

Design and Implementation of ME-VPNS

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Abstract— In this paper, we describe the Metro Ethernet VPN provisioning System (ME-VPNS) that is designed and implemented to control and manage the end-to-end VPN paths through metro and access networks. To test ME-VPNS, we built the metro network that is composed of MPLS-TP routers providing Metro Ethernet Services and the access networks (PONs) that involve OLTs and ONUs. ME-VPNS control and manage VPN service in a centralized way in cooperation with other provisioning systems such as PPS and APS. In this paper, we describe the details for our ME-VPNS implementation.

Keywords— Metro Ethernet, Access Network, VPN, MPLS-TP, PBB-TE, PON

I. INTRODUCTION

Ethernet [1] is evolving from an enterprise Local Area Network (LAN) technology to a much more robust, carrier-grade transport technology for metropolitan service networks. Ethernet is the dominant LAN technology in most offices, with ubiquitous 10/100 Ethernet and GigE interfaces used to interconnect high-speed corporate networks. Ethernet's popularity as a LAN technology is driven by the fact that it is simple and very inexpensive.

However, some of the attributes that make Ethernet simple and inexpensive for office LANs impede its use for carrier-grade data services over larger metropolitan networks. Because of these limitations, mission critical corporate data networks have traditionally relied on Frame Relay (FR), Asynchronous Transfer Mode (ATM) [2] or point-to-point private line connection-oriented services due to their high reliability and guaranteed service delivery.

In the last ten years, the amount of corporate, home, and internet data traffic has increased exponentially. Carriers are looking for new, less expensive ways to transport data services over metropolitan areas, while ensuring guaranteed end-to-end connections and Service Level Agreements (SLAs). To fulfill this need for data connectivity over much larger areas, Ethernet has recently incorporated several enhancements. This new Ethernet is called Metro Ethernet.

A Metro Ethernet is a computer network that covers a metropolitan area and that is based on the Ethernet standard. It is commonly used as a metropolitan access network to connect subscribers and businesses to a larger service network or the Internet. Businesses can also use Metro Ethernet to connect branch offices to their Intranet [3].

Ethernet has been a well-known technology for decades. An Ethernet interface is much less expensive than a Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) [4] interface of the same bandwidth. Ethernet also supports high bandwidths with fine granularity, which is not available with traditional SDH connections. Another distinct advantage of an Ethernet-based access network is that it can be easily connected to the customer network, due to the prevalent use of Ethernet in corporate and, more recently, residential networks. Therefore, bringing Ethernet in to the Metropolitan Area Network (MAN) introduces a lot of advantages to both the service provider and the customer.

A typical service provider Metro Ethernet network is a collection of Layer 2 or/and Layer 3 switches or/and routers connected through optical fibre. The topology could be a ring, hub-and-spoke (star), or full or partial mesh. The network will also have a hierarchy: core, distribution (aggregation) and access. The core in most cases is an existing IP/MPLS backbone, but may migrate to newer forms of Ethernet Transport in the form of 10Gbit/s, 40Gbit/s or 100Gbit/s speeds.

A Virtual Private Network (VPN) is a network that uses primarily public telecommunication infrastructure, such as the Internet, to provide remote offices or travelling users access to a central organizational network. VPNs typically require remote users of the network to be authenticated, and often secure data with encryption technologies to prevent disclosure of private information to unauthorized parties.

VPNs may serve any network functionality that is found on any network, such as sharing of data and access to network resources, printers, databases, websites, etc. A VPN user typically experiences the central network in a manner that is identical to being connected directly to the central network. VPN technology via the public Internet has replaced the need to requisition and maintain expensive dedicated leased-line telecommunication circuits once typical in wide-area network installations.

In this paper, we describe the details of our implementation that control the end-to-end VPN service. This implementation perform the VPN service on access networks based on Passive Optical Network (PON) and metro network based on Metro Ethernet Forum's (MEF's) Metro Ethernet Services.

This paper is organized as follows. Section II provides the related works with our works. In Section III, we give a full detail of ME-VPNS. Finally, Section IV concludes this paper.

II. RELATED WORKS

A. Metro Ethernet Services

Metro Ethernet services are now offered by a wide range of service providers. Some providers have extended Ethernet services beyond the metropolitan area and across the wide area. To evolve Ethernet to a Metro Ethernet service and transport technology, several enhancements have been added to the standard over the last couple of years. In addition, the MEF has been active in defining five attributes of Metro Ethernet services [3][5][13].

