Technology to Operate and Maintain Transport System for Handling Spikes and Variations in Traffic

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The amount of mobile data traffic around the world has been growing rapidly in recent years. This is due, in part, to the increasing number of mobile devices such as smartphones or tablets. Such devices allow the user to access various types of image data, streamed content or anything in the cloud, and they account for much more data traffic than ever before. This tendency is also seen in Japan, where the resources that are available currently fluctuate depending on the demand of traffic, and they are forecast to be depleted especially in urban areas in the immediate future. In this paper, first we review Japan's current network technologies and examine the problems that they have. Then, we present Fujitsu's new technology which will be key to solving those problems. Next, we consider what will happen when this new technology is applied, including some new problems that will arise when operating networks. Last, we refer to Automatically Switched Optical Network (ASON), a concept that various parties are discussing with a view to making it internationally standardized, and depict future networks.

1. Introduction

Recently, the amount of traffic in transmission networks has been showing significant variations depending on the time and location. Causes of this phenomenon include the generation of traffic from unspecified locations of mobile devices such as smartphones and tablets and the increase in the number of customers who transfer large volumes of data within specified periods when they transfer backup data and files due to the increased number of cloud centers. The present transmission networks are unable to adequately handle the variations and increases in traffic volumes and the realization of a new network with flexibility is a challenge. Meanwhile, Automatically Switched Optical Network (ASON) is an internationally standardized technology as a transmission scheme that provides wideband paths according to the network traffic demands. However, this scheme autonomously sets up transmission network paths in response to requests from end users, which is different from the current network operation and maintenance implemented by network service providers, and some problems with this scheme have been pointed out.

This paper describes the current conditions of transmission networks in Japan and presents recommendations for the realization of a new transmission network, trends of standardization of ASON operation and future prospects.

2. Present conditions of transmission networks

The increase in the number of network users along with the rapid diffusion of smartphones and tablets is causing the volumes of communication traffic, mainly including images and videos, to rapidly and dynamically increase. Its impact is beginning to show in the fluctuation of demand for transmission network resources especially in urban areas. This section describes the configuration of transmission networks in the present conditions (**Figure 1**).

Characteristically, they have a multi-tiered (layered) configuration as explained below.

1) Layer 0 (L0)

Uses wavelength division multiplexing (WDM) technologies including dense wavelength division multiplexers (DWDMs), which constitute core networks

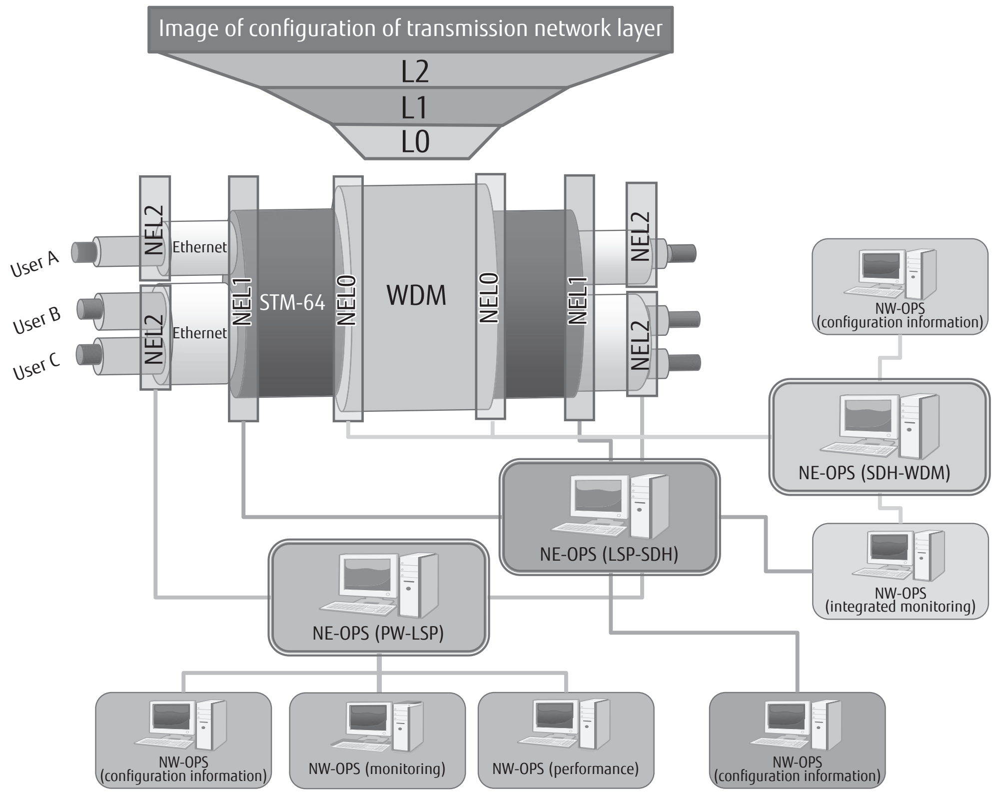

Figure 1
Transmission network configuration (present).

