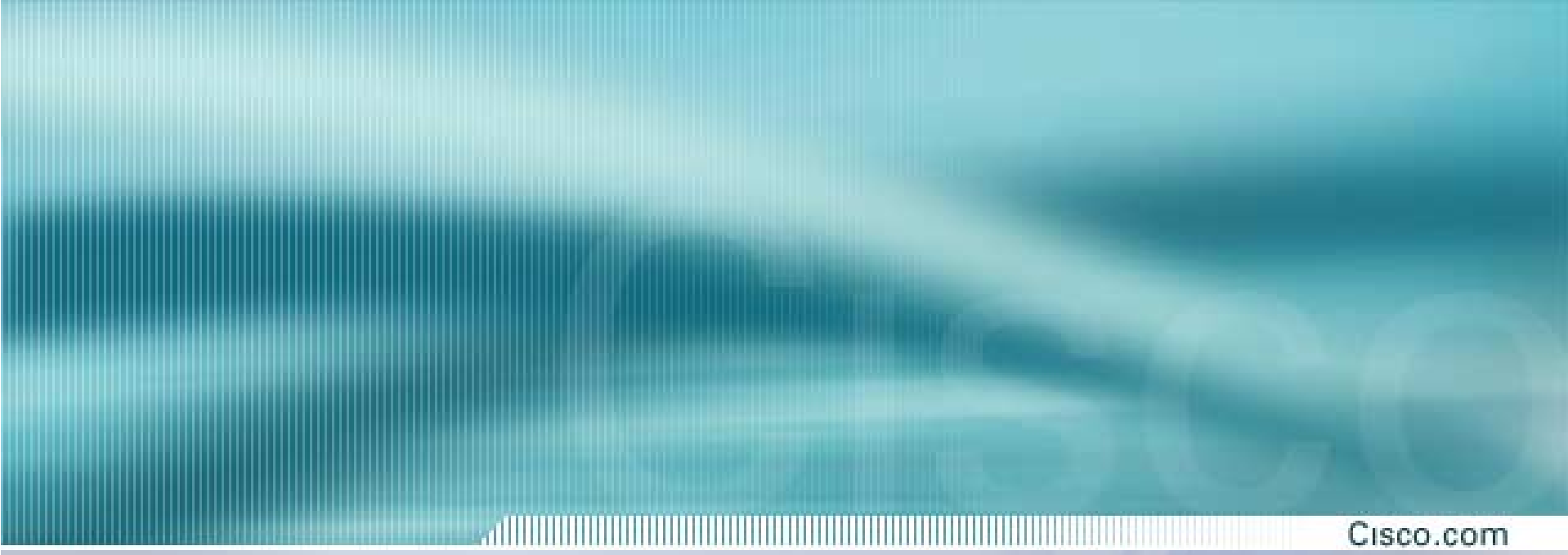

MPLS Network Management MPLS Japan 2004

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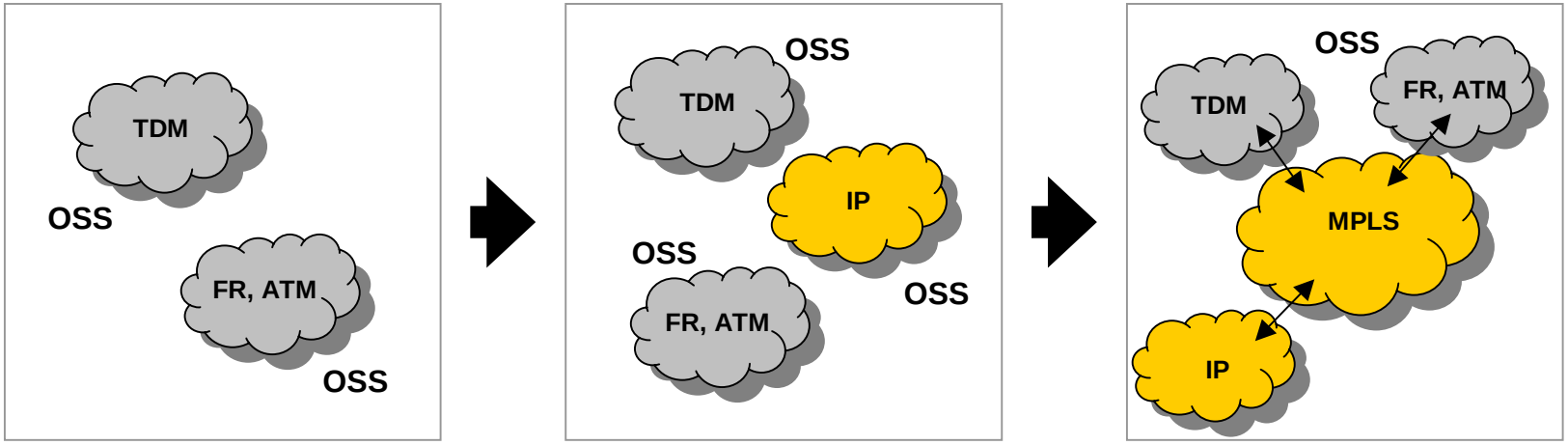
Agenda for Today

