Optical Access System for North American CATV Operators

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OVERVIEW: In reaction to the fully optical high-speed access line services being offered by telecommunication carriers, CATV operators in North America are investigating the introduction of fully optical networks in addition to their existing access lines that use a mix of optical fiber and coax cable. Hitachi is developing, based on the GE-PON optical access system, the DePON optical access system which is compatible with existing access monitoring and control systems for CATV operators. This minimizes the new investment in monitoring and control systems by CATV operators and allows the construction of an access line network fast enough to compete with the carriers.

INTRODUCTION

NORTH America has general CATV (cable television) operating companies known as MSOs (multiple system operators) that manage the operations of a number of CATV operators. For example, of the nine major MSOs in the USA, the top three companies (Comcast Corporation, Time Warner Cable Inc., and Cox Communications, Inc.) have approximately 70% of the market.

To acquire subscribers and increase sales per subscriber, CATV operators are expanding their services to include data communications, VoIP (voice over Internet protocol) telephony, VOD (video on demand), and other services.

On the other hand, telecommunications carriers such as Verizon Communications Inc. and AT&T Inc. are rolling out triple-play services that combine telephony with data communications and video. Similarly, satellite broadcast operators such as The DIRECTV Group, Inc. and DISH DBS Corporation offer digital television and HD (high definition) television services at a lower price than the CATV operators. The result is fierce competition between these three different groups, namely CATV operators, carriers, and satellite television broadcasters.

Consequently, North American CATV operators are investigating introducing access lines that support fully optical networking in addition to their existing access lines that use a mix of optical fiber and coax cable.

In response, Hitachi Communication Technologies America, Inc. (HCTA), a Hitachi Group company, is developing DePON [DOCSIS (data over cable system interface specifications) over Ethernet*1—PON (passive optical network)].

This article describes DePON which is compatible with the monitoring/controlling method used by North American CATV operators and uses GE-PON access lines.

TECHNICAL TRENDS IN NORTH AMERICA

The main distribution method used by North American CATV operators is HFC (hybrid fiber coax) which replaces the link from the transmission center to the user's neighborhood with optical fiber and uses optic/electric converters for the coax cable running to each home.

Cable Television Laboratories, Inc. established the DOCSIS standard to allow various data services to be added and the latest version of the standard (DOCSIS 3.0) released in 2006 provides a maximum downstream speed of 160 Mbit/s (the maximum upstream speed is 120 Mbit/s). Deployment of DOCSIS 3.0 is already underway and it is used to supply triple-play and similar services.

Meanwhile, by adopting PON access lines that use optical fiber, carriers are offering triple-play services with a maximum of 600 Mbit/s using B-PON (broadband PON) access lines or with a maximum of 2 Gbit/s using G-PON

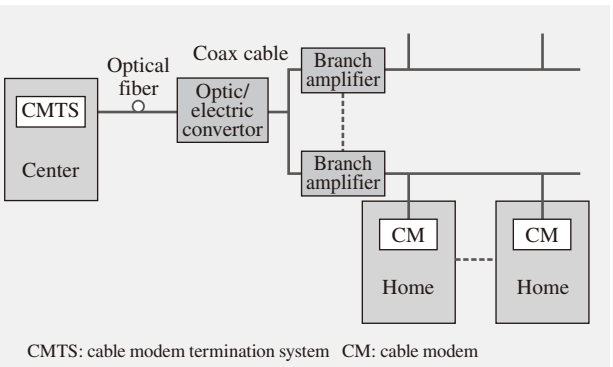


Fig. 1—Characteristics of HFC Method.
In the HFC (hybrid fiber coax) method, an optic/electric convertor converts the optic signal in the optical fiber into an electric signal which is distributed to the homes via coax cable.

*1 Ethernet is a registered trademark of Xerox Corporation.

(gigabit-capable PON), both of which are faster than the DOCSIS 3.0 standard used by CATV operators.

To compete, the CATV operators are now investigating adopting full optical networking for their access lines in addition to their current HFC method that combines coax cable and optical fiber.

COMPARISON OF CATV OPERATOR AND CARRIER ACCESS METHODS

CATV Operator Access Method

Fig. 1 shows an overview of the HFC method used by CATV operators.

Distribution from the center uses optical fiber. The optic signal is converted to an electric signal by an optic/electric convertor located in the users' neighborhood which is then distributed via branch amplifiers by multi-drop coax cable.

Carrier Access Method

Fig. 2 shows an overview of the PON method used by carriers. The optical fiber from the center connects to a splitter located in the users' neighborhood which splits the line into separate optical fiber lines to each home.

Comparison of Methods

Table 1 lists a comparison of the HFC and PON methods.

