Operations Systems for Type-X and the MPLS Network

Kenichi Oshikiri, Yasushi Honma, Toshio Oimatsu†*, and Toshihiro Nishizono*

Abstract

One of the keys to maintaining a carrier-class multiprotocol label switching (MPLS) network system is an operations system for designing and managing highly reliable large-scale MPLS paths and achieving a managed network. This article describes the operations system (X-OSS) developed to achieve this goal.

1. X-OSS system architecture

The Type-X operations support system (X-OSS) monitors and controls Type-X routers and manages network resources to design the multiprotocol label switching (MPLS) network paths, i.e., label switched paths (LSPs), and establish them in Type-X. Design and management by X-OSS ensures a flexible MPLS path network to satisfy high quality and reliability. This X-OSS consists of the four systems shown in Fig. 1.

1) The Type-X element management system (X-EMS) manages (i.e., monitors and controls) the Type-X routers and supervises network topology data (the connection between router interfaces). It also establishes the MPLS paths (LSPs) accord-

† NTT Network Service Systems Laboratories
Musashino-shi, 180-8585 Japan
E-mail: oimatsu.toshio@lab.ntt.co.jp

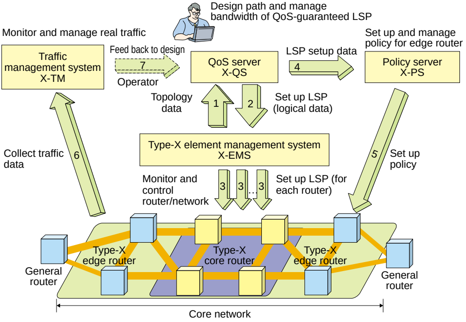


Fig. 1. Entire X-OSS architecture and MPLS management flow.

ing to the end-to-end logical LSPs setup requests from X-QS.

2) The quality of service server (X-QS) system assigns, sets up, and manages the routes and bandwidth of LSPs in the core network based on the network topology data managed by X-EMS.
3) The policy server system (X-PS) sets up and manages policy information in the edge-router based upon LSPs designed by X-QS.
4) The traffic management system (X-TM) collects and manages actual traffic data from each line interface and each LSP. This traffic data enables operators to compare predicted bandwidth with actual traffic volumes and feed the results back in order to redesign the line and LSP bandwidths.

2. X-EMS

2.1 X-EMS equipment management function

The Type-X-dedicated equipment management functions are added to the OpenView™ IP network management function, allowing the Type-X router to be controlled easily through a graphical user interface (GUI) (Fig. 2). Features include an alarm display, a fault display in each router, and equipment management based on mounted devices.

2.2 X-EMS MPLS management function

(1) Topology management and LSP setup

X-EMS provides X-QS with the network topology data used for IP network management. It also translates logical LSP setup requests from X-QS into actual requests that set up LSPs to each router. It also collates the LSP identifier (equivalent to the MPLS label value) of each router with the logical LSP identifier of the entire network designated by X-QS, so that differences in the way LSPs are set up among various kinds of routers can be masked.

(2) Faulty LSP group management

X-EMS can also manage the status of each LSP by combining LSP setup data with its monitoring function. X-OSS sets two or more LSPs that take the same route in a Type-X router as one LSP group, and when a fault occurs in a certain LSP group, the Type-X router automatically switches to the secondary LSP group. The LSP group list is displayed on the screen, so an operator can easily identify the fault status (normal or faulty) of the relevant LSP group, along with the type (primary or secondary) of the route currently in use. After the system has recovered from the fault, the LSPs that have been switched to the standby routes can be safely switched back while the status of each LSP in the relevant group is monitored (Fig. 2).

3. X-PS/QS

3.1 Basic functions

The X-QS system designs LSPs according to each QoS class (expedited or assured forwarding: EF/AF). This system manages network resources such as network topology data and link bandwidth under each QoS class, and the queue buffer size in a router; this enables the design and setup of the optimum MPLS path (LSP) based on user-defined destination, band-

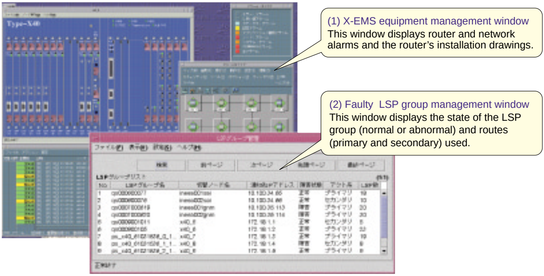


Fig. 2. Examples of X-EMS windows.

width, QoS class (EF/AF), and objective functions (e.g., design requirements such as the minimum number of hops and minimum delay).

