



# **MPLS Protocol & Services Interoperability Event SUPERCOMM 2002**

# MPLS Offering

Service/Network Characteristics desired by End-user or Service Provider	The relevant MPLS features
Low connection loss/ packet loss	Traffic Engineering (TE) feature which allows for multiple Explicit Routes (ER) for the same source-destination for fast restoration
Low jitter, Low latency	TE/ER
Security	MPLS VPN support – with the caveat that there is no encryption
Control of traffic distribution	TE/ER to route around congested shortest paths
Independence from layer 2 (co-existence of IP, FR, ATM, Optical networks)	MPLS architecture
Co-existence of MPLS and non-MPLS networks	MPLS architecture
Various service levels e.g. Gold etc.	Service QOS guarantees using TE, Differentiated Services (DiffServ)
New Revenue Generating Services	Label stacking for scalability

# Meeting carrier objectives: MPLS technology Components

- Control component (control plane)
  - Label binding concept per flow or per “Forwarding Equivalence Class” (FEC)
  - Allows various applications:
    - Traffic engineering
    - Service provisioning (in a scalable fashion)
    - Differentiated Services (& Quality of Service)
    - Restoration Services
- Forwarding component (data plane)
  - Label swapping paradigm
    - Per-label forwarding and queuing
    - Efficient look-up and forwarding

# Current Interoperability Initiatives

- IOL, UNH - Initial RSVP-TE, LDP & CR-LDP testing
- EANTC - RSVP-TE, LDP & CR-LDP, BGP/MPLS VPN testing
- AIL, GMU - RSVP-TE, LDP, BGP/MPLS VPN testing
- Isocore - Layer 2 over MPLS, RSVP-TE Fast Reroute testing
- Also N+I iLABs holds public MPLS interop events
- MPLS Forum's goal is to bring achievements to public view

# Basic Terminology

- P - Provider Core Router
- PE - Provider Edge Router
- CE - Customer Edge Router
- VPN - Virtual Private Network
- BGP/MPLS VPN - Layer 3 MPLS VPN using BGP-4
- VRF Table - VPN Routing and Forwarding Table
- L2oMPLS - Layer 2 over MPLS Transport
- EoMPLS - Ethernet over MPLS Transport
- “Martini Draft” - A draft proposing a L2oMPLS solution - in this context only the Ethernet over MPLS part was used.

# The Interoperability Test Plan

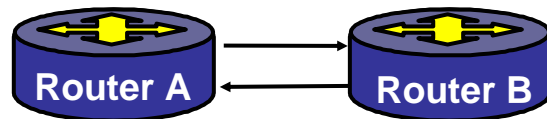
- Technology
  - RSVP-TE Signaling Protocol
  - LDP Signaling Protocol
  - LDP over RSVP-TE Signaling
- Services
  - Ethernet / VLAN over MPLS
  - BGP/MPLS VPN

# The Interoperability Test Plan

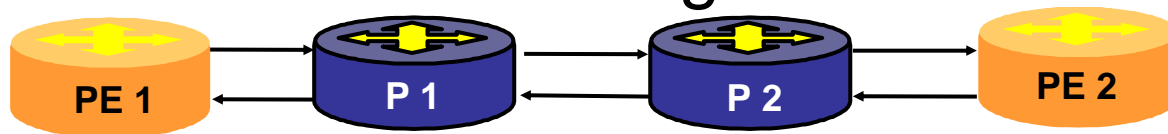
- Key Contributors:
  - Laurel Networks
  - Celox Networks
  - European Advanced Network Testing Center (EANTC)
  - University of New Hampshire Interoperability Lab (IOL-UNH)
  - Agilent Technologies
- Discussed on a series of conference calls!

# The Testing

- Signaling Protocol Testing
  - LDP
  - RSVP-TE
- Round 1: One-on-One Testing



- Round 2: Quad Testing



- Round 3: Putting the network together

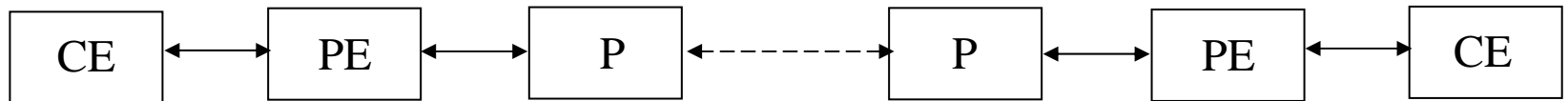


# The Demo Network

- Building & Testing a Core Network
  - Based on results from Rounds 1 and 2, a core network was constructed
  - Full mesh of RSVP-TE tunnels tested
- Testing the Edge devices
  - One-on-one Services testing
- Building & Testing the complete network
  - Connect the Edge devices to the Core network
  - Run Services over tunnels across the network

# The Demo Network

- The test scenarios looked like this - sometimes had up to four P routers.



