Optical Access Systems for Triple-play Broadband Services

Yukio Nakano, Dr. Eng.
Masaki Ohira
David Foote

OVERVIEW: Optical-access technology, which is even faster than ADSL and cable-modem technologies, plays an important role in the evolution of broadband-access services. Accordingly, Hitachi has been undertaking research and development on optical-access systems since the 1980s and, recently, has developed several versions of such a system with a 1-Gbit/s-class data rate. The "AMN1220 GPON system"—based on the ITU-T G.984 standard—provides "triple-play" services incorporating existing telephony, analog video, and data including IP voice and video.

INTRODUCTION

TO transmit large amounts of data over long distances, optical transport systems between metropolitan areas and undersea communications have been widely used. The conversion of network services such as Internet connections to "broadband" has been continuing. As a result, access systems need increased bandwidth to transmit data to users. In that area, optical-transmission technology has begun to be used as well. At first, broadband-access systems used either ADSL (asymmetric digital subscriber line) systems utilizing existing phone lines or cable modems utilizing CATV (cable TV) lines. However, to provide services requiring high-speed transmission like that for video streaming, optical transmission technology—which can attain much higher speed transmission than those systems—has started to be used for access systems. Optical access systems using optical fiber have the capacity for almost unlimited increases in speed; accordingly, they are considered the ultimate method for broadband access.

Hitachi has been undertaking research and development on optical access systems since the 1980s. In 2002, we developed a world-leading system called the BPON (broadband passive optical network) and introduced it on a large scale across Japan. With a downstream data rate of 600 Mbit/s and an upstream of 150 Mbit/s, this system made a major contribution to the popularization of optical broadband access in Japan. As for optical access recently, demands for data rates of 1 Gbit/s or more have been growing especially for video services. In accordance with these demands, Hitachi has developed 1-Gbit/s-class PON systems as described in this article.

REQUIREMENTS FOR OPTICAL ACCESS SYSTEMS

Optical access systems must meet two major requirements, among others, as described below:

(1) Compliance with international standards

Compliance with international standards is required to support interoperability between devices of different vendors. The latest main international standards for optical access systems are the ITU-T (International Telecommunication Union—Telecommunication Standardization Sector) G.984 series, known as GPON (gigabit-capable passive optical network), and IEEE 802.3ah known as gigabit Ethernet* PON or GE-PON (gigabit Ethernet-passive optical network).

ITU-T, with membership composed of telecoms operators and manufacturers from various countries, has been carrying out international standardization of telecommunication technologies (starting with telephony) for a long time. Accordingly, GPON standardized by ITU-T is configured so that it can easily bring in existing telecommunications services as well as IP (Internet Protocol)-based applications. Moreover, it includes improved management-control functions that meet the demands of telecom operators.

In the meantime, the Institute of Electrical and Electronics Engineers, Inc. (IEEE)—the organization

* Ethernet is a registered trademark of Xerox Corp.

carrying out standardization of Ethernet technologies—has introduced the IEEE 802.3ah standard with interface rules specialized for Ethernet technologies. As a result, IEEE 802.3ah is suited to standardization of systems that make broadband Internet-access faster.

(2) Handling multiple-service configuration

The configuration and evolution format of broadband services vary from country to country. Moreover, the strategy for providing services varies according to each network operator. For example, in Japan and other parts of Asia, IP-based services have become mainstream. In North America, the demand for IP-based services plus backward compatibility with existing telephony and CATV is strong. As a result, optical access systems need user interfaces that respond to the assorted demands for a multitude of services from network operators. A variety of ONTs/ONUs (optical network terminals/units) located at the customers' premises are required, ranging from simple systems with only Ethernet interfaces to integrated systems incorporating both telephony and video ports.