On the other hand, user traffic in LSPs must be regulated to ensure congestion-free, stable data transfer. To meet this requirement, X-PS compares the bandwidth of LSPs with that of individual user traffic to determine whether user traffic can be transferred via certain LSPs or not. It also manages and sets up this user traffic and LSP-mapping information or policy information (Fig. 3).

3.2 QoS management

The X-QS is extended to manage the queue buffer in a router, whereas a general design system manages only link bandwidth between routers as a network resource. IP packets are actually discarded or delayed when traffic on a specific line card (LINF: Line Interface) in the router is congested. Queue management in the router, therefore, is essential for tight QoS control. Figure 4 shows the way to manage an internal router to meet this tight requirement. X-QS calculates and assigns the size of the queue buffer for the router output and the weight of each buffer based on the router hardware configuration, the status of mounted devices, and the requirements for each QoS class in order not to discard any data packets. This method guarantees tight QoS.

3.3 Highly reliable LSP configuration

X-QS can design three types of LSPs, as shown in Fig. 6 on page 51 to handle network faults.

(1) Primary LSP: active LSP in normal condition

(2) Secondary LSP: a backup to a primary LSP if the primary LSP fails. This LSP has a different route at the same ingress/egress of the primary LSP.

(3) Sub-gate LSP: standby LSP ready for an ingress/egress router of the primary/secondary LSP or access network fault. This LSP has a different route and different ingress/egress from the primary LSP.

Combining these three types of LSP makes it possible to select various types of redundancy.

Fig. 3. Examples of X-PS/QS windows.

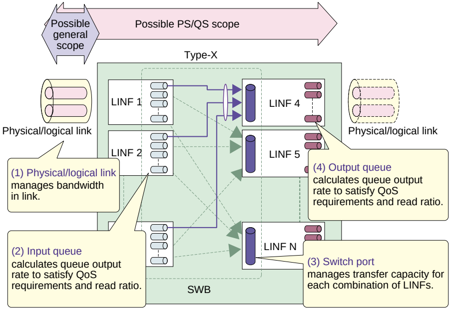


Fig. 4. QoS management coverage.

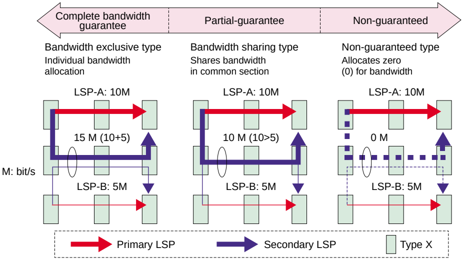


Fig. 5. Standby LSP bandwidth management method.

3.4 Efficient design of standby LSP bandwidth

The standby LSPs use the following three bandwidth management methods (Fig. 5):

(1) Bandwidth exclusive type (1:1): The bandwidth of the primary LSP is guaranteed in the standby LSP.

(2) Bandwidth sharing type (N:1): A standby LSP's bandwidth is shared with other standby LSPs.

(3) Non-guaranteed type: A standby LSP's bandwidth is not guaranteed (zero allocation).

Although the bandwidth exclusive type needs the largest bandwidth, it can virtually provide leased circuit services. Conversely, the non-guaranteed type, which is a best-effort-type transfer service, needs zero bandwidth for the standby LSPs.

Combining these bandwidth management methods with the standby LSP configuration in (3) of 3.3 achieves a wide range of reliable LSPs according to quality and economic requirements.

3.5 Highly reliable design management

Discrepancies between the data of designed LSPs in X-PS/QS and that of LSPs set in the actual router could cause network mismanagement. Therefore, a highly reliable audit function is implemented to collate this data.

3.6 Efficient design of large-scale LSPs

Designing and setting data for a large number of LSPs individually using the GUI needs a tremendous amount of effort. To reduce the effort of designing large-scale networks, X-PS/QS has functions for importing large amounts of LSP data from text files.

