A Virtualization and Management Architecture for Carrier Ethernet Network

Wonhyuk Lee†, Yong-Suk Cho††, and Hyuncheol Kim†††

†Korea Institute of Science and Technology Information (KISTI), Deajeon, 305-806 Korea
††Dept. of Electronic and Information Engineering, Kon Yang University, Nonsan, 320-711 Korea
†††Dept. of Computer Sciences, Namseoul University, Cheonan, 331-707 Korea

Summary
With the establishment of logic network among particular research groups such as high-energy physics and climate, recently, a demand for a kind of private network by group has increased in science technology research network. In response to the current trend, a demand for a management framework on the logic network by group has also increased from the research network NOC perspective in Carrier Ethernet-based science technology research network. This paper has made it possible to express the data (ex: the operating, topology, performance and fault information of science technology research network infrastructure resources) n the specification system which has been designed in accordance with international standards and manage them in an integrate manner. For this, the key information which is necessary for the management has been collected after approaching each L2 logic network node which is consisted of PBB-TE using SNMP. Then, the management framework has been designed to make it possible to save the collected information in the database which has been designed in accordance with international standards and manage the logic network anytime and anywhere through the web. It is expected that network management would become more efficient through a more systematic and specific network if the established logic network management framework is used.
Key words:
PBB-TE, Logical Network, Carrier Network, Network Management Framework, Network Management Schema[1]

1. Introduction

With the establishment of logic network among particular research groups such as high-energy physics, KOCED, climate and construction, recently, a demand for a kind of private network by group has increased in science technology research network. At present, KREONET has played a leading role in providing services in Korea. Internationally, Internet2 (the U.S.), CANARIE (Canada) and SURFnet (the Netherlands) have provided the services. In Korea as well, a logic network has been organized using Carrier Ethernet protocol technologies such as VLAN (Virtual LAN), PBB (Provider Backbone Bridge) and PBB-TE (Provider Backbone Bridge-Traffic Engineering). To provide stable services, therefore, a demand for the management framework on a logic network by group from the NOC (Network Operations Center) perspective has increased [1].

With these reasons, many studies have been conducted for establishment of an efficient operating and management system on a variety of network infrastructure resources such as communication technology between homogeneous networks and circuit bandwidth. GEANT, a research network group in Europe has a network information management system on a research network called 'cNIS.' The technology information which is necessary to realize a logic network has been partially expressed in Network Description language (NDL) and Network Markup language (NML) [2][3].

Therefore, it is necessary to establish a specification system in accordance with international standards using the operating, topology, performance and fault information of science technology research network infrastructure resources. Then, operational cooperation among international research network operating centers and organic sharing of operating technology as well as th efficient of a science technology research network would become possible. Hence, this paper has attempted to investigate the schema of a logic network management and web-based management framework to express and manage the Carrier Ethernet-based logic network.

This paper consists of as follows: Carrier Ethernet and Ethernet OAM (Operation, Administration and Maintenance) were described in Chapter 2. In Chapter 3, NDL is briefly introduced. Chapter 4 introduces the schema of a logic network management. In Chapter 5, the realization of a logic network management framework and the operation are introduced. In Chapter 6, conclusion and suggestions are stated.

2. Carrier Ethernet

A variety of transmission protocols such as SONET/SDH (Synchronous Optical NETwork/Synchronous Digital Hierarchy) and ATM (Asynchronous Transfer Mode) exist

1 Funding for this paper was provided by Namseoul university

Manuscript received November 5, 2010
Manuscript revised November 20, 2010

in the Carrier network. To support all these functions, therefore, it is necessary to provide management functions on all network layers.
Because classical Ethernet has not been able to support these functions, strict service quality could not be guaranteed. Due to a very weak protective function on faults, in addition, it has not been appropriate to apply the functions to the Carrier-level network. Therefore, new functions which satisfy various requirements such as Service Level Agreement (SLA) and OAM & Protection have been added to the Carrier Ethernet [4][5]. At present, about 150 service providers around the world are providing or plan to provide Ethernet services. The related industrial firms have kept promoting technology standardization process in international standardization organizations such as IEEE 802, ITU-T and MEF (Metro Ethernet Forum).

