Next Generation IP/Optical Integrated Network in KDDI

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Outline

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- **Background**
  - Broadband services and all-IP telephone services
  - Common backbone network for multi services
- **Integrated IP/Optical networks**
  - Network Model
  - GMPLS early field trial
  - Service transport over GMPLS networks
- **Conclusions**

Broadband Services on All-IP Network

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- **FTTH "Hikari-Plus" Triple play services**
  - **GE-PON(100Mbit/s), MC(100Mbit/s), MC+VDSL(50Mbit/s)**
    - ✓ **High-quality VoIP (POTS equivalent)**
      low jitter/low latency/low packet loss
    - ✓ **DVD-quality VOD and Multicast streaming**
      low jitter/low latency/low packet loss
    - ✓ **High-speed Internet**
- **Copper line "Metal-Plus"**
  - ✓ **High-quality VoIP (POTS equivalent)**
  - ✓ **High-speed Internet**
- **3G mobile "Win"**
  - **CDMA 2000 1x, 1xEVDO(2.4Mbit/s)**
    - ✓ **EZ-channel**
    - ✓ **Mobile Internet**

Triple Play Services with GE-PON

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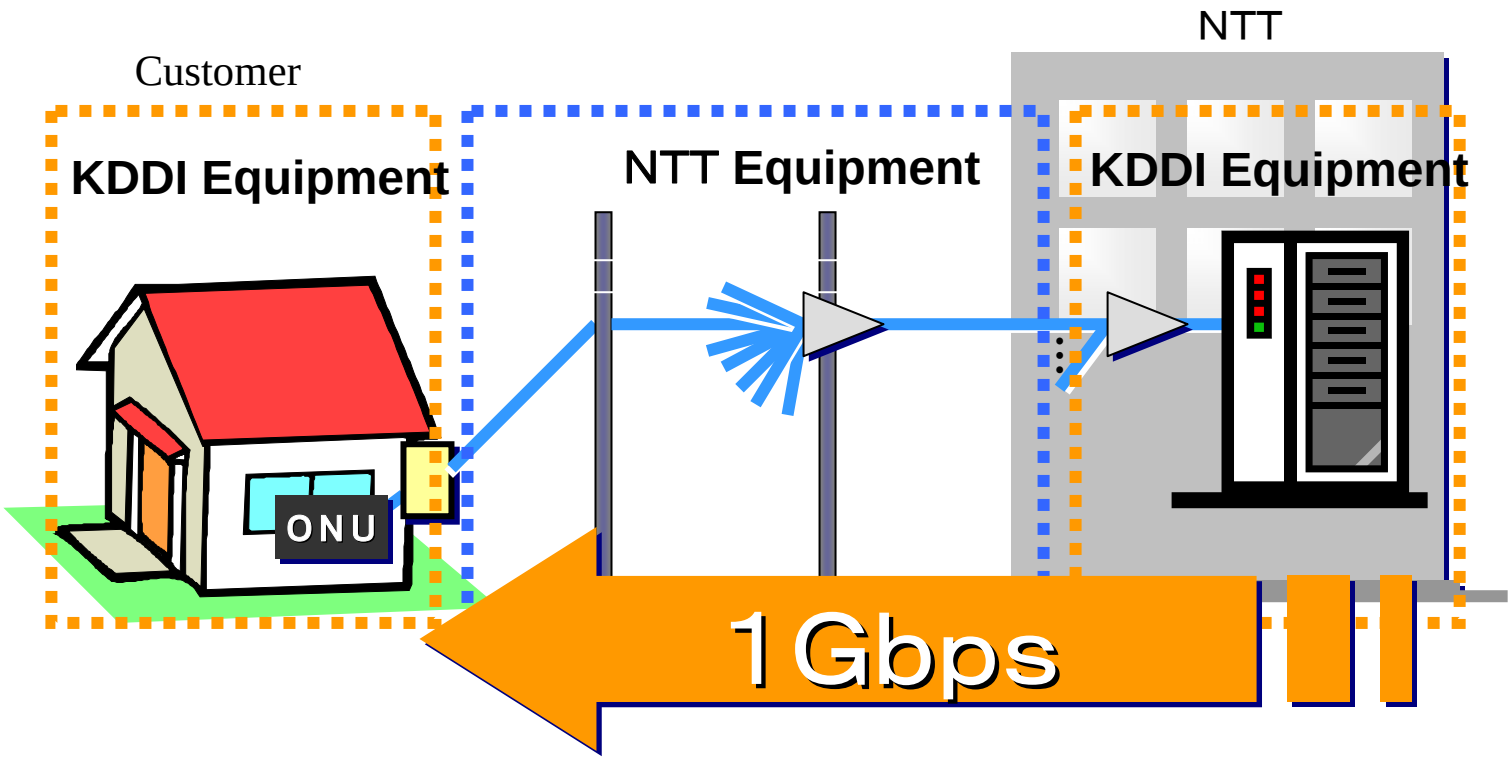
- Multi-channel broadcast with minimum capacity by IP multicast
- High-quality for real-time traffic (Voice and Video) by QoS (priority queuing) in access and metro/core networks
- Reduction in infrastructure cost by PON architecture



Evolution of Telephone Service from PSTN to IP Network

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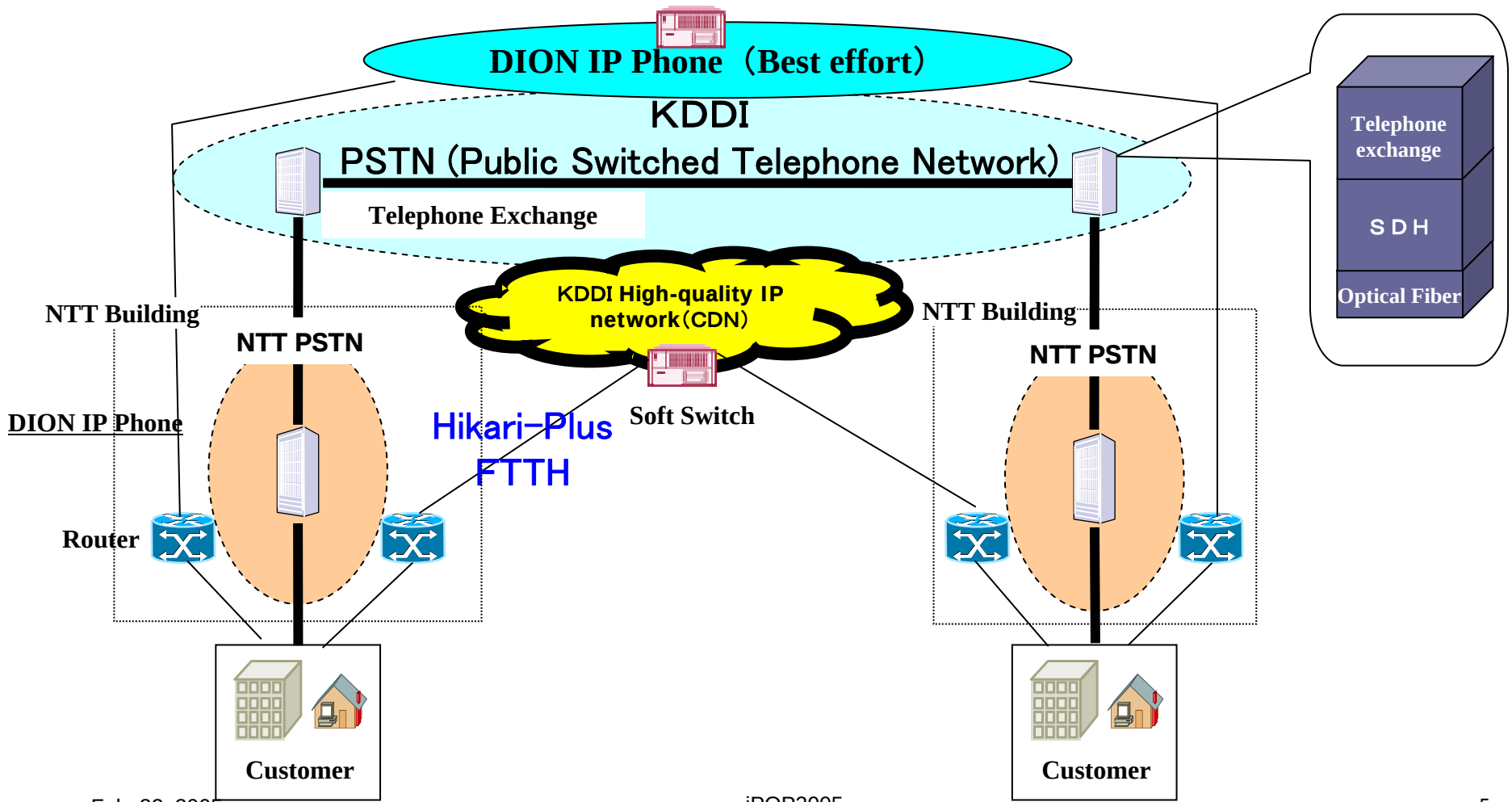
- Telephone service is mainly provided by PSTN(64Kbit/s switched network)
- KDDI Hikari-plus phone is provided by high-quality IP network CDN



