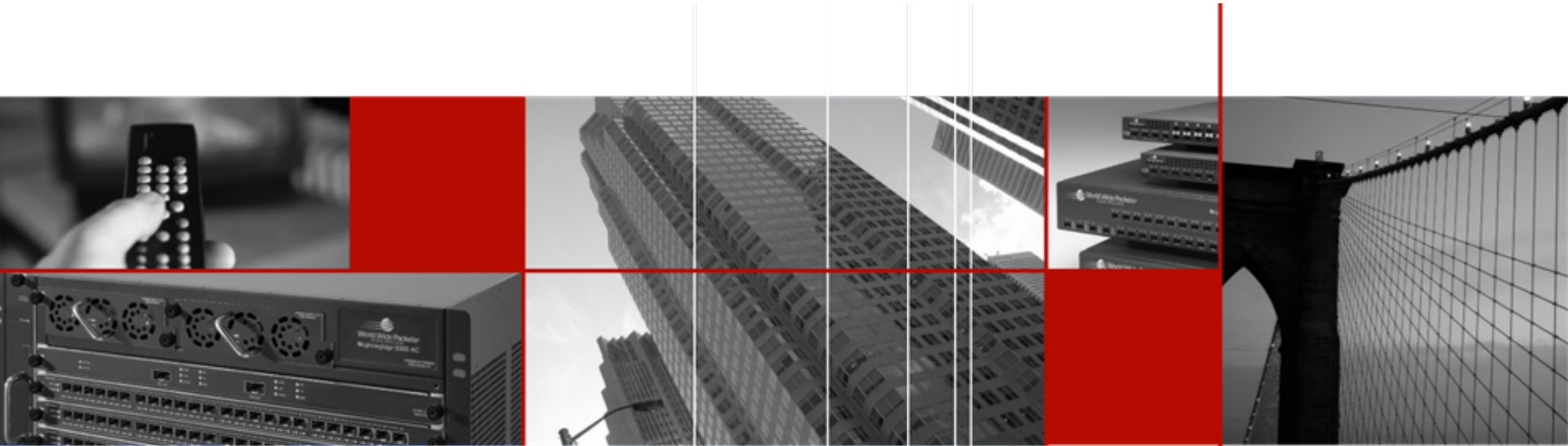


Future Networks



Eric Davison
Technical Director, EMEA

Company Overview

■ Mission:

- Accelerate the adoption of next generation Ethernet services by developing cost effective, highly resilient networks for operators serving business and residential customers

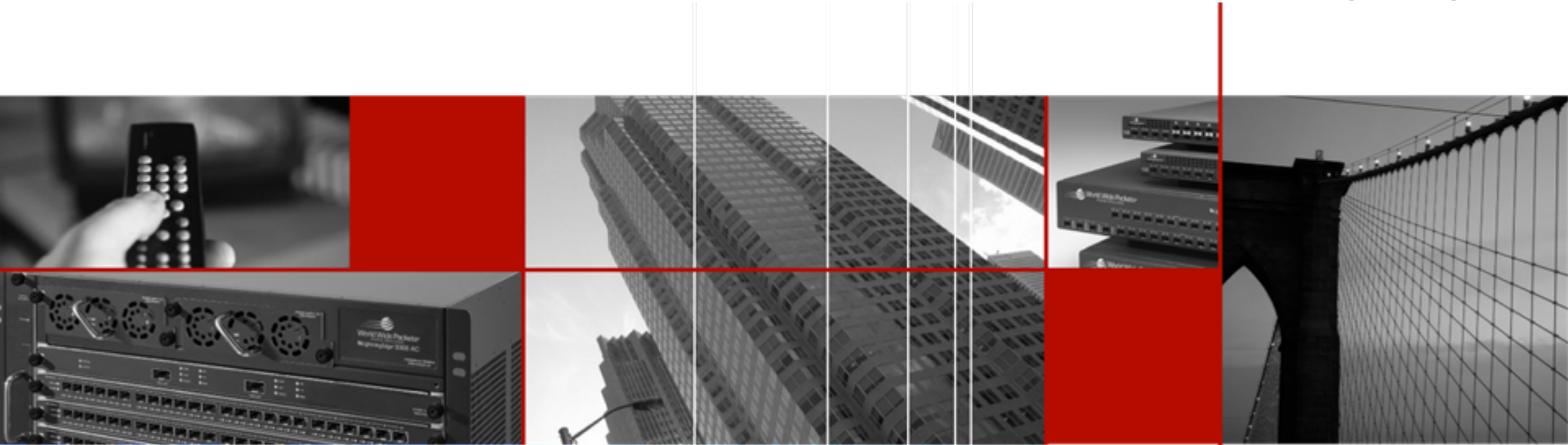
■ Technology

- Purpose built carrier class Ethernet solutions for next generation aggregation and access networks
- Agnostic to the transport model
 - 802.1Q, 802.1ad, 802.1Qay or MPLS
- Enable ubiquitous connectivity to minimise operational cost

■ Formed 2000

- R&D in Spokane, WA and San Jose, CA
- 140+ staff
- ISO 9001:2000 registered since 2004

Where's the Carrier Ethernet market going?