The PON method is superior to the HFC method in terms of line speed, maintenance, and noise tolerance. On the other hand, the HFC method can support a larger number of branches than the PON method. However, as both the PON and HFC methods involve multiple homes sharing a single optical fiber from the center, increasing the number of branches reduces the maximum line speed per subscriber.

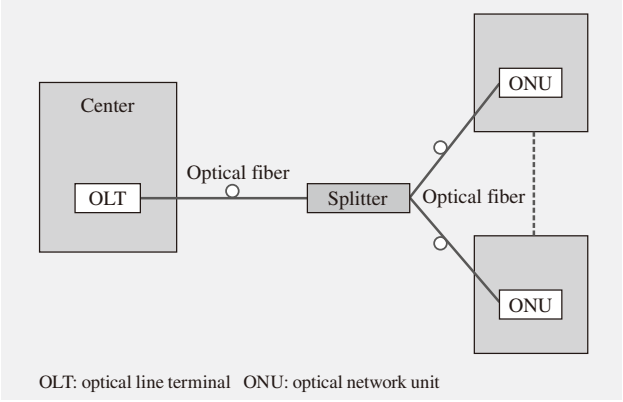


Fig. 2—Characteristics of PON Method.
The PON (passive optical network) method uses optical fiber all the way to the home.

TABLE 1. Comparison of HFC and PON Methods
As the HFC method uses coax cable, its maximum line speed, maintenance, and noise tolerance are inferior to the fully optical PON method.

	HFC method	PON method
Maximum line speed (Mbit/s)	Upstream 120 Downstream 160	Upstream 4,000* Downstream 4,000*
Access line maintenance	Maintenance is required a minimum of twice a year.	No maintenance required
Maximum branches	2,000	256*
Noise tolerance	Susceptible to interference by external noise.	Largely immune to interference by noise

* When using wave multiplex with four upstream wavelengths and four downstream wavelengths

DEPON SYSTEM

Aims of DePON Development

North American CATV operators are investigating the adoption of fully optical access lines as a response to the triple-play services offered by carriers. Also, they use the DOCSIS OSS (operation support system) for monitoring and control.

If a new monitoring/controlling method is made to coexist along with DOCSIS OSS when access lines are replaced with optical fiber, not only does this increase costs, it also makes management more complex.

Accordingly, Hitachi investigated a fully optical access line system that can be controlled using the existing DOCSIS OSS monitoring and control system and HCTA developed DePON. HCTA currently supplies GE-PON (gigabit Ethernet PON) to Bright House Networks, LLC., an MSO in the USA that initially adopted it as an optical access network in 2006.

DePON Characteristics

The following lists the main characteristics of DePON.

(1) Wave multiplex (four upstream wavelengths and four downstream wavelengths) is used to achieve a maximum line speed of 4 Gbit/s. This will be able to be extended to 10 Gbit/s in the future.

(2) By connecting to DOCSIS OSS, a fully optical access system can be supplied without any modification to the existing monitoring and control system.

(3) Changing to fully optical access lines reduces maintenance costs.

(4) Supports the bandwidth guarantee and service guarantee (MEF-9 and MEF-14) specified by the MEF (Metro Ethernet Forum), an industry organization that defines Ethernet technical specifications and implementations for carriers.

HFC Method Product Structure

For comparison with the DePON system developed by HCTA, Fig. 3 shows the product structure of HFC which is the main method currently used by CATV operators.

HFC consists of a CMTS (cable modem termination system) and CM (cable modem).

(1) CMTS

The CMTS is located at the center and is used to provide the subscriber with high-speed data communications, VoIP telephony, and other services. It also incorporates management and control functions that integrate with the DOCSIS OSS monitoring and control system.

(2) CM

The CM is located in the home or other subscriber premises and uses bi-directional communications with the CMTS to provide the user with high-speed data communications, VoIP telephony, and other services.

Product Structure of DePON PON System

DePON consists of an OLT (optical line terminal), ONU (optical network unit), and D-Server (see Fig. 4).

(1) OLT

The OLT consists of the terminators for the PON interfaces with the ONUs and the monitoring and control interface with the DOCSIS OSS.

One OLT can handle up to 1,792 ONU connections (see Fig. 5).

(2) ONU

The ONU provides the end-user with triple-play (voice, data, and video) services and a wireless LAN (local area network) access point. The video services include both television broadcasting using conventional CATV transmission and IPTV (Internet protocol television) which provides video and audio over a dedicated IP network.

