Architecture and Design of Metro Ethernet over Optical Transport Networks

Architecture and Design of Optical Transport Networks

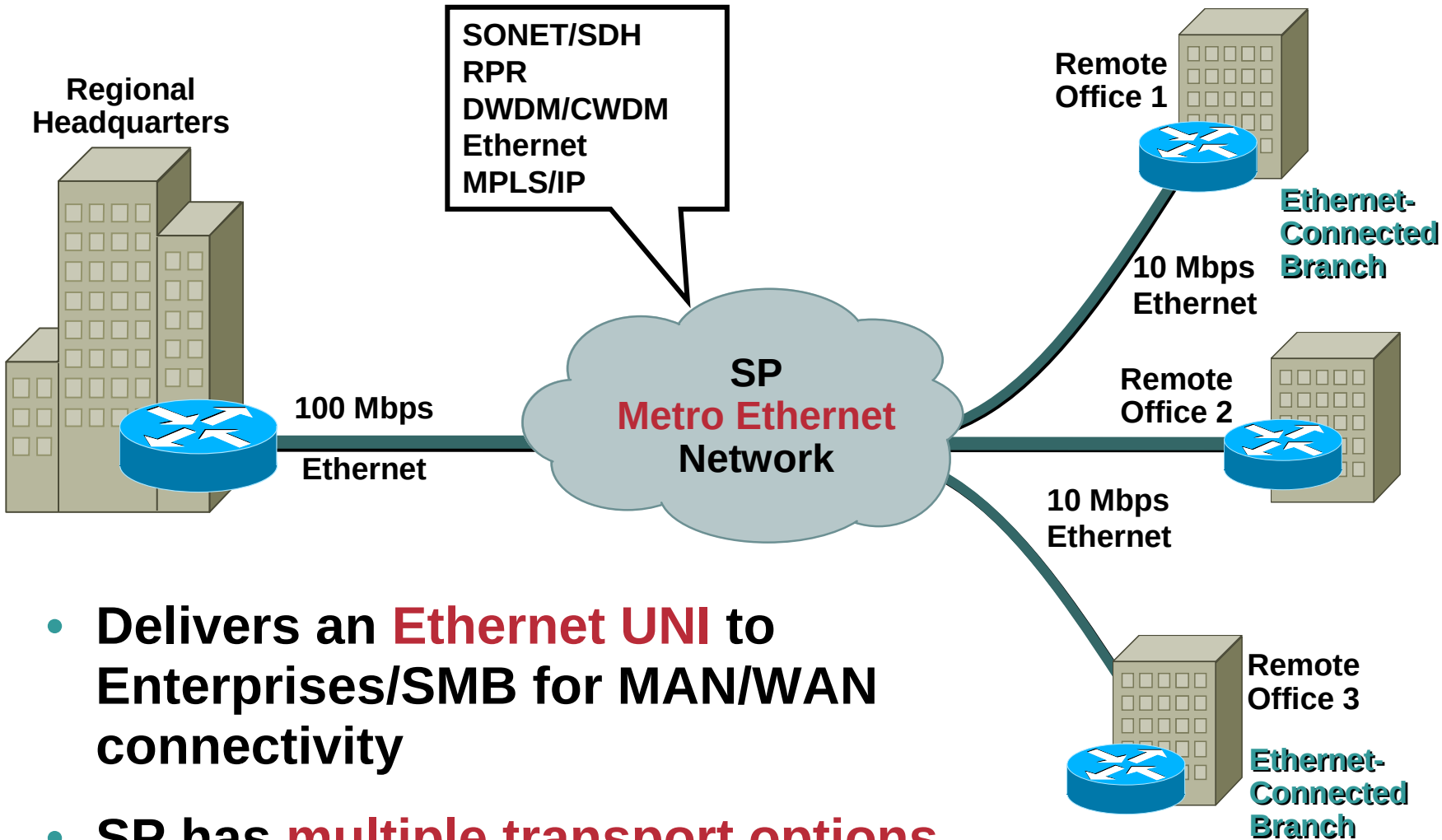
- Metro Ethernet Services
- Metro Ethernet options
- Mapping Data over SONET
- Optimizing SONET for Data Transport
- Topologies and Architectures

Metro Ethernet Services Market

- **Ethernet Private Line (EPL) Pt-Pt CAGR:58.6%**
- **Ethernet Internet Access (EIA) CAGR: 102.4%**
- **Ethernet Any-to-Any CAGR: 134%**

Yankee Group Report August 19,2003

What is Metro Ethernet?



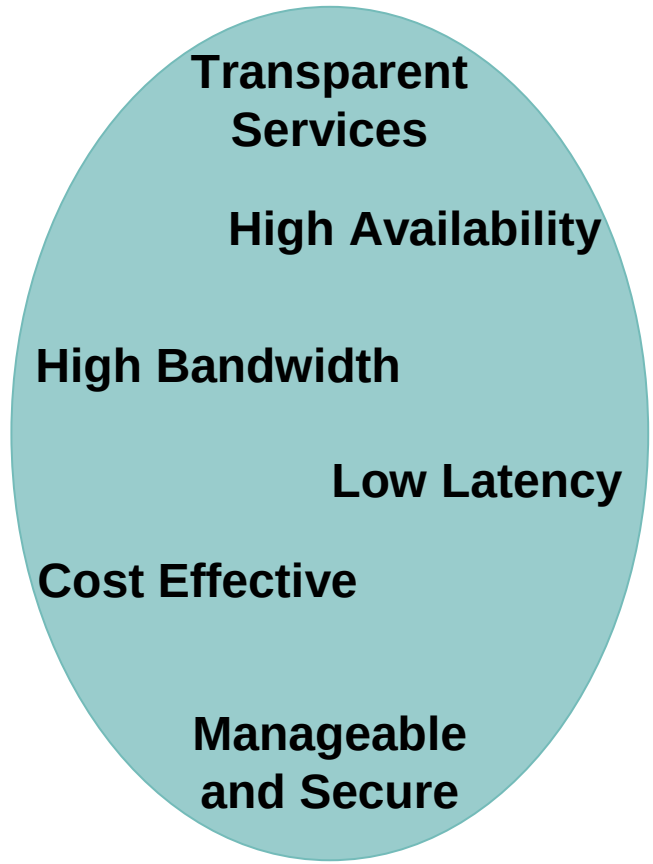
- Delivers an Ethernet UNI to Enterprises/SMB for MAN/WAN connectivity
- SP has multiple transport options

What Does Ethernet as a LAN/MAN/WAN Transport Offer?

- Ethernet becomes the ubiquitous interface: single technology for LAN, MAN and WAN
- Efficient packet-based infrastructure: IP friendly
- Cost effective interface with flexible bandwidth offerings: 10/100/1000/10000 Mbps
- Geographical independence: Ethernet over Optical, IP or MPLS

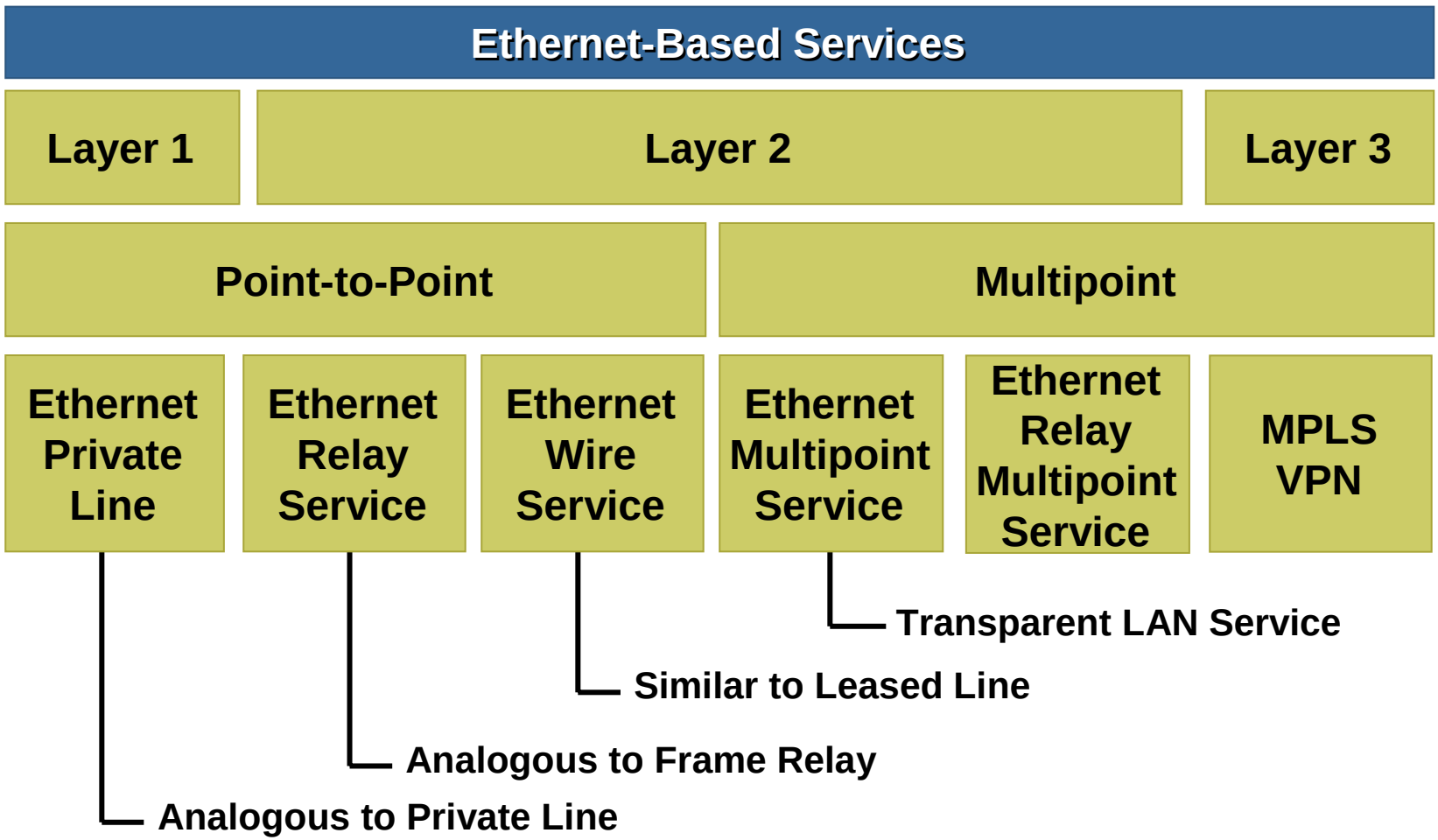
Enterprise Applications Drive Metro Ethernet

- LAN interconnect
- Service aggregation
- Interconnect data centers
- Backup and disaster recovery
- Connect to hosting services
- Value-added services

