Ethernet Access Switch for Carrier Ethernet That Contributes to Operation Expenditure Reduction

Junichi MICHIMATA*, Hisashi KATAYAMA, Kunihiko NAKAMURA, Toru INOUE, Akinobu YOSHIMURA, and Hiroyuki TAKAHASHI

Sumitomo Electric Industries, Ltd. has developed an Ethernet access switch for Carrier Ethernet that contributes to the reduction of operation expenditures. We have integrated functions of a fiber optic media converter and a layer-2 aggregator into one Ethernet access switch. This has enabled a power- and space-saving solution compared with conventional device sets. The switch features hitless firmware upgrades, zero touch provisioning, NETCONF, alarm notifications and line test capabilities. At the end of the paper, we report on the experimental results of Streaming Telemetry.

Keywords: Carrier Ethernet, 100G Ethernet, zero-touch provisioning, NETCONF, Streaming Telemetry

1. Introduction

The total download traffic of broadband service in Japan has been increasing year by year, and the increase rate in 2019 is predicted to be around 20% over the previous year.[1] Passive optical network (PON) systems, which use optical fibers capable of transmitting and receiving a large amount of data, are widely used for residential services. The systems allow two or more subscribers to share a single optical fiber in order to efficiently deliver broadband services. Sumitomo Electric Industries, Ltd. developed and commercialized GE-PON (1 Gbps max.) in 2005 and 10G-EPON (10 Gbps max.) in 2011.[2]-[4]

Meanwhile, when companies and public offices use a communication service, most of them subscribe to a Carrier Ethernet service instead of PON systems. This service provides each subscriber with one-to-one connections that do not share an optical fiber in order to assure the reliability of communications. Sumitomo Electric has newly developed FSU8100 series Ethernet access switches that enable Carrier Ethernet service. This paper describes an overall picture of the access switches.

2. Overview and Features of FSU8100

2-1 Overview

Each of the FSU8100 series access switches is composed of a central office switch that is installed at the central office building of a telecommunications carrier and customer-premises equipment (CPE) that are located at customers' premises. The central office switch and CPE are used by connecting them via optical fibers with a maximum length of 80 km (see Fig. 1).

There are three types of CPE (FTE8011, FTE8023, FTE8032) available depending on communication speed. Their access network interface (ANI) speeds for connection to a central office switch via an optical fiber and user-network interface (UNI) speeds for connection to a service subscriber-side device are 100 Mbps, 1 Gbps, and 10 Gbps, respectively. These CPE support a maximum of 256 virtual LANs (VLANs) and also enable line monitoring and line testing for each VLAN (see Table 1).

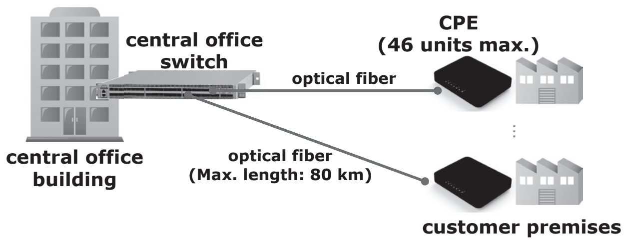

Fig. 1. Network structure of FSU8100

Table 1. Principal specifications of CPE

Item		Specification		
Product type		FTE8011	FTE8023	FTE8032
Max. service speed		100 Mbps	1 Gbps	10 Gbps
ANI	Quantity	1		
	Shape	SFP		SFP+
UNI	Quantity	1	2*	1
	Shape	RJ45	RJ45/SFP	SFP+
VLAN	Quantity	256 units max.		
Line monitoring		featured		
Line test		featured		
Outside dimensions		210 mm (width) × 164 mm (depth) × 32 mm (height)		
Power supply		100 VAC (use of power supply adapter)		

*: Either one of two ports can be used.

There are two types of central office switches, FSU8120 and FSU8130, available depending on the type of CPE to be connected. The former is compatible with the FTE8011 and FTE8023, while the latter is additionally compatible with the FTE8032. The central office switches have 46 access network interface (ANI) ports for connection to CPE and have 4 network-network interface (NNI) ports for connection to the upper side network. The FSU8120 supports communication speeds of 1 Gbps and 10 Gbps, while FSU8130 supports 100 Gbps for NNI ports. Each central office switch supports a maximum of 4,096 VLANs and can push/pop or swap VLAN tags. They are also provided with zero-touch provisioning, power-off notification, and UNI link failure notification capabilities as CPE management functions, together with command line interface (CLI), simple network management protocol (SNMP), and network configuration protocol (NETCONF) capabilities as maintenance management tools (see Table 2).