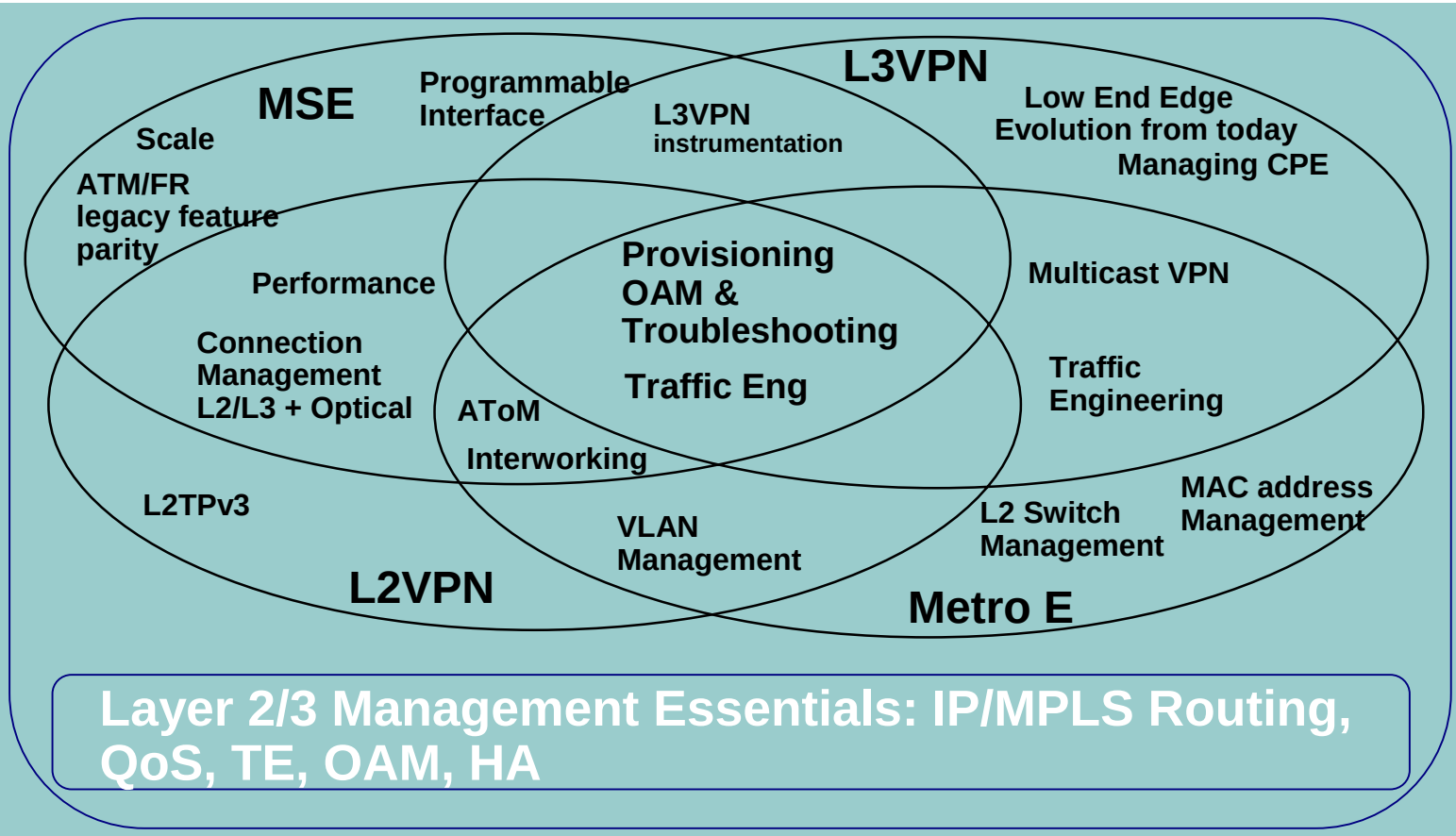
- Drivers for MPLS Management
- Technical Requirements
- Update on IP/MPLS Tools
- Summary

Service Provider Network Operation



- **Create operational efficiencies and increase automation in a highly technology-intensive market**
- **Enable competitive differentiation and customer retention through high-margin, bundled services**
- **Progressively consolidate disparate networks**
- **Sustain existing business while rolling out new services**

MPLS Services and Transport Network Management



MPLS Service Provisioning Challenge

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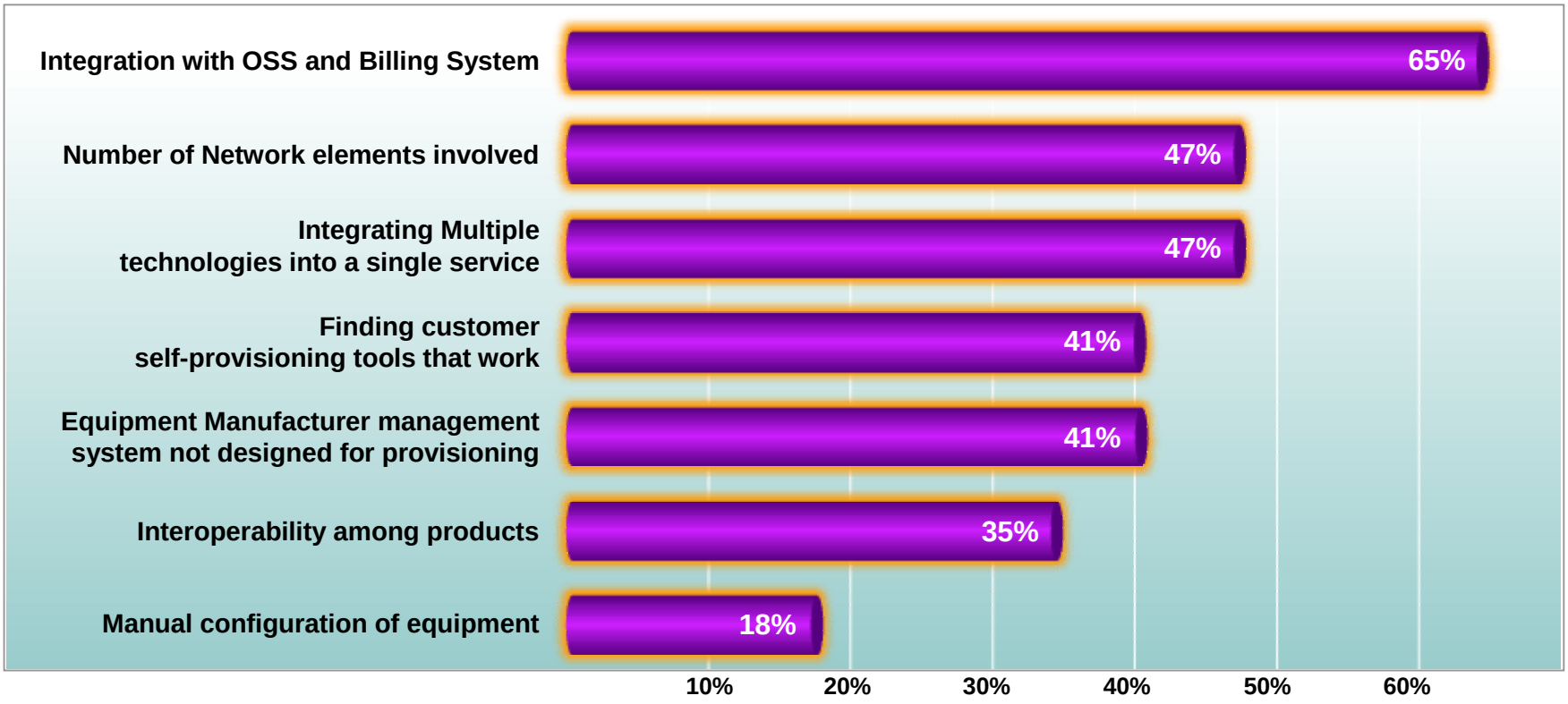
Challenges in VPN Service Provisioning