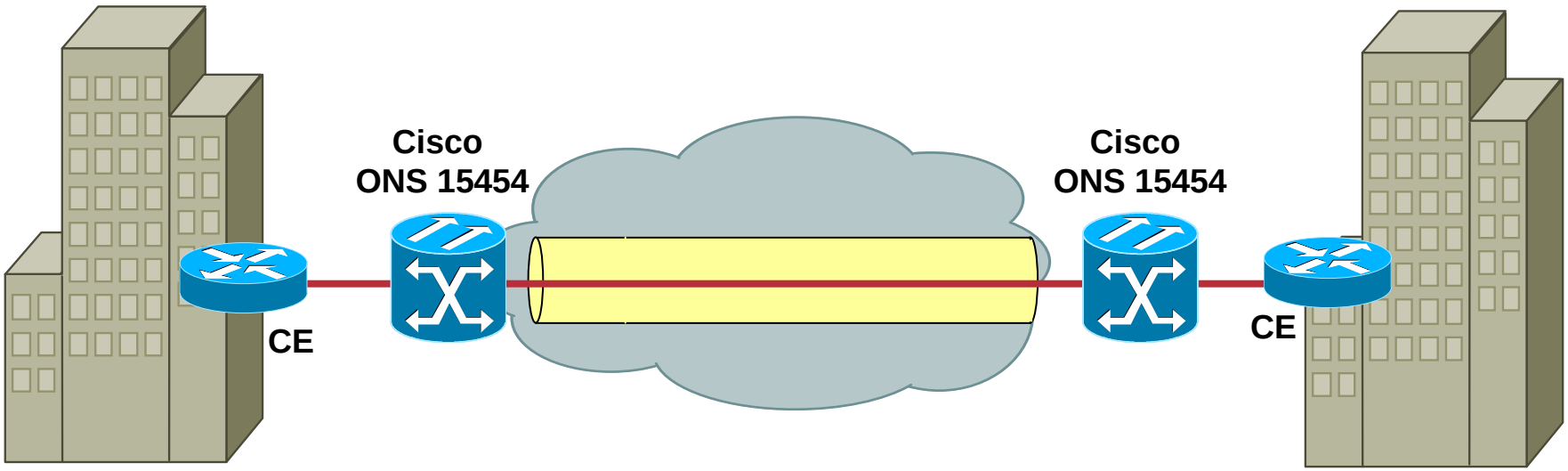


How SPs Deliver This Is Largely Irrelevant…
Metro Ethernet Is Simply a Tool in the Tool Box

Summary of Ethernet-Based Services

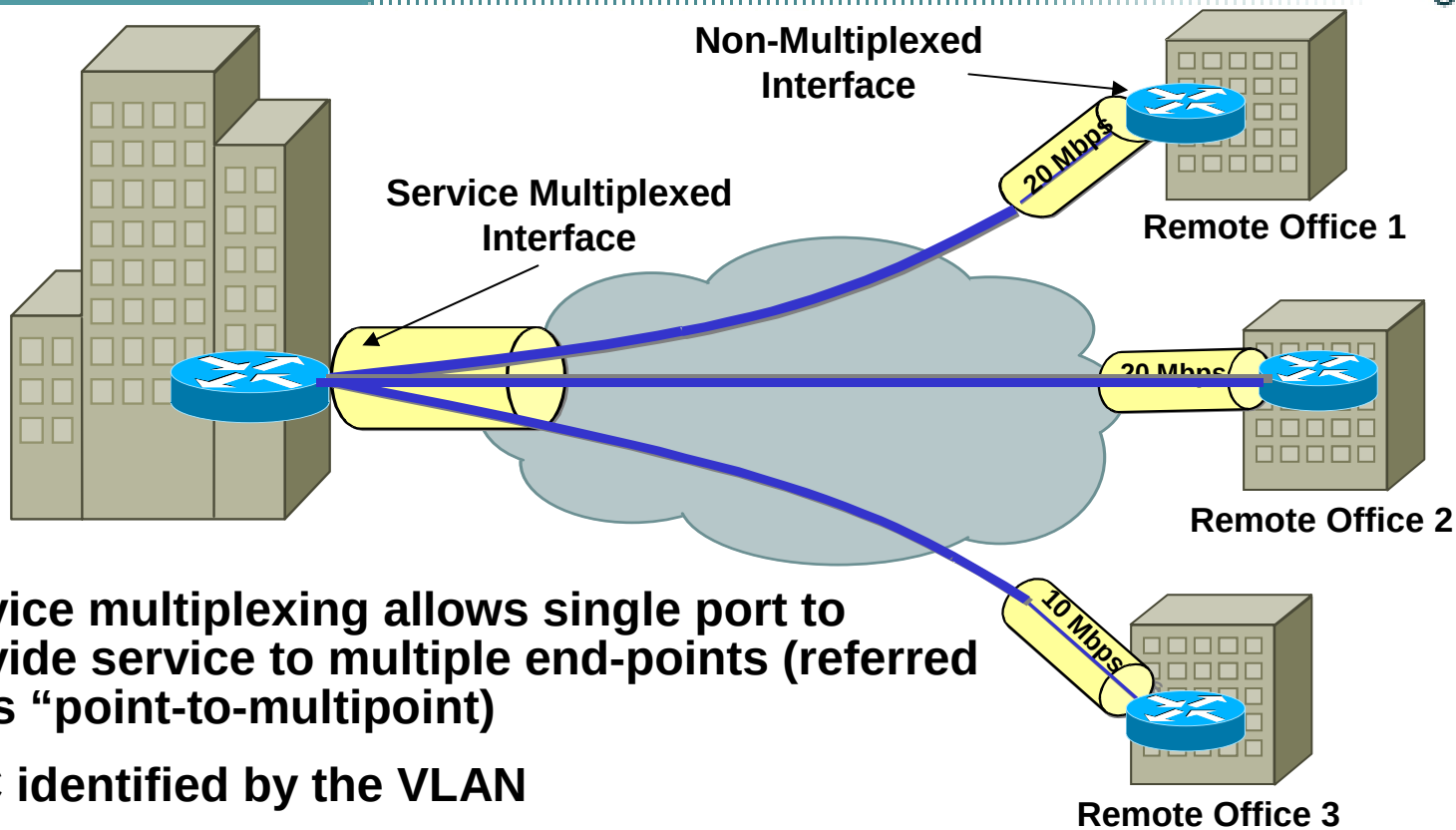


Offering a Gigabit Ethernet Private Line Service



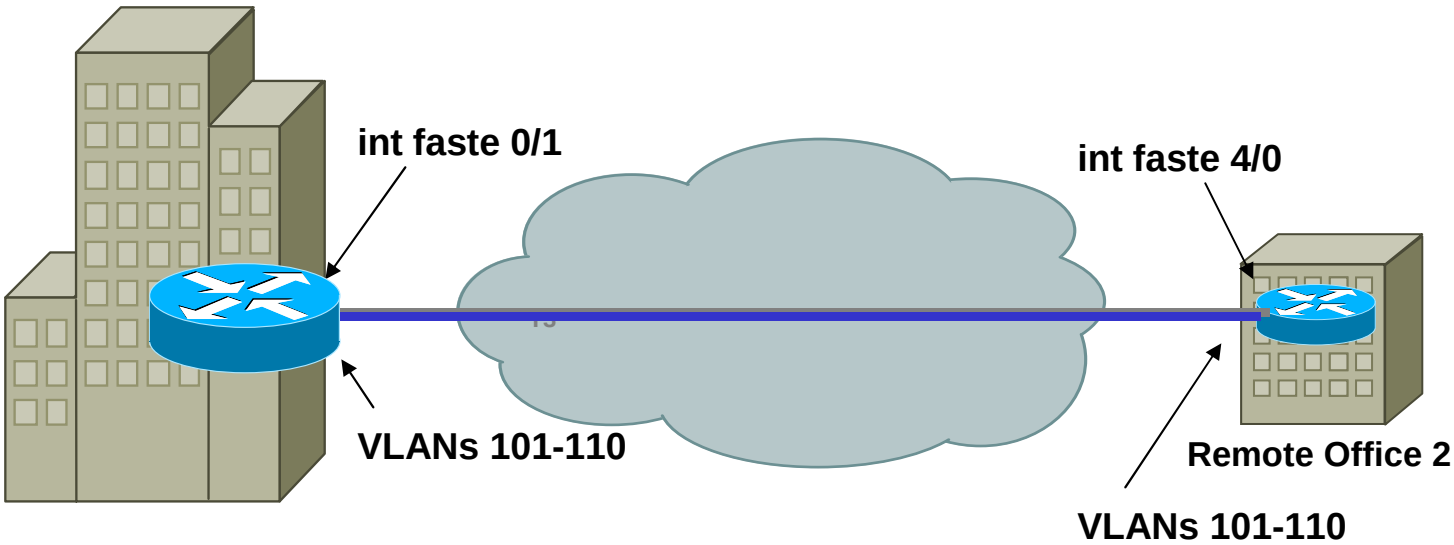
- Dedicated, transparent private line between sites
- Guaranteed SLAs per connection
- Built with dedicated bandwidth/wavelength
- ML-series card integrates switching functionality within the ONS-15454
- Can be built with SONET, CWDM, DWDM

The Ethernet Relay Service (ERS)



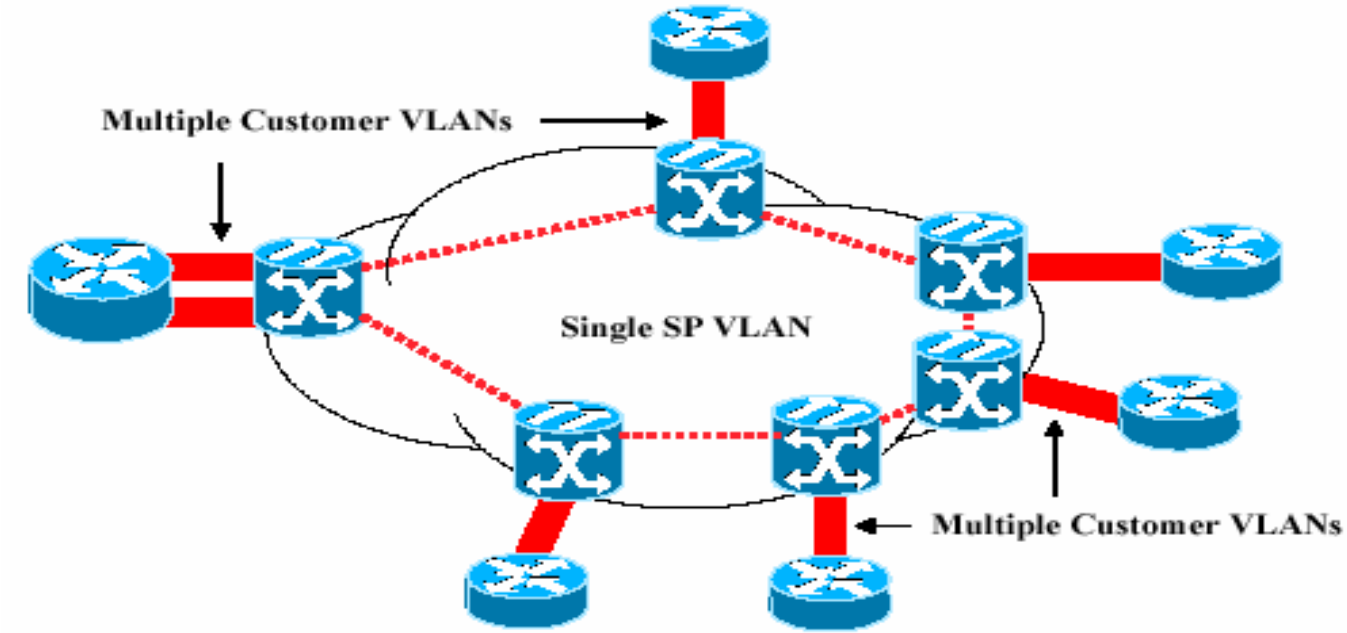
- Service multiplexing allows single port to provide service to multiple end-points (referred to as “point-to-multipoint)
- EVC identified by the VLAN
- CE-VLAN must be the same as SP-VLAN
- Service analogous to Frame Relay, functionally, it is the same – encourages a router as CE edge device, not a switch (except for remote site)
- ERS allows interworking with FR/ATM (future)

