# Solutions for Optical Access Systems as Platform for Comfortable Communication

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*OVERVIEW: To achieve easy, stress-free communication, it is necessary to provide a high-speed access network that can transmit and distribute all kinds of media — namely, voice, data, and still/video images — without delay. At present, the conversion of access networks to optical technologies is continuing apace, and access systems providing bandwidths supporting transmission speeds of 10 Mbit/s to 1 Gbit/s are being rapidly introduced. As regards access systems, it is necessary to strike a balance between broadband and fine bandwidth control, high cost-performance, and high reliability. In the current paper, first, the application scope of access systems is categorized as three kinds of users: businesses, general households users, and apartment complexes. Hitachi's solutions to meet the demands of each kind of user — respectively, an Ethernet* converter, a gigabit Ethernet PON (passive optical network), and a hybrid access system — are then described. Next, taking up the gigabit Ethernet PON (which utilizes the latest optical access technology standardized by the IEEE802.3 standards committee) as the topic of discussion, the paper describes the transmission method, system features, and optical transmission technologies applied by this solution.*

## INTRODUCTION

TO realize "easy communication," the provision of broadband access networks which can transmit and distribute all kinds of media (i.e. voice, data, and video) without delay is becoming increasingly important. Currently in Japan, the number of subscribers to

* Ethernet is a registered trademark of Xerox Corp.

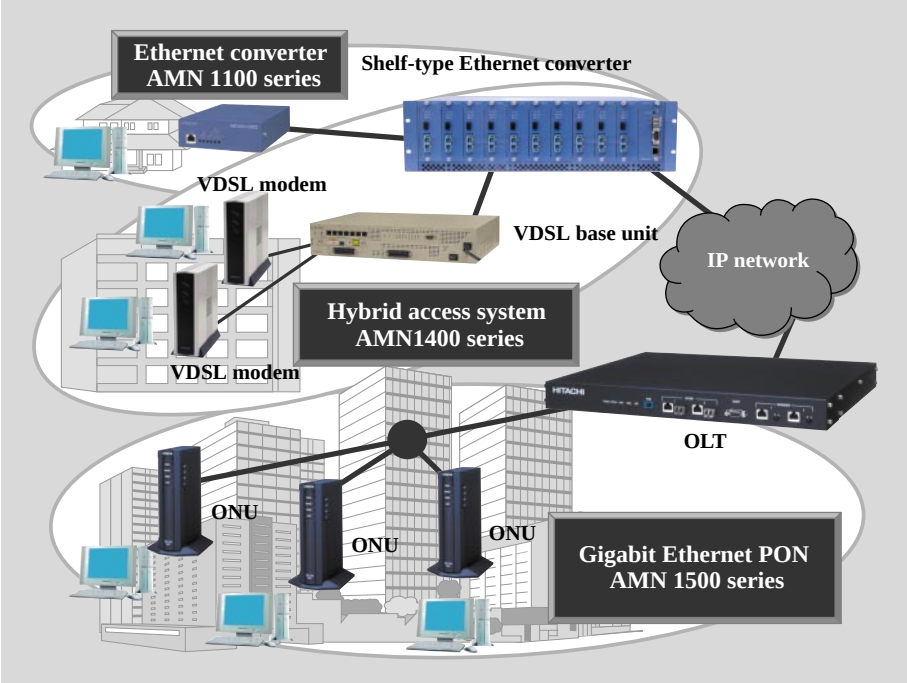


*Fig. 1—Solutions for Optical Access Systems.*
*Optical access systems can be categorized into three application areas: businesses, general households, and apartment complexes. This solution uses the Ethernet converter mainly for business users, the gigabit Ethernet PON for business users and household users, and the hybrid access system for apartment complexes.*

VDSL: very-high-speed digital subscriber line
OLT: optical line terminal
ONU: optical network unit
IP: Internet Protocol

ADSLs (asymmetric digital subscriber lines) which utilize existing phone lines to provide high-speed Internet access has surpassed 10 million in Japan. However, in the case of ADSL, as the distance from the central exchange increases, the transmission speed decreases proportionally. Moreover, compared to the down-link transmission speed, the up-link speed is slow. As a consequence of these drawbacks, bi-directional communication of large volumes of data is restricted.