(networks connecting between cities), and optical add-drop multiplexers (OADMs), which constitute metro networks (networks constituting metropolitan areas).

2) Layer 1 (L1)

Uses synchronous digital hierarchy (SDH) technologies including time division multiplexing SDH devices on the premise of telephone services.

3) Layer 2 (L2)

Uses Ethernet technologies including L2 devices that multiplex and transmit Ether signals.

Operation and maintenance of these transmission networks are carried out by Network Element-Operation Systems (NE-OPSs) and Network-Operation Systems (NW-OPSs) that manage devices and network information for the respective subnetworks on each layer. The layered configuration allows complicated and diverse services to be accommodated such as leased line, telephone and Internet services.

Transmission networks are constituted by devices including L0 WDMs (NEL0), L1 SDH devices (NEL1) and L2 multiplex switches (NEL2), and NE-OPSs and NW-OPSs as their respective operation systems. Operation and maintenance (management plane) for monitoring and control for each layer according to the network characteristics is established and the systems are independent between the individual layers.

For this reason, the existing layer-specific configuration is considered to be unfit for flexibly handling the fluctuation in demand for transmission network resources. The following section describes a new transmission network and new operation.

3. New transmission network

Our basic concept for the new transmission network is to make it optical and fully IP-based. It will allow the construction of a system capable of changing the network configuration according to user demands and usage conditions and an effective transmission system by integrating layers, which we believe will help reduce operational expenditure (OPEX) and capital expenditure (CAPEX).

There are two major goals:

1) Flexible network configuration

For a network that integrates layers, a flexible system architecture is constructed in which the reconfigurable optical add-drop multiplexer (ROADM)/optical cross-connect (OXC) function in L0 function block or carrier-grade packet transport function in L2 function block can be freely selected according to the required transmission capacity and transport function.

2) Saving of space and energy

Saving of space and energy of the devices and operation systems for the respective layers is realized by integrating layers. Integrating the transport function of layers, which was implemented with multiple NEs, with one NE opens up the possibility of integrating packages between layers and reducing inter-layer connection, which raises expectations for saving space and energy by streamlining the NEs themselves.

In order to accomplish these goals, the following new technologies are being introduced into the network.

1) WDM capacity increase

To meet the bandwidth demand that has continued to grow in recent core networks, capacity increase and multi-wavelength operation of the ROADM/OXC in L0 function block are in process. In addition, multi-degree technology is being established for core networks so as to build flexible mesh networks.

2) WDM flexibility improvement

Use of optical multiplex/demultiplex technology with the colorless and directionless features instead of the existing optical multiplex/demultiplex technology allows the wavelength and route to be freely switched without modifying the optical wiring. To switch the wavelength or route, control can be provided from the operation system without affecting the transmission quality of the existing optical paths and, in the event of failure, the operation system can switch remotely and promptly to a relief route that has been prepared in advance.

3) WDM and packet integration

An inter-layer integration function is provided in which the packet transport function in L2 function block terminates the optical signals from the ROADM/OXC function in L0 function block and distributes them in the packet transport function in L2 function block as Multi-Protocol Label Switching Transport Profile (MPLS-TP) packet signals. This eliminates the need for a package equipped with a transponder function, which was required for connecting to the network with the packet transport function in L2 function block, in the ROADM/OXC function in L0 function block. This is attracting attention also from the perspective of reducing CAPEX.

4) Transparent transmission by packets

Handling of dynamic traffic is difficult with the conventional L1 transmission networks based on SDH technologies. Meanwhile the packet transport technology facilitates Quality of Service (QoS) guarantee transmission that is transparent (with guaranteed transparency).