2.1 Definition of Carrier Ethernet

According to the definition of Metro Ethernet Forum in which the term 'Carrier Ethernet' was first used, and technology standardization, product certification and marketing have been actively promoted, Carrier Ethernet means standardized Carrier service and network which have five attributes; standardized service which is differentiated from the LAN-based Ethernet, scalability, reliability, quality of service and service manageability [5].

2.1.1 Standardized Service

Through the platforms which have been independently standardized to the media and infrastructure, services are provided locally or globally. In the Metro Ethernet Forum, three different services are defined; Ethernet-Line service, E-LAN service and E-tree service. For more information on each service, refer to the Carrier Ethernet Service in the next section. However, it is now allowed to change customers' LAN equipment or network to support these services. In addition, the system should be capable of accepting a conventional network such as TDM traffic or signaling. Standardized services can be applied to a network in which voice, video and data are converged. Diverse and specific bandwidth and service quality are provided to users.

2.1.2. Scalability

Network services for extensive business, information & communication and entertainment applications including voice, video and data to numerous customers. Services are provided across the nation or around the world through a variety of infrastructure which has been established by service providers. Specified bandwidth from 1 Mbps to 10 Gbps is supported.

2.1.3. Reliability

The requirements on service quality and availability are satisfied by providing the function to discover and recover a problem when it occurs in the link or node. When a network problem occurs, quick recovery time (50ms or less, equivalent to SONET/SDH) is provided.

2.1.4. Service Quality

A service level agreement which delivers the end-to-end performance which is required for voice, video and data services in the business and residential network is provided. Provisioning is provided through the service level agreement which provides committed information rate, frame loss, frame delay and frame delay variation.

2.1.5. Service Management

The functions to monitor, diagnose and manage a network based on the standard method are provided. A Carrier-level OAM performance which can be integrated with the conventional service provider model is supported. In addition, fast service provisioning which can be compared to the conventional service is provided.

2.2 PBB-TE Technology

PBB-TE (or PBT) is a method to realize the VLAN-aware bridge (provider backbone bridge)-based packet forwarding technology which was proposed by BT & Nortel. Its standardization into IEEE 802.1Qay has been promoted since May 2007 [6][7].

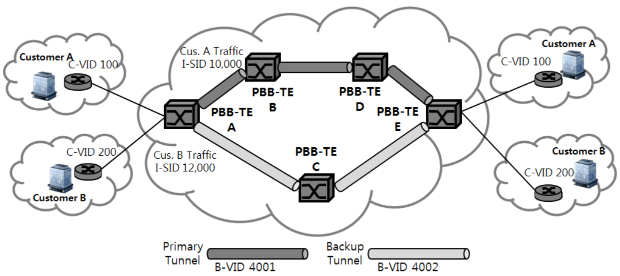

Fig. 1 A PBB-TE-based Ethernet Trunk Configuration

In principle, a bridge performs various functions such as learning, forwarding and filtering based on spanning tree protocol. In PBB-TE, it is required to set point-to-point and point-to-multi point tunneling paths which are traffic-engineered through the distributed control plane (ex: GMPLS-IETF RFC 3945, etc.) or SNMP instead of spanning tree protocol without using the flooding of unknown [8],[9]. For this, PBB-TE has defined B-VID for

PBB, the separation of B-VID domain for PBB-TE, disposal of unknown-destination address frame, connection fault management in the traffic engineering path and protection switching including road sharing. However, multi point-to-multi point service is provided on the PBB through the IS-IS link state protocol-based IEEE 802.1aq SPB control plane [10][11].

