Photonic-GMPLS Leading Edge Code Research Consortium :

Photonic Internet Lab. (PIL)

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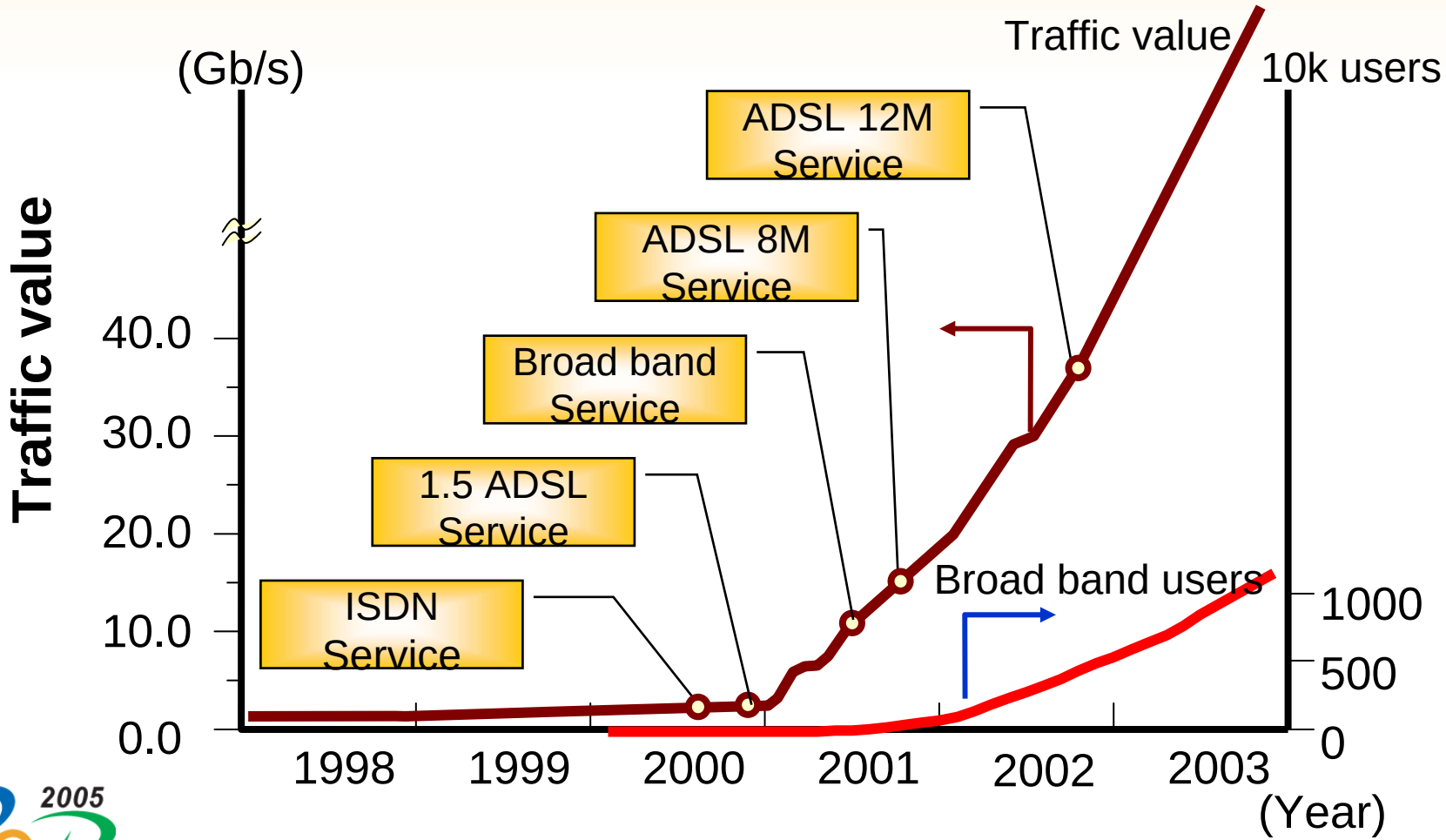
http://www.pilab.org

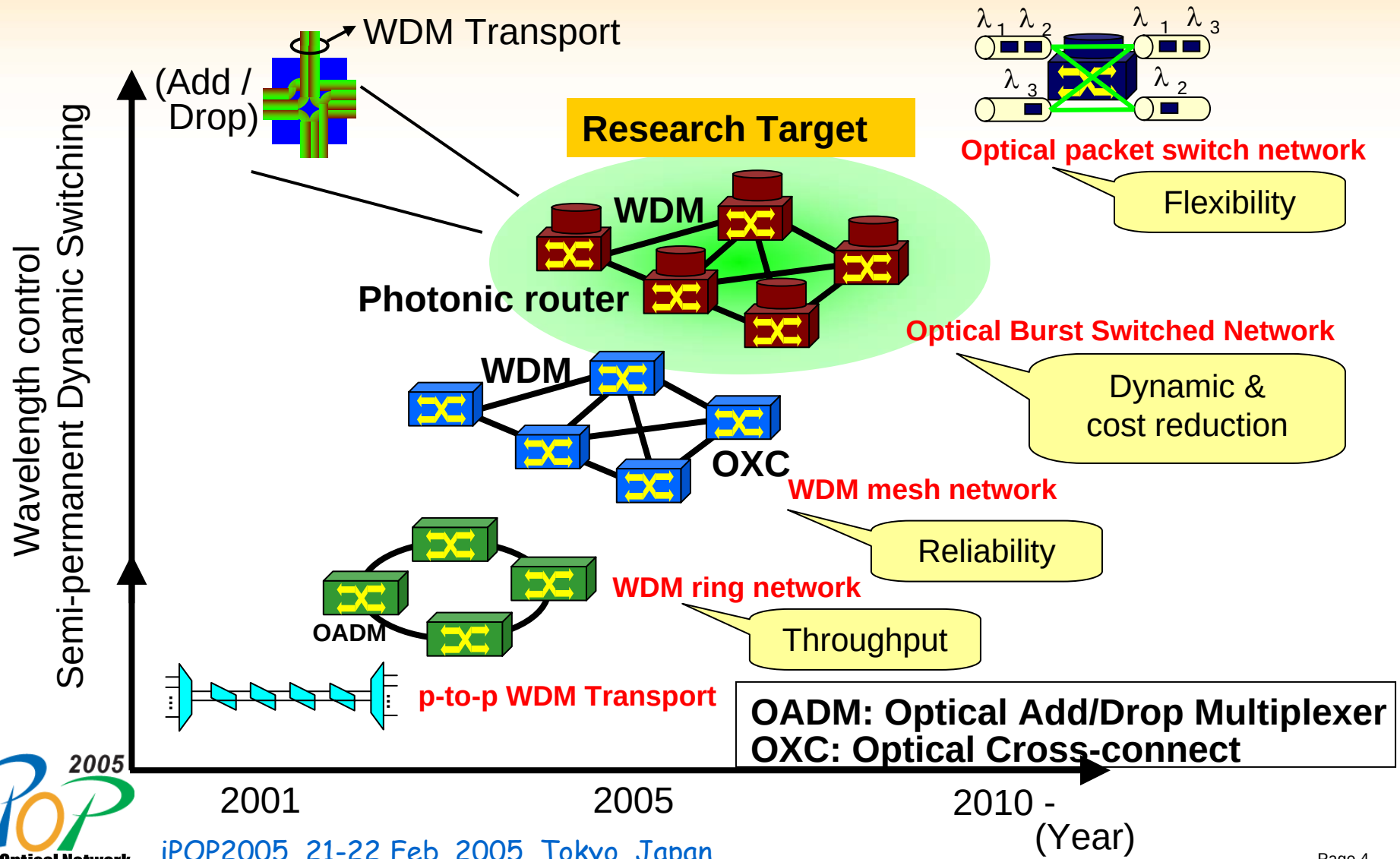
Outline

- **Introduction**
- PIL: Photonic Internet Labs.
  - Mission & Organization
  - Multi-layer, Multi-route & Multi-vender experiment
  - MPLS / GMPLS Interworking
- PIL member activities
- iPOP2005 GMPLS showcase and workshop
- Conclusion