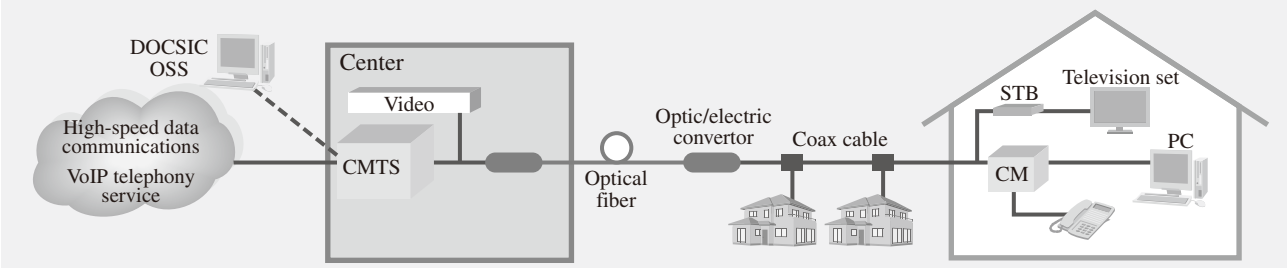
Also, the PON interface with the OLT provides the user with a 1-Gbit/s access line that complies with The Institute of Electrical and Electronics Engineers, Inc. (IEEE) 802.3ah (see Fig. 6).

(3) D-Server

The D-Server connects to the DOCSIS OSS and behaves in the same way as a CMTS in the existing CMTS/CM system in order to emulate the CMTS management functions. Each D-Server manages multiple OLTs and ONUs and can support a maximum of 20,000 ONUs (see Fig. 7).

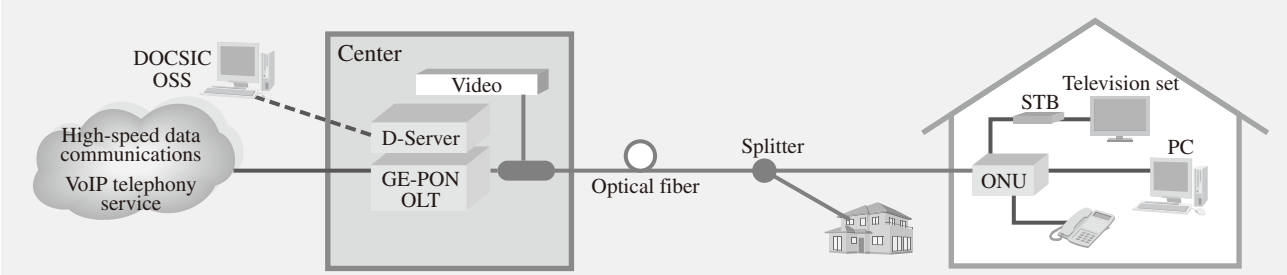
Future Development Plans

Work has been ongoing on the standardization of 10G-EPON (10-gigabit Ethernet PON) under the IEEE802.3av standard and this was completed in



DOCSIS: data over cable system interface specifications OSS: operation support system VoIP: voice over Internet protocol STB: set-top box
PC: personal computer

Fig. 3—Product Structure of HFC Method.
The CATV operator configures the access system by installing a CMTS at the center and a CM at the home.



GE-PON: gigabit Ethernet passive optical network

Fig. 4—Product Structure of DePON System PON Method.
DePON consists of a D-Server and OLT located at the center and an ONU located at the home. The D-Server emulates the CMTS management functions.

Fig. 5—DePON OLT.
The OLT consists of PON interface terminators and a monitoring and control interface.

Fig. 6—DePON ONU.
The ONU provides the end user with triple-play services and a wireless LAN (local area network) access point.

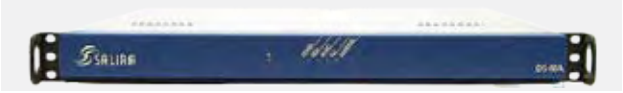


Fig. 7—DePON D-Server.
The D-Server connects to the DOCSIS OSS and emulates the management functions of the CMTS. SALIRA is a brand name of the Salira division of HCTA.

September 2009. 10G-EPON can provide 10 times the bandwidth of the existing GE-PON access lines used by DePON.

Hitachi intends to develop DePON further to support IEEE802.3av-compliant 10G-EPON lines to meet the growing demand for data communications with higher speed and larger capacity, particularly from enterprises.

CONCLUSIONS

This article has described DePON which is compatible with the monitoring/controlling method used by North American CATV operators and uses GE-PON access lines.

By adopting DePON, CATV operators can improve the speed of their access lines and reduce maintenance costs without any new investment in their monitoring and control system.

HCTA is developing DePON for MSOs in the USA by taking advantage of its experience as a supplier of GE-PON and is also working on development for Canadian MSOs.

Future plans include extending the product to the United Mexican States, Central and South America, and the Asian market.

REFERENCES

(1) SALIRA, Press Releases, http://www.salira.com/news/press_release/042408.html (Apr. 2008).
(2) T. Izumi et al., "Cable Television Technology," Corona Publishing Co., Ltd. (1994) in Japanese.
(3) W. Ciciora et al., "Modern Cable Television Technology," Morgan Kaufmann Publishers, Inc. (1999).

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