4. X-TM

4.1 Basic functions

X-TM is the IP/MPLS network traffic data collection system based upon InfoVista™. It can collect traffic data from not only Type-X series routers but also other commercially available ones. The platform customization functions allow users to create and add user-defined traffic items, spreadsheets, graphics layout design, reports, statistical forms, and so forth. In addition, a standard report (Fig. 6) and standard form (Fig. 7) are prepared in advance to support the management of a carrier-class large-scale network.

4.2 Line traffic data collection

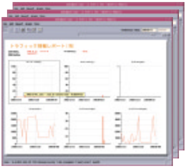
X-TM has forms for reporting traffic data, identifiers of lines that exceed a traffic threshold, and the top 10 band usage rates. It can display this data graphically in real time. In addition, the daily, weekly, and monthly data displays also provide easy identification of short-, medium-, and long-term traffic characteristics. Some forms are explained below.

(1) Top 10 form

This form lists the top 10 band usage rates at thousands of observation points, helping users to understand the trend of network traffic and find potential network congestion effectively.

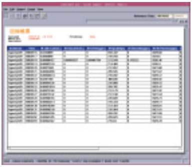
(2) Excess line threshold form

This form indicates the number of discarded and errored packets, exceeding the preset threshold in each line (at each collection point), facilitating a speedy response to user feedback and fault prevention.



Report shows trend.

Fig. 6. Example of standard X-TM report.



Cross-sectional compilation and statistical analysis to collect results for a form listing the top 10 lines with highest line utilization rate, for example.

Fig. 7. Example of standard X-TM form.

4.3 Traffic data collection in each LSP

Like traffic data collection in each line, X-TM can collect traffic data of each LSP from Type-X routers and display it graphically (violation of committed rate, violation of peak rate, etc). This enables users to recognize the real traffic status of the designed LSP bandwidth and helps them to optimize the LSP design (i.e., by bandwidth re-allocation).

5. Experience to date and future plans

X-OSS has been used in an operating company since fiscal 2001. It has already designed and managed thousands of LSPs, and is continuing to design and manage a growing number of LSPs. Based on its operational results, we are planning to enhance X-OSS and support other commercially available routers as a multi-vendor carrier-grade MPLS path design system.

Kenichi Oshikiri
Engineer, First Promotion Project, NTT Network Service Systems Laboratories.
He graduated from the Nippon Engineering College, Tokyo. He joined NTT in 1992. Initially, he worked on maintenance operations of transmission systems. He is currently engaged in developing IP network operation support systems.

Yasushi Honma
Engineer, Network Management Development Project, NTT Network Service Systems Laboratories.
He graduated from the department of electrical engineering of Tokyo Metropolitan College of Technology, Tokyo, in 1994. Since joining the Network Service Systems Laboratories, NTT, Tokyo, Japan in 1998, he has been involved in research and development of ATM network operation support systems. He is currently developing IP network operation support systems.

Toshio Oimatsu
Senior Research Engineer, Network Management Development Project, NTT Network Service Systems Laboratories.
He received the B.S. and M.S. degrees in electronic engineering from Toyama University, Toyama, in 1983, and 1985, respectively. Since joining the Electrical Communication Laboratories, NTT, Tokyo, Japan, he has been involved in research and development of STM/ATM network operation support systems. He is currently developing IP network operation support systems. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan.

Toshihiro Nishizono
Senior Research Engineer, Supervisor, Network Software Service Project, NTT Network Service Systems Laboratories.
He received the B.S., M.S., and Ph.D. degrees in information engineering from Kyushu University, Fukuoka, in 1978, 1980, and 1990, respectively. In 1980, he joined the Electrical Communication Laboratories, Nippon Telegraph and Telephone Public Corporation (now NTT), Tokyo, Japan. He worked on the development of DDX packet switching systems and ATM switching systems. From 1990 to 1993, he worked in Advanced Telecommunication Research Laboratories, Kyoto, Japan, on software specifications and distributed operating systems. From 1998 to 2001, he was engaged in international communication service deployment and IP service development in NTT Communications Corporation, Tokyo, Japan. He is currently working on IP control and management service research.