2.3 Ethernet OAM Technologies

PBB-TE checks connectivity of Ethernet service and manages its performance by selectively using i) IEEE 802.1ag CFM which defines the connectivity check, loopback and link-trace functions for fault detection and notification, ii) ITU-T Y.1731 [12] which defines frame delay, frame delay variation and frame loss for performance monitoring and iii) ITU-T G.831 [13] for linear protection switching. For example, there are two kinds in Ethernet OAM; ETY Layer OAM which handles a fault on the physical Ethernet link and ETH Layer OAM which takes care of a fault on the Ethernet MAC-based connection route (ex: PBB-TE tunnel). ETY Layer OAM-related standards include IEEE 802.3ah EFM while ETH Layer OAM standard include IEEE 802.1ag, ITU-T Y.1730/1731 and MEF 17.

2.3.1 Fault Management

The typical Ethernet fault management functions which are defined in IEEE 802.1ag and ITU-T Y.1731 include [12][14]

- Fault Detection
- Fault Verification
- Fault Isolation
- Fault Notification

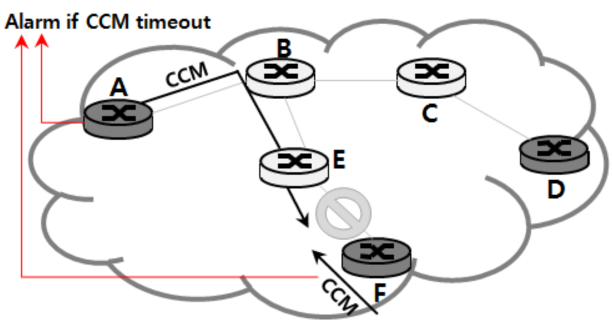

Fig. 2 Fault Detection (ITU-T Y.1731, IEEE 802.1ag)

'Fault Detection' is a function which turns on protection S/W if Continuity Check Messages (CCM) are not successfully forwarded for a certain period of time.

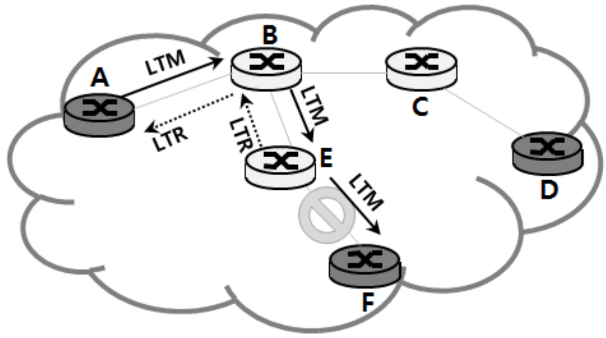

Fig. 3 Fault Isolation (ITU-T Y.1731, IEEE 802.1ag)

'Fault Isolation' uses Linktrace Messages (LTM) and Linktrace Reply (LTR). For example, Node A first transmits LTM as shown in Fig. 3. Then, the nodes (B and E) in the middle return LTR and reforward LTM to the node F. Because no LTR is returned in the node F, it is concluded that there is a fault on the link.

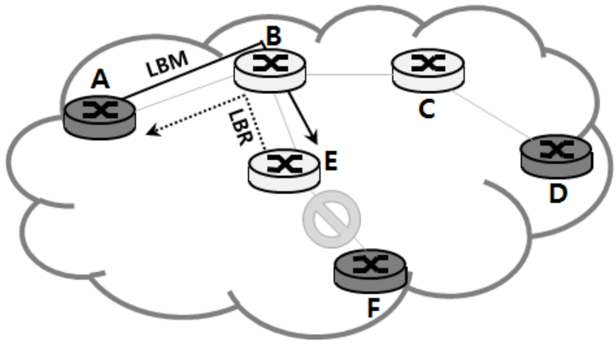

Fig. 4 Fault Verification (ITU-T Y.1731, IEEE 802.1ag)

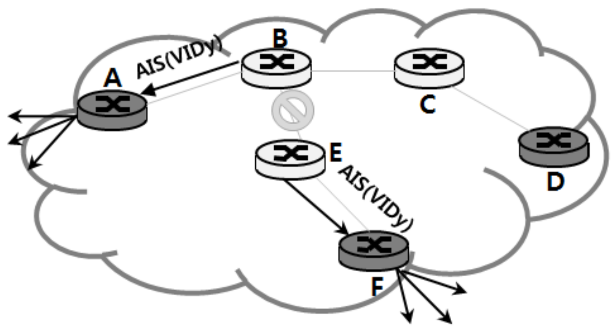

Fig. 5 Fault Notification (ITU-T Y.1731)