To address the restrictions mentioned above, access networks are rapidly being converted to optical systems, and access systems that provide bandwidths ranging from 10 Mbit/s to 1 Gbit/s are being implemented at a fast pace. This paper describes Hitachi's efforts in developing an optical access system based on a gigabit Ethernet PON (passive optical network)[2)] which utilizes the latest optical-access technologies being developed by the IEEE802.3 standardization committee.

## SOLUTIONS FOR OPTICAL ACCESS SYSTEMS

### Application Areas of Access Systems

An access system connects user sites such as businesses and households with the service node in the central office of a telecom carrier and provides transmission coverage over a distance range up to 20 km. The application area of access systems can be categorized as the following three kinds of users.

(1) For business users

The role that the Internet plays in all aspects of business from marketing and sales up to after-sales care is increasing and, at the same time, the spectrum bandwidth required for business networks is also increasing. On the other hand, given that decreasing communication costs is an important measure undertaken as part of the reform of business management, the demand for broadband and low-cost communication services by means of wide-area LANs (local area networks) is currently growing. Furthermore, taking account of the infinite variety of bandwidths demanded by business users with different priorities, it is preferable to provide a communication service that can control sensitive communication traffic. On top of that, in the business field, because transmission bottlenecks are directly related to financial losses, it is essential to ensure reliability. From the standpoint of the requirements mentioned above, it is clear that an access system must provide broadband and fine bandwidth control, high cost performance, and high reliability at the same time.

(2) For household users

In the case that general consumers are the target, the main need now is to shorten the Internet access time required for downloading image data. As for such usage, it is sufficient to secure a transmission speed of less than several megabits per second, and it is invariably not necessary to ensure constant communication bandwidth. Consequently, "best effort" services — which do not guarantee communication bandwidth — are being provided. However, if the continuing development of future IP (Internet Protocol) telephony and IP video delivery is taken into account, it is considered that, while providing certain best-effort services, it is necessary to assure a certain amount of bandwidth, and even if total network traffic increases, it becomes important to provide individual services that do not suffer quality degradation or cause disruptions.

(3) For apartment complexes

In the case that the same kind of general consumers are targeted in an apartment-complex environment, because many households inhabit the same building, it is relatively easy to implement a "hybrid access system" — namely, the building is connected by optical fiber, and then after the received optical signals are converted to electrical signals within the building, they are transmitted to each household via the building's internal metal cables. However, although the sharing of optical-fiber capacity is economical and reduces the amount of construction work needed, it must be considered that the capacity of the optical fiber may not be enough to meet increased bandwidth demands in the future.

In addition, common to the above three conformations is the expectation of mutual connectivity between vendors (by means of systems based on international standards) as well as easier procurement of hardware and improved economic efficiency.

### Hitachi's Solutions for Optical Access Systems

Hitachi's access-system solutions are comprised of an Ethernet converter, a hybrid access system, and a gigabit Ethernet PON system (see Fig. 1). The features and application scope of each of these systems are described below.

(1) Ethernet converter

The Ethernet converter AMN1100 series can transmit an Ethernet signal over a maximum distance of 30 km at 100 Mbit/s. As for equipment on the office

side, shelf-type (21 circuits) and box-type units are provided and set up according to demand. This converter thus provides the best solution to meet the large bandwidth demand of business users.

(2) Gigabit Ethernet PON system

The gigabit Ethernet PON system AMN 1500 series is an Ethernet optical access system that provides 1-Gbit/s bi-directional communication in compliance with the IEEE802.3ah draft currently being standardized. Accommodating a maximum of 64 subscriber sites branched out from a single optical fiber, this solution can meet the demands of a wide range of users from businesses to general households.

(3) Hybrid access system

The hybrid access system AMN1400 series combines the 1-Gbit/s Ethernet converter with VDSLs (very-high-speed digital subscriber lines) with transmission speeds of 30 to 50 Mbit/s in order to provide high-speed communication over existing phone lines. This solution is best suited to services aimed at users in apartment blocks.