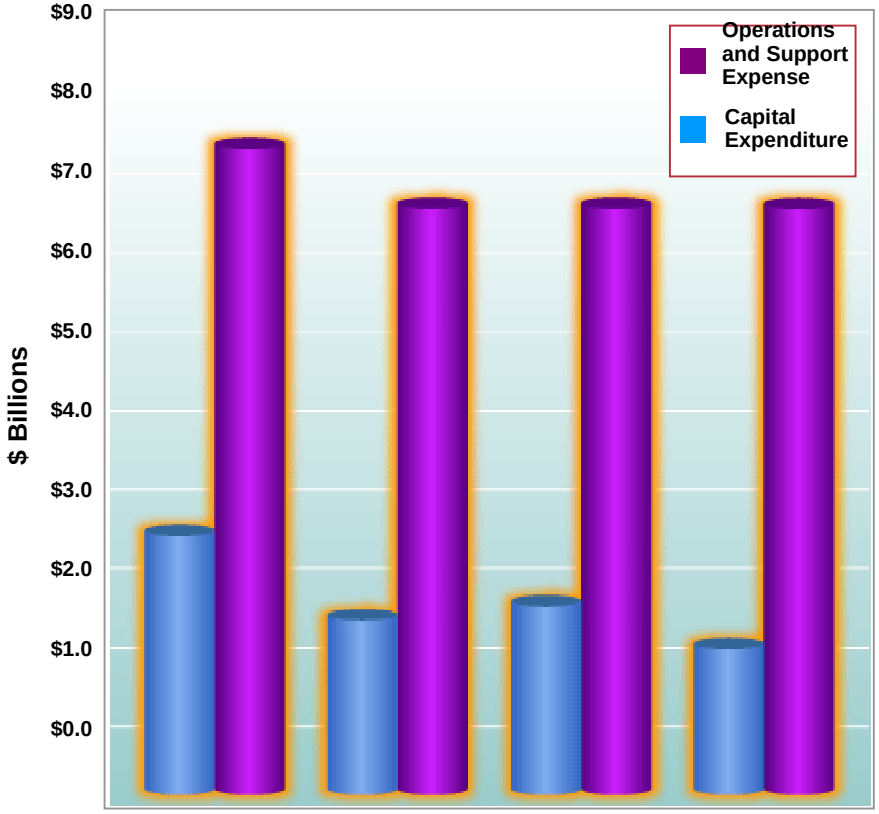


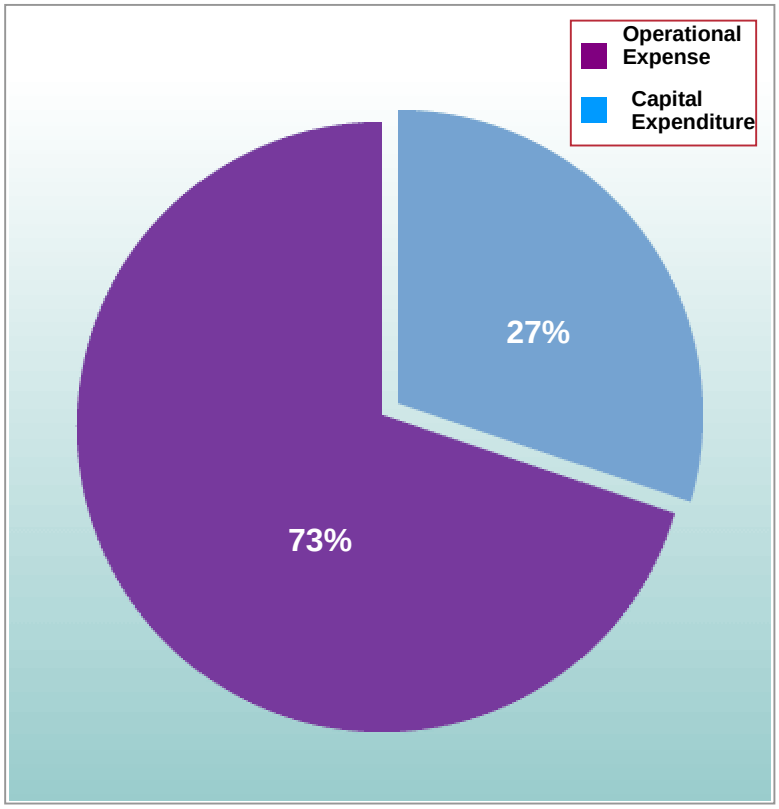
Source: Infonetics, 2003

Service Provider CapEx vs. OpEx

- CapEx typically follows the economy
- OpEx is consistent

- Typical ratio of a Tier 1 carrier CapEx vs, OpEx spending
- OpEx efficiencies have higher profitability and a higher ARPU

