 serving SUBNET "GETER IP TELEPHONY SVC" WLAN1/PRISM1: 10.0.0.1/30 serving SUBNET "WIRELESS" GATEWAY: 10.0.0.2 OSPF authentication simple, OSPF authentication key "clagn96", networks 192.168.1.0/24, 192.168.2.0/24, 10.0.0.0/30 SSID1="bwr-c" default channel, default power setting for TX output		
[C] Linux Host for ISP services	Motherboard, CPU, Memory, Case, Power Supply, Monitor, Mouse	Used existing DELL Optiplex computer of ETC	1
	Hard Disk	1 x 1GB IDE, 1 x 2GB IDE	
	Operating System	Linux Slackware Distribution 9.2	
	CONFIGURATION:: NAME: "public" DOMAIN NAME: "ketema.net" IP ADDRESS: 192.168.1.2/24 GATEWAY 192.168.1.1 Applications/Services: DNS, FTP, HTTP, SSHD, BASH		
[D] Ethernet Hub	Generic, on loan from ETC staff	1 Hub for KETEMA SERVICE subnet 1 Hub for GETER SERVICE subnet	2

The Network for POCD-II was setup using the following equipment

[E] IP TELEPHONY GATEWAY (KETEMA)	VIP-200	2 xFXS Port IP Telephony gateway for POTS connections, 2-wire. CONFIGURATION:: IP ADDRESS: 192.168.2.2/24 GATEWAY: 192.168.2.1 AREA CODE: 02	1
[F] IP TELEPHONY GATEWAY (GETER)	VIP-200	2 xFXS Port IP Telephony gateway for POTS connections, 2-wire. CONFIGURATION:: IP ADDRESS: 192.168.2.2/24 GATEWAY: 192.168.2.1 AREA CODE: 06	1
[G] Plain old Telephone Sets, 2 wire	Any telephone	2 Wire, DTMF Touch Tone	4
[H] Windows XP Workstation	Dell Optiplex	Any standard PC with Windows 98/2000/XP Operating System	1
[J] Windows 2000 Server	Clone Pentium 4 Server	256MB RAM, Windows 2000 Professional/loan from Cybersoft	1
[K] HP Laptop	Any spec	Any spec/loan from Cybersoft	1

Record of the Attendance of POCD-II

No.	Name of Participant	Organization	Tele. No.	E-mail Address
1	Wossenyeleh Tigu	ETC	652442	Tele.agency@telecom.net.et
2	Adebabay Birru	Vision Computer	527777	adebabay@visc2000.com
3	Fethi Abdulahi	Ifcom Enterprise	09-200200	fethi@telecom.net.et
4	Abadu Emeru	Ministry of Federal Affairs	514102	rass@telecom.net.et
5	Helock Tilanun	Microtech computer engineering	537832	M_tech@telecom.net.et
6	Fillagot Menbere	Microtech computer engineering	537832	M_tech@telecom.net.et
7	Yonathan Mersha	Microtech computer engineering	537832	M_tech@telecom.net.et
8	Ketama Bayou	Addis Ababa Chamber of Commerce (AACC)	528122	ketema@addischamber.com
9	Bekele G. Medhin	MoCB	537312	bekele@telecom.net.et
10	Gemechu Geleta	MoCB	537412	Gemech_Geleta@hotmail.com
11	Michael Shebelle	United System Integrators	627303	Michael.shebelle@usi.com.et
12	Tewoldemedhin Aberra	Cybersoft		VOLUNTEER
13	Mesfin Kebede	Bizsoft	531060	dDesta@Bizsoftplc.com
14	Mulat Agumas	ETA	668203	Mulat.Agumas@ties.itu.int
15	Tafese Refera	AACC	518055	tafeser@hotmail.com
16	Bogale Demissie	EITPA	09-233983	bogaled@telecom.net.et
17	Deres Tesfaye	Omnitech	09-228525	tesfayed@telecom.net.et
18	Yilak Yehualashet	United System Integrators	09-206996	Yilak.Yehualashet@usi.com.et
19	Tekeste Berhan Habtu	Cybersoft	09-209466	thabtu@cybersoft.intl.com
20	S. T. May	Ethiopian Amateur Radio Club	09-201744	ET3SiD@TiSALi.co.uk
21	Zelalem Begashaw	MoCB	09-225486	Zbb@Freemail.et
22	Ghion Abelneh	MoCB	09-237807	ghion@operamail.com
23	Eshetu Alemu	ETA	656011	Tele.agency@telecom.net.et
24	Daniel Admassie	Mehtodic PLC	635606	methodic@telecom.net.et

International Case Studies

Indonesia

The innovative efforts to build a bottom-up Internet service infrastructure by independent Indonesian educators, engineers and enthusiasts over the last decade have been noticed by many ICT practitioners who are involved in similar projects to bring global connectivity to rural and poor areas.

The great success that Indonesia now enjoys with a world-class infrastructure, vibrant Internet-connected society and a stable, democratic administration actually had very humble roots. None of the early generation projects were financed by commercial entities or financed to make profit. In the words of one of the leading "internet activists" on the way that the movement was able to achieve its early goals:

"*It is not money, technology nor government help, in Indonesian Internet development, it is clearly shown that human factor; the community education is the most important key factor in empowering a self-finance bottom-up Indonesian Internet infrastructure. The community / society education processes are driven by many Indonesian volunteers. Consequently, only small fraction, if none, of World Bank, IMF, and ADB funding have ever been directly received by these communities. In some cases, some organizations may claim the success of Indonesian Internet development to get funding from various donor agencies."*[23]

from an archipelago of 17,000 islands. About 6,000 islands are inhabited and spread over a total of 1.9 million sq. km. (land is 1.8 million sq. km) and is the home for approximately 234 million population. By 2003, the ISP service provider industry had formed its own regulatory body APJII (Asosiasi Penyelenggara Jasa Internet Indonesia) or Indonesian ISP Association which is a non-profit organisation for all ISP's in Indonesia.

[23] "An Experience in Empowering a Bottom Up Indonesian Internet Infrastructure", Dr. Onno W. Purbo, Presented in Mediating Human Right Conference, Curtin University, Australia, February 2002

Currently there are 135 ISP's that became members of APJII from almost 200 ISP licenses issued by the government. 90 ISP's are already operating and the rest are preparing to operate[24].

The interesting fact is that the Gov't of Indonesia did not initially support the activities of the "Internet Activists" and allowed them to implement their own solutions. The activists did not hold all the information to themselves and they actively embarked upon a multi-year effort to educate their own communities on how to connect *by themselves* to the Internet through innovative resource sharing networks and use of wireless and wired infrastructure. The following pictures were provided by one the vanguards of this grass-roots initiative which is characterized by (a) use of common-off-the-shelf equipment (b) low-cost entry into new markets (c) user-based community-level support with no commercial sales/support organization (d) collaborative effort (e) research and development into local *Open Source Software* development possibilities to customize Internet content and applications into local languages (f) adaptation of common-off-the-shelf equipment to harsh environment in Indonesia (very heavy rain, very humid, very difficult terrain).

