MPLS to GMPLS Migration: From Concept to Validation

An update from Isocore, NTT and KDDI

Rajiv Papneja
rpapneja@isocore.com
Eiji Oki
oki.eiji@lab.ntt.co.jp
Kenichi Ogaki
ogaki@kddilabs.jp

ISOCORE

2006 IP+Optical Network

Outline

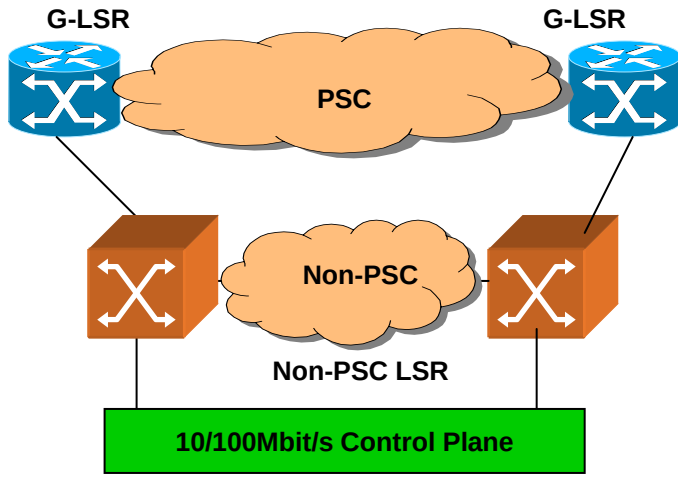
- MPLS-GMPLS Migration and Interworking
- Challenges in MPLS-GMPLS (IP+Optical) Interworking – A year in review
  - Addressing and Interoperability Issues
  - Understanding the IP layer at Optical layer
- Status and Progress of GMPLS
  - MPLS 2005 Public Demonstration
  - Isocore Spring LEC testing
  - iPOP 2006 Demonstration - Multi-Site IP-Optical Integration Demonstration
  - MPLS 2006 Public Demonstration Invitation

ISOCORE

2006 iPOP IP+Optical Network

MPLS to GMPLS Migration / IP+Optical Motivation & Background

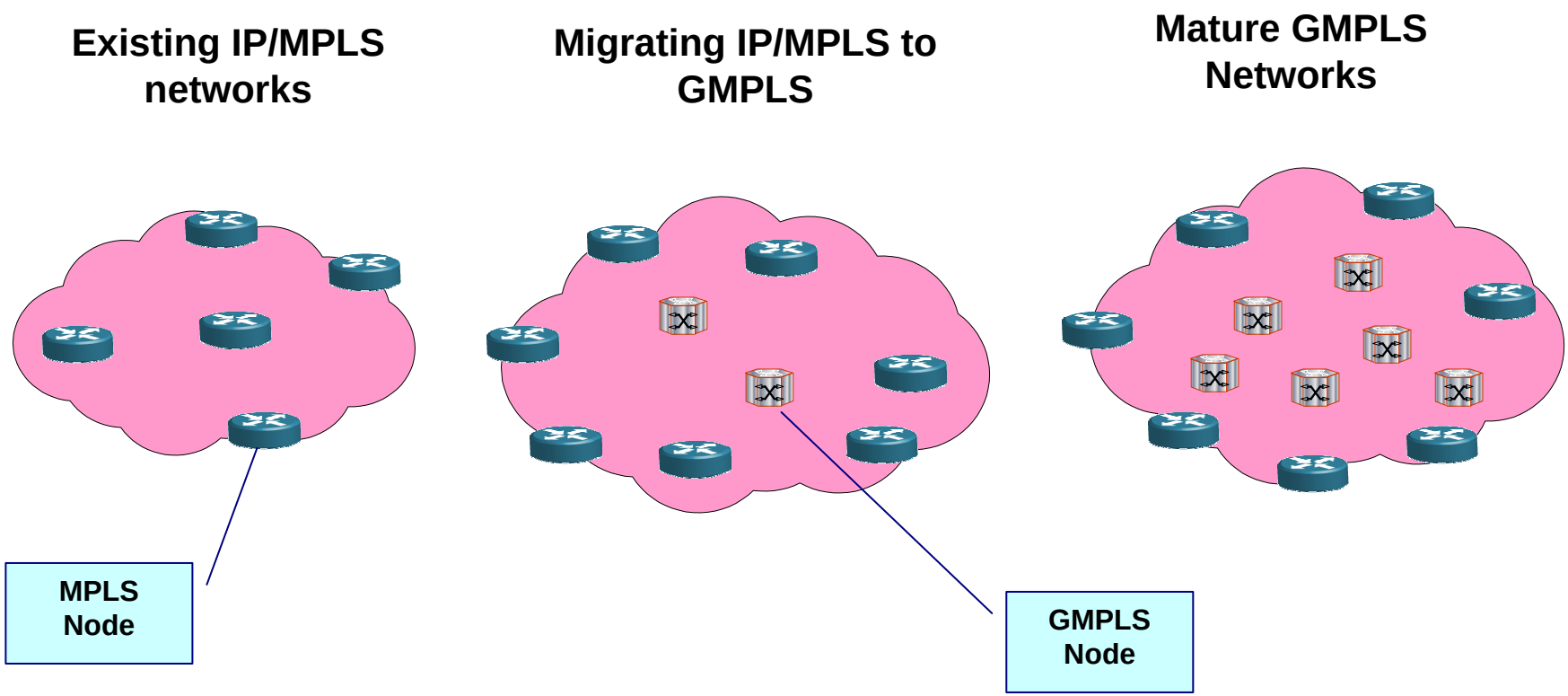
- To have PSC MPLS layer to control non-PSC optical layer utilizing GMPLS
- GMPLS LSRs having control of MPLS and GMPLS LSPs
- GMPLS LSRs having complete view of the multiple IGP areas
- Integration of multiple networks administered by different organizations (Inter-Carrier)
- This helps MPLS capable devices to interoperate with OXCs supporting only GMPLS based extensions



ISOCORE

2006 IP+Optical Network

MPLS – GMPLS Migration Path
A Unified Vision



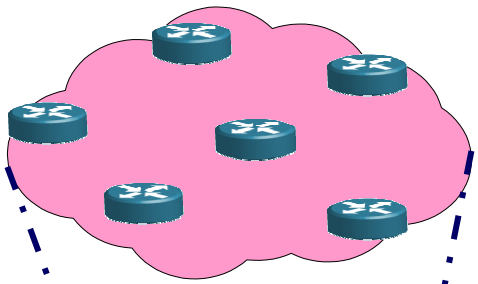
To Evolve an MPLS-TE-based control plane to a GMPLS-based control plane