- All PE and P routers came from different vendors
- Testing covered LDP, RSVP-TE, BGP/MPLS VPN and Ethernet over MPLS
- Interfaces used in the network were POS OC-12 and OC-48 and Gigabit Ethernet

# The 21 Companies

- Agilent Technologies
- Alcatel
- Avici Systems
- Celox Networks
- Charlotte's Web Networks
- Ericsson
- Extreme Networks
- Foundry Networks
- Intel
- Ixia
- Juniper
- Laurel Networks
- Lucent Technologies
- Mahi Networks
- Marconi Communications
- Nettek
- Riverstone
- Spirent Communications
- Tenor Networks
- Unisphere
- Vivace

# The Edge Devices

## Network Equipment:

- Celox SCX 192
- Extreme BlackDiamond
- Foundry NetIron 400
- Juniper M5
- Laurel ST200
- Lucent Springtide 7000
- Mahi Mi7
- Riverstone RS8000
- Tenor TN250G
- Unisphere ERX 1400
- Vivace Viva 1050

## Provider Edge Emulators:

- Agilent RouterTester 900
- Intel® MPLS Signaling Protocol
- Ixia 1600
- Nettek InterEmulator
- Spirent Adtech AX4000

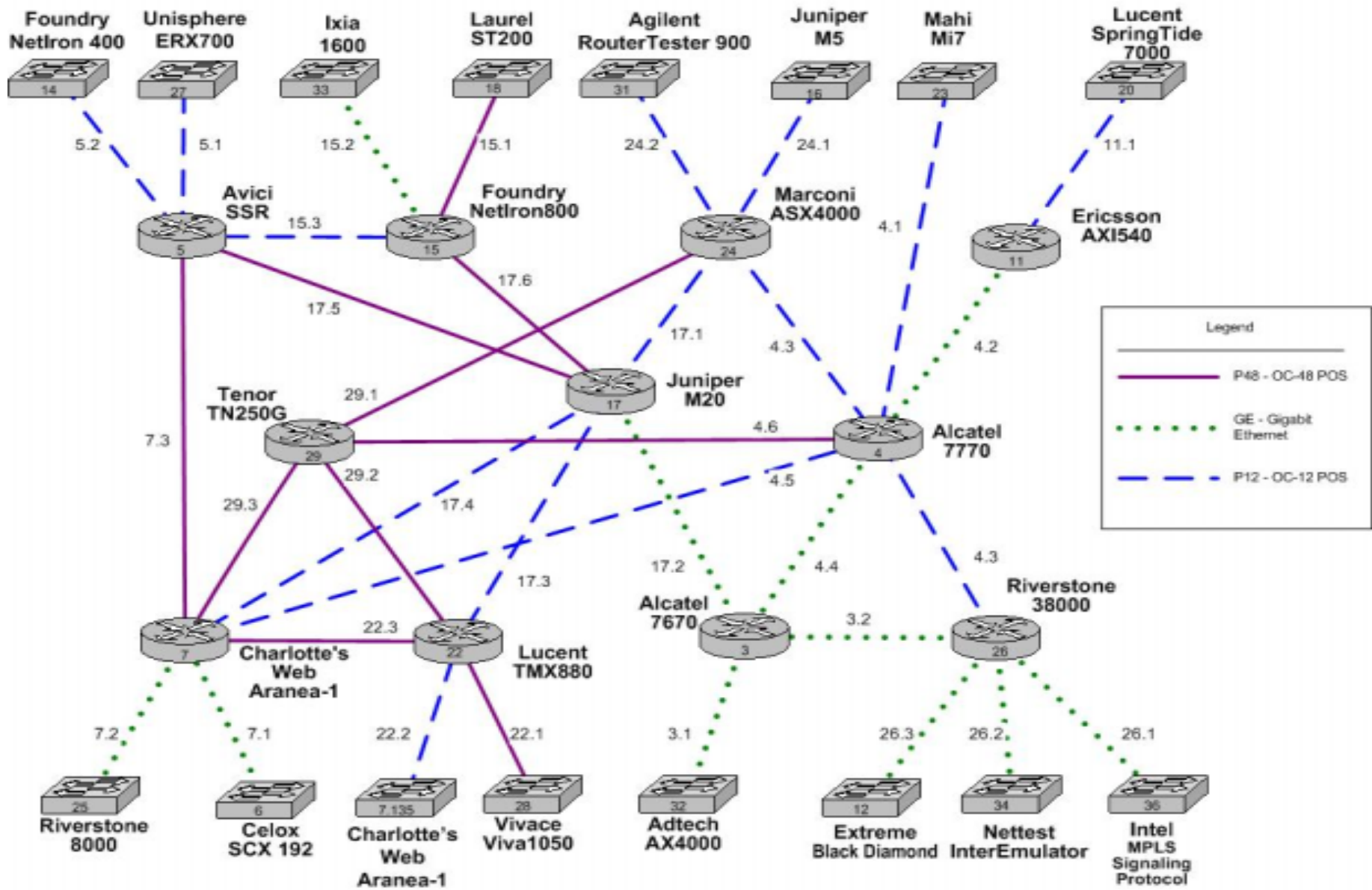
## Customer Edge Emulators:

