'Doing More with Less', or Deploying Broadband Communication Networks In Large Areas with Small Budgets.

Mr. Samudra E. Haque

S21X/N3RDX

Managing Director, PraDeshta Limited

haque@pradeshta.net

Abstract

There are an increasing number of data communication technologies in use in the modern world such as xDSL or Wireless Access, Wireless Local Loop, Frame Relay, ATM, Voice over IP, Voiceover FR etc. that cannot be economically be implemented in the developing regions of the third world. More often than not, limitations of availability of technology are cited along with lack of per-capita revenue to justify decisions to not deploy services for the mass population. For example, in Bangladesh, by 2002 there will be 129 (one hundred twenty nine) million people who will NOT have access to telephone services, a staggering error in judgement when compared to the lucky 1(one) million people who will have the privilege of calling someone using their own telephone.

This paper presents a partial report of work in the continuing design, fabrication and deployment of a BroadBand Wireless IP Router working in the S-band using Spread Spectrum in order to develop a flexible, portable data communications network operating at between 2 Mb/s and 5.5 Mb/s over 16-30 Km or more. Using the newly developed router as an implementation tool and a commitment to use already developed computing and communications technologies, It can be shown that it would be relatively easy to implement meshed, fault-tolerant telephony/internet delivery service in a broad geographic area while leaving more than enough bandwidth for value added services such Video/Audio Conferencing and two way Tele-education or Tele-medicine applications, in an affordable manner.

Introduction

A model data communication network has been established in Dhaka, Bangladesh that is being used as a testbed and prototype of a new method for implementing a Broadband Multi-service Switching Transmission and Distribution Architecture (BMSTDA). The network was developed under the leadership of the Author by engineers of PraDeshta Limited, a data communications service company in Bangladesh and the first successful trial of 16 kilometers line-of-sight distance at 3.2 Megabit/second throughput took place in November 1999 between DOHS, Mahakhali in Dhaka and Kanchpur on the outskirts of Dhaka. Commercial use of the technology started in February 2000 with a 3.2 kilometers link between Banani and Shamoli in Dhaka city, for carrying dialup Internet traffic as well as video conferencing and telephony services. The link has been averaging 3.9 Mb/s throughput and is providing service on a continuous basis, replacing a dial-leased connection and allowing for the first time, metropolitan area wide dynamic routing and service provisioning. The Shamoli end of this link is being extended southwards to a region of the city called Armanitola (distance 7.6 km) and a sister link is planned to be implemented from Sylhet city in North Eastern Bangladesh eastward over 33-35 km distance to a remote region called Durgapasha for providing educational internet services to schools there.

I would like to take the opportunity provided by this forum to inform the world community of some of the benefits that we have found in deploying commercially operating broadband links and to what extent we believe the technology we have developed and adopted can be put into use for many regions of the world. In order to attract entrepreneurial interest in deploying more networks using the concept I am focussing on the financial aspects of the current technology, as technology is likely to be volatile and cheaper to develop in larger quantity, but unless sample networks can be implemented to show benefit we would not be able to develop that critical mass to develop cheaper versions of the engineering products required to roll out. In essence, by showing the costing structure first, in its highest form, we hope to dispell the myth that smaller-and-better technology is not really worth implementing when compared to the standard telecommunication switching, transmission and distribution infrastructure available in the market today.

Validation of the need of this Broadband Multi-service Switching Transmission and Distribution Network (BMSTDN) architecture

The genesis of the concept took place during the brainstorming sessions held in Dhaka in April 1999, with the participants of the *Workshop on Internet: South Asian Realities and Opportunities*[1], participants from all the countries of the local region expressed their views, and comments on what they thought needed to be done to improve the penetration of Internet services into their regions where the penetration of basic Telephony was still in a moribund state. While some esoteric ideas such as the Satellite-simplex downlink assisted packet radio uplink, or the small-VSAT TDM/TDMA[2] systems using a regional satellite projects were floated and mulled around, the slow deployment of these technologies and the cost as projected to be involved initially made the concepts unattractive. Technology projects that were thought to be feasible were eventually finalised in the form of the proposed "Jono-Gono Project", where leaky FM-Radio or VHF-TV signals were re-transmitted from QRP[3] stations where it was conceived that the Micro-Community Broadcast Stations would be provided with an automated computer workstation and server network being slaved via a Broadcast Communications Receiver.

In fact in June/July of 1999 a demonstration network was setup by PraDeshta[4] to show the capability of a home PC to Prip Trust/Learn Foundation[5]to act as a full TV broadcasting station with a potential service coverage of about 1 to 1.5 miles diameters from the antenna position. This led to the understanding that antenna height was more important than radiated power, and that even low power such as 60-70 dBmV was able to reach large population areas if care was taken in making the feed point of the antenna matched efficiently and carefully as possible to the transmitter which could possibly be just a simple amplifier used in Cable Television.

