Gigabit Ethernet: Is it a disruptive technology?

Ronald Skoog
Telcordia Technologies
732-758-2406
rskoog@research.telcordia.com

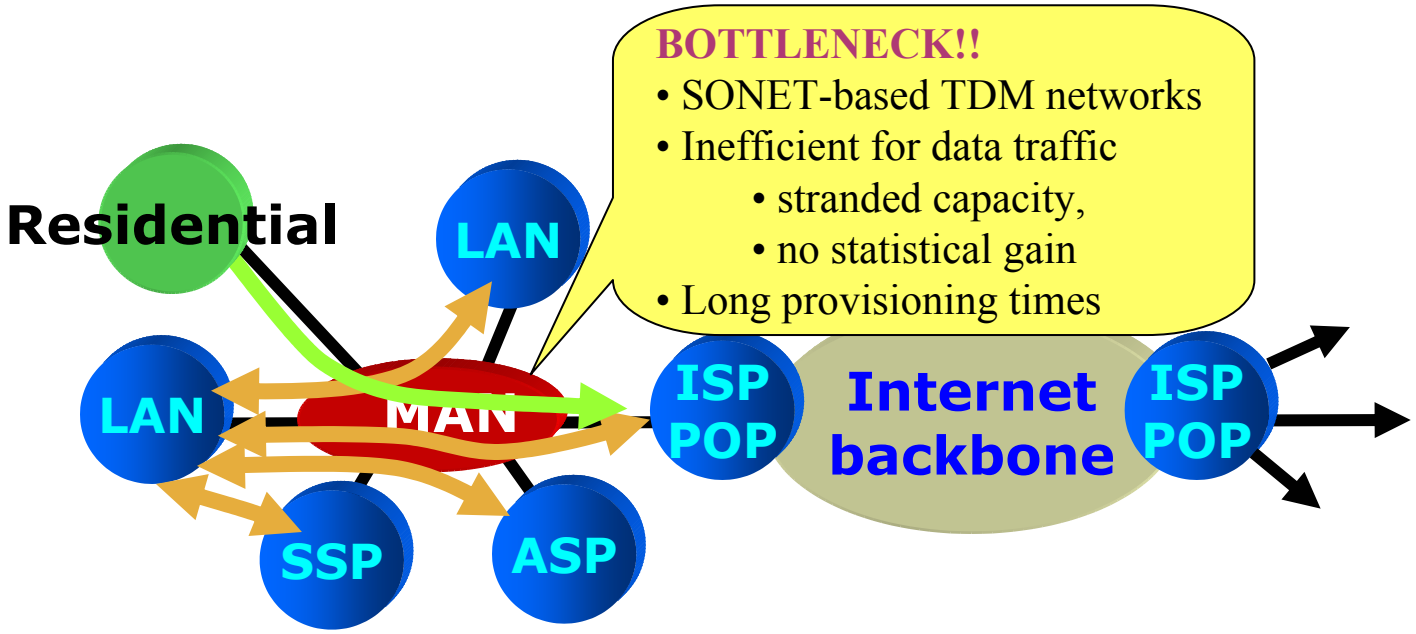
Outline

- Background:
  - The Metro Network Environment and the Technology Choices
- Ethernet and Gb/10Gb Ethernet Technology Background
- Gb/10Gb Ethernet Capabilities and Deficiencies
- Related Standards and Industry Forum Activities and Service Providers
- Conclusions and Summary

Telcordia Technologies
Performance from Experience

LTS

Metro Network Environment



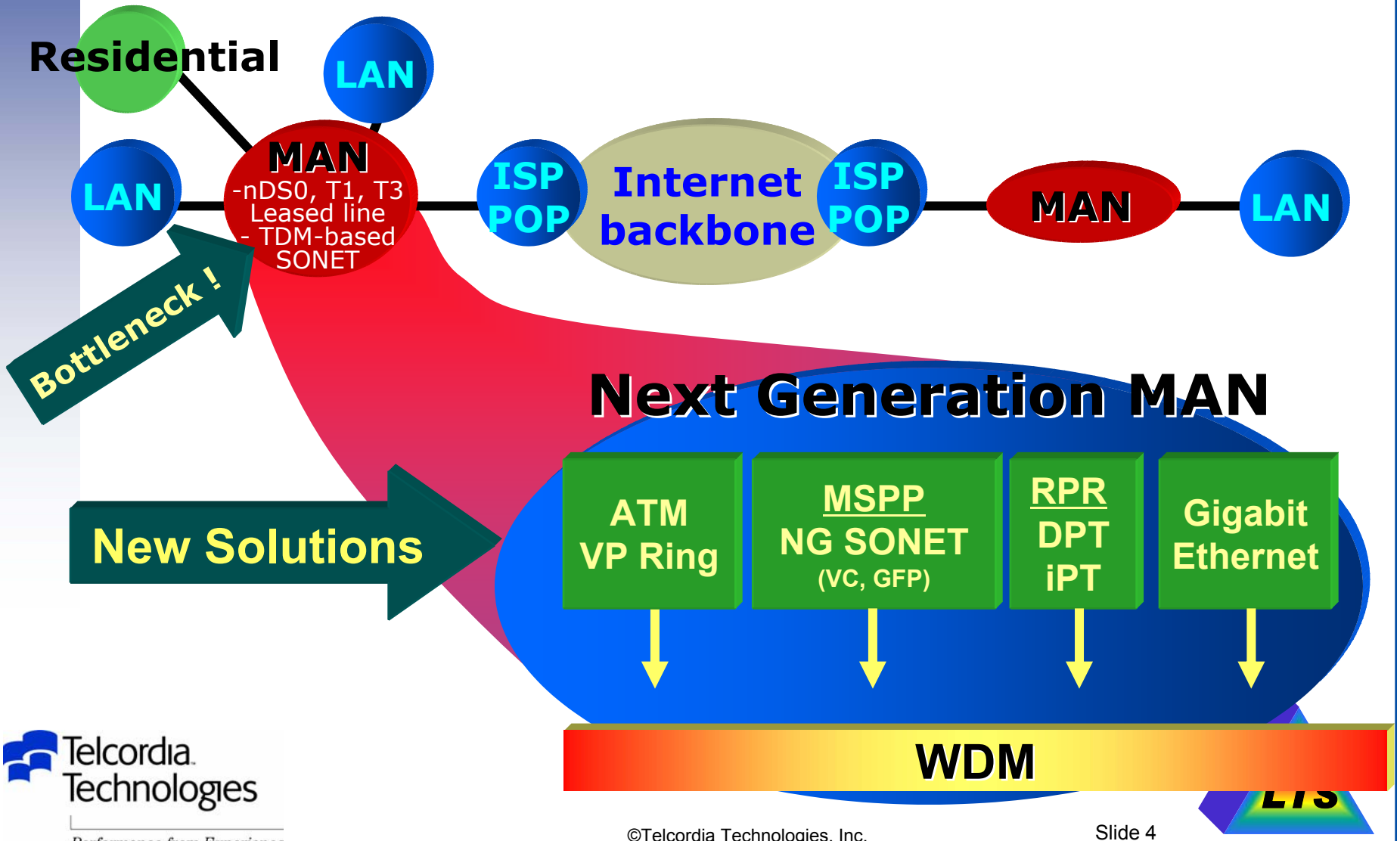
- Business Services/Apps
  - Access to Internet, ASPs, SSPs, etc.
  - LAN-LAN, VLANs, VPNs
  - Flexible, granular bandwidth choices
  - Quick and efficient service provisioning
  - Voice and video