2.3.2 Performance Monitoring

The typical functions for Ethernet performance monitoring, which is defined in ITU-T Y.1731 are [12][14]

- Frame Loss Ratio
- Frame Delay

∘ Frame Delay Variation

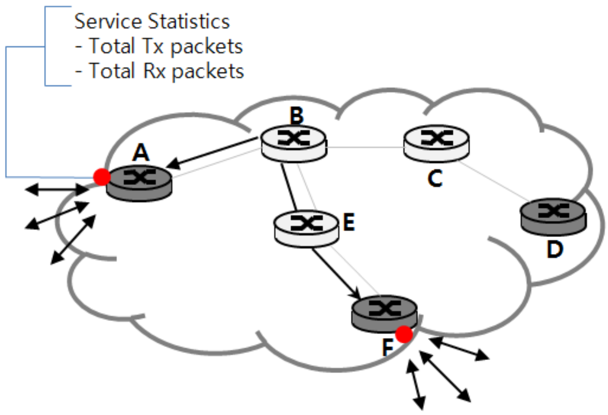

Fig. 6 Frame Loss Ratio (ITU-T Y.1731)

'Frame Loss Ratio' is a method to calculate loss ratio after forwarding CCM from the both ends and comparing the number of frames received.

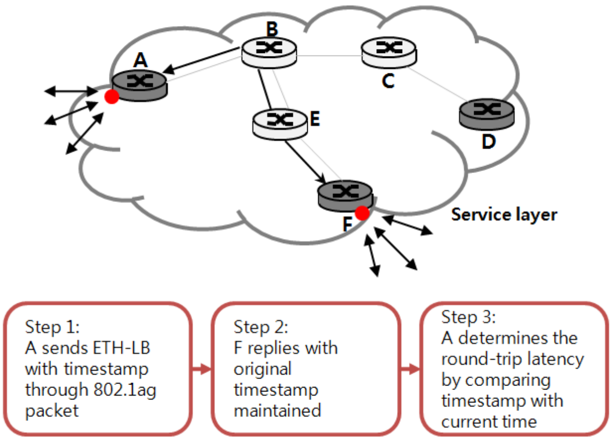

Fig. 7 Frame Delay (ITU-T Y.1731)

'Frame Delay' is calculated without clock synchronization among equipment using Delay Measurement Message/Relay (DDM/DMR).

3. NDL

A network has continuously evolved and become more complicated. Therefore, Network Description language (NDL) is efficient in reducing the complexity of computer network problems. In addition, it offers a method to describe a network in a significant manner. After making network ontology using Resonance Description Framework (RDF), it has made it possible for users to understand it in a clear and simple manner. In fact, a method to explain the words that are common in sharing the optical network and multi-domain lightpaths are required. At present, GLIF and other research institutes have requested cooperation in using the common language, NDL [15][16].
To solve various problems associated with the operation of hybrid network, an algorithm which makes it possible to create a useful network map and find a path easily has been proven. SURFnet6 plans to conduct a study on the Netherlands and provide education network lightpath and IP services using NDL [2]. In reality, the NDL schema consists of five core schemas:

① Topology schema: A description on equipment, interface and the link is defined. Local class is also defined here.

② Layer schema: It is also known as 'abstract schema.' It explains particular network technology and inter-network layer relations.

③ Functional schema: Functions are explained.

④ Domain schema: Management domain, domain in the service and how to provide the abstract part of the domain are explained.

⑤ Physical schema: Network equipment and physical aspects (blade, chassis layout, additional attributes of chassis and local class, etc.) are explained.

4. Logical Network Management Schema

4.1 Topology Schema

As the topology class which expresses the configuration of logic network, it has trunk class as a subordinate class. Trunk class consists of two classes; Vlan class which contains logical information for management of Carrier Ethernet trunk and interface class which physical information. Fig. 8 illustrates a complete view of topology schema. It has the class to control the trunk class.
As a UML diagram of topology schema, it shows specific parameters which are used in the class. Each parameter has been defined using enterprise MIB information. The logic network has been configured based on based on the definition of PBB-TE technology.