In fact, it is admirable in the opinion of this consultant that they have taken steps to ensure their collected knowledge is now available through the internet and available free of charge being sponsored where possible by International donor and development agencies.

While there are few examples of Indonesian technology development, recently local manufactured, high performance radio antennas have been observed to be produced which is reducing cost of infrastructure roll-out even further down to the purchasing power of the common people.

In 2002, the activists wrote in their own words, "*Based on the technology & business plan described freely in http://www.bogor.net/idkf, we managed to reduce the cost for public users to access Internet at Rp. 5000 / hour (approximately US$0.5/hour) at various Internet cafés. At Indonesian schools, the cost for accessing the Internet can be brutally reduced to Rp. 5000 / month / student (approximately US$ 0.5/student/month). Thus, Internet is actually accessible to a much wider range of people than simply those who can afford a personal computer. Investment for building Internet café in the range of Rp. 50-100 million (approximately US$5-10.000) would return easily within one (1) to two (2) year time. Thus, it is not surprising to see many small medium businesses as well as schools are now putting their money to build their own Internet infrastructure. Internet Café is an affordable solution for Indonesian to access the Internet. Having 25.000 high schools with 2-3 million students, it would a strategic move increase the Internet penetration by Interneting the schools (currently only 1200+ schools & 200+ universities are on the Internet). We have to admit that Dr. Gatot H.P. (gatothp@aol.com) at Ministry of Education is phenomenal in leading the Indonesian vocational schools to the cyberspace. If conducive policy is implemented, it may enable 20+ million Indonesians to Internet in next 4-5 years. More over, no loan is necessary from the World Bank, IMF & ADB*".

Indonesia has close proximity to the industrial electronics exporters of Taiwan, China, Hong Kong, Singapore and Malaysia, so it is not too surprising that they don't need to innovate hardware, rather they are as a whole concentrating on rolling out and deploying mass-communications infrastructure. For example, in the following picture, commercial equipment has been put into a waterproof box (*ala BMSTDA:MMRU*) and affixed at the top of a mast for savings of RF signal power.

[24] Facts quoted from a CD-ROM Publication dated 1 March 2004 by the APJII

Some of the homebrew projects are only simple setup of equipment in a small enclosed area, this shows the versatility of the concept of do-it-yourself and in a general way validates the reasons why the BMSTDA concept is needed, it saves money and it gives service to small areas at large distances with high capacity. If any type of hardware device was found that had a commercial grade connector and was earmarked for special use only, a short cable adapter could be locally manufactured that would allow it to be used in an open, external environment.

For example, the following picture shows an Indonesian way of building a device similar to BMSTDA:BWR.

In order to cater for the extremely wet atmospheric conditions of Indonesia, common sense engineering steps have been adopted to integrate items into a single infrastructure in a weather proof box. The box is often mounted on posts, towers, walls, or even in some cases affixed to the drains.

The users of the grass-roots internet networks are not just using for browsing the web, or sending e-mails, they are using for advanced ICT applications such as research collaboration, video conferencing (shown below). This is a very good example of low-cost approach to establishing communications infrastructure as it is provided on top of an existing communications service (Internet Protocol) that will be alive any time of the day, due to the nature of TCP/IP, it is never turned off. Note that this type of service is available throughout the whole of Indonesia, so that is a big accomplishment for a group of amateurs.

The equipment doesn't have to be expensive, just as cheap as can be afforded. In the following pictures a neighbourhood switching point is shown (*ala* BMSTDA:ISE)

The genesis of the Internet in Indonesia did not get its start from the traditional telecommunications infrastructure; on the contrary it was given its first few nodes by concerted efforts of Indonesia amateur radio operators. The Gov't of Ethiopia may choose to investigate how the Indonesian Internet Activists setup their own non-commercial free-of-cost wide area network using simple radio communications, and as a start the following text written by Dr. Onno is reproduced with permission below.

"The early Internet development in Indonesian is inspired by the activities in Indonesian amateur radio especially the Amateur Radio Club (ARC) ITB in 1986. Equipped with HF SSB Kenwood TS430 belong to Harya Sudirapratama YC1HCE and Apple][computer with 64Kbyte RAM belong to YC1DAV, 10-20 young ITB students, such as, Harya Sudirapratama YC1HCE, J. Tjandra Pramudito YB3NR (now a lecturer at UNPAR), Suryono Adisoemarta N5SNN (now a Professor in Texas, US) and me YC1DAV, we learn to our senior amateur radio such as Robby Soebiakto YB1BG, Achmad Zaini YB1HR, Yos YB2SV, YB0TD in 40m band. Mas Robby Soebiakto YB1BG is one of the amateur radio guru among us in Indonesia, he teaches us how to perform data communication over radio known as packet radio, and interact using TCP/IP protocols on top of it. YB1BG teaches us on using the amateur satellites for data communication. The learning process is later helped by many Indonesian mailing lists, such as, ybnet-l@itb.ac.id, ybqrp@yahoogroups.com, orari-news@yahoogroups.com etc.

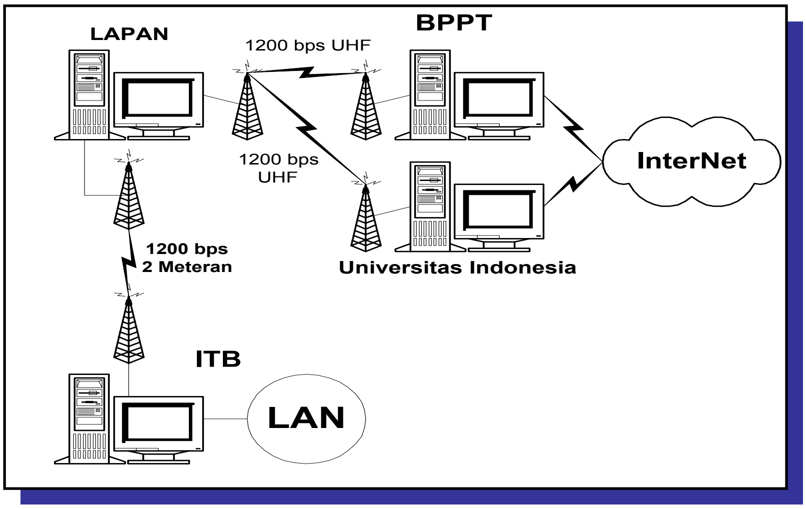
The packet radio technology developed by the amateur radio, is the early Indonesian Internet technology implemented to link friends at Ministry of Research and Technology (Jakarta), University of Indonesia (Jakarta), Indonesian Aerospace Institute (Bogor) and Institute of Technology Bandung (Bandung), later known as Paguyuban Network in 1992-1994.