Wireline Investment Drivers

- Growing bandwidth, applications
 - L2VPN, broadband, gaming, virtualization, etc, etc,
- Customer retention, acquisition
 - Landline erosion
 - Desire for consolidation of service provider offerings
- Media transition from copper to fiber
- Transport applications
 - 3G/Wireless mobile
 - DSLAM aggregation

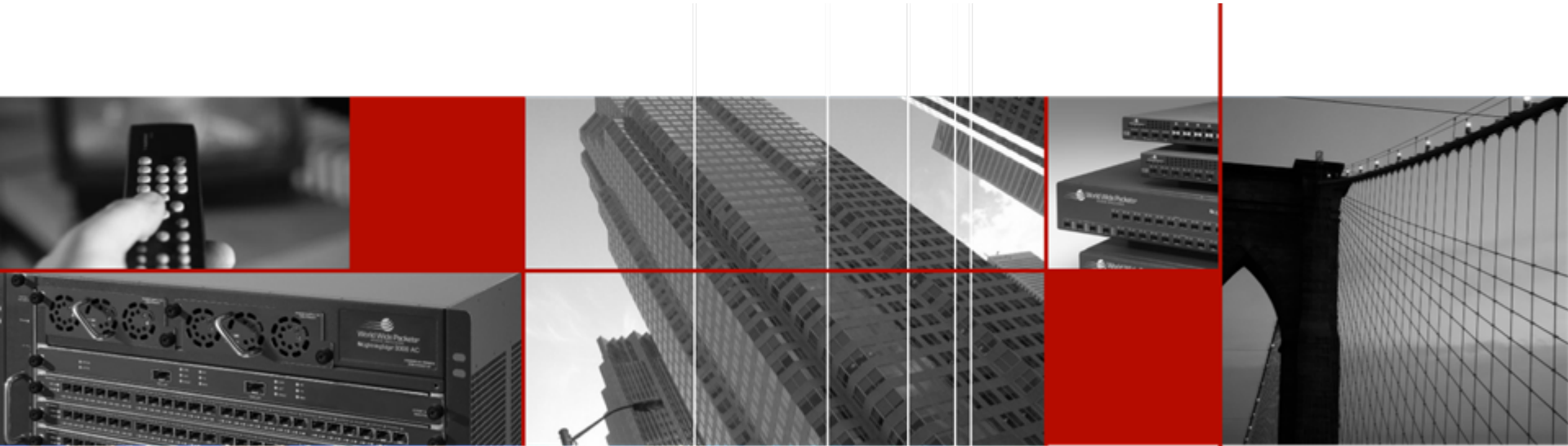
Ethernet Services & Applications

Heavy Reading Framework

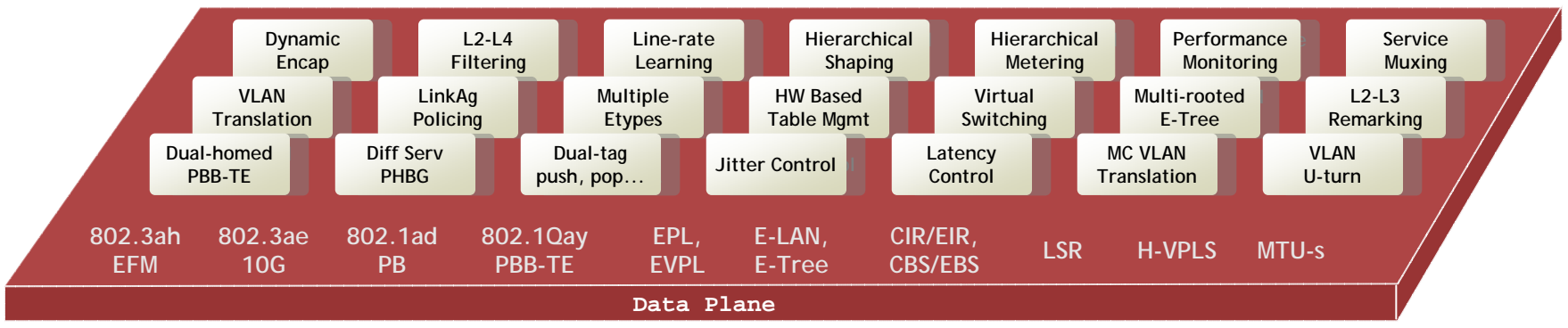
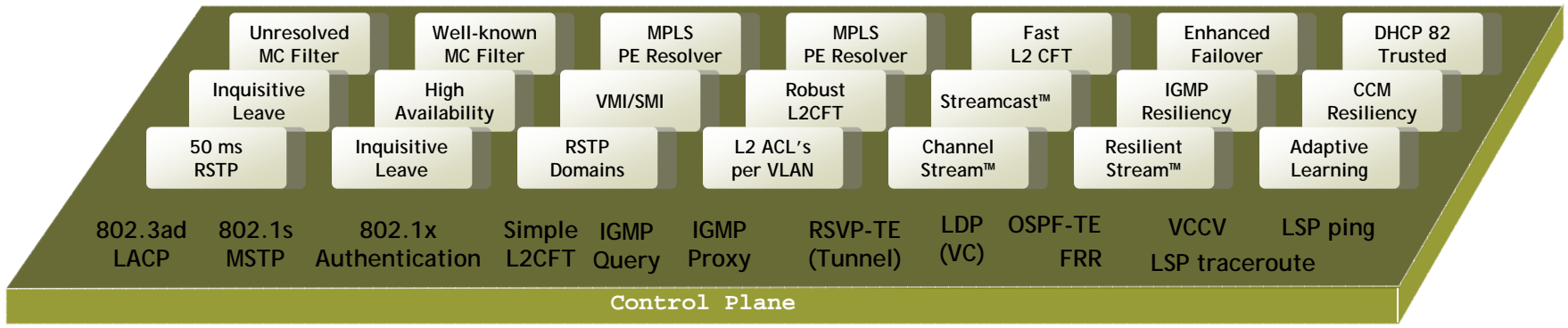
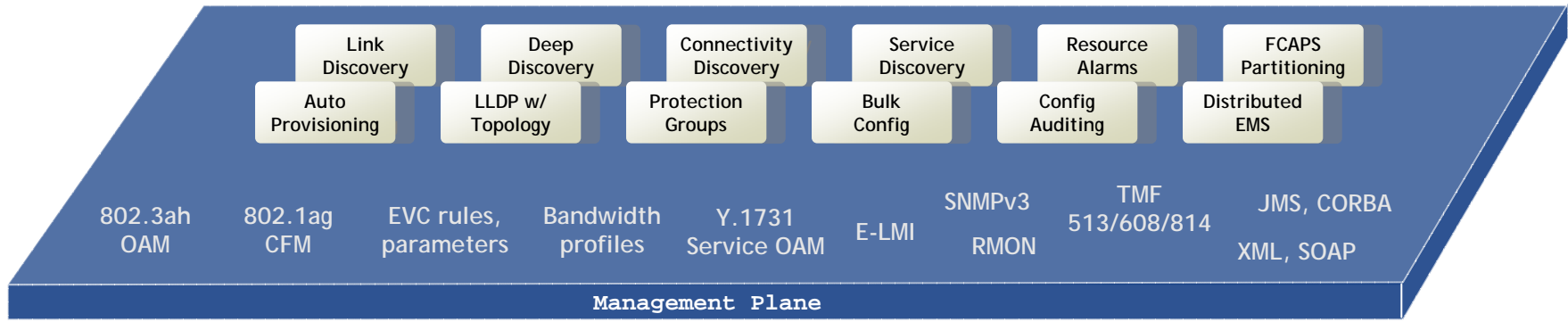
Consumer Services/Apps	VOIP	Online Gaming	Video Conferencing	IPTV/VOD	} Service Providers Will Compete	
	Home Monitoring	Internet Access	Distance Learning	Video/Audio Stream		
Business Applications & Network Services	VOIP	Disaster Recovery	Distance Learning	Video Streaming		
	Video Transport	Storage Extension	E Access To IP VPN	Content Distribution		
	VOIP Transport	Internet Access	E Access To FR/ATM	Private Line - CE		
Ethernet Connectivity	Eth Private Line	Eth Virtual Private Line	Eth Private LAN	Eth Virtual Private LAN		} Service Providers Will Compete & Cooperate
	Inter-Metro – Int'l	Inter-Metro – Int'l	Inter-Metro – Int'l	Inter-Metro – Int'l		
	Inter-Metro – Nat'l	Inter-Metro – Nat'l	Inter-Metro – Nat'l	Inter-Metro – Nat'l		
	Intra-Metro	Intra-Metro	Intra-Metro	Intra-Metro		
Ethernet Service Type	E-LINE		E-LAN			
Network Technology	EFM - PON	WiFi / WiMAX / Other	Core IP Router	VPLS/HVPLS		
	EFM - Copper	CESR	MSE Platform	MPLS		
	EFM - Fiber	Packet Transport	ESE Platform	Mac-in-Mac		
	Eth Over TDM Loop	MSP	Transport Switch	PBT		
	Access WDM	Metro/Region DWDM	LH/ULH DWDM	RPR		