The Ethernet Wire Service (EWS)



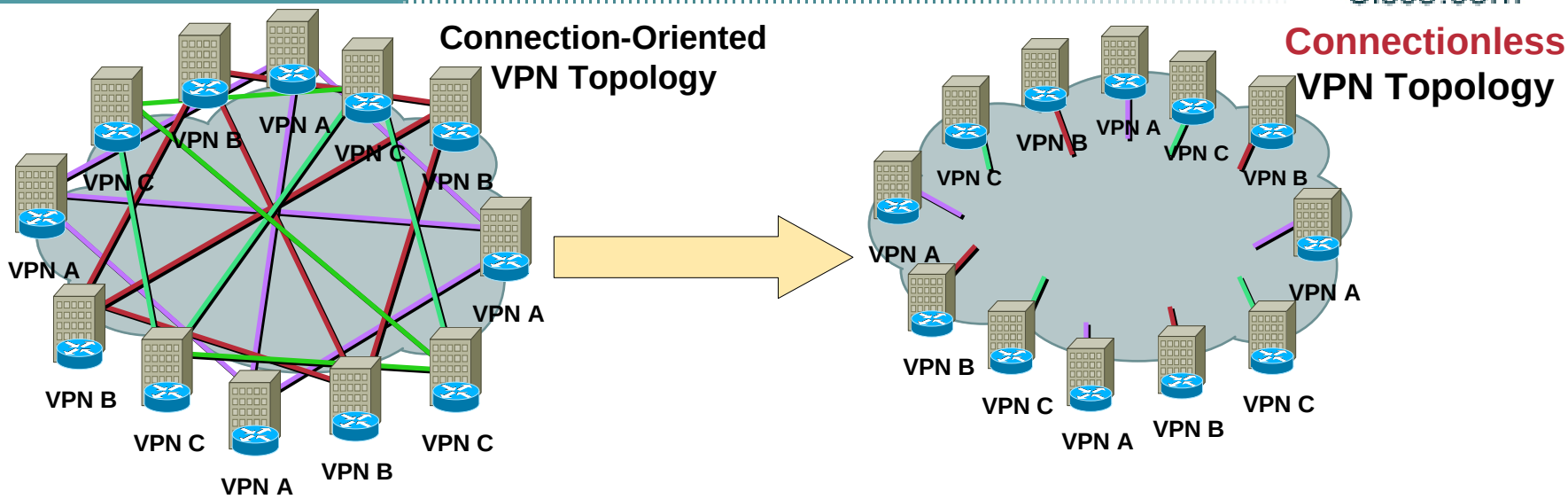
- **Analogous to a private line in that all data transverses, unaltered across the EVC**
- **Port-to-Port mapping, no service multiplexing allowed. Therefore all services must exist on one port (All-to-One Bundling)**
- **Switches or routers can be deployed as CE edge devices**

The Ethernet Multipoint Service (EMS)



- **Often referred to as a Transparent LAN Service (TLS)**
- **Service Provider cloud appears to be a switch, with UNI supporting VLAN transparency and All-to-One Bundling**
- **While multipoint by definition, it can also be point-to-point (such as EWS)**

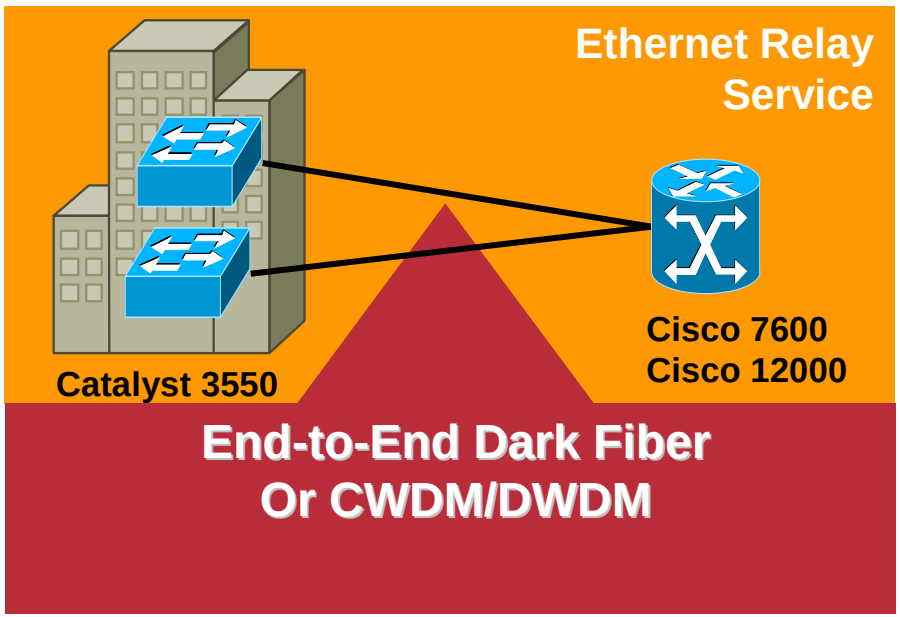
Ethernet-based MPLS VPNs

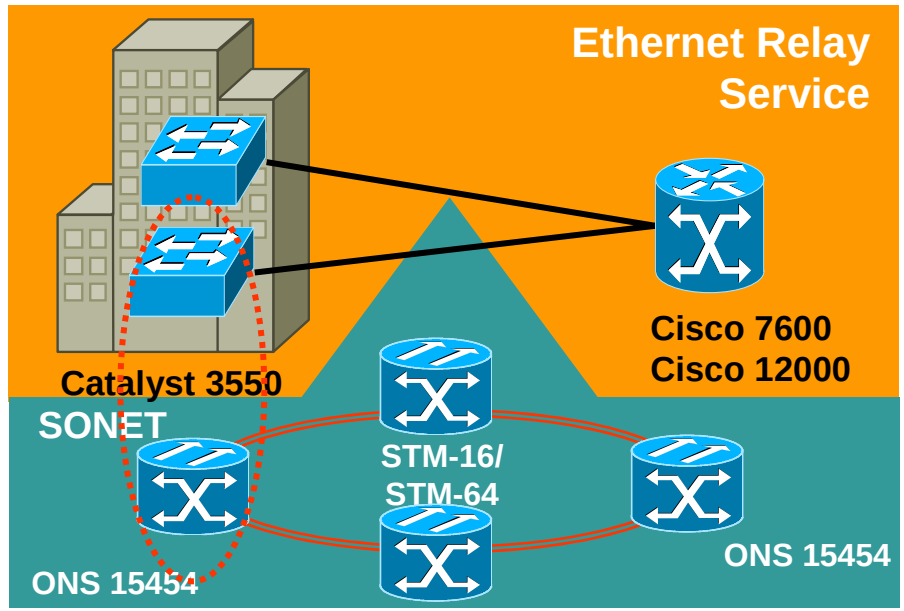


- **Managed service opportunity for the provider (more money for the SP)**
- **Opportunity for provider to offer “value-added” services (such as content hosting, IP Centrex)**
- **Ethernet access provides low-cost, “customer friendly” interface**
- **Any Layer 2 access mechanism at the UNI (interworking comes “for free”)**

Metro Ethernet Options

Transport Options – Ethernet over Sonet vs.Ethernet over Dark Fiber/xWDM

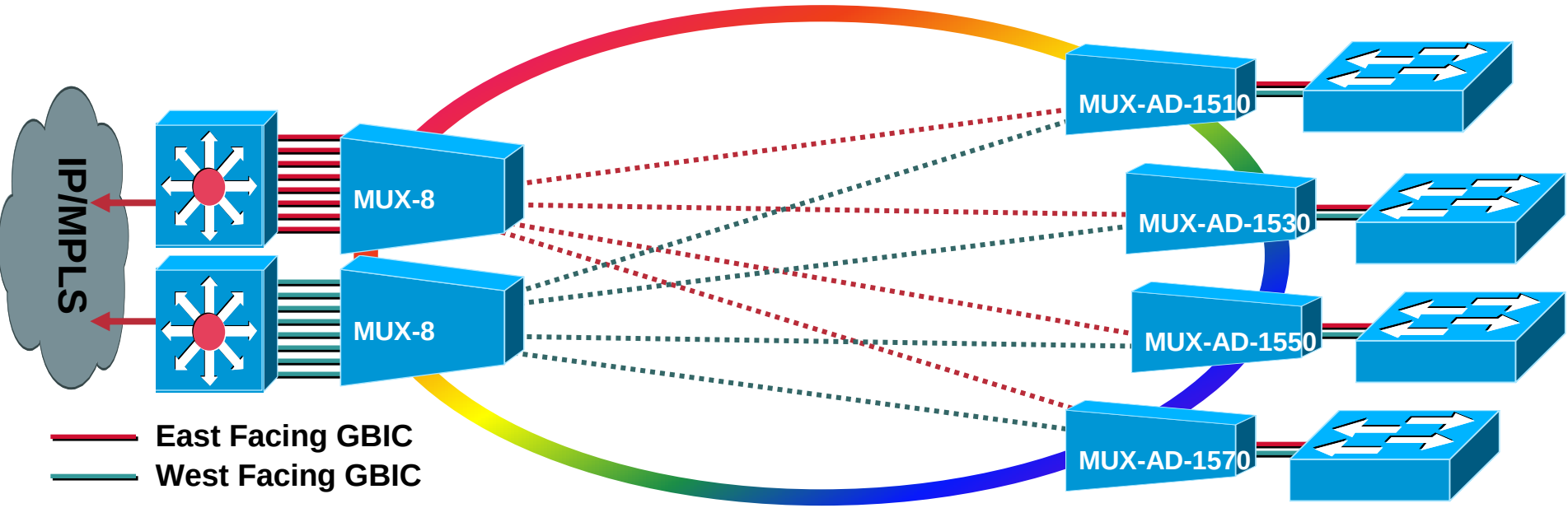




- Transparent LAN-optimized
- Greenfield and overbuild architectures
- Effective for a small number of customers
- Redundancy has to be carefully planned due to Spanning Tree and MPLS

- Ethernet service over an existing structured transport network
- Single CPE
- Larger implementations
- Build-in resiliency scheme (UPSR, BLSR, SRP) can eliminate Spanning Tree