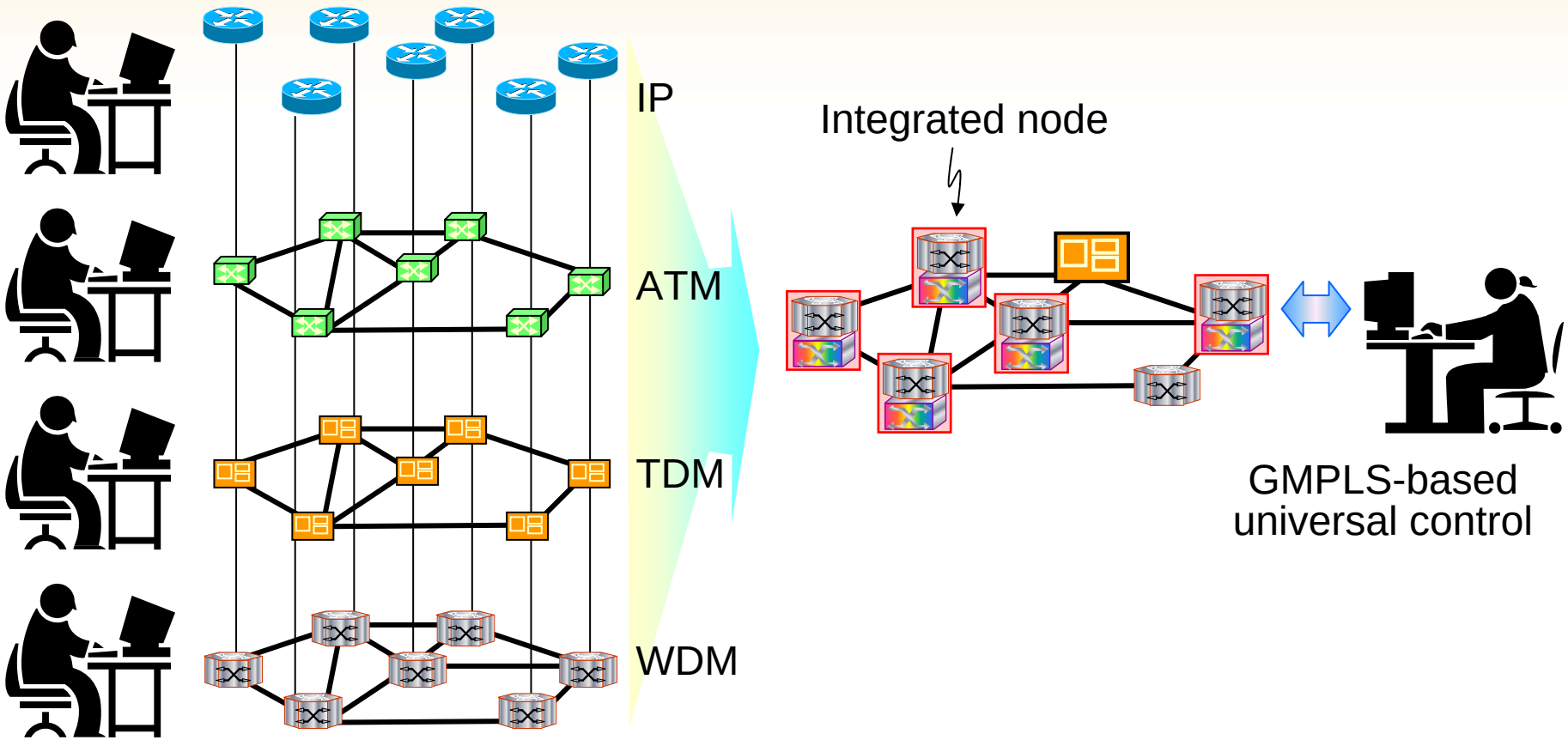
Domestic backbone traffic demand



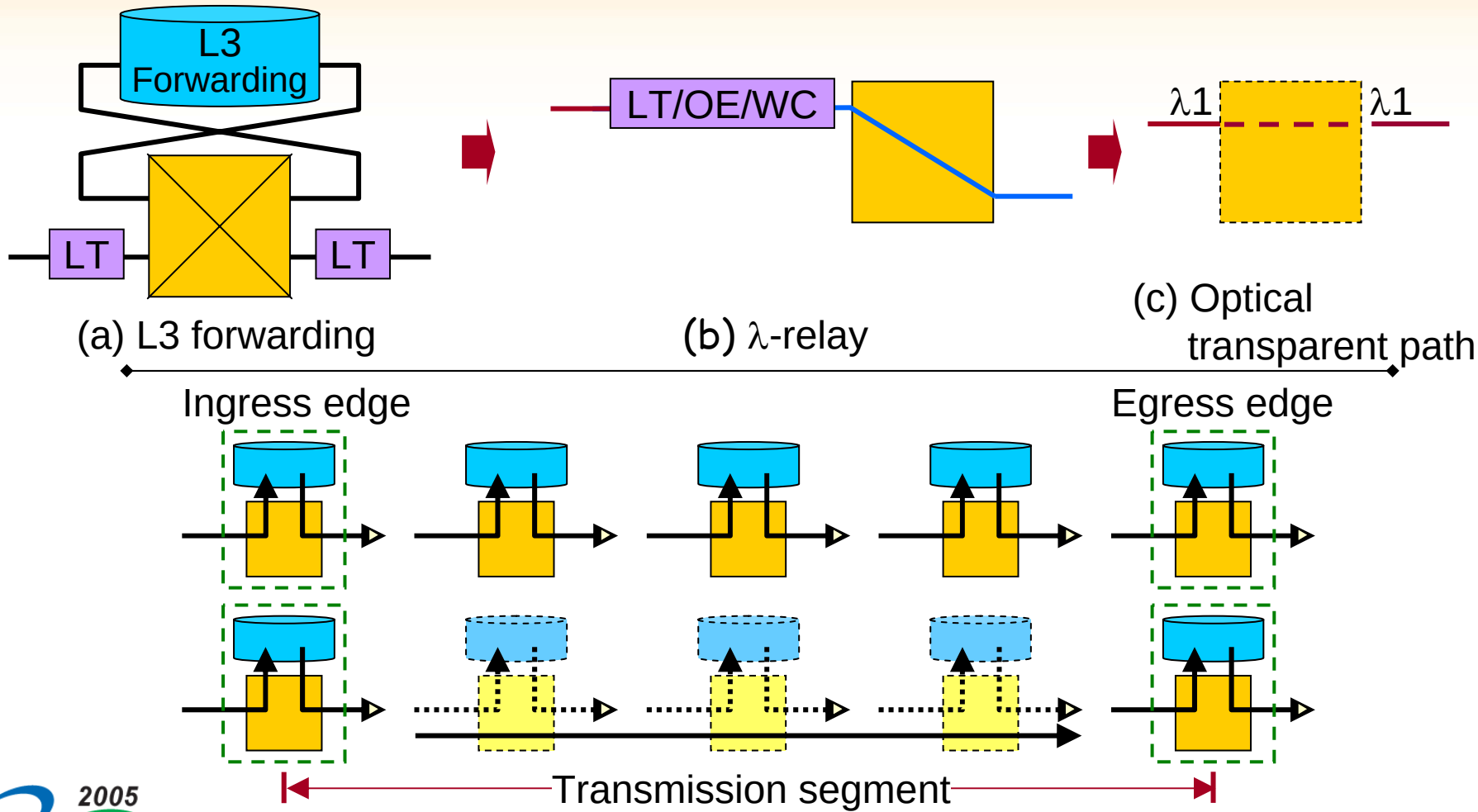
Trend on Optical Switching network



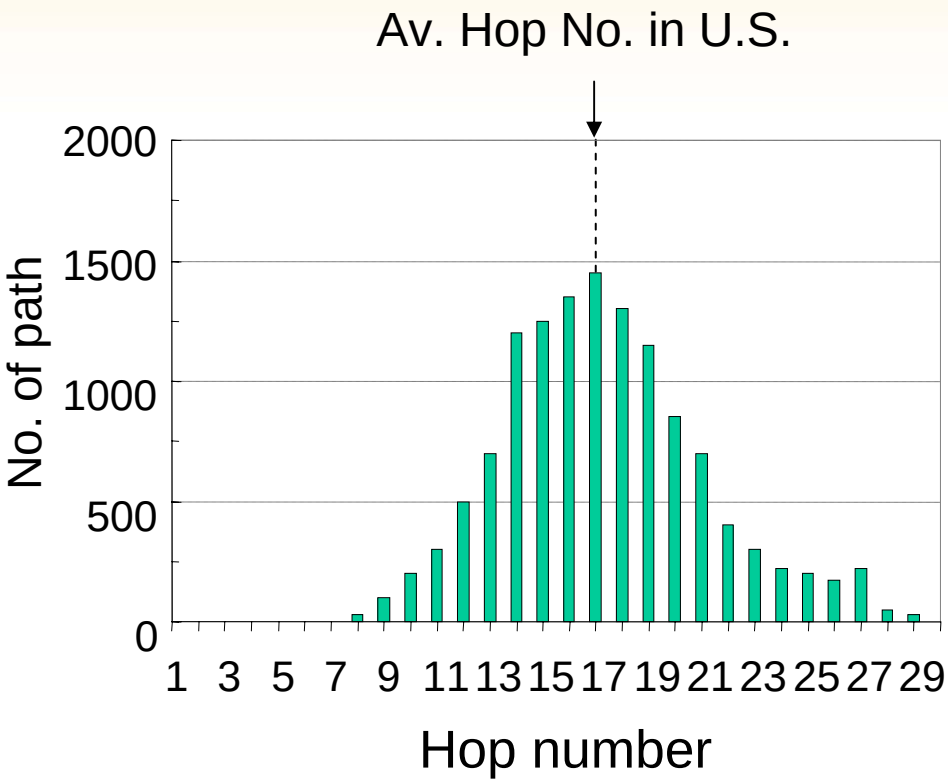
[A] Universal control

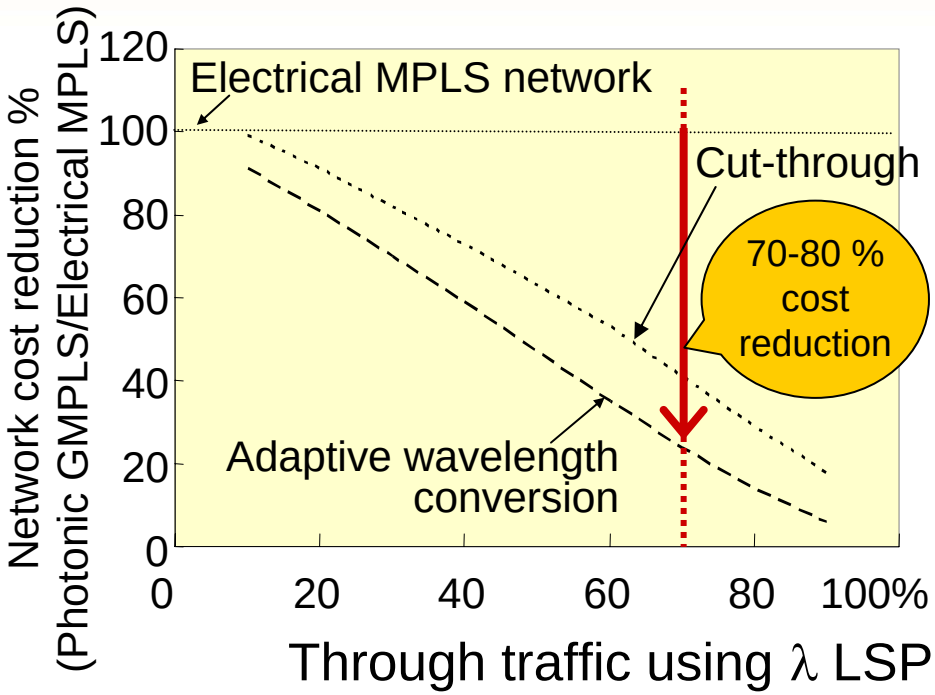


Optical Transparent path

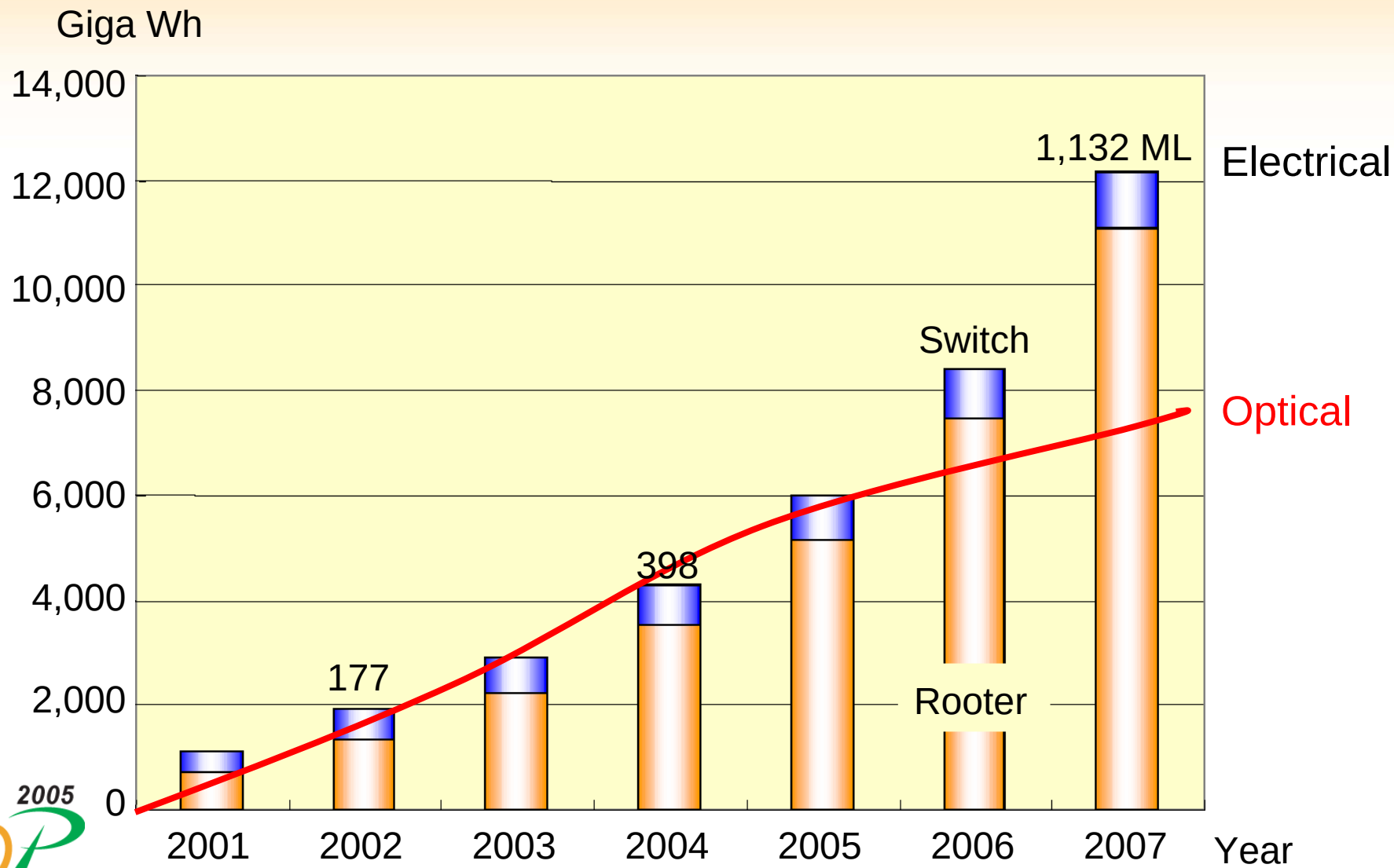


Effectiveness of the optical cut-through

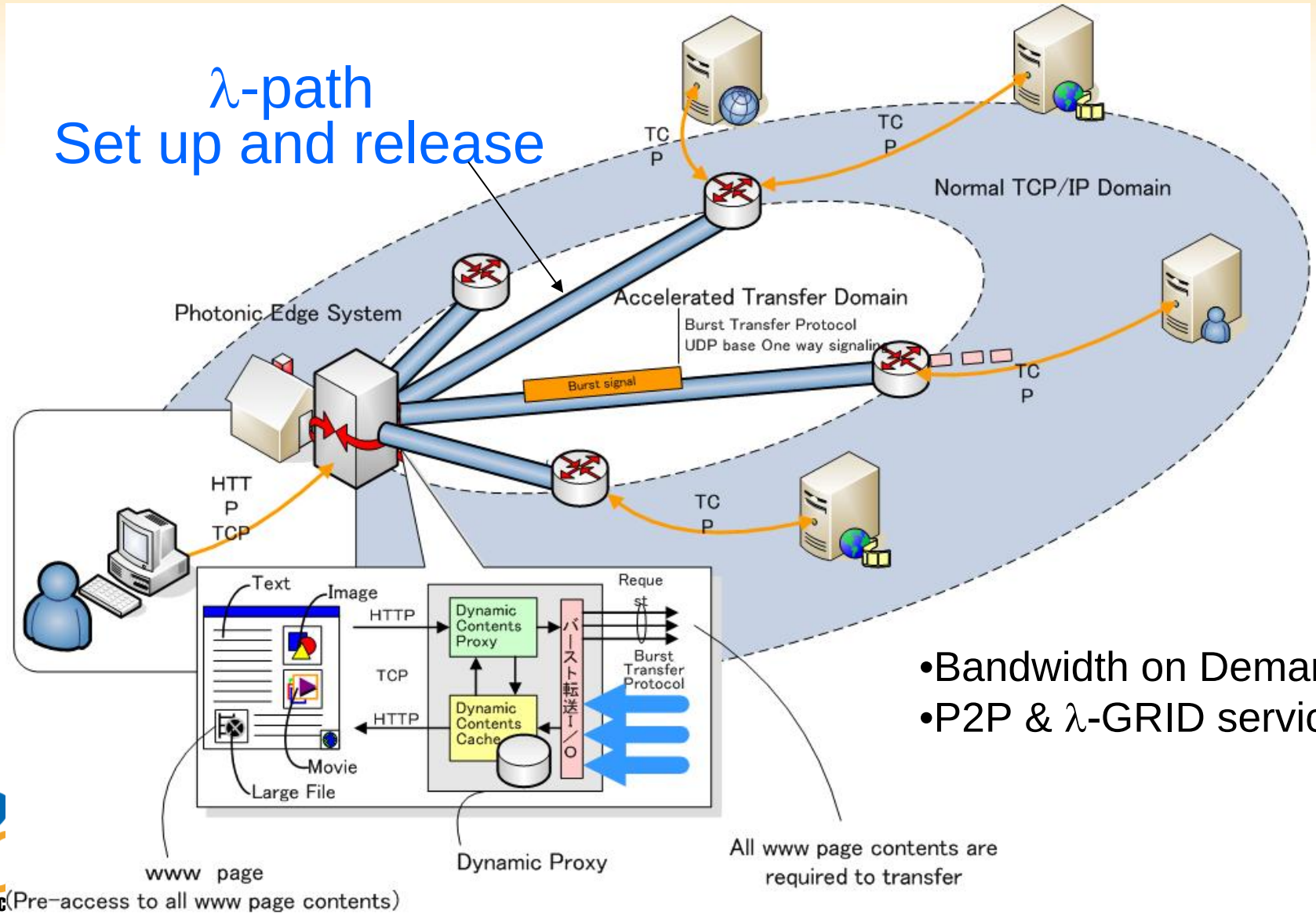




Total power consumption of the network node



Creation of new service

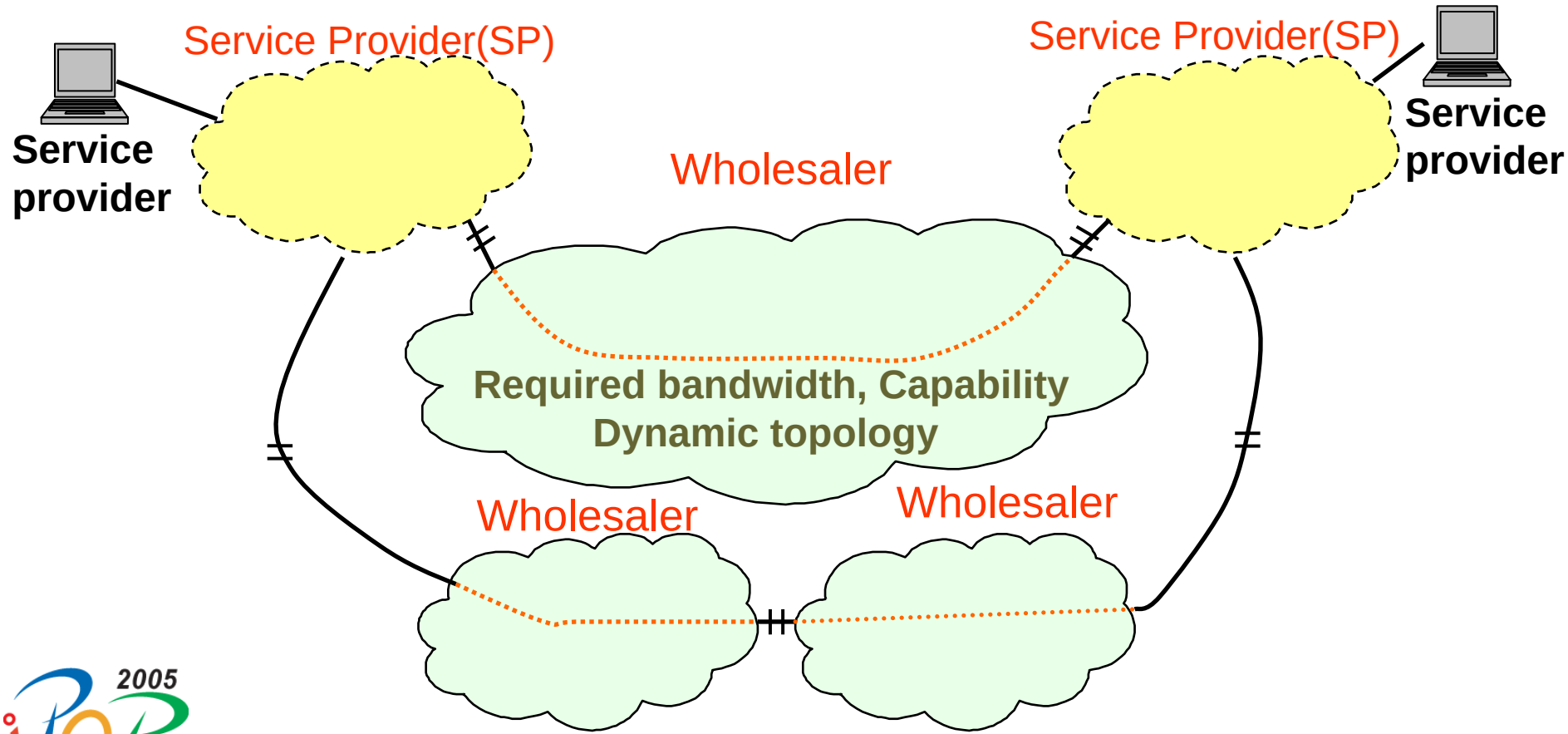


- Bandwidth on Demand
- P2P & λ-GRID service

(Pre-access to all www page contents)

New service provider service

Dark fiber ⇨ Dark network service



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Member Companies

- Keio University
- Nippon Telegraph and Telephone Corporation
- NEC Corporation
- Fujitsu Laboratories Ltd.
- Furukawa Electric Co., Ltd.
- Mitsubishi Electric Company
- Oki Electric Industry Co., Ltd.
- Hitachi, Ltd.
- IP infusion

Mission

- PIL is promoting R&D on next-generation photonic network technologies encourages its members to submit proposals to global standardization bodies such as ITU-T, IETF, and OIF. It also tests the photonic network control programs developed by its member companies.
- PIL has two objectives: i) to create new control technologies that can be accepted as international standards and ii) to rigorously test the protocol software code developed by each company.
- Founded in September 2002, 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. and Hitachi, Ltd.
- PIL activities are supported by the research and development aimed at acquiring international technical standards as part of the Strategic Information and Communications R&D Promotion Scheme of the MIAC (Ministry of Internal Affairs and Communications) for funding selected IT activities.