Next Generation All-IP Telephone Network

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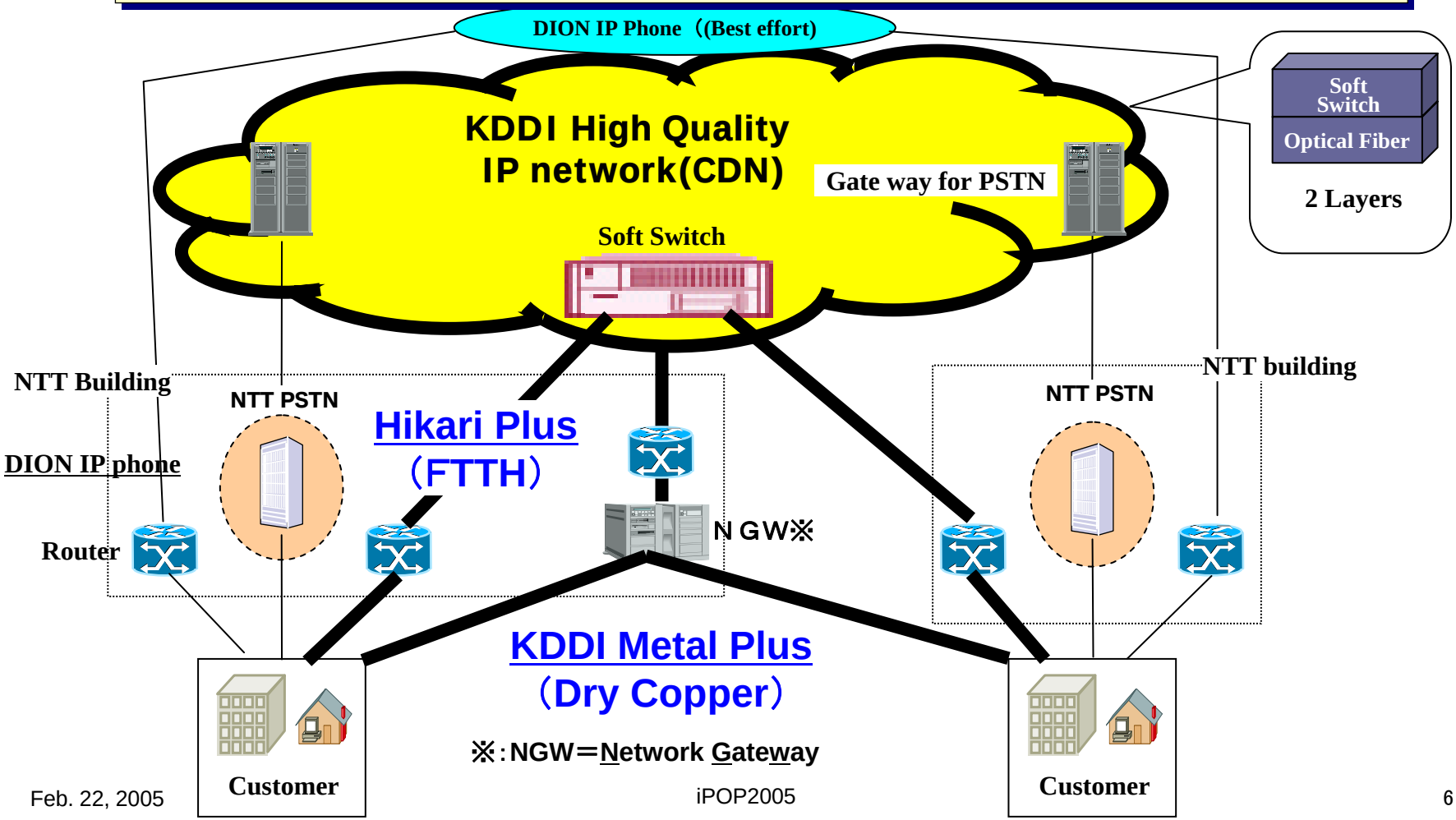
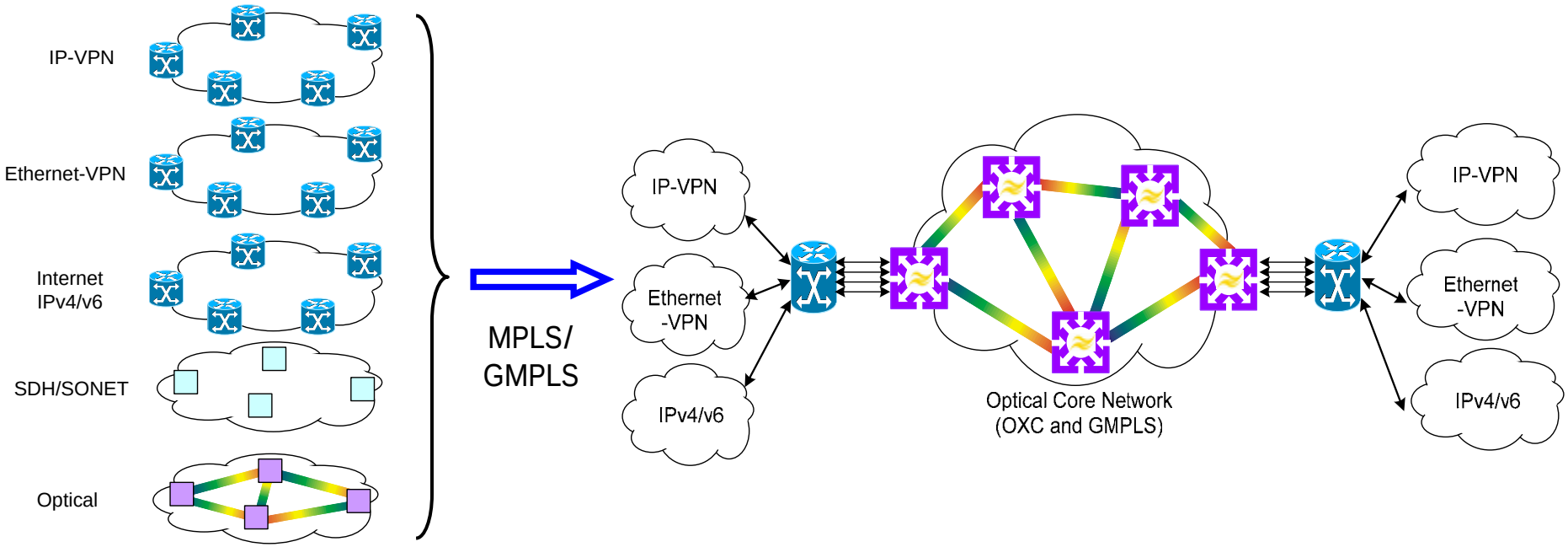
- Direct customer accommodation to CDN by Hikari-Plus and Metal-Plus
- Replacement of existing telephone exchange to soft switch
- Construction of All-IP telephone network will be completed by Mar. 2008