The packet transport function in L2 function block allows large-volume traffic to be efficiently transmitted by using the MPLS-TP system that builds transparent transmission by packets. The key functions of MPLS-TP include:

- Efficient accommodation of traffic by statistical multiplexing
- Connection-oriented relay transmission
- Carrier-grade operations, administration and maintenance (OAM)/protection function

This new transmission network requires new technologies for the management plane of the network as well. **Figure 2** shows the configuration of a future transmission network. Devices are integrated across L0 and L2 and a tunnel LSP by MPLS-TP is implemented to realize the L1 function in L2. Along with the integration of the devices, the NE-OPS for network operation also integrates L0 and L2. As possible future improvements, we think that there is a need to change the configuration of the management plane for technologies other than new network technologies. In addition, having operation systems for the respective network layers causes the system to be complicated and massive, which means that integration is necessary mainly for monitoring network faults and quality.

We believe that the new transmission network helps make operations efficient by integrating layers. However, introducing new technologies by integration accompanied by a significant change in operation may, on the contrary, cause confusion for the network operator, possibly leading to increased burdens or higher operation costs due to redundancy with the existing system. Accordingly, an operation system is called for that supports new technologies without requiring any

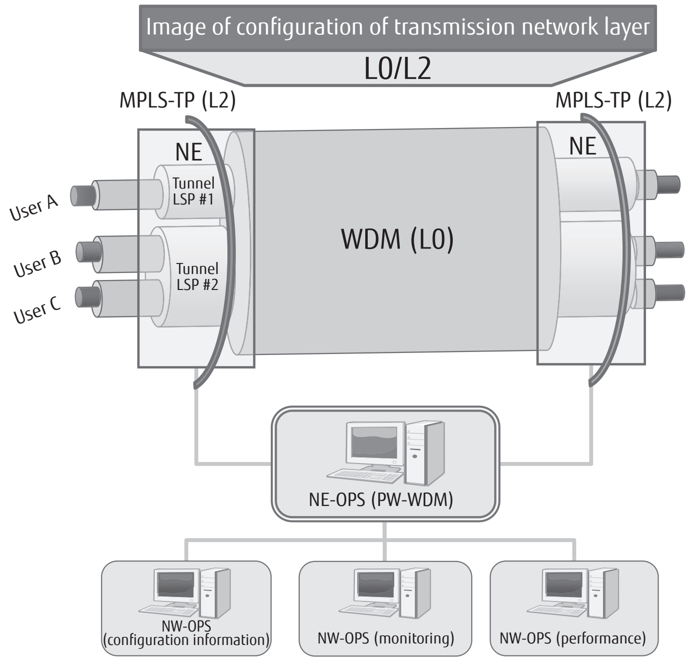

Figure 2
Future transmission network configuration.

significant change in operability.

4. Approaches to network operation and maintenance

An NE-OPS system with integrated layers requires an operation system equipped with functions that are not provided by the existing system. To provide some of the operability of an NW-OPS together with the operability of an NE-OPS, we are taking the following approaches.

4.1 Layer-integrated indication/operation

Multiple layers for optical and packet networks are indicated in a graphic and, as shown in **Figure 3**, alarms generated across the layers are analyzed so as to differentiate between cause and repercussion alarms and correctly identify the failure location. Associating the paths, which were managed for the respective layers, in terms of path accommodation between layers allows the extent of impact on the paths to be promptly identified. In this way, the realization of the inter-layer integration function is raising expectations for a significant reduction in OPEX by having flexible network operation.

4.2 Reduction of NE-OPS machines

Integration is considered to bring a similar effect to an operation system for NE monitoring and control. Changing from the conventional configuration, which has separate operation systems for the respective layers, to a configuration that provides integrated monitoring of all layers with one operation system is expected to save space and energy for the entire operation system.

In addition, there is a growing need in relation to integration with an operation system that monitors and controls legacy devices. We expect the approach to realizing different operation systems coexisting on one server by utilizing virtualization technology will become more popular in the future.

1) Handling of diverse system configurations

With the existing NE-OPSs, visual system configurations are provided by using network diagrams with sections (physical connections) between NEs graphically represented. The new transmission network, however, also covers systems that are too complicated to be graphically represented and configurations are represented in two styles: network diagrams and lists.

2) Scale-up

The number of NEs monitored by an existing

NE-OPS was up to about 1000. With the new NE-OPS, the NW management block that manages subnetworks and the NE management blocks that manage NEs are separated as shown in **Figure 4**. The system is extended to increase the number of NEs to be monitored by each NE management block to be in the thousands, which means that the system is capable of monitoring up to 10 000 NEs.