- Traffic Generators
- Agilent RouterTester 900
- Ixia 1600
- Adtech AX4000

# The Core Devices

- **Alcatel 7670**
- **Alcatel 7770**
- **Avici SSR**
- **Charlotte's Web Aranea-1**
- **Ericsson AXI 540**
- **Foundry NetIron 800**
- **Intel® MPLS Signaling Protocol**
- **Juniper M20**
- **Lucent TMX 880**
- **Marconi ASX4000**
- **Riverstone RS38000**
- **Tenor TN250G**

# MPLS Forum SUPERDemo Network Topology



# The Results - issues identified

- OSPF Traffic Engineering extensions
- LDP Modes of Operation
- RSVP-TE Reservation Style
- RSVP-TE Explicit Route
- RSVP-TE Reservation Confirmation info.
- Label Engine

# OSPF-TE Issue

- **Issue**
  - TE extensions to OSPF are not supported by all equipment
  - They are mandatory for some equipment to set up RSVP-TE LSPs
- **Temporary resolution**
  - Used a device that supports OSPF-TE, but does not require it to be used in between the device that requires OSPF-TE and the device that does not support it.
- **Recommendation**
  - TE extensions should not be mandatory in equipment



# LDP Issue

- **Issue**
  - Some vendor implementations only support label distribution of DoD or DU (irrespective of interface types).
- **Temporary resolution**
  - No resolution possible
- **Recommendation**
  - Recommendations in in RFC-3036 need to be followed to prevent this from occurring.

# RSVP-TE Reservation Style Issue

- **Issue**
  - Some vendors implementations are inflexible since they only support FF or SE style reservations.
- **Temporary resolution**
  - No resolution possible
- **Recommendation**
  - Recommendations of RFC-3209 stating that the receiver determines the reservation style need to be followed and accepted by the sender

# RSVP-TE ERO Issue

- **Issue**
  - ERO is supported but the IP address contained in the ERO may be incoming address of the next hop router or the outgoing address of the router or the loopback interface of the next hop router.
- **Temporary resolution**
  - In many sections of the network, we did not build TE LSPs with EROs due to these incompatibility.
- **Recommendation**
  - More discussion is necessary to what these addresses need to be and which ones are valid.

# RSVP-TE RESV\_CONFIRM Issue

- **Issue**
  - Some routers support the sending of the RESV\_CONFIRM object while other do not.
- **Temporary resolution**
  - The RESV\_CONFIRM was disabled were it could be and in other cases there was no resolution.
- **Recommendation**
  - The object should be configurable or ignored by the receiver.

# Label Engine Issue

- **Issue**
  - Some vendor implementations did not support the explicit null label.
- **Temporary resolution**
  - Routers were configured to not send explicit null label.
- **Recommendation**
  - All routers need to support the explicit null label.

# Next Steps

- A small number of outstanding issues which need to be resolved quickly
  - Need to be addressed from implementation perspective
  - To help interoperability and easy deployment (to not have to fix problems after deployment)
- The results are part of an IETF draft:  
<http://www.ietf.org/internet-drafts/draft-jensen-mpls-interop-00.txt>
- The draft was presented at the IETF meeting in Japan in the MPLS WG to initiate discussions to firm up the recommendations