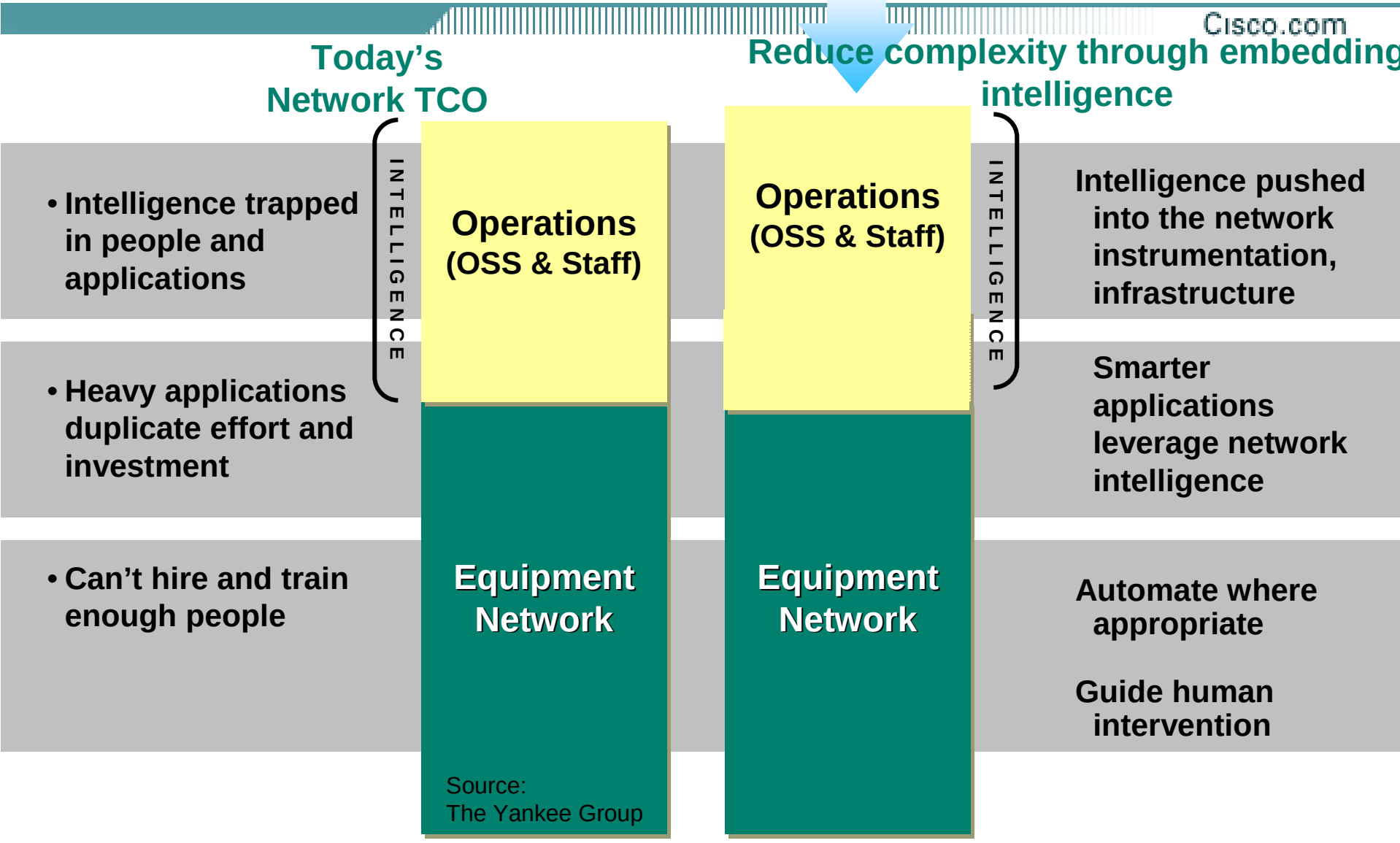




Source: Typical Incumbent Carrier Balanced Sheet, Frost & Sullivan

Intelligent Information Networks

Complex networks require simplification through Management



A Sample of Typical SP Customer Concerns

- With all the flow through provisioning the most complicated part is to make sure that the configuration has worked
- Solving MPLS VPN connectivity problems is a complex task for CCIEs
- Is QOS configuration network specific or service specific and is complicated to manage and troubleshoot
- Troubleshooting performance degradation in MPLS/IP networks is the most labor intensive NOC activity
- How do I transition PVCs from our ATM core to IP/MPLS infrastructure and that too in a Multi-Vendor Network
- Can you help me get better use of IP/MPLS core – particularly increased use of existing network bandwidth resource

Customer Requirements - Fault

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Fault Detection and Isolation

- **Control Plane Verification**
  - **Consistency check**
  - **Authentication**
- **Data Plane Verification**
  - **Ability to verify connectivity and trace**
    - **Paths from PE to PE – Global routing table as well as VPNs**
    - **Paths from CE to CE within a VPN**
    - **TE tunnels**
    - **Pseudo-wires**

- **Data plane OAM packets must follow same path they are testing!**

Customer Requirements – Fault (Continued)

- Need for Fault management functions at all layers – Device, Network, Service, EMS, Partners
- Provide Reactive and Proactive Fault Mgt tools
- Ability to identify specific service failure to a node or line card failure
- Interwork with other technology fault management tools to provide end-to-end fault correlation – OAM Interworking

Customer Requirements –Configuration/Provisioning

- Configure OAM functions on the network devices depending on the PE, P, Managed CPE roles
- Verification of Service after Configuration
- Alarm Mapping - configuration
- Automate OAM functionality for pro-active monitoring
- Large Scale Service Provisioning
- Standards based interfaces to devices – SNMP, Programmatic Interface

Customer Requirements – Accounting/Performance

- MPLS Flow accounting – with label stack information
- Flexible and extensible export format – Netflow v9
- Measurement of Key end-to-end MPLS performance statistics like – Network delay, Packet Loss, Jitter, Connectivity
- Proactive Performance measurement by raising triggers based on events like Connection loss/Timeout, RTT threshold etc
- Historical and Real time MPLS statistics

Basics: VCs & LSPs

Virtual Circuits	Label Switched Paths
Bi-directional	Usually Uni-directional
Established via ATM Signaling or Management	Establishment tied closely to control planes
Fixed hierarchy VP/VC	Variable Label Stack
Connection oriented	Can be “connectionless”
Single route	May use ECMP
No penultimate popping	Penultimate hop popping

IP Troubleshooting Tools

- Based on ICMP Echo Request and Reply
  - IP Ping
  - IP Traceroute
  - VRF Ping
  - VRF Traceroute
- Issues with ICMP Ping for MPLS network
  - Different behavior based on IP or MPLS core
  - Does not detect MPLS data plane failure if IP layer works fine
  - Does not provide sufficient reply data to isolate fault to MPLS specific issue

MPLS LSP Ping/Traceroute

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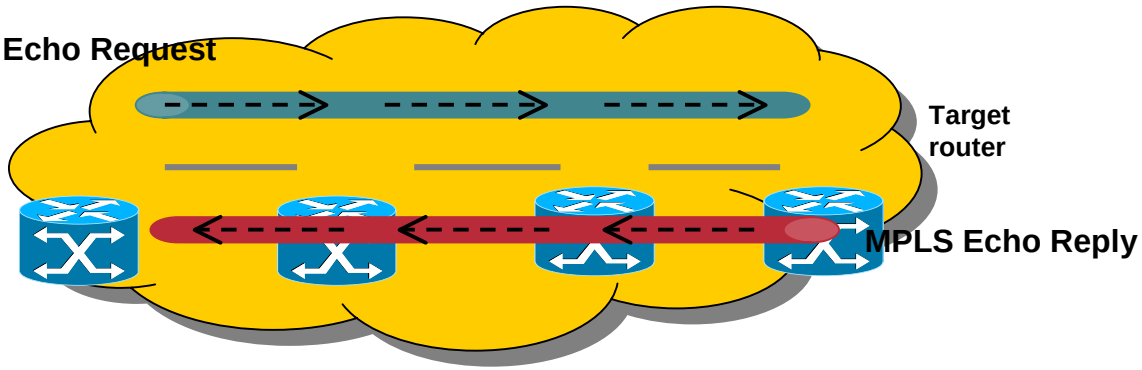
Requirement	• Detect MPLS traffic black holes or misrouting • Isolate MPLS faults • Verify data plane against the control plane • Detect MTU of MPLS LSP paths
Solution	• MPLS LSP Ping for connectivity checks • MPLS LSP Traceroute for hop-by-hop fault localization • MPLS LSP Traceroute for path tracing
Applications	• IPv4 LDP prefix, VPNv4 prefix • TE tunnel • MPLS PE, P connectivity for MPLS transport, MPLS VPN, MPLS TE applications
IETF Standards	• Draft-ietf-mpls-lsp-ping-06.txt