Residential Services/Apps
xDSL, Cable, ETTH
HDTV Video
Games
Voice

Telcordia Technologies
Performance from Experience

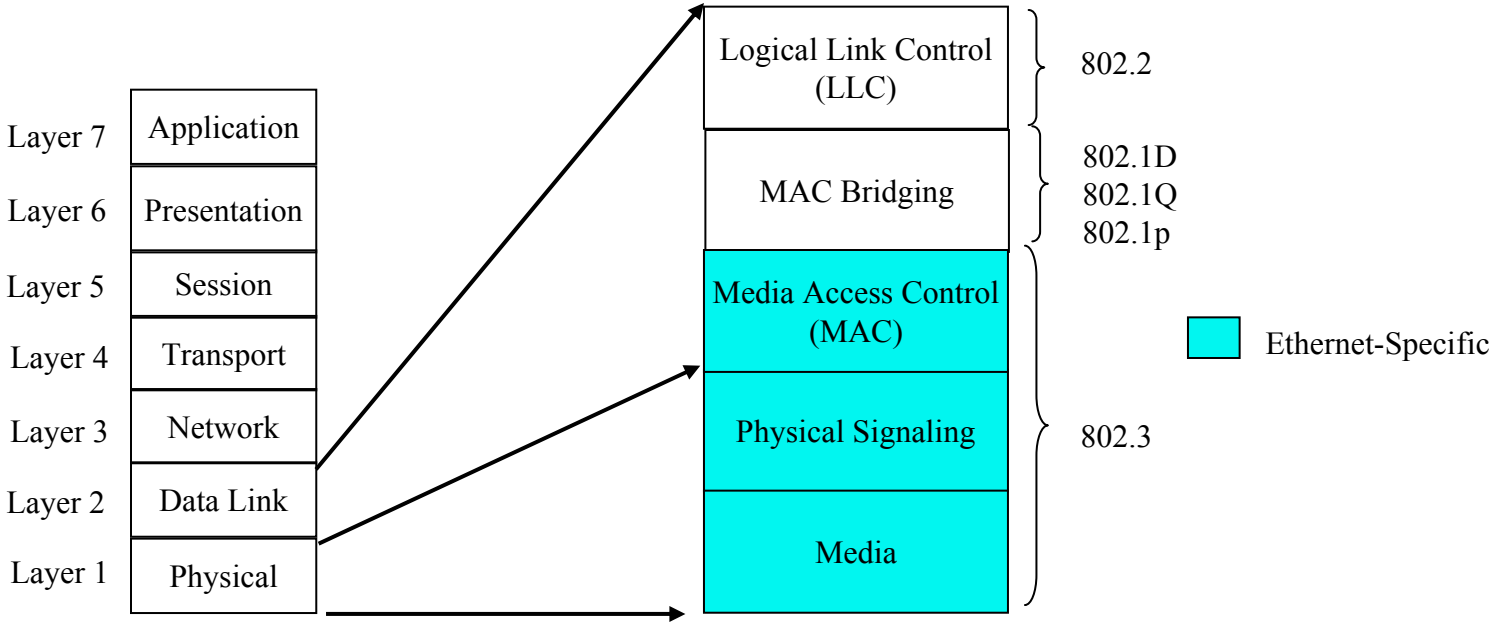
LTS

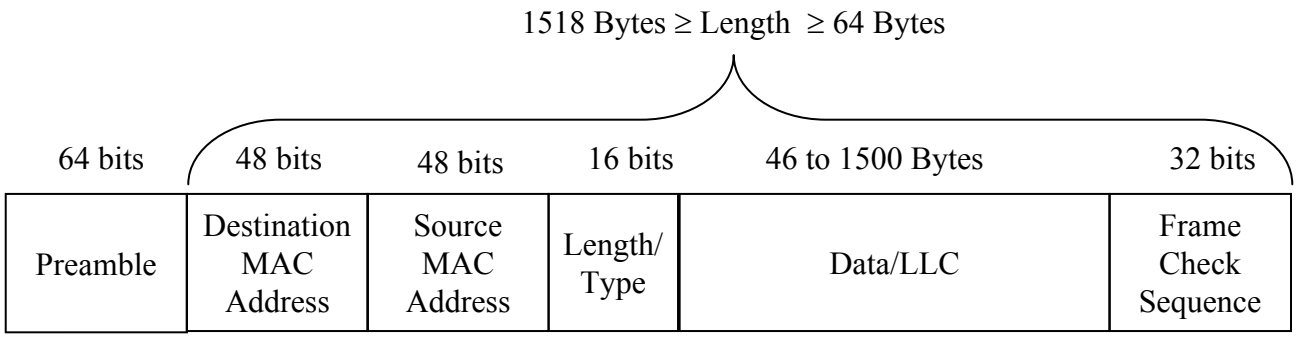
New Alternatives to SONET



Telcordia Technologies
Performance from Experience

Ethernet Protocol Structure



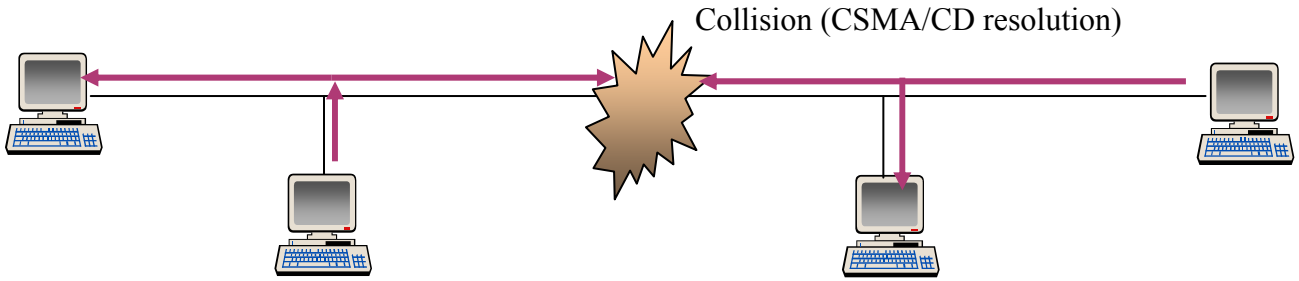


Ethernet Frame Structure

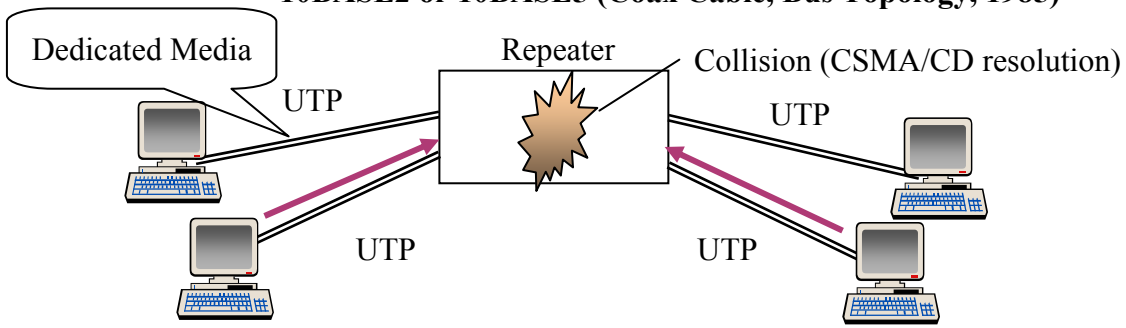
Telcordia Technologies
Performance from Experience

LTS

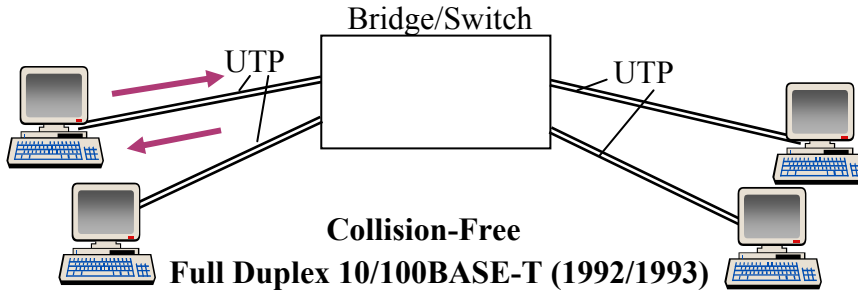
Evolution from Shared-Media, Half-Duplex to Dedicated-Media, Full-Duplex



10BASE2 or 10BASE5 (Coax Cable, Bus Topology, 1985)



Half-Duplex 10BASE-T (Star Topology, UTP cable, 1990)



Collision-Free
Full Duplex 10/100BASE-T (1992/1993)

