Development of 10G-EPON to Better Handle Increased Traffic

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Abstract

Japanese fiber-optical Internet services are built primarily around PON systems. However, as Internet traffic grows ever more complex and data-intensive, it becomes more difficult for these systems to handle the increased load. For example, the growing popularity of high-definition video streaming has massively increased traffic, as has mobile data communications caused by Wi-Fi offloading. In response to accelerating demand for higher speed and capacity over the past few years, NEC has developed a 10G-EPON system that achieves transmission speeds 10 times faster than conventional PON systems. In this paper we will first look at the basic technological underpinnings of PON and then outline the configuration and features of NEC's 10G-EPON system. Finally, we will look at standardization activities and future trends.

Keywords

PON, FTTH, access network

1. Introduction

Fiber-to-the-home (FTTH) broadband services in Japan are primarily based on the Gigabit Ethernet-Passive Optical Network (GE-PON) system, in which multiple subscribers share 1-Gbps class transmission speed optical lines.

Today, those systems are beginning to show the strain of attempting to cope with not only the constantly increasing volume of mobile data communication traffic caused by Wi-Fi offloading, but also the even greater increase in traffic expected to accompany compatibility with high-image-quality TV (4 K/8 K). As a result, bandwidth exhaustion has become a major issue for access networks. To help solve this issue, NEC has developed a 10 Gigabit Ethernet PON (10G-EPON) system that achieves transmission speeds in the 10-Gbps class. This paper gives an overview of the PON technology and outlines the configuration and main features of NEC's 10G-EPON system. We will also look at standardization activities and future trends.

2. Overview of the PON Technology

A PON, or passive optical network, consists of an optical line terminal (OLT) and a number of optical network units (ONUs). The OLT is installed at the FTTH service provider's central office while the ONUs are installed near end users. This system is extremely economical as the OLT and ONUs can share a single optical fiber, instead of requiring multiple fibers to serve multiple customers. In the PON system, the OLT and ONUs use different transmission optical wavelengths; as a result, single-conductor bidirectional communication is achieved by wavelength division multiplexing (WDM) technology.

Downstream communication (from the OLT to the ONUs) is broadcast to all the ONUs through the optical coupler. Each ONU receives only those communications specifically addressed to itself and discards the rest (**Fig. 1**). The payload section is encrypted in the address to each ONU, so communications addressed to other ONUs cannot be read.

While downstream communications are effectively separated, upstream communication (from the ONUs to the OLT) can collide if the ONUs transmit simultaneous-

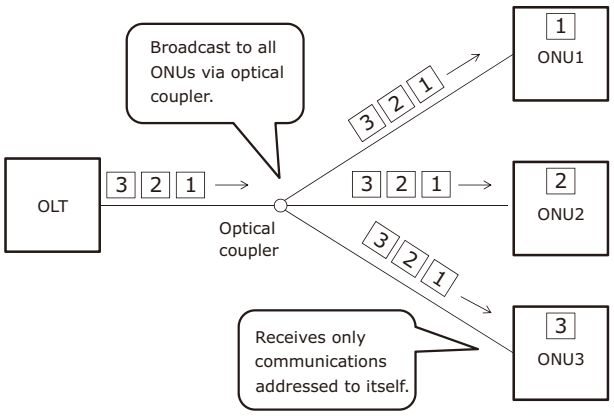

Fig.1 PON downstream communication system.

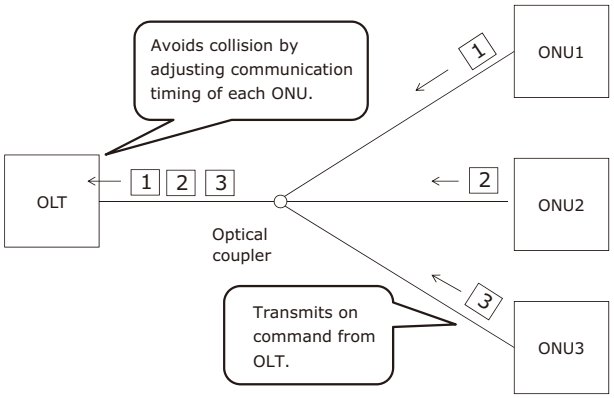

Fig.2 PON upstream communication system.

ly. To avoid this, a time division multiple access (TDMA) system (**Fig. 2**) is used. The OLT takes into account the bandwidth selection and connection distance of each ONU, then calculates the appropriate timing for communication permission and duration of communication. This calculation function is called dynamic bandwidth allocation (DBA).