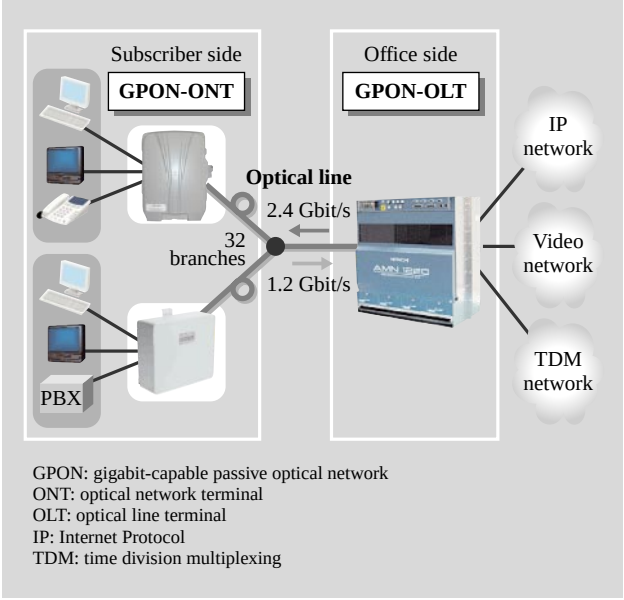

Fig. 1—ITU-T GPON System (AMN1220). Three kinds of networks (IP, video, and TDM) are accommodated, and "triple-play" services with data, images, and telephony can be provided.

GPON SYSTEM

Hitachi developed optical access systems to conform to the ITU-T international standards for gigabit-class transmission.

The system described in this article, called the AMN1220 GPON, complies with ITU-T G.984[(1)].

The AMN1220 GPON system is best suited to "triple-play" services (which combine telephony, video, and data transmission) and business-oriented services. This system is composed of multiple user interfaces and ONTs with an abundance of functions like bandwidth management for every user. To implement the triple-play service over GPON, the system is based on Ethernet transport architecture combined with several devices supporting conventional signals such as ordinary telephone and CATV (cable TV) signals. Several key components are developed especially to support the ITU-T G.984 standard. Among them are optical transmission module and VLSIs handling GPON signals.

GPON SYSTEM FEATURES

The details of the AMN1220 optical-access system are as follows. In addition to voice transmission, this system supports Ethernet, DS1 (digital signal–level 1), IP data transmission, and video distribution services. Moreover, in the PON section, the GPON signal supports an optional RF (radio frequency) video signal that is also independently wavelength division multiplexed. The AMN1220 GPON system consists of OLT (optical line terminal), a family of ONTs, and an EMS (element management system) as shown in Fig. 1. The main features of the AMN1220 optical-access system are listed below:

(1) It is suited to "triple-play" services (which combine telephony, video, and data transmission) with QoS (quality of service) control of bandwidth, latency and the performance characteristics tailored to each service requirement.

(2) Since all equipment on the central office side is shared by a maximum of 32 or 64 users, the total network cost is more economical.

(3) G.984 GPON provides broadband performance with a downstream of 2.4 Gbit/s and an upstream of 1.2 Gbit/s. The 2.4-Gbit/s downstream is effective for large-capacity "multicasting" such as HDTV (high-definition TV). It provides the highest usable bandwidth of any broadband access technology today.

(4) The uplink bandwidth of 1.2 Gbit/s is effectively utilized by applying QoS for assigning uplink bandwidth according to the transmission demand of each user.

(5) Very efficient bandwidth utilization is achieved for all service types (voice, video, IP data) by "capsulization" and "segmentation" of data into multi-

purpose GEM (GPON encapsulation mode) frames in both upstream and downstream transmission on the PON link.
(6) Advanced video services like VOD (video on demand) can be provided via IP video distribution including IP multicast.
(7) Hitachi's VLSI high-speed technology and high performance optical devices are used.