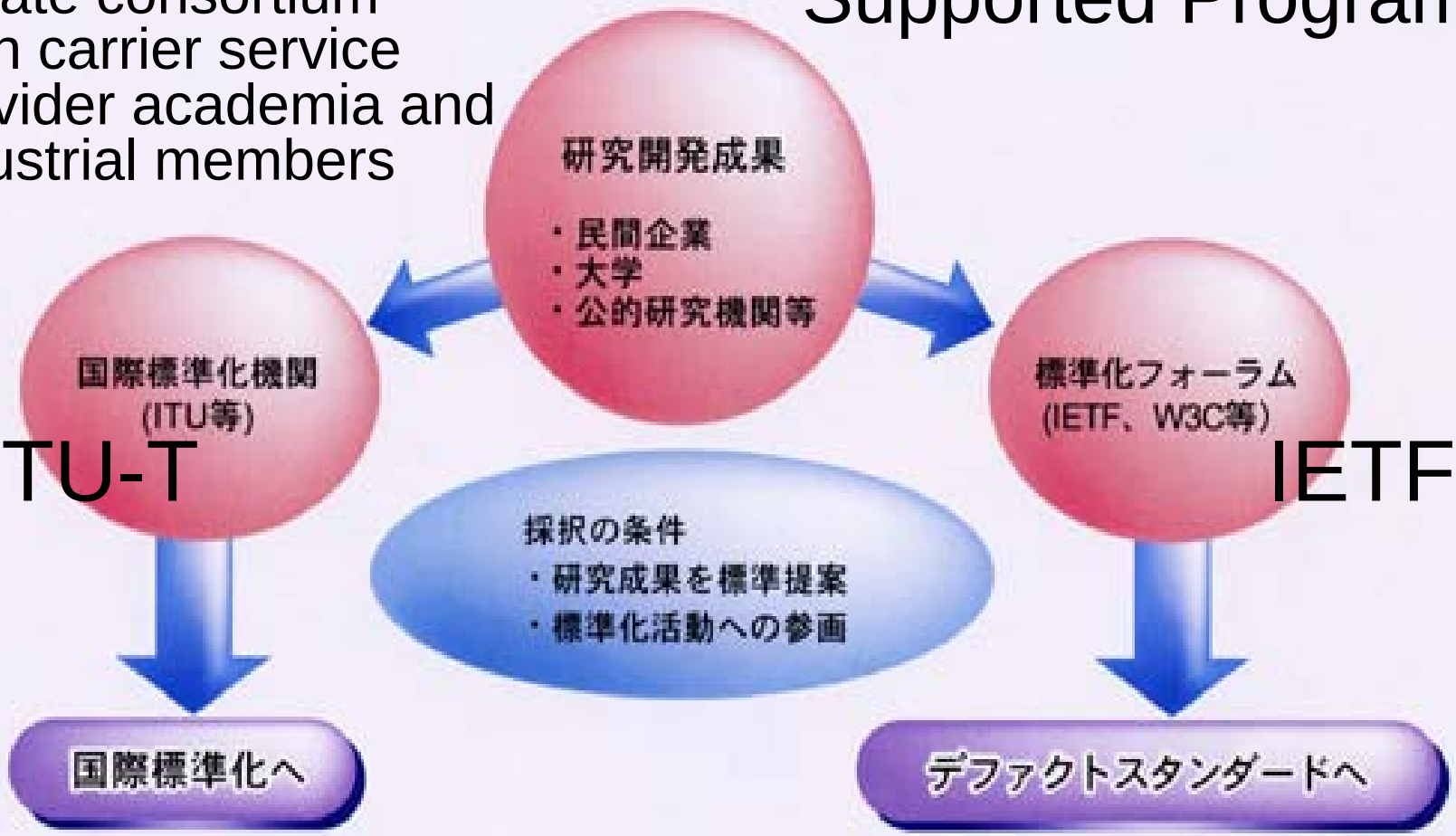
国際技術獲得型研究開発

Global technologies and standardizations

研究成果が実際に活用され社会に普及するためには、新たに開発された技術を市場へつなげる手段である標準化を積極的に行うことが必要です。そこで、国際標準の獲得に必要不可欠な研究開発の課題を公募し、委託研究を実施します。

Create consortium
With carrier service provider academia and industrial members

Supported Program



Organization

Photonic Internet Lab.

Steering Committee

PIL governance

Standardization Strategy WG

Technical arguments on the investigation and discussion of members' standardization proposals and the exploration of technical themes.

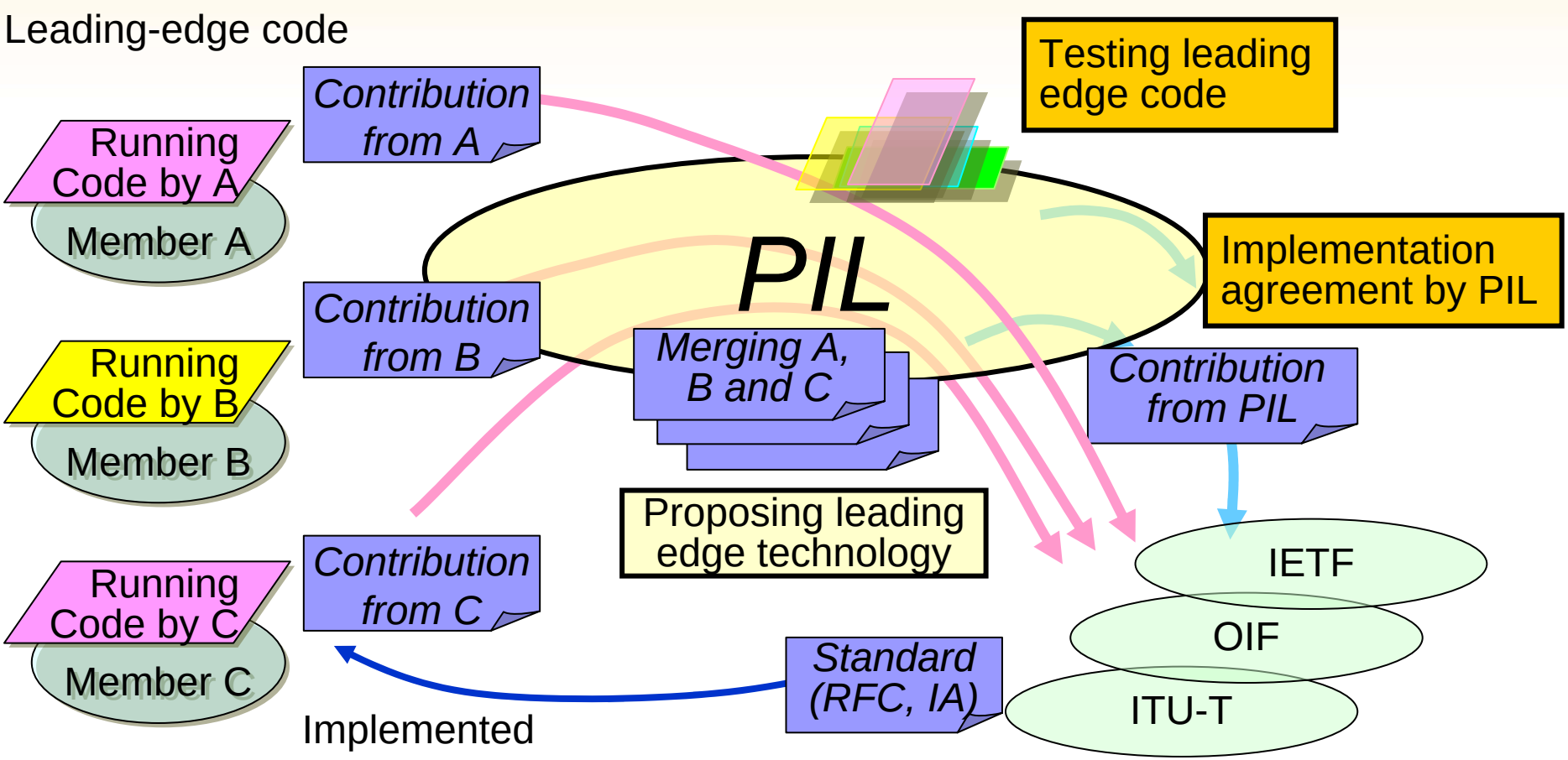
Technical Test WG

Technical testing of the leading-edge protocol codes developed in each company

PIL member Companies

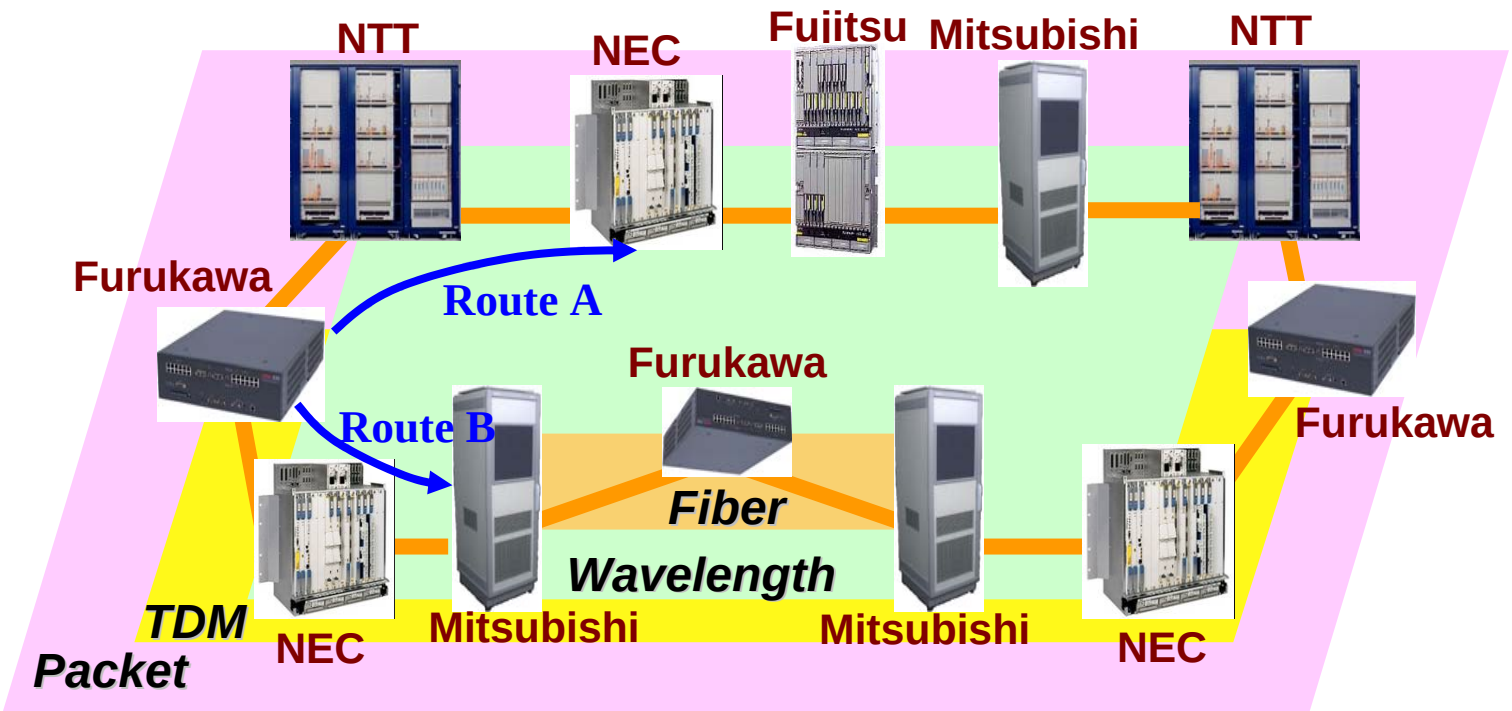
Keio Univ. | Oki | Fujitsu | Furukawa Electric | Mitsubishi Electric | NEC | Hitachi | IP infusion | NTT

PIL activity framework

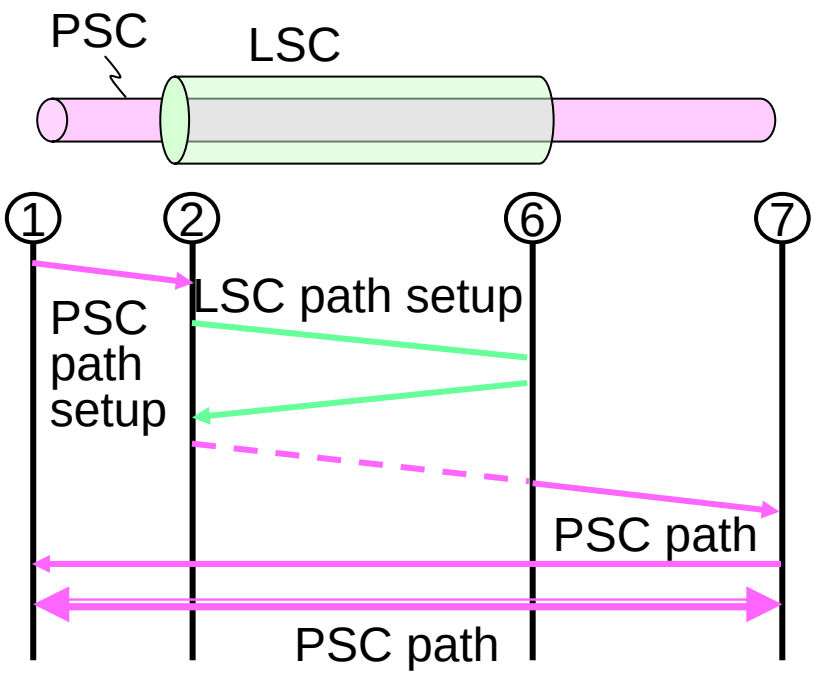


Multi-layer (Multi-region), Multi-vender, and Multi-route GMPLS operation trial

- Interoperability test of **GMPLS control systems**.
- 5 members, 8 types of equipment controllers.



