Building Educational Information Network and Accessing World Wide Internet on Ethiopian Telecommunication Environment

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Abstract

As computer technology advances, numerous networking concepts along with their implementations invented to utilize shared resources. Of them, Internet attained absolute popularity to give birth to global community where limitless amount of information is available. Internet became key technology used to mobilize information resources and is currently ubiquitous over the world. With this sense, Ministry of Education in Ethiopia deployed networking infrastructure and incepted its services with limited access to world wide Internet due to low capacity of underlying communication subsystems, while educational community is paying considerable attention on it. In this paper, specification of MoE network implementation including special techniques applied to Internet access will be described for the reference of educational community.

1 Introduction

Ethiopian educational sector is on the verge of considerable reformation on its administration and management[1, 2]. As a part of reformation, there was mobilization[3, 4] to promote information accessibility by the introduction of networking system with the sense that classical paradigm for information management may not sustain educational system any more. Accordingly, Ministry of Education (MoE) implemented networking system as a test bed recently.

The purpose of this paper is to enhance network inter-operability among educational organizations by disseminating outcome of MoE network implementation. In following sections, the past and future of Internet and role of educational information network will be shown. Then, the structure of MoE information network will be described in detail. Based on MoE networking system infrastructure, one of world wide Internet access strategy will be suggested.

2 Background

2.1 Internet Prospect

Nowadays, the Internet is the most widely used form of networking computers and equipments. When it was implemented as ARPANET (The Advanced Research Project Agency NET) for military use by U. S. Department of Defence in 1969, it did not receive much attention from public. The specification was also kept confidential. Nobody, at that time, could expect that the Internet would open new era, so called, "Sea of Information."

As it could be adopted in commercial sector since 1987, the growth of Internet connectivity became, literally, explosive[5]. The number of computers connected to Internet was twenty eight thousand (28,000) in initial stage. After that, the growth was multiplied repeatedly, nearly every several months, as shown in [6]. Hundred thousand (100,000) computers were on operation in 1989, ninety five million (95,000,000) end users were subscribing Internet services in 1997, and expected number of end users in 2002 will be three hundred million (300,000,000)[6].

The Internet is merely one of networking forms among what have been developed so far. However, superiority in view of reliability, portability, and flexibility made the Internet get absolute popularity. The Internet technology is, now, not only part of computing technology

but that of human society.

2.2 Educational Network as Pioneer

Compared to other types of networks, namely, to be used for commercial purpose or governmental administration, educational network is free from rigid stability on its operation in initial phase. In other words, network perturbation does not affect the benefit of information service to reasonable extent. This loose condition gives educational sector initiative to exercise network services more earlier than for others to do. If the establishment and operation of educational network is successful, the accumulated experience will form the cornerstone as byproduct.

In most cases over the world, practical networking service had started from educational sector and penetrated into other sectors thereafter. For instance, in Korea, shortly after the Internet service introduction, educational network was built up as test bed to analyze feasibility and used as information service itself.[7]. Even after the network is stabilized and the technology is transferred to other sectors, major network information centers are still located in national universities to apply new technologies from there. This implies that educational network is starting point of all the network services. According to such an evolutional procedure, educational network should play a pivotal role to spread information technology over the country by standing in the midst of leading edge.

3 Ministry of Education Information Network

3.1 Overview

The Ministry of Education (MoE) of Ethiopia is the highest authority in educational administration, though decentralization of the power is the basis of Ethiopian Federacy. As a central point of educational system, the Ministry has endeavored to devise effective way to manage information with the help of networking technology. Furthermore, proper communication with external organizations was one of big issues in the stage of deployment planning. In response to this consensus, information network was recently implemented in MoE[8, 9].

The MoE network was designed to operate as educational network framework. The design philosophy, first, aims at rendering information service directly to MoE by fully utilizing available resource. Secondly, partial portion of MoE network resource is dedicated to connect external network to MoE. The current capacity of MoE network can cover whole Ministry

complex, while the amount of resource allocated for external network is lower than needed. Expansion of connectivity to MoE network is being done gradually.