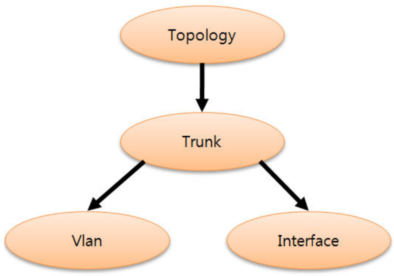

Fig. 8 Topology Schema

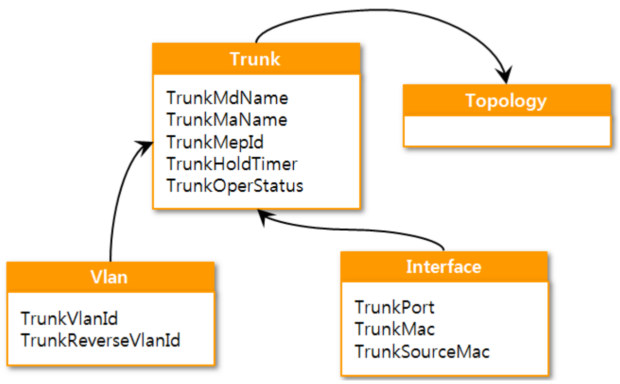

Fig. 9 Topology UML Schema

4.2 Performance Monitoring Schema

The performance monitoring class has the following subordinate classes; Throughput, Frame Loss and Frame Delay. It consists of Frame Loss Class, Fame Loss Ratio and Fame Delay Variation. Fig. 10 shows a complete view of the performance monitoring schema. In fact, it has five classes to monitor logic network performance. Each class has been prepared based on the performance monitoring technology which is defined in ITU-T Y.1731.

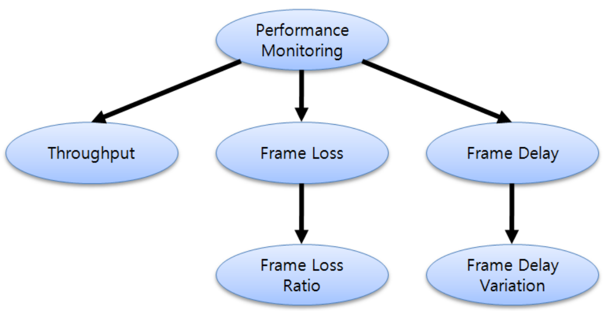

Fig. 10 Performance Monitoring Schema

In terms of a UML diagram of the performance monitoring schema, specific parameters have been used. Each parameter has been defined using enterprises MIB information. The most important information in monitoring logic network performance has been based on the OAM definition of ITU-T Y.1731.

