Optical Access

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Abstract

The means of broadband connections to communication carriers and service providers is shifting from metallic access using telephone lines to optical access using optical fibers that feature a high-speed data communication capability. In addition, the demand is on the increase for a triple play system, in which a single broadband connection provides telephone and broadcasting services at the same time as an Internet service.

This paper aims to provide an overview of the requirements of the optical access system of the next generation network (NGN). It goes on to review the future orientation of the main functions of the NGN and introduces some of the efforts that are being made by NEC in this field.

Keywords

triple play, packet integration, GE-PON, G-PON, optical device

1. Introduction

The broadband access service is expanding rapidly as a practical means of providing services. The triple play system is one of the practical representative services that are able to integrate data, audio and video services. Particularly, with the use of the optical access that uses optical fibers for the high-speed transmission of high-definition video information; domestic use is increasing rapidly in leading the global dissemination of the system.

At NEC, we provide a wide range of means of access from metallic access to optical access in order to support the construction of economical and flexible access networks. We are also developing new products for use with the next generation network (NGN) that feature the use of IP technology and packet-based transmission. These products are being commercialized by fully utilizing the optical, digital transmission, IP, audio, network management and device technologies that we have developed over long years of experience.

2. Requirements for Optical Access

Broadband access includes the metallic access, optical access and wireless access. When metallic access such as the ADSL (Asymmetrical Digital Subscriber Line) was developed, the access system was positioned as the competitive basis for subscribers of communications carriers. As a result of advancements and the practical implementation of technologies brought about by competitive prices and speeds, metallic access is still continuing to be disseminated on a global scale. On the other hand, the optical access is the means of access featuring the highest speed and broadest bandwidth, and it is being disseminated mainly in North America and Asia. **Fig. 1** shows the positioning of optical access with regard to the NGN.

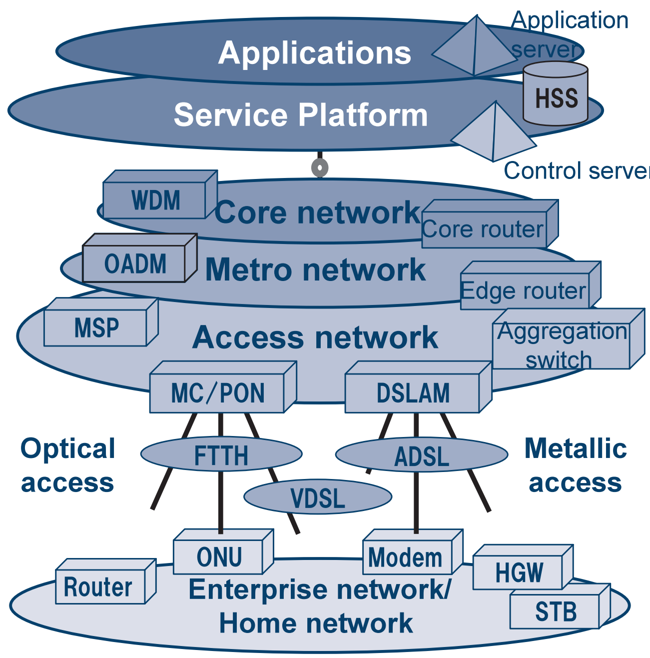

Fig. 1 Positioning of optical access.

2.1 Packet Integration in Access Networks

In the NGN, services are provided via IP networks. The IP network integrates the existing networks that are constructed on a per-service basis in order to create a network architecture that features high cost efficiency from the viewpoint both of investment and operation.

The IP network transfers data in packet form. When a telephone service provided with a circuit switched network, a private line service provided with a TDM (Time Division Multiplexing) network and a broadcasting service provided with ground transmission are integrated into an IP network, the subscribers' service interface needs to turn the transferred information into packets and also to handle the signaling in packets. The service interface should also be compatible with IP protocols such as the VoIP (Voice over IP) used in IP telephony and the IP multicast system used in IPTV transmission. In addition, inter-network interfacing with existing TDM and circuit switched networks should be made possible by installing gateways. The current system broadband connections to the Internet should also be inherited.

The migration toward integration into IP networks makes it possible to provide composite services such as triple or quatro play by means of customer packages so that subscribers can enjoy the benefit of multiple services from a single physical network connection.