3.2 MoE Network Structure

MoE complex in Arat Kilo, Addis Ababa consists of largely two parts. One is old building where offices for ranking government officials reside. The other is new building where computing center and offices for working level staffs reside. Regardless of physical separation between two buildings, they were consolidated into one logical network in data link level[10] owing to underground cable installation between them[8]. On the basis of data link level network formation, MoE network was categorized into four subnetworks[11] in network level[12] as listed in table 1.

Table 1: MoE Subnetworks

Subnet ID	Domain Suffix	Physical Coverage
`moe`	*.moe.go.et	MoE Computing Center
`emis`	*.emis.moe.go.et	EMIS Panel
`beso`	*.beso.moe.go.et	BESO Project
`arat`	*.arat.moe.go.et	MoE Offices except EMIS and BESO

The partitioning enables subnet administrators to mange network independently. Each subnetworks, currently, render basic Internet services–E-mail, FTP, and WWW. MoE computing center supports management of Ministry wide facilities like switch configuration, top level DNS, E-mail forwarder, WWW page redirector, and so on[13]. Table 2 indicates capacity of MoE network. The utilization ratio did not reach maximum level that it will be important task from now to increase the number of connectivity to the subnetworks.

Table 2: Capacity of MoE Network Services

Service	Unit	Capacity	(Estimated) Allocation
E-mail	Users	1500	30
WWW Page	Users	1500	30
FTP	Storage (GB)	30	8
Software Archive	Storage (GB)	30	13
Internal LAN Connection	Port	180	80
Remote PPP Connection	Line	2	2

3.3 Interconnection between MoE and Outer Organizations

The advantage of networking is for client users to share resource available on the systems. The concept was also applied to MoE network internally. Notably, the same concept can span outer organizations via ordinary telephone lines with limited access. The only requirement is the arrangement of telephone line along with modem. Due to the limitation inherited from telephone line, end station can not fully utilize MoE network facilities. However, the method is quite applicable and meaningful with the sense that it provides communication medium between MoE and others.

In MoE computing center, two telephone lines were prepared to facilitate it. Remote access service is operational on separate server. The server is placed in MoE computing center and under the direct surveillance of MoE network administrator. The communication channel is protected from abrupt power interruption. The uptime of this service is 24 hours a day. This means that it guarantees accessibility of MoE network services invariably to whoever wants it. If there is demand for expansion, the number of telephone lines for this service will be increases accordingly. Table 3 shows the specification and scope of remote access service.

Table 3: Characteristics of MoE Remote Access Service

Maximum Number of Concurrent Connections	Two
Access Protocol	Point to Point Protocol (PPP)
Access to MoE Network Services (E-mail, WWW, FTP, ...)	All Granted
Massive Data Transfer (Download)	Practically Infeasible

4 Ministry of Education World Wide Internet Connectivity

4.1 Necessity of World Wide Internet Connectivity

The beauty of network system comes from resource sharing and information exchange. When it comes to world wide Internet specifically, resources scattered over the globe can be forged into personal station. It says, "All roads lead to the Internet." Even though network system is locally constructed and isolated from world wide Internet due to technical or administrative obstacles, it is meaningful as what it is. Only narrow facet of Internet substance can be seen on that case. However, if there is a way within hand to connect our network to Internet, the way should be idealized not to loose the chance to meet new information era.

The necessity of Internet connectivity also arises from technical requirement to run brand-new software systems. For example, a certain software would not start if there is no Internet connection. The same situation that the existence of computer is meaningless without Internet connection will happen to us more frequently in near future. The necessity of Internet connection is beyond our controversy.

4.2 Ethiopian Telecommunication Environment

Networking system is highly sophisticated and involves extensive knowledge to establish and operate it. It depends on telecommunication infrastructure. Naturally, world wide Internet access strategy will be closely related with it. As a background to develop the point of argument, current situation of Ethiopian telecommunication environment will be introduced.