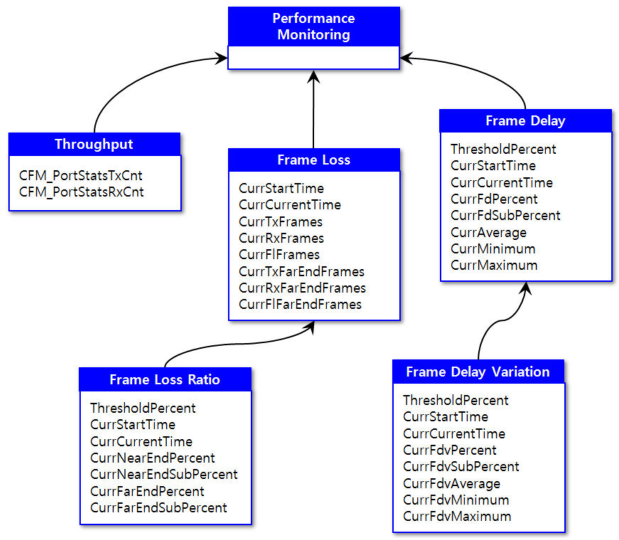

Fig. 11 Performance Monitoring UML Schema

4.3 Fault Management Schema

The fault management schema which is aimed to manage logic network faults has the following subordinate classes; Fault Verification, Power, Fault Notification, Fault Isolation and Fault Detection. Power Class includes Power Status Class which can analyze current power supply status and control the warning process and Warning Threshold Class. Fault Isolation Class has Linktrace Messages Class which can figure out network faults by analyzing LTM/LTR messages and Linktrace Relay Class. The Fig. 12 shows a complete view of the fault management schema. It consists of five super classes and four subordinate classes. Each class has been prepared based on the fault management technology which is defined in ITU-T Y.1731 and IEEE 802.1ag.

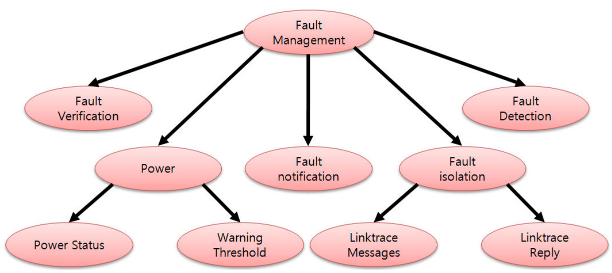

Fig. 12 Fault Management Schema

As a UML diagram of the fault management schema, it shows specific parameters which are used in the class. Each parameter has been defined using enterprise MIB information. The most important information in the management of logic network faults has been based on the

CFM and OAM definition in ITU-T Y.1731 and IEEE 802.1ag.

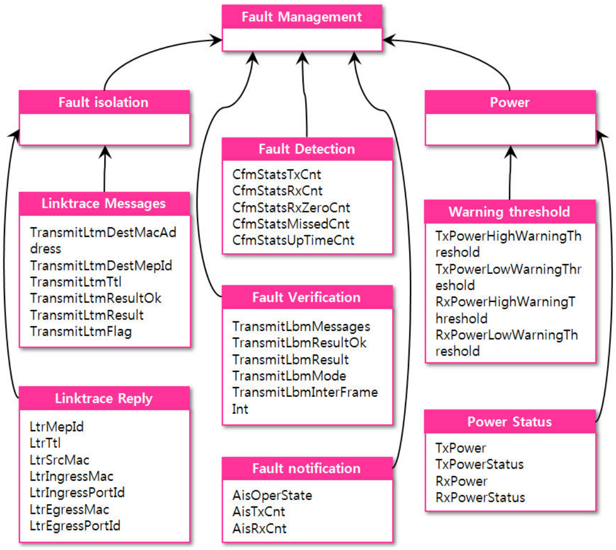

Fig. 13 Fault Management UML Schema

5. Development of Logical Network Management Framework

5.1 Construction of Logical Network

At present, MERS 8610 which has been used for logic network configuration has been installed in four sites across the nation. PBB-TE is operated through MERS equipment. To configure logic network, primary secondary trunks are connected to each node. Right now, it is operated in Seoul, Daejeon, Gwangju and Busan. In this paper, a framework has been established using the MERS 8610 installed in the said four spots.

5.2 Testbed

The logic network management framework system has been constructed using Linux-based net-snmp and PHP. The test bed for system construction is shown in Table 1.

Table 1: TEST BED

	Program
OS	CentOS 5.3
Apache	httpd-2.2.16
Mysql	mysql-5.1.50
PHP	php-5.3.3
Net-snmp	net-snmp-5.4.3

5.3 Database Design

5.3.1 Total Database

The logic network management framework established in this paper consists of three databases. As shown in Fig. 14, it is comprised of mers_info, OOO_topo and OOO_inter databases.

```
mysql> show tables;
+----------------+
| Tables_in_mers |
+----------------+
| BUS_inter      |
| BUS_topo       |
| DJN_inter      |
| DJN_topo       |
| GWJ_inter      |
| GWJ_topo       |
| SEL_inter      |
| SEL_topo       |
| mers_info      |
+----------------+
9 rows in set (0.01 sec)
```