2.2 Separation of Service Controls in Access Networks

The NGN should be considered by separating it into two layers; the transport layer for data transfer and the service control layer for data transfer control. As a result of recent trends in FMC (Fixed Mobile Convergence), the convergence of services such as telephone, data and video is crossing category boundaries, with a consequent integration of the transmission media and business carriers, and the service control is required to be independent from the transport system.

The service control system controls the functions of the transport system forming the access and backbone networks in order to guarantee the quality of service of each application. For example, the resource reception control subsystem manages and controls the transport system based on policy and session controls. On the other hand, the transport system is required to provide a service control system with a control interface that is independent of individual access media and operates according to controls applied by the service control system. In addition, it is also necessary to package the functions of Layer 3 or higher. These functions include for example first priority and quality of service controls according to the service types as well as security controls to prepare for attacks by viruses and worms etc.

2.3 Universality and Extendibility of Access Networks

Interoperability and extendibility are important functions for integrating various means of access. For this purpose, it is desirable that the specifications of the access system meet the requisite international and industry standards.

In the field of optical access, compliance with the specifications established by standardization organizations such as FSAN, DSL Forum WT-101, 3GPP/IMS and ETSI/TISPAN not only facilitates interoperability between carriers but also makes easy the construction of access networks and network management systems in accordance with the properties and business modes of the provided services.

As it is estimated that the access media will diversify further following the development of networks and services, it is an important issue to avoid forced upgrading of the system but allow existing solutions to be usable as long as possible. To design networks in consideration of the future and provide it with extendibility or, in other words, allocation of the address management and subscriber authentication functions properly will play an important role in solving these problems.

3. Configuration and Functions of Optical Access Systems

An optical access system is composed of an OLT (Optical Line Terminator) installed by the communications carrier or service provider, and the ONU (Optical Network Unit) installed in the office or household of the subscriber. In the subscriber's home, the home LAN, TV and telephone are connected through the HGW (Home Gateway) and STB (Set Top Box). When the subscriber's home is an apartment building, the optical fiber is terminated at the caretaker's office and the broadband connection to each apartment is provided using VDSLs (Very high-bit-rate Digital Subscriber Lines). **Fig. 2**

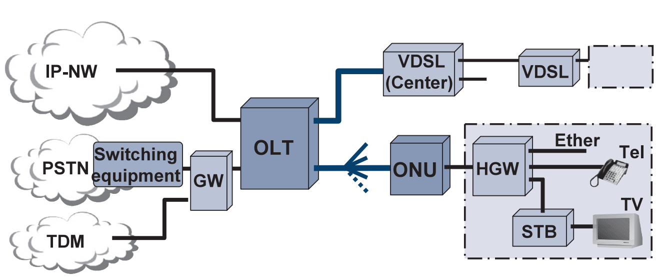

Fig. 2 Example of the configuration of an optical access system.

shows an example of an optical access system configuration.

3.1 Optical Access Method

Optical access can make the uplink and downlink transmission speeds symmetrical and achieve long-distance, high-quality ultrahigh-speed data transmission that is less dependent on the line conditions compared to metallic access. The transmission medium is the optical fiber, and the recent progress of technical developments has already overcome the issues of introduction such as distribution of optical fiber lines and indoor installation work. At present, subscribers in Japan are increasing at a rate of about 200 thousand lines per month.

The optical access method includes the SS (Single Star) technology and PON (Passive Optical Network) technology and the latter is currently being used more widely. The PON technology started to be researched in the eighties. After the A-PON (ATM-PON) and B-PON (Broadband PON), the commercialization of G-PON (Gigabit-PON) is going to be started. In Japan, the commercialization of GE-PON (Gigabit Ethernet-PON) is already underway.

3.2 Main Functions Required for Optical Access System

The main functions required for the optical access system are as follows.

(1) Subscriber Authentication

This function authenticates the subscriber after a connection request. The ONU and OLT incorporate the authentication function of 802.1x and execute the subscriber authentication in linkage with the RADIUS server or HSS (Home Subscriber Server).

(2) Traffic Aggregation

This function collects the traffic of the subscriber and transfers it to the aggregation network. Identification of the subscriber port and service is performed using VLAN or GEM (Generalized Encapsulation Method) in the section from the ONU to OLT, and using 802.1ad Provider Bridge VLAN or MPLS LSP in the uplink path from the OLT.

(3) QoS (Quality of Service)

This function provides the QoS according to the SLA (Service Level Agreement) with each subscriber. For this purpose, features including the packet service class identification, filtering, polishing, shaping and marking are distributed in the access system.