Using UUCP Protocol UI helps us transfer the mail from our slow radio network in Indonesia to the Internet vice versa. Muhammad Ihsan was a research staff member at LAPAN Ranca Bungur not too far from Bogor south of Jakarta in early 1990's. M. Ihsan was supported by his supervisor Dr. Adrianti and working together with DLR (equivalent of NASA in Germany) trying to setup packet radio computer network in 2 m and 70 cm band, later known as JASIPAKTA. M. Ihsan station, located in Bogor, is the one who relays the traffic from ITB in Bandung to Jakarta.

Mr. Firman Siregar was the driving force at Ministry of Research and Technology who managed packet radio gateway in 70 cm band. A simple 386 machine running Network Operating System (NOS) on top DOS operating system servers as the main radio gateway for the traffic from LAPAN and ITB. Indonesian Internet is in its infancy, traffic to the Internet uses X.25 packet network connected to the gateway at DLR in Germany. The network at Ministry of Research and Technology was later known as Research and Technology Network (a.k.a IPTEKNET) http://www.iptek.net.id.

Putu is the name attached to the development of PUSDATA (Data Center) at Ministry of Industry and Trade during Mr. Tungki Ariwibowo's time. Started with a small Bulletin Board System (BBS) in early 1990 and provides free e-mail service to public, we may now enjoy the transparency many public policy and public documents of Ministry of Industry and Trade at http://www.dprin.go.id. Both Putu and Tungki Ariwibowo should receive most of the credit in transforming a government institution into cyberspace. Mr. Tungki Ariwibowo is the first Indonesian Minister who actively responds to e-mails.

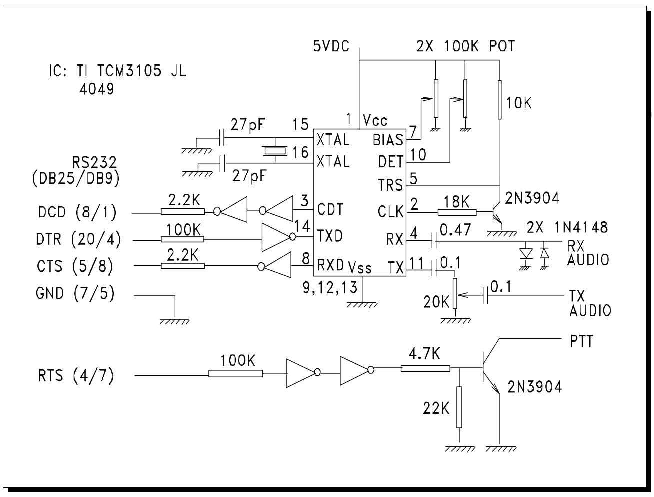
Start with a slow 1200bps packet radio in early 1993, ITB gradually built the Internet communities in Bandung and its surroundings. In 1995, ITB received a free 14.4Kbps leased line to RISTI Telkom as part of IPTEKNET. It really open the mind set of many the students and young Internet enthusiasts in Bandung. In September 1996, it was the main turning point for ITB, they invested on Ku-Band satellite ground station and integrating ITB into Asia Internet Interconnection Initiatives (AI3) research network to Japan at 1.5Mbps bandwidth (now 2Mbps). ITB added 2Mbps interconnection to TelkomNet for local traffic, which in the end set ITB as one of the leading institution to integrate 25+ Indonesian educational institutions to the Internet around 1997-1999 known as AI3 Indonesia network.



I have to admit that ITB is not the only one who led integrating education institutions to the Internet. Dr. Gatot H.P. at Ministry of Education is also leading integrating 1000+ vocational schools to the Internet. We are still long way to go with the total of 1300 colleges / universities, 10,000 high schools, 10,000 madrasah / pesantren / Islamic schools, 4,000 vocational schools. It would be a challenging task to integrate all of these educational institutions.

It is glimpse of some historical aspects on Indonesian Internet. It was a fun process and involving many good and dedicated Indonesians who like to share their knowledge, expertise and resources for the good of Indonesian society." (2002)

With permission, this consultant is reprinting another section of Dr. Onno's article which contains publicly distributed know-how to build radio based communication networks which are relevant to Ethiopian future demand in the vast outlying areas:



"The Indonesian Internet network topology in early 1993 is fairly simple. It connects four (4) institutions, namely, BPPT Ministry of Research and Technology, University of Indonesia, LAPAN Indonesian Space Institute, and Institute of Technology Bandung. Using the amateur radio technology based, a radio network running at Very High Frequency 144MHz, and Ultra High Frequency 430MHz are used to link all of these institutions. The network is running at very slow speed 1200bps (1.2Kbps). PC 286 running DOS 3.3 with Network Operating System (NOS) downloaded from ftp://ftp.ucsd.edu/hamradio/packet/tcpip/ is commonly used at the main gateway and router. BPPT & UI are acting as the main gateway to the worldwide network.

Since then, homebrew radio modem based on TCM3105 one chip modem as shown in the picture was commonly distributed among the Indonesian network geek to build our own network. The same technology is currently being used to integrate schools in remote areas to the Internet. To name a few, schools in southern mountain of Jogyakarta are the one that are implementing this technology.

I have to admit, this simple & low cost technology is limiting the Internet usage for e-mail only. It takes approximately one night for sending a one (1) Mbyte of data. Although, it is enough to open the mind set people in remote areas and integrate them into the cyber society.

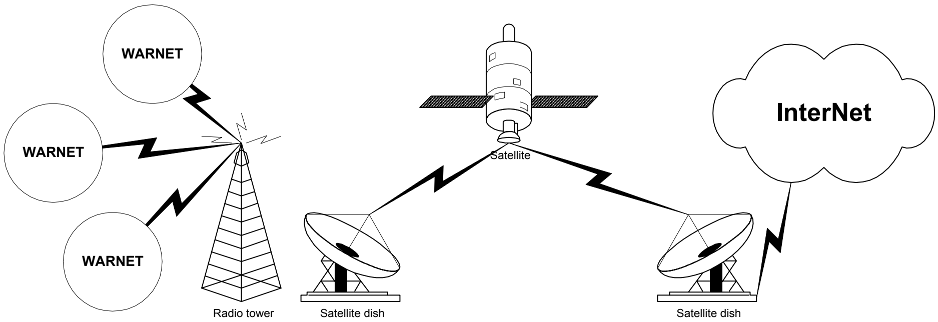
As Internet café grows, it spurs alternatives technology to use old 486 machines as Internet terminal. Linux with Linux Terminal Server Program (LTSP), can be found in http://www.ltsp.org or http://www.ltsp.or.id, solves our problem in both low cost investments as well copyright problem. It is not surprising to see a lot of Indonesian Internet café with geek administrator would use old 486 terminals.