ISOCORE

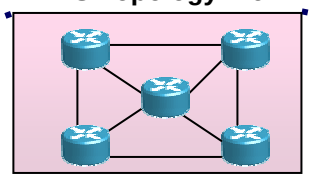
2006 IP+Optical Network

MPLS-GMPLS Interworking - Scenarios
Permanent Test Bed at Isocore

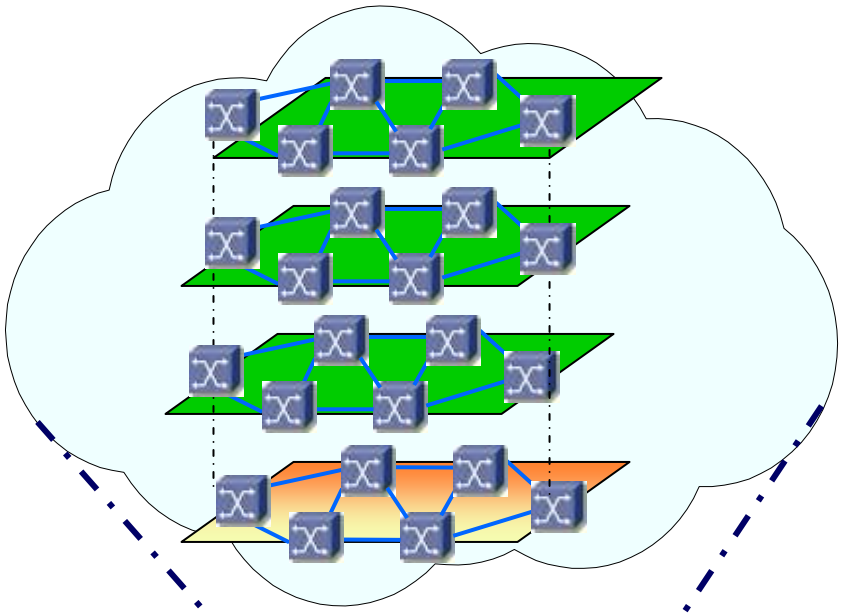
Routing information
FA LSP information in the LSDB
Opaque Router LSA (MPLS)
MPLS TE LSDB



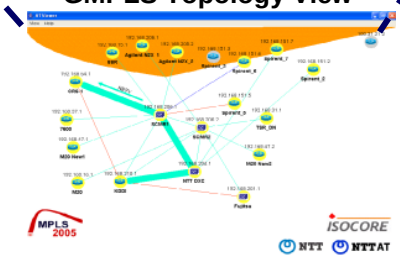
MPLS Topology View



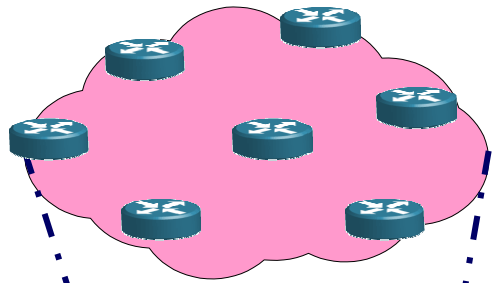
Optical Domain TE LSAs
Summary LSAs from IP layer
(if diff. areas)
GMPLS LSP Views
Transport Hierarchy



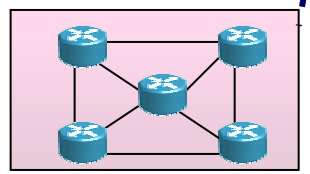
GMPLS Topology View



Routing information
FA LSP information in the LSDB
Opaque Router LSA (MPLS)
MPLS TE LSDB



MPLS Topology View



ISOCORE

2006 IP+Optical Network

MPLS-GMPLS Interworking - Scenarios IP+Optical Integration

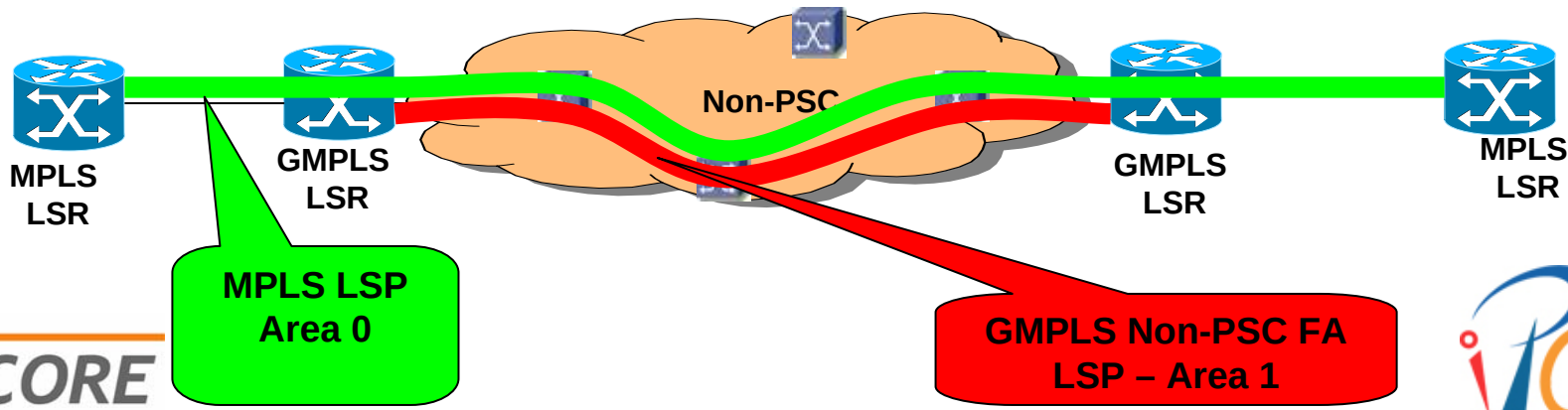
- Isocore in support with its carrier is in process of evaluating following MPLS-GMPLS interworking scenarios
  - MPLS domain and GMPLS (non-PSC) domain
    - MPLS-GMPLS (non-PSC)-MPLS
    - GMPLS (non-PSC)-MPLS-GMPLS (non-PSC)
  - MPLS domain and GMPLS (PSC) domain
    - MPLS -GMPLS (PSC)-MPLS
    - GMPLS (PSC)-MPLS-GMPLS (non-PSC)
    - GMPLS (PSC)-MPLS (ingress: GMPLS (PSC), egress: MPLS)
    - MPLS-GMPLS (PSC) (ingress: MPLS, egress: GMPLS (PSC)