Source: Heavy Reading

True Carrier Ethernet™

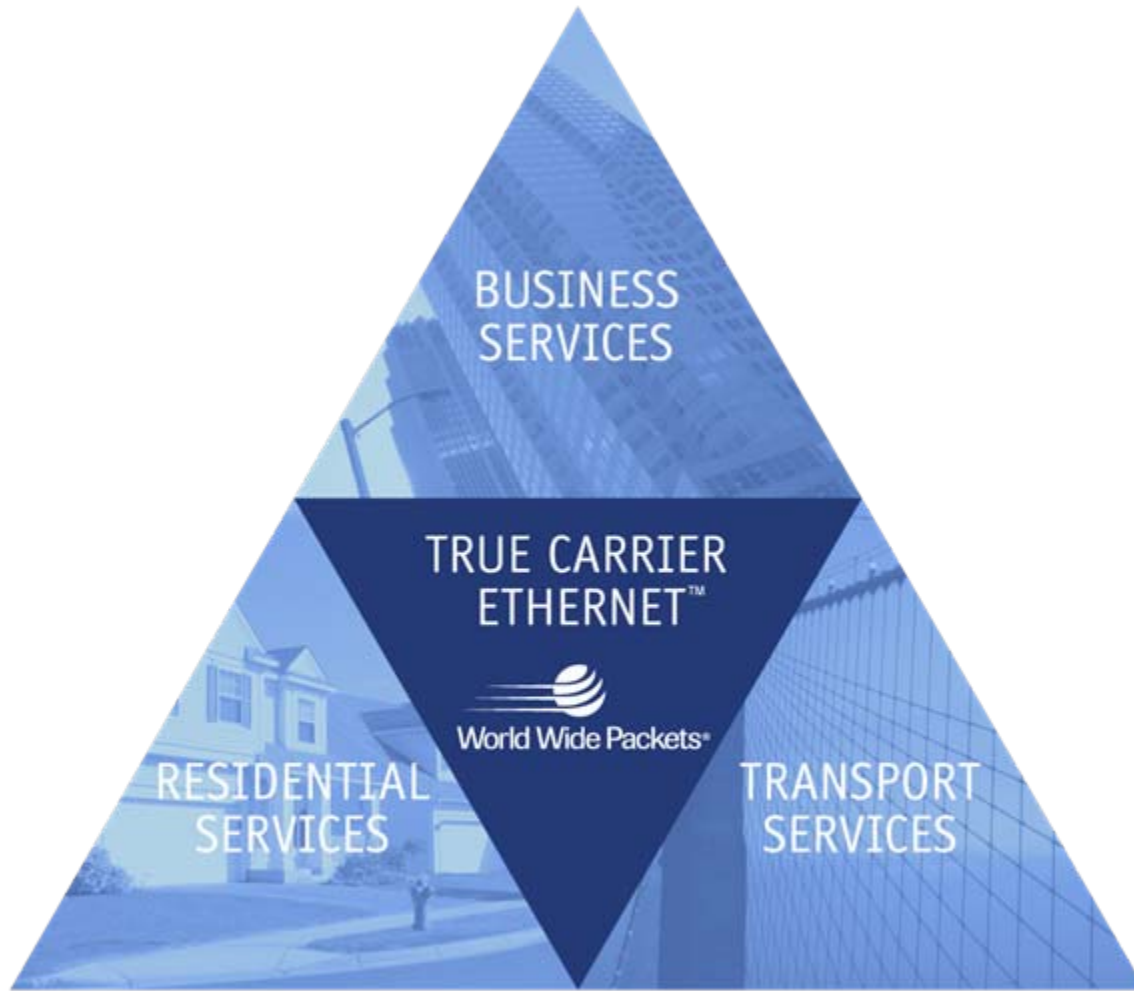


True Carrier Ethernet™ Defined



True Carrier Ethernet™ Scope

Multiple Markets, Applications

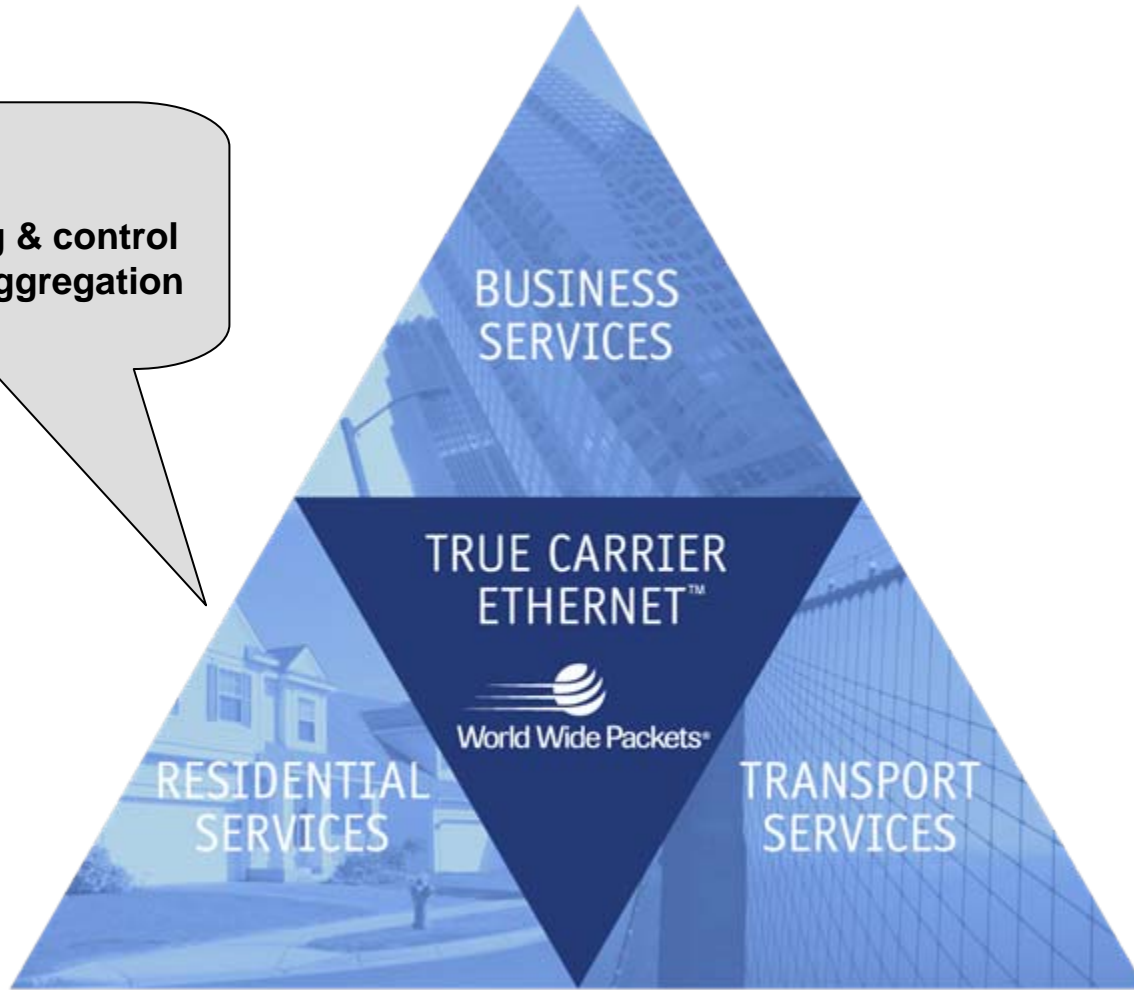


True Carrier Ethernet™ Scope

Multiple Markets, Applications

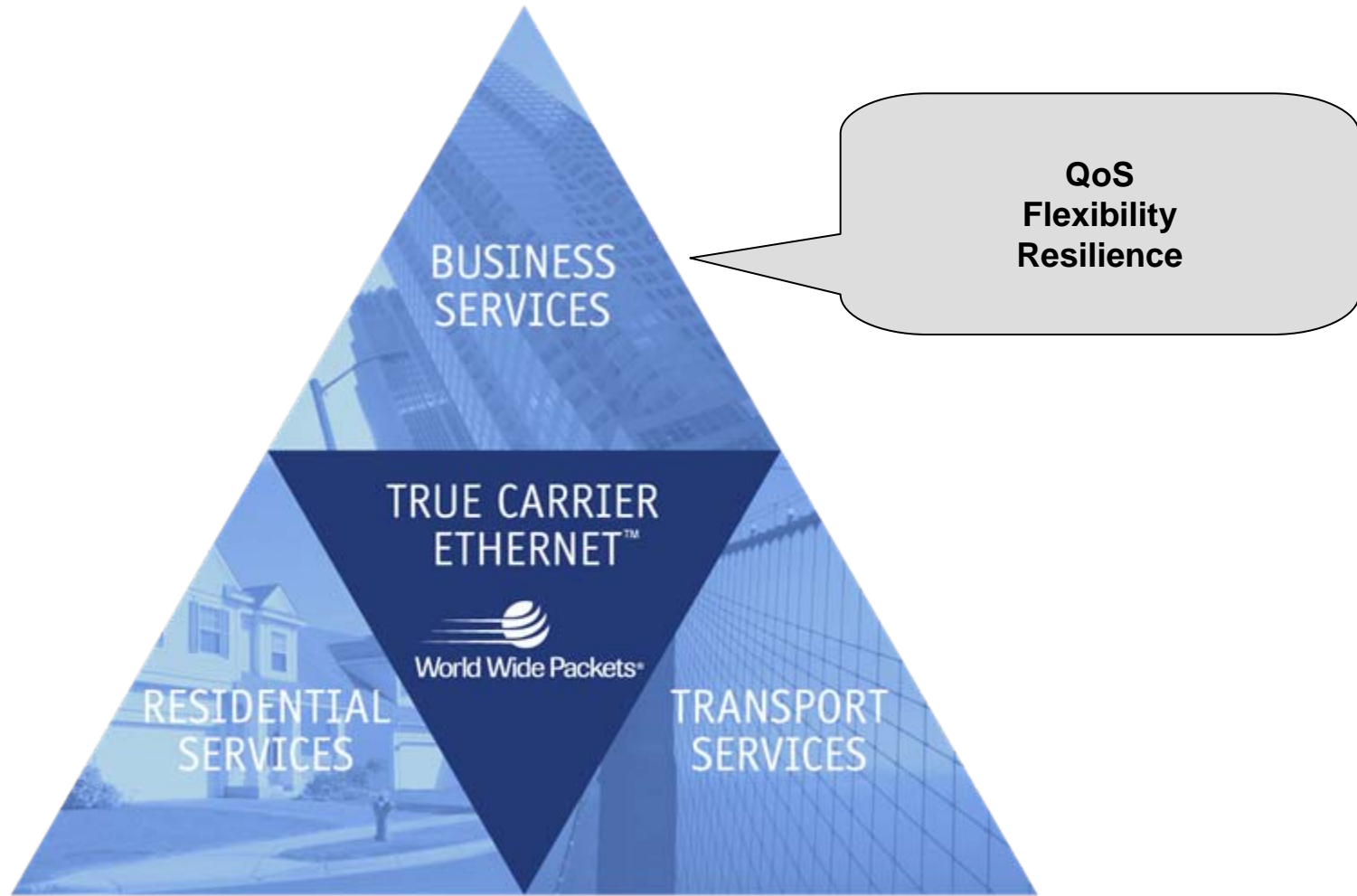
CoS

**Multicast scaling & control
Grooming and Aggregation**



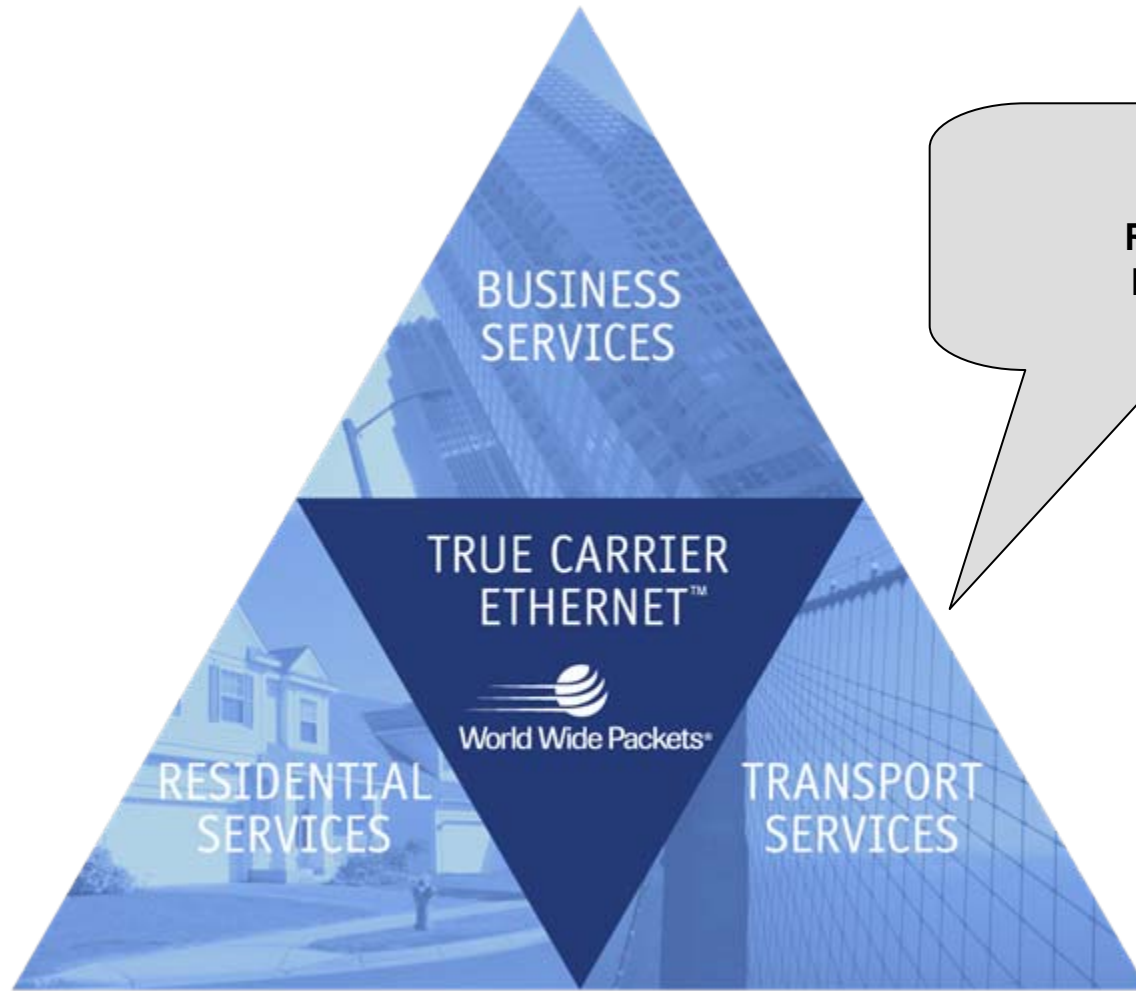
True Carrier Ethernet™ Scope

Multiple Markets, Applications



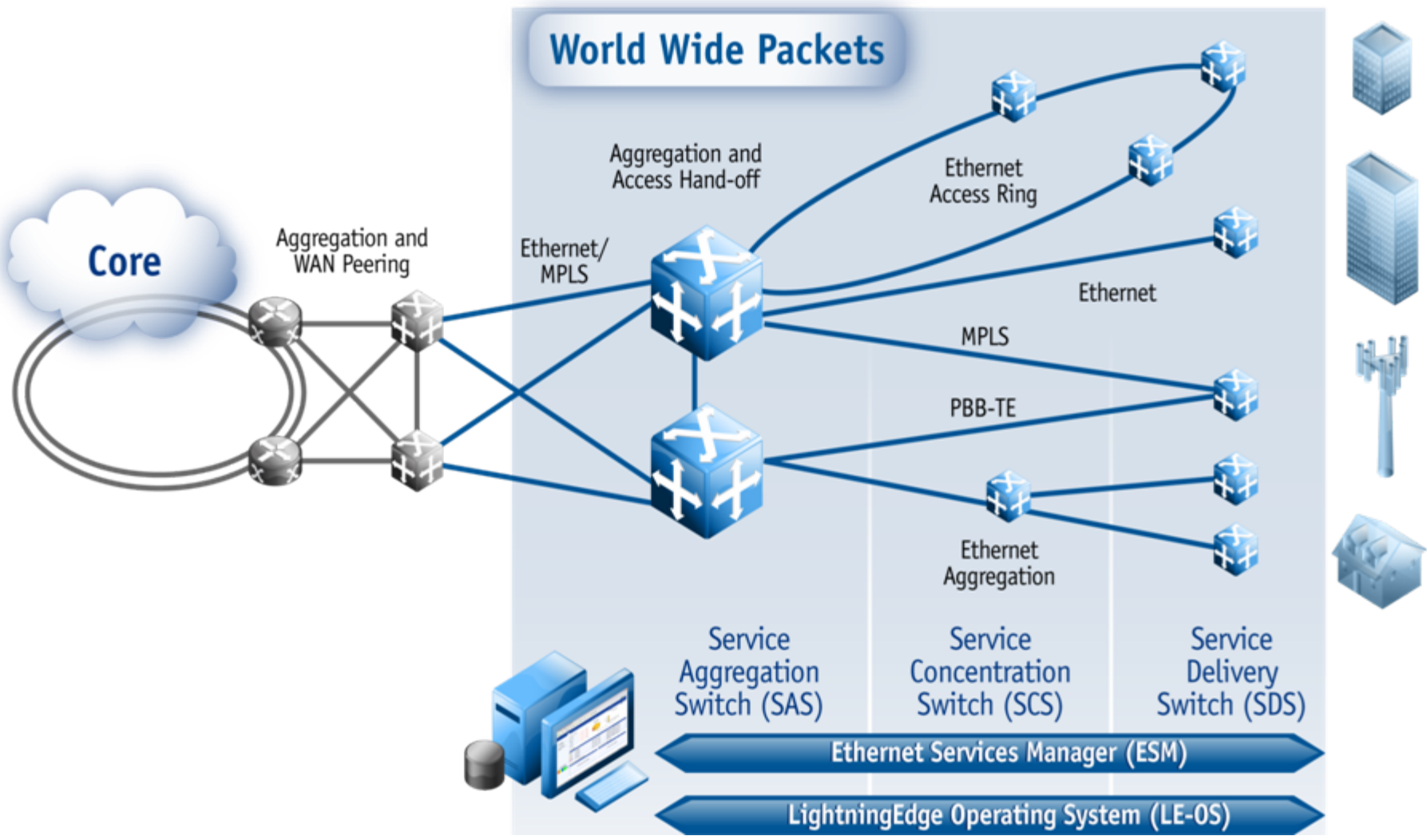
True Carrier Ethernet™ Scope

Multiple Markets, Applications



**Scaling
Resilience
Flexibility**

Metro Ethernet Reference Architecture



Product Portfolio

Service Aggregation Switch (SAS)



- Multiple gigabit connections with aggregation to 10 Gig uplinks
- High density distribution with guaranteed QoS & sophisticated tag/label manipulation
- Physical and control plane redundancy
- Up to 120 Gigabit ports, up to ten 10G ports

Service Concentration Switch (SCS)



- Aggregate multiple 100M and Gig links into a gigabit or multi-gigabit uplink
- Services are virtualized with guaranteed QoS honored individually or as a group
- SFP based with redundant power and fans
- Up to 24 100M ports, up to 16 gigabit ports

Service Delivery Switch (SDS)



- Business and residential class devices
- Deliver service by customer, port, service type, or any combination of the above
- Enforce multiple service and multiple customer guaranteed QoS policies
- Up to 24 10/100 ports, up to 4 gigabit ports

LightningEdge™ Operating System (LE-OS)

- Modular Design for Ultimate Scalability
- Integrated Device Activation
- Consistent Multi-Platform CLI and MIB

LightningEdge™ Ethernet Services Manager

- L2 Topology Discovery and Inventory
- Comprehensive Configuration Management
- Device Service Activation (MEF 7)