A corollary from the Workshop held in April, left us with the impression that rural communities have a definite and profit-potential need for telephony services yet are denied access to the switched telecommunication network as the incumbent operators may have planned their resources for those areas that have higher density of communication users and not for the sparsely spread rural or urban communities. In fact, the insistence of the incumbent telecom operators in the region to use centralised switching, transmission and distribution facilities meant that in order to use a telephone (be it cellular, fixed, radio-telephone, optical, infrared) and perhaps a fax machine. This led me to believe that a Community Communication Center[6] (CCC) was going to be a central part of any alternative telecommunications network. Due to Arun Mehta's insistence that whatever new technology be introduced would be quick to implement, cost less (obviously) and be rolled out without re-inventing the wheel the primary thought driving the development of the specification of what is now BMSTDA, was to combine elements of existing technology in a unique fashion to derive the goal without worrying about what the equipment could really do, only what we asked it to do.

However the problem of switching and distribution remained, and those were very nicely solved by adopting some technology being used in the wireless LAN market, where ordinary Radio LAN cards using spread spectrum transceivers at extremely low power (typically +15 dBm at 2.4 GHz) were coupled with a suitable operating system (DOS, Linux, NT or other custom system) and were in trial use in many locations worldwide as an alternative to expensive leased lines. However we were unable to find any research reports or commercial products worldwide where the inherent capability of these technology devices to be put to use to build a fault-tolerant multi-service network for use in convergent networking such as the carriage of Voice Telephony, E-mail, Internet, Database services, Video Conferencing all under one common infrastructure was tested and deployed till date, and we decided to build our own comprehensive network to validate the concept and to fulfill what we perceived was a definite need.

Elementary, My Dear Watson!

The essential elements of BMSTDA are:

Community Communications Center	CCC
Telephony Service Equipment	TSE
Internet Service Equipment	ISE
Video Conferencing System	VCS
Power Supply	PS
Main Telecommunciation Switch	MTS

Transmission, Switching and Distribution infrastructure, includes:

Mast Mounted Router Unit	MMRU
Base Tripod	BT
Microwave cable	CABL
Antenna Tower	TWR
Antenna	ANT
Redundant Radio Links	RRL
Mast Mounted Amplifier	MMA
Local Network Interface	LNI
DSL modem pairs .	DSL
Wireless Access Point	AP

The formula for setting up a BMSTDA

One BT supports one TWR

TWR can support upto 4 ANT

BT supports at least one MMRU upto three MMRU

MMRU contains: Operating System, Memory, Storage, RRL and LNI interfaces and PSU

MMRU is connected to ANT through a RRL

Each MMRU must support upto 3 RRL and 2 LNI

MMRU can be operated in conjunction with an AP

The combination of the above is termed “Micro-community Communication Node” or MCN and has the ability to switch, transmit, receive, route, distribute.

Each CCC will have at least one MCN, but note that each TWR can support upto 4 ANT. There will be at the minimum of two RRL for each ICN, and all RRL and LNI will be under the control of a dynamic routing engine. In the prototype network this was implemented using OSPF v2[7] with support for VSLM[8], and service-reach of the RLL can be estimated at being at least 16-25 kilometers without needing an MMA. The use of an MMA can increase the service distance of an RRL to 30-45 kilometers. We are quoting conservative figures here, allowing for different types of weather and environment, however by optimising the CABL length, extra gain can be achieved and by use of matched high gain antennas, we estimate a increase of 10-15% can be possible. The eventual range achieved will be implementation dependent in all cases of RRL implementation.

Once in the field, each village or community will have its own MCN linked to other MCN in a meshed network. The rulesets for the MCN are that each MCN will have a RRL designated as Primary (RRL-P) and other links as Secondary (RRL-S). All links are treated to be equal, and the network architecture will interact with the dynamic routing protocol (OSPF) in use to build its own routing table which will survive failures of independent RRL-S or RRL-P, as data can flow through the second links. ICN failures are expected to be rare, but just in case, our BMSTDA implementation concept encourages for two or more MMRU to be installed in each BT to provide additional RRL service capability.

Since RRL is essentially a Direct Sequence Spread Spectrum Transceiver, it can be set to use many coded sequences, separating transmissions of all RRL-pairs from each other, and permitting frequency spectrum re-use. RRL-pairs can be assigned various parts of the spectrum in either the 2.4 GHz band, or 5.x GHz band as the local regulations see fit, or simply left to be implemented by whatever transceiver technology will be available. Particular care has to be taken to ensure the QRP signal of the transceiver is efficiently and economically matched for maximum delivered gain at the Antenna output from the RRL inside of the MMRU. It is this simple fact that drives the BMSTDA concept, “maximum gain for minimum input” and is at odds with those who prefer to put a wireless router at their data center and then run expensive microwave *hardline* to the antenna feed point which is often on top of a roof far away.

The CCC with the MCN is able to be a part of a dynamic routed Internet, and is independent of all others, as it can be readily moved to far away locations due to the fact that no foundation is necessary for the TWR / BT placement. In fact the MCN can be far away from the CCC as the LNI can be either UTP, BNC or Fiber media.