Analyzing the money flow in these Internet cafés, it would clearly shown that most of the money is actually going into Indonesian Telco pocket for paying the telecommunication lines, not to mention, current increase in Indonesian Telco's tariff. It really drives the community to seek solution to build our own network with out having to rely on Indonesian Telco. The easiest way, supported by ample technology for building the network is the wireless LAN technology running at 2.4GHz. With approximately US$150 / unit, one with strong Linux background may easily build a low cost gateway / router to integrate a LAN or a community to the Internet at 11Mbps if we put external antenna with sufficient gain to reach the Access Point. Shown in the picture is my 19 dBi 2.4GHz antenna used at home to integrate my LAN at home as well as my surrounding neighborhood to the Internet for 24 hour access at 11Mbps at Rp. 330.000 / month (approximately US$30 / month).

The 2.4GHz radio and modem is integrated into a US$150 wireless LAN card. It is fairly similar to normal Ethernet card. The major difference is in the antenna connector pop up at the end of the card to be used to connect the coax cable and external antenna to the card. The Linux O/S driver of the card is available in public domain, such as http://www.sourceforge.org which will really help those who like to build their own infrastructure.

The 2.4GHz wireless Internet solutions can easily find on the Internet, such as, http://hydra.carleton.ca, http://www.wavelan.com, http://www.ydi.com, http://www.wipop.com, or at http://www.google.com use WLAN or 2.4GHz as keyword. One should explore alternative on 5 or 5.8GHz for the newest equipments.

Having the solution to build an alternative for high-speed local access network, we need to think on how to build the regional network. The only liberalized infrastructure for regional network is the satellite network. Most of Internet cafes in Bandung, Jogyakarta, Surabaya, Malang etc, are now adopting a hybrid satellite and wireless Internet infrastructure to build the whole community based infrastructure. As shown in the figure, several Internet Cafés, also known as WARNETs, share the satellite access to the Internet. Two ways satellite access will remove their dependence on any Indonesian Telco operators for regional access.



Satellite access is quite expensive; it costs approximately US$5000 per Mbps per month. Thus, sharing the cost with 10-20 Internet cafés is very logical to reduce the cost to US$250-500 / month / Internet café. US$500 / month / Internet café is affordable knowing some of these cafés can easily get US$50-100 / day from their customer. High-speed wireless technology is used to share the bandwidth among these Internet cafés.

Another emerging controversial technology is the Internet telephony. References on it are freely available at http://www.ietf.org, http://www.iptel.org, http://www.sipforum.org and can be used to build a community based telephone network at very low cost. More and more heroic stories may pop up in the near future in building the infrastructure and bypassing the high tariff-ed conventional incumbent infrastructure. As expected, the government would likely to protect the interest of incumbent telecommunication operators.

I have to admit that these solutions may not be appropriate for some countries, especially those with tight rules on frequency usage. Most, if not all, the time, we run the equipments without any license from the government. Fortunately, the Indonesian media helps keep us from being jailed. We only hope to give the best and low cost solutions for the Indonesians to be integrated into the Internet & reducing any existence of digital divide."

Pakistan

Pakistan is a country not usually associated with ICT Research and Development; rather it has a very good Manufacturing industry for telecommunications switches and cables (fiber optics, copper cables) and recently has been in the news this calendar year (2004) for publicly opening up its entire gamut of telecommunications sectors. The market is huge, 150 million inhabitants in only 0.8 million sq. km of land[25]. While this would not at all be out of the ordinary as many developing countries are doing the same, the open, transparent process by which the documentation was published and made available to all,

as well as the clear-cut and obvious push to have a collaborative but competitive telecommunication industry with private/public participation is a commendable course of action that could be reviewed by telecommunications policy administrators of the Gov't of Ethiopia and the stakeholders themselves in order to find a common ground between the needs of the Regulator and the needs of the customers.

The main website of the Pakistan Telecommunication Authority (PTA) is http://www.pta.gov.pk which has a stated vision to "Create a Fair Regulatory Regime to Promote Investment, Encourage Competition, Protect Consumer Interest & Ensure high quality ICT Services.

On 8th March 2004, PTA issued the long awaited Information Memorandum on Long Distance International (LDI) and Local Loop (LL) Fixed Line Telecommunications Service Licences. The complete set of documents has already been published to the web in various formats and the documents are clear and understandable. The documents include a wealth of detail of the existing makeup of the national telecommunication network, and discusses significant issues such as Availability of Licenses, Price

[25] See http://www.cia.gov/cia/publications/factbook/geos/pk.html

Regulation, Universal Service Fund, Radio Frequency Spectrum Availability and Specific Rights and Obligations of LL Licencees, Service Quality, Roll-out Requirements, Access to existing submarine cable, Access to other international transmission facilities, interconnection to other operators etc. These are invaluable pointers to emerging independent telecommunication regulatory agencies who are developing their own custom regulations and policies such as the Ethiopian Telecommunication Agency.

The need to have modern, liberal licensing schemes to allow private or other semi-autonomous government agencies to provide services (perhaps to compete with each other, perhaps to provide services on a joint basis) is underscored by the fact that no single Gov't in a developing country can be expected to be able to mobilise all the funds necessary to invest and build the entire country communications infrastructure on a permanent basis. In addition, private sector or semi-autonomous are by nature able to manage their own resources so that they can address the needs of the market they want to serve, and ultimately the benefit of the extra competition gets passed on to the consumer.

BMSTDA is a concept that would allow small private ICT companies and semi-autonomous government agencies to operate as telecommunication services provider. As discussed in this report earlier, the BMSTDA architecture allows design and deployment of wide area data communication networks providing multiple numbers of services between regions and to/from regions. To ensure satisfactory quality of service, and to ensure that isolated regions get equitable access to the national telecommunications backbone network, the operators of these wide area multi-service networks will have to be considered as independent telecommunications service providers, and as such should be monitored and regulated through an appropriate licensing scheme. With regard to the approach taken by the Gov't of Pakistan in adopting a phased approach to de-regulation of the telecommunications sector, the De-regulation Policy for the Telecommunications Sector was announced July 2003. The Policy was issued by the Ministry of Information Technology, IT & Telecommunications Division[26]. The groundwork for the intending/interested applicants was laid by the Gov't in an open and easy manner as shown in the excerpt of the document below:

4. Number and Type of Fixed Line Telecommunication Service Licenses

1. It is proposed that there will be two types of licenses for fixed line operators:
   - Local loop ("LL") fixed line telecommunication within a PTCL region
   - Long-distance and international ("LDI") fixed line telecommunication
2. **Local Loop Licensing:**
   Entry to Local Loop market will be unrestricted and open. Any person who requests for a license, and meets the licensing requirements, will be eligible to get a license on payment of the prescribed fee which will be set at the Pak rupee equivalent of **US$ 10,000** for a LL license.
3. **LDI Licensing**:
   Entry to LDI market will be unrestricted and open. Any person who requests for a license, and meets the licensing requirements, will be eligible for a license on payment of prescribed fee, which will be set at the Pak Rupee equivalent of **US$ 500,000**. In order to ensure that only serious players enter the market under this regime, stringent requirements of technical and financial capabilities, experience and rollout will be incorporated in the licensing documents. The decision of award of license will be preceded by an open, public hearing process.
4. A company can hold both (LL / LDI) types of licenses.
5. Existing licensees of telecommunication services in Pakistan would be permitted to retain their current licenses or O&M agreements with PTCL. They may compete for a new Long Distance International or seek a Local Loop license.
6. Tariffs of both types of licensees (LL / LDI) will not be regulated by PTA until they attain SMP status. However, PTA has the right to regulate tariffs in case of evidence of unfair and burdensome pricing to consumers.