Network Integration for Multi Services

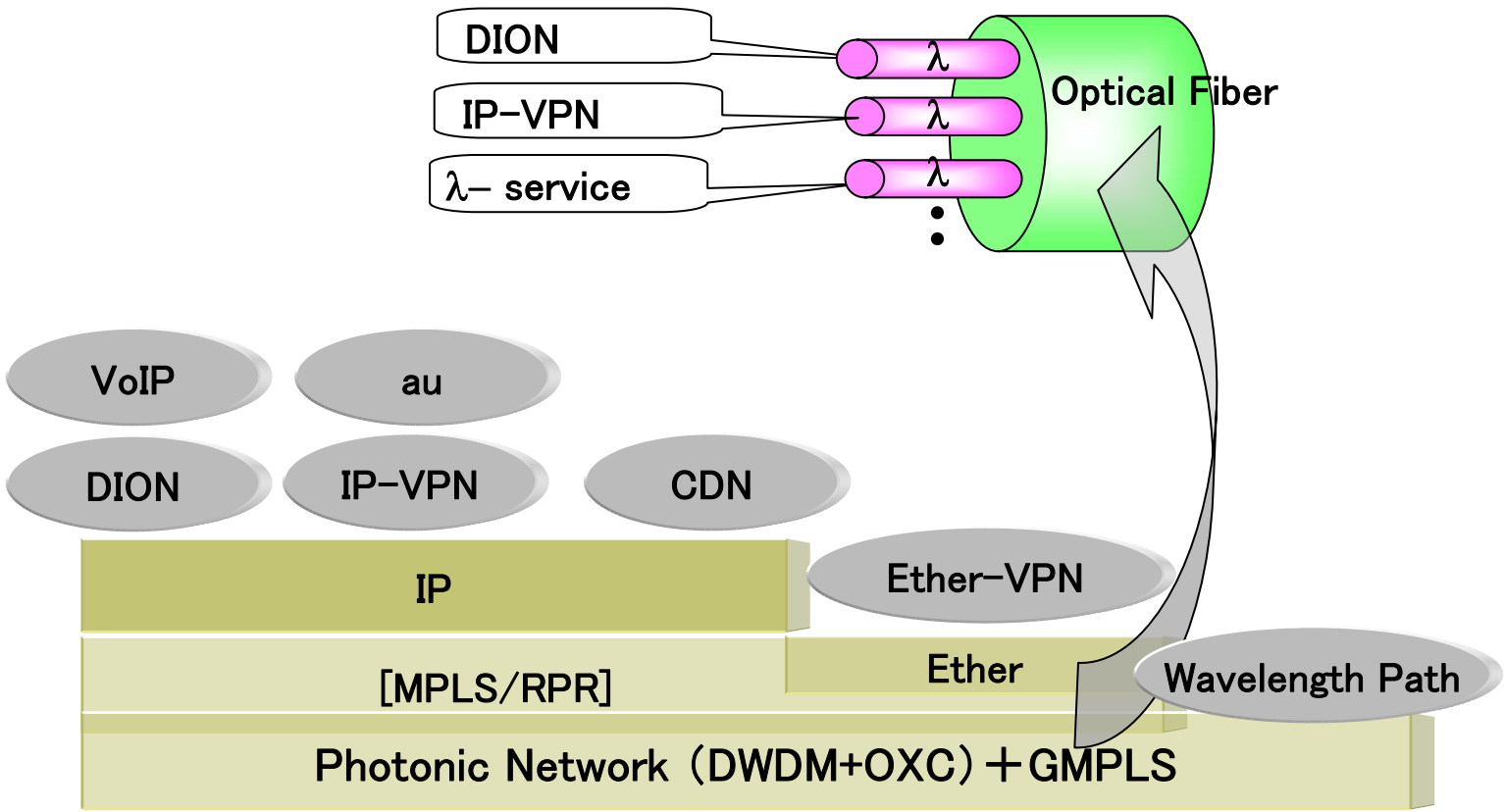


- A network per a service and per an operational division
  - Service specific functions
  - Equipment specific skills
  - Merger of companies

- Network integration of multi services and multi layers
  - Efficient OAM
  - High resource utilization
  - High network resiliency

Model of Integrated Core Network

- Wavelength assignment to each service
- GMPLS controlled intelligent photonic network