Bandwidth reservation and delay reduction by means of DBA (Dynamic Bandwidth Allocation) and the scheduling in the packet buffer are also provided as part of the QoS function.

(4) Legacy Service Compatibility

Integration of the existing telephone service requires conversion of the signaling into H.248 or SIP (Session Initiation Protocol) and that of the audio signals into the RTP (Real-time Transport Protocol) using an audio codec such as G.711 and G.726. The TDM service is provided by means of circuit emulation, etc.

(5) Service Provisioning

The network management of the NGN is expected to become a dynamic configuration based on the establishment of the subscriber authentication and service sessions provided by the service control system. The access system therefore needs to have a standard higher-level interface for use in setting a variety of parameters related to the subscribers and services.

4. Efforts Made by NEC

At NEC, we are developing products based on the technology acquired through past experience in the PON technology development so that we are able to provide solutions for both GE-PON and G-PON.

4.1 GE-PON

GE-PON is defined by IEEE802.3ah, which was standardized in 2004 with the idea of best fitting it to the full Ethernet-based network environments. It implements the ONU identification by attaching a special header to an ordinary Ether frame, and the uplink traffic by means of TDMA (Time Division Multiple Access).

In addition to their compliance with the IEEE standard, our GE-PON products also have the following features;

1) over 20 km optical transmission using an optical module with a 29dB dynamic range capability;

2) support of max. 512 ONUs with a single OLT, and;

3) provision of multiple user authentication methods including 802.1x.

Photo 1 shows our GE-PON products. The OLT has a com-

Photo 1 GE-PON products (Left: OLT, Right: ONU).

pact size with a depth of 12 inches (about 30cm) and is designed to be capable of flexible operations including back-to-back packaging or installation in small-scale remote stations.

4.2 G-PON

G-PON is defined by ITU-T-G.984, which was standardized with the idea of not limiting the traffic in the PON section to a specific protocol. For this purpose, it defines a method called GEM to encapsulate the traffic to be transferred. For ATM, the ATM cells can be sent or received by explicitly specifying their transfer domain destination. In addition, with the downlink frames, network synchronization can be achieved by transferring sync information every 125μs.

In addition to the compliance with the ITU-T standard, our G-PON products have the following features:

1) equipment architecture based on the concept of MSAP (Multi Service Access Platform);

2) downlink 2.5G/uplink 1.2G, with the optical specification compliant to the 20km transmission loss budget that is called “Class B+” by the ITU-T standard, and;

3) versatile VLAN function, and advanced packet filtering under multiple conditions such as MAC/VLAN/CoS/IP/Port as well as compatibility with IGMP/MLD.

The overall system is capable of triple play, and the ONU offers the Ether, POTS (Plain Old Telephone Service) and RF (Radio Frequency) outputs for the user interface.

Photo 2 shows our G-PON products.

4.3 Optical Devices

Optical devices are the key to any optical communication system supporting the optical access network, and the most representative of these is the optical transceiver that mutually converts optical and electrical signals. The optical transceivers marketed by NEC for use in optical access networks include those for the peer-to-peer systems in compliance with ITU-T or IEEE and those for the PON systems. Particularly, with regard to the optical transceivers for the PON systems, an optical transceiver for use in the GE-PON compatible OLT/ONU is commercialized in Japan based on past experience with the development of A-PON and B-PON. More recently, we are commercializing an optical transceiver for use with the OLT/ONU that features GPON Class B+ triple play compatibility for use in North America. **Photo 3** shows our optical transceivers for use with optical access systems.

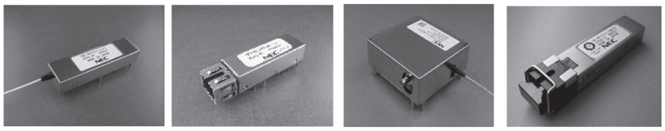

Photo 3 Optical transceivers for optical access systems.

Photo 2 G-PON system (Far: OLT. Near: ONU).

5. Conclusion

In this paper, we have offered an overview of the requirements of optical access to the NGN and we have also commented on the technical issues that remain to be solved and the efforts that are being made by NEC for their solution.

At NEC, we will continue the promotion of R&D into advanced technological solutions in the field of optical access and make positive proposals for the promotion of highly reliable systems that will enable us to deal flexibly with the services and applications of the next generation.

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