employing new international standards for an optical network using wavelength division multiplexing (WDM). The OTN based on a 43-Gbit/s channel, a standard proposed by NTT, enables the experimental system to handle 32 channels of GbE (Gigabit Ethernet) signals at high quality without processing the client signal. Furthermore, by applying a bandwidth-efficient line coding (CS-RZ format[*2]) proposed by NTT and based on an automatic dispersion compensation function, NTT Network Innovation Laboratories upgraded the tone modulation of the CS-RZ signal for long-distance WDM transmission at over 1 Tbit/s. In this joint experiment, they will conduct a stability test based on long-term actual use of applications, and verify and evaluate the system design during testing.

*2 CS-RZ (carrier suppressed return to zero) is an optical transmission format appropriate for high-capacity long-haul WDM transmission. It enables easy implementation of automatic compensation technology, which is indispensable for handling transmission impairments after transmission at 43 Gbit/s.

For further information, please contact
Science and Core Technology Laboratory Group
Atsugi-shi, 243-0198, Japan
E-mail: st-josen@tamail.rdc.ntt.co.jp

NTT, NEC, Furukawa Electric, and Mitsubishi Electric Succeed in the World's First Interworking of GMPLS and MPLS

NTT, NEC Corporation, The Furukawa Electric Co., Ltd., and Mitsubishi Electric Corporation conducted the world's first successful demonstration of interworking between legacy MPLS (multiprotocol label switching) for IP network control and GMPLS (generalized MPLS) for next-generation photonic network control. This interworking will produce an economical broadband IP network environment and lead to the smooth introduction of the next-generation high-speed flexible backbone network without demanding changes to the existing IP and MPLS network configurations. It will also enable the novel high-speed and flexible network services offered by GMPLS technology to be provided in addition to existing IP and MPLS services. This demonstration was performed at the Photonic Internet Lab (PIL)[*1] where these four companies took part in the planning.

This interworking experiment was demonstrated from October 26 to 28, 2003 at an exhibition booth at the international conference MPLS2003 in Washington D.C. In MPLS2003, telecommunication carriers and vendors from around the world debated the novel *de facto* MPLS technology, which is an advanced IP network control technology used to provide IP VPN services.

Background

Due to the explosive increase in the number of Internet users and various new services, traffic volume is doubling every year. This trend will continue because new network applications like VoIP (voice

*1 Photonic Internet Lab (http://www.pilab.org/). PIL, which was founded in September 2002, is promoting research and development of next-generation photonic network technologies. It encourages the submission of proposals from its members to global standardization bodies like ITU-T, IETF, and OIF. It also tests photonic network control programs developed by PIL member companies. This experiment directly supported these goals. At present, PIL consists of seven companies: Fujitsu Ltd., Oki Electric Industry Co., Ltd., and Hitachi Ltd. joined after the four companies mentioned above. PIL activities are supported by the R&D support scheme of the MPHPT (Ministry of Public Management, Home Affairs, Posts and Telecommunications) for funding selected IT activities.

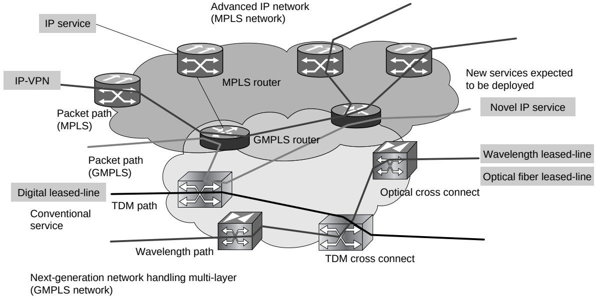

Fig. 1. Schematic of next-generation network and services over various paths.

over Internet protocol) and video on demand are emerging. These types of services are difficult to achieve on the existing best-effort-type IP network. Accordingly, enterprise users, which employ various network applications, utilize dedicated network services like IP-VPN[*2] and Ethernet as well as leased-line service. This suggests the need for an adaptive network control mechanism that offers various transmission speeds and levels of communication quality to support user demands and new applications in the next-generation network. MPLS[*3] and GMPLS[*4] are the key technologies to achieve this adaptive network control mechanism (**Fig. 1**).

MPLS controls traffic in the IP network. Using the circuit switching concept seen in the telephone network, it establishes and handles traffic flows that satisfy different service quality demands. At present, MPLS technology is being used to manage traffic by Internet service providers and to provide IP-VPN services.

GMPLS is a new control technology designed for the next-generation photonic network. It extends the MPLS concept from the circuit switching network to the optical fiber network. It enables unified control management of the network layers (packet, TDM[*5], wavelength, and optical fiber). Its use can unify network operations which will yield significant reductions in network operation costs. Moreover, it will enable optical wavelength leased-line service in which users can freely change destination and quality.

The proposed MPLS-GMPLS interworking technology will enable the next-generation network to be introduced smoothly without any existing IP network equipment needing to be altered.

Technical points

PIL succeeded in seamlessly connecting an MPLS network and a GMPLS network by using GMPLS routing and signaling technology. The trial network setup is shown in **Fig. 2**.

(1) Roles of the four companies

The GMPLS domain consists of a photonic

*2 An IP-VPN offers a virtual private network on the Internet protocol network.

*3 MPLS is a packet transmission control technology for the IP network.