Advantages of GMPLS interworking

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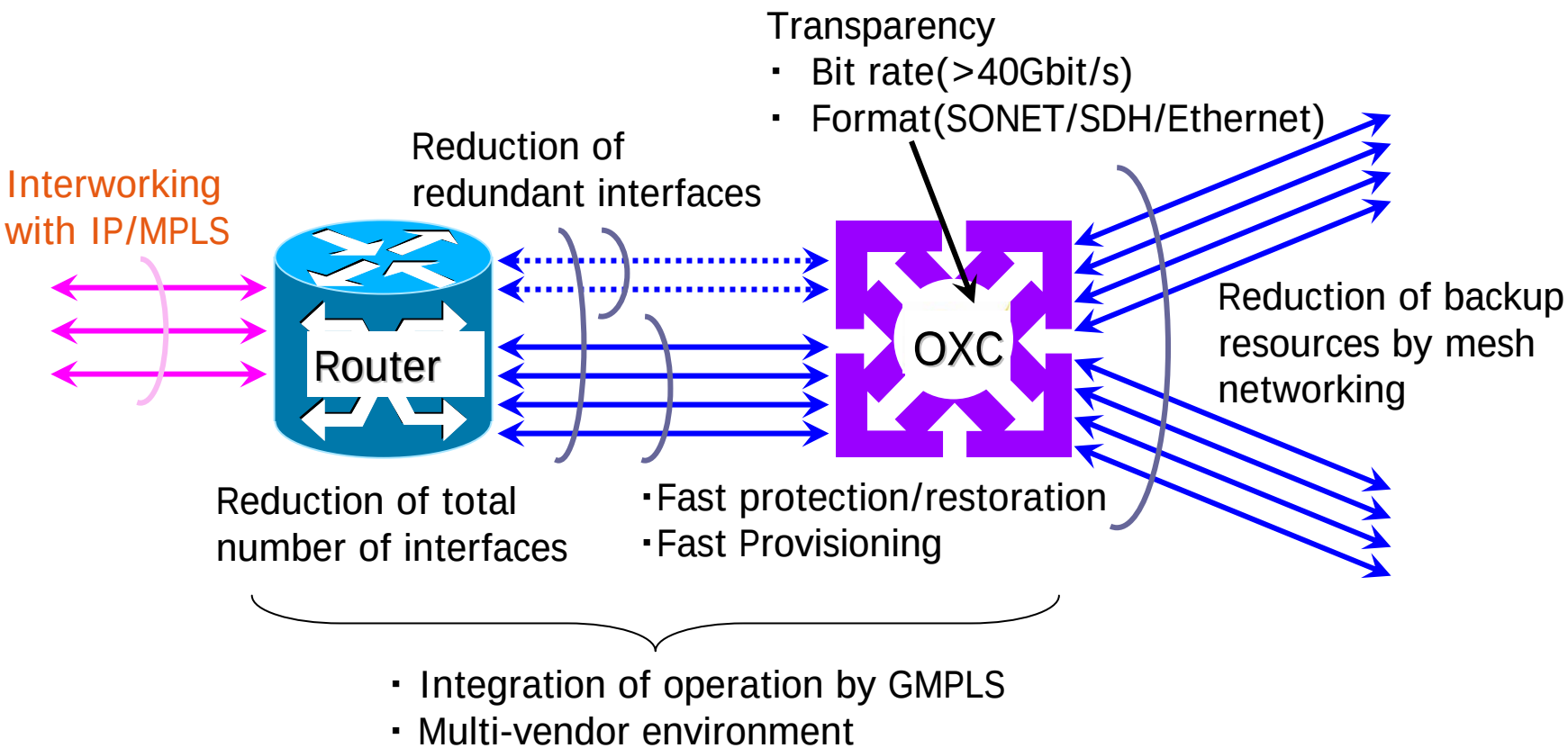
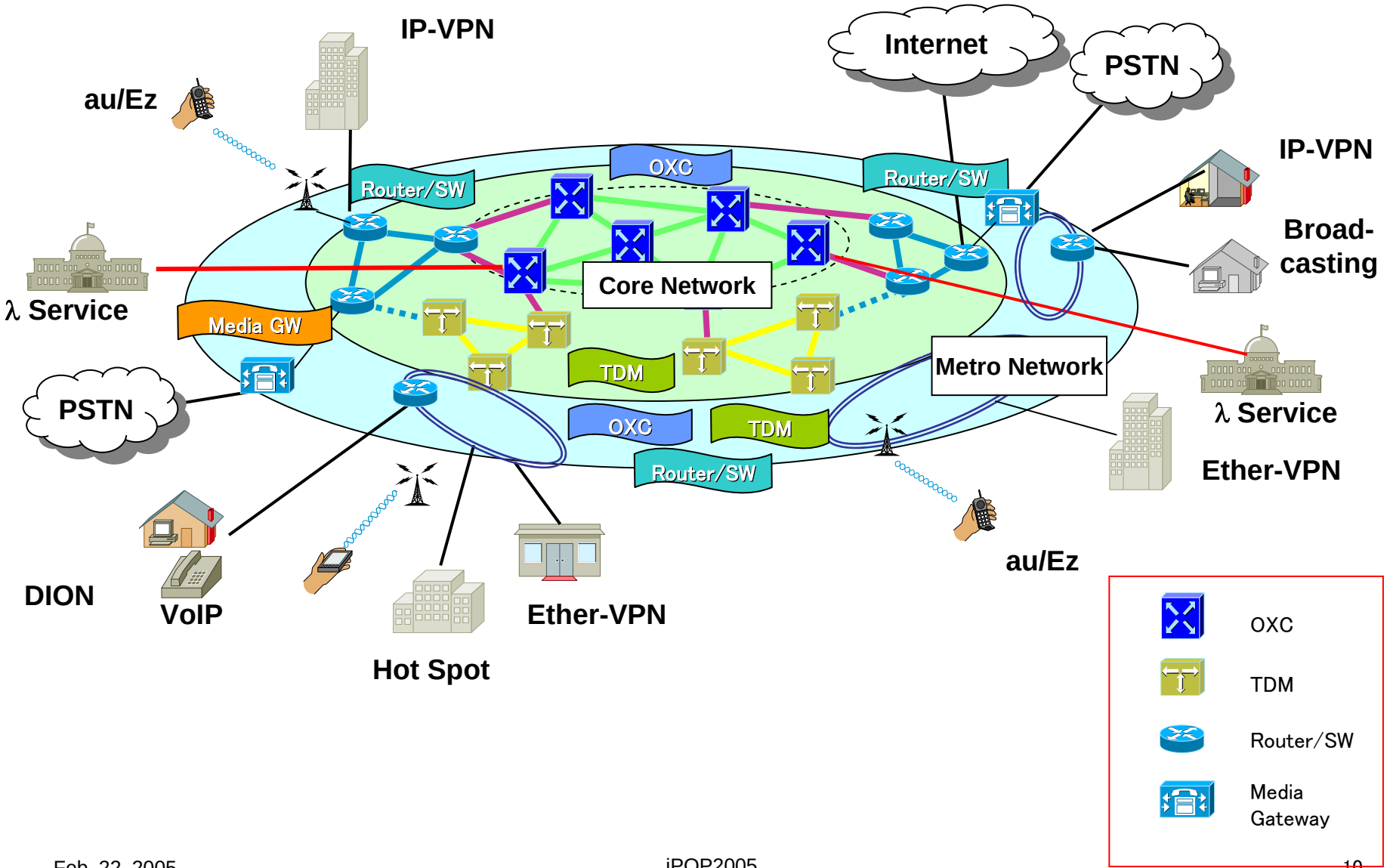
- Introduction of an integrated IP/optical network



Next Generation IP/Optical integrated Network



GMPLS early field trial (2003)

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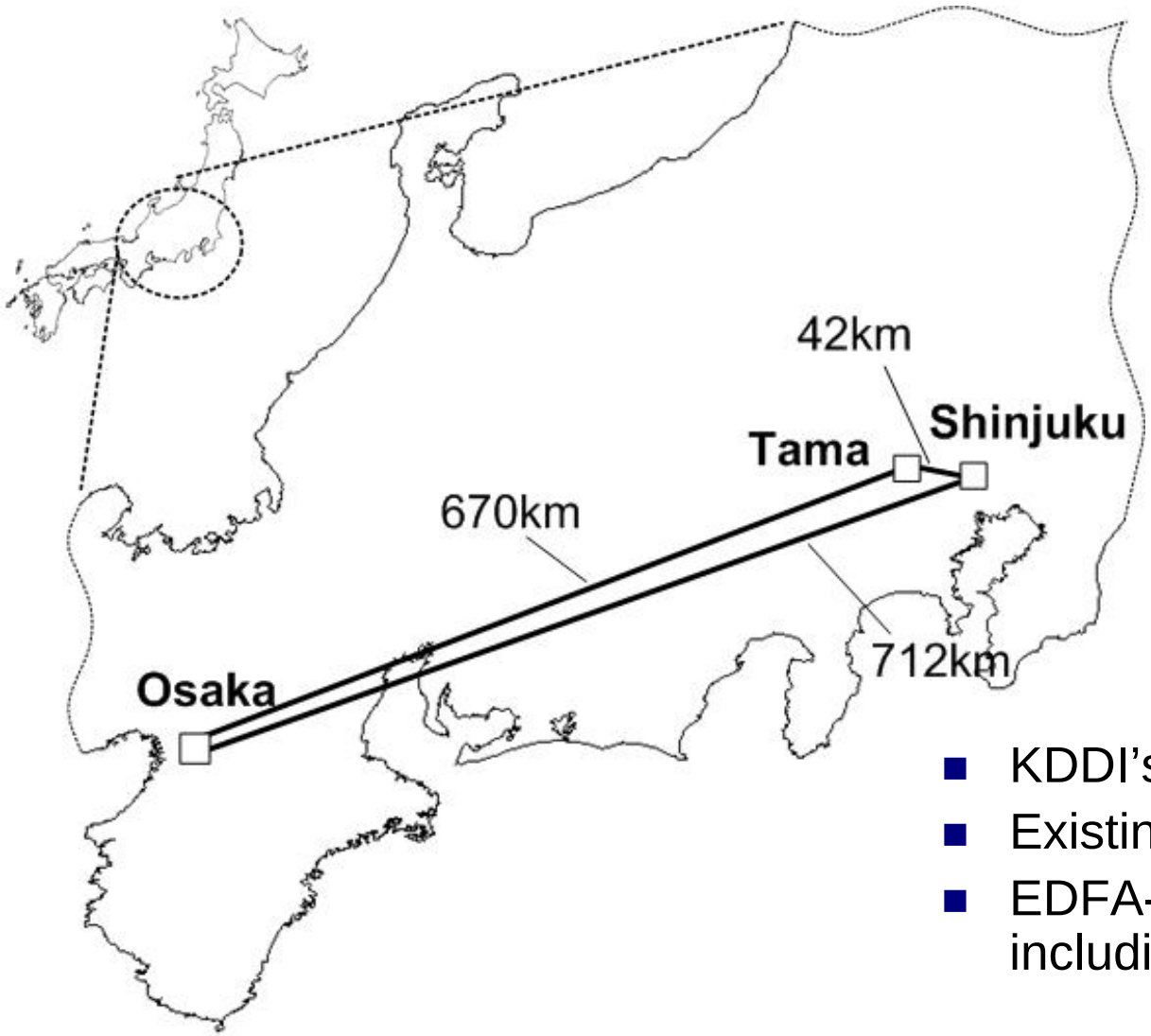
Objective: **Evaluation of GMPLS-controlled equipment in the actual operational environment, in order to introduce a very simple and effective next generation lambda based photonic network.**