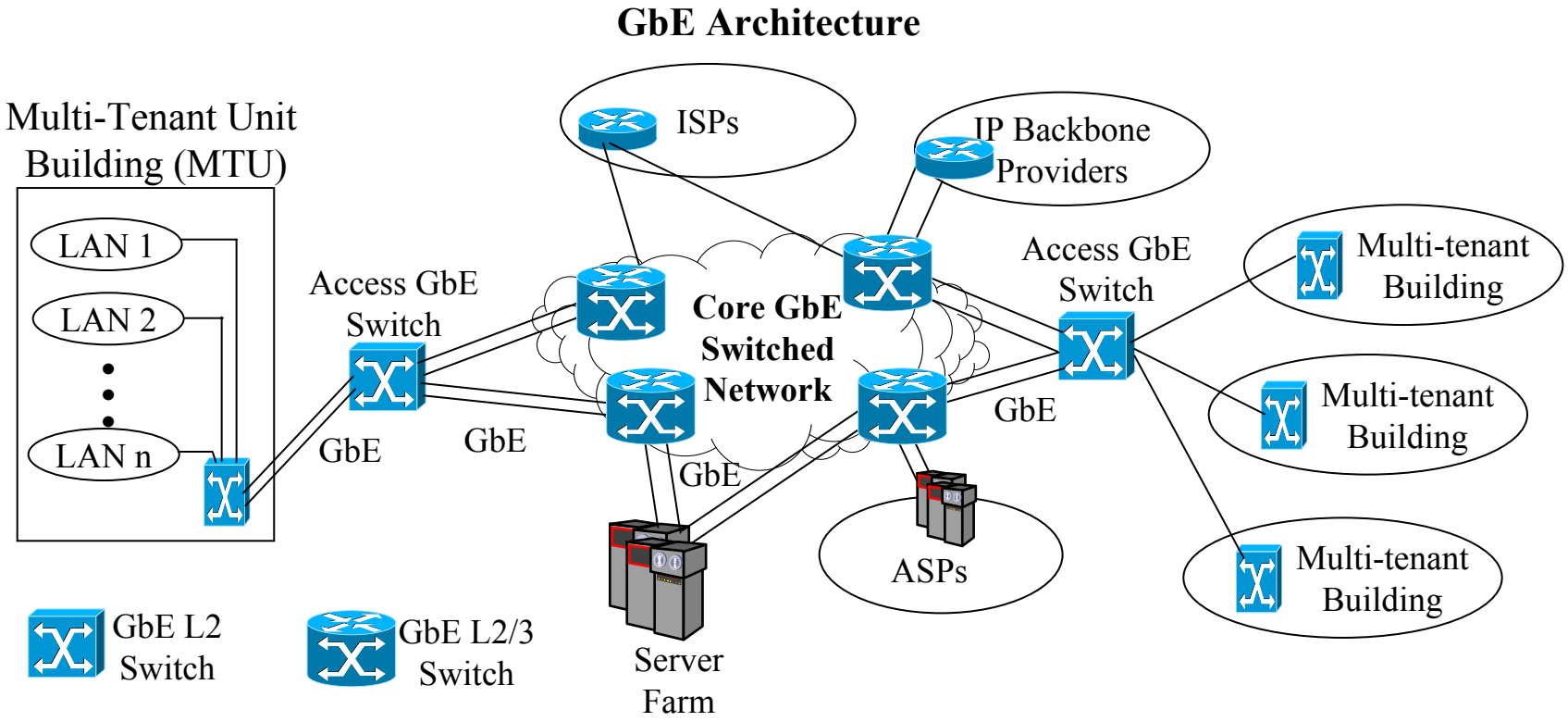
The Critical Development

- LAN backbone and NIC speeds are independent
- Networking is now possible

Telcordia Technologies
Performance from Experience

LTS

Switched GbE Network Architecture



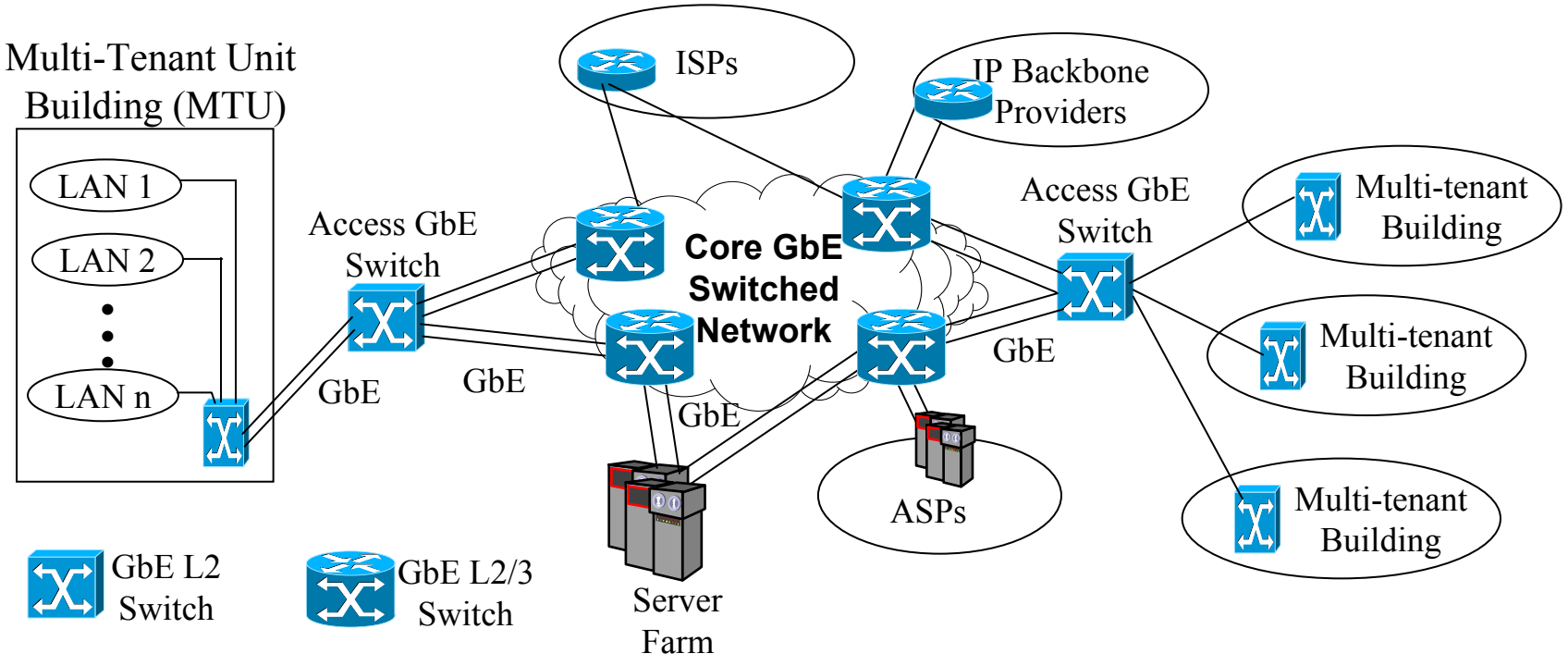
Optical Ethernet Service Categories

- Internet access
- LAN-LAN Interconnection (Ethernet PL)
- Metro Transport (Transparent LAN Service)