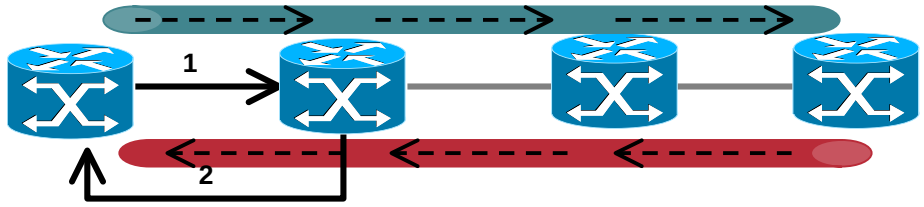
LSP Ping/Traceroute Example

Ping

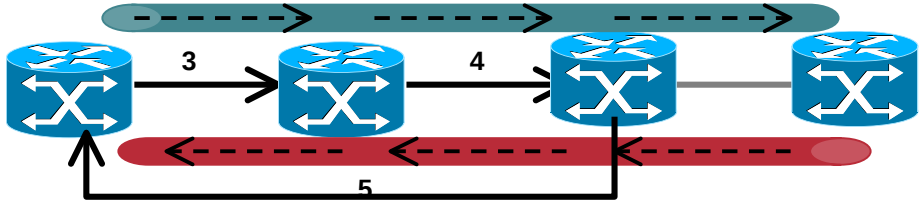


Traceroute

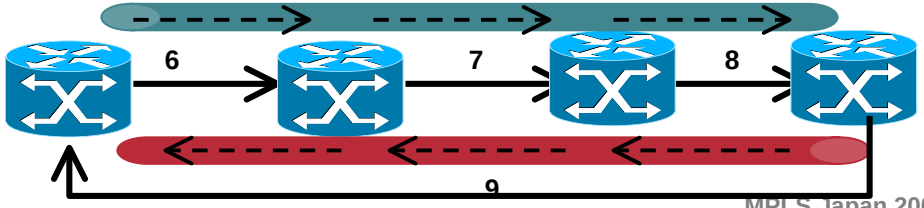
TTL=1



TTL=2



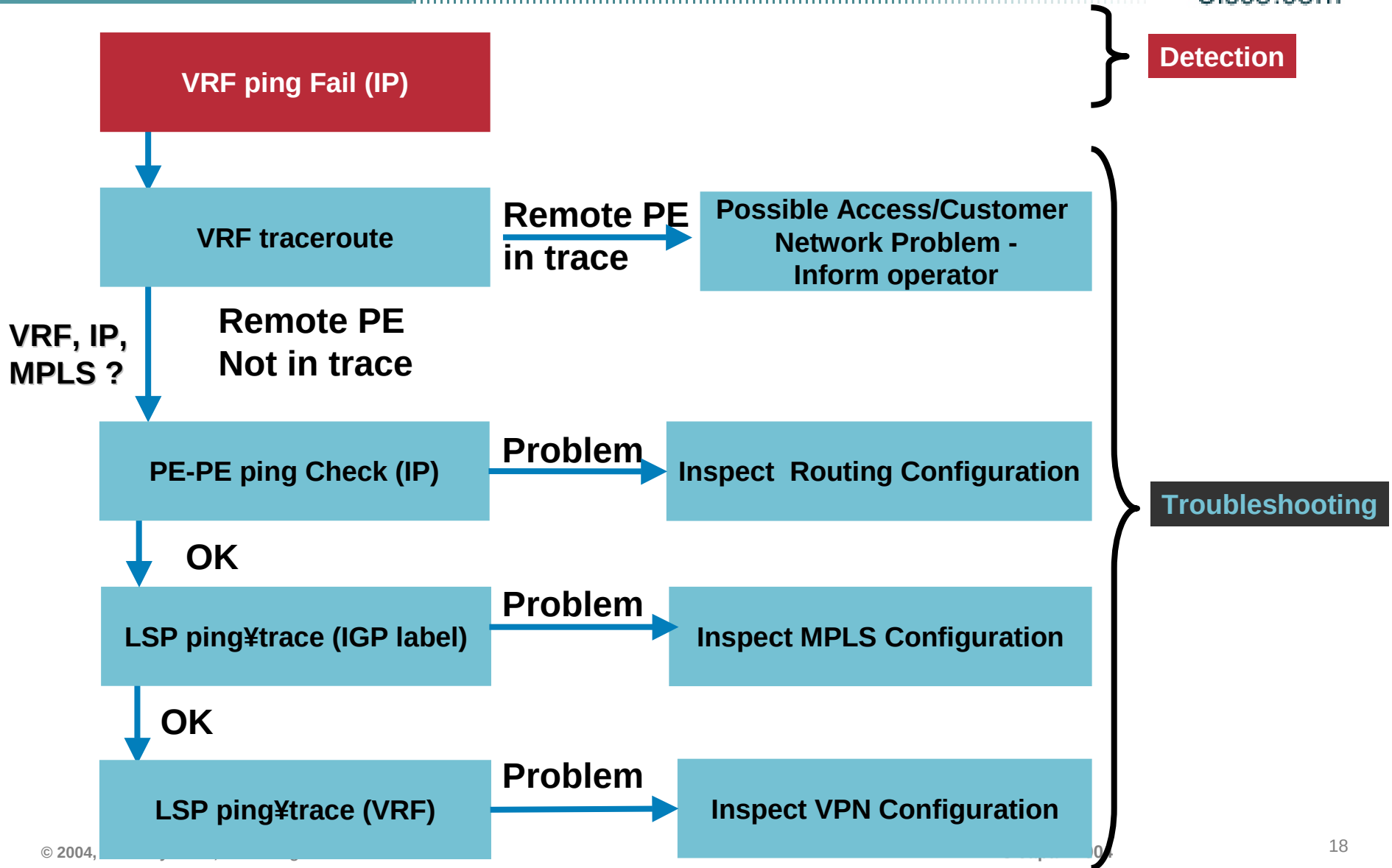
TTL=3



MPLS AToM Virtual Circuit Connection Verification (VCCV)

Requirement	• Ability to provide end-to-end fault detection and diagnostics for an emulated pseudowire service One tunnel can serve many pseudowires. MPLS LSP ping is sufficient to monitor the PSN tunnel (PE-PE connectivity), but not VCs inside of tunnel
Solution	• AToM VCCV allows sending control packets in band of an AToM pseudowire. Two components: Signaled component to communicate VCCV capabilities as part of VC label Switching component to cause the AToM VC payload to be treated as a control packet Type 1: uses Protocol ID of AToM Control word Type 2: use MPLS router alert label
Applications	• Layer 2 transport over MPLS FRoMPLS, ATMoMPLS, EoMPLS
IETF Standards	• Draft-ietf-pwe3-vccv-xx.txt