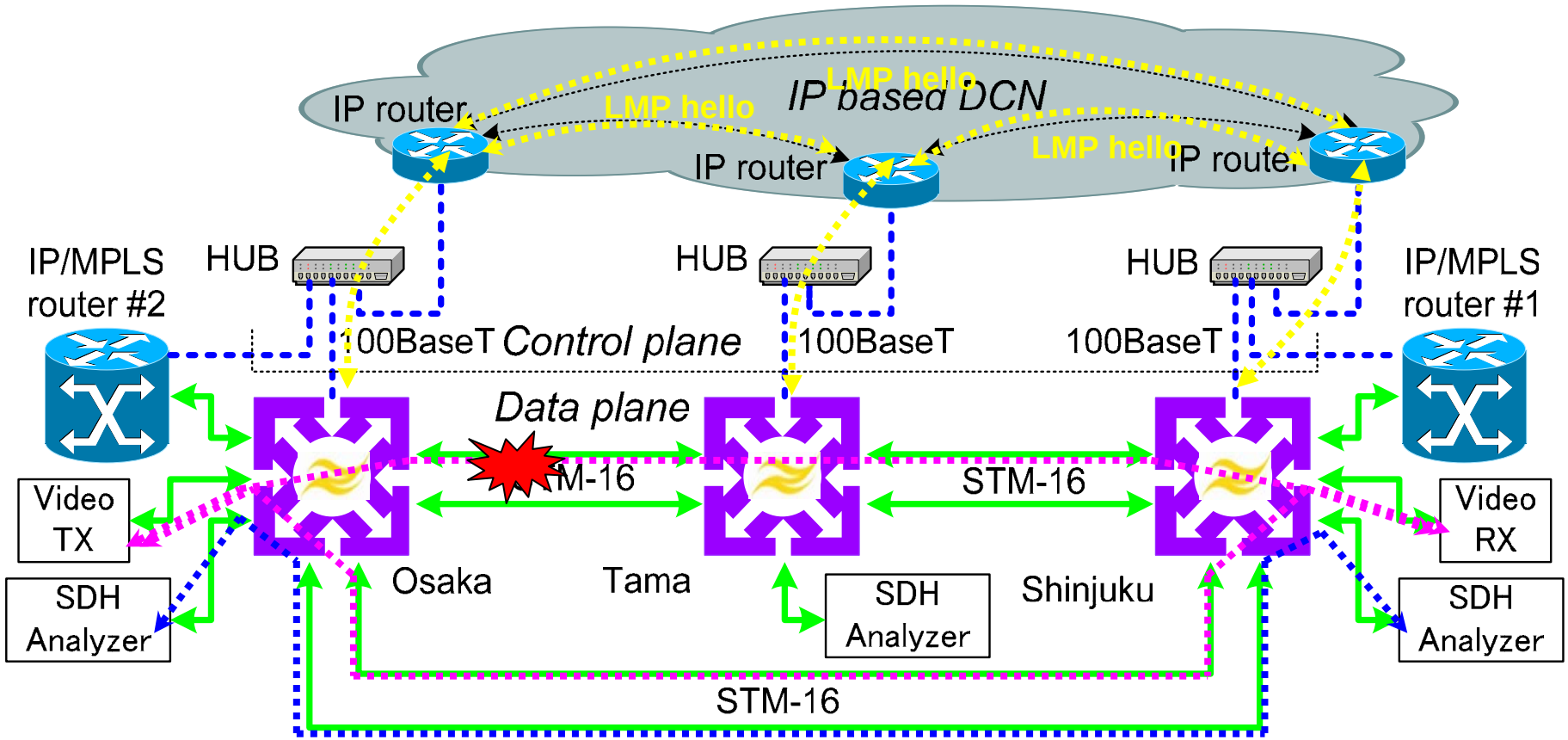
- **GMPLS (Generalized multi-protocol label switching)**
  - can control and manage core nodes (OXC, PXC) as well as client nodes (IP/MPLS router, MSPP) by an unified control plane.
  - provide flexible and reliable end-to-end services as well as achieve flat network management over optical infrastructure.
- **GMPLS-controlled photonics cross-connect (PXC)**
  - Evaluation from the point of operation and maintenance
    - All-optical SW, bit rate and format transparent
    - Simple, cost effective, low power consumption
  - Evaluation of interoperability with IP/MPLS routers
    - Signaling level
    - Routing level
- **Investigation of reusing an IP-based DCN for a control plane**

Location of field trial



- KDDI's backbone network
- Existing WDM link (STM-16)
- EDFA-based WDM links including regenerators

Field trial configuration



GMPLS interoperability results (1)

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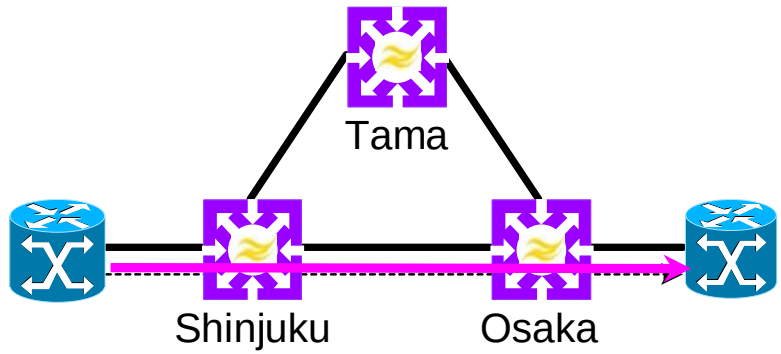
- Evaluation of GMPLS interoperability between PXCs and IP/MPLS router on both signaling and routing levels