In Ethiopia, Ethiopian Telecommunications Corporation (ETC) is the authority responsible to operate telecommunication services, to repair, to assemble and manufacture telecommunications equipment, and to render training services. ETC offers wired and wireless telephony, telex, telegraph, and Internet service[14, 15, 16, 17]. Technically speaking, both of telephony and network system involves identical technology on underlying infrastructures whether the traffic is conveyed through teretial cables or free space medium like satellites microwave that the analysis of telephone systems can drop a hint. Table 4 shows potential on telecommunication capacity regarding telephony and Internet service[18].

Table 4: Capacity of Telecommunication Systems in Ethiopia

1989–1990 E.F.Y		
	1996/97	**1997/98**
Telephony		
Installed Capacity	196,322	211,108
Number of Subscribers	156,538	164,140
Waiting List	206,562	230,225
Expressed Demand	363,100	394,365
Telephone Lines per 100 inhabitants	0.27	0.27
Internet		
Internet Subscription	1,164	2,025

Listed figures give us a little pessimistic implication. Telephone system can not fully cover demand. The number of Internet subscribers can not be reckoned as enough capacity to come

up to network service demand. The accomplishment expressed in table 4 is done through 7th telecommunication development program (1986–1990 E.F.Y). Newly formulated program may be under implementation now. Ethiopian government is trying to open telecommunication market partially, while the government and ETC have influential privilege to monopolize the whole[19]. Considerable change is reported to public these days. There are alleged news in connection with network system expansion. Nevertheless, most of things still remain in uncertainty.

4.3 Fundamental Techniques

It needs the steepest growth of telecommunication capacity to change networking environment ideally. In other words, if that is not feasible, another way should be introduced based on existing technologies. In Ethiopia, PPP (Point to Point Protocol)[20] is the only way to access world wide Internet as shown in figure 1. Nobody can establish networks which can access world wide Internet directly, because there is only one gateway authorized by international Internet authorities like IANA and ARIN[21, 22]. In addition, all exclusive privileges required to control Ethiopian Internet were endowed to ETC. There will be no alternatives in place of PPP temporarily.

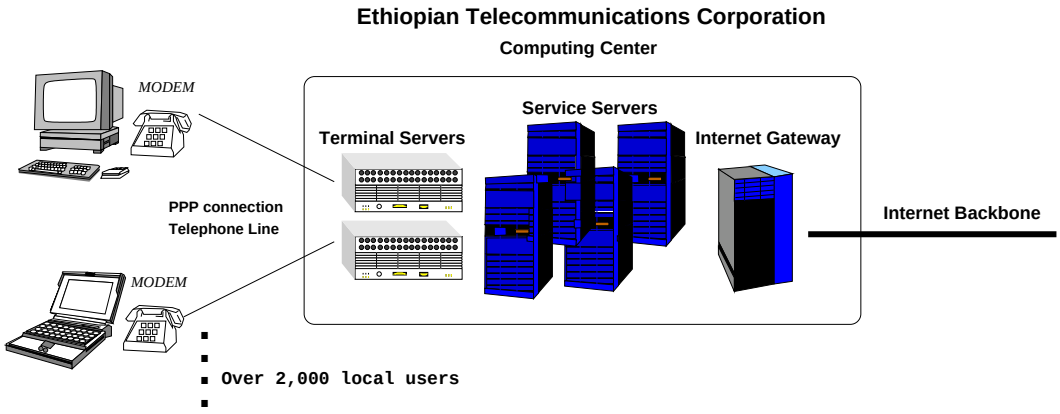

Figure 1: Schematic Diagram of Internet Infrastructure in Ethiopia

The NAT (Network Address Translation)[23, 24, 25] is the second technique to be used to connect educational network to Internet. It was developed in quest of solution for IP address block depletion. Basically, Internet ready station should secure authorized IP address from local ISP (Information/Internet Service Provider), network authorities, or Internet registries[26, 21, 22, 27, 28, 29, 30, 31, 32]. The number of assigned IP addresses reached

nearly its upper bound of 2^{32} (= 4294967296)[33]. Therefore, the NAT can be applied as one of solutions.