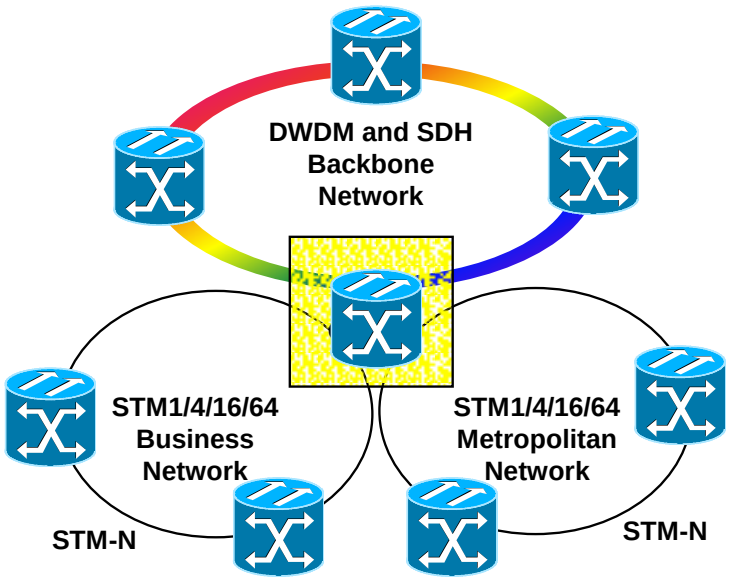
Logical Hub-and-Spoke on a Physical Fibre Ring



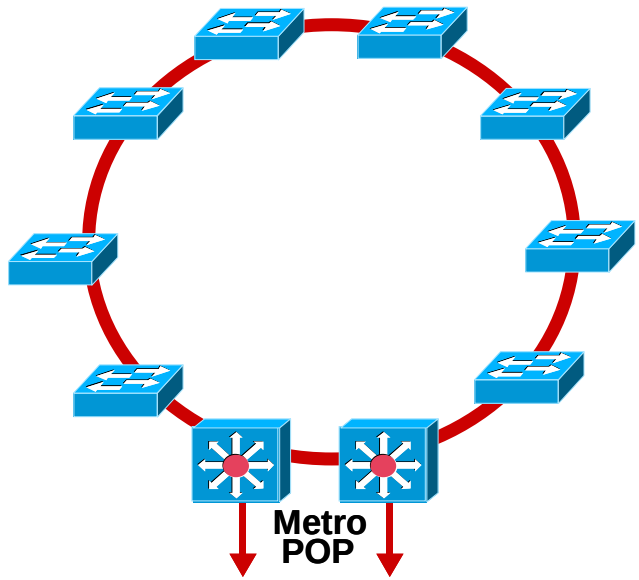
- Many providers will look to deploying a physical ring, but using a logical point-to-point service with guaranteed SLAs on top
- Technologies such as SONET/SDH, CWDM, and DWDM provide this capability

Different Methods Solve Different Problems

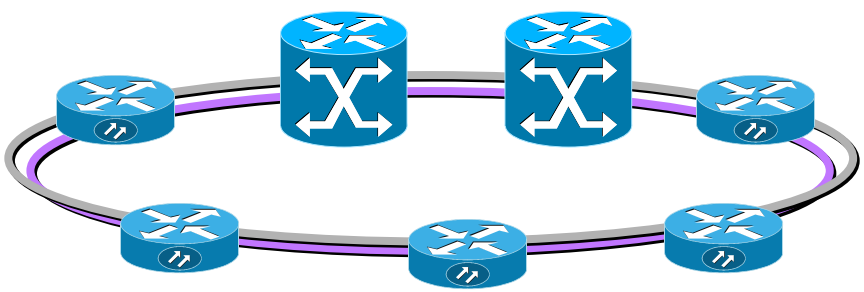
SONET/SDH



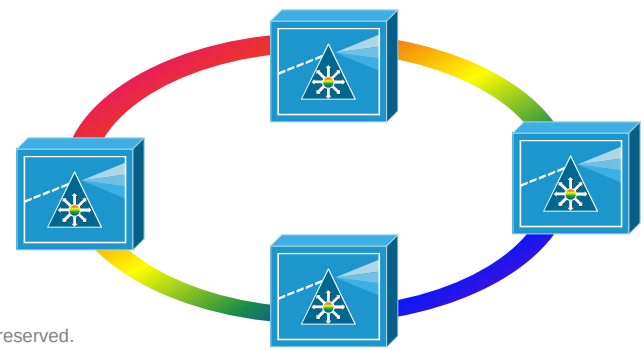
Switched Ethernet using Spanning Tree Protocol



DPT/RPR



DWDM/CWDM



Comparison of Ring Technologies

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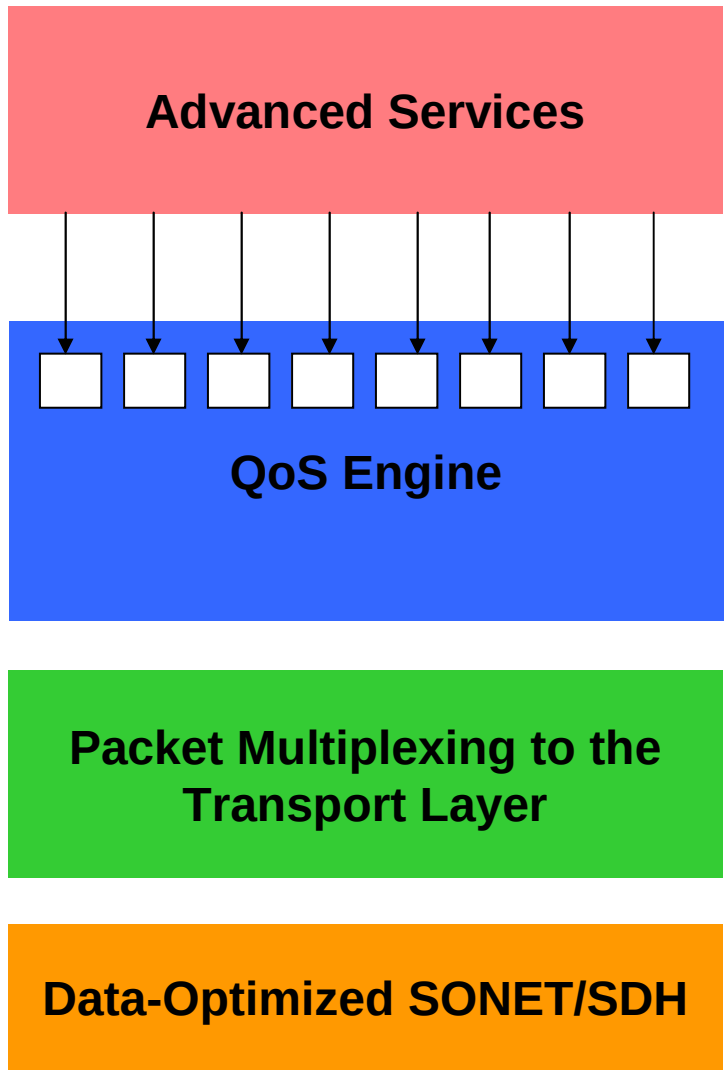
SONET/SDH	Switched Ethernet using Spanning Tree
• Installed base in service providers • Evolutionary approach for the service providers vs. revolutionary • Best choice for large scale deployments • Best use of fiber infrastructure • Hierarchical bandwidth • Best fiber utilization for dual homing • Next-gen SONET, with VCAT, LCAS, GFP, will help optimize SONET for data • 50 ms convergence	• Low cost solution over dark fiber • Perceived simplicity of Ethernet switching • Fairness, bandwidth, delay/jitter dependant on location on the ring • 10-12 node limit • LAN switch as edge device (no MPLS, Traffic shaping, BGP, etc) • 1-50 seconds convergence (standard 802.1d or 802.1w)
DPT/RPR	**CWDM**
• Shared packet ring scales bandwidth up to 5 Gbps • SONET framing provides insertion point for many providers • Spatial reuse provides good bandwidth utilization • Optimized for Layer 3 (currently) • Large number of nodes (128) per ring • 50 ms convergence	• Guaranteed bandwidth per lambda up to 8 nodes • Logical star over a physical ring • EtherChannel or Layer 3 load balancing for redundancy • 200 millisecond failover • More consistent delay/jitter and better access onto the ring •Still a low-cost Ethernet switch at edge

Cisco COMET Multiservice over SONET/SDH (MSOS) Strategy

- Deploying advanced services is key to profitability
- Ethernet, Video, VoIP, and SAN Interconnect key service needs
- QoS is necessary for advanced services and providing SLAs
- Cisco IOS provides advanced per-packet, per port QoS
- Packet Multiplexing is crucial for network efficiency and scale
- Cisco technology innovations (MPLS, DPT, CDL, EoS) enable this
- SONET/SDH will need to become more efficient
- GFP, CCAT, VCAT, and LCAS all offer incremental improvements



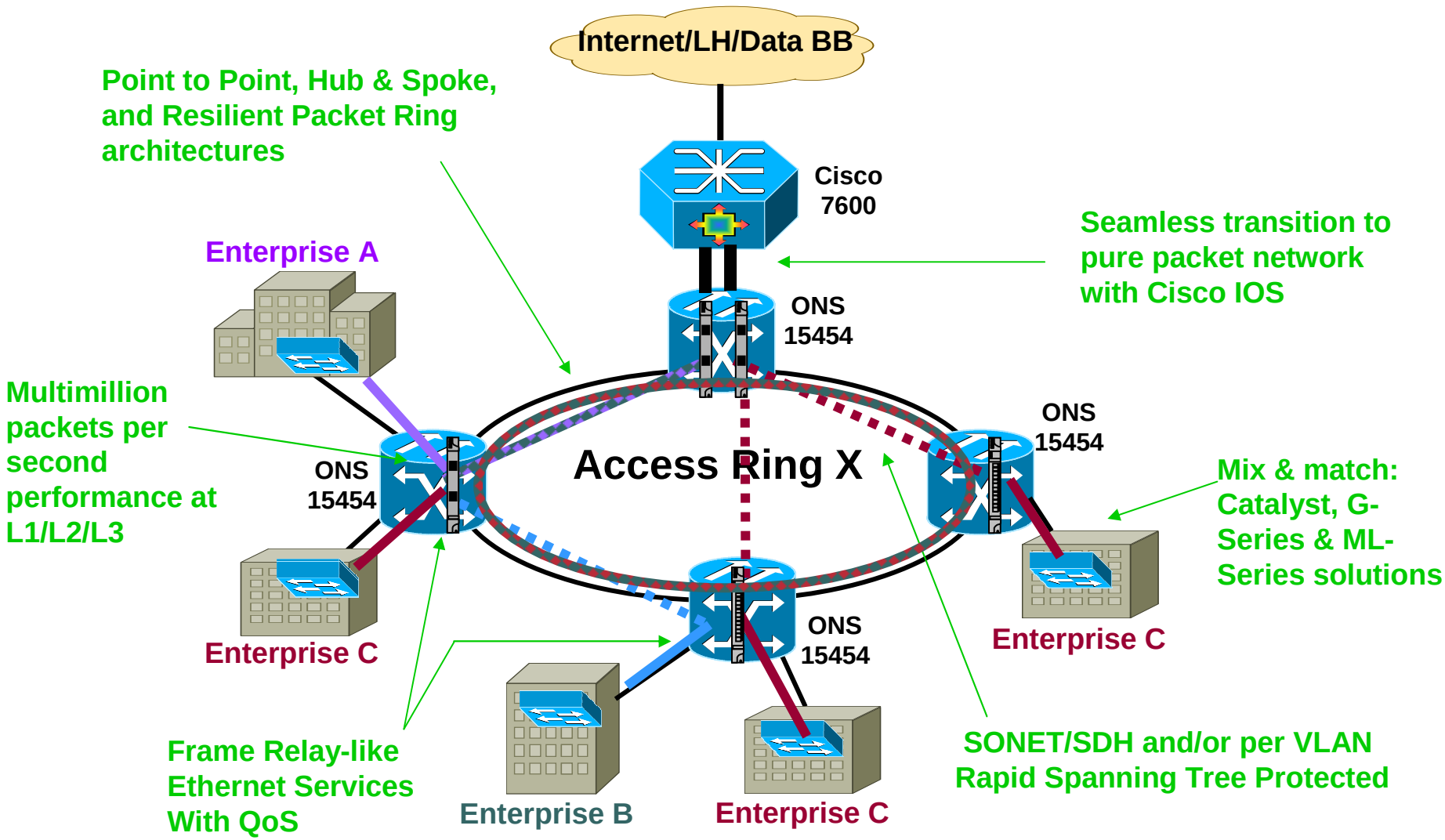
ONS 15454 ML-Series Ethernet Cards

- **ML-Series enables private line services and Layer 2/3 Packet Multiplexing into SONET/SDH**
- **Packet processing capabilities allow creation of multipoint services**
- **Common QoS feature set and code base with existing enterprise networks**
- **Common management with Cisco Transport Manager, as well as SNMP and TL1 support**