## GIGABIT ETHERNET PON

### Transmission Method Used by Gigabit Ethernet PON

A PON is a system that enables multiple users to share a single optical fiber. In a PON, a single optical fiber from the OLT (optical line terminal) on the office side is connected to an optical splitter, from where it is branched out to ONUs (optical network units) on the multiple-terminal side (see Fig. 2). Standardization of the gigabit Ethernet PON was promoted by the "Ethernet First Mile" task force set up by the IEEE802.3 standardization committee, and final approval was given in July 2004. The main features of the standardized gigabit Ethernet PON are described below:

(1) By utilizing multi-wavelengths of 1.49 μm and 1.31 μm, bi-directional traffic can be accommodated by a single core fiber, and by utilizing an additional wavelength of 1.55 μm, signals for video distribution can be transmitted on multiple wavelengths.

(2) Because Ethernet frames are transmitted as units, compatibility with LAN devices on the user side is good.

(3) OAM (operation, administration, and maintenance) signals are defined, so bottlenecks in the access network can be easily identified.

These three features have made an access system that can economically transmit digital or analog signals a reality.

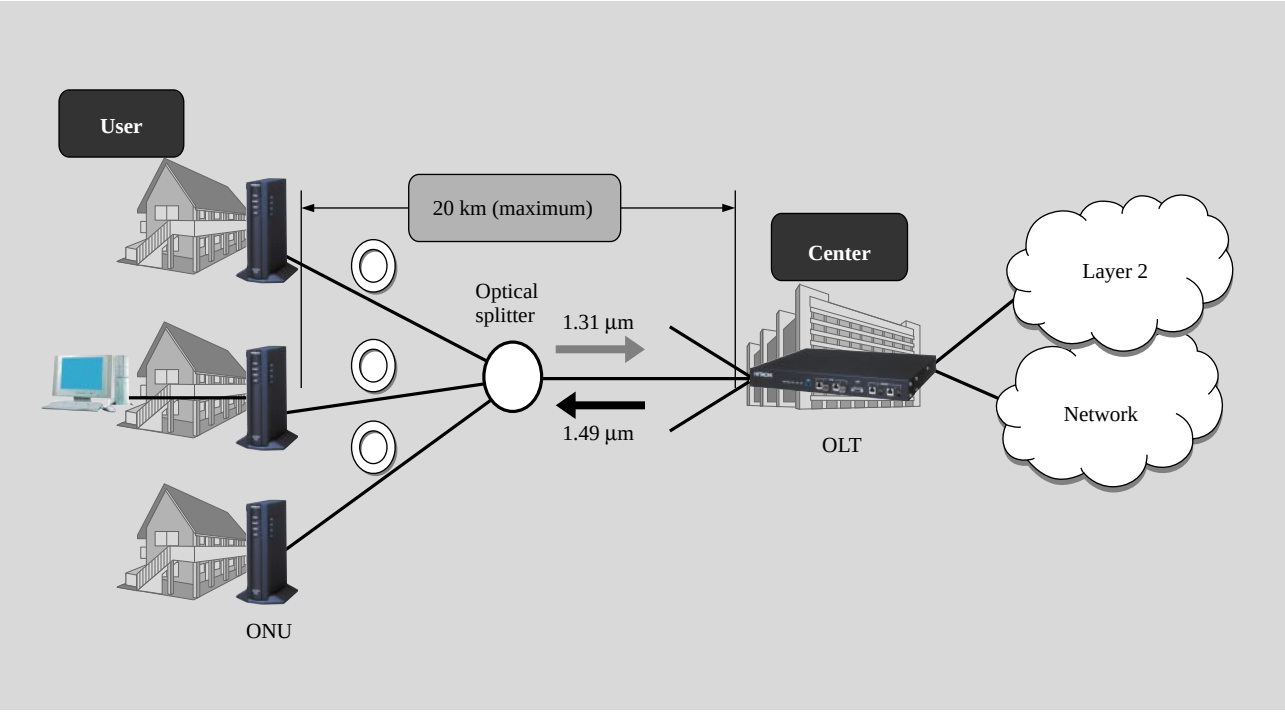


*Fig. 2—Basic Configuration of Gigabit Ethernet PON.*
*Gigabit Ethernet PON is configured by an OLT installed at the carrier's office and ONUs installed at user sites. Bi-directional transmission is made possible by utilizing an optical wavelength of 1.49 μm for the down-link signal and 1.31 μm for the up-link signal.*