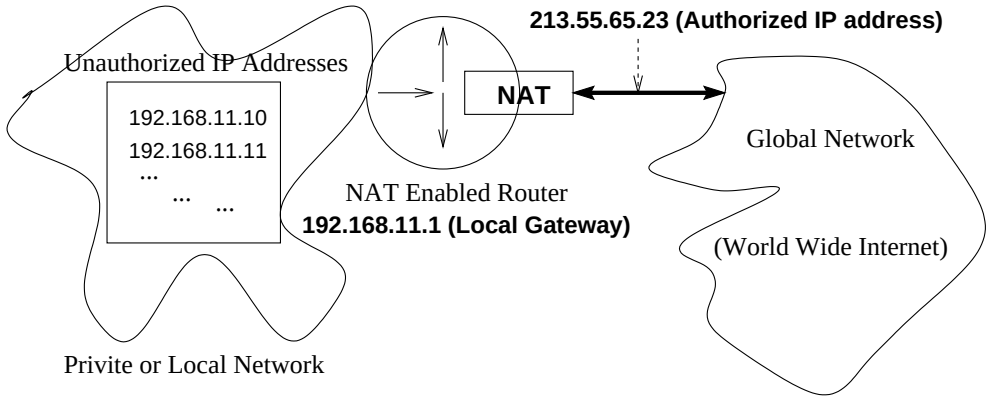

Figure 2: Network Address Translation Structure

As shown in figure 2, NAT is usually incorporated into router[12] where data exchange is performed between private network and global network like world wide Internet. If it is applied into private network, arbitrary IP address block can be assigned for that network. Gateway IP address will be assigned for the router in private network side. One authorized IP address will assigned in global network side.

Once a certain network is established that way, it is operational as a part of global network. Mechanism is as follows,

1. If data exchange occurs on private network, the data will be delivered directly to the destination as is the case of standard delivery.

2. If data is destined to global network, the data will be sent to the router. The router will modify data to make it eligible for world wide Internet routing by attaching appropriate information based on both of private and authorized IP addresses. At this point, NAT will not touch the original contents form the data.

3. Then, the data will be sent to global network and handled as normal data. Acknowledgment and reply from global network to private network[34] will processed by reverse order.

The critical point is that only one authorized IP address was involved during the procedure. There is no restriction on the number of unauthorized IP addresses and the range of IP address block for the private network.

By colligating the two techniques, groups of end stations can get world wide Internet connection. First step is to construct local network with arbitrary IP address block. Second step is the attachment of NAT-enabled router to the network. Finally, authorized IP address for the router should be arranged. In Ethiopia, ETC maintains authorized IP address pools and assign one IP address on the request through PPP connection. No other preparation is needed if and only if the ultimate goal is to connect private network to world wide Internet.

4.4 MoE Internet Gateway

4.4.1 MoE Gateway Router

Figure 3 depicts logical structure of MoE network including access types from each subnetworks. The main network and subnetworks operate on 100 Mbps Ethernet links. The line speed between MoE and outer network is 33,600 Bps. Once the external network succeeds in parameter negotiation with MoE network during connection establishment process, it will be considered as part of '`arat`' subnetwork after that. Browsing network resources can be done from any points of subnetworks.