(i) Automatic path provisioning

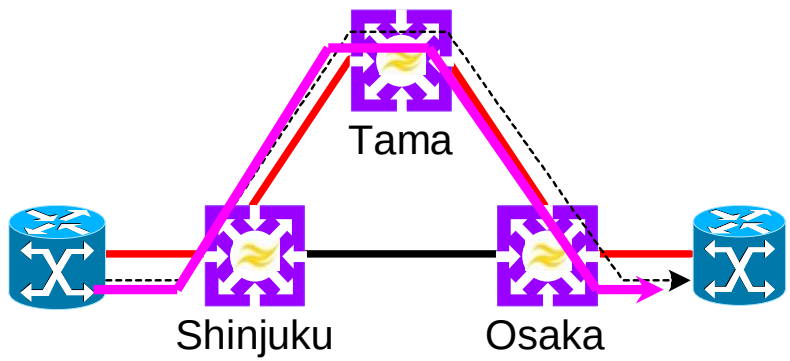
- Automatically generated the explicit route (Source routing)
- Selected the shortest path



A shortest path exists

(ii) Explicit path provisioning

- Specifying an IP address (Node ID) of interfaces
- Signaling the specified route



Explicit routing（selected red links）

GMPLS interoperability results (2)

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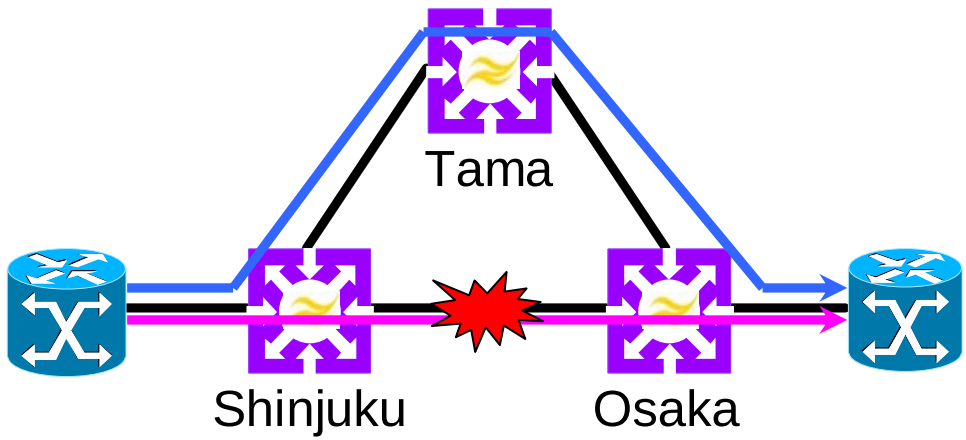
- End-to-end restoration of a Lambda LSP between routers
  - Disruption time measured by traffic generators
  - Detecting Fiber failure and fault isolation by LMP
  - RSVP-TE re-signaling
  - Restoration time : 700ms (now)



GMPLS technology not only improves the network resource utilization, but also provides network resiliency to a client equipment.

Interworking between PXCs and DWDMs

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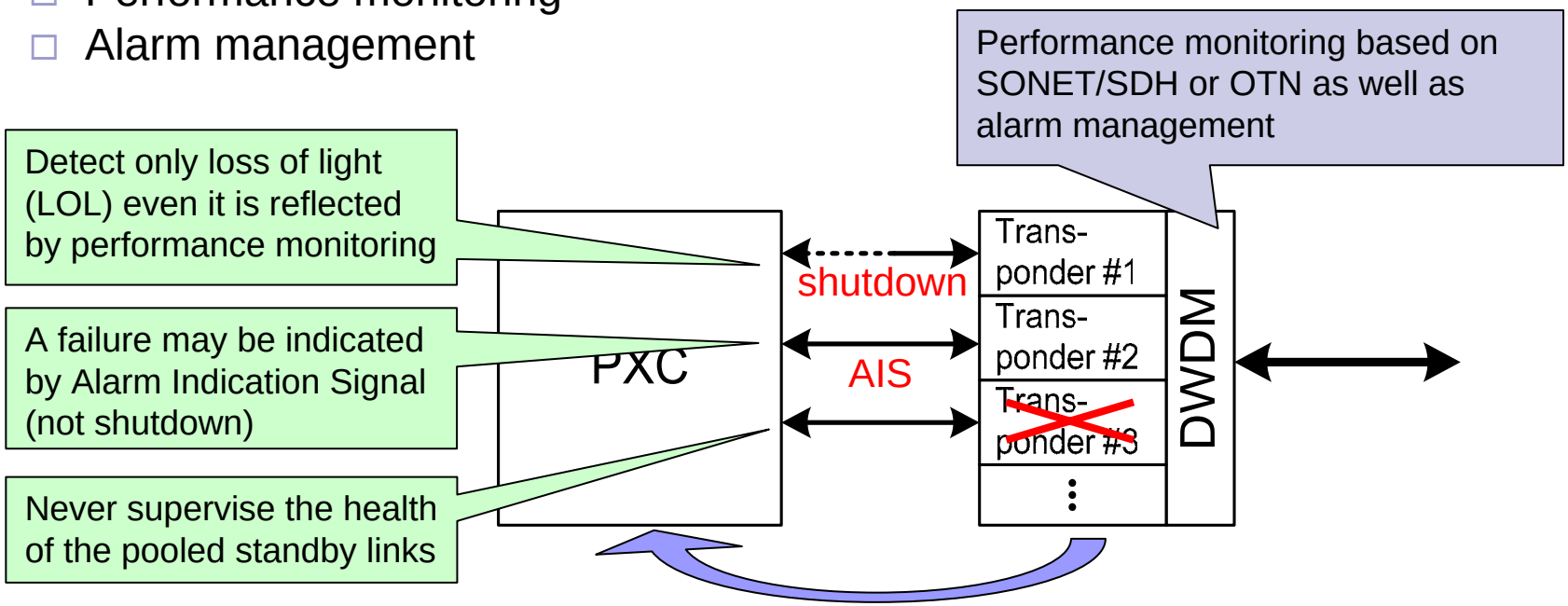
- Operational improvement of GMPLS networks, compared with SONET/SDH-based network
  - Performance monitoring
  - Alarm management



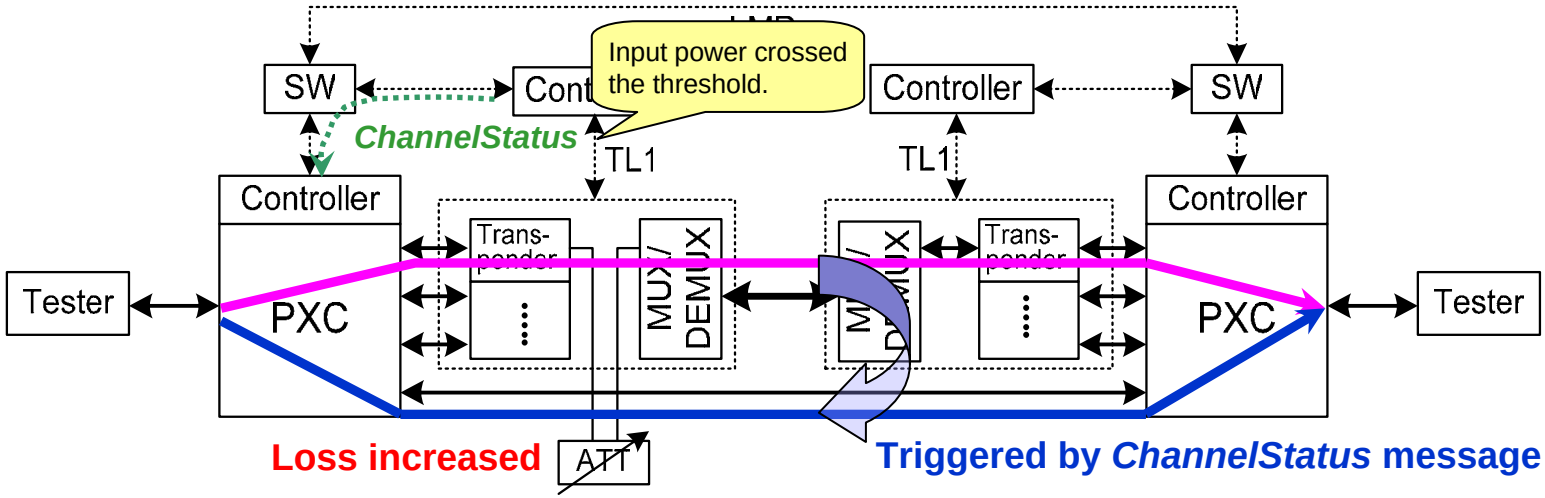
Integrating DWDM equipment with PXC by using a control plane in order to enhance performance monitoring and alarm management

