Activities of Photonic Internet Laboratories

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Summary

Photonic Internet Lab. (PIL) is shooting for the leading edge photonic-GMPLS (Generalized Multi-protocol Label Switching) that utilizes wide-band, cost-effective photonic technology to implement IP-centric managed networks. PIL is a consortium for researching the GMPLS protocol and advancing a de facto standard in this area. Members make leading edge GMPLS code modules and test them at the lab site. The experimental results, new ideas, and protocols are contributed to standardization bodies such as IETF and OIF. This paper also describes the world's first trial of GMPLS /MPLS interworking using multi-route, multi-vender signaling.

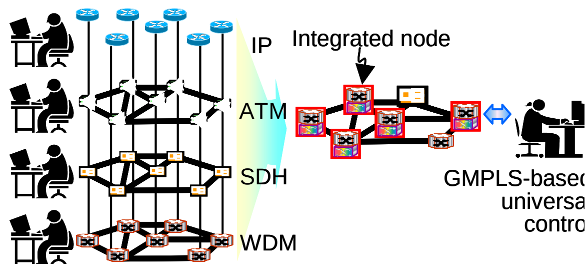

Fig. 1 GMPLS-based universal control

1. Introduction

The popularity of broadband access services is dramatically raising the amount of Internet backbone traffic. Broadband access is now adopted by more than 10 million users in Japan via ADSL (Asymmetric Digital Subscriber Line) and FTTH (Fiber To The Home) technology. These high-speed subscribers are stimulating new broadband services including content delivery such as still and moving pictures, and VoIP services. It couses IP traffic is about double every year.

Fortunately, MPLS (Multi-protocol Label Switching) realizes reliable and managed networks that offer Multi-QoS capability [1]. To meet the growth in traffic, the photonic MPLS, the GMPLS protocol, and its extension have been proposed [2, 3]. In addition, new breakthrough optical device technologies such as the PLC (Planar Lightwave Circuit) and MEMS (Micromachine Electro Mechanical System) have been developed WDM and photonic GMPLS. These technologies are now being prepared for service introduction.

To meet the traffic demands, we started researching on GMPLS future networking to advance three breakthroughs.

The first is universal operation system that integrates IP, ATM, Ethernet, SDH, and WDM. GMPLS can realize a universal control mechanism for all those layers. In addition, its universal operation mechanism provides multi-layer (multi-region) switching that can integrate several layer switching capabilities (Fig. 1). It creates not only low cost operations but also flexibility for multi-layer resource control.

The second is multi-layer (region) integrated resource control. This is realized by the unified signaling / routing protocol of GMPLS. Conventional resource control is realized individually, layer-by-layer. That means each layer optimizes each resource independently. However, GMPLS provides a unified routing and signaling protocol, so each node can know all layer resource information and can control any layer path as shown in Fig. 2 [4]. In Fig. 2, OLSP stands for optical label switched path. IP traffic demand between routers i and j is shown as R_{ij} and optical path resource between optical routers k and l is shown as O_{kl}. In addition, GMPLS also provides a unified signaling protocol, so any layer devices can be control by edge node. This multi-layer control can dramatically reduce the network resources needed.

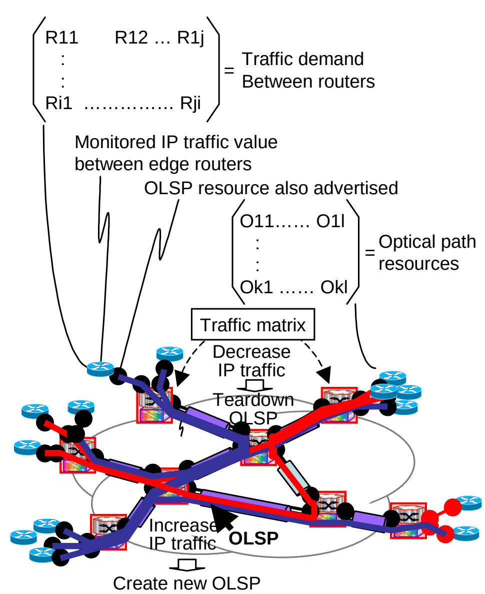

Fig. 2 Multi-layer (region) resource control that combines IP traffic and OLSP residual resources

The third is the optical transparent path that is a mid to long term target. This path is realized without any complicated electrical operation such as re-timing, re-shaping, or re-generating. In addition, SDH functions such as error monitoring, frame recovering and monitoring are also omitted. The optical signal is transparently handled in a photonic layer. This means that the photonic GMPLS network can create a combination of Layer 3 forwarding, λ relay, and transparency adaptively.