Multi-layer signaling



News Release

- Establishing a Global Standard for the Next-generation Photonic Network
  - TOKYO, May 20, 2003 - NTT, NEC Corporation, Fujitsu Laboratories Ltd., The Furukawa Electric Co., Ltd., and Mitsubishi Electric Corporation are pleased to announce the successful conclusion to the world first GMPLS signaling interoperability test using a multilayer 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 optimal communication path from among all possible paths that can be established on the multilayer network.
  - The results of this experiment were reported on May 22, 2003 in the Workshop held in Kagoshima University organized by the Technical Group on the Photonic-Network-based Internet and the Technical Group of Photonic Switching in the Institute of Electronics, Information, and Communication Engineers of Japan.

ネットワーク

複数レイヤーを統一制御

5NTTなど社 相互接続実験に成功

NTTとNEC、富士通研究所、古河電気工業、三菱電機の五社は二十日、ネットワークにおける複数レイヤー（階層）を統一的に制御・管理し、効率的な信号制御ができる実験に世界で初めて成功したと発表した。

（GMPLS）（汎用化マルチプロトコル・ラベルスイッチング）の成功により、アプリケーションの違いや混雑具合に応じて、複数のレイヤーの組み合わせ方から、通信速度や品質、ネット全体の効率などを考慮した最適経路を設定できるようになる。

従来のネットワークは、パケットやTDM（時分割多重）、光波長、光ファイバーといったレイヤーごとに独自に構築され、各ネットワークに固有の技能を持った運用管理者がそれぞれの制御装置を介してネット運用していた。

GMPLS対応装置は、運用管理手法を統一しただけでIPとTDMレイヤーではこれまで同様にそれぞれ別個に扱うことができなかった。

今回、複数レイヤーの経路設定・解除が可能な制御ソフトウエアを各社で開発し、ルーター、電気クロスコネクト（経路間接続装置）、光クロスコネクト、光ファイバースイッチなどの制御装置に実装して相互接続し、レイヤーが異なる経路を比較して、最適な経路を選ぶマルチレイヤーシグナリングの動作検証に成功した。この実験は、次世代光ネットワークで日本発の世界標準化を推進する活動のなかで行われた。

ーネットでのパケットを交換方式であるMPLSと同様に、IP（インターネットプロトコル）技術を適用したレベルの運用管理者が、装置間の制御や経路設定が定めるようになる。

現行の対応装置は、レイヤーが異なる経路を比較して、最適な経路を選ぶマルチレイヤーシグナリングの動作検証に成功した。この実験は、次世代光ネットワークで日本発の世界標準化を推進する活動のなかで行われた。

科学技術

GMPLS

複数レイヤーで相互接続実験成功

NTTなど5社連合

NTT、NEC、富士通研究所（川崎市、藤崎道雄社長）、古河電気工業、三菱電機は20日、次世代光波ネットワーク用に複数レイヤーに渡って信号経路を設定する相互接続実験に初めて成功したと発表した。次世代の制御用通信手順であるGMPLSで、すべてのネットワークを統一的に扱えるようにした。通信の複雑度合いなどに応じて、異なるネットワークで、最適な経路を効率的に設定可能になる。

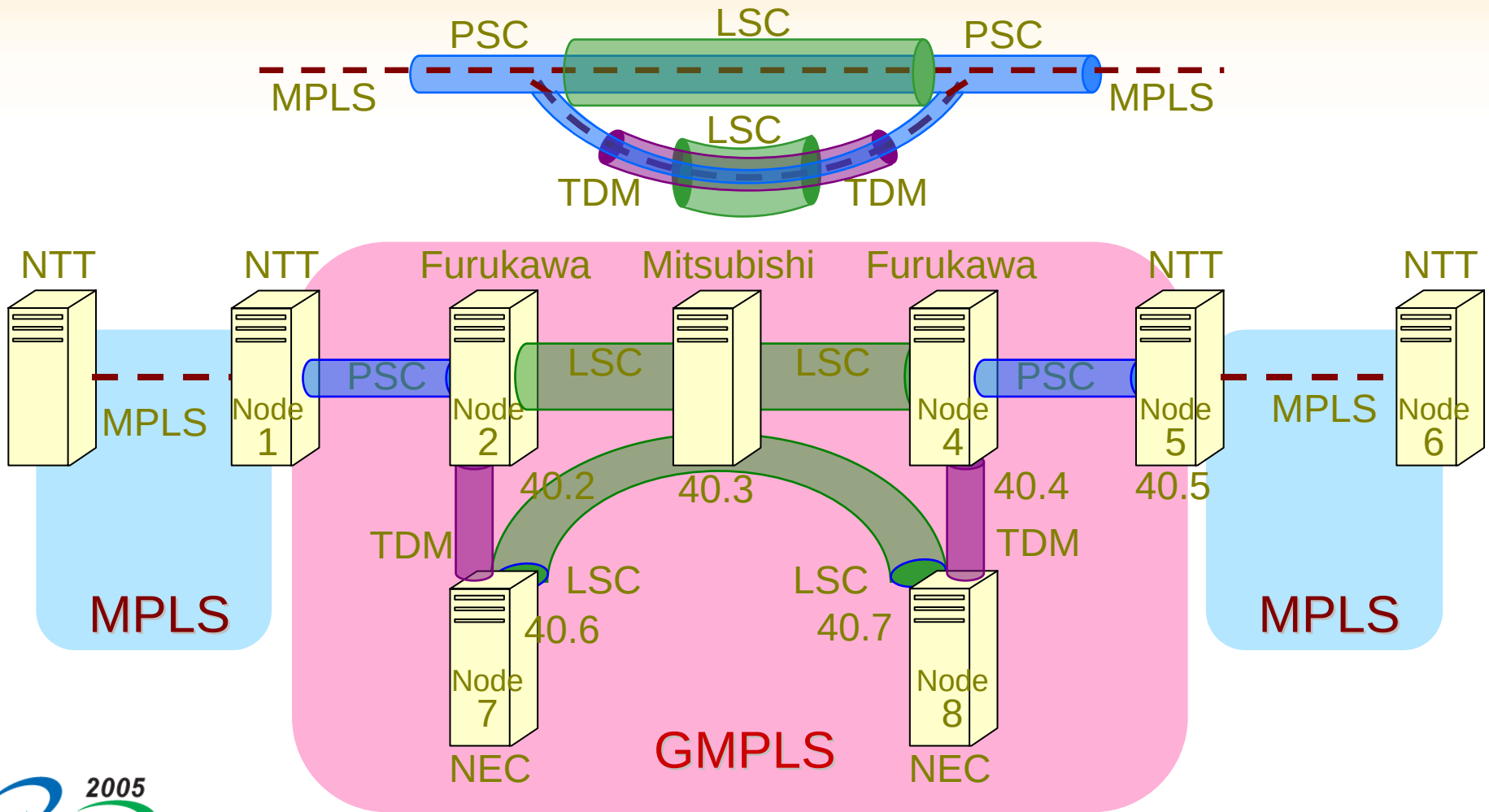
GMPLSは次世代光ネットワークのパケット、時分割多重、光波長、光ファイバーの異なるレイヤーとその経路を統一的に制御管理する。今回、これら複数レイヤーの経路設定・解除を行う制御ソフトウエアを各社で開発、これを実装した装置を相互接続して、レイヤーの異なる経路を設定する複数レイヤーシグナリング動作の検証実験に成功した。

従来のGMPLS対応装置では、運用管理手法を統一しただけで、インターネットプロトコル（IP）と時分割多重や光波長それぞれのレイヤーのネットワークはそれぞれ別個に扱うことしかできなかった。

GMPLSが実用化すると、これまで別に構築し、管理手法もまちまちだったIPや光波ネットワークの管理を統合でき、運用経費の削減が可能になる。また、種々の光波長経路をニーズに応じて接続・変更する光波長単位のような新サービスも可能になる。

この成果は29日に鹿児島市の鹿児島大学で開催の電子情報通信学会研究会で発表する。

MPLS2003 PIL-MPLS / GMPLS demo



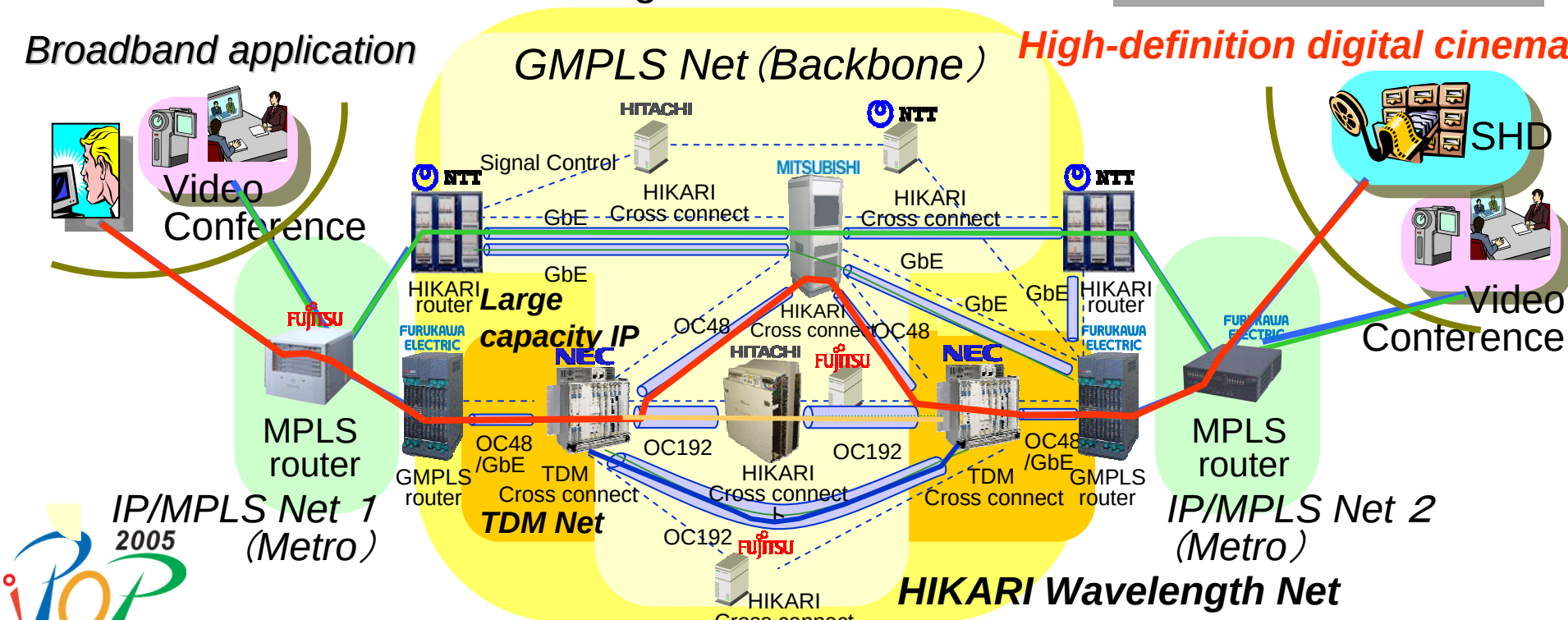
MPLS 2003 International Conference and Exhibits Opens in Washington, DC

- BUSINESS WIRE
- October 27, 2003; McLean, Virginia
- Isocore today announced the opening of the MPLS 2003 International Conference which will provide a forum for leading MPLS vendors, test equipment manufacturers, and premier ISPs to showcase next generation MPLS products and services.

  .....
- **Also participating at the exhibits is NTT Network Systems Laboratories demonstrating world's first Multicast MPLS protocol jointly developed with Motorola. The demo will shows various data distributing scenarios over traffic engineered multipoint LSPs. Additionally, NTT, NEC Corporation, Furukawa Electric Co., Ltd., and Mitsubishi Electric Corporation will highlight PIL's activities.**

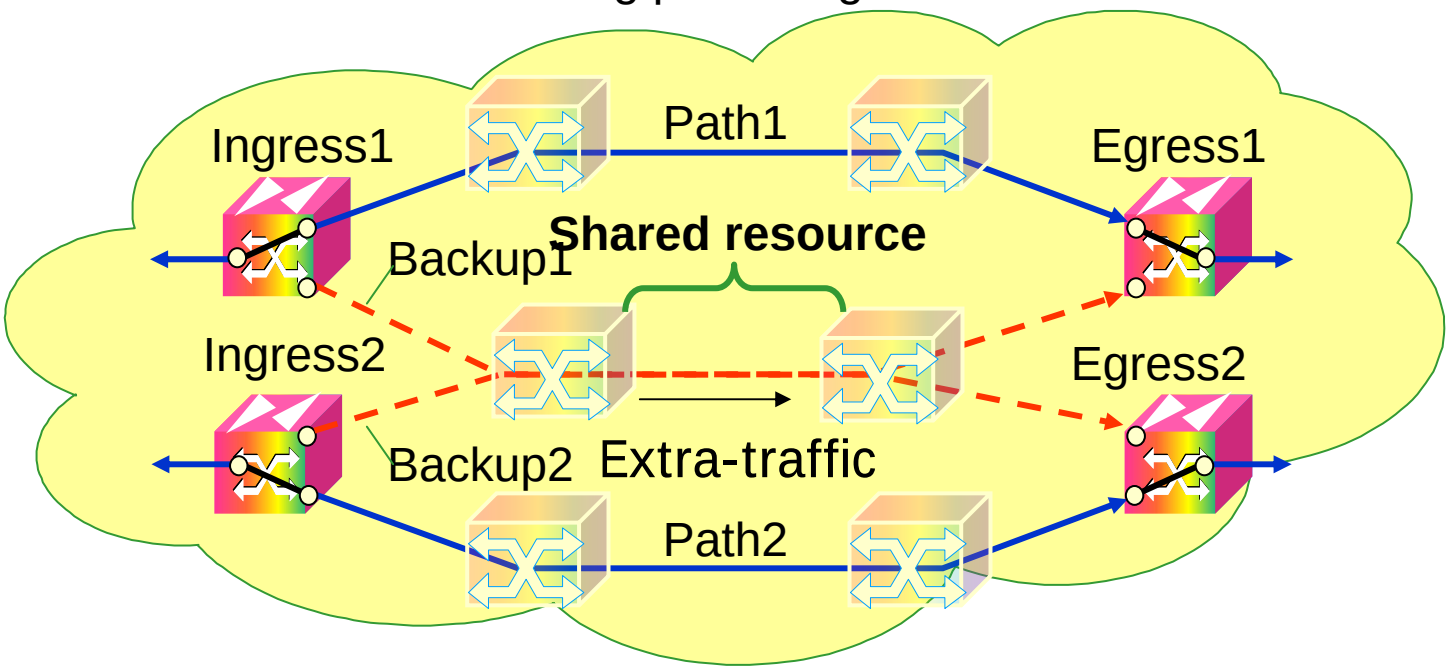
HDTV Video on GMPLS network @ JGN Symposium

- Multi-vender Gbit/sec GMPLS network
  - GMPLS signaling and routing (OSPF, RSVP-TE)
  - High-definition digital cinema transfer
- Automatic restoration
- MPLS/GMPLS interworking



Topics 1 Restoration

- 1+1 Protection
  - Hot standby for Fast restoration
- 1:1 Shared restoration
  - Pre-determined backup route but resources are shared with other route …High-network utilization.
  - draft-pil-ccamp-extra-lsp-0x.txt by NTT NEC Mitsubishi Fujitsu Furukawa
  - Extra class LSP service using protecting resources in GMPLS networks



Topics1　Protection & Restoration (Detail)

Why GMPLS based Recovery?