The key features of the system's OLT, which is located in the service provider's network center or central office, are summarized below:
(1) Efficient multiplexing and division of signals are possible by means of QoS function and a large-capacity upgradable L2/L3 switch. Switching of TDM (time division multiplexing) signals is also possible.
(2) The OLT supports up to sixteen 1-Gbit/s optical Ethernet NNIs (network node interfaces) and 112 DS1 interfaces for TDM. Upgrading to four 10-Gbit/s optical Ethernet NNIs is also possible.
(3) The OLT optical Ethernet interfaces use SFP (small form-factor pluggable) optics, so the operator only incurs the cost of optics devices when they are actually needed based on traffic capacity needs.
(4) The OLT needs up to 32 PON lines each with 2.4 Gbit/s downstream and 1.2 Gbit/s upstream.
(5) TL1 (transaction languages 1) is adopted for the management interface protocol.
(6) Common parts can optionally be duplicated, so reliability is high.
(7) The OLT can be initially deployed in a "half shelf" configuration to minimize the upfront capital cost for the service provider.

The key features of the system's ONTs are summarized below:
(1) The ONT family has GST (gigabit single terminal) for single users or GMT (gigabit multi terminal) for 24 multi-dwelling (residential) or multi-tenant (business) end users. Both ONTs accommodate a wide range of environmental temperatures so that equipment can also be placed outdoors.
(2) Both kinds of ONTs have Gigabit-Ethernet user interfaces.
(3) Legacy telephone-system lines and VoIP (voice over IP) signals are both accommodated. As a result, connection with existing digital telephone exchanges and support of legacy telephony services are possible. At the same time, by connection with software switches, IP-phone services (which have been rapidly spreading) can be supported.
(4) Digital signals can accommodate analog-system RF video signals by independent wavelength-division multiplexing.
(5) Depending on the mix of GSTs or GMTs and split ratio of 32 or 64, a single AMN1220 system can support between 1,000 and 16,000 end users.

Key features of the AMN EMS for the OLT and ONT are listed below:
(1) A GUI (graphical user interface) facilitates easier high-speed management.
(2) Management of network ranging from small scale to large scale is possible. In the case that hundreds of OLTs are managed, a UNIX* server with multi-CPU is used. In configuration where just several OLTs are managed, an economical PC can be used.
(3) Through a northbound interface, the GPON system can be managed from the network operator's NMS (network management system).
(4) The EMS can optionally be configured in a fully redundant, hot standby configuration which provides a multi-processor, fault tolerant, high-availability management system.
(5) The EMS interacts with the OLTs and ONTs to auto-discover new devices and automatically provide services to each end user based on service provider defined profiles which greatly reduces service activation time and cost.

CONCLUSIONS

This article described optical access system AMN1220 for providing broadband services by optical fiber to the home and businesses. The key feature of the AMN1220 GPON system—based on the ITU-T G.984 standard—is that it can provide a multitude of new IP-based services as well as existing telephony and CATV services.

The state of affairs and strategy regarding the implementation of optical access systems vary from country to country and network operator to operator. So that we can respond to the various demands of network operators, Hitachi will continue to improve its optical access systems and technologies.

REFERENCES

(1) ITU-T G.984.3 Gigabit-capable Passive Optical Networks (G-PON): Transmission Convergence Layer Specification (Feb. 2004).
(2) IEEE 802.3ah.

* UNIX is a registered trademark in the United States and other countries, licensed exclusively through X/Open Company Limited.

ABOUT THE AUTHORS

Yukio Nakano, Dr. Eng.

Joined Hitachi, Ltd. in 1983, and now works at the Access Products Planning Department, Hitachi Communication Technologies, Ltd. He is currently engaged in the planning of optical access products. Dr. Nakano is a member of The Institute of Electronics, Information and Communication Engineers (IEICE), and The Institute of Electrical and Electronics Engineers, Inc. (IEEE).

Masaki Ohira

Joined Hitachi, Ltd. in 1991, and now works at the GD Project, Hitachi Communication Technologies, Ltd. He is currently engaged in the development of optical access systems. Mr. Ohira is a member of IEICE.

David Foote

Joined Hitachi Telecom USA, Inc. in 1985, and is currently the Chief Technology Officer (CTO). He is currently responsible for product strategy and planning for optical access, transport, and wireless-cellular products in North America.