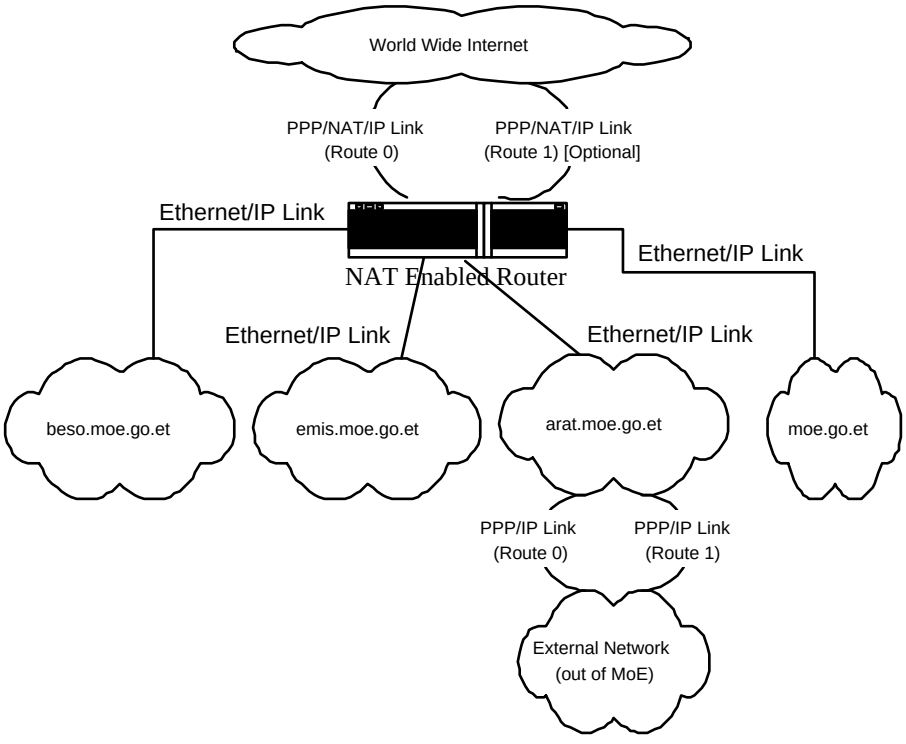

Figure 3: Schematic Diagram of MoE Network

To coordinate packet routing among subnetworks, one software router was deployed with

NAT module. Prior to this deployment, the functionality of experimental router was tested and monitored over one year in separate place of MoE. On the start of MoE network implementation, the equipment was positioned on MoE computing center. When Internet connection is available from the router, any stations in MoE network can access world wide Internet. Due to low bandwidth of PPP connection, another PPP line may be used to enlarge line capacity with load balancing mechanism if needed. Though maximum number of concurrent connection from end stations toward Internet was not analyzed qualitatively, reasonable performance was identified in the field tests with 20 connections.

Base hardware composition for the router consists of Pentium II 300 MHz CPU, 160 MB main memory, hard disk drive sized of 3 GB, four network interface cards for each subnetworks, and two external modems for Internet PPP access mounted on motherboard. Combined operating system is FreeBSD 4.3-RELEASE, one of UNIX clone.

4.4.2 Readiness for Transition to Dedicated Internet Access

Ideal approach to Internet connection is the placement of hardware router with dedicated or leased communication line where high bandwidth is guaranteed in constant rate. Current configuration in MoE is a sort of emulation to ideal case while direct access to Internet is not available. The leased line and hardware router will simply replace PPP line and software router, respectively, if leased line is introduced to MoE. This implies that readiness of MoE network will make swift switch from PPP-NAT to dedicated Internet access without changing existing infrastructure.

5 Concluding Remarks

This paper showed what had been done in MoE headquarter to build up information technology infrastructure, how external organizations can be incorporated into MoE main network, and how the whole MoE network can access world wide Internet. Till now, all possible measures in technical aspect have been mobilized to accomplish the tasks. Furthermore, MoE network is about to enter stable state after recent assessment on functionality proved to be. The leftover things to be tackled from now will be proper management of the network and introduction of dedicated Internet line.

In the matter of network management, MoE is in urgent need of skillful man power from the Ministry side to manipulate the network systems. Other educational organizations may

suffer the same problem. Compared to other fields of computer technologies, knowledge accumulation on networking systems can not be attained within short time because long term experience on network along with extensive knowledge on general computing system beforehand is decisive factor. The requirement of man power as the first priority should be met by all manner of means and without compromise, whether the solution is capacity build of internal staffs, additional recruitment, or the such.

Finally, it is the necessity of Internet connection acquisition that was emphasized in the latter of this paper. The matter seems to be a bit difficult to settle up because the solution is tightly coupled with ETC's resolution. In that case, applying the suggested way toward Internet access as an alternative with the combination of software router, PPP, and NAT will be meaningful for the time being.

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