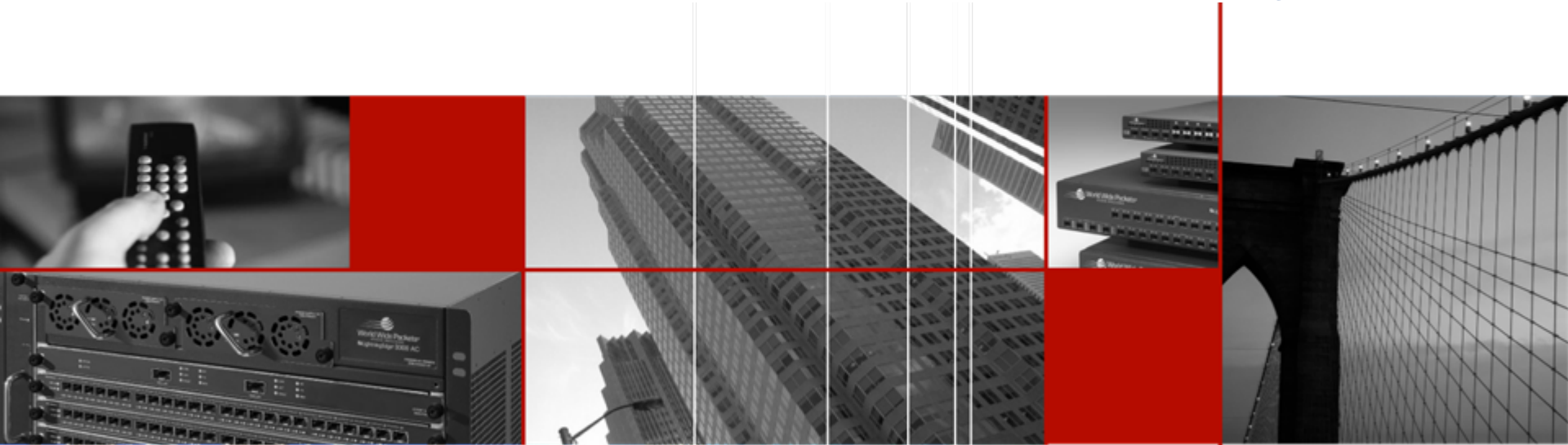


Active Leader in Standards Development

<p>IEEE 802.1 WG L2 Bridging, Mgmt</p>	<p><i>Contributor to;-</i> 802.1ad Provider Bridges 802.1ag Connectivity Fault Management 802.1ah Backbone Provider Bridges 802.1aq Shortest Path Bridging 802.1Qay Provider Backbone Bridging - Traffic Engineering</p>
<p>IEEE 802.3 WG Ethernet</p>	<p>802.3ah EFM Operations, Administration and Maintenance (<i>editor</i>) 802.3as Frame expansion for Q-in-Q, MPLS over Ethernet (<i>chair</i>) (supports 802.1ad Provider Bridging, 802.1ah Backbone Provider Bridging, MPLS over Ethernet)</p>
<p>Metro Ethernet Forum</p>	<p>MEF 9 Certified MEF 14 Certified</p>



IEEE 802.1Qay PBB-TE



Status

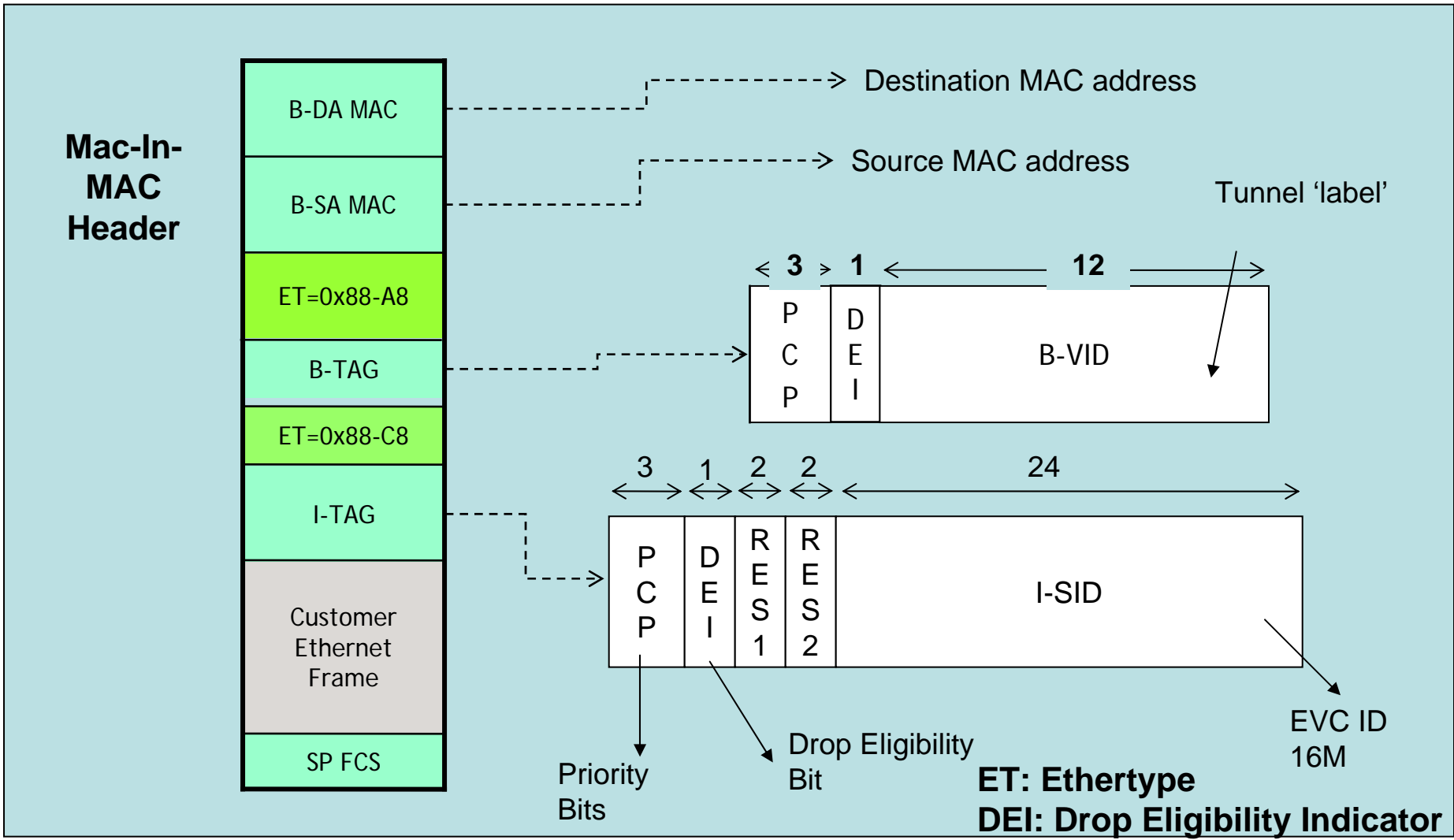
Provider Backbone Bridging - Traffic Engineering