ONS 15454 Ethernet Capability
Customer Driven – Continued Traction

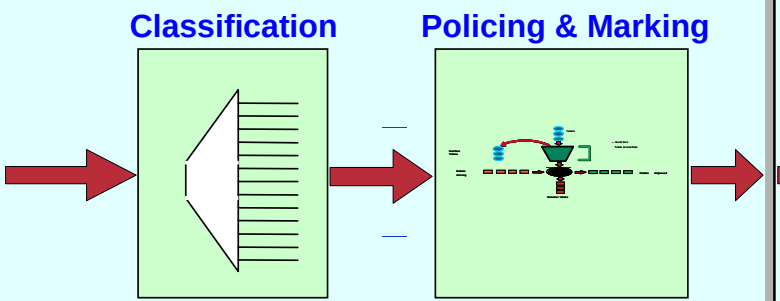
	Shipping Since	Ports Deployed	Services Deployed
E-Series	1999	Tens of Thousands	Layer 1 Private Line and basic switched services
G-Series	2002	Thousands	Line Rate Gigabit Ethernet Private Line
ML-Series	2003	Trials	Integrated Layer 2/3 capabilities to provide advanced switched services and SLAs

Packet Multiplexing – Flexible Architectures



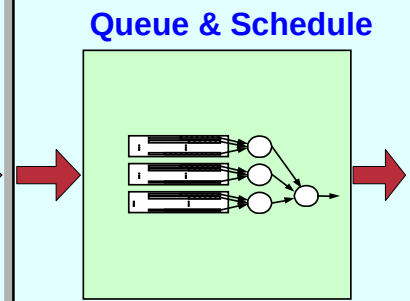
Advanced QoS and Layer 3 Capabilities

QoS Actions at Ingress



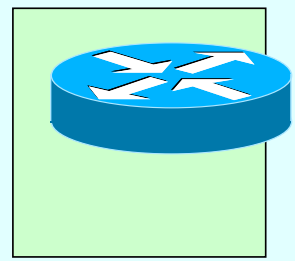
- Classification by:
  - Interface
  - Bridge Group
  - 802.1p
  - IP Precedence
  - DSCP
- Mark or Discard non-conformant packets

QoS Actions at Egress



- Fairly allocate unused bandwidth
- Multiple queues/port

Layer 3 Functionality



- Static IP routing:
  - OSPF, ISIS, EIGRP, BGP, RIP, HSRP, VRF-Lite and ACL
- MPLS-capable

Provisioning of ML-Series based Profitable Ethernet Services

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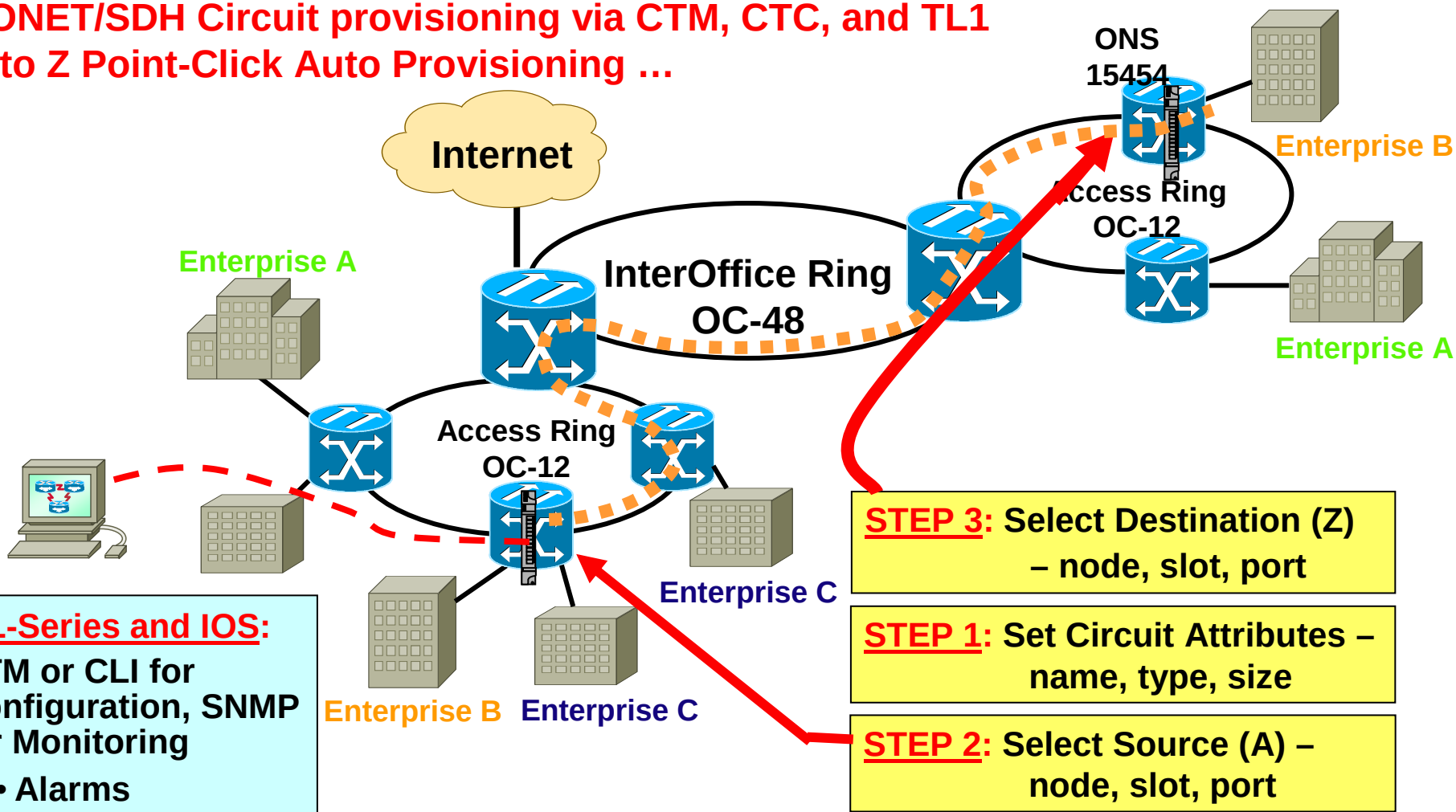
SONET/SDH Circuit provisioning via CTM, CTC, and TL1
A to Z Point-Click Auto Provisioning …



STEP 3: Select Destination (Z) – node, slot, port

STEP 1: Set Circuit Attributes – name, type, size

STEP 2: Select Source (A) – node, slot, port

ML-Series and IOS:

CTM or CLI for Configuration, SNMP for Monitoring

- Alarms
- Performance
- All L2/L3 Features

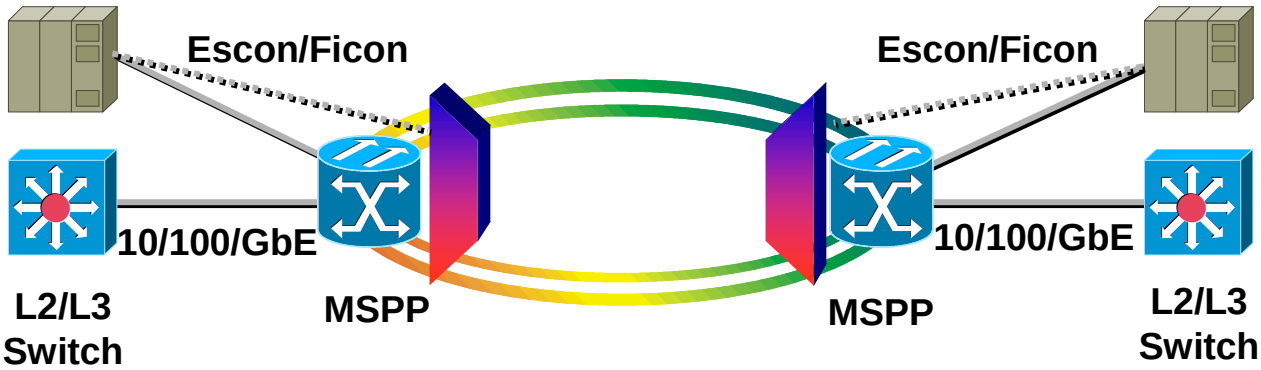
Mapping Data over SONET/SDH

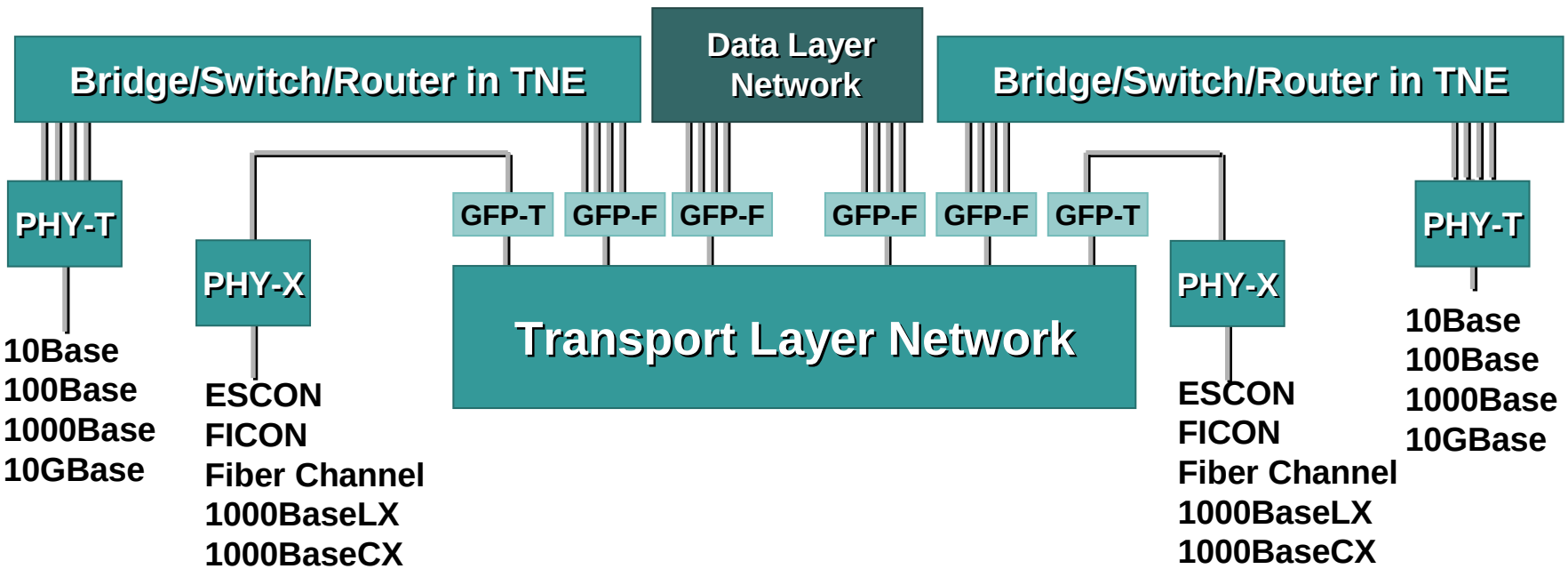
(GFP—Generic Framing Procedure)

