A Metropolitan Ethernet Network (MEN) Testbed

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Abstract

This paper describes the project, the development and deployment of a Metro Ethernet Network in the city of Morungaba, SP, Brazil. The Ethernet is a widely deployed technology that has proved its robustness and cost-effectiveness. The Ethernet standards guarantee transmission rates from 10Mbps to 10,000Mbps. When used in the scope of the Metropolitan Network, the Ethernet standard can allow the increase of network capacity very cost-effectively. In conjunction with the new WDM technology, Ethernet has the potential to power the changes of paradigm long waited in the Telecommunication Industry arena by allowing the convergence of Telecom services toward the Global Internet.

1. Introduction

The Ethernet was standardized by the IEEE 802.3 standards committee. It uses as a medium access control (MAC) a technique called CSMA/CD what stands for "carrier sense multiple access with collision detection". This technique can be termed a random access technique because the time any station shall transmit cannot be predicted before hand. In this technique the station is free to use the medium any time, but it must check to verify the medium is free for transmission. If the medium is not free, the station should check again at a later time. If the medium is free, the station can transmit. However, there case were a collision can happen in the transmission. In this case, the technique uses a procedure the get out of the collision and allow the network go back to the normal operation process.

This technique is very simple and efficient. However, when the number of station checking the medium to communicate grows high, the number of collisions starts to increase very fast and the network can become easily congested. This is the price to pay for simplicity. This transfer model fits very well in networks that can work with the so called best effort model. However, to convey voice and other real time signals, the network must be capable to offer some kind of guarantee of dedicated bandwidth to individual stations, and the original Ethernet model cannot offer that.

The Ethernet standard states that it was originally intended for use in commercial and light industrial environments. The use in heavy industrial or any other environment with high network processing demand was not in the original scope of the standard. Normally, the demands of Metropolitan networks exceed far beyond those of local or light industrial environments. Besides having a much higher demand for data communication bandwidth, the capacity to provide circuit switched connections or virtual circuit switched connections must be present in the MEN.

This paper presents the description of the project for the development and the deployment of a Metropolitan Ethernet Network in Morungaba, SP, Brazil. The Morungaba testbed aims at experimenting with all the aspects of the MEN, from the optical WDM network integrated with an wireless access infrastructure in the physical and link layers to the e-Gov or Multimedia DB applications in the application layer.

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2. The Morungaba Network Project

Morungaba is a city located in the interior of the State of São Paulo, at about 80km off São Paulo City. The city has a population of about 10,000 inhabitants and is considered a Brazilian Good Climate Region because of the excellent condition of its weather. The reason to install this experimental testbed in Morungaba are due to its excellent localization, close to the cities of São Paulo and Campinas, and its proximity to the interstate network backbone that is being deployed between Campinas, São Paulo and Rio de Janeiro. Because Morungaba is a very small city, the burden generally associated to the installation of network backbones in large cities doesn't have a large impact in the project in this case.

To attend the demand of the Brazilian Public Administration Modernization Program, the project of the Metropolitan Network of the city of Morungaba must consider not only the Metro Ethernet Network but also the applications to allow the providing of services to the municipal citizen. This modernization program requires development of applications in three main areas: Public Management Applications (Fiscal, Tributary and Human Resources systems), Management of Community Services Applications (Educational Systems, Health Systems, etc), and Telecommunications over the MEN (VoIP, VoMPLS, TVoIP, etc).

The installation of the network will be divided in two phases. In the first phase, that shall take from June to December of 2003, a WLAN backbone will be launched to support Ethernet and IP interconnection among the city main public institutions. In this phase the following services will be developed and installed:

1 Public Management Applications:
   1.1 Fiscal and Tributary Systems
2 Management of Community Services Applications:
   2.1 Public School Administration System
   2.2 PGL e-Learning system

In the second phase the full MEN network will be installed, from the optical backbone to the real time protocols that shall allow the development and deployment of the QoS Telecom over MEN solutions. In this phase, the main characteristic of this project as an experimental backbone will become more apparent when the several research and development initiatives in the most different areas, varying from Optical Engineering to Social Research, start to be implemented. This phase shall start in the beginning of 2004 and must last for three years. During this phase is our goal not only contribute with the national and international development of the technology related to the Metro Networks, but also contribute to leverage the MetroNet as a new concept in Communication Engineering in Brazil.

3. Metro Ethernet Standard and Services

The Metro Ethernet Network concept is based on the idea of a having a simple, ubiquitous, cost-effective, packet based, ease of internetworking, with rapid provisioning on demand service. This goal can be achieved through the use of the IEEE 802.3 Ethernet standard in conjunction with a variety of other standards that, by interworking with the Ethernet, complete the needs of MEN customers. These standards are such as Optical WDM, SONET, ATM, MPLS, etc. However, despite the participation of these complementary standards, the customer still see its services like

the traditional Ethernet service. Figure 1 presents an idea on how customer interwork with MEN services through MEN service provider.