Troubleshooting - VRF data plane

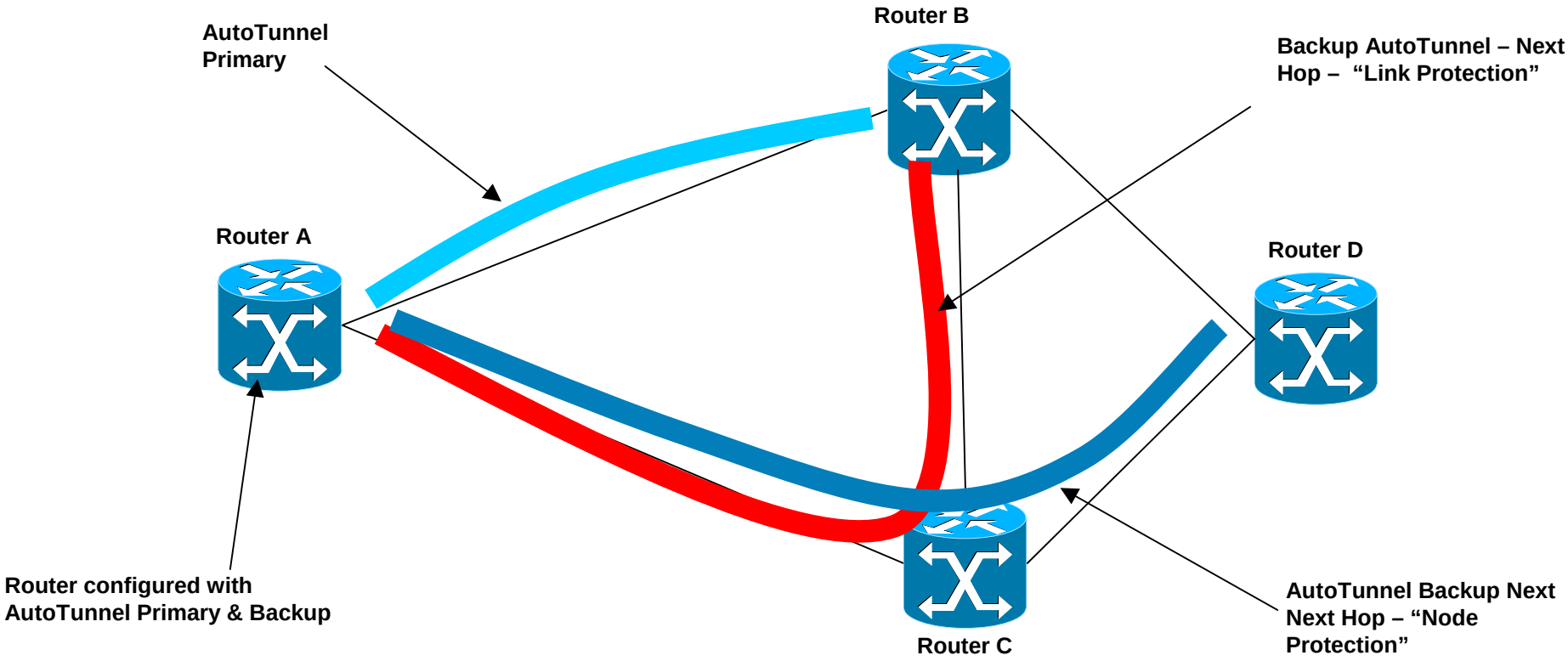


MPLS Traffic Engineering: AutoTunnel – Primary, Backup, & Mesh Groups

Requirement	• Ability to protect links and nodes with no requirement of "traffic engineering" • Need to ease configuration of "increased bandwidth inventory" MPLS TE designs such as full mesh
Solution	• Backup AutoTunnel—Enables a router to dynamically build backup tunnels • Primary one-hop AutoTunnel—Enables a router to dynamically create one-hop primary tunnels on all interfaces that have been enabled with MPLS TE tunnels • Mesh Group AutoTunnel – Enables automatic establishment of full- or partial-mesh of TE tunnels
Applications	• MPLS VPN with multiservice SLAs (voice, video, and data sites) • MPLS AToM-based Layer 2 services with "Bandwidth Assurances" • Enhanced SLA service offerings with low packet loss during failure condition – "Bandwidth Protection"
IETF Standards	• draft-ietf-mpls-rsvp-lsp-fastreroute-03.txt • draft-ietf-ospf-cap-01.txt • draft-vasseur-mpls-ospf-te-cap-xx.txt

MPLS Traffic Engineering AutoTunnel – Primary & Backup

Router A establishes AutoTunnels to adjacent routers – "automates" configuration of Link & Node Protection