3. Overview of the NEC 10G-EPON System

NEC's 10G-EPON system consists of an OLT and multiple ONUs. The OLT houses an integrated gateway unit (IGU) and a line terminal unit (LTU), which serve as a main signal control section (**Fig. 3**).

(1) OLT

Housed in a 4U19-inch rack chassis, the OLT includes up to 2 power supply units, a cooling fan, up to 2 IGUs, and up to 8 LTUs. The OLT's main specifications are shown in **Table 1**. The power supply section is duplicated and selectable from either 48 V DC or 100 V AC. The OLT is designed to operate even with a single power supply.

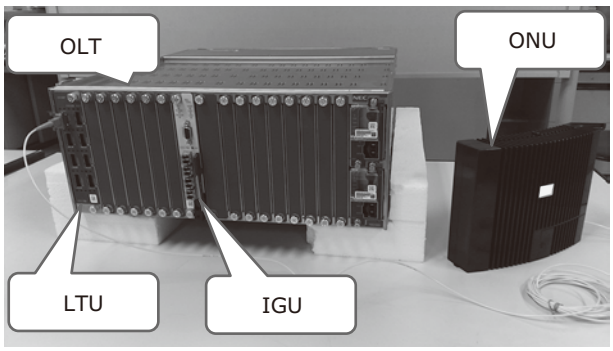

Fig.3 Overview of NEC's 10G-EPON system.

Table 1 OLT specifications.

	Item	Specification
IGU	Max. no. of loadable units	2
	Upstream interface	10GBASE-SR or 10GBASE-LR, 4 ports
	Traffic functions	MAC address learning, VLAN, priority control, link aggregation, etc.
	Control interface	DSUB9 and RJ45
	Control functions	Local console, Telnet, SNMP, NTP, log, etc.
	Redundancy function	Provides IGU Redundancy
LTU	Max. no. of loadable units	8 (when DC power supply is used)
	PON interface	10GBASE-PR30, 10GBASE-PRX30; and 1000BASE-PX10 compatibility, 8 ports
	Traffic functions	IP multicast, VLAN, MAC address learning, priority control, bandwidth control, error correction, etc.
	Security functions	Encryption, terminal authentication, etc.
	Max. no. of connectable ONUs	128/PON port
Power supply	Max. no. of loadable units	2
	Power supply/voltage	48 V DC or 100 V AC
	Max. power consumption	1,260 W (when DC power supply is used)
External dimensions (HxWxD)		176 x 440 x 480 mm

(2) IGU

The IGU is equipped with Layer 2 Switch (L2SW) and device control functions. With two IGUs, you can use card redundancy and port redundancy. Each IGU is provided with 4-port 10 GbE interface and aggregates traffic of up to 8 LTUs.

(3) LTU

Equipped with a circuit termination function on the station side and the L2SW function, the LTU is provided with 8-port 10G-EPON interface and can house as many as 128 ONUs in each PON port. The chassis can incorporate up to 8 LTUs and can house up to 8,192 ONUs for each OLT.

(4) ONU

The ONU is a circuit termination device on the subscriber side. Its main specifications are shown in **Table 2**. A dual-purpose 10GBASE-T/1000BASE-T

Table 2 ONU specifications.

Item	Specification
User interface	10GBASE-T/1000BASE-T, 1 port
PON interface	10GBASE-PR30, 1 port (10 G upstream/downstream); or 10GBASE-PRX30, 1 port (10 G downstream/1 Gupstream)
Max. no. of logical links	8
Traffic functions	MAC address learning, VLAN, priority control, error correction, etc.
Security functions	Encryption, terminal authentication, etc.
Power supply/voltage	100 V AC
Max. power consumption	19.4 W
External dimensions (HxWxD)	160 x 70 x 210 mm

interface is provided for end user communication. Two types of optical line can be used to connect to the ONU - a symmetric type that communicates at 10 G both upstream and downstream and an asymmetric type that communicates at 10 G downstream and 1 G upstream.