[26] See http://www.moitt.gov.pk

Note that the license fee for a local loop provider has been set at a basic rate of $10,000 and a Long Distance International license applicant will have to pay a prescribed fee of only US$500,000 which is a small amount compared to the revenue potential of a legally licensed international gateway. In addition, the Gov't cleared the way for awarding dual-licenses to a qualified company and made sure that no one company would enjoy monopoly protection in their own market, incumbent operators and other qualified companies would also enjoy a facility to conduct legal service business as long as they fulfilled their key commitments and paid the prescribed fee.

Vietnam

The Gov't of The Socialist Republic of Vietnam has at the time of writing this report just announced that they would officially sanction, and use, *Open Source Software* as a national incentive to develop in-country expert resources. This is important in an impoverished country of 329,560 sq. km and 81 million people[27].

On 2nd March, 2004 the Prime Minister of Vietnam the adoption of a Master Plan to apply and develop open source software over a four year period until 2008. Amongst its objectives[28] are:

- Accelerating the application and development of open source software (OSS), enhancing copyrights protection and cutting costs of software purchase, promoting the development of Vietnam's information technology in general and software industry in particular.

- Forming a base of competent technical experts who master advanced technology and leverage their creativity in OSS application and development.

- Creating some typical IT products that respond particularly to domestic conditions and practical needs of OSS development.

Some of the major tasks that the Gov't of Vietnam feels important to conduct under this new-generation Master Plan are:

- Establishing and enforcing mechanisms, policies to encourage OSS application and development in order to delegate the participation of training, education, and research organizations in OSS training and research; encourage overseas Vietnamese and foreign experts as well as international companies and institutions to invest in business development, technology transfer and training
- Organizing pilot application of OSS, first in some ministries, organizations and local areas, later proliferating those applications nation wide.
- Utilizing OSS in some professional applications and national defense. Establishing and utilizing high productivity computer systems and OSS-based

[27] See http://www.cia.gov/cia/publications/factbook/geos/vm.html
[28] Details provided by Nguyen Trung Quynh, Gov't of Vietnam

network calculating to find solutions to practical problems that require high calculation capacity of ministries, sectors, and localities throughout the country.

- Organizing the training of OSS teachers and professor for universities, colleges, vocational schools, as well as instructors for state officers and staff training.
- Establishing a competent base of experts capable of developing and implementing OSS applications in the ministries, sectors, and localities.
- Providing for the training of technical staffs to assist with the implementation and network support for OSS applications in ministries, sectors and localities; training and maintaining this support staff network.
- Establishing and developing training programs on OSS applications for state employees, students in universities, colleges, vocational schools, and high schools. Developing utility software and applications to be used in teaching and learning.
- Attract domestic and foreign individuals and organizations, overseas Vietnamese to participate in OSS training in Vietnam.
- Sending teachers, instructors, distinct students abroad for short-term and long-term OSS training.
- Developing core software, formulating OSS standards, establishing the training and qualification system for all levels of expertise.
- Organizing suggestive researches and developing core software for Vietnam, selecting and localizing some foreign software to respond to the basic application demands of Vietnam.
- Establishing an OSS product quality testing and verification system that provides usage recommendations for the community.
- Researching and formulating OSS technical standards and skill standards, establishing a system for OSS skill testing and qualification.
- Encouraging the formation of OSS development organizations, businesses, science institutions, and educational establishments to provide OSS support services. Building the development center and research laboratory for OSS applications.
- Actively participating in regional and international OSS organizations and associations to promote cooperation and experience sharing among their members.

Notable in the newly adopted Master Plan of Vietnam is that they are interested right away to sponsor developing core software for satisfying the basic needs of applications for Vietnam in local languages, including it is learnt, tele-communications

Thailand

Open Source Software initiatives introduced by Thailand's Information, Communications and Technology (ICT) ministry have resulted in significant benefits for consumers in all respects. They are able to get local language applications at affordable price, and also they are able to get international quality ICT applications from leading software vendors at much lower than world market prices, legally. This suits the country population, which stands at about 64 million people living in a land of only 0.5 million sq. km.

Hewlett-Packard laptop computers with Linux TLE, the Thai-language version of the Linux operating system, regularly sell for less than US$458, and that is a bargain when compared to the features of a laptop with graphics user interface and business software applications suite but with a regular Windows Operating System. The product was described in the international media; please see the following link for a pointer to the details.
http://asia.cnet.com/newstech/systems/0,39001153,39129420,00.htm

However some months after that product release, due to the extra-ordinary demand of low-cost, advanced technology laptops, the world's most famous software company Microsoft was forced to reduce its prices of branded software including its very lucrative MS-Office product which is now sold in Thailand with a specific country-only authentic software license. In a large departure from its regular business practice, Microsoft was forced to adjust its marketing strategy and offered low-cost alternative pricing to Thailand consumers for only … US$40 per license.
http://news.com.com/2100-1012-5067051.html

Now, Ethiopia has so far not made any significant progress in *Open Source Software* initiatives in a large fashion, so it will obviously take some time and resources to promote the concept that the ICT professionals in Ethiopian society can do the same as, and are as smart as the international software development companies. Only then would the Gov't of Ethiopia have a mandate to negotiate cheaper and more affordable prices from large software giants who set price according to their own standards not the customers of the country they are selling in.

Open-Source Software Applications

For the purposes of creating low-cost, flexible, BMSTDA devices operating systems, application programs, utility software, configuration and management software, etc. all have to be programmed by a developer or developers. So far the major examples of successful router / switches / hubs / telecommunication devices have all been programmed by commercial companies who make a business out of selling the upgrades and patches to a specific hardware-oriented software platform. There are very few open-source ICT applications that are suitable, or have been programmed for telecommunication applications to date. Everything seems to be built or designed for a specific purpose.

It is however evident that the gradual growth of Linux Operating System adoption by many hardware manufacturers the possibility of true cross-platform implementation of software applications is slowly becoming possible. Perhaps by the time Linux will be adopted by all the ICT hardware manufacturers whatever they build, we will not recognize the Linux as the text-based operating system that we know today, perhaps it will be embedded beyond recognition, allowing a greater degree of software application portability between different hardware.