- Standardized Services
- Scalability
- Reliability/Protection
- Service Management
- Quality of Service

The MEF has defined three basic service types discussed below. Other service types may be defined in the future. The Ethernet Line Service (E-Line Service) provides a point-to-point Ethernet Virtual Connection (EVC) between two User Network Interfaces (UNIs) as shown in Figure 1. The E-Line Service is used for Ethernet point-to-point connectivity.

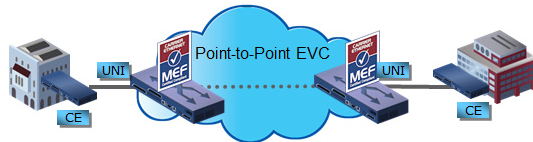


Figure 1. E-Line Service using Point-to-People EVC

The Ethernet LAN Service (E-LAN Service) provides multipoint connectivity, i.e. it may connect two or more UNIs as illustrated in Figure 2. Subscriber data sent from one UNI can be received at one or more of the other UNIs. Each UNI is connected to a multipoint EVC. As new UNIs are added, they are connected to the same multipoint EVC thus simplifying provisioning and service activation. From a subscriber standpoint, an E-LAN Service makes the Metro Ethernet network look like a LAN.

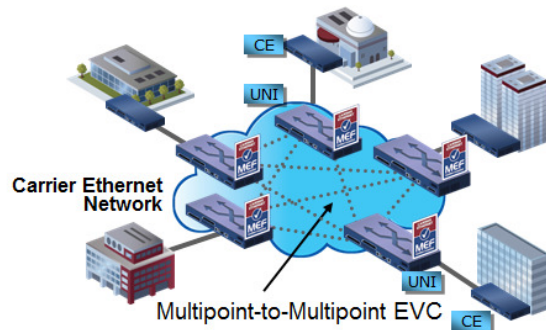


Figure 2. E-LAN Service using Point-to-Multipoint EVC

The Ethernet Tree Service (E-Tree Service) enables point-to-multipoint services with less provisioning than typical hub and spoke configuration using E-Lines and provides traffic separation between users with traffic from one “leaf” being allowed to arrive at one of more “Roots” but never being transmitted to other “leaves”.

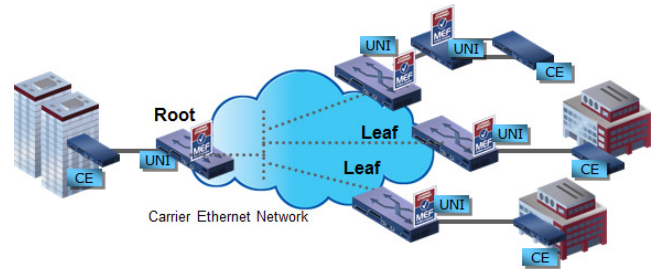


Figure 3. E-Tree Service using Rooted-Multipoint EVC

B. OLT and ONU

An optical line termination (OLT), also called an optical line terminal, is a device which serves as the service provider endpoint of a passive optical network. It provides two main functions:

- To perform conversion between the electrical signals used by the service provider's equipment and the fiber optic signals used by the passive optical network.
- To coordinate the multiplexing between the conversion devices on the other end of that network called either Optical Network Terminals (ONTs) or Optical Network Units (ONUs).

An ONU is a device that transforms incoming optical signals into electronics at a customer's premises in order to provide telecommunications services over an optical fiber network. It implements a PON protocol, and adapts PON PDUs to subscriber service interfaces [8]. In some contexts, an ONU implies a multiple subscriber device. An Optical Network Terminal (ONT) is a special case of an ONU that serves a single subscriber.

III. ME-VPNS

A. Network Configuration

The test network for the ME-VPNS is configured as shown in Figure 4. Metro Network is composed of routers or switches based on MPLS-TP or PBB-TE [12] technology and Access Network is composed of OLTs and ONUs. An OLT is a device which serves as the service provider endpoint of a PON. The two main functions in the OLT are to perform conversion between the electrical signals used by the service provider's equipment and the fibre optic signals used by the PON and to coordinate the multiplexing between the conversion devices on the other end of that network called either ONT or ONU. An ONU is a device that terminates any

one of the endpoints of a fibre to the premises network, implements a PON protocol, and adapts PON PDUs to subscriber service interfaces.