ISOCORE

2006 IP+Optical Network

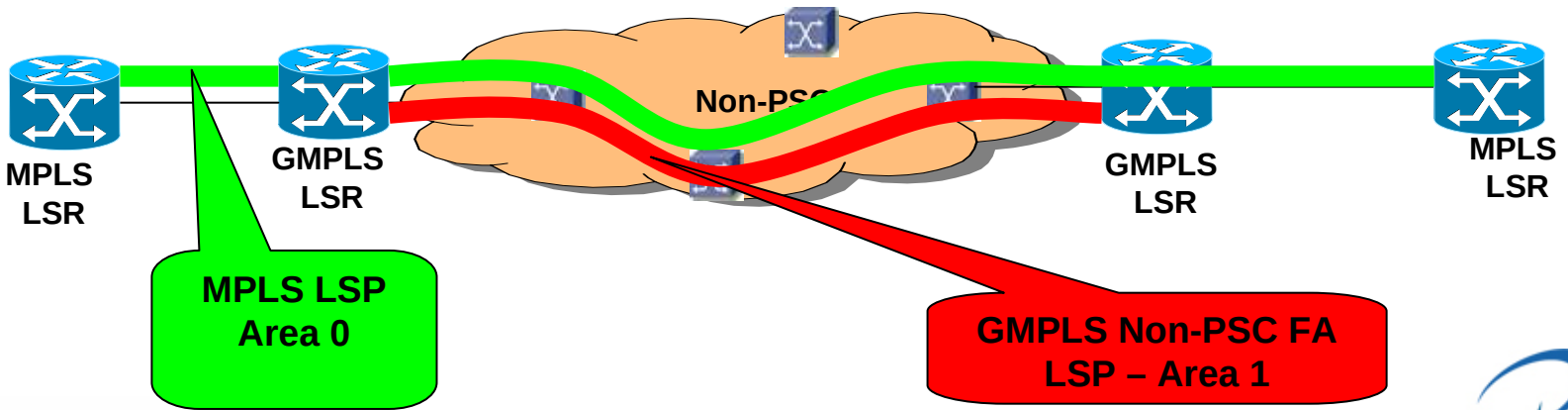
Focus of MPLS-GMPLS Migration Scenarios

- MPLS domain and GMPLS (non-PSC) domain
  - MPLS-GMPLS (Non-PSC)-MPLS
    - Nested Signaling – Pre-Provisioned with Pre-configuration (FA-LSP):
      - GMPLS Non-PSC LSP establishes as FA-LSP with pre-configuration at either ends
      - MPLS LSP may be established as FA-LSP through the GMPLS Non-PSC LSP
      - FA LSPs are advertised in areas in which they are setup, underlying LSPs could be in different areas



Focus of MPLS-GMPLS Migration Scenarios

- Pre-Provisioned with no Pre-configuration (FA-LSP)
- MPLS node can establish an MPLS LSP that is nested by a pre-provisioned GMPLS LSP (PSC)
- Setup of GMPLS LSP triggered by MPLS LSP

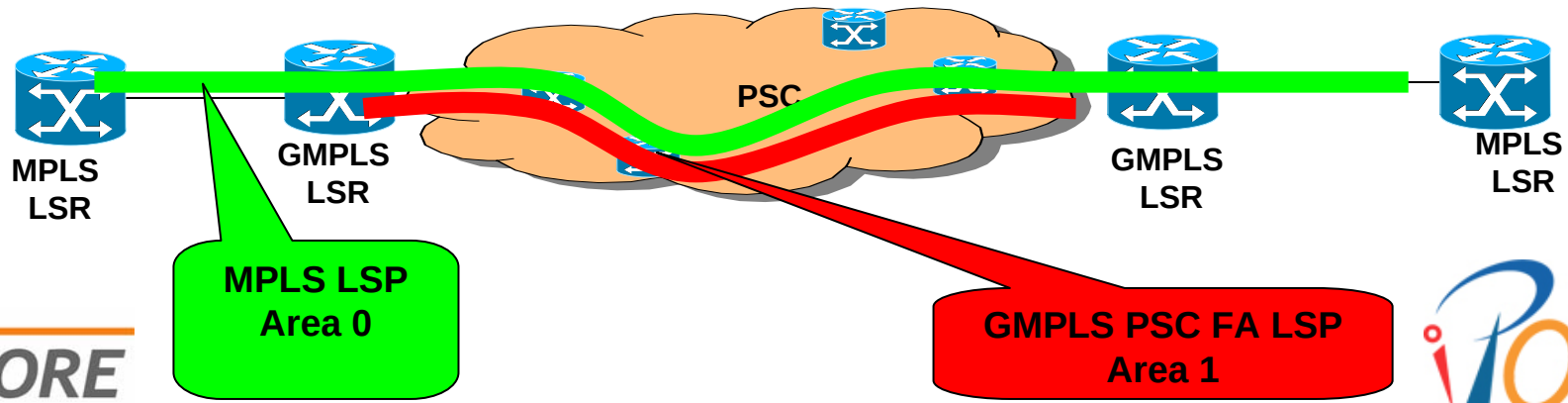


ISOCORE

2006 IP+Optical Network

Focus of MPLS-GMPLS Migration Scenarios

- MPLS-GMPLS (PSC)-MPLS
  - Planned for MPLS 2006 Conference demonstration
  - Nested Signaling
    - Pre-provisioned
      - MPLS node can establish an MPLS LSP that is nested by a pre-provisioned GMPLS LSP (PSC).
    - Triggered
      - MPLS node can establish an MPLS LSP that is nested by a GMPLS LSP (PSC) that is setup triggered by the MPLS LSP setup



Outline

- MPLS-GMPLS Migration and Interworking
- Challenges and results from Isocore Test Efforts: A year in review
  - Addressing and Interworking Issues
  - Understanding the IP layer at Optical layer
- Status and Progress of GMPLS
  - MPLS 2005 Public Demonstration
  - Isocore Spring LEC testing
  - iPOP 2006 Demonstration - Multi-Site IP-Optical Integration Demonstration

ISOCORE

2006 iPOP IP+Optical Network

Challenges/ Results from Isocore LEC testing Update since iPOP 2005

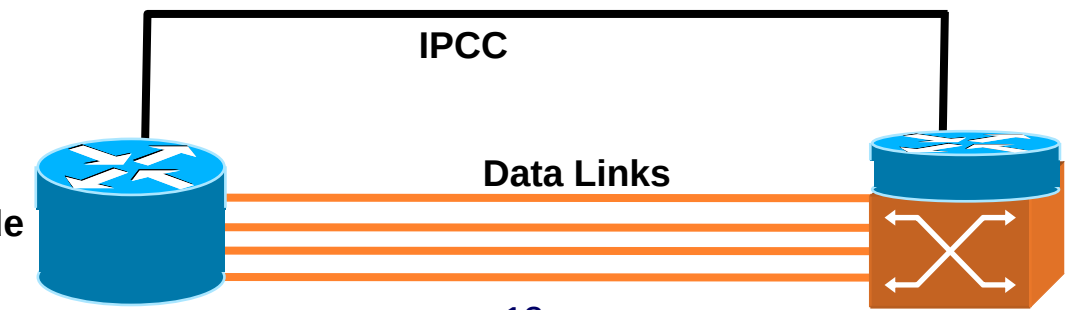
- Isocore along with NTT and KDDI conducted 3 LEC testing events since iPOP 2005
- Spring 2005, Fall 2005, and Spring 2006
- Fall 2005 results showcased at MPLS 2005 International Conference
- Spring 2006 LEC results beings showcased locally here at iPOP 2006 showcase
- Primary focus has been:
  - MPLS-GMPLS Interworking
  - GMPLS UNI within context of L1VPNs
  - ASON-GMPLS Interworking
  - LSP Hierarchy and LMP