MPLS Traffic Engineering AutoTunnel – Mesh Groups

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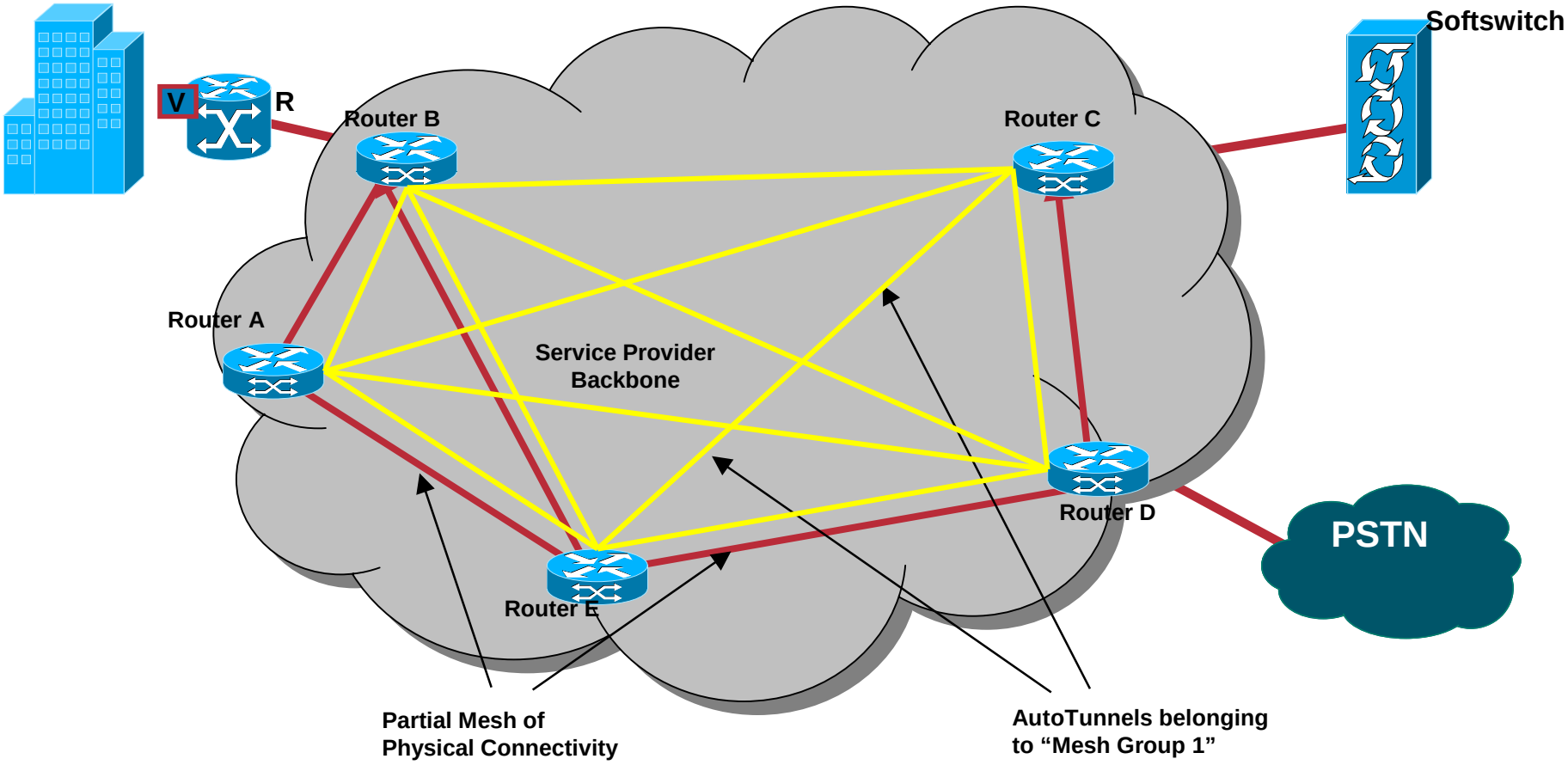
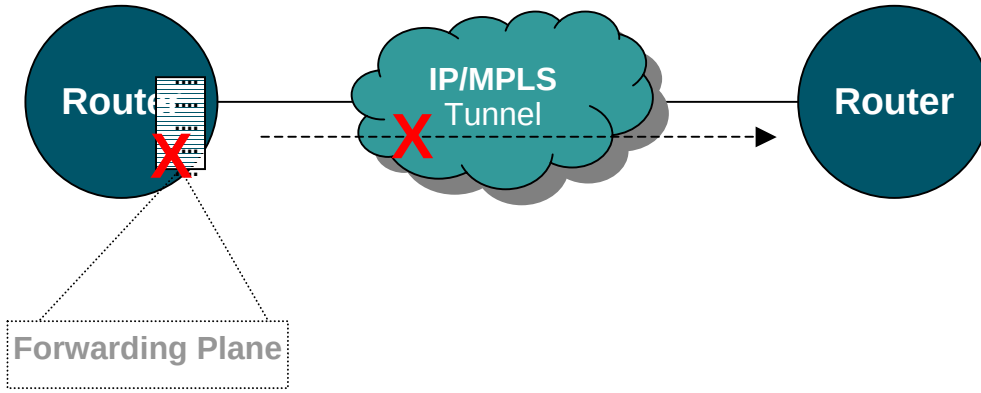
Routers A, B, C, D, E – defined as members of "Mesh Group 1"
Capable of building multiple meshes for DiffServ aware Traffic Engineering
Automates configuration of full mesh of TE Tunnels resulting in operational efficiencies



BFD for MPLS LSPs

Low-overhead, short-duration failure detection in the path between adjacent forwarding engines

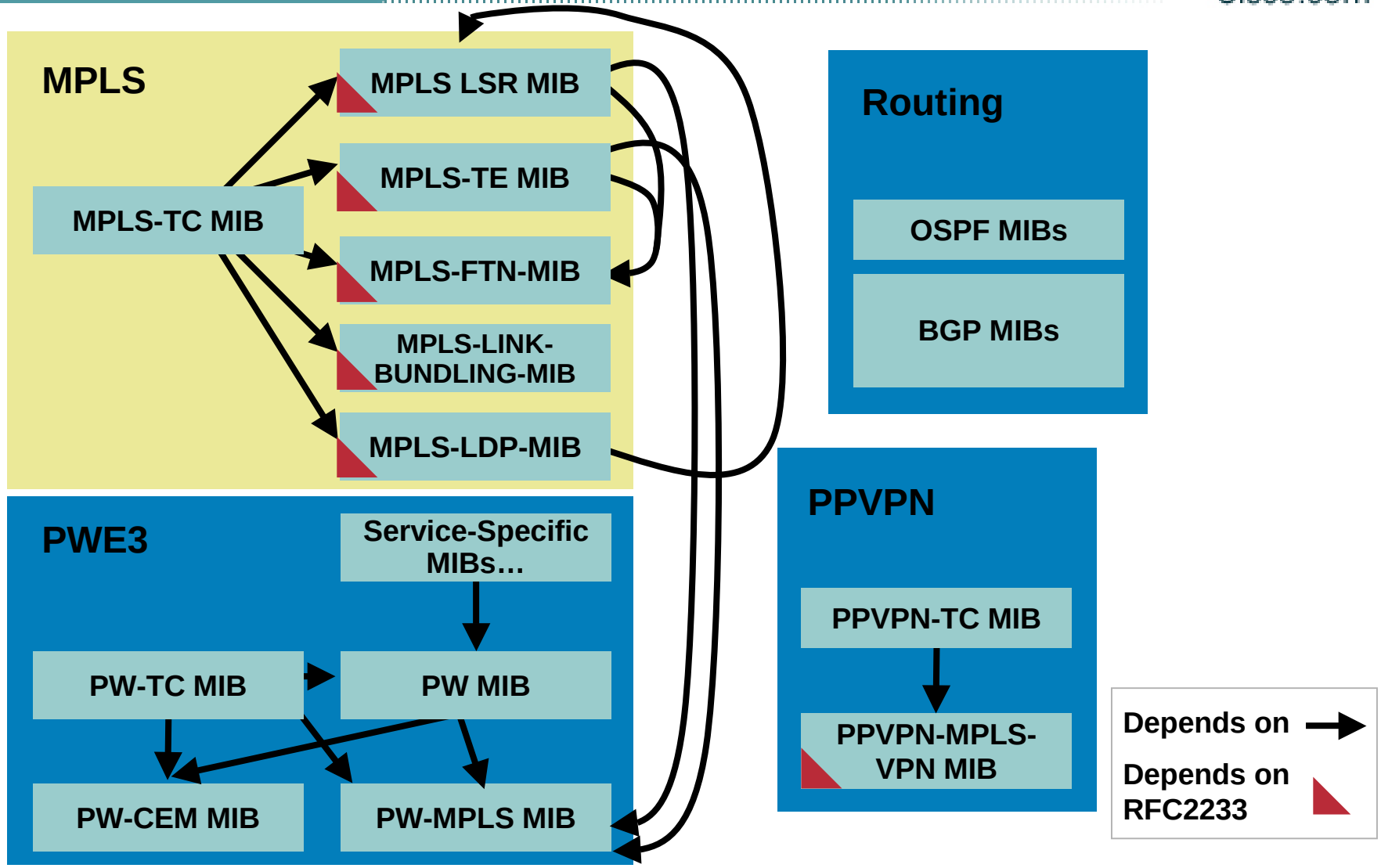
Including the interfaces, data link(s), & forwarding planes