Table 2. Principal specifications of central office switch

Item		Specification	
Product type		FSU8120	FSU8130
CPE that can be connected	FTE8011	✓	✓
	FTE8023	✓	✓
	FTE8032		✓
ANI	Quantity	46	
	Shape	SFP	SFP/SFP+
NNI	Quantity	4 (= LAG × 2 pairs)	
	Shape	SFP/SFP+	QSFP28
	Transmission speed	1Gbps/10Gbps	100 Gbps
Management port		100/1000BASE-T × 1 Console port × 1	
VLAN	Quantity	4,096 units/central office switch (256 units/ANI)	
	VLAN tag manipulation	no operation, push/pop, swap	
Bridge mode		Media converter mode, aggregation mode	
Link redundancy		LACP and static	
Zero-touch provisioning		Featured	
Power off notification of CPE		Featured	
UNI link failure notification		Featured	
Maintenance management		CLI, SNMP, NETCONF	
Outside dimensions		1 RU (height) × 424 mm (width) × 520 mm (depth)	
Power supply		−48 VDC, 100 VAC (redundant)	

2-2 Features

(1) Power and space saving

A Carrier Ethernet service is usually configured by using media converters in the access network and integrating two or more media converters into a host device by a L2 switch in the central office building. The problem with this configuration is that it is necessary to combine two kinds of devices at the central office building and this increases power consumption and device installation space. Some telecommunications carriers rent a space in the central office building of an outside provider to provide communication services. The development of a power and space saving device contributes to a reduction in the operation cost of these carriers. Provided with a function to integrate media converters and a L2 switch, Sumitomo Electric's FSU8100 series central office switches consume less power and reduce the device installation space to one-fifth or less than that of the conventional configuration (see Fig. 2).

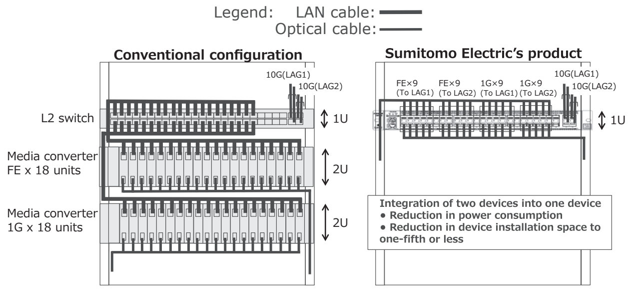

Fig. 2. Comparison between conventional configuration and FSU8100

(2) Hitless firmware upgrades

Carrier Ethernet services support the base of service subscribers' business by configuring their internal intranet system. When a communication service breaks down, even for a short period of time, the telecommunications carrier is required to perform various tasks, such as notification of the failure to the service subscriber, adjustment of the upgrade date and time and correspondence at night. These tasks result in an increase in operation cost. To make the carrier free from such tasks, Sumitomo Electric's central office switches, which exchange communications of a large number of service subscribers, support a hitless firmware upgrade that enables upgrading firmware without interrupting the communications of subscribers.

3. Reduction of Operation Management Workload

In Japan, the labor shortage in association with a decline in the productive population has become a serious issue even in the field of communication facility operation management. Saving labor necessary for opening a communication line and automating service operation management are critical for telecommunication carriers. Furthermore, carriers are facing a growing user need for more economical and stable communication services. To meet this demand, it is crucial for carriers to facilitate the detection and location of failures. As the tools for solving these problems, the FSU8100 is provided with zero-touch provisioning capability that helps reduce a communication line opening work, NETCONF capability that helps automate service operation management, and alarm notification and line monitoring capabilities that help automate service operations in the event of communication failures (see Table 3).