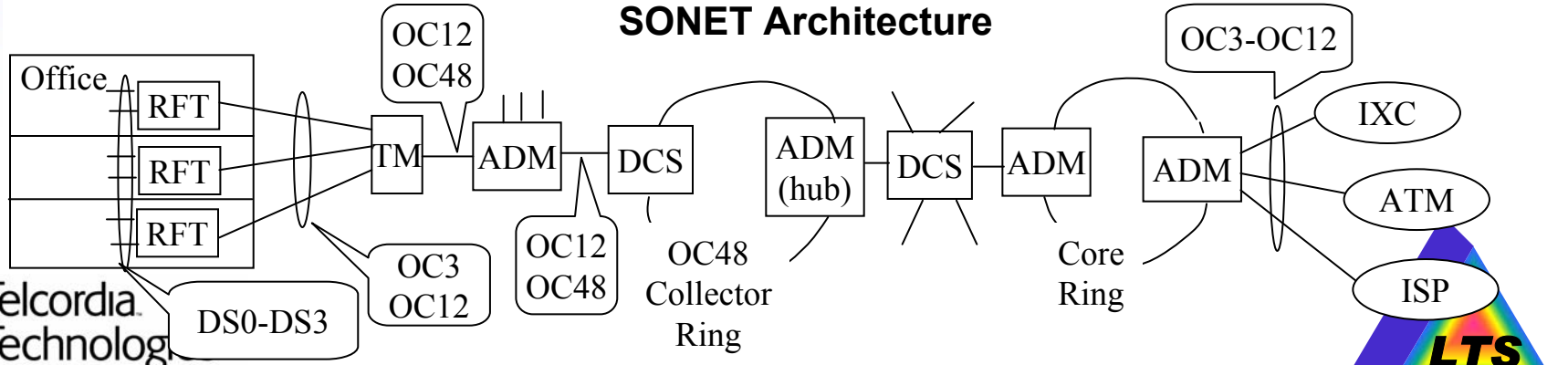
Telcordia Technologies
Performance from Experience