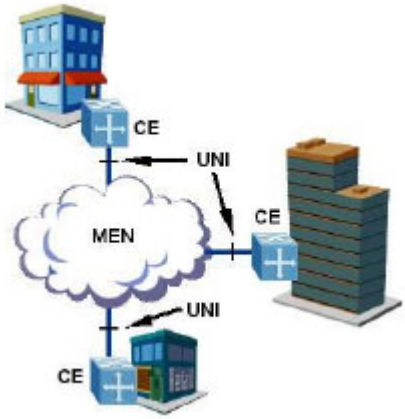

Figure 1 – Basic model for Ethernet services

In the basic model, the Ethernet service is provided by the Metro Ethernet Network service provider. One can see from Figure 1 that the Customer Equipment (CE) attaches to the MEN through a User Network Interface (UNI). The UNI can use several standards, from pure Ethernet standards (10Mbps, 100Mbps, 1Gbps and 10Gbps Eth interface) to complementary standards like ADSL, E1, E3, STM1, IEEE 802.11b, etc. However, the idea of the MEN is that the costumer shall still see the Ethernet from its side of the UNI.

4. Morungaba Metropolitan Network TestBed

The Morungaba Metropolitan Network TestBed is developed to provide the city of Morungaba with a high speed and high performance integrated services network. The network can be divided into three layers, as shown in Figure 2: MetroNet Application Layer (MAL), Information Technology Layer (ITL) and Digital Infoway Layer (DIL). The DIL is composed by the physical and logical resources necessary to connect the local area networks (LANs) of the municipal institutions, such as the city hall, hospitals, schools, universities, etc. The DIL is a high speed network based on the MEN. The Information Technology Layer offer computational resources needed to storage and manage the information being generated, stored and flowing over the network. Finally, the MAL is composed by all the systems that provide services directly to the end user, like e-Gov applications, e-Learning applications, multimedia database applications, and many others.

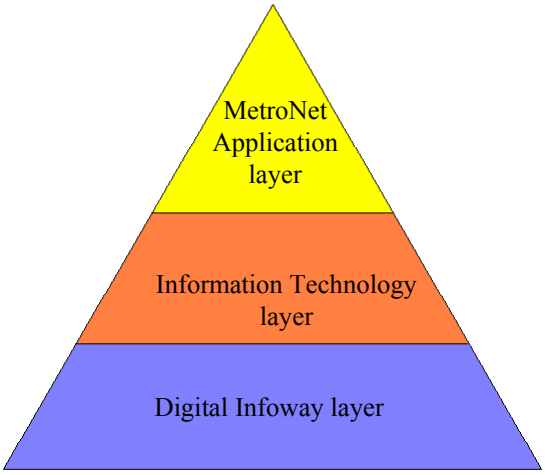

Figure 2. Layer characterization of the Morungaba Metropolitan Network

4.1 Digital Infoway Layer

The DIL is built to convey data, both best effort and synchronous, among the LANs and VLANs that compose the Metropolitan Network. The DIL is created upon the Metropolitan Ethernet Network technology standards. The physical infrastructure of the network is formed with an DWDM optical backbone with high transmission capacity, whose aim is to provide the high bandwidth needed to high performance applications.

Upon the optical layer will rest a Metropolitan Ethernet Network where customer access equipment (CE) will connect theirs LANs and VLANs to network through User Network Interfaces (UNI). The MEN will be formed essentially of LANs interconnected through UNIs at 10Mbps, 100Mbps, 1Gbps and 10Gbps. These interfaces will open the door of the network to the various services predicted for the MEN. In fact, this backbone, along with QoS implementation for the Ethernet, qualify the network to serve even as backbone for networks that demand synchronous services like the PSTN.

To allow the interchange of the information among the LANs and VLANs it is necessary to define services to transfer the data between the end points. This transfer can be accomplished through especial virtual circuit services defined for the MEN or through using the network protocol IP. Some models using the Internet Protocol that are complementary to the MEN or compete with it are: IP/MPLS/Optical layer, IP/Optical layer, IP/ATM/Optical layer, IP/SDH/Optical layer. The IP protocol ensures interoperation of the network with several other networks, including with other Metropolitan Networks and with the Internet. Figure 3 shows how this architecture can be built.