Table 3. Customers' problems with service operation management and their solutions

Problem and need	Solution by FSU8100
Saving of a communication line opening work	Zero-touch provisioning
Automation of service operation management	NETCONF
Detection of failure	Alarm notification
Locating failure point	Line monitoring

3-1 Zero-touch provisioning

The FSU8100 is provided with zero-touch provisioning capability which operates the CPE according to the parameters preset in the central office switch when these devices are connected to each other. As part of a Carrier Ethernet service communication line opening work, a telecommunication carrier installs a CPE at the customer's premises. Conventionally, the field worker is required to install the CPE while communicating over the phone with the operator staying at the operation center. Zero-touch provisioning eliminates the need for communication with the operator and automatically configures the CPE. The only work left for the field worker is to connect the optical fiber connected to the central office switch to the CPE. Thus, zero-touch provisioning makes it possible to reduce field workers' and operators' work, save CPE installation time, and reflect the contract contents in each device at once.

A control management protocol between a central office switch and CPE is used to realize zero-touch provisioning. When the central office switch detects that the CPE has been connected, the former sends a preset parameter to the latter. The latter performs a series of operations to configure itself according to the parameter.

3-2 NETCONF

NETCONF is a protocol that is used to acquire the status information and configuration of a device, thereby operating and managing a large number of devices supplied by different vendors under a unified standard. The main feature of NETCONF is transaction management in device configuration. In addition to setting two or more pieces of configuration information to a device at once, all the information can be automatically rolled back (recovered) if any one of the settings fails. Thanks to these features, NETCONF is very effective to automate service operation management.

The NETCONF protocol implemented in the FSU8100 makes it possible to automate service operation management.

3-3 Alarm notification

Some media converters used for conventional configurations cannot detect failures of the device. In contrast, the FSU8100 has been designed so as to detect failures of the CPE. In particular, the FSU8100 uses a control management protocol to monitor the status of the CPE to detect its failure and notifies an alarm to the upper-level service operation management system. In addition to the already described NETCONF, the SNMP trap, which is a time-honored management protocol, can be used for the notification. Whether or not each alarm should be notified can be set in advance.

3-4 Line monitoring

If a communication failure occurs in a Carrier Ethernet service, the communication carrier is required to locate the line and its section in trouble. The FSU8100 monitors the access network between a central office switch and CPE as well as the entire line of communications between each CPE, thereby easily identifying the line in trouble.

A control management protocol between a central office switch and CPE is used for the line monitoring of an access network.

Monitoring of an entire line is performed by Ethernet OAM that transmits and receives data between CPE. Data transmission by Ethernet OAM is possible for each VLAN, and this enables failure detection, delay measurement, bandwidth measurement and packet loss confirmation for up to 256 routes.

4. Failure Prediction by Streaming Telemetry

In conventional network device management protocols (such as SNMP and NETCONF), the service operation management system issues a request for acquisition of device information data model. The information is acquired by receiving the response to the request. Meanwhile, Streaming Telemetry technology (hereinafter referred to as "Telemetry") that periodically transmits information from a device to the service operation management system has been attracting attention in recent years. Telemetry is expected as a means of acquiring device information on a real-time basis and autonomously controlling the device in response to a change in the status of the device.[5] We have been promoting R&D of Telemetry, which can be used to automatically predict failures and respond to them in the customer's environment. At the first stage of the proof of concept (PoC), we performed a comparative verification of data transmission time by conventional technology and Telemetry.

4-1 Performance verification of Telemetry

In the conventional method for acquisition of information from equipment (pull type), it is necessary to issue an information acquisition command (GET request) for each piece of device information. The problem with the above method is that, when a large amount of information is acquired, the information acquisition time increases due to the overhead associated with GET request transmission. In contrast, Telemetry uses a push-type configuration in which the device information collector preliminarily declares subscription to the information to be acquired, and the device periodically transmits a stream of data to the collector according to the contents of the subscription. Thus, Telemetry minimizes the overhead. In addition, Remote procedure call (RPC), especially gRPC developed by Google Inc., is generally used as a communication protocol of Telemetry. We also used gRPC for our PoC verification. Since gRPC serializes the transmission data (while maintaining data structures) and compresses the data in a binary form, this protocol reduces the data size compared to the XML format, which NETCONF uses, and other similar protocols, enabling communications at higher speeds.