- There is no discovery mechanism in BFD
- Need a means to bootstrap

- In some cases carriers would like to monitor LSPs
- Accomplished with a TLV in LSP Ping that carries the BFD discriminator
- Applications – BFD+LDP, BFD+VCCV, BFD+TE, BFD+BGP, BFD+IGP

MPLS Network and Services MIB Summary and Concept/ Architecture/Dependencies



Putting It All Together

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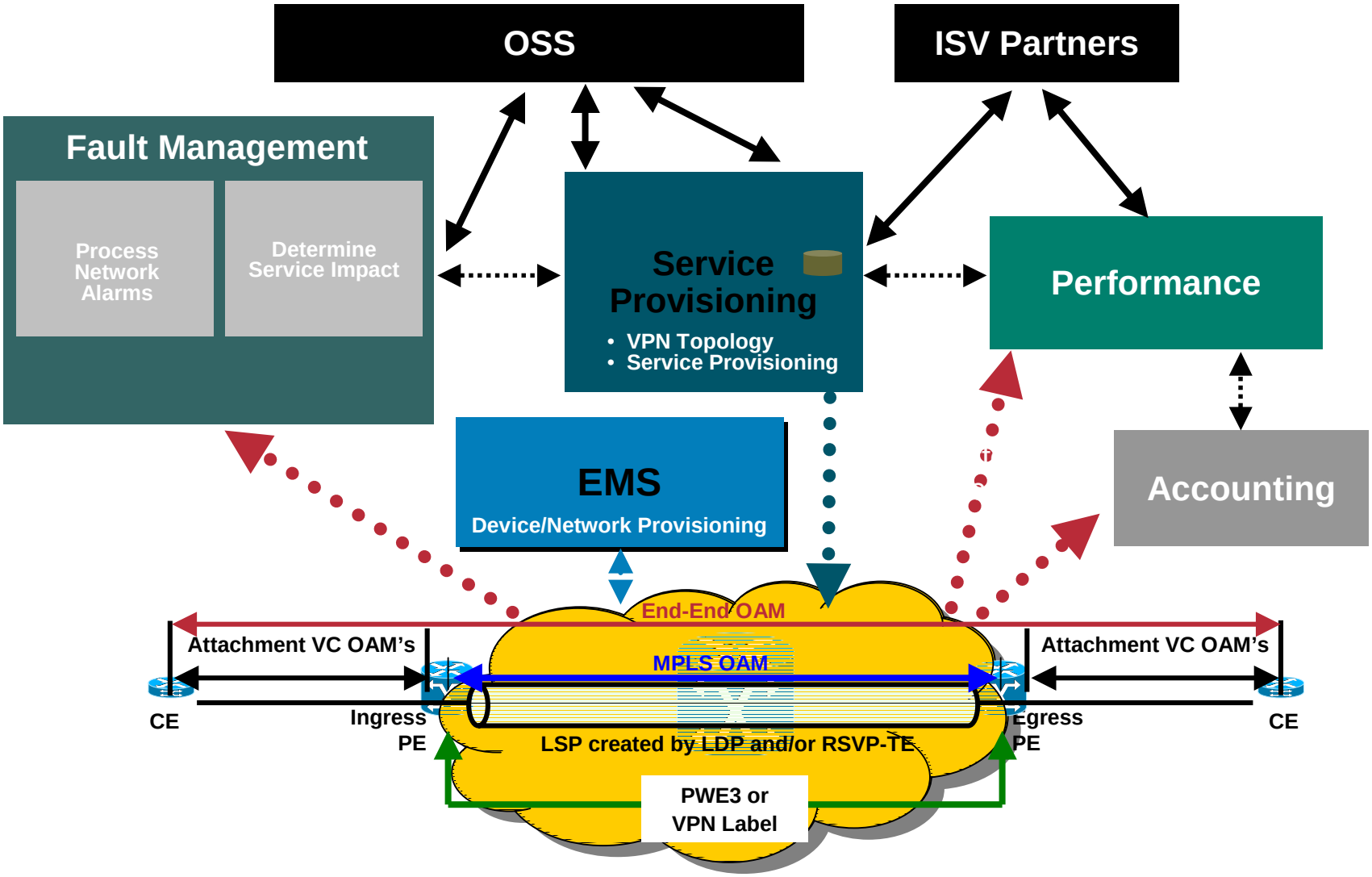
Media type	CC CP	CC DP	Loopback	Performance	Traceroute
ATM VP	ILMI	F4 (VC-3)	F4 (VC-4)		-
ATM VC		F5 (PT 100)	F5 (PT 101)		-
FR	LMI	Keepalive	-	-	-
Ethernet last mille	IEEE 802.3ah	ITU-T Draft Y.ethoam			-
Ethernet provider bridge		IEEE 802.1ag (dot1q broadcast domain)			
MPLS LDP	LDP Hello	MPLS BFD	LSP Ping	ITU-T Draft Y.17fw	LSP TR
MPLS TE	RSVP Hello			-	
MPLS PW	LDP Hello	VCCV BFD	VCCV Ping	-	-
IPv4	IGP/BGP Hello	BFD	IP Ping	-	IP TR

- **OAM Interworking for End-to-End Network and Service Level OAM**
- **Not just Vendor Interoperability but Standards alignment as well**

MPLS Network Management Life Cycle



Summary

- Cost pressures driving convergence, consolidation and virtualization
- Complexity of networked systems and scarce expertise are increasing Total Cost of Ownership (TCO)
- MPLS Network management require systems and solutions perspective
- Standards-based open interfaces for easier and faster integration