- **Service provider's view point**
  - ➢Provide services with low operational cost
    - → *Unified mechanism to control heterogeneous network*
- **Customer's view point**
  - ➢Subscribe appropriate service (reasonable cost and reliability)
    - → *Require multiple classes of service (CoS)*

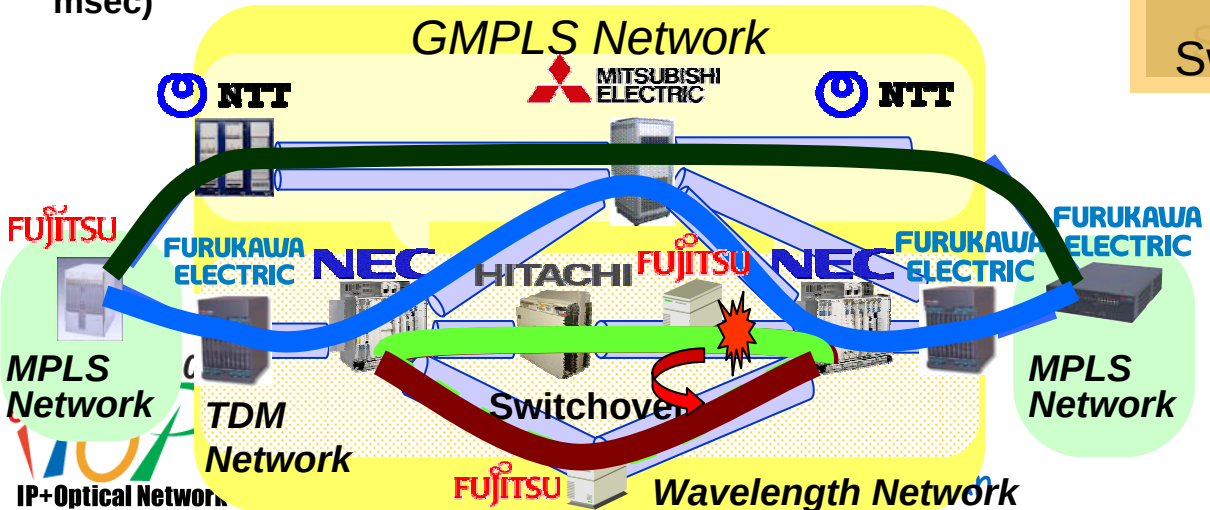
GMPLS can offer a sufficient recovery type to support multiple CoS with achieving unified control of heterogeneous networks.
PIL verified Medium service class using E2E Recovery Signaling

Interoperability Test Results

PIL has successfully demonstrated the wavelength path restoration with E2E Recovery Signaling

- **Recovery time: 420 msec**

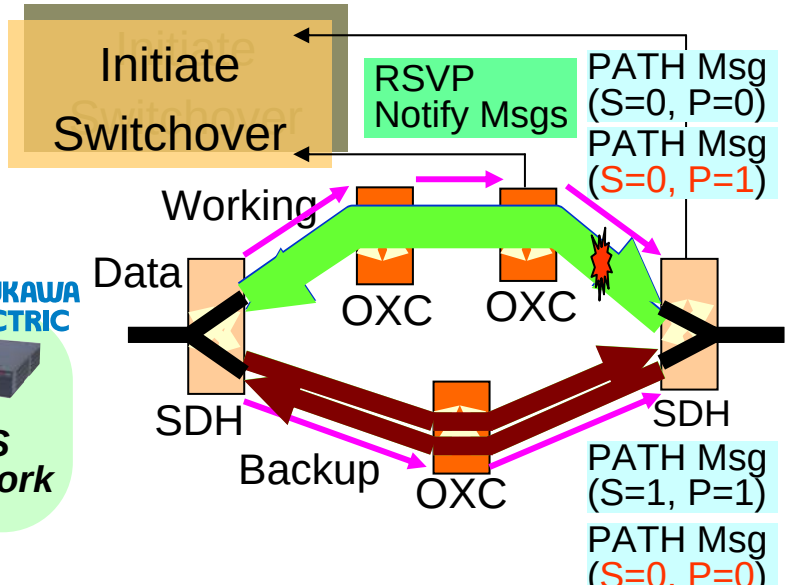
(Failure notification:10 msec, Signaling processing time: 410 msec)



E2E Recovery Signaling

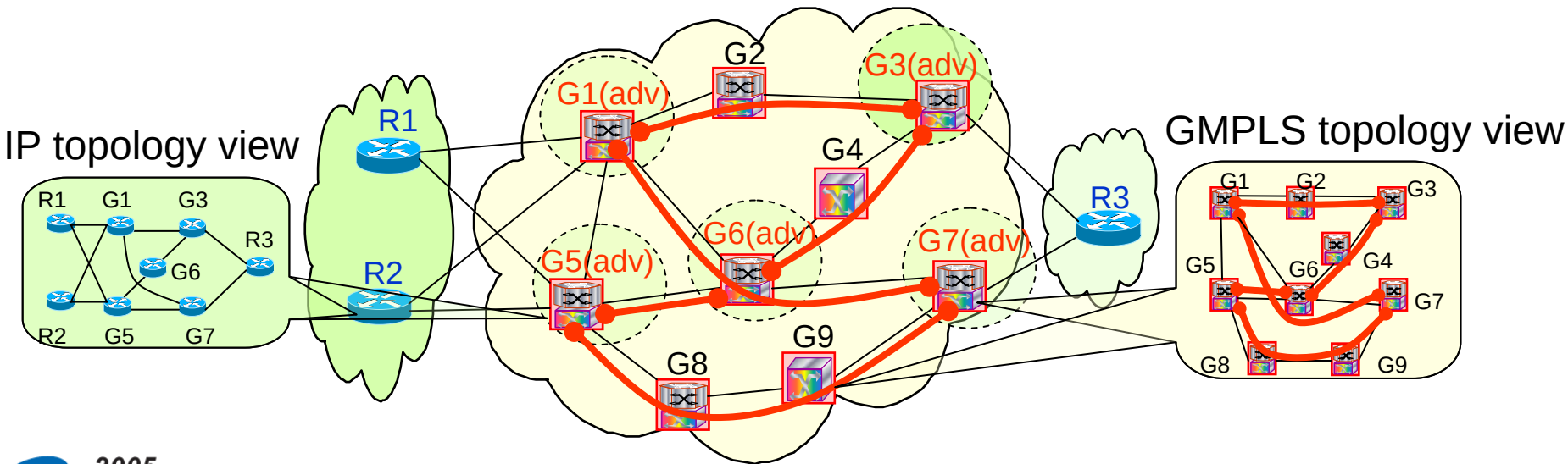
- **draft-ietf-ccamp-gmpls-recovery-e2e-signaling-01.txt**
- **Path setup**
  - Working (S bit=0, P bit=0)
  - Backup (S bit=1, P bit=1)
- **Switchover**
  - Working (S bit=0, P bit=1)
  - Backup (S bit=0, P bit=0)

E2E Recovery Signaling is initiated when RSVP Notify Msgs is received.



Topics 2 MPLS/GMPLS interworking

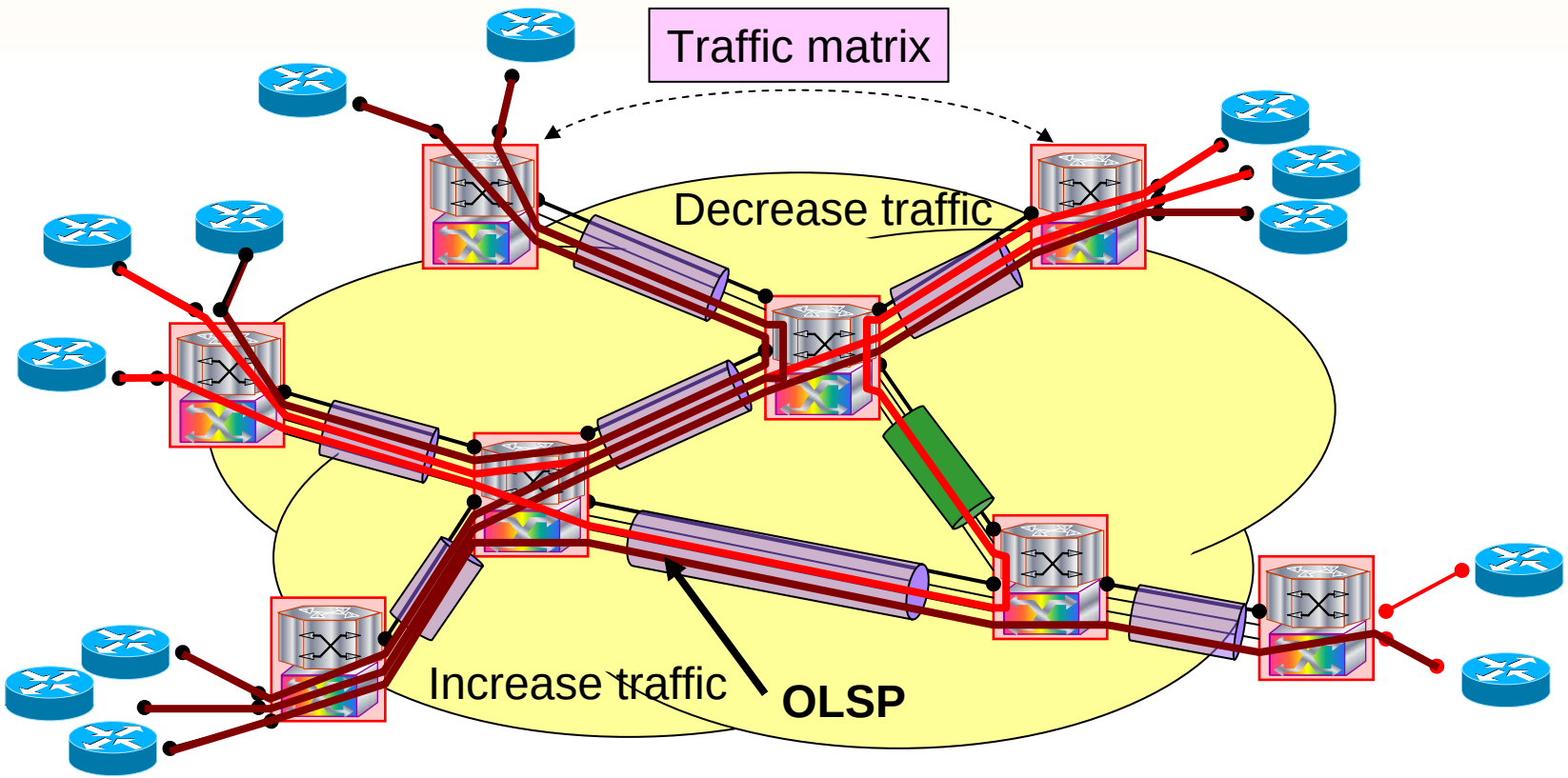
- Migration from conventional MPLS NW to GMPLS NW
  - Advertising GMPLS resources to conventional MPLS path
  - Routing…FA-LSP(GMPLS) >> Opaque or Router LSA(MPLS)
  - Signaling…Tunneling and Switching method
  - draft-oki-ccamp-gmpls-ip-interworking-0x.txt



GMPLS Network

Topics 3 Multi-layer (Multi-region) backbone network design

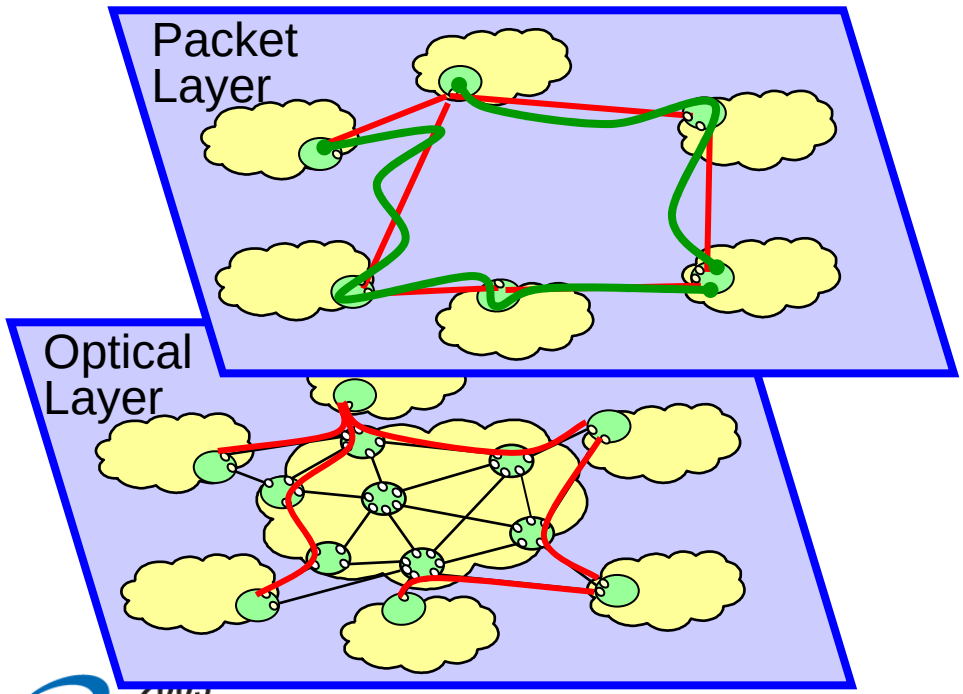
Packet/IP region



Optical/lambda region

Topics3 Multi-region Traffic Engineering (Detail)

- Optical-layer provides virtual network topologies (VNT) for packet layer.
- VNT is reconfigured according to traffic demand fluctuation.
- VNT reconfiguration is performed by setup/release of optical paths.
- Ref: draft-vigoureux-shiomoto-ccamp-gmpls-mrn-04.txt



Traffic demand

$$\begin{pmatrix} r_{1,1} & r_{1,2} & \cdots & r_{1,n} \\ r_{2,1} & r_{2,2} & \cdots & r_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n,1} & r_{n,2} & \cdots & r_{n,n} \end{pmatrix}$$