ITU Recommendation G.7041 (GFP)

- **Generic Framing Procedure expands on functionality of X.86 in that it provides for:**
  - **Encapsulation of L2/L3 PDU client signals (GFP-F)**
  - **Encapsulation/mapping of block coded client signals (GFP-T)**
  - **Multiplexing of multiple client signals into a single payload**

GFP Network View





Pros and Cons GFP

- **Pro:**

  Supports Ethernet, PPP and SAN interfaces

  ITU Standard

- **Con:**

  Added flexibility adds complexity (not really that bad though and can be overcome by a good provisioning scheme)

Pros and Cons BCP

- **Pro:**
  - **IETF endorsed**
  - **It is simple**
  - **Can be deployed today!**
- **Con:**
  - **Most customers want GFP**

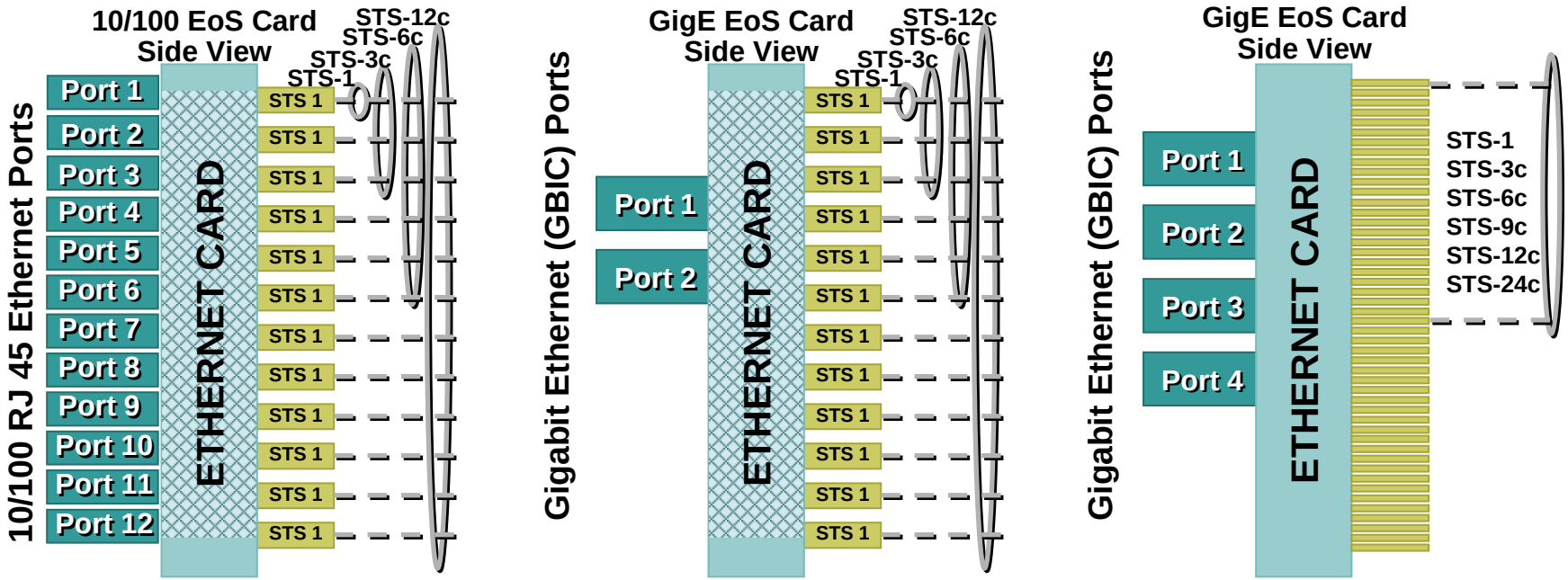
Points To Be Heard

- **In terms of overhead, GFP has more overhead; however, BCP uses padding and GFP uses idle patterns for synchronization; these can all add considerable overhead, thus making the two roughly equal**
- **BCP transports Ethernet and some useless LAN protocols, while GFP transports Ethernet, PPP and SAN protocols**
- **GFP is an ITU standard which carries more weight with IXCs, RBOCs and PTTs**

Optimizing SONET/SDH for Data Transport

(STS BW Scaling, Virtual Concatenation)

STS Bandwidth Scaling



Example:

- **100 mbps service required for a CMTS (residential cable access) and a high school LAN**
- **Assume STS bandwidth scaling onto a shared STS-3c**
- **Service provider preserves 155 mbps of transport bandwidth (enough to deliver 84 DS-1 services for over $20K/month or 3 DS-3 services for over $10K/month)**

Note: Same Operation for SDH, Mapping Changes to Fit VC-n Structure

SONET/SDH Virtual Concatenation (VC)

- **Virtual Concatenation is a method of creating a payload made up of 2 or more associated SPEs transported through a network completely independently**
- **Channels are "administrated" together; common processing of channels is limited to end points**
- **Channels not constrained to same path (end point delay equalization required)**
- **Channels not necessarily constrained to same transport channel (e.g., same STS-12)**

SONET: Virtual Concatenation Efficiencies

SONET Paths (SPEs)

Service	Bit Rate	Without VC	With VC
Ethernet	10 Mbit/s	STS-1 (20%)	VT1.5–7v (89%)
Fast Ethernet	100 Mbit/s	STS-3c (67%)	STS-1–2v (Approx. 100%)
Gigabit Ethernet	1000 Mbit/s	STS-48c (42%)	STS-3c–7v (95%)
Low Speed ATM	25 Mbit/s	STS-1 (50%)	VT1.5–16v (98%)
Fibre Channel	200 Mbit/s	STS-12c (33%)	STS-1–4v (100%)
Fibre Channel	1000 Mbit/s	STS-48c (42%)	STS-3c–7v (95%)
ESCON	200 Mbit/s	STS-12c (33%)	STS-1–4v (100%)

Link Capacity Adjustment Scheme

- **A mechanism for dynamically adjusting the size of a virtually concatenated channel**
  - **Allows TDM services more flexibility for handling dynamic bandwidth demands**
  - **Relies on the NMS/EMS to provision the bandwidth change**
  - **Allows channel size adjustment to be hitless**
- **Currently defined for SONET/SDH**
  - **Proposed for inclusion into G.709 OTN with ODUk VC**
- **Bit-oriented protocol encapsulated in control packets**
- **Applies to high order (STS) and low order (VT)**

LCAS Signaling Protocol

- **For high order VCs, it is communicated in a control packet carried in bits 1–4 of the H4 Path Overhead byte**

  Carried across a 16 frame multiframe

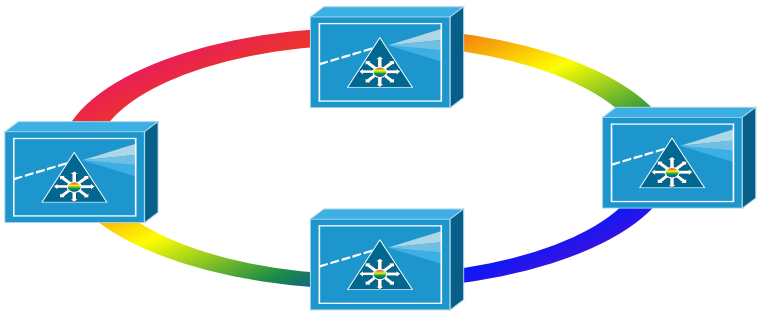
- **For low order VCs, it is communicated in a control packet in bit 2 of the Z7* Path Overhead byte**