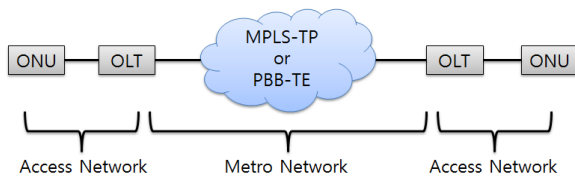


Figure 4. Network Configuration

B. Configuration

ME-VPNS communicates with Access Provisioning System (APS) and Packet transport layer Provisioning System (PPS). APS is a system that controls and manages OLTs [11]. An OLT configures the several ONUs using ONT Management and Control Interface (OMCI) [8]. PPS is a system that controls the routers on Metro Ethernet network and establishes paths [7].

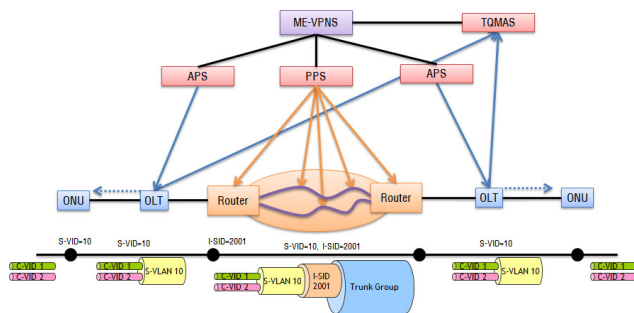


Figure 5. Configuration Scenario

To establish end-to-end VPN paths, ME-VPNS requests to establish paths in Metro Ethernet network to the PPS and then requests to configure paths in access networks to the APS as shown in Figure 5.

PPS configuration procedure is as follows:

1. Trunk Configuration
2. Traffic Engineering Service Instance (TESI) Configuration and Trunk mapping Configuration
3. QoS Configuration on Trunk or TESI
4. Backbone Service Instance (BSI) Configuration at a UNI (Port and Service VLAN ID (S-VID))
5. UNI QoS Configuration
6. BSI Mapping to TESI
 - A. E-Line $\rightarrow$ 1:1
 - B. E-LAN $\rightarrow$ 1:n

Besides, to configure the end-to-end VPN paths, we should establish paths in access networks. The procedure of the establishment is as follows:

1. Tag Configuration for inserting an S-VID per ONU
2. T-CONT/GEM Port Mapping per S-VID
3. T-CONT/GEM Port QoS Configuration for Upstream

4. Downstream ONU QoS Configuration per S-VID

C. Functional Architecture

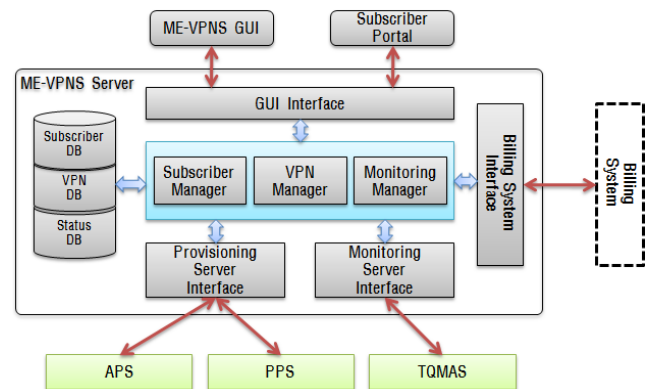


Figure 6. Functional Architecture of ME-VPNS

Figure 6 illustrates the functional architecture of ME-VPNS. The main functions of ME-VPNS are subscriber manager, VPN manager, and monitoring manager.

The subscriber manager stores the VPN service subscriber information into a Subscriber Database. The subscribers that want to use the VPN service can subscribe to the service using an external subscribing portal server.

The VPN manager of the ME-VPNS is the main function that manages and controls the end-to-end VPN service. It communicates with APSs and a PPS using a Provisioning Server Interface. As mentioned above, the VPN manager of the ME-VPNS establishes and manages the paths for VPN service in cooperation with APSs and PPS.