ISOCORE

2006 iPOP IP+Optical Network

Challenges in MPLS-GMPLS (IP+Optical) Interworking – Control Plane Setup

- Control Plane convergence: Are we there yet?
  - IPCC Connectivity
    - Using GRE Tunnels
      - Most of the vendors now support this functionality
      - Further validated in Spring 2006 LEC event
      - Limits the unnecessary OSPF adjacencies established
      - Control the OSPF hello
      - Numbered and Unnumbered
    - Other Options still very strongly and widely support
      - Broadcast mode over native Ethernet
        - All implementations support this functionality
      - IP-in-IP supported by a minimal subset of vendors
      - P2MP a very viable option but limited support
        - Plans to attempt again in fall 2006 LEC event



Challenges in MPLS-GMPLS (IP+Optical) Interworking – Routing/ Reachability

- OSPF-TE used for all three Isocore LEC events
  - Most of the implementations only have OSPF-TE at this time
  - Restricts us to use only OSPF at IP-Layer
- OSPF LSAs at IP and Optical Layer
  - All test bed had two OSPF areas
  - OSPF Area 0 configured at IP layer, and Optical Layer configured with Area 1
  - FA-LSPs are advertised as a TE links in Area 0
  - Optical devices have to handle large no. of summary LSAs when multiple routing instances are used
  - Challenge in handling the reachability to the TE router-ID (multiple paths) from IPCC as well as IP layer
    - More testing needed to verify the isolation and behaviors

Challenges in MPLS-GMPLS (IP+Optical) Interworking – TE Links/ Addressing

- Addressing draft tested in Fall 2005 testing
  - Most of implementations supporting the addressing defined in draft-ietf-ccamp-gmpls-addressing-03.txt
- TE-Router ID reachable address
- TE links identification
  - Still implementations offer mixed support
    - Numbered and Unnumbered
  - Certain implementations only support one of the two
  - Restricts the flexibility of vendor interworking
  - Encoding type used for CSPF calculations
    - Ambiguity exists
    - Draft-otani-ccamp-gmpls-cspf-constraints clarify this scenario
- More verification of addressing draft is required

ISOCORE

2006 IP+Optical Network

Challenges in MPLS-GMPLS (IP+Optical) Interworking – Signaling/ Messaging

- Handling of G-PID
  - Significance and interworking still to be resolved
  - How strict an implementation should be in accepting the connections, if it does not support a signaled G-PID value in the LSP
    - Strictly speaking unsupported G-PID should not be accepted
- RSVP Messages/ Refresh reduction
  - Implementations should either agree for SREFRESH or Full refresh
    - Reference to refresh reduction capability bit as defined in RFC 2961
  - LSP times out observed due to implementations not agreeing on refresh type – refresh timers expiring
  - Support for Message ID/ and protection objects
    - Implementations reject Path messages if these objects exists
    - Proprietary protection should be ignored
    - Implementations should consider supporting recovery-e2e-signaling-03.txt

Challenges in MPLS-GMPLS (IP+Optical) Interworking – Signaling/ Messaging

- Path Setup and Tear Down
  - Graceful tear down is supported by most of the implementations
  - Graceful restart of RSVP-TE is also supported and handling of the recovery label
- A comprehensive set of tests were planned
  - To evaluate the combination incoming or outgoing interface in the ERO definition
- LSP switching type
  - All signaling types were evaluated
  - PSC/TDM/LSC and FSC

Clear understanding of Lambda labels needed

Challenges in MPLS-GMPLS (IP+Optical) Interworking – Current Status

- Addressing draft greatly simplified the understanding of the IP paradigm at Optical layer
- Most of the vendors consider and are aligning the implementations to this draft
- This has simplified the adoption of GMPLS technology
- All implementations should strictly adhere to this draft, and should be considered as a checklist for all future test events
- Since last year, the implementations have improved in stability
- More testing needed for LMP
- More testing needed in the L1VPN, and GMPLS UNI area

ISOCORE

2006 IP+Optical Network

Outline

- MPLS-GMPLS Migration and Interworking
- Challenges in MPLS-GMPLS (IP+Optical) Interworking – A year in review
  - Addressing and Interoperability Issues
  - Understanding the IP layer at Optical layer
- Status and Progress of GMPLS
  - MPLS 2005 Public Demonstration
  - Isocore Spring LEC testing
  - iPOP 2006 Demonstration - Multi-Site IP-Optical Integration Demonstration