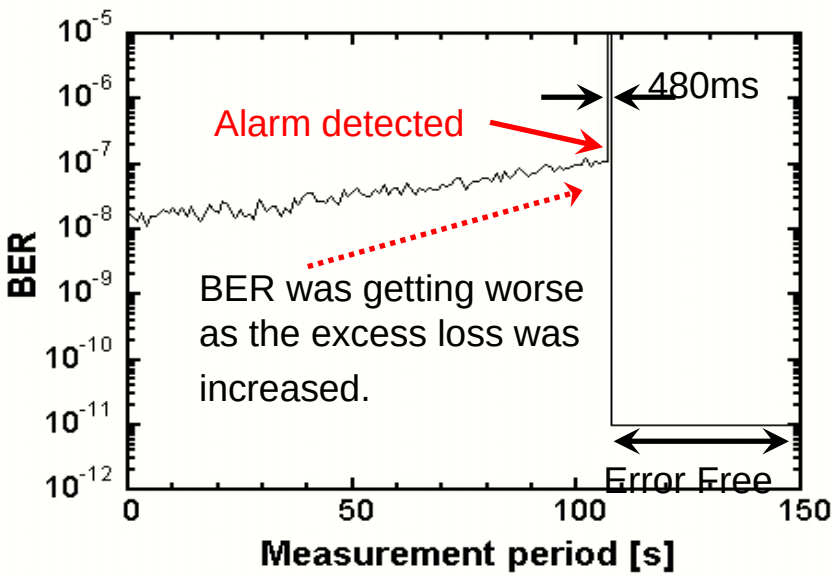
LMP-WDM protocols

- Generalized multi-protocol label switching (GMPLS): Control plane technology for (all-)optical switching networks
  - Signaling: RSVP-TE
  - Routing: OSPF-TE
  - Link management protocol (control channel maintenance/link property correlation/fault management/link verification)
    - LMP: between nodes
    - LMP-WDM: between PXC and DWDM equipment
- By introducing control plane based on LMP-WDM in addition to shutdown functionality of DWDM,
  - PXC can be notified of various types of information on DWDM links
  - PXC can manage and monitor pooled (standby) link resources

Demonstrated results

DWDM with shutdown functionality





Service Migration

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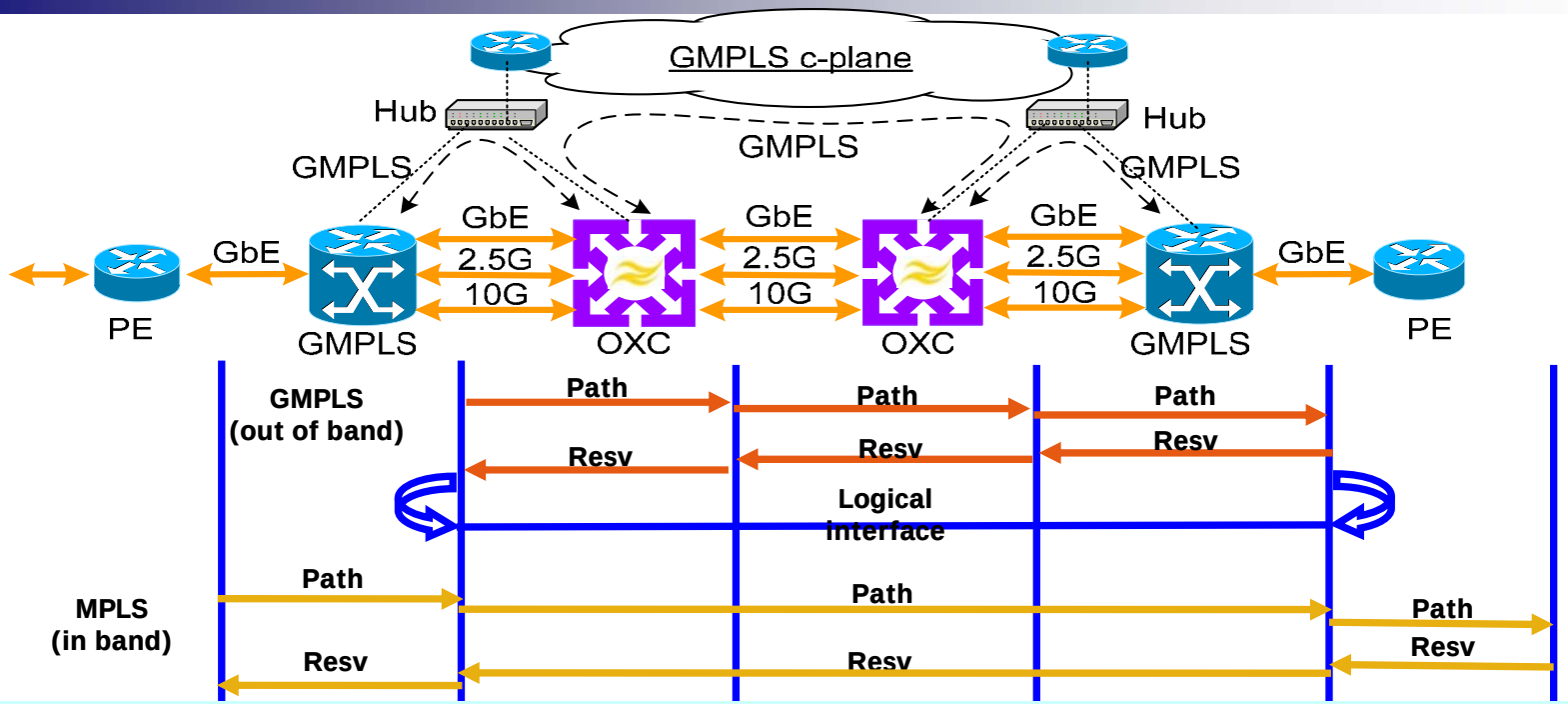
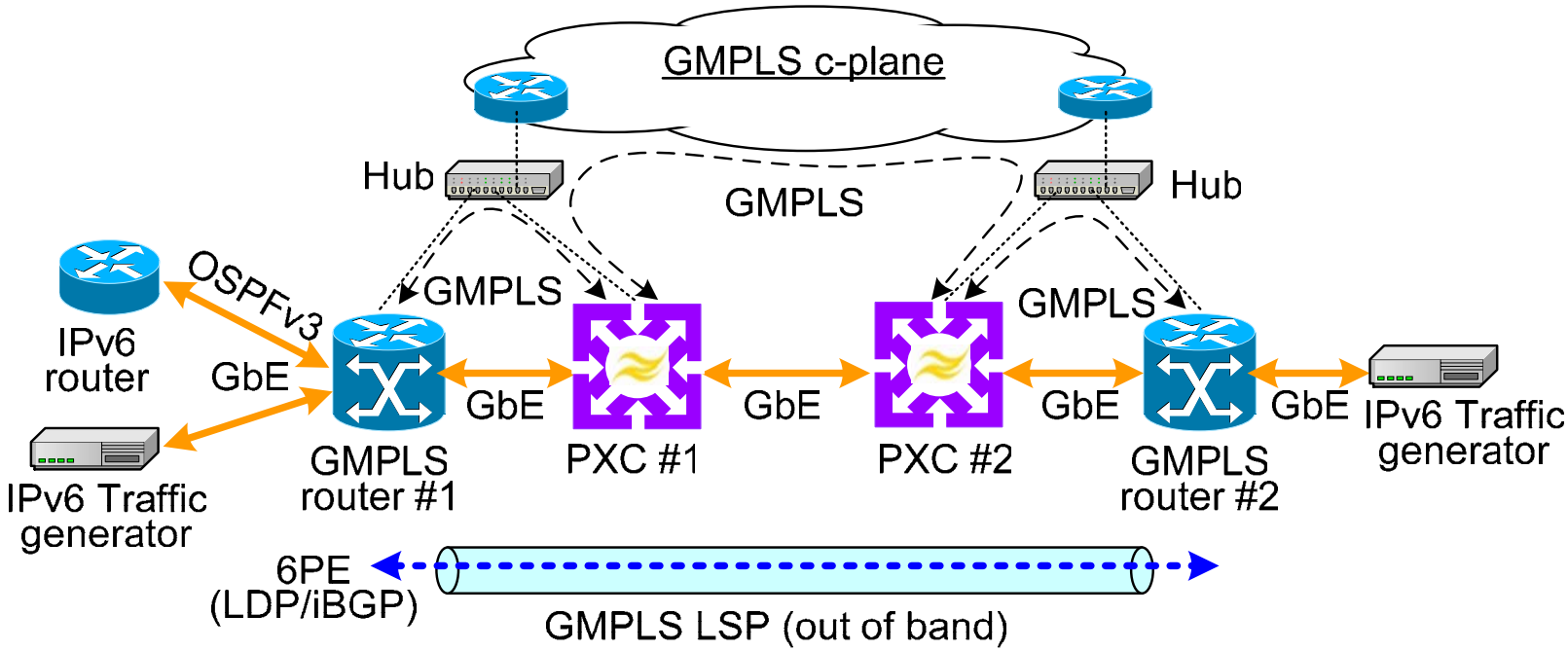
- **Service migration from GMPLS point of view**
  - **MPLS interworking with GMPLS**
    - Major services (IP-VPN, Ethernet-VPN) are based on MPLS
    - Legacy services (ATM/FR) can be transported using MPLS
  - **IP interworking with GMPLS**
    - IPv4 as well as IPv6 is to be supported.
    - BGP-4 is to be transported over GMPLS