*4 GMPLS (generalized multiprotocol label switching) is a protocol that establishes generalized MPLS in all layers of the IP network: layer 2, TDM (time division multiplexing), wavelength (WDM), and the fiber. The basic MPLS is a control mechanism that attaches fixed-length labels to IP packets. GMPLS is attracting attention for controlling the next-generation photonic network. Standardization of GMPLS is being advanced mainly by IETF (The Internet Engineering Task Force). The basic functions of GMPLS were released as a Proposed Standard in February 2003, with registration number RFC 3471-3473. In order to make it a complete and truly practical protocol, world-wide efforts are needed to elaborate the remaining details and develop protocol code that can be directly installed in network equipment.

*5 TDM: Transmitting technology using time division multiplexing. One example is SDH/SONET, which is used widely in many networks.

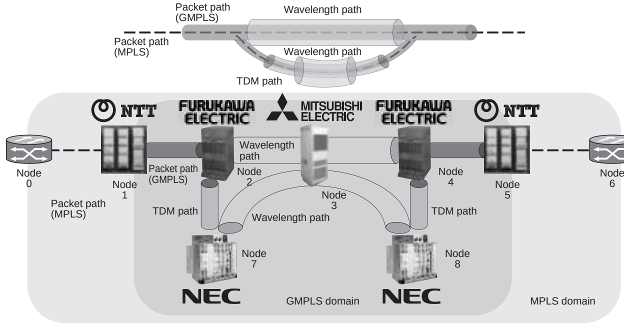

Fig. 2. Setup for PIL interoperability test.

MPLS router*6 (IP/wavelength) from NTT, a digital cross connect (TDM/wavelength) from NEC, a GMPLS-supporting MPLS router (IP/TDM/wavelength) from Furukawa Electric, and an optical cross connect (wavelength/fiber) from Mitsubishi Electric. Only the control parts of these components were examined. Control software that can handle at least two layers was developed and implemented by each company. The terms in parentheses above indicate the function and layer handled by each company's equipment. All equipment can run a GMPLS-compliant routing protocol (GMPLS OSPF-TE). Each active component advertises the function and layer that it handles. This allows all GMPLS equipment to recognize the layers handled by other equipment.

(2) Progress prior to the trial

Since a wide variety of network equipment (e.g., IP routers and cross connects) will coexist in a GMPLS network, it is essential to verify the interoperability between network equipment from multiple vendors. The four companies had already established a multi-layer GMPLS signaling technology using the GMPLS signaling protocol (GMPLS RSVP-TE). That trial verified cooperation between GMPLS routing and signaling technologies. The multi-vendor GMPLS network environment successfully demonstrated that equipment information could be exchanged and that a GMPLS communication path could be set up.

(3) Results of this trial

This trial examined the interworking between MPLS and GMPLS networks using a newly developed routing interworking function. **Figure 3** shows a schematic of the interworking mechanism between the MPLS and GMPLS networks. This interworking mechanism has been proposed by NTT as an IETF internet-draft. In the GMPLS network, the GMPLS link information of each node is advertised by the GMPLS routing protocol. Unfortunately, conventional IP and MPLS routers cannot correctly recognize this GMPLS link information. To overcome this problem, the GMPLS edge routers that are directly connected to conventional MPLS routers (G1, G3, G5, and G7), translate and advertise the GMPLS information to the MPLS routers. This means that the MPLS domain side recognizes nodes G1, G3, G5, G6, and G7 as MPLS routers and the link states in the IP layer are advertised among the MPLS nodes. This approach allows the MPLS side to

*6 Photonic MPLS: In the legacy MPLS, an additional header in the IP packet or the path/channel discernment of asynchronous transfer mode is used as an MPLS label. As a concept, Photonic MPLS subsumes the MPLS technology of using wavelength as a label and the future optical IP technology of adding label headers based on optical signaling to optical IP packets.

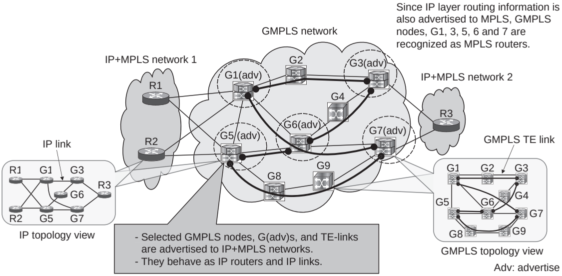

Fig. 3. IP+MPLS and GMPLS interworking.

recognize not only the GMPLS nodes directly connected to the MPLS domain, but all nodes inside the GMPLS domain. GMPLS domain resources can be efficiently managed from the MPLS domain, such as shortest path setup and traffic control. In our trial, only NTT and Furukawa nodes could handle the IP layer across the GMPLS domain (Fig. 2). This technology provides easy extension of the GMPLS network to the legacy MPLS network. The precise routing information of the MPLS network can be transmitted across the multi-vendor GMPLS network, which confirms the practicality of this technology.

Future plans

PIL is planning to conduct interoperability tests with a number of global companies, although the present trial was performed using control software of only PIL member companies.

For further information, please contact
NTT Science and Core Technology Laboratory Group
Atsugi-shi, 243-0198, Japan
E-mail: st-josen@tamail.rdc.ntt.co.jp