3) Improvement of maintainability

Because of the increased complexity of the

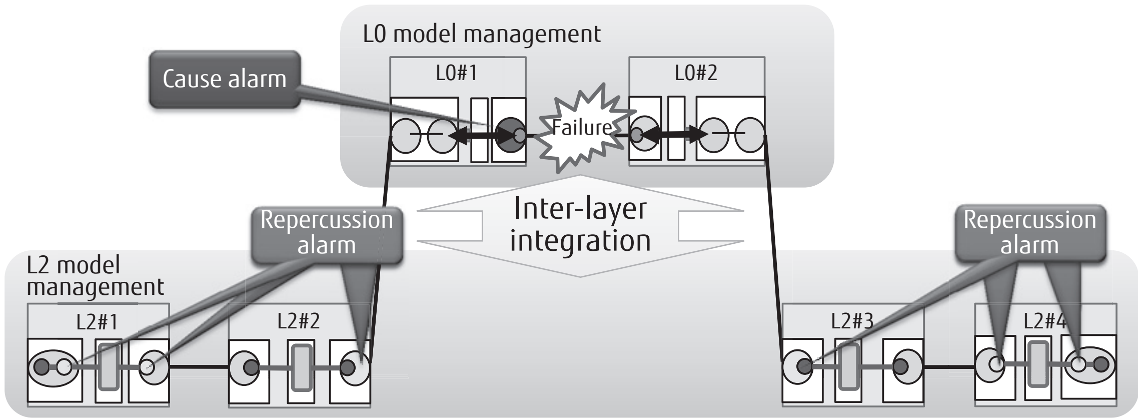

Figure 3
Inter-layer integration (association of cause and repercussion alarms).

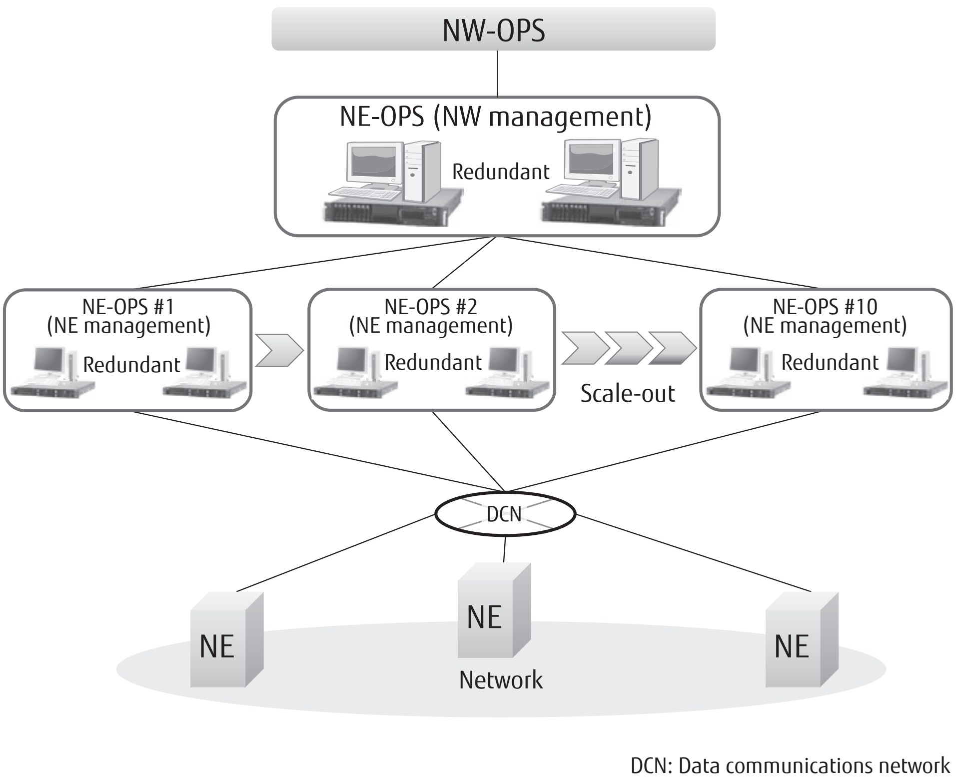

Figure 4
System configuration of layer-integrated NE-OPS.

transmission network, more time and effort is necessary to investigate the cause and impact of any failure generated. A function is provided in which information on logical connections and on physical device configurations is retrieved from the information about accommodation between layers and path information for carrying out fault assessment.

4) Provision of NW-OPS interfaces

The following interfaces for NW-OPSs allow application to various customer operation systems.

- Notification interface
  a) Monitoring system (failure and operation status notification)
  b) Performance system (maintenance and service integration)
- Information import interface
  a) Configuration information system (information about the configuration of devices, etc.)
  b) Control system (setting and maintenance operations)

Functions compatible with the new transmission network are provided while the advantages of the existing NE-OPSs are inherited.