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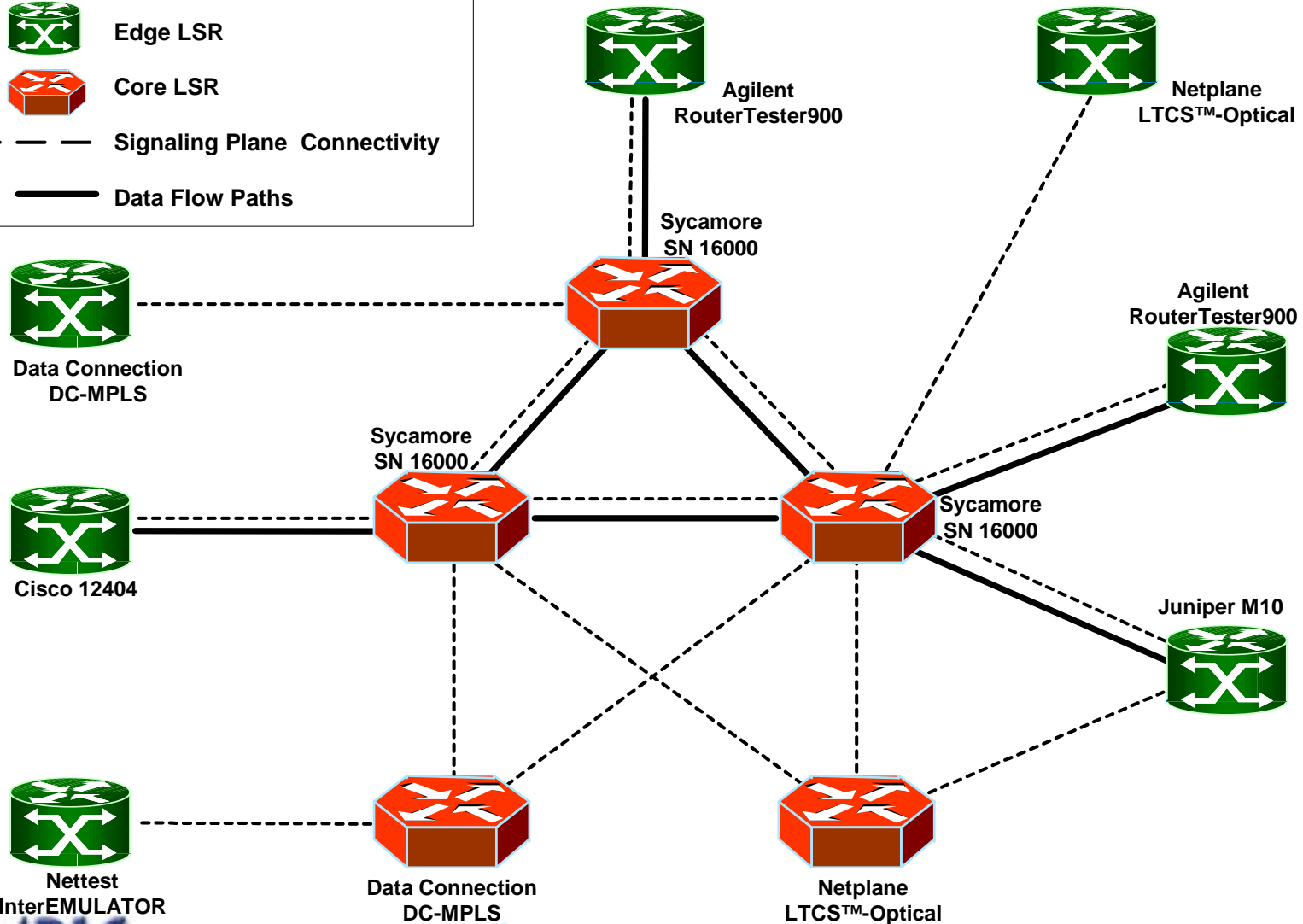
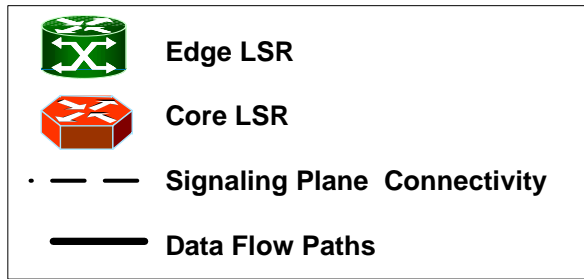
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# Recent GMPLS Interoperability Event

- GMPLS Interoperability test event held at UNH-IOL in October, showcased at NGN 2002
- Full Peer model demonstrated
- Signaling and OC-48 data plane tested
- Seven participants:
  - Edge Devices - Cisco, Juniper
  - Edge Emulators - Agilent, Data Connection, Netplane, Nettek
  - Core Device - Sycamore Networks



# GMPLS Test Configuration



# Links

- To learn more about the **MPLS** Interoperability Event, visit: <http://www.mplsforum.org/Supercomm.htm>
- To download the white paper on the **MPLS** Interoperability event with more details, please visit: [http://www.mplsforum.org/whitepaper\\_info.html](http://www.mplsforum.org/whitepaper_info.html)
- To learn more about the **GMPLS** Interoperability Event, visit: <http://www.mplsforum.org/NGN2002demo.html>
- To download the white paper on the **GMPLS** Interoperability event with more details, please visit: <http://www.mplsforum.org/GMPLSwhitepaper.pdf>