Current VNT

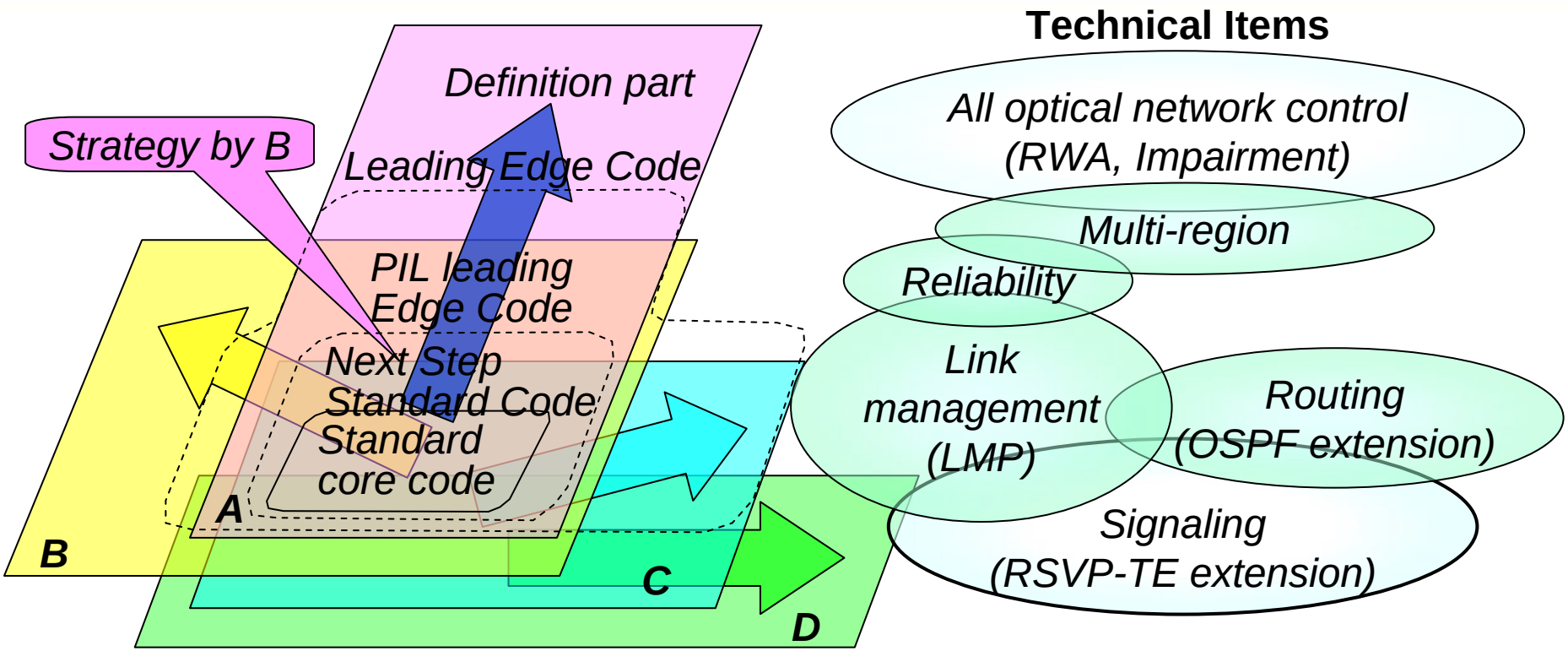
$$\begin{pmatrix} P_{1,1} & P_{1,2} & \cdots & P_{1,n} \\ P_{2,1} & P_{2,2} & \cdots & P_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n,1} & P_{n,2} & \cdots & P_{n,n} \end{pmatrix}$$

New VNT

$$\begin{pmatrix} P_{1,1} & P_{1,2} & \cdots & P_{1,n} \\ P_{2,1} & P_{2,2} & \cdots & P_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n,1} & P_{n,2} & \cdots & P_{n,n} \end{pmatrix}$$

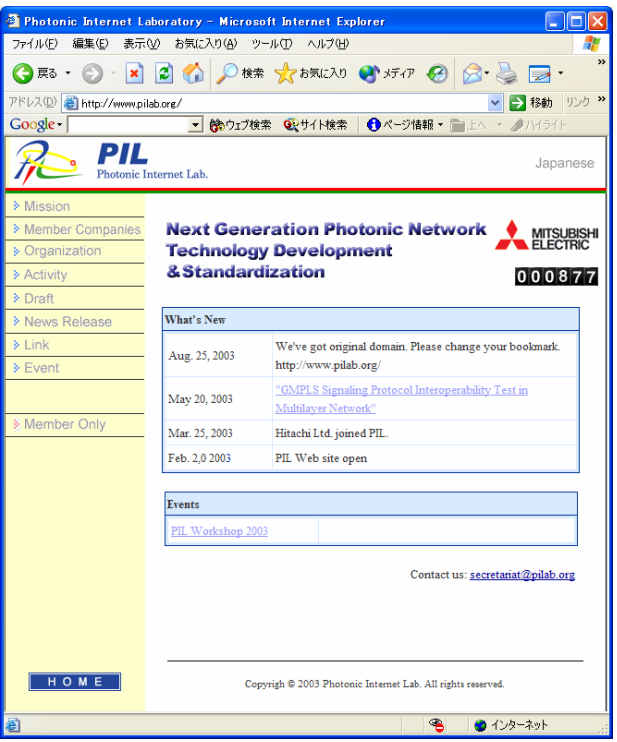
VNT: Virtual network topology

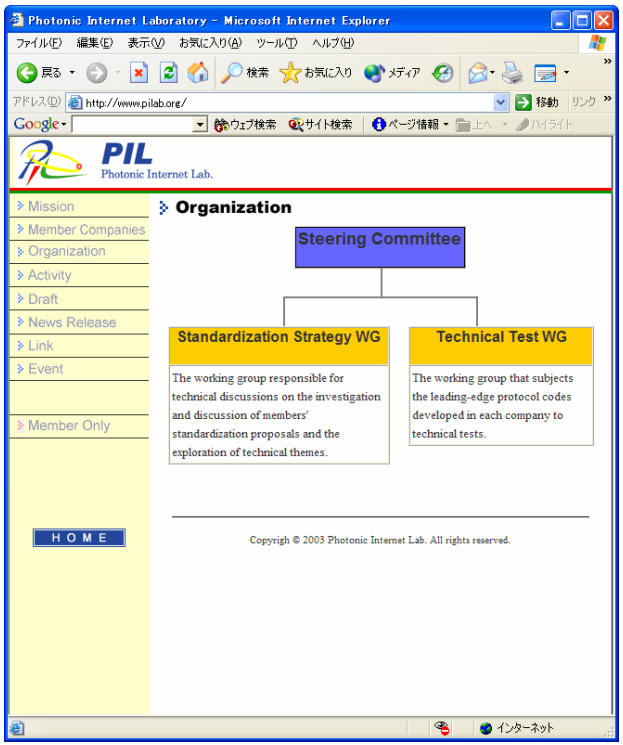
Leading edge for next generation photonic network

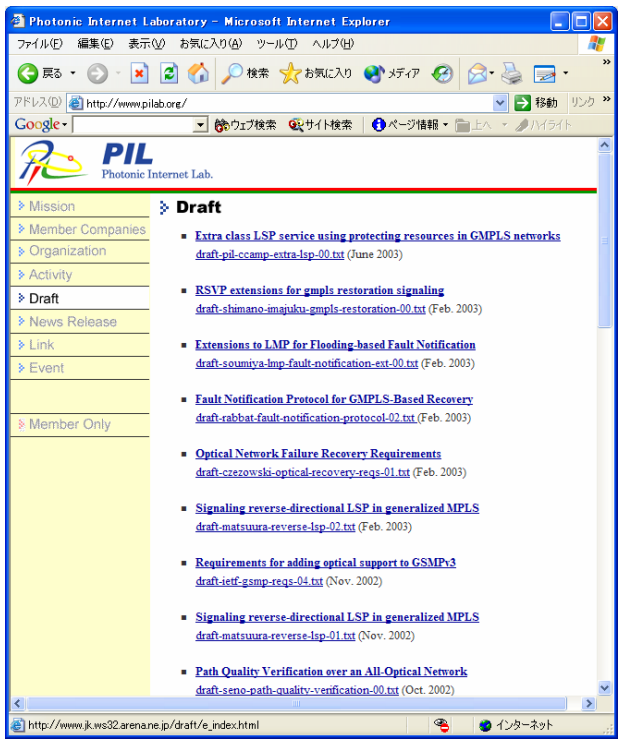


English www page

- PIL has own English page. We discuss and contribute more than 10 draft to IETF. Details are shown http://www.pilab.org/.







Contribution example to international sanitation

- Oct 2004
- IP/MPLS - GMPLS interworking in support of IP/MPLS to GMPLS migration
  draft-oki-ccamp-gmpls-ip-interworking-04.txt | 03.txt | 02.txt | 01.txt | 00.txt
- Requirements for GMPLS-based multi-region and multi-layer networks
  draft-shiomoto-ccamp-gmpls-mrn-reqs-00.txt
- Generalized Multi-Protocol Label Switching (GMPLS) Protocol Extensions for Multi-Region Networks (MRN)
  draft-papadimitriou-ccamp-gmpls-mrn-extensions-00.txt
- July 2004
- Requirements for Path Computation Element in GMPLS and IP/MPLS Networks
  draft-oki-pce-gmpls-req-00.txt
- June 2004
- Analysis of Misconnection Scenarios in GMPLS Networks
  draft-shiomoto-ccamp-misconnection-analysis-00.txt
- April 2004
- Generalized Traffic Engineering Protocol
  draft-oki-ccamp-gtep-00.txt
- Feb. 2004
- Generalized MPLS Architecture for Multi-Region Networks
  draft-vigoureux-shiomoto-ccamp-gmpls-mrn-04.txt | 03.txt | 02.txt | 00.txt
- Extra class LSP service using protecting resources in GMPLS networks
  draft-pil-ccamp-extra-lsp-02.txt 01.txt | 00.txt
- Generalized MPLS Architecture for Multi-Region Networks
  draft-vigoureux-shiomoto-ccamp-gmpls-mrn-04.txt | 03.txt | 02.txt | 00.txt
- Oct. 2003
- Control plane architecture in GMPLS networks
  draft-shiomoto-ccamp-cplane-architecture-00.txt
- Feb. 2003
- Extensions to LMP for Flooding-based Fault Notification
  draft-soumiya-lmp-fault-notification-ext-00.txt
- RSVP extensions for gmpls restoration signaling
  draft-shimano-imajuku-gmpls-restoration-00.txt
- Fault Notification Protocol for GMPLS-Based Recovery
  draft-rabbat-fault-notification-protocol-02.txt |
- Signaling reverse-directional LSP in generalized MPLS
  draft-matsuura-reverse-lsp-02.txt | 01.txt | 00.txt
- Optical Network Failure Recovery Requirements
  draft-czezowski-optical-recovery-reqs-01.txt | 00.txt
- Nov. 2002
- Requirements for adding optical support to GSMPv3
  draft-[illegible]reqs-04.txt |

- Oct. 2002
- draft-vigoureux-ccamp-gmpls-architecture-hpn-00.txt
- Path Quality Verification over an All-Optical Network
  draft-seno-path-quality-verification-00.txt
- June 2002
- Generalized MPLS architecture for multi-region networks
- Multi-area multi-layer traffic engineering using hierarchical LSPs in GMPLS networks
  draft-shiomoto-ccamp-multiarea-te-01.txt |
- Upstream label set support in RSVT-TE extensions
  draft-oki-ccamp-upstream-labelset-00.txt
- Requirements for using RSVP-TE in GMPLS signaling
  draft-matsuura-gmpls-rsvp-requirements-01.txt | 00.txt
- Multilayer routing using multilayer switch capable LSRs
  draft-imajuku-ml-routing-02.txt | 00.txt
- May 2002
- Extensions to OSPF-TE for supporting shared mesh restoration
  draft-yagyu-gmpls-shared-restoration-routing-00.txt
- Apr. 2002
- OSPF Extensions in Support of Transport Plane Sub-networks
  draft-maeno-ospf-optical-subnet-00.txt
- Feb. 2002
- Extensions to RSVP-TE for Supporting Multiple Protection and Restoration Types
  draft-suemura-gmpls-restoration-signaling-00.txt
- Requirements of optical link-state information for traffic engineering
  draft-oki-ipo-optlink-req-00.txt
- Dec. 2001
- Protection of Hierarchical LSPs
  draft-suemura-protection-hierarchy-00.txt
-
  [Reference]
- Generalized MPLS Recovery Functional Specification
  draft-bala-gmpls-recovery-functional-01.txt
- Analysis of Generalized MPLS-based Recovery Mechanisms (including Protection and Restoration)
  draft-papadimitriou-ccamp-gmpls-recovery-analysis-03.txt
- Recovery (Protection and Restoration) Terminology for GMPLS
  draft-ietf-ccamp-gmpls-recovery-terminology-01.txt

Future Target of PIL

Extension of Testing protocol

Activity of PIL 2003

Plan 1 **Field network test**

*Consideration of the field tests

- NTT Musashino－Yokosuka
-NICT Keihannna －Koganei
- ISOCORE D.C.—PIL Tokyo

NICT Keihanna

Confirmation of the running and reliability on equipment

Confirmation of the running and reliability on NW

Lab test phase
7 Domestic companies

Field test phase (2004)

Service test phase (2005-)

Overseas company

Plan 2 **Contribution with major overseas vendors**

* Consideration of the plans
-Individual test with major overseas vendors (2003)
-PIL joined in ISOCORE as group member (2004-)
- Sister site of PIL with ISOCORE (2004-)