There are countless thousands of engineers in all of the ISPs in the world today who use *Open Source Software* in their everyday jobs, tasks, projects and services that it is impossible to tabulate what they use and how or why. It is sufficient to say that if there is a need for a particular type of application, chances are that someone, somewhere has written a program to solve the needs for that type of application, or knows someone who has. There are of course opportunities to take advantage for, but as any Software Programmer will be able to certify writing "better" code (compared to someone's existing code base) is easier by far than writing "original" software code applications. Most of the world's largest software applications are running on *Open Source Software* engines. We all know Google is an excellent search engine, but did you know that it runs entirely on *Linux* operating system on standard computers?
Please see http://www.internetwk.com/lead/lead060100.htm

Software code can be written and licensed in such a manner that its owners remain the copyright holders, but give permission to allow others to include that work in their different disciplines as long as adequate credit of some kind is given.

Open Source Software implies that no one is particularly responsible for the development, and at the same time, all the users of that particular application are either directly or indirectly responsible for its upkeep and maintenance. *Open Source* doesn't mean that it is free but rather that its support is to be paid for, but the base software is "borrowed with permission". 2nd Generation OSS developers are actually highly regarded as adding value to the original code base, and therefore the reputation of the individual OSS developer is often wider than the original OSS author.

Conversely, if everybody had to purchase all software regardless of size, complexity, then it is likely that the world market for computers and peripherals would be controlled by only a few companies, innovativeness would not be rewarded and small markets would be ignored in favour of profitable market campaigns.

OSS developers are uniquely situated to use open source tools and to create an open source *legacy*, in which their products live on after the development phase has ended and as long as there is practical use for their ideas.

OSS developers can be easily relied upon to develop local language applications and the challenge is to make sure that the local language applications follow standard coding practices so that they can be in turn exported to the global ICT market when the time is right, as a good software is always in need wherever the connected world is.

Please see:
http://www.opensource.org/docs/definition.php
http://www.gnu.org/
http://www.gnu.org/directory/
http://www.simtel.net
http://www.tucows.com
http://sourceforge.net

Findings

Assessment

Ethiopia has under utilized human resources and needs to mobilize its assets faster and to build up a forward looking technology development track program to excite the new generation of engineers, technicians, planners and users.

Ethiopian engineers need to be assisted in going out of the country and visiting emerging and developing markets around the World as part of visiting trade and industry missions, in order to get a good understanding of the world market and its opportunities and threats.

Ethiopian society seems to have a "can do" attitude but it doesn't seem to have a "lets do it now" understanding of technology issues. If Ethiopians want to be followers, they are progressing in the right direction. If however technology leadership and moral leadership are desired, a capacity building strategy must be started where small Research and Development projects are funded through competition and the results must be publicly exposed for peer-review. Also, interaction with international researchers and practitioners must be encouraged and facilitated so that the quality of Ethiopia is understood worldwide, not just talked about within Ethiopia.

Currently Ethiopia's contribution to the global ICT industry is not well known. A "spear-head" and "leap-frog" rapid technology development track is needed to motivate and build up the confidence for the younger generation of Ethiopians, and to re-invigorate the education process which is supposed to build visionaries of the future not engineers for the present.

Ethiopian researchers may consider establishing pilot projects in conjunction with researchers in other developing countries who are emerging from pre-Internet age to Internet-connected age and knowledge-economy and should devote considerable attention to team building in all aspects of ICT industry. The exchange of experiences and ideas will ultimately shape a better and brighter future for industry professionals and service holders who will get better positions in a global economy.

Ethiopians need a challenge to bring focus to their efforts at joining the global knowledge economy. This may be a far flung challenge such as deciding to set a date to export some form of high technology to nearby markets such as the Middle-East, or to set a very difficult challenge such as build a robotic medical diagnosis unit which would assist doctors in remote situations by administering health care. There are definitely thousands of legitimate research, development and manufacturing areas that are waiting to be undertaken by dedicated developers – and Ethiopians should make it a point to stimulate the ICT professionals to apply for grants/funds/scholarships/seed capital/investment in order to get off the mark.

Ethiopians need to stop worrying about their own situation which is neither good nor bad compared to other countries and start worrying about how to capture a piece of the global marketplace with products and services. The Gov't of Ethiopia needs to give incentives for export oriented projects of ICT industry, and to introduce at the earliest possible stage a technology / business practice know-how transfer program to build up entrepreneurs in the society.

Technical Solutions Identified

Communication Towers can be manufactured in Ethiopia from available Galvanised Iron pipes through local engineering process. Each tower should have the capability to be shipped in a disassembled manner, and to be able to be re-assembled with only two or three persons from a Completely Knock-Down kit. The tower should have the ability to withstand the wind-loading for several large antennas and at least one person who would do the installation.

Chassis for BSMTDA products BR, BWR, MMRU, MCBS, MMTS can be manufactured locally from available steel/plastic sheets through local engineering process. The hardware for building the electronics payload for BR, BWR, MMRU, MCBS, MMTS can either be imported or can be assembled through SKD and CKD kits, including some amount of local systems integration or board level SMT construction work.

The firmware for remote monitoring and management for BMSTDA network equipment can be manufactured locally in Ethiopia without outside assistance. Such technology would be in great demand in the global market.

The software for operation of the BMSTDA devices could be easily developed in Ethiopia, but testing of the software would have to be done with various hardware configurations in other countries to ensure it had real world survivability in all possible conditions.

The applications for use on a BMSTDA network could easily be simulated and developed in Ethiopia but for certified testing and validations they would have to be tested in real world situations outside of Ethiopia in other developing countries.

Satellite Earth Stations allow BMSTDA networks to be run in an affordable manner serving domestic and international customers. By establishing a separate VSAT Earth Station (with an antenna diameter of less than or equal to 4.5m) and employing additional TVRO (Television Receive Only) Dish Antenna for receiving DVB/IP broadcasts from foreign Internet service gateways, cheap Internet service can be organized and obtained.

A software configuration guide/interactive application could be made to predict the best locations of establishing MCN and such an application could later be used to remote manage and monitor the performance of MCN from a standardised network management location.

BMSTDA is a mature concept; it can be implemented right away in pilot projects until a set of common hardware is designed and then large scale MCN networks can be rolled out in Ethiopian rural areas. Commercial products exist that can do basic BMSTDA functions and they can be used as much as possible. However for best optimization custom hardware configurations will be necessary. The applicability of the BMSTDA is not limited to ICT solutions and needs, but can be extended with good results to Defense, Satellite, Transportation Management, Power, Chemical, Manufacturing, Banking industries. Detailed research work can be undertaken to explore opportunities in this regard.

Human Resource Requirement Identified

There needs to be a inter-disciplinary academic course at the Undergraduate and Graduate degree level in Ethiopia on BMSTDA and affiliated low-cost technology. The course must include terrestrial data communications, satellite data communications as well as a challenging project that takes the theoretical concepts and applies them to a real world solution. For example, a satellite station could be installed just for training and setup of live networks by qualified students and teachers. A Amateur Radio station could be very cheaply setup to allow practicing introduction to the world of communications in all modes, voice, digital, facsimile, television, satellite, telemetry, remote sensing. Challenging projects are needed in order to create critical resource pools:

- Hardware/Electronics Engineers at least 2,000 professionals
- Software Engineers at least 7,000 professionals
- Radio Engineers at least 5,000 professionals
- Civil Engineers at least 4,000 professionals
- Network Architects at least 1,000 professionals
- Telecommunications Switch Engineers at least 2,000 professionals
- Satellite Engineers at least 500 professionals
- Mechanical Engineers at least 5,000 professionals
- Electrical Engineers at least 3,000 professionals

Ethiopian programmers are hampered by lack of adequate bandwidth to connect to the internet. For this purpose separate dedicated network for ICT developer industry should be considered to be setup which can be financed on different scale of business than existing ETC services. The dedicated network will have to be high speed and users will have to contribute to its operation and maintenance and upkeep to reduce the loading on the Government.