5. ASON configuration

ASON, a concept of flexible transmission network, was approved as a recommendation by ITU-T in 2001 and is realized by a configuration with the MP, CP and TP as described below.

1) MP (Management Plane)

Equipped with the resource management, monitoring and setting functions for ASON operation and shares some functions with the CP.

2) CP (Control Plane)

Has the function of collecting the configuration information of ASON and path-setting signaling control in response to a user request.

3) TP (Transport Plane)

Has the function of encapsulating data from an end user, transporting it and switching along the path route.

While the network resource information is shared and managed by the MP and CP, the CP is capable of signaling control in response to a data transfer request from a customer and autonomous path setting to an arbitrary point. **Figure 5** shows the ASON architecture.

6. Problems with ASON operation and trends in standardization

Conventionally, after a path-setting request from a user was issued to the network service provider, the service provider made the setting with the network to realize the path desired by the user. With ASON, a user directly requests the network for path setting and the network autonomously realizes the path. This is different from the conventional operation and poses an

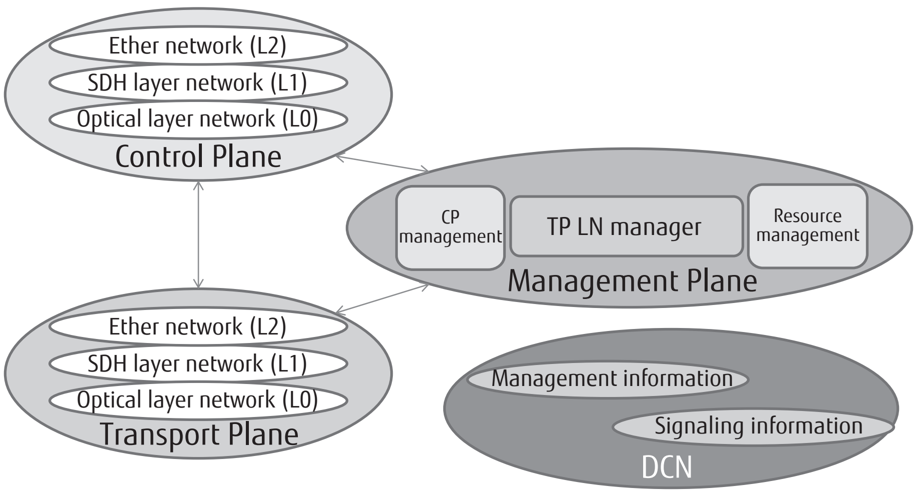

Figure 5
ASON architecture.

issue of how to implement and manage the autonomous operation.

There are recommendations in relation to ASON operation:

1) Architecture for the automatically switched Optical networks (ITU-T G.8080)[1)]

Provides for the roles of the MP, CP and TP.

Network resource information is shared by the CP and MP but the global resources such as reserved resources are managed by the MP. In addition, the CP is responsible for path connection setting and fault and quality detection but notification to the MP is required.

2) Architecture of control plane operation (ITU-T G.7716)[2)]

Provides for an outline of the introduction of ASON.

Describes the introduction planning, platform, and functions and operation of the respective elements of ASON and the details of the roles of the MP, CP and TP prescribed by G.8080.

3) Framework for ASON management (ITU-T G.7718)[3)]

Defines the ASON management models.

It describes autonomous operation and the need for no interrelated influence of the MP, CP and TP. It also prescribes that the region of resources that allows dynamic path setting is available to the CP but paths set in a fixed manner are under the management of the MP. The examples presented include:

- CP across multiple domains (multiple carriers)
- Element Management System (EMS)
- Network Management System (NMS)
- Connection between an existing network and ASON

The first version of 1) above was issued in 2001 and 2) on operation in 2010. While the first version of 3) was issued in 2005, full-fledged discussion began only recently. Operation of the CP is being discussed also by the Optical Interworking Forum (OIF).[4)]

None of the recommendations and reports clarifies all of the problems with operation. The point is how to have the conventional operation coexist with the ASON operation, and it must be possible to search and grasp the usage state and history of resources together with operation of the existing networks. In relation to this, we made proposals in the past.[5)] A system where there is coexistence with regards to resource management of the existing and autonomous networks is expected to be studied.

7. Conclusion

For traditional transmission networks, the volume of flowing traffic was predictable to some extent but the rapid increase in IP traffic in recent years has created demand for a new transmission network that tolerates variations in the amount of traffic. Operation and maintenance systems must also be capable of supporting the new network.

Fujitsu intends to continue studying new network operation while inheriting the stable and safe systems, which are key features of transmission networks.

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