GbE and SONET Network Architectures

GbE Architecture

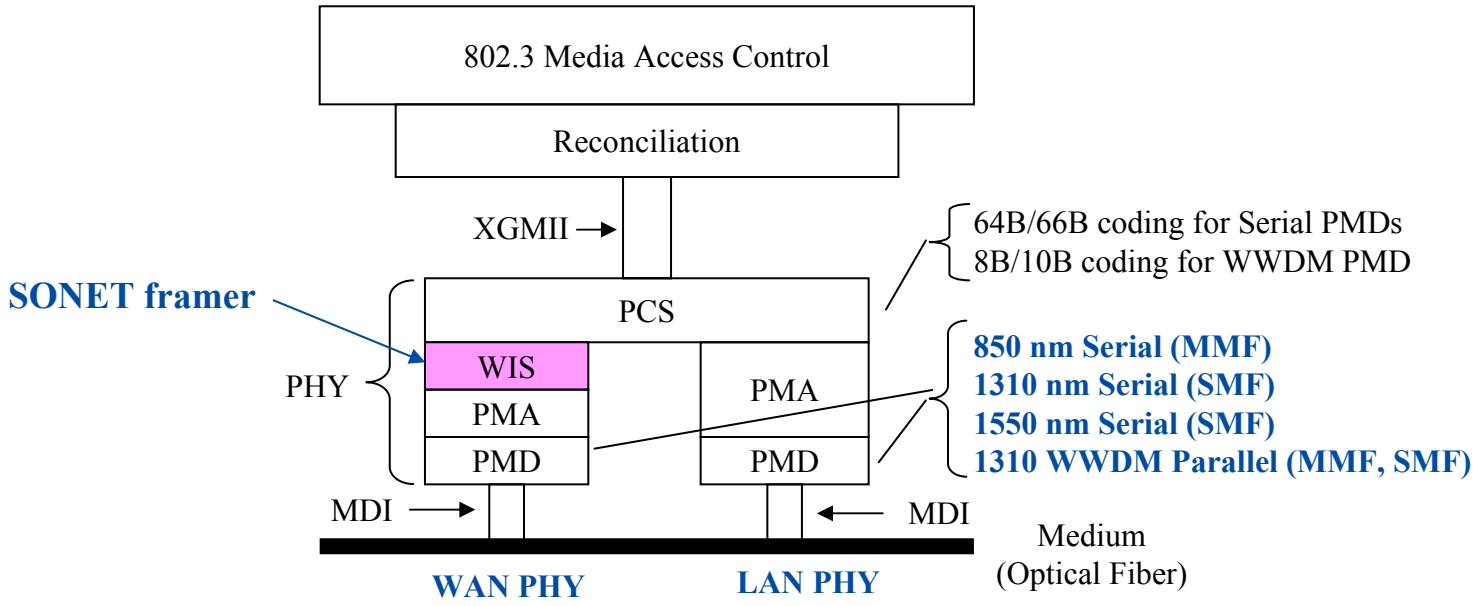


SONET Architecture



Telcordia Technologies
Performance from Experience

10 Gigabit Ethernet Layer Architecture

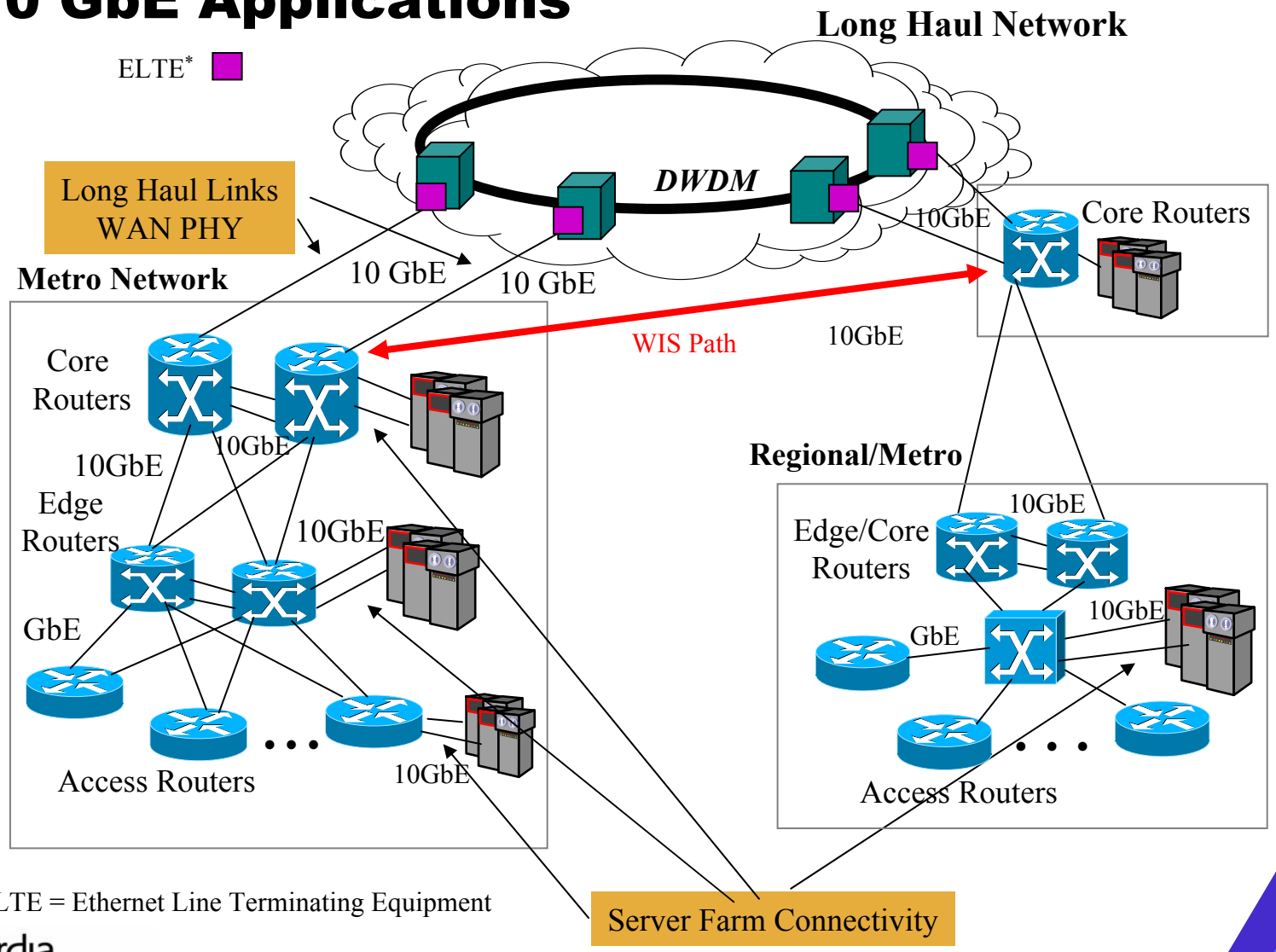


- **At Layer 2, 10 GbE is mostly unchanged, except NO SHARED MEDIA**
- **Two Physical (PHY) Layers: LAN PHY and WAN PHY**
- **Multiple Physical Media Dependent (PMD) layers:**
  - **MMF and SMF**
  - **Minimum distance requirements from 65 m to 40 km**

Telcordia Technologies
Performance from Experience

LTS

10 GbE Applications



* ELTE = Ethernet Line Terminating Equipment

Telcordia Technologies
Performance from Experience

LTS

Gb/10Gb Ethernet Capabilities

- Full duplex point-to-point links with long reach to 40 -70 km
- Big port cost advantage over SONET and ATM (~8:1 in port costs)
- 'Plug-and-play'
- VLAN capability (802.1Q)
- Spanning tree routing (802.1D) at layer 2
- Aggregate link capability (802.3ad)
- Priority capability (aggregate flow QoS) provided by 802.1p at Layer 2 and DiffServ at layer 3
- Policy based QoS
- Traffic policing, shaping and monitoring at customer interface

Optical Ethernet has a significant arsenal of Networking Capabilities

Telcordia Technologies
Performance from Experience

LTS

Gb/10Gb Ethernet Deficiencies

- Protection/restoration times are on the order of 1 second compared to SONET 50 ms capability
- QoS is in a similar state as IP QoS
  - over-provisioning needed to provide delay/jitter sensitive apps.
  - QoS provided for traffic aggregates, not individual flows
  - Routing protocols don't balance load very well on link capacity
- Performance monitoring and fault management are not as good as SONET and ATM.
  - Ethernet provides no overhead for performance monitoring, alarms, protection signaling, etc.
    - 10GbE WAN PHY has some of this capability
- Not clear how well GbE OA&M will scale (e.g., service provisioning, loopbacks, single-ended maintenance)

Telcordia Technologies
Performance from Experience

LTS

Missing OAMP Functionality in Ethernet

- Fault Detection, Sectionalization, and Alarming
- Protection and Restoration (SONET: 50msec)
- Secure Single-Ended Maintenance
- PHY-Layer Link Quality Monitoring (BER)
- Loopbacks

Telcordia Technologies
Performance from Experience

LTS

Why is Ethernet Cheaper?