The adaptive optical transparent path is shown in Fig. 3 [5]. Layer 3 forwarding is used if traffic is relatively small and IP level aggregation is used if necessary. On the other hand, optical cut through paths are created if traffic loads are heavy. Such paths attempt to use the same wavelength dispense with wavelength conversion and 3R-functions. This would dramatically reduce network cost as shown in Fig. 3. In Fig. 3, 0 % through traffic using OLSP represents a pure IP router network. In this case, there is no optical cross-connect system or wavelength converter in the network. On the other hand, 100 % through traffic using OLSP represents an all optical cross-connect network. This network does not use any IP router. According to our evaluation result, 70 % OLSP cut-through is possible and yields a 70 – 80 % cost reduction. This is another very important target for photonic GMPLS.

To create these three photonic GMPLS technologies and protocols, PIL started to submit contributions to standardization bodies. They include ITU as well as IETF and OIF.

PIL consists of two working groups, Technical Testing WG and Standardization Strategy WG. These activities are done at NTT Musashino Labs. and CRL Keihanna Labs [3]. The following section will provide details of the activities and the structure of PIL.

2. PIL organization

Photonic Internet Laboratory, PIL, was founded in September 2002 to promote research on and development of the next-generation photonic network and to encourage global standardization activities. PIL currently consists of seven companies: Nippon Telegraph and Telephone Corp. (NTT), NEC Corporation, Fujitsu Laboratories Ltd., The Furukawa Electric Co., Ltd., Mitsubishi Electric Corporation, Oki Electric Industry Co., and Ltd., Hitachi, Ltd, and Keo Univ. PIL activities are supported by research and development aimed at establishing international technical standards as part of the Strategic Information and Communications R&D Promotion Scheme of the MPHPT (Ministry of Public Management, Home Affairs, Posts and Telecommunications), which is funding selected IT activities [6, 7].

PIL consists of two Working Groups (WGs). Technical test WG tests leading-edge protocol code modules developed by member companies. On the other hand, the standardization strategy WG is responsible for technical discussions on standardization proposals. It has submitted 8 standardization proposals to IETF and OIF as of Oct 2004. All the contributions are posted on PIL's WWW site [8].