ISOCORE

2006 iPOP IP+Optical Network

MPLS 2005 Demonstration
The Complete Picture

Source 100 IPTV channels

STB

N2X

IPv4 MPLS/Multicast Core

RR-L3VPNv4/v6

MPLS DS- ELSPs

VPLS with IGMP Snooping

MPLS P2MP TE for IP Multicast & MVPN TEST

SR-7

SR-1

7600

Ixia

SE800

GSR410

Chiaro

Fujitsu

7600

CRS

SSR

CRS

TSR

SSR

SN 16000

SN 16000

NTT OXC

FUJ

GSR406

M20

GMPLS/UNI Core Transit Domain

M20

M20

M20

GSR

SR-7

ERX

SE800

HA-LDP/BGP

HA- RSVP-TE

LDP Fast Reroute

N2X

Source 100 IPTV channels

7200

GSR

M20

6PE & 6VPN
IPv6 VPN over IPv4

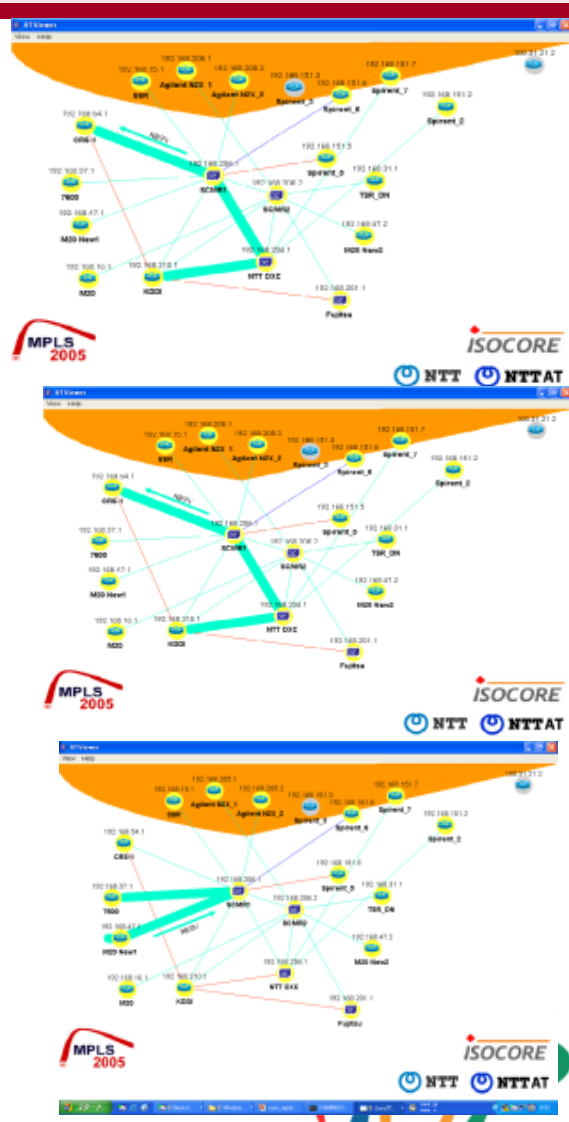
ISOCORE

2006

IP+Optical Network

MPLS 2005 Demonstration Overview: Devices are becoming more Stable on LSP Setup

- GMPLS LSP Path Setup and LMP
  - For the first time LMP was tested
    - The Effort only included the basic link property correlation
  - 16 Successful GMPLS LSPs (FSC/TDM) were established during 4 days of testing Effort
    - Success attributed to the agreement amongst the vendors to support common addressing
- MPLS/GMPLS Migration
  - LSP Hierarchy was successfully tested and was used to carry IPTV traffic – FA LSPs
  - GMPLS LSPs supported the VPLS/M-VPN traffic for IPTV delivery
  - Test Equipment was used to send traffic across the GMPLS LSP and receive at the IP/MPLS layer



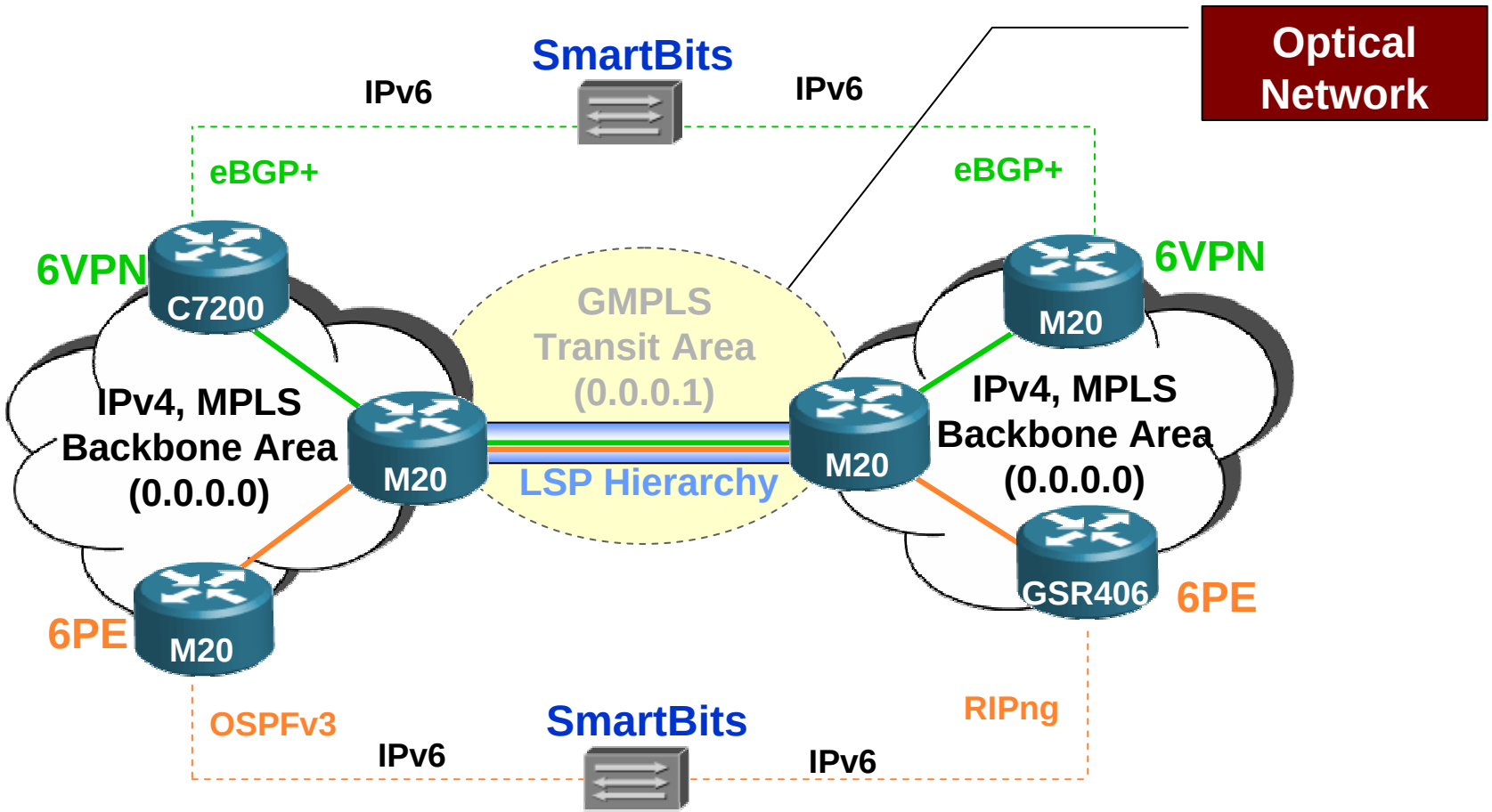
MPLS 2005 Demonstration Overview
Success of LEC – GMPLS/OIF UNI Test Effort

- IETF GMPLS – UNI (Overlay Model)
  - For the first time GMPLS Overlay model was verified
    - Support for the Ethernet over SONET is being showcased during the demo
    - GMPLS-UNI LSPs were used to be configured for LSP hierarchy
    - OIF-UNI and GMPLS Interworking scenarios were also attempted as part of this testing effort
- ASON and GMPLS Interworking
  - Focusing on Inter-carrier translation mechanisms