- Simple Technology
- Backwards Compatibility
- Strict Standardization and Interoperability
- Customer Familiarity and Acceptance
- Large Volumes

OPTICS:
High-Volume, Mass Assembly
Plastic Packaging

ELECTRONICS:
Byte-oriented
Line coding (e.g, 8B10B)
Simple frame delineation
Relaxed timing and Jitter

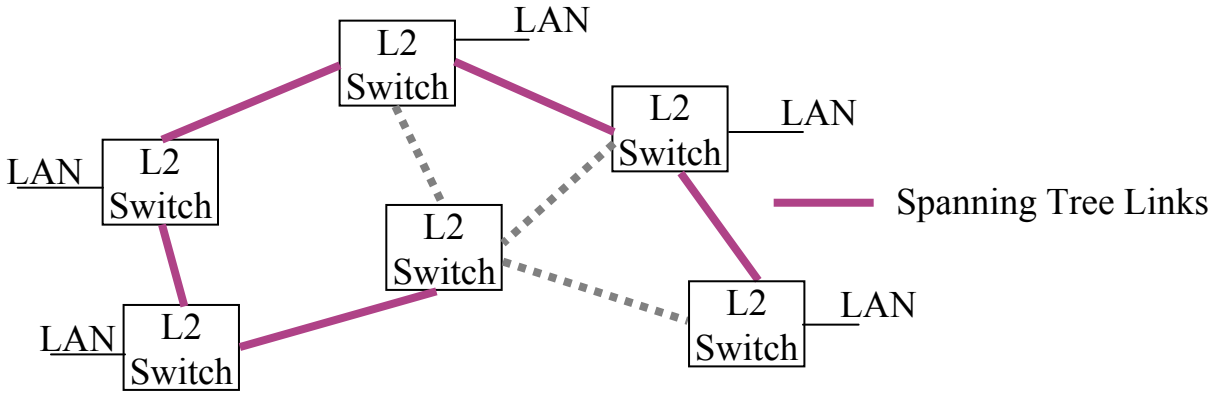
Source: Martin Nuss, Internet Photonix

Telcordia Technologies
Performance from Experience

LTS

Spanning Tree Capability (802.1D)

- Routing in layer 2 switched networks uses the spanning tree algorithm
  - spanning tree routing is prone to traffic concentrating on a small number of links and switches;
  - spanning tree reconfiguration is relatively slow (30-50 seconds required);
- An improved algorithm is being developed (P802.1w) that will converge in < 1 sec. (maybe in 10s of ms)
- Multiple spanning tree capability is being developed in P802.1s



SWITCHES LEARN TOPOLOGY BY
EXCHANGE OF CONFIGURATION MESSAGES

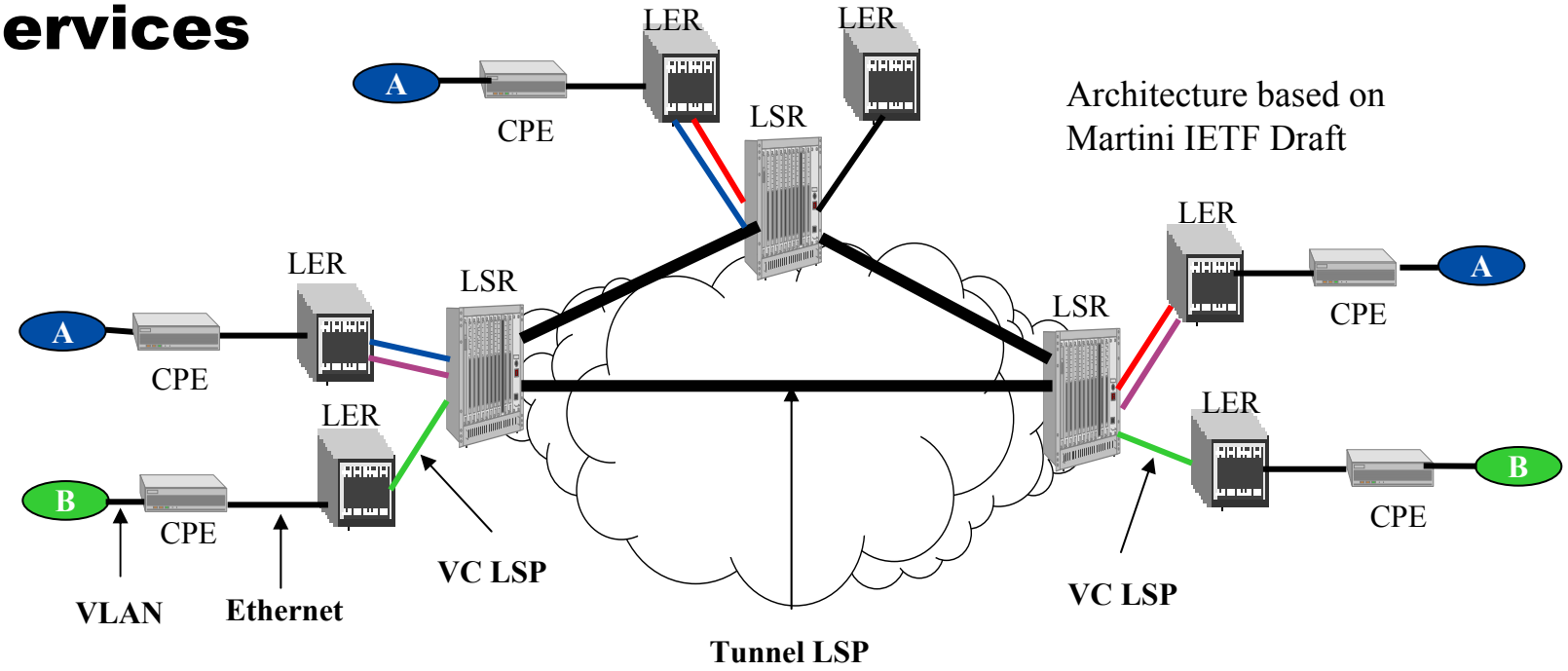
Telcordia Technologies
Performance from Experience