The framework of the standardization strategy WG is

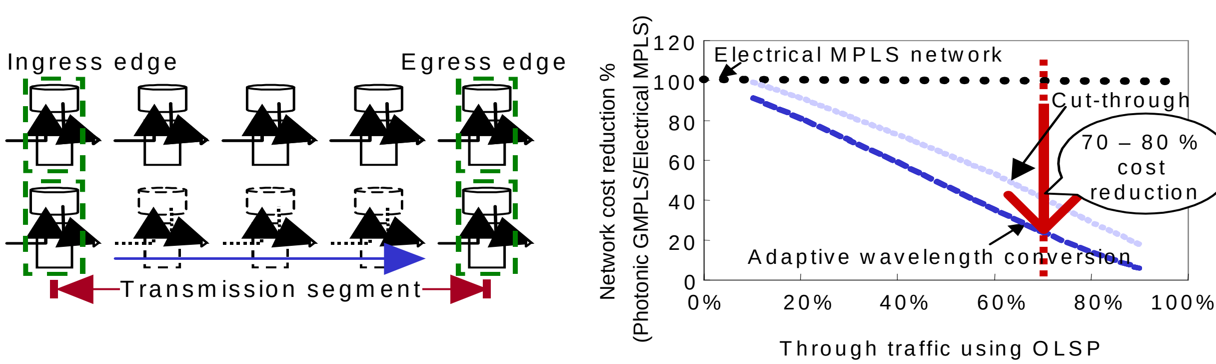

Fig. 3 Adaptive optical transparent path and its effectiveness

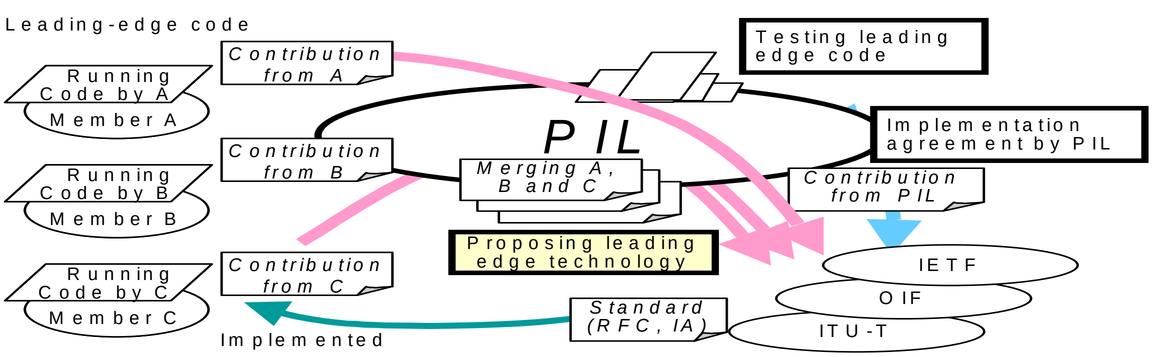

Fig. 4 PIL's Standardization approach

shown in Fig. 4. As shown in Fig. 4, each member company researches and develops new ideas, protocols and running code modules. The topics tackled by PIL are organized by the steering committee. Each proposal is discussed and tested by PIL.

3. Leading Edge Code testing

3.1 Multi-layer (multi-region), multi-route, and multi-vendor testing.

PIL members, NTT, NEC Corporation, Fujitsu Laboratories Ltd., The Furukawa Electric Co., Ltd., and Mitsubishi Electric Corporation successfully concluded the world's first GMPLS signaling interoperability test using a multi-layer (region) network consisting of packet, TDM, wavelength, and fiber layers. Given the quality requirements set by the application or traffic state, it is possible to select the appropriate communication path from among all possible paths that can be established on the multi-layer network [9, 10].

If the cross-connect equipment supports GMPLS control, a path can be set up by exchanging control packets between these control devices as well as IP routers. Therefore, a network operator who has IP expertise can manage both IP/MPLS router and cross-connects.

In the demonstration, control software programs for setting up and releasing paths in the multilayer network were newly developed and installed in the network control devices of each company. The fact that these control devices could be mutually interconnected is a key factor in the success of the interoperability test that examined path setup of multilayer signaling: a world first. These control devices exchange signals based on the protocol RSVP-TE [11], extended to GMPLS, to set up and release multilayer paths on the multilayer network.

The test setup is shown in Fig. 5. It was designed to replicate a multilayer network with various kinds of network equipment including packet routers, electrical connections, optical cross-connects, and optical switches for fiber port switching. The devices are listed in Table 1. Each system's control plane was ported to a personal computer, PC and tested.

The multi-layer, multi-route test established two routes: route-A and route-B. Route-A is a packet path and route-B is a TDM path. Both paths are initiated by device 1 and terminated by device 7.

The experiment was realized as follows. It provides control functionality for both packet and TDM paths using control devices 1 and 7. Control device 1 can freely set the packet path of route A and the TDM path of route B. Control device 2 on Route A has path control functions or switching capability for both packet and wavelength paths. Control devices 2 to 6 are for optical cross-connect function, and so can set up the wavelength paths. They newly set up a wavelength path for the packet path from devices 1 to 7. Thus, the setup and release of a multilayer path can be performed by exchanging a control signal among all the control devices handling a particular layer.

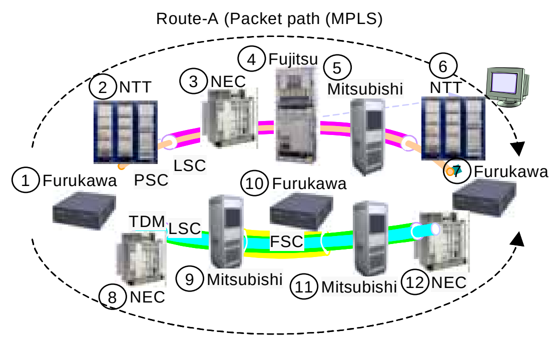

Fig. 5 PIL's GMPLS C-plan interoperability testing demonstration configuration

3.2 MPLS / GMPLS interworking

Fig. 6 shows that the MPLS / GMPLS interworking test configuration consists of MPLS electrical routers and different GMPLS sets. The conventional network is already employing the MPLS protocol but traffic loads are increasing rapidly. The preferred response is to employ GMPLS multi-region (Multi-layer) operation with on-demand cut-through between MPLS regions.