  Carried across a 32 frame multiframe

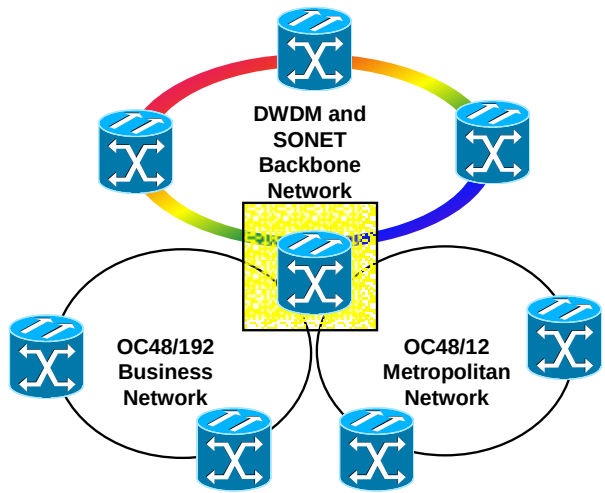
* **aka K4 and originally V8**

Topologies and Architectures

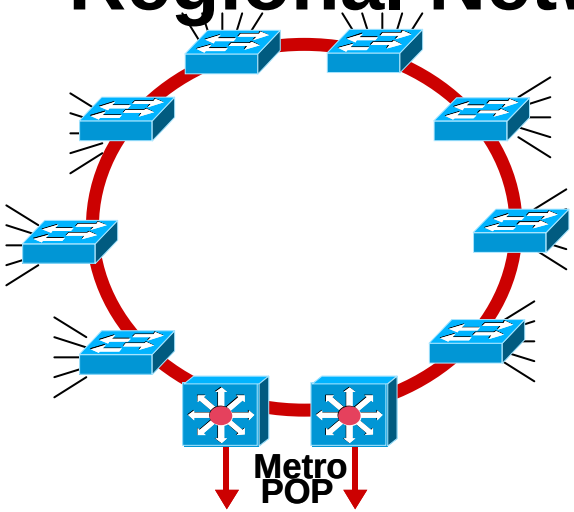
Architecture Scenarios



- **Dedicated Network**

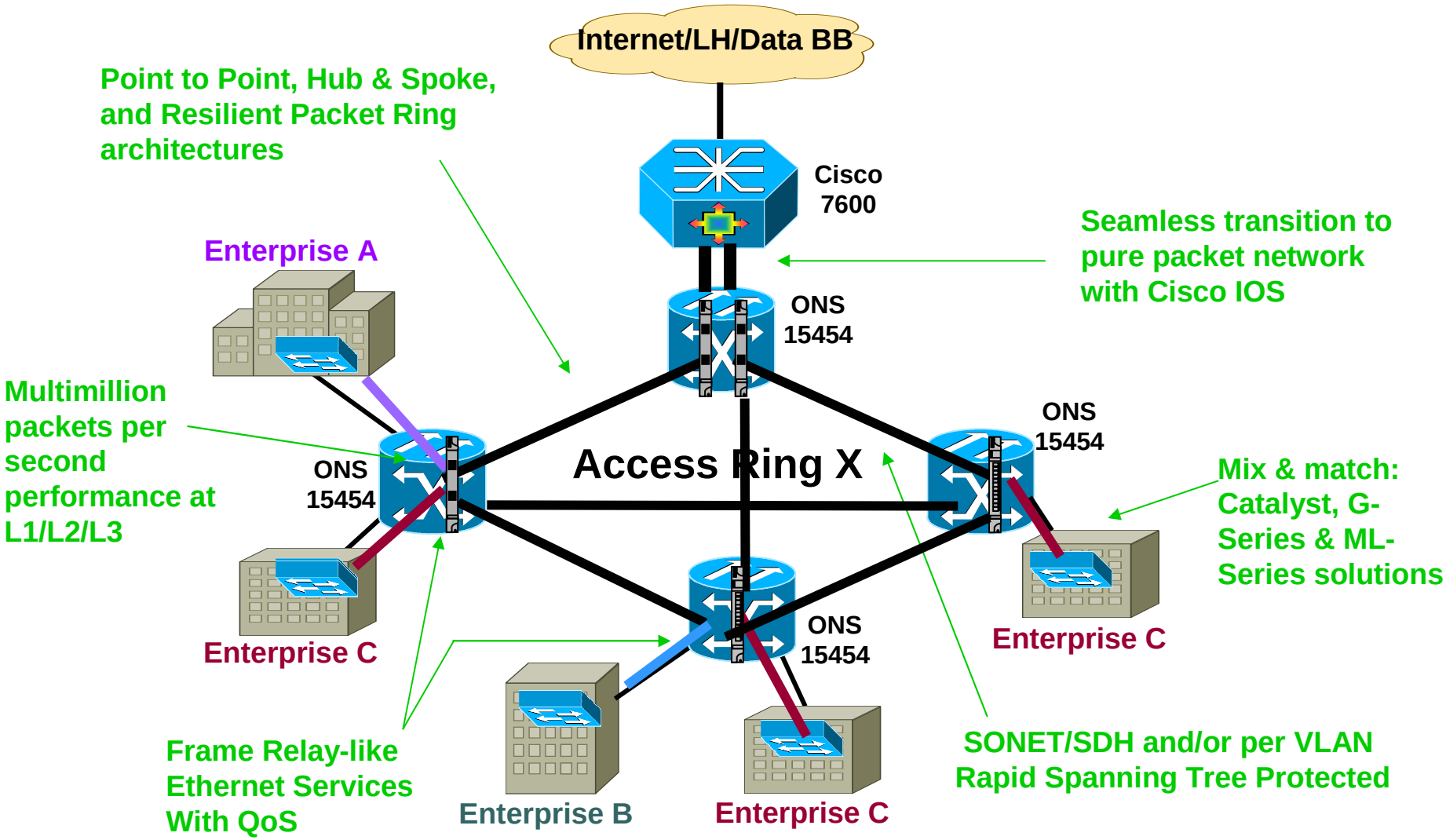


- **High Capacity Regional Network**



- **High Volume Metro Network**

Packet Multiplexing – Flexible Architectures



ML-Series Layer 2 Features For Service Providers

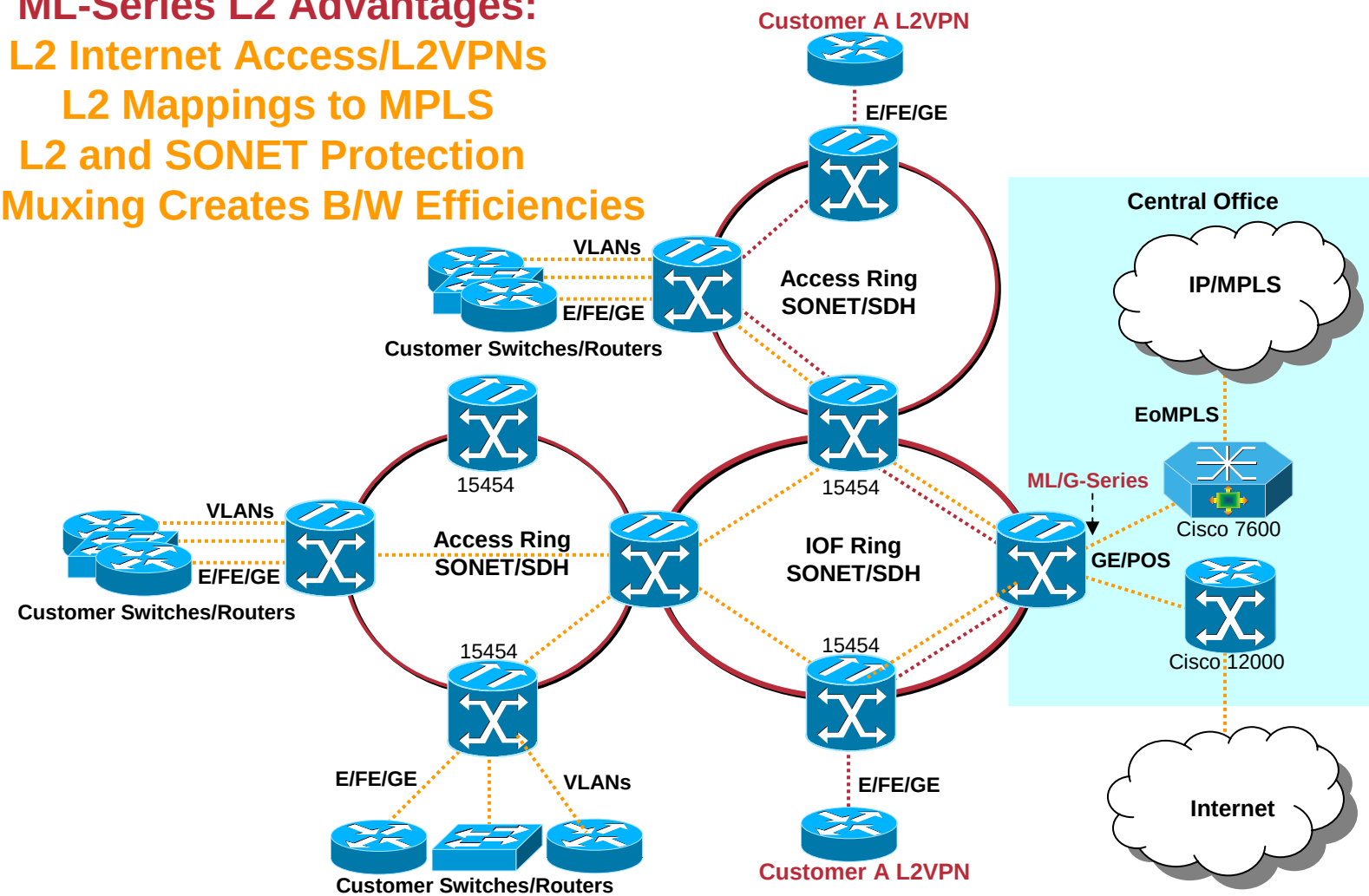
ML-Series L2 Advantages:

L2 Internet Access/L2VPNs

L2 Mappings to MPLS

L2 and SONET Protection

Stat Muxing Creates B/W Efficiencies



ML-Series Layer 3 Features For Service Providers

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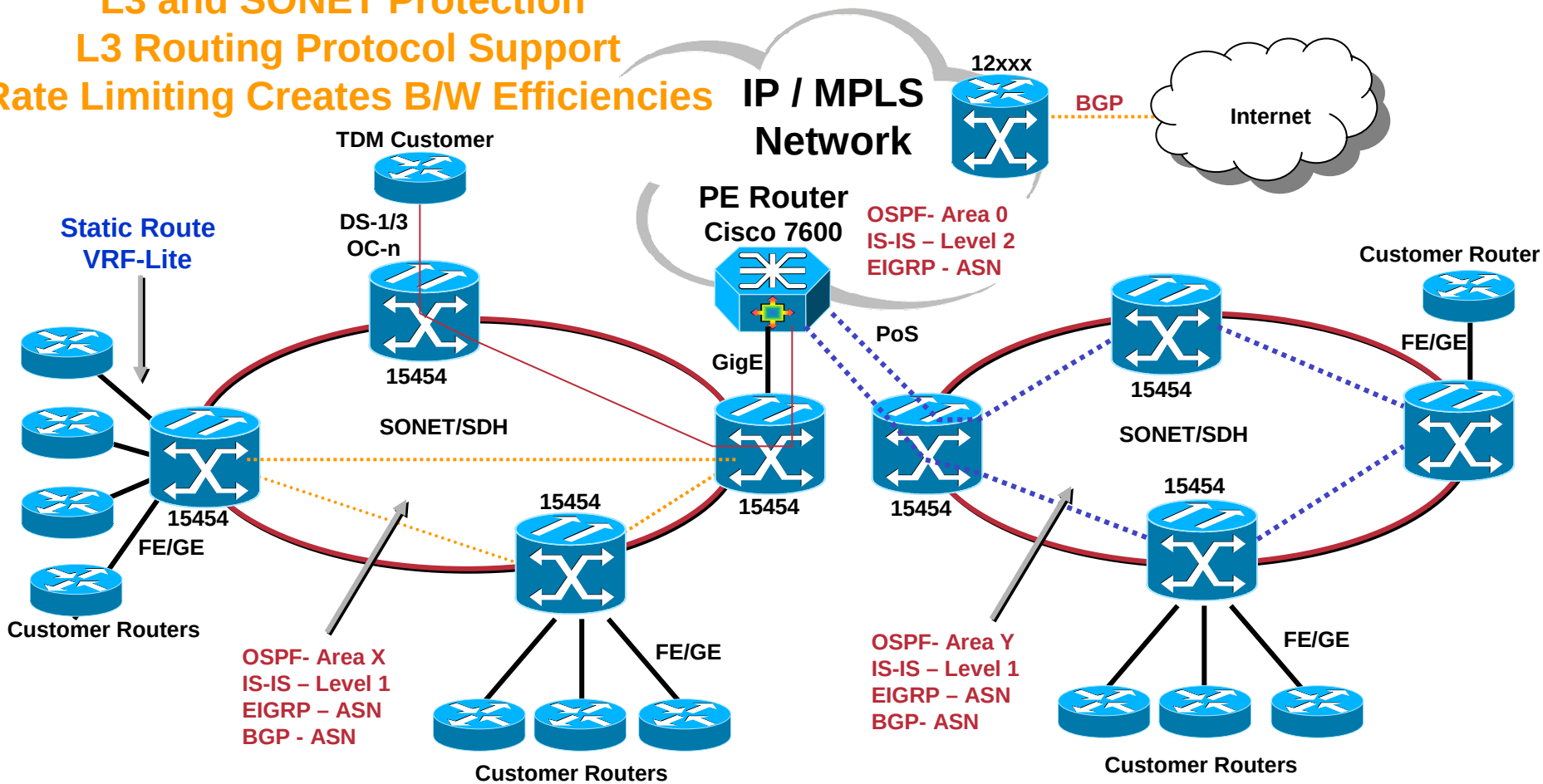
ML-Series L3 Advantages:

L3 Internet Access for Customers

L3 and SONET Protection

L3 Routing Protocol Support

Rate Limiting Creates B/W Efficiencies

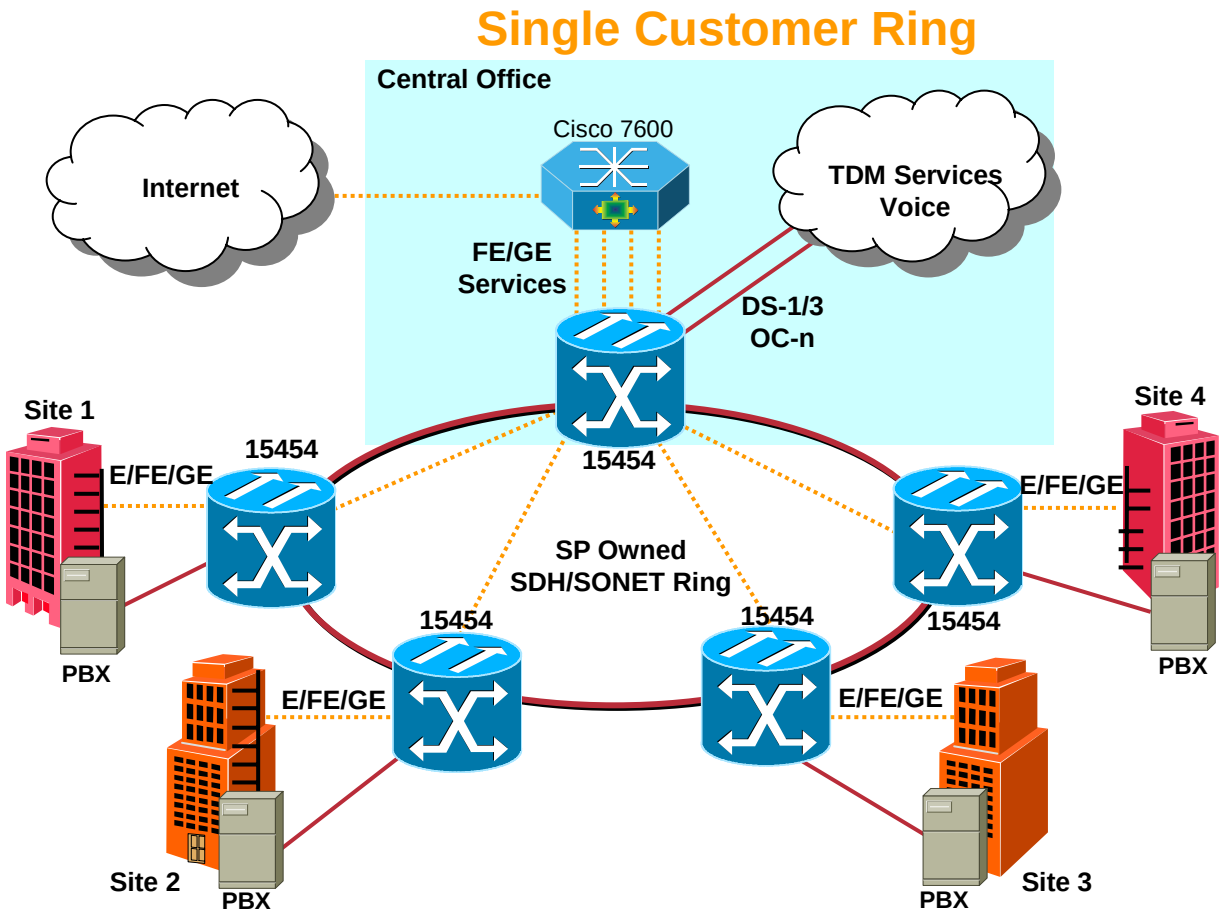


ML-Series Managed Services For Service Providers

ML-Series Advantages:

Provide L2/L3 Services

Internet Access/Private Line



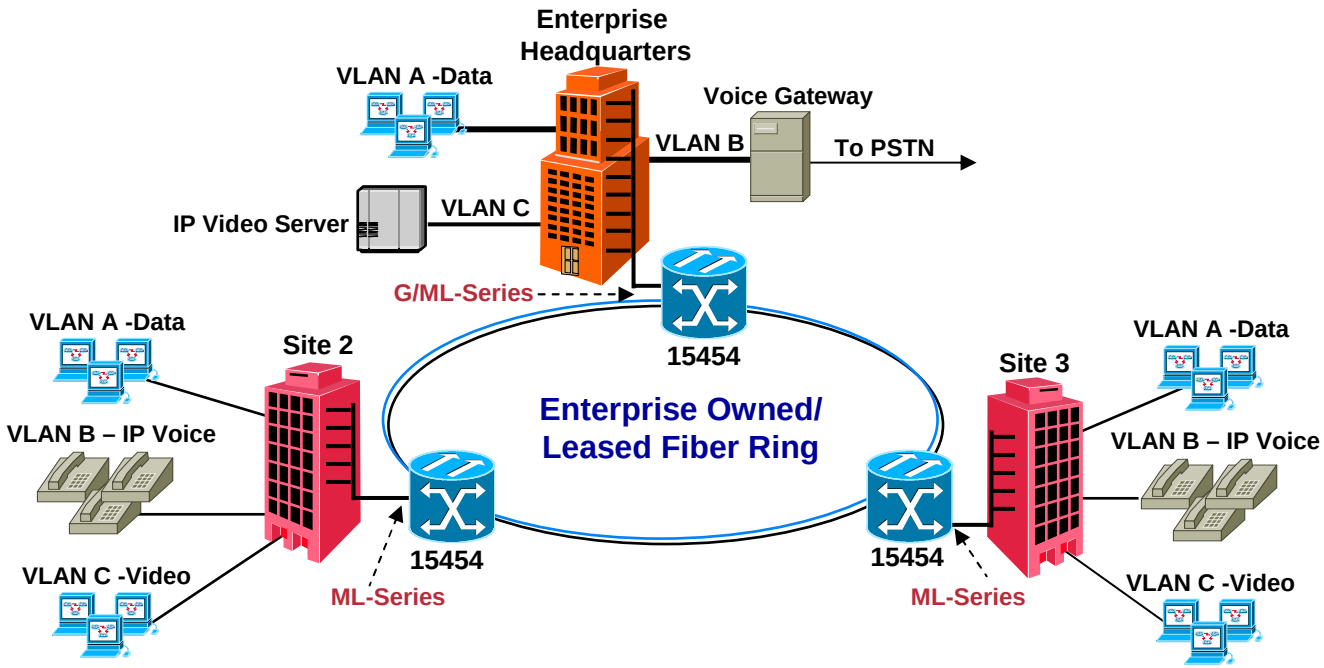
ML-Series Layer 2 Features For Municipalities and Large Enterprises

ML-Series L2 Advantages:

LAN Interconnection

IP Video Distribution

VoIP – QoS Guarantees



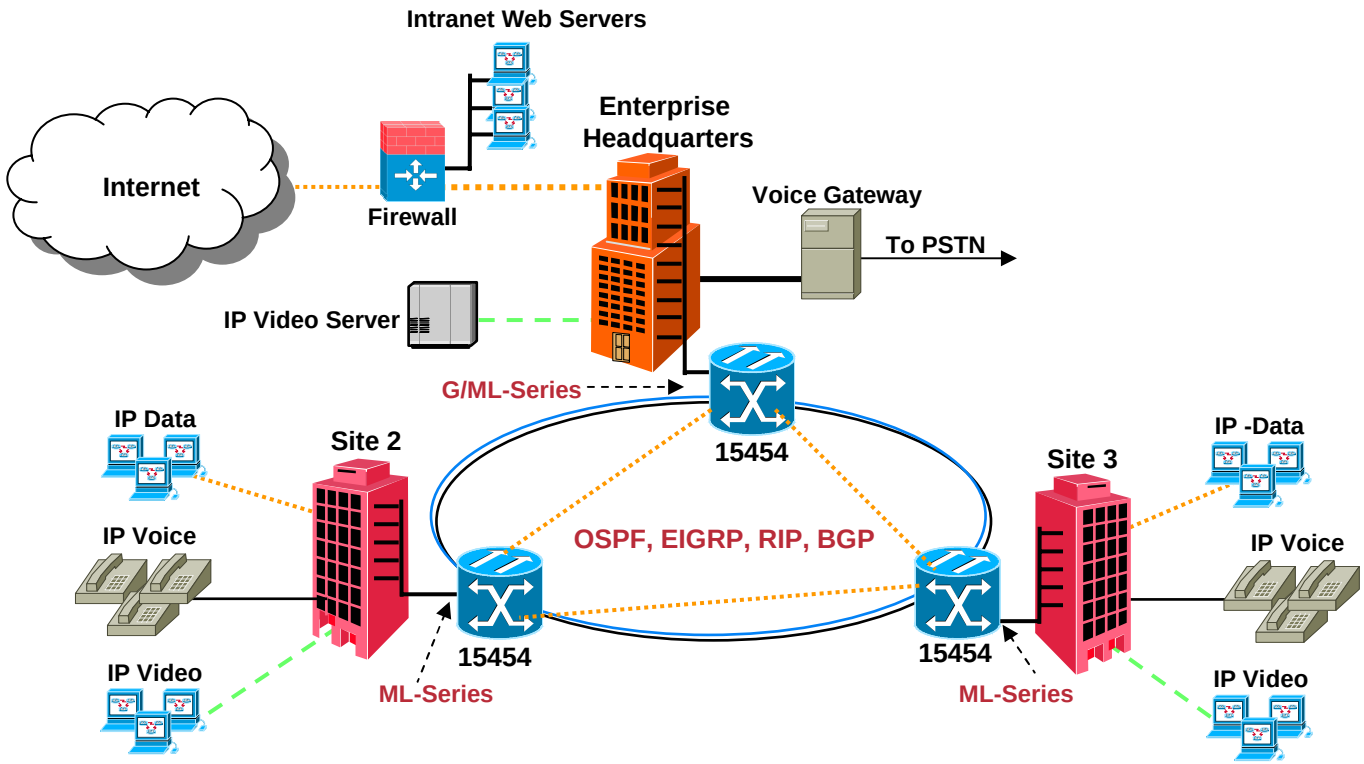
ML-Series Layer 3 Features For Municipalities and Large Enterprises

ML-Series L3 Advantages:

Internet Access/Intranet Web Access

IP Routing Protocol Support

Works with L2 Features



Summary

- **Cisco's Multiservice over SONET/SDH (MSOS) Strategy enables profitability through:**
  - **Support for Advanced Services**
  - **Enhanced QoS**
  - **Integrated Packet Multiplexing**
  - **Data Optimized SONET/SDH Transport**
- **ML-Series for the ONS 15454 Multiservice Provisioning Platform (MSPP) delivers private line and switched Ethernet services**
- **Only Cisco Systems has the expertise in both packets and circuits**