Fig. 14 Database Items

5.3.2 MERS System Information Database

The database table which should be created first after the establishment of framework is mers_info. It contains MERS configuration, performance, fault management table names as well as basic information on MERS equipment.

```
mysql> desc mers_info;
+-------------+-------------+------+-----+---------+-------+
| Field       | Type        | Null | Key | Default | Extra |
+-------------+-------------+------+-----+---------+-------+
| ipAddr      | varchar(15) | NO   | PRI | NULL    |       |
| sysName     | text        | NO   |     | NULL    |       |
| sysDescr    | text        | YES  |     | NULL    |       |
| sysLocation | text        | YES  |     | NULL    |       |
| sysUpTime   | varchar(20) | YES  |     | NULL    |       |
| topoTable   | varchar(10) | NO   |     | NULL    |       |
| perfoTable  | varchar(10) | NO   |     | NULL    |       |
| faultTable  | varchar(10) | NO   |     | NULL    |       |
| interTable  | varchar(10) | NO   |     | NULL    |       |
+-------------+-------------+------+-----+---------+-------+
9 rows in set (0.00 sec)
```

Fig. 15 MERS Information Table

5.3.3 MERS Configuration Information Database

It is a database table in which logic network configuration information is stored. This table is automatically created when MERS equipment is added. It is automatically named in the form of 'OOO_topo.' For example, Fig.16 shows MERS equipment in Daejeon so that it is named 'DJN_topo.'

```
mysql> mysqlDJN_topo;
+--------------------+-------------+------+-----+---------+-------+
| Field              | Type        | Null | Key | Default | Extra |
+--------------------+-------------+------+-----+---------+-------+
| TrunkPort          | varchar(4)  | NO   |     | NULL    |       |
| TrunkMdName        | varchar(22) | YES  |     | NULL    |       |
| TrunkMaName        | varchar(22) | YES  |     | NULL    |       |
| TrunkSourceMac     | varchar(20) | YES  |     | NULL    |       |
| TrunkMac           | varchar(20) | NO   |     | NULL    |       |
| TrunkVlanid        | varchar(4)  | NO   | PRI | NULL    |       |
| TrunkReverseVlanid | varchar(4)  | YES  |     | NULL    |       |
| TrunkMepid         | varchar(2)  | YES  |     | NULL    |       |
| TrunkHoldTimer     | varchar(4)  | YES  |     | NULL    |       |
| TrunkOperStatus    | varchar(8)  | YES  |     | NULL    |       |
+--------------------+-------------+------+-----+---------+-------+
10 rows in set (0.00 sec)
```

Fig. 16 MERS Topology Table

5.3.4 MERS Interface Information Database

It is a database table in which MERS interface information is stored. It is also automatically created when MERS equipment is added just like topology table. It is automatically named in the form of 'OOO_inter.' For example; Fig.17 shows MERS equipment in Daejeon so that it is named 'DJN_inter.'

```
mysql> mysql> desc DJN_inter;
+-----------------+-------------+------+-----+---------+-------+
| Field           | Type        | Null | Key | Default | Extra |
+-----------------+-------------+------+-----+---------+-------+
| ifIndex         | varchar(4)  | NO   | PRI | NULL    |       |
| Descr           | text        | YES  |     | NULL    |       |
| Mtu             | int(11)     | YES  |     | NULL    |       |
| Speed           | bigint(20)  | YES  |     | NULL    |       |
| PhysAddress     | varchar(20) | YES  |     | NULL    |       |
| OperStatus      | varchar(10) | YES  |     | NULL    |       |
| InOctets        | bigint(20)  | YES  |     | NULL    |       |
| InUcastPkts     | bigint(20)  | YES  |     | NULL    |       |
| InNUcastPkts    | bigint(20)  | YES  |     | NULL    |       |
| InErrors        | bigint(20)  | YES  |     | NULL    |       |
| OutOctets       | bigint(20)  | YES  |     | NULL    |       |
| OutUcatPkts     | bigint(20)  | YES  |     | NULL    |       |
| OutNUcastPkts   | bigint(20)  | YES  |     | NULL    |       |
| OutErrors       | bigint(20)  | YES  |     | NULL    |       |
+-----------------+-------------+------+-----+---------+-------+
14 rows in set (0.01 sec)
```

Fig. 17 MERS Interface Table

5.4 Operation of Management Framework

5.4.1 MERS System Information

The basic information of MERS equipment can be viewed. Fig. 18 shows the information on MERS equipment in Seoul. The information which can be accessed with MERS such IPAddress, system name, system description, system location and system operating time is available.