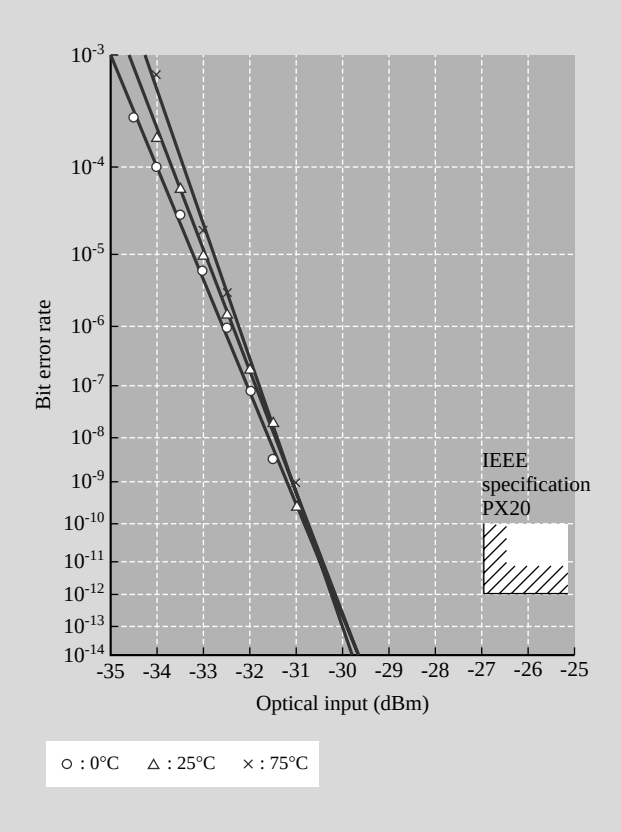


*Fig. 3—Reception Characteristics of the OLT for Optical Burst Signals.*
*Meeting IEEE specification PX20, the OLT is compatible with a maximum optical span loss of 25 dB. It can thus handle a multitude of users separated from the head office by a long distance.*

### Features of Gigabit Ethernet PON AMN 1500 Series

While meeting the IEEE802.3 standard, the Gigabit Ethernet PON AMN 1500 series has the main features listed below:

(1) An NNI (network node interface), namely, an electrical or optical interface consisting of two 1-Gbit/s ports, that enables connection within or between offices and ensures high reliability by means of redundancy on the network side.

(2) A UNI (user network interface) equipped with a negotiation function that automatically adjusts transmission speed of user terminals between 10 Mbit/s and 1 Gbit/s

(3) A function required for inserting or converting VLAN (virtual local area network) tags for broadband Ethernet services

(4) A "traffic shaping function" that sets 100-kbit/s units in order to provide fine bandwidth control.

In meeting the demands of business users, the above functions provide broad bandwidth and fine bandwidth control as well as high reliability.

### Long-reach, Multipoint Burst Optical Transmission Technology

To receive burst optical signals transmitted from multiple ONUs in a time-division manner, the OLT (optical line terminal) needs advanced optical-receiver technology. Since each optical burst signal is received with different amplitude and phase according to the distance between the OLT and each ONU, the receiver in the OLT performs high-speed synchronization in order to combine the amplitude and phase of each received signal within 1 μs. Applying a dedicated analog IC (integrated circuit) and weak-signal amplification by means of an avalanche photodiode (APD), the AMN1500 series meets long-distance specification PX20 stipulated in the IEEE standards (see Fig. 3). Note that there is a trade-off between the number of ONUs accommodated by one PON line and the maximum transmission distance. That is to say, by fulfilling this specification, it is possible to accommodate 16 ONUs at a maximum distance of 20 km from the carrier's central office or 64 ONUs at a maximum distance of 8 km.

## CONCLUSIONS

Hitachi's "access system solutions" — centered on the gigabit Ethernet PON currently being standardized by the IEEE802.3 standards committee — are described in this paper. As regards future access systems, balancing broadband and fine bandwidth control, high cost-performance, and high reliability all at a high level will be necessary. Moreover, it is considered that the development of information networks and the broadband conversion of access networks by IP conversion of phone services, image/video services, etc. will advance steadily. Accordingly, in regards to bandwidth demand driven by business users, followed by household users while assessing the communication applications of various users, Hitachi will strive to promote comprehensive "access system solutions."

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