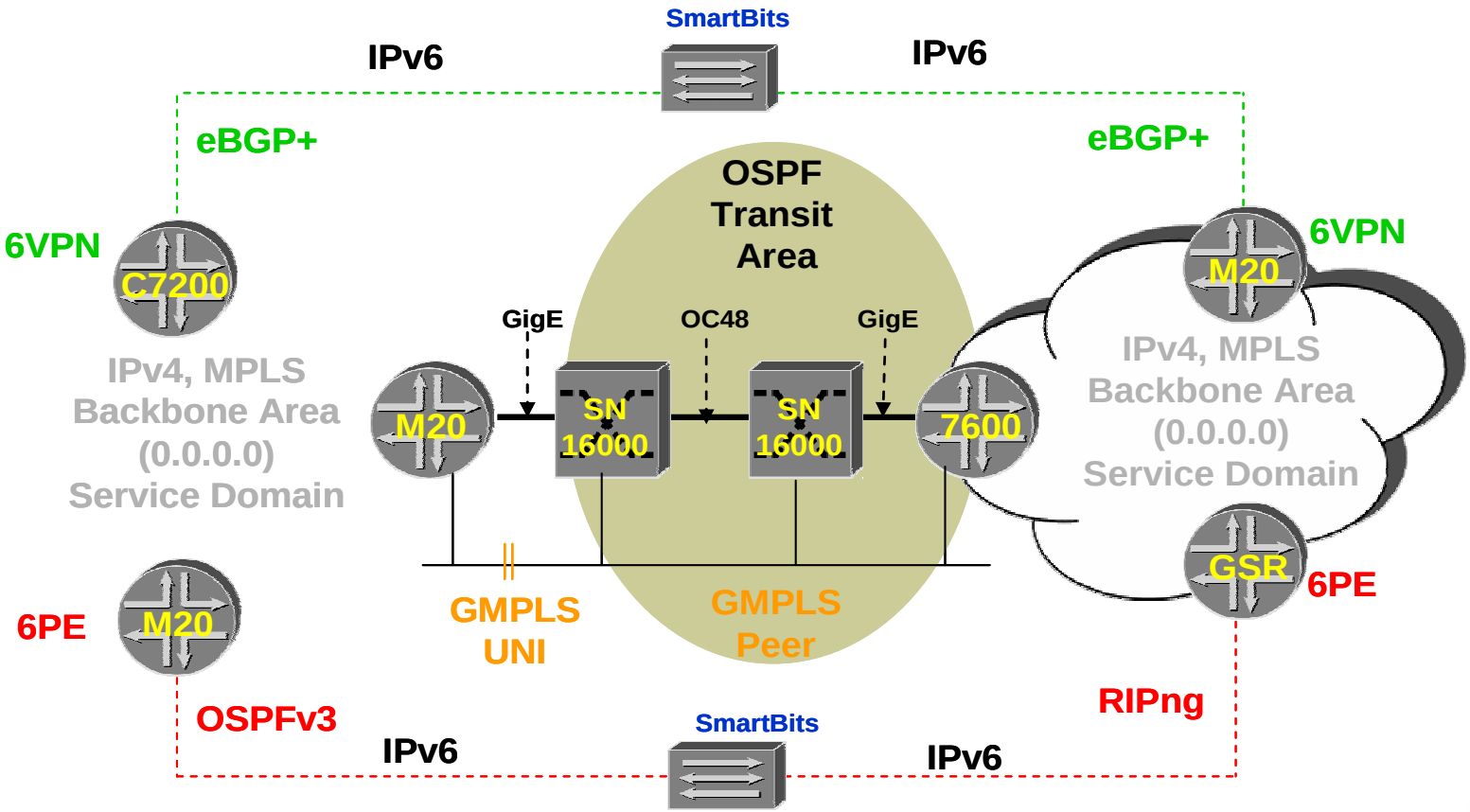
ISOCORE

2006 iPOP IP+Optical Network

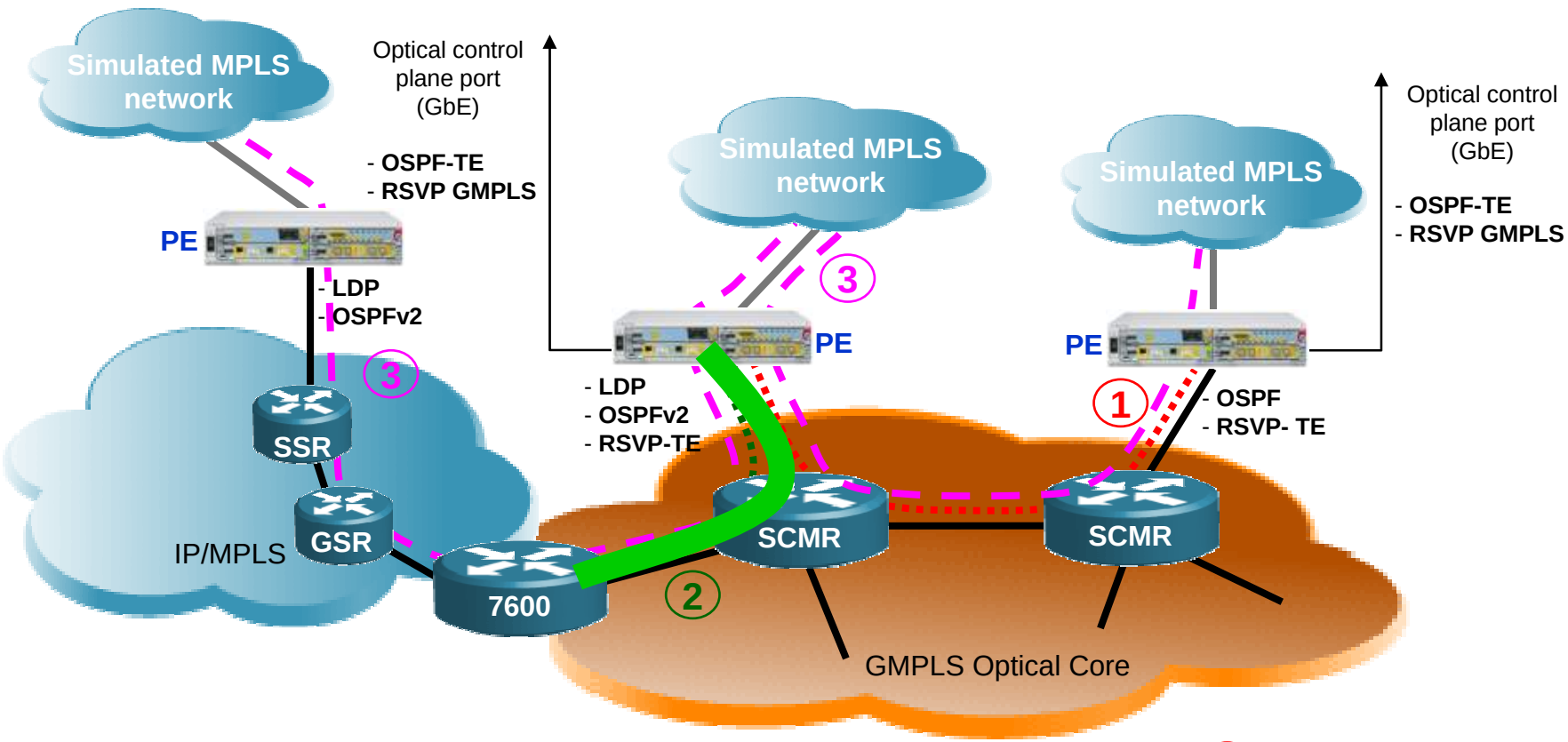
6PE & 6VPN Demonstration
Supporting IPv6 over IPv4 IP-Optical Core