MERS-SEL System Information

ipAddr : 134.75.250.12
sysName : MERS-SEL
sysDescr : MERS-8610co (6.0.1.10E)
sysLocation : 4655 Great America Parkway,Santa Clara,CA 95054
sysUpTime : 15:22:54:17.00

System Refresh

Fig. 18 MERS System Information

5.4.2 MERS Configuration Information

It is the most important part in management framework. The logic network in which MERS equipment is configured across the nation can be precisely understood. Fig. 19 shows MERS in Seoul. It can be understood at a sight that it consists of MERS equipment and trunk in Daejeon and Gwangju. In addition, MAC address, Vlan ID and port number which are essential in configuring PBB-TE can be checked.

MERS-SEL Topology Information

Trunk Port	Trunk MdName	Trunk MaName	TrunkSourceMac	TrunkDestMac	Trunk VlanId	Trunk ReVlanId
192	Trunks	DJN-SEL-P	00 24 43 97 73 DF	00 24 43 BE 83 DF	2001	2001
193	Trunks	DJN-SEL-S	00 24 43 97 73 DF	00 24 43 BE 83 DF	2002	2002
192	Trunks	SEL-GWJ-P	00 24 43 97 73 DF	00 25 C3 D3 C3 DF	2009	2009
193	Trunks	SEL-GWJ-S	00 24 43 97 73 DF	00 25 C3 D3 C3 DF	2010	2010

Fig. 19 MERS Topology Information

5.4.3 MERS Interface Information

Fig. 20 reveals the interface information of MERS equipment. As L2 switch equipment, MERS equipment has several interfaces. It includes MAC address per interface, MTU size, current operating status and port number which is essential in configurating a logic network.

MERS-SEL Interface Information

ifIndex	Descr	Mtu	Speed	PhysAddress	OperStatus	InOctets	InUca
64	1000Gbic850Sx Port 1/1 Name	1950	1000000000	0:24:43:97:70:0	up	22119063	20
65	1000Gbic850Sx Port 1/2 Name	1950	1000000000	0:24:43:97:70:1	up	6424	
66	1000Gbic Port 1/3 Name	1950	1000000000	0:24:43:97:70:2	up	942171299	38158
67	1000Gbic Port 1/4 Name	1950	1000000000	0:24:43:97:70:3	up	2524115896	7491
68	1000Gbic Port 1/5 Name	1950	0	0:24:43:97:70:4	down	0	
69	1000Gbic Port 1/6 Name	1950	0	0:24:43:97:70:5	down	0	
70	1000Gbic Port 1/7 Name	1950	0	0:24:43:97:70:6	down	0	
71	1000Gbic Port 1/8 Name	1950	0	0:24:43:97:70:7	down	0	
72	1000Gbic Port 1/9 Name	1950	0	0:24:43:97:70:8	down	0	
73	1000Gbic Port 1/10 Name	1950	0	0:24:43:97:70:9	down	0	

Fig. 20 MERS Interface Information

6. Conclusion

This paper has investigated a framework in which a logic network is described and managed by particular application based on science & technology research network resource specification. As a result, a schema through which topology, performance and fault information can be systematically managed in accordance with international standards has been completed. In addition, database has been created based on the schema which has been designed in accordance with international standards, and a network management framework through

which a logic network can be managed has been built. Then, information has been brought from the current Carrier Ethernet equipment and provided to an administrator.
However, a further study needs to be conducted on the construction of a management framework which can reveal topology, performance and fault information in a more dynamic manner using the collected information. Even though the current management framework shows the configuration of a logic network in a static manner using a table, the network could be operated more effectively once a management framework just like a weather map is built.

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