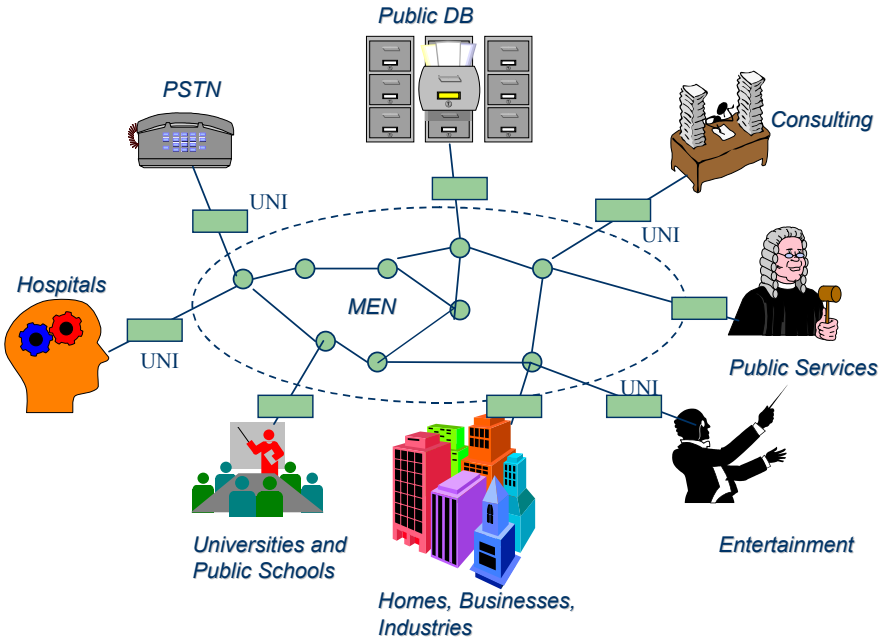

Figure 3 – Metropolitan Network: The municipal LANs are interconnected through a Metropolitan Ethernet Network that support all data flow among city units and is capable to switch connections toward PSTN networks.

This network can interoperate with other networks in the city through Ethernet or IP protocols. These networks can be created upon such technologies as ADSL, WiFi, Satellite or others. Some of these can be seen as secondary networks and their access speed may vary from 64kbps through 10Mbps or beyond.

4.2 Information Technology Infrastructure

The Information Technology Infrastructure offers the resources to support the organization, operation, protection, authentication, etc, of the data in the network. The basic resources associated to IT are:

- Data Center – Is responsible for the housing of the server farm, the databases, the call centers and the main management systems of the network. It includes database management.
- Security Systems – Are responsible for the protection of the information stored in or flowing through the network. It includes firewalls, backup strategies, security policies, privacy and authentication.
- Call Center – Are responsible for the offering of resources for data, voice or video support centers in the network.
- Virtual Private Network (Intranet) – Offer the logical infrastructure to allow the creation of logical, independent networks to attend the demand of specific subnetworks internal to the Metro Network.
- Server Farm – Includes the software and hardware necessary for the operation of the Call centers, Web Servers, FTP servers, proxy servers, e-mail servers, VoIP servers, etc.

4.3 Metro Ethernet Application Layer

The MetroNet Application Layer refers to the set of applications running in the network and providing services to the end users directly. Among others, the MAL allows the

development and deployment of applications in the area of e-Gov, e-Learning, e-Health, Telecom over Ethernet (with MPLS?), Telecom over IP, etc. The MAL can be particularly useful in the integration and modernization of all the aspects of public administration, through the creation and implementation of an electronic counterpart of the city government, permitting also the offering of several high technology services to the citizens. These services can be divided in two areas: Public Administration and Telecom Applications. Applications in the Public Administration area can include Finance Administration, Health Service Management, School Administration, and Human Resource Administration. In the area of Telecom Applications solutions include Voice over IP, Broadband Internet access, Video on Demand, e-Learning, Web TVs, Web Radios, etc.

In spite of being called Metro Ethernet Application Layer, most of the applications mentioned above run upon IP protocols. However, some applications may demand or benefit enormously from protocols that bypass the IP interconnection allowing solutions like end-to-end virtual connections over the MEN.

5. Conclusions

There are many benefits coming from the use of a Metropolitan Ethernet Network. The Ethernet networks can be view as a conceptually simple but highly efficient multi purpose high speed network. The Ethernet provides application developers with all sort of network infrastructure for the development of multimedia applications. The Metropolitan Ethernet Network is an extension of the Ethernet Network for the Metropolitan Network area. With the Ethernet technology the Metropolitan Network can become an integrated service network conveying information from the most different networks, such as Internet, Telephony or Cable TV. It can also benefit from all the development made for the LAN Ethernet, including the extensive use of almost inexpensive open standard equipment. All this facts can make the MEN a very powerful but yet very cost effective high speed integrated service network.

The Morungaba Metropolitan Network is an experimental testbed to permit the creation of an environment for R&D in MEN and MEN applications. It will allow the construction of a whole new paradigm in communications network in Brazil. This network will have two very important impacts. The first for the Brazilian Public Administration Modernization Program and the second in the creation of alternative network backbone to convey telecommunication signals. This experimental network will permit also that other researchers study and develop new solutions that can bring important contributions in the most diverse areas, from optical engineering to social research.

Acknowledgements

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