PIF Asia

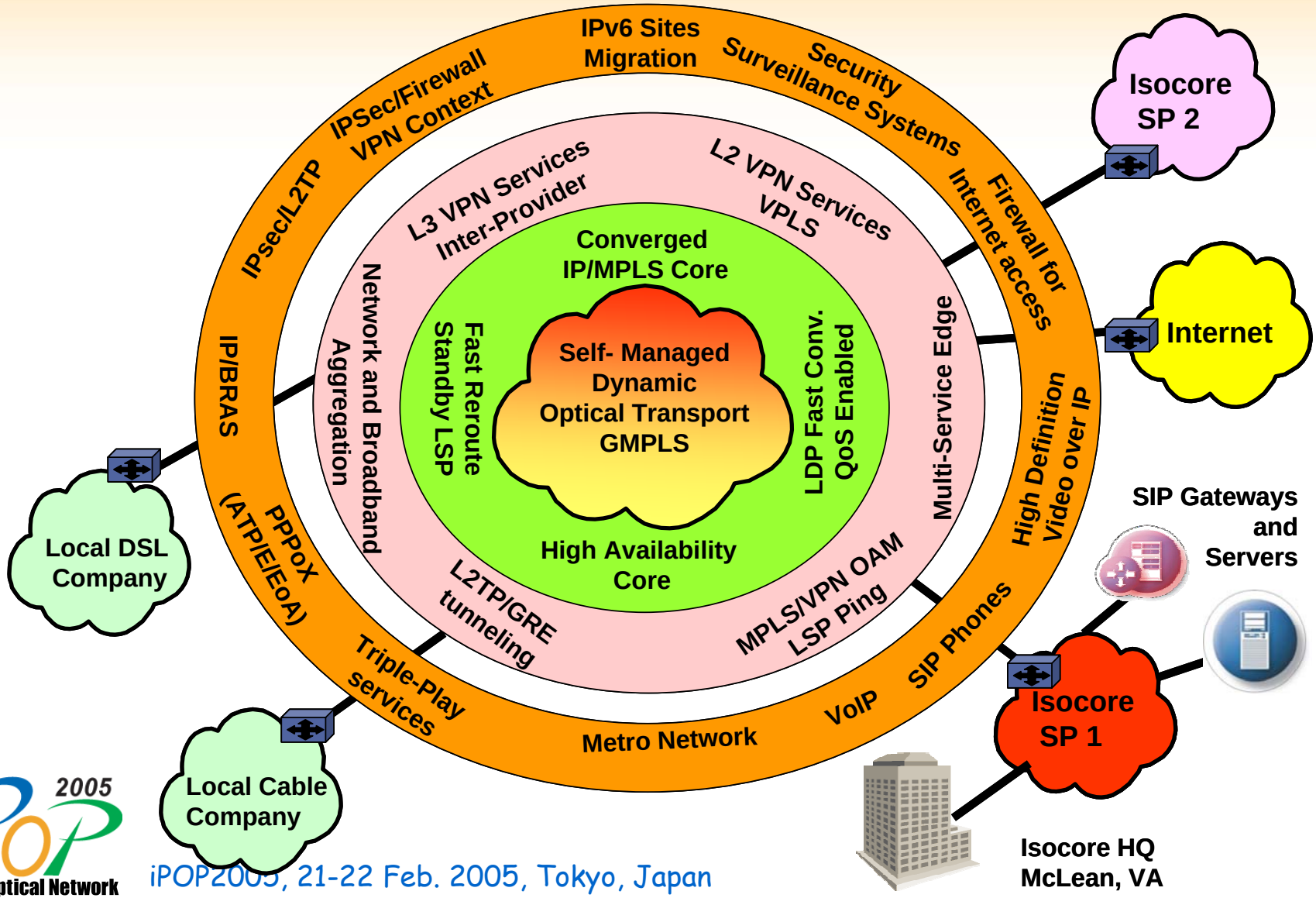
ISOCORE USA

Cooperate with OIF World Interoperability Demonstration on March 2004

- The OIF World Interoperability Demonstration showcases an international consortium of optical networking carriers and vendor participants, hosting the industry's first joint-carrier, multi-vendor interoperability demonstration.
- The interoperability demonstration highlights network interoperable solutions among the participating vendors on OIF implementation agreements in a multi-carrier environment. This global networking event included testing in the following areas:
- Service Adaptation (GFP) /VCAT /LCAS
- UNI 1.0 R2 + E-NNI (control and data plane, out-of-band signaling)

Supercom 2004 collaborate with ISOCORE USA

(from White paper)



ISOCORE Booth collaborated with PIL

Time slot of presentation

NTT's presentation

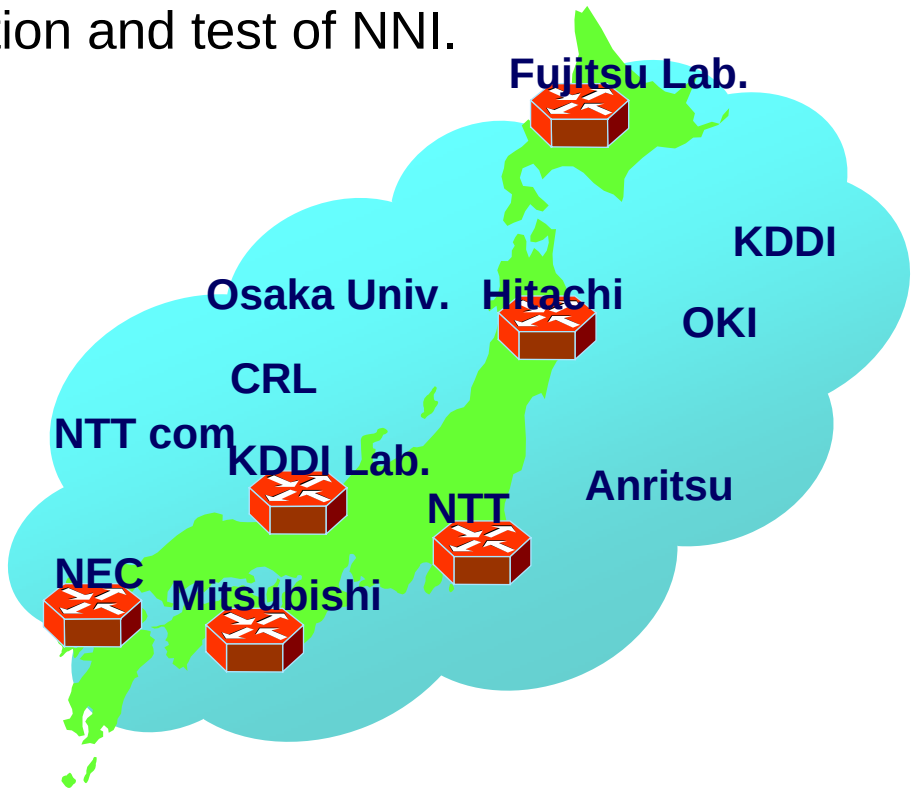
Join to Research promotion of “NICT Open Lab”

- Jointly developing the innovative technology in the next-generation network: novel communication architecture, protocol, switching technology, and transmission technology as the international standard from Japan towards the world
- Performing interoperability verification and test of NNI.

NICT Open Lab

•The open laboratories site established by the NICT which is Incorporated administrative Agency (formerly a section of the Ministry of Public Management, Home Affairs, Posts and Telecommunications)

•Joint research of industry, academia and government

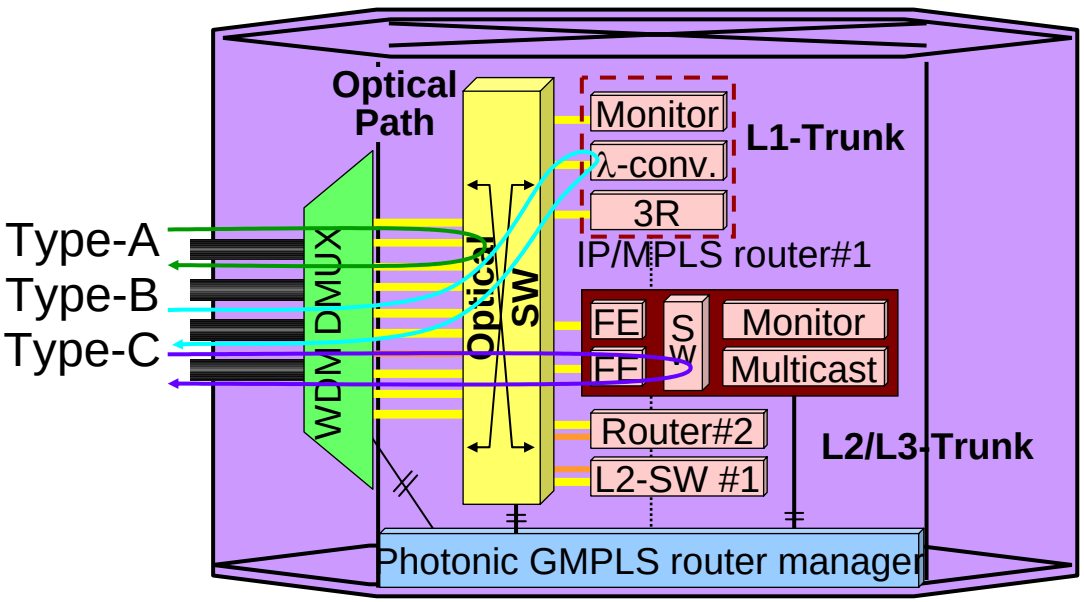


Outline

- Introduction
- PIL: Photonic Internet Labs.
  - Mission & Organization
  - Multi-layer, Multi-route & Multi-vender experiment
  - MPLS / GMPLS Interworking
- PIL member activities
- iPOP2005 GMPLS showcase and workshop
- Conclusion

NTT HIKARI Router

- IP+Optical function.
- GMPLS based Multi-layer controlling
- All optical SW (AWG) technologies



Hardware structure

Control Plane Box (CP-Box)

Enables New Services

- Bandwidth on Demand
- Optical VPN
- SLA

Reduces Service Delivery Time

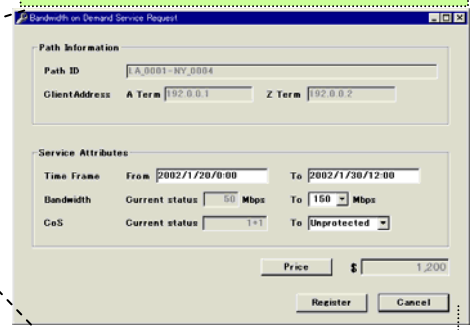
- Rapid Provisioning

Cuts Capital/Operational Costs

- Mesh Network
- Automatic Discovery

CP-Box connecting with NE will be up graded to ASON/ GMPLS aware NE.

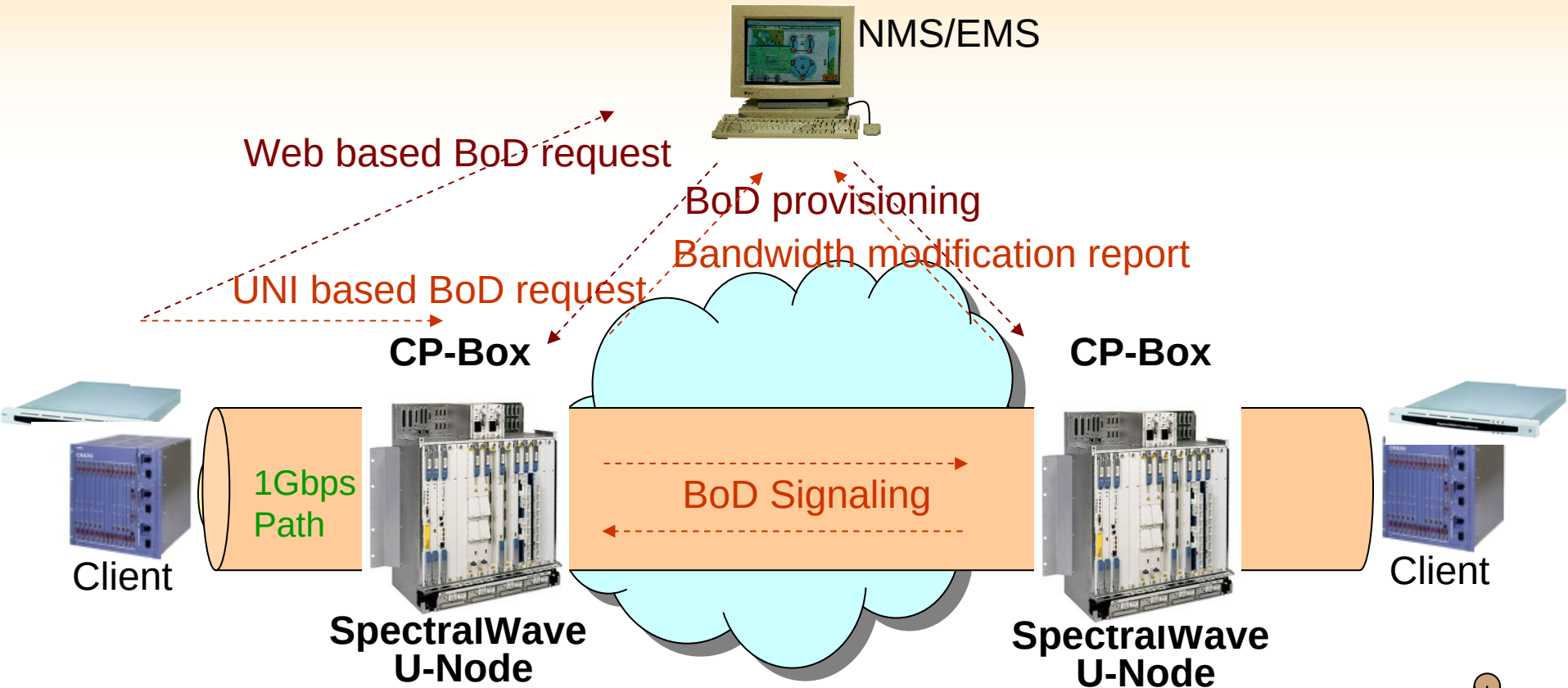
GUI for Bandwidth on Demand



Reserves bandwidth & time frame.

UNI: User-Network Interface
NNI: Network-Node Interface

Bandwidth on Demand



- Rapid Provisioning enables **Faster Service Delivery**
- BoD provides **New Network Services & Revenue**
- U-Node's VCat/GFP feature enables **Efficient Bandwidth Utilization**

IPv6 Edge Router with GMPLS control capability

THE FURUKAWA ELECTRIC CO., LTD.

Equipment		FFITELnet-G80
Switch Capability		128Gbps (Full Duplex)
Interface		line card (FastEthernet x 48, GigabitEthernet x 6, or OC-48 POS x 2) 8 slots for line cards
Management Function		FastEthernet x1
Layer 2	MAC address	802.1Q VLAN, VLAN tunneling, 802.1p, 802.1x
Layer 3(IPv4)	Routing Protocol	RIPv1/v2, OSPF, BGP-4, Static
Layer 3(IPv6)	Routing Protocol	RIPng, OSPFv3, BGP-4+, Static
MPLS	Protocol	LDP, RSVP-TE, DiffServe-TE, EoMPLS
Multicast(IPv4)	Protocol	IGMPv1/2, PIM-SM
Multicast(IPv6)	Protocol	MLD, PIM-SM
GMPLS		RSVP-TE, OSPF-TE, LMP, O-UNI
QoS/CoS		PPQ, WFQ, DiffServ, Static configuration, Policing, Shaping, RED
Provision/Redundancy		ECMP Dual CPU, Routing processor, Power Unit & Fan
Management Function		TELNET, FTP, SNMP(IPv4, IPv6), SYSLOG(IPv4, IPv6), NTP
External Memory I/F		PCMCIA x2 (ATA or CF Available)
User I/F		Command Line
Power	Type	DC-48V (AC100V option available)
	Dissipation	2kW
Size		430(W)x753.5(H)x570(D)mm
Weight		Max.60kg (at full installation)

FITELnet G80

Mitsubishi's Optical Cross Connect (OXC)

MITSUBISHI ELECTRIC

The All-Optical OXC with GMPLS and Multi-class Protections

The OXC Prototype

Features of the Implemented Prototype

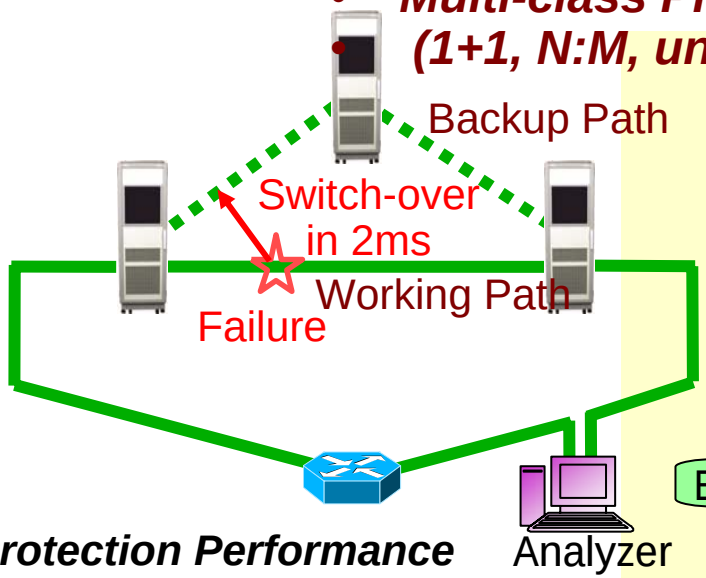
(a) Distributed Routing and Signaling of Optical Paths Enabled by the GMPLS Protocols