Conventional and Telemetry systems were compared in terms of the data acquisition time when getting the statistical information of traffic that flows through the ANI port of a central office switch. For the comparative measurement, a single ANI port and 46 ANI ports were used to acquire the information. As shown in Fig. 3, the Telemetry system reduced the data acquisition time and also reduced the effect (overload) of an increase in the number of ports (acquisition targets).[6]

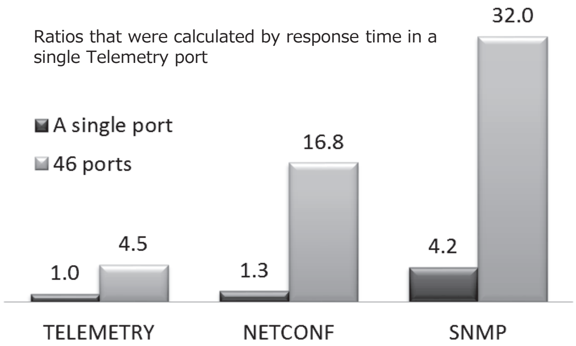

Fig. 3. Comparison in terms of statistical information acquisition time (ratio)

4-2 Automating service operation management by Telemetry

A closed-loop autonomous control has been proposed that visualizes the data acquired by Telemetry, analyzes the visualized images with artificial intelligence (AI) installed on a server, and automatically feeds the analysis results back to the configuration of a device.[7] Real-time acquisition of information, the effectiveness of which has been confirmed by our PoC verification, enables autonomous control of the device (and network) shown in Fig. 4. At the second stage of our PoC, we verified the visualization of acquired data.

The practical data visualization method is as follows. The Telemetry data acquired by a collector are stored in an external time-series database. An external dashboard extracts the data in accordance with a structured query language (SQL) instruction and displays the data on a web browser (see Fig. 5). It becomes possible to autonomously predict failures by using AI to analyze the data that are acquired on a real-time basis and then visualized.

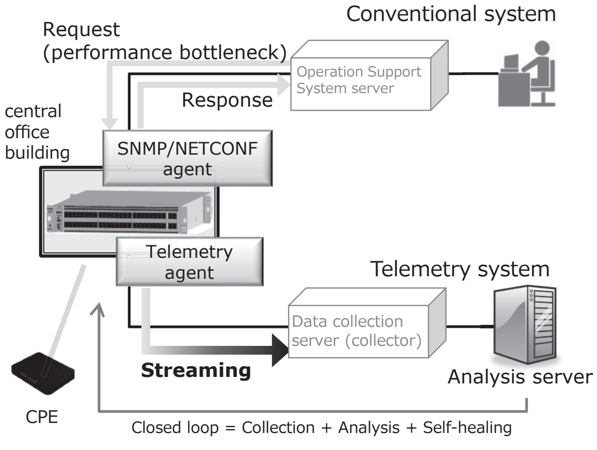

Fig. 4. Outline of conventional and Telemetry systems

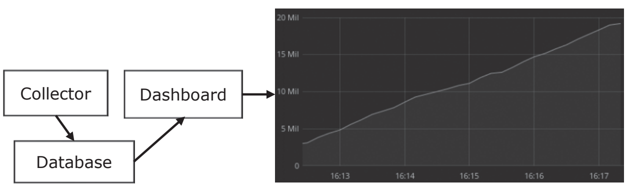

Fig. 5. Visualization of Telemetry data

5. Conclusions

This paper has described the FSU8100 series Ethernet access switches developed for Carrier Ethernet service applications. Power and space can be saved by integrating stand-alone media converters and a L2 switch into one unit. The new Ethernet access switches also support hitless firmware upgrades. They are equipped with zero-touch provisioning, which saves communication lines start-up work. In addition, they support NETCONF, alarm notification, and line monitoring functions, which helps reduce service operation management work. As a beginning of failure sign detection, PoC verification of Streaming Telemetry was performed to confirm that it enables high-speed acquisition of statistical information and visualization of acquired data.

We will continue to expand the functions of our products in response to the needs of society and promote R&D of new technologies in order to contribute to technological development in the field of access network.

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Contributors The lead author is indicated by an asterisk (*).

J. MICHIMATA*
- Assistant Manager, Information Network R&D Center

H. KATAYAMA
- Assistant Manager, Information Network R&D Center

K. NAKAMURA
- Broad Networks Division

T. INOUE
- Group Manager, Information Network R&D Center

A. YOSHIMURA
- Group Manager, IoT R&D Center

H. TAKAHASHI
- Assistant General Manager, Broad Networks Division