Local Ethiopians must be encouraged and facilitated to takes trips abroad for knowledge building and awareness gathering and must visit professional exhibitions and trade shows.

IT based investment programs with low collateral requirements or IT-specific venture capital funds must be allowed and encouraged to be setup to bolster the entrepreneurial initiatives and new ideas.

Foreign multi-national companies may be invited to partner with the Gov't or Private sector in order to sponsor market-specific and product-specific human resource building programs. Ethiopian Gov't needs to consider how to establish cross-cultural and cross-discipline student and professional exchange programs with developing and developed country private sector and gov't administrations.

The average pay of ICT professionals must be rationalized to be at par in the Middle-East region or some incentive must be provided to prevent the trained ICT professional leaving for better salary and benefits out of Ethiopia. The investment that would be done by increasing the average salary of the ICT worker in Ethiopia would be paid many fold by the growth in captive intellectual capital and the benefit that would be gotten from their input to the Gross Domestic Product.

Estimated Costs

According to the TOR of this consultancy, a sample costing for a 5-year project was calculated for comparison to existing technologies (*comparison to be done later with other sources*). For a pilot project of 100 MCN serving 3000 plain-old-telephone customers, approximately US$2.6 million will be required over a 5-year period to roll-out a network using current off the shelf products. The network can act as a purely domestic service and not incur any additional operating costs and can act as a domestic backbone. If internet connection is desired from the outlying areas of Ethiopia through this network, then an independent Satellite gateway needs to be established which will incur over a 5-year period an estimated cost of about US$2.5 million for a shared 8Mbps Duplex Tier-1 service from an Asian teleport. These costs are quoted on the basis of a "high" estimate and need to be verified before implementation as most Satellite operators are reluctant to predict cost of their payloads on a particular transponder as the cost varies from month to month as the demands of the customers change frequently.

During this five year operational period, private sector industry in Ethiopia and Academic departments in established Universities can consider how to startup and implement research programs to develop the Hardware, Firmware, Software needed to have a compatible domestic product that would be ready in 1 to 1.5 years and that could be put into the field after testing by about two years from now. A joint research project with international academic institutions can be considered, but in case an isolated program is desired then the estimated cost of such a research program is not unreasonable. The cost would have to be about $1 million over 3-4 years, which would include creation of the silicon intellectual property / chipsets necessary to build embedded versions of BMSTDA technology. After a successful prototype of the domestic version of the products are tested and approved they can be shifted to manufacturing which would be done by private sector. In addition, export market can be tapped and features identified that would be incorporated into a international market prototype which would have to pass rigorous certification for truly global operation. This R&D program would be more expensive and time consuming (approximately $1-2 million), but the payback is that a whole new class of technology would be exportable *from Ethiopia*. The export market is vast, including Africa, Australia, China and Russia and significant parts of South America all are large territories with very sparse coverage of terrestrial/satellite connectivity.

Regulatory Issues Identified

As early as possible, the proposer of a pilot / prototype project will need to apply for a "Research and Development Operational Permit" from the Ethiopian Telecommunications Agency. The Agency will evaluate the request for Satellite connectivity, terrestrial connectivity and interconnections with existing or future national connectivity and other private connectivity and then most probably approve the pilot operation for a limited period. This period needs to be at least several years to allow for false-starts and equipment re-design issues as this is likely to be a truly groundbreaking concept in Ethiopian society.

In order to encourage the active participation of the private sector, a policy feasibility review is suggested that would formulate the guidelines for private telecommunications service operator licenses similar to countries such as Bangladesh and India which has provisions for Metropolitan ISP licenses, Rural ISP licenses, Nationwide ISP licenses, VSAT Provider Licenses, Domestic Data Communications Service Provider Licenses and Cyber Café Licenses. In addition to allow even more connectivity options for consumers in Ethiopia, the proposed policy feasibility review could consider adopting lessons from the Pakistan, Indian, Singapore, Indonesia models of collaborative and de-regulated telecommunications administration models. For non-commercial, educational use, the policies to permit Amateur Radio service for use by private individuals and schools/club stations need to be reviewed and compared to other countries where the growth of ICT industry has been noticeable. For more information, please contact the IARU (http://www.iaru.org).

VSAT Satellite Service for the purposes of a distributed internet/data communications network use, needs to be encouraged as it is not possible for a single-entity, top-down data service network architecture to be able to serve a country as large as Ethiopia. Such service can help in reducing the "wait-time" for regions to be connected and the cost of such service can be offset by the fact that the services will be distributed over greater number of regions serving larger number of people, in lesser time. A policy and sectoral review of the opportunities of the VSAT Service can be efficiently done as there are pan-Africa and pan-Asian studies of VSAT Service in this regard already done and available throughout the industry. A significant source of such knowledge about country-policy in the areas of VSAT is the Regulatory Database of the Global VSAT Forum (http://www.gvf.org).

Researchers in the ICT industry in Ethiopia will need to setup experimental services and experimental networks, as well as they will need to occasionally do real-world testing with their transmission equipment and transmission accessories/peripherals. Such experimental class of license policy needs to be considered and permitted in order to foster technology growth opportunities.

For the purposes of low-cost Internet access supplementary to the existing Internet service of Ethiopian Telecommunications Corporation and in preparation for a future de-regulation of the industry, the use of Digital Video Broadcast/Internet Protocol (DVB/IP) or Digital Video Broadcast/Return Channel over Satellite (DVB/RCS) should be permitted through regulations and proactive policy. Significant corporate establishments and building operators should be encouraged to share Internet connections with each other (pending permission from the regulator to act as a Service Provider) as long as they conform to commonly acceptable Service Provider guidelines. There are various reference sources of the models by which internet exchanges and internet resource pools can be organized, and it is possible to address this at a later date, providing some progress is achieved in letting small businesses to be setup to run their own managed Internet service for customers.

In order to provide equitable access to ICTs in metropolitan areas, CATV and SMATV networks should be able to be authorized and setup with only minimum technical know and it is recommended that Cable Television operators be allowed to be setup to receive many satellite channels and distribute them through fixed hybrid fiber coaxial cable connections along with internet service if so desired. There are thousands of such operators who are providing valuable service to customers in the developing regions of the world and this phenomenon has been most visible in the South Asian countries such as Pakistan, India, and Bangladesh.