The Monitoring manager monitors the status of OLTs and routers. It performs the monitoring with the help of an external Traffic Quality Measurement and Analysis System (TQMAS) [9] using a Monitoring Server Interface. The information received from the TQMAS is stored into a Status Database and is sent to the Billing System. Billing system can use this information for generating new information for billing.

D. VPN Configuration

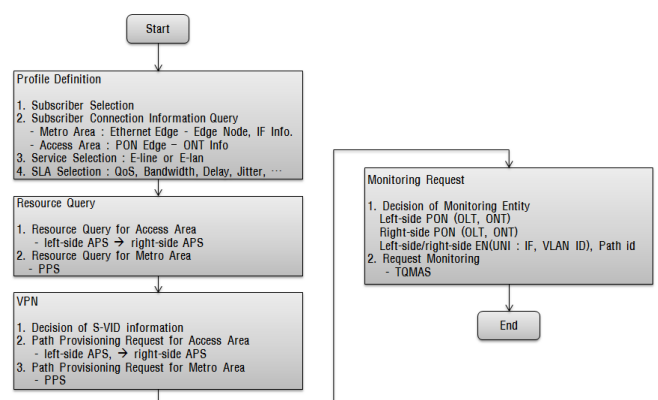


Figure 7. The Procedure for VPN Configuration

Figure 7 shows the procedure for VPN configuration in our ME-VPNS. The first step is a profile definition step that is composed of 1) subscriber selection, 2) query for subscriber connection information to metro and access network, 3) service selection among E-Line/E-LAN/E-Tree, and 4) SLA selection. In the sub-step for SLA selection, we can choose the values for QoS, bandwidth, delay, jitter etc. The second step for querying resources in networks is composed of the two sub-steps as follows: 1) resource query for access networks and 2) resource query for metro network. The third step is a VPN service provisioning step. In this step, the S-VID information used in access networks is decided and path provisioning is requested to APSs for access networks and to a PPS for metro network respectively. Finally, in the fourth step, the traffic and QoS monitoring request is initiated to an external TQMAS. To begin with, we should decide the monitoring entities in this step. The monitoring entities are the PONs composed of an OLT and ONUs and the UNIs of the metro network (e.g. IF ID, VLAN ID, and Path ID). After that, the monitoring of the entities is requested to the TQMAS.

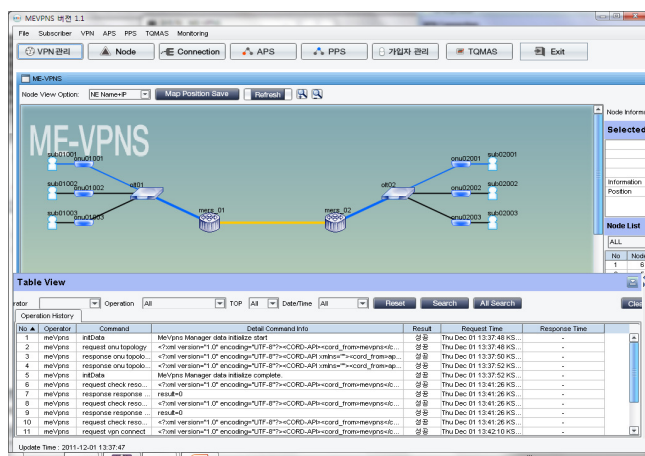


Figure 8. ME-VPNS Graphic User Interface

Figure 8 shows an ME-VPNS Graphic User Interface (GUI). Our test network is composed of two MPLS-TP routers in metro network and two OLTs and several ONUs in access networks. In this figure, the thick and yellow line between the two MPLS-TP routers shows the path established in metro network and the thin line shows the connection status between OLT and ONU. And the right side of the GUI illustrates the list of discovered by ME-VPNS and the information about a node selected by an administrator. And also, the lower side of the GUI shows the history of ME-VPNS operations.

IV. CONCLUSIONS

In this paper, we described the ME-VPNS that provides a centralized end-to-end VPN control and management service through PON based access network and MPLS-TP based metro networks in coordinate with APSs and a PPS. Also, this paper described the functional architecture of ME-VPNS and the details of each component. The procedure to provide the end-to-end VPN service by using ME-VPNS is described.

And finally, we provided an example establishing an end-to-end path by using ME-VPNS GUI.

ACKNOWLEDGMENT

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