The GMPLS Edge router selects a suitable path having multi capability such as SDH / SONET and WDM.

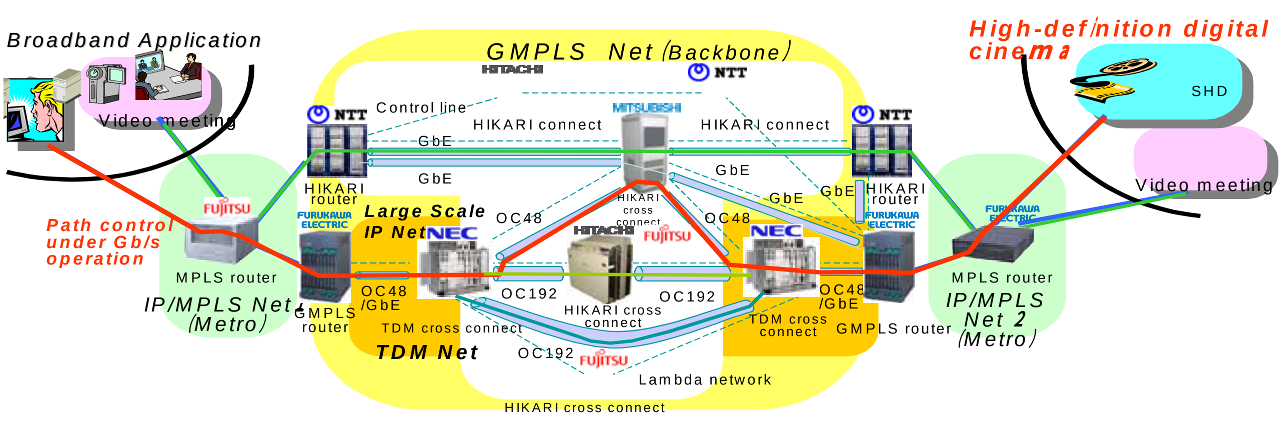

Fig.6 MPLS / GMPLS interworking test structure

We note that routers in the conventional MPLS router network have no special function for GMPLS control. In other words, the GMPLS edge router provides an MPLS emulated path between MPLS areas. GMPLS traffic parameters are converted into the equivalent MPLS metrics that can be handled by the conventional MPLS router.

For confirm MPLS / GMPLS interworking, PIL first successfully transferred high-definition TV through a QoS guaranteed path. This demonstration also verified GMPLS restoration. The new restoration method and the MPLS / GMPLS interworking protocol have been proposed to IETF for standardization.

4. Future works

Most PIL activities are discussed openly on our WWW site and in the press. Some however involve confidential know-how and shared only among members.

PIL is proceeding in two directions. One is globalizing our standardization efforts, and the other is conducting real field trials. Because basic GMPLS code modules are being standardized by international standardization bodies, tests on leading edge code modules and interoperability tests must be performed globally. To realize this, PIL is collaborating with the global standards test consortium, ISOCORE [14]. Some test items are shared and also results are exchanged. In addition, PIL has become a test user of the CRL Keihanna open laboratory [15] that has WDM national wide network. PIL will test newly developed GMPLS protocols on the national wide network. In addition, GMPLS base restoration [17, 18] and management for GMPLS are next topics for PIL standardization and test.

5. Conclusion

The Photonic Internet Lab. (PIL) was founded by Nippon Telegraph and Telephone Corporation, NEC Corporation, Fujitsu Laboratories Ltd., Furukawa Electric Co., Ltd., Mitsubishi Electric Company, Oki Electric Industry Co., Ltd., Hitachi, Ltd. and Keio University for achieving global standards and leading-edge technologies.

Its targets include GMPLS, a combination of photonic technology and multi-layer, managed control. PIL is active in advancing GMPLS standardization and conducting tests on leading edge code modules. The two working groups are testing and contributing new leading edge GMPLS protocols.

In addition, PIL members have successfully developed and demonstrated the world's first MPLS/GMPLS interworking having multi-layer, multi-route and multi-vendor GMPLS signaling capability.

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