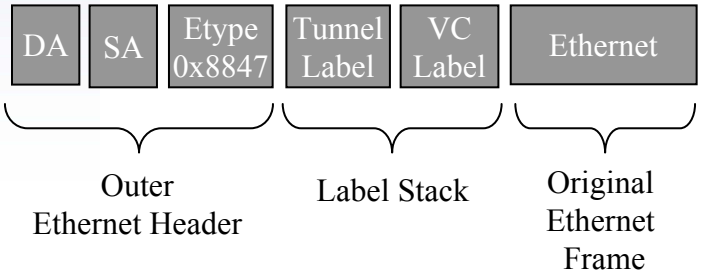
LTS

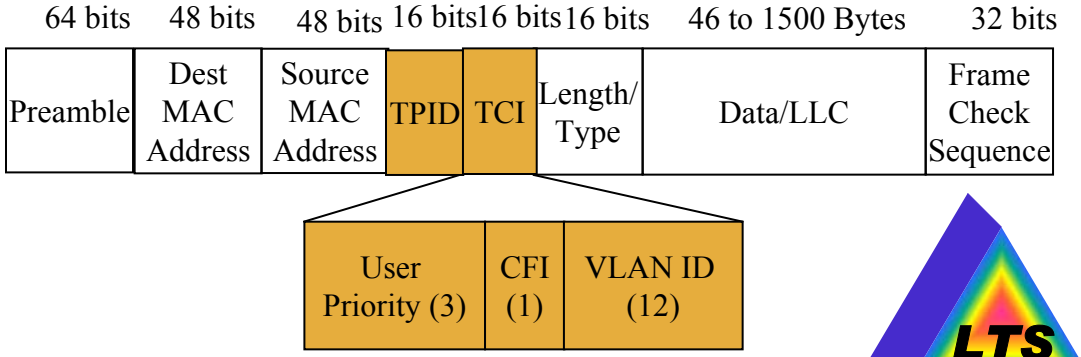
Virtual LAN (VLAN) Capability

- Virtual LAN and priority capabilities are provided by 802.1Q/p:
  - a VLAN tag is provided by 802.1Q to identify VLAN membership
    - Limited to 4096 VLANs – this is a potential scalability issue
  - the VLAN tag has a 3-bit priority field that allows 8 possible service classes (matches DiffServ's 8 possible classes)
- Why VLANS?
  - LAN scalability:
    - limits broadcast domains (limits broadcast storms);
    - also limits multicast, chatty protocols, etc., reducing overall network traffic.
  - Network efficiencies: traffic flows from different VLANS can be segregated
  - Allows non-physical grouping of nodes that share similar resources
  - Allows easy changing of LAN membership
  - Reduces the amount of level 3 (IP) routing
  - Security: limits snooping; authentication required (via GVRP) to join VLAN

VLANs and MPLS-Based Transparent LAN Services







Telcordia Technologies
Performance from Experience

LTS

Related Standards and Industry Forum Activities

- Resilient Packet Ring (RPR) – IEEE 802.17
  - Data efficient ring (distributed switch) using spatial reuse, 50 ms protection, and bandwidth management (allocation and fairness)
- Ethernet in the First Mile (EFM) Study Group – IEEE 802.3ah
  - Remote management of customer terminal for testing (loopbacks)
  - Link OAM overhead for BER monitoring, alarm indication, etc.
- ITU Study Group 13 (Multi-Protocol and IP-based Networks & ...)
  - Link OAM and end-to-end OAM
  - Leverage link OAM from EFM
- Metro Ethernet Forum (Industry Alliance)
  - Ethernet service definitions, technical specifications, and interoperability
  - MPLS protection mechanisms to 50 ms protection
  - OAM&P is on the agenda (leverage EFM link OAM work)

Service Providers with Ethernet Services/Plans

ELECS	ILECS
Cogent	Bell Canada
Fiber City	BellSouth
IntelliSpace	Qwest
Yipes	SBC Communications
	Verizon
Emerging metro/regional carriers	**Full Service CLECS**
EPIK Communications	Electric Lightwave
Looking Glass	Group Telecom (Canada)
OnFiber	Time Warner Telecom
Sphera	XO Communications
Telseon	
Emerging IXCs	**Traditional IXCs**
Broadwing	AT&T
Global Crossing	Sprint
Level 3	WorldCom
Williams Communications	

Source: RHK Inc.

Is Gigabit Ethernet a Disruptive Technology?

We believe that GbE is likely to be a Disruptive Technology

- It has a huge cost advantage
  - ~8-to-1 in port costs, less in provisioning and operations
- Currently serving niche markets
  - Internet access at 20%–30% equivalent SONET $/bps prices
  - IP-based (iSCSI) SAN or data backup solution for smaller sites giving them Fibre Channel like performance
- No ‘killer’ issues have been identified
- There will always be gaps in capabilities,
  - but they are getting smaller, and
  - closing the gap may not be worth the price

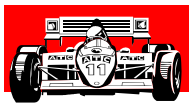
Telcordia Technologies
Performance from Experience

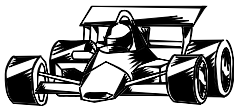
LTS

Conclusions

There is a Race going on at the Optical Edge

- The main contenders are Gb/10Gb Ethernet, MSPP technologies and RPR technology.
  - The MSPPs and RPRs may become more Ethernet-based
  - The SONET-based MSPPs and RPRs may have more competitive cost structures





- It is not clear which technology direction will prevail
  - Is multi-service/Multi-protocol capability needed, or will Ethernet become the ubiquitous layer 2 standard?

- There is no one answer for all networks
  - Options need to be carefully considered for each carrier and service provider

But, GbE Technology will be a Major Player

Telcordia Technologies

Performance from Experience

LTS