MPLS over GMPLS



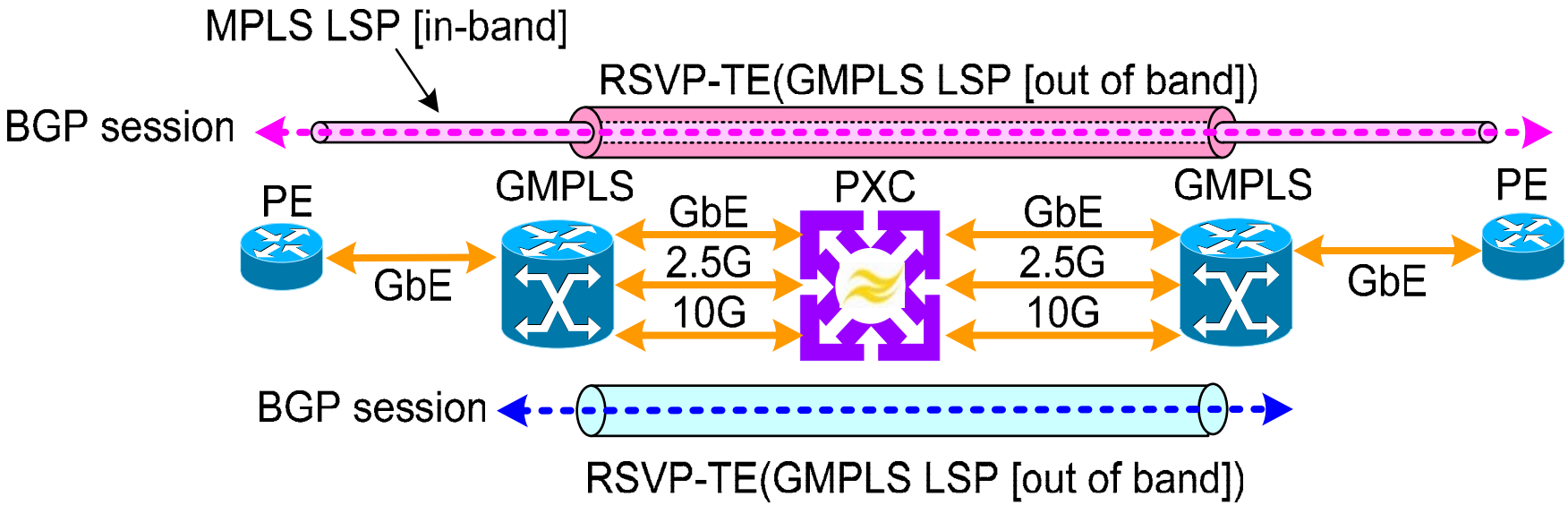
- MPLS LSP creation over a GMPLS LSP
  - A (bidirectional) GMPLS LSP is created between GMPLS routers.
    - LSPs can be created with GbE, 2.5G and 10G bandwidth
    - The tunnel is logically numbered as IPv4 addresses.
  - A MPLS LSP is created between PE routers.
    - LSPs can be created specifying logically created interfaces.
- IP traffic restoration by GMPLS
  - IP traffic can be restored within GMPLS restoration time (700ms)
    - The MPLS signaling storm can be avoided by GMPLS restoration (and protection).

IPv6 over GMPLS



- IPv6 transport over GMPLS
  - Assisted by the 6PE function on GMPLS routers
    - An iBGP session over GMPLS tunnels
    - A LDP session encapsulating IPv6 packets over GMPLS tunnels
  - IPv6 packets can be transmitted over GMPLS
- OSPFv3 with GMPLS routers
  - Interoperability under the multi-vendor environment
  - Reachability confirmed by ICMPv6

BGP over GMPLS



- BGP-4 over GMPLS
  - GMPLS LPS creation between GMPLS routers (w/o OSPF-TE)
  - BGP-4 session establishment over a GMPLS LSP
    - Different ASes are connected over a GMPLS core
  - BGP-4 session establishment over a MPLS LSP

Future investigation and challenge

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- Actually operational migration
  - Addressing, AS number, etc.
- Control of multi layers
  - Dynamic interaction between (IP/)MPLS/GMPLS
- High resiliency of GMPLS networks
  - Data plane recovery as well as control plane recovery
- GMPLS multi-domain
  - GMPLS Inter AS/area
- Interoperability
  - To assure multi-vendor environment

Conclusion

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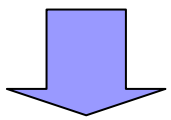
A nation-wide field trial using GMPLS controlled PXCs, IP/MPLS routers and existing DWDM systems was successfully demonstrated.

- Fast provisioning/protection & restoration of PXCs
- Interworking operation between PXCs and IP/MPLS routers on both signaling & routing levels
- Reuse of the IP-based DCN as a GMPLS control plane
- PXC Interworking with DWDM by using LMP-WDM protocol.



In addition….

- Demonstration of MPLS/IPv6 transport over GMPLS networks
  - MPLS/GMPLS
  - IPv6/GMPLS
  - BGP-4/GMPLS

A GMPLS controlled network can be deployed in a carrier's actual environment and is expected to improve carriers network operation and service management.