Success of LEC – GMPLS UNI Test Effort



A Migration Deployment Scenario



1 *LSP 1*

2 *LSP 2*

3 *MPLS over GMPLS*

ISOCORE

2006 IP+Optical Network

MPLS 2005 Demonstration Participation

Agilent Technologies

ALCATEL

ARCHITECTS OF AN INTERNET WORLD

AVICI SYSTEMS

CISCO SYSTEMS

EMPOWERING THE INTERNET GENERATION

CHIARO

FUJITSU

IXIA

Juniper NETWORKS

KDDI

KDDI R&D LABS

NTT AT

NTT

Redback NETWORKS

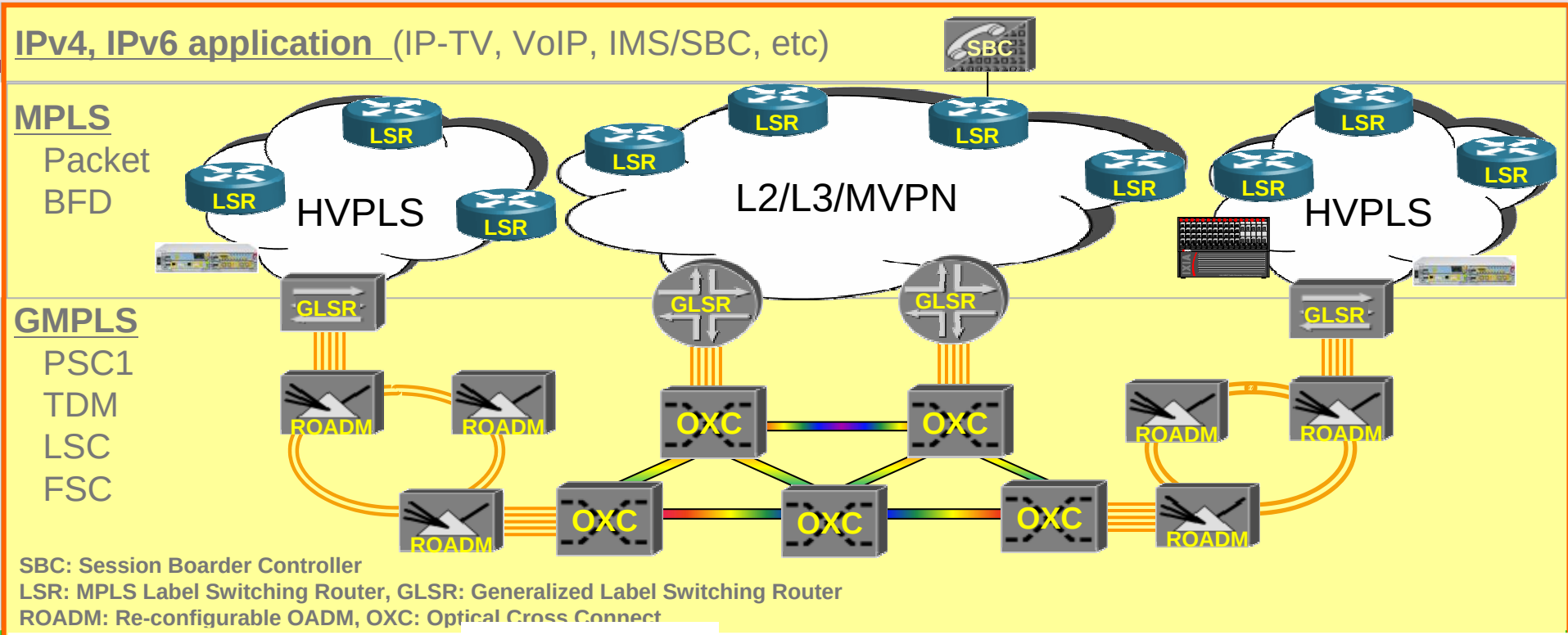
SPIRENT Communications

SYCAMORE NETWORKS

ISOCORE

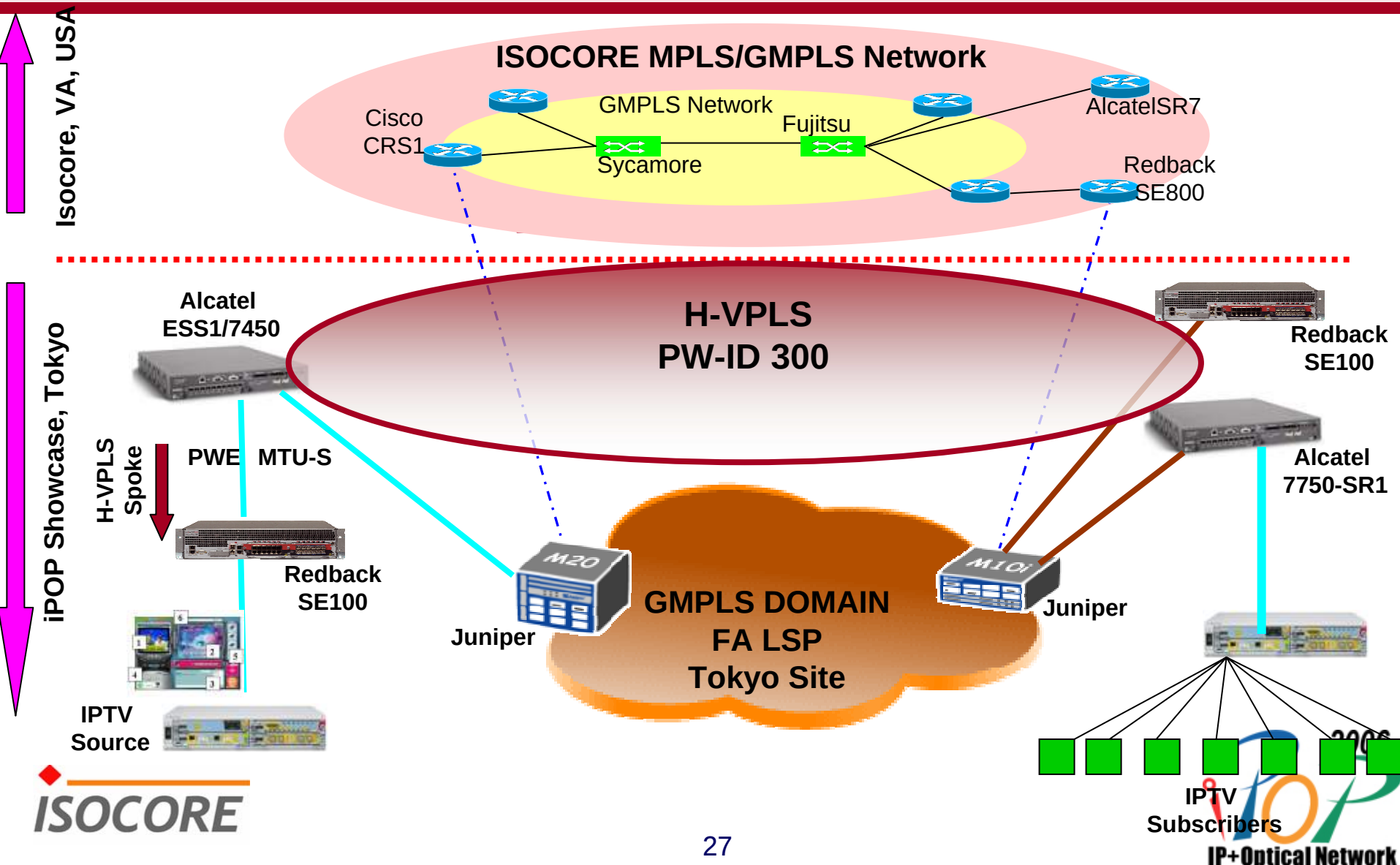
2006 IP+Optical Network

Case Study – Isocore Spring LEC 2006



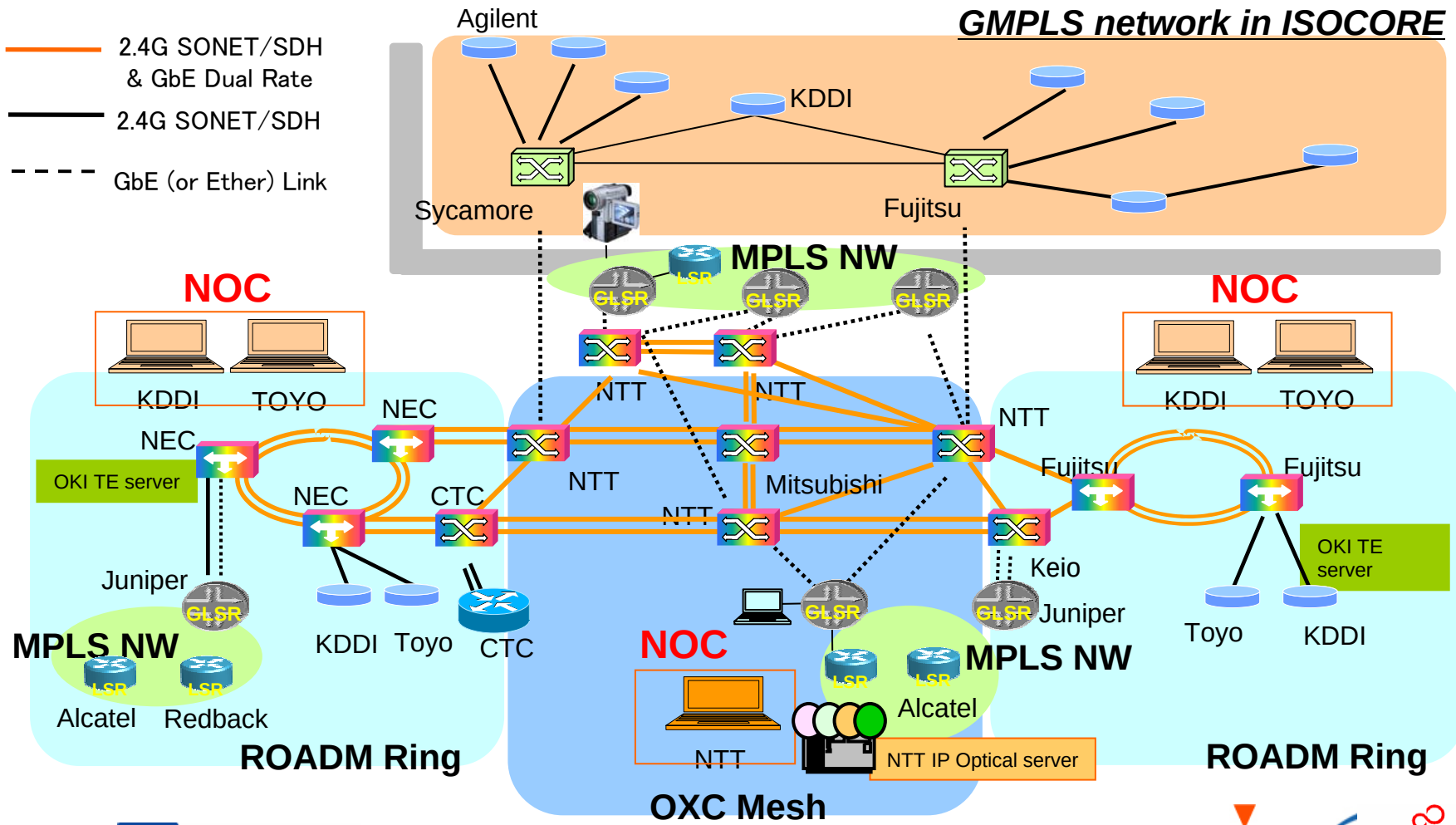
Agilent Technologies
Cisco Systems
IXIA
NAVTEL
ALCATEL
FOUNDRY NETWORKS
Juniper NETWORKS
NTT AT
ANUE
FUJITSU
KDDI
KDDI R&D LABS
Redback NETWORKS
AVICI SYSTEMS
ISOCORE
NTT
SYCAMORE NETWORKS

Ethernet Services over MPLS/GMPLS LSPs
Multi-site Isocore-iPOP Demo – Results of Spring 06 LEC



iPOP 2006 Showcase Network

PIL Photonic Internet Lab. ISOCORE



NEC Juniper NETWORKS OKI Agilent Technologies Redback NETWORKS ALCATEL FUJITSU

KDDI KDDI R&D LABS SYCAMORE NETWORKS CTC TOYO Corporation MITSUBISHI ELECTRIC NTT

Upcoming Isocore LEC Testing – Fall 2006
MPLS 2006 Public Demonstration

- MPLS 2006 International Conference
  - www.mpls2006.com
  - October 15-18, 2006 – Washington D.C.
- Tentative Focus
  - L1 VPNs
  - ASON/GMPLS
  - LSP Hierarchy
  - Inter-Carrier Scenarios
  - PCE/VNT
  - MPLS – GMPLS migration
  - LMP

ISOCORE

2006 IP+Optical Network

Thank You!

Please email your questions to rpapneja@isocore.com

The proof of the next generation Internet