(b) Pure Optical Switching by means of the Bascule Optical Switch

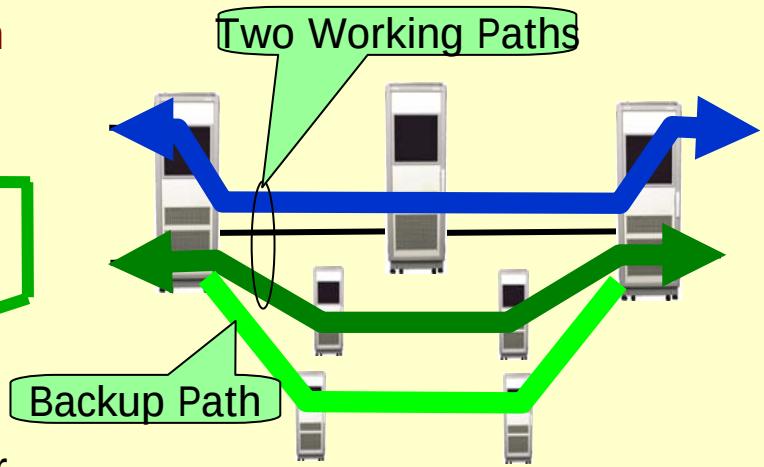
(c) Multi-class Protections Offering a Wide Range of Reliability According to User Requirements

(d) The Common Platform Incorporating IP Switching and Optical Switching

- ***Multi-class Protections (1+1, N:M, unprotected, extra traffic)***



- ***1+1 Protection Performance***



- ***1:2 Protection Example***

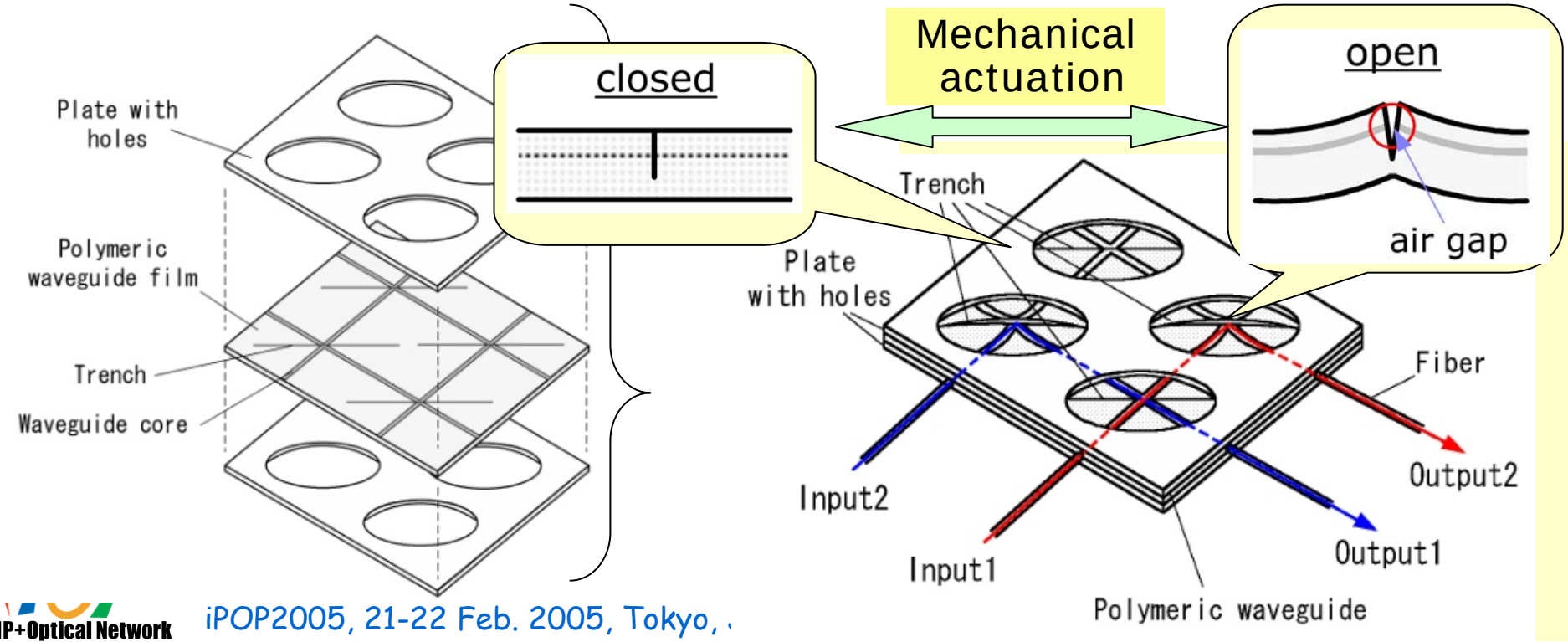
The Bascule Optical Switch

MITSUBISHI ELECTRIC

Revolutionary Mechanical Waveguide-actuation System!!

– Features –

- ***Bascule** structure → Lossless Connection by Physical-Contact Waveguide*
- ***Flexible Polymeric Waveguide → Low Cost***
- ***Mechanical Actuation → Fast Switching with Low Power Consumption***

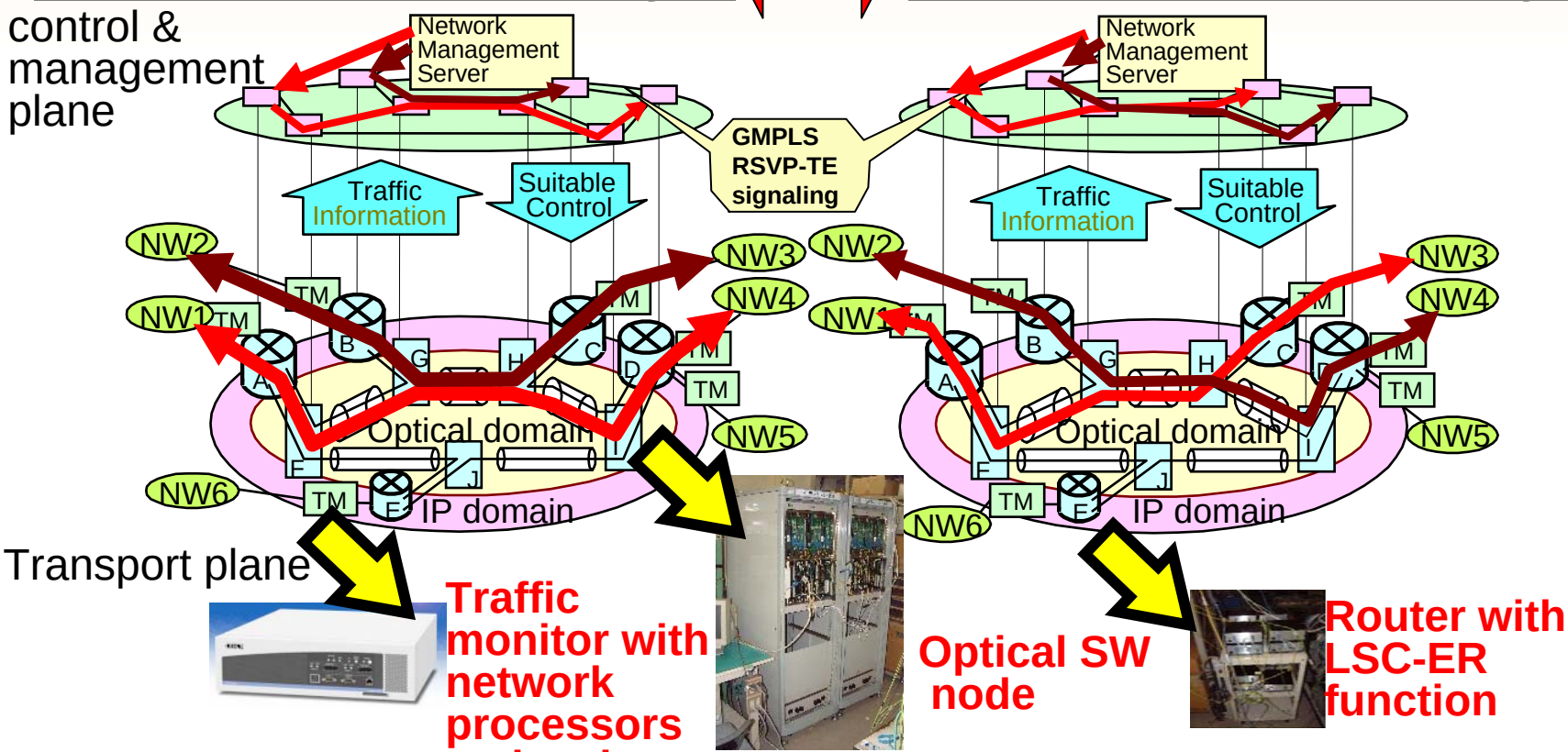


Traffic based dynamic optical path allocation system

OKI

Case1: Traffic between NW1 and NW4, NW2 and NW3 are heavy

Case2: Traffic between NW1 and NW3, NW2 and NW4 are heavy



A part of this work is supported by Telecommunications and Advancement Organization of Japan(TAO)

iPOP2005 （2005.2.21-22)

http://www.ipop2005.com

ISOCORE

PIL Photonic Internet Lab.

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Tomonori Aoyama
University of Tokyo

Bijan Jabbari
ISOCORE

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Exhibition Committee Chair: Satoru Okamoto, NTT, Japan,

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Secretary: Kazumasa Morita, Furukawa Electric, Japan, and Naomichi Nonaka, Hitachi, Japan.

SPONSORSHIP

PIL Photonic Internet Lab.

PIL (Photonic Internet Lab, http://www.pilab.org), founded by 6 vendors and 1 service provider in 2002, is promoting R&D on next-generation photonic network control protocols based on photonic technologies for managed networks.

PIL Members

NTT, Furukawa Electric, Keio University, NEC, OKI, Fujitsu, Mitsubishi Electric, Hitachi (Inspire the Next), ipinfusion

ISOCORE

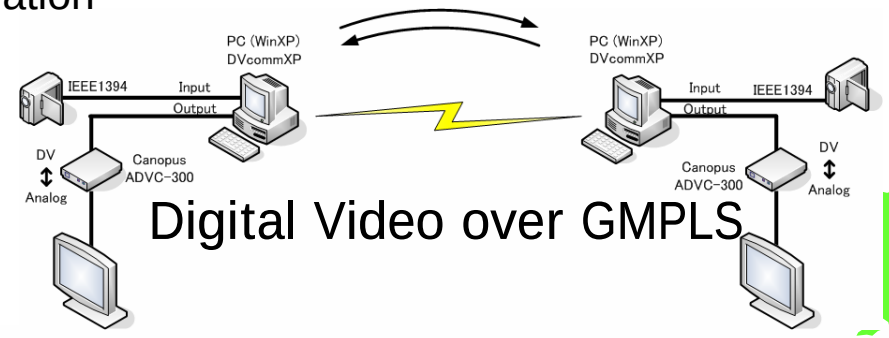
ISOCORE (Isocore Internetworking Lab, http://www.isocore.com) is the leading technology validation lab in the next generation IP and optical networking. Its goal is to advance internetworking through technology validation and product verification and to promote development and rapid deployment of innovative networking technologies.

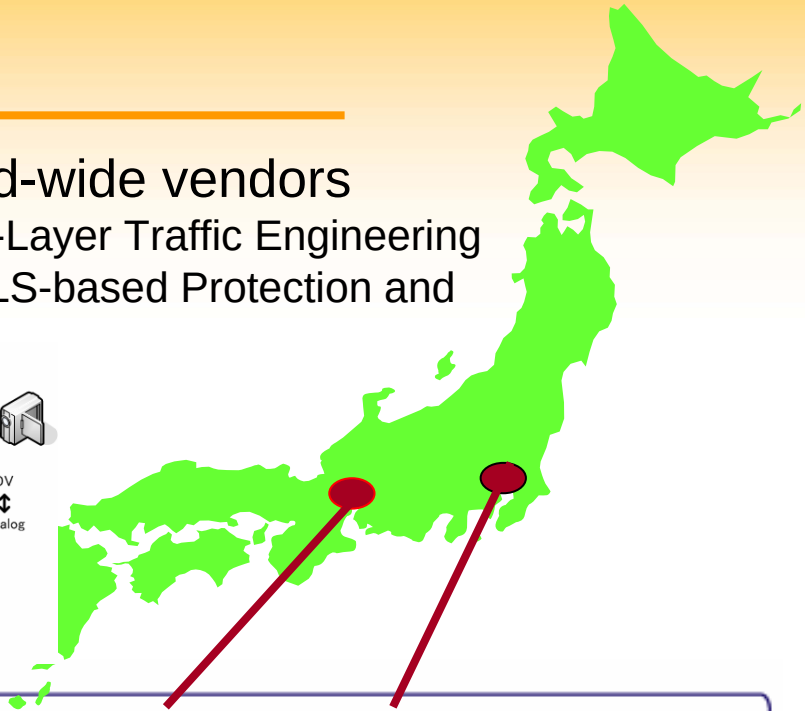
PHOTONIC INTERNET FORUM

PIF (Photonic Internet Forum, http://www.scat.or.jp/photonic/english/) is a non-profit organization contributing to the progress of info-communication technology to realize all optical ultra-high-speed networks.

GMPLS showcase supported by PIL and ISOCORE

- GMPLS Interoperability Showcase by world-wide vendors
  - Multi-Region Routing and Signaling
  - Multi-Layer Traffic Engineering
  - MPLS/GMPLS Migration
  - GMPLS-based Protection and Restoration





Participants (tentative)

Tokyo, Japan

NTT
MITSUBISHI ELECTRIC
HITACHI
Inspire the Next
KEIO UNIVERSITY
NEC
KDDI
KDDI R&D LABS
FUJITSU
東陽テクニカ
SYCAMORE NETWORKS
Juniper NETWORKS

Virginia, USA

AVICI SYSTEMS
ISOCORE
SYCAMORE NETWORKS
and more...

2005 iPOP IP+Optical Network

Conclusions

- Target for GMPLS, next generation IP backbone protocol.
  - Universal control
  - Scalable service
  - Low-cost universal backbone
- The Photonic Internet Lab. (PIL) was founded Autumn 2002 by 7 companies (6 venders and 1 service provider) for realizing new photonic network control protocols based on photonic technologies for managed networks.
  - The Japanese government is supporting PIL.
- PIL has two activity streams;
  - Advanced code testing for optimizing new GMPLS protocols.
  - Standardization efforts with running code.
- In addition, PIL has successfully demonstrated Multi-layer (Multi-region), Multi-vender Multi-route GMPLS operation. In addition, MPLS/GMPLS interworking testing is also performed.
- iPOP 2005 will be held in Feb 21-22 at Tokyo Fashion town, which is GMPLS interoperability showcase, open testing and technical invited session related to GMPLS http://www.ipop2005.com