At the CCC there will be suitable low-cost ISE, essentially a managed ethernet switch or hub which will have at least one server containing a VOIP Switch or a PC-Server with VOIP Switch. In the latter case the VCS can be very cheaply intergrated into the TSE. There are several manufacturers of VOIP products that can be integrated into the BMSTDA. We are assuming FXS interface for the TSE along with a POTS telephone set for each channel.

The entire network can be connected to one or more MTS with RRL which can be either 16, 30, 45 or 60 kilometers away from the nearest ICN.

CCC can have ISE and TSE equipment distributed in the locality by using DSL modem pairs.

Bandwidth

We have tested the ICN/RRL architecture and can report the following results:

Distance	IP Data Rate Range (Mb/s)
0-5 kilometers	5.5

5-16 kilometers	3.2-3.9
16-30 kilometers	2 Mb/s (calculated)
Note: by using Amplifiers the range can be increased for each link providing both transmit power and receiver gain is increased on both sides in symmetrical fashion. Each VOIP connection only takes a maximum of 10-12 kb/s and therefore on EACH of the RRL it is possible to put in excess of 200 simultaneous telephone calls in addition to a 1 Mb/s IP connection between each ICN.	

Costing

Assuming we use existing based products in our implementation of a BMSTDA of 15 ICN and stipulate that at each node there will be at least 2 (two) telephone sets with dialtone, 1 (one) video conferencing system, and an internet connection for upto four additional devices, as well as allowing the VCS to be used as a internet browsing workstation, and excluding the cost of the Internet gateway connection but including the cost of a 30-port VOIP switch and a router at the MTS, we can hypothetically estimate:

#	Item	Qty	Unit Price (Maximum, USD)
	32 channel VOIP switch with E1 Channel Bank at MTS with router for upstream connectivity[9]	1	33,000
	Server with 2 channel FXS/VOIP Switch interface, Video Conferencing Hardware for ISE and TSE Service	10	3,500
	RRL + CABL	29	700
	ANT	29	250
	MMRU	12	1000
	MMA	9	1000

<table>
<tr><td></td><td>TWR + BT</td><td>11</td><td>800</td></tr>
<tr><td></td><td>LNI</td><td>11</td><td>100</td></tr>
<tr><td colspan="4">Calculations:

For 10 ICN, 30 ports Telephony service capability: USD136,450.

Per port price over 12 months repayment period (20 ports): USD568.54 per month

Per port price over 12 months repayment period (20 + 10 additional ports Telephony service): USD406.81 per month

Per node costing (MTS, ICN == 10 nodes) = USD13,645</td></tr>
</table>

Subscribers of this network will be able to place calls intra-network as well as outside of the network. Area codes can be assigned, E-mail services, Data Archival, Software Development, Software archival

For a detailed sample of network configuration please see the animated presentation in Power Point attached separately.

Summary

The costing of the network deployment for 10 sample stations is significant but not untowardly expensive, and provided the cost is recovered in 12 months only, the operations cost after that point is extremely negligible. The meshed nature of the BMSTDA makes this sample network very reliable in terms of possibilities that individual links may fail or be put out of commission for other reasons.

By utilising small scale technology, in rural and urban areas, the introduction of the BMSTDA will generate employment (not treated in this paper), and empower entire population segments hitherto ignored by standard telecommunication systems.

The actual presentation will demonstrate scalability of the system and cost per unit-deployment graphs to prove it would be easy to roll out this type of network in many areas of the world, including areas with mountainous territory and geographical impairments.

Intellectual Property Issues

Portions of this document contain concepts that have been applied for as a patent with the Gov't of Bangladesh and the Patent offices of other countries at the time of publication. For clarification please contact the author directly at:

Mr. Samudra E. Haque

Managing Director

PraDeshta Limited

House 50/I, Road 1

Banani, Dhaka 1213

BANGLADESH

Phone: +880-18-212138

---

[1] 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 URL http://sasianet.org/ for full text reference)

[2] Time Division Multiplex/Time Division Multiplexed Access

[3] QRP – meaning "Very Low Power", a code word used by Ham Radio Operators and a part of the Q-Code alphabet set. There are a number of Q-codes, see http://www.arrl.org for links to amateur radio sites.

[4] PraDeshta Limited, House 50/I, Road 1, Banani, Dhaka 1213, Bangladesh. Fax: +880-2-9881396

[5] Learn Foundation, Sylhet. http://www.bangladesh-web.com/learn

[6] As far as I can recollect this term I heard from Vickram Crishna or Madanmohan Rao

[7] Open Shortest Path First, Routing protocol

[8] Variable Length Subnet Mask refers to Classless Internet Domain Routing (CIDR)

[9] Based upon estimates of Nortel Networks (http://www.nortelnetworks.com) and Valiant Communication Products (http://www.valiantcomm.com) products, February 2000.