4. Features of the NEC 10G-EPON System

4.1 PON Control

(1) 10G/1G coexistence capability

The 10G-EPON system can provide existing asymmetric 10 G services at 10 G upstream and 1 G downstream for consumers and 10 G services at 10 G both upstream and downstream for businesses, as well as existing GE-PON services - all on the same PON lines.

The downstream optical signals are multiplexed into a single signal using WDM technology, which uses dedicated signals for 10 G and 1 G respectively. Upstream optical signals are received with TDMA technology, which divides mixed 10 G and 1 G signals on the same frequency channel into different time slots.

To facilitate migration from existing 1G services, NEC's10G-EPON has the same optical loss budget as the GE-PON. To achieve that, we have incorporated a high-output, low light-receiving optical transceiver with error correction using Reed-Solomon codes.

(2) Bandwidth control

An ONU is physically equipped with a single PON interface port, the interface can be treated as up to 8 logical ports. This logical interface makes it possible to apply individual settings to the main signal system, allowing network designers to allocate each logical interface to different services such as telephone or Internet. NEC's 10G-EPON system lets you set maximum bandwidth restriction, minimum guaranteed bandwidth, and bandwidth allocation ratio during congestion all via logical interfaces, thanks to the OLT's DBA function. For example, you can perform flexible bandwidth control by setting the bandwidth allocation ratio at 10:1 or 1:1 for a 1 G service or 10 G service.

(3) Security

This system encrypts the communication path between OLT and ONUs. In so doing, it eliminates data leakage by preventing malicious users from sneaking a peek at the data in the optical intervals. It is also provided with a function to authenticate the host of the ONU itself or its subordinate host as well as broadband routers. By giving permission only to registered hosts, it can deny access to unauthorized users, thereby improving security.

4.2 Device Architecture

(1) Migration from existing systems

NEC's 10G-EPON system is designed to support easy migration from existing GE-PON systems. The 10G-EPON OLT can house GE-PON LTUs and take over management of the GE-PON system, controlling the entire system using the same operations to control the entire system. By utilizing the existing hardware resources used by the GE-PON system and by taking over existing operation and maintenance methods, we've made it easier to transition to the 10G-EPON system.

(2) Redundancy control

A card redundancy configuration is also possible by housing two IGUs in the chassis. Normality is mutually monitored between the cards. So even when a problem occurs in one IGU, the service can be maintained with the other IGU. A function is also provided that selects multiple 10 GbE interfaces from an arbitrary IGU port and treats them as a single logical port (link aggregation). By configuring link aggregation with upper switches and routers, continuation of service is possible even when there is a problem in the upper line, such as a malfunctioning optical module or line disconnection.

4.3 Conversion into High Density and Low Power Consumption

Like the GE-PON system, the 10G-EPON system is designed for high density and low power consumption. Equipped with up to 64-port 10G-EPON interface in a 4U19-inch rack-size chassis, it can house as many as 8,192 ONUs, while consuming less than 1,260 W of power.

5. Standardization Activities and Future Trends

NEC is participating in ITU-T and IEEE standardization meetings aimed at standardization of next-generation optical access technology and commercialization of related products. The new international standard for the next-generation optical access system (NG-PON2[1)]) has been stipulated by the ITU-T as a 40 Gbps-class communication bandwidth PON. The IEEE has also begun study of a 100 Gbps-class PON[2)].

Next-generation optical access systems will extend beyond conventional broadband services, covering mobile backhaul and fronthaul which are now facing tremendous growth in traffic.

6. Conclusion

In this paper, we have introduced the basic technologies underlying PON systems used for FTTH, and shown how these will be improved and expanded with the 10G-EPON system now under development at NEC.

Building and expanding on the PON technology we have already developed, we will continue to develop products that meet market needs, while also contributing to international standardization of next-generation optical access systems.

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