Some of the skills to implement cost-effective ICT programs will not be available in Ethiopia until it is imported in the form of know-how and knowledge-transfer from outside sources. A mechanism needs to be adopted by the Gov't of Ethiopia that would allow for foreign ICT workers to be hired by local companies in exchange for Knowledge transfer through an open process and for this bi-lateral or multi-lateral work visa regulation may be considered.

Concise Recommendations

1. The Ministry of Capacity Building should take steps to obtain a permit from Ethiopian Telecommunications Agency for permission to setup an experimental research Satellite Earth Station for Multi-Service (Data, Video, Voice, Other). Permission should also be requested to interconnect the Satellite Earth Station to a terrestrial network that would be built by authorized private contractors conducting ICT Research and Development activities, and permission should be requested to interconnect it with existing Points-of-Presence of Ethiopian Telecommunications Corporation.

2. The Ministry of Capacity Building should take steps to obtain a independent permit to operate a HF Radio communications network to facilitate communications between any *Woreda-net* site or communications between any of the satellite and terrestrial nodes that will be setup as part of activities pertaining to authorized ICT Research and Development work that may take place in the future.

3. The Ministry of Capacity Building should consider issuing an RFP the local ICT and regional industry and encourage entrepreneurs to develop and demonstrate prototypes of ICT communication devices suitable for rural use in a low-cost, zero-infrastructure environment.

4. The Ministry of Capacity Building should be prepared to provide reference material and specifications and if required, upon special request, matching funds to supplement the R&D costs of the private sector, as long as the results, deliberations, process is made transparent to all stakeholders.

5. The Ministry of Capacity Building can consider sponsoring fact-finding and technology-acquisition programs in which leading, qualified local *technologists* are sponsored to travel to other countries and to observe current technology development efforts which could then be adapted to Ethiopian situation.

6. The Ministry of Capacity Building must work with Ethiopian Television to conduct a trial of their television broadcast in digital form through Satellite and Terrestrial digital communications service through locally developed ICT communication devices.

7. The Ministry of Capacity Building must consider establishing a technical working group in conjunction with the private sector, semi-autonomous organizations or other governmental body to validate new communications technology that may or may not have practical implications.

8. The Ministry of Capacity Building should take steps to initiate a "Pilot ICT Research and Development Multi-Service Network" showcase project which must be supported by Academic and Industrial sponsorship and follow-on projects.

Goals must be set for the project in that it must deliver tangible results over a multi-year period of operation and validation and the project must produce exportable technology.

9. The Ministry of Capacity Building should consider undertaking dialogue with established Academic institutions to collaborate jointly with foreign research and development centers of excellence to have a trans-national development project in high technology.

10. The Ministry of Capacity Building must prepare to support the local entrepreneurs and researchers in their efforts to break into the World Market by promoting through the relevant Gov't departments concerned with export, their successful accomplishments and the products and to protect the intellectual property and license their technology appropriately worldwide.

11. Lastly, the Ministry of Capacity Building should allow interested private sector companies to utilize the lessons learned through this Consultancy and in conjunction with the existing inventory of resources contributed through this project to establish more involved demonstrations of communications technology in order to disseminate the knowledge imparted by this consultant. In case that the private sector wants to implement on their own a large scale demonstration of communication services, such an effort must be encouraged in all respects and credit given for successful implementation.

Next Steps and Time Frame

It is proposed that a phase wise approach be adopted to implement the Concise Recommendations:

Phase	Objective	Target
I	Select Target Region for Pilot ICT Research and Development Multi-Service Network suitable for connection of 100 distinct nodes in a wide area with difficult terrain.	2Q/2004
II	Select ICT companies who will contribute manpower, resources, intellectual capital for creating new ICT technology	2Q/2004
IIIa	Conduct foreign tour of developing and developed countries where ICT device research and development is being done.	3Q/2004
IIIb	Conduct workshops and formulate collaborative strategy to have joint development projects between international partners and domestic partners interested in building ICT technology for use in Rural Networks	3Q/2004
IV	Solicit proposals for Research and Development of (a) Gateways (b) ICT Devices (c) Software Application (d) Training Program (e) Infrastructure and Solicit first level RFP for both <u>commercial business model</u> and <u>community-ownership model</u> interests in the above.	4Q/2004
IV	Award technology sponsorship grants ("Seed Grants") for multiple-parties and allocate regions for them to test out their own prototype networks in a competitive manner – all networks must interoperate with each other.	4Q/2004
V	Evaluate the progress of trial of Domestic ICT Devices; Evaluate the progress of International efforts to make a combined ICT Device; Start marketing campaign to showcase product at international trade fairs. Publish research reports in international conferences, workshops.	2Q/2005
VI	Conduct real-world tests; validate and develop commercial prototypes and pre-production demonstration models; Conduct Rigorous Testing and Certification; Have licensable Intellectual Property available for adoption by the global ICT industry, Promote as appropriate solution for ICT-poor countries	4Q/2005
VII	Conduct Trial of ICT Devices in other countries and register for international intellectual property protection	1Q/2006
VIII	Transfer knowledge to Manufacturing Industry	By 3Q/2006

<u>Annexure</u>

Terms of Reference

Excerpt from "Contract Agreement Between Ministry of Capacity Building of The Federal Democratic Republic of Ethiopia and Mr. Samudra E. Haque (Rural Connectivity)" as a "Short Term International Consultant on Rural Connectivity Planning and Related Locally Sustainable Technologies", February 17, 2004, Addis Ababa.

3. Duties and Responsibilities

The Consultant will visit Addis Ababa for two weeks during February, 2004 to carry out a preliminary assessment of existing telecommunications infrastructure pertaining to provision of rural connectivity, and to provide a draft report on possible locally sustainable technologies and technical solutions that could augment the existing telecom infrastructure to provide community level connectivity and voice/data communications

The consultant will focus on:

- <u>Assessing needs</u> and proposing locally sustainable communications technologies and technical options that can facilitate increased inter and intra connectivity;
- Identifying <u>technical solutions</u> that could provide cost-effective and sustainable solutions for community level connectivity using wireless or other technologies
- Identifying the <u>human resource requirements</u> for support and maintenance of proposed technical solutions;
- Providing <u>realistic</u> cost estimates for any proposed solutions and/or options, including cost for training, human resource development, per unit cost estimate for equipment, cost per connection over 5 years, cost of communications per minute based on the proposed solutions (including applicable interconnection charges), etc.;
- Discussing the various options and technical solutions with the Government's technical teams, including ETC, ETA, the ICTAD project preparation team and other relevant groups;
- Providing a <u>hands-on demonstration</u> of the proposed solutions, if possible;
- Preparing a detailed report on the consultant's findings, feasibility study, assessment results, cost estimates, training and human resource requirements, and any other recommendations as necessary;
- Providing a <u>concise list of recommendations</u> and costing for the proposed solutions;
- Proposing an appropriate <u>list of next steps and time frame</u> for implementation of respective options/solutions.