- PBB-TE is currently in the early stages of standardisation by the IEEE
 - Generally would have been known as 802.1ay, but ...
 - Specifically is an extension to IEEE 802.1Q so is denoted as IEEE 802.1Qay
- PBB-TE is a transport technique providing point-to-point tunnels using various components from other IEEE and ITU standards;
 - MAC-in-MAC frame format of IEEE 802.1ah Provider Backbone Bridging (PBB)
 - Frame formats are totally compatible with intermediate PBB-TE unaware switches
 - QinQ frame marking from IEEE 802.1ad Backbone Bridging (BB)
 - Virtual LAN technology from IEEE 802.1Q
 - Primary/Backup tunnel failover using Connectivity signalling from IEEE 802.1ag Connectivity Fault Management (CFM)
- PBB-TE has no control plane, tunnels are statically assigned
 - PBB-TE tunnels are not supposed to be protected by any other mechanism!

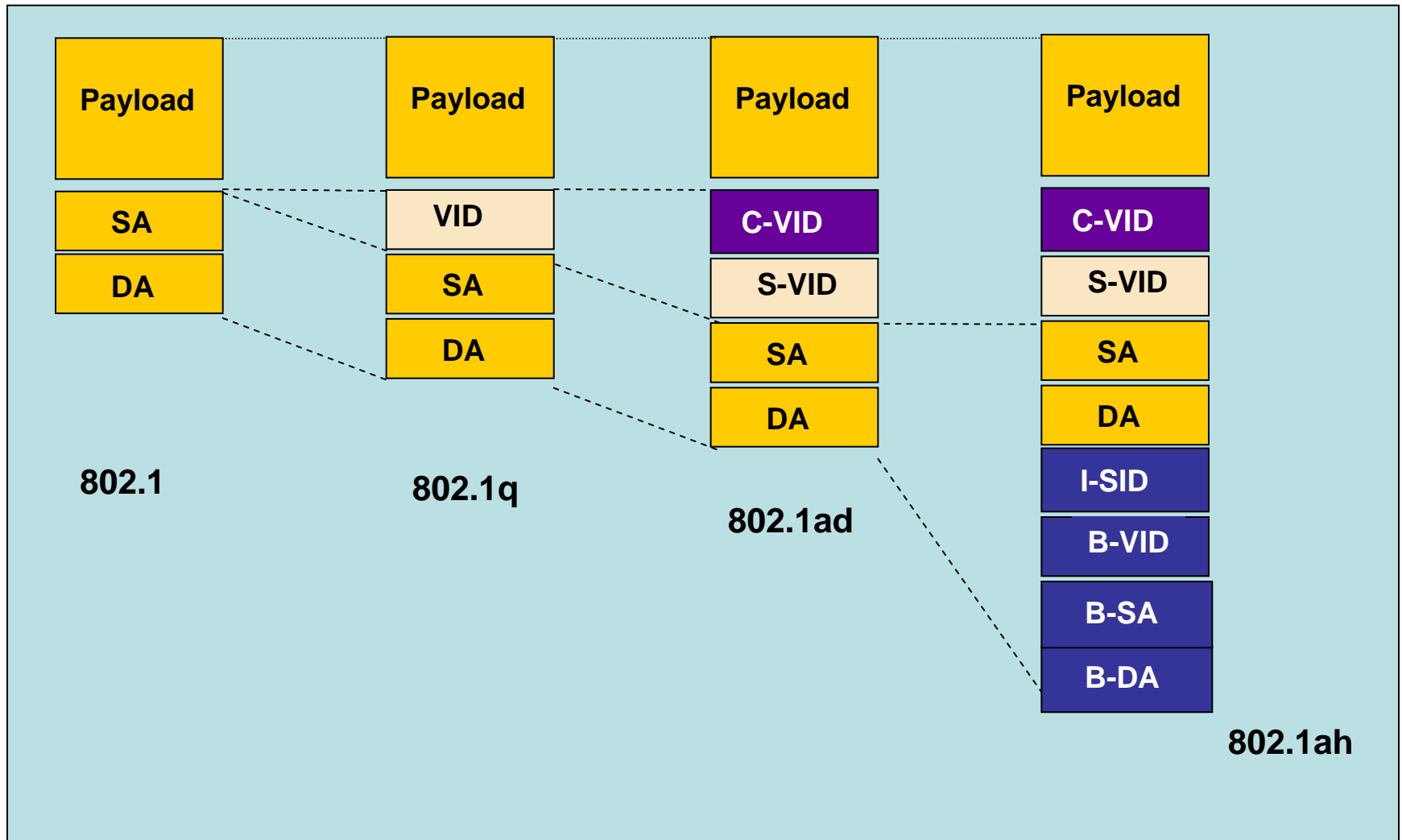
IEEE 802.10ay PBB-TE

- Task force discussion topics:
 - IEEE 802.1ag CFM extensions
 - Changes to support MAC Linktrace
 - Changes to support MAC ping (Loopback)
 - Scope
 - P2P trunks or MP2MP trunks?
 - Performance management
 - Include in project or separate project
- Proposed development timeline
 - Start sponsor ballot 2Q09
 - Suggests completion late 2009 (best case)
- Drafts
 - Current draft = rev 0.0 (editor's first draft)
 - Rev 0.1 = October (editor's second draft)
 - Rev 1.0 = December (first task force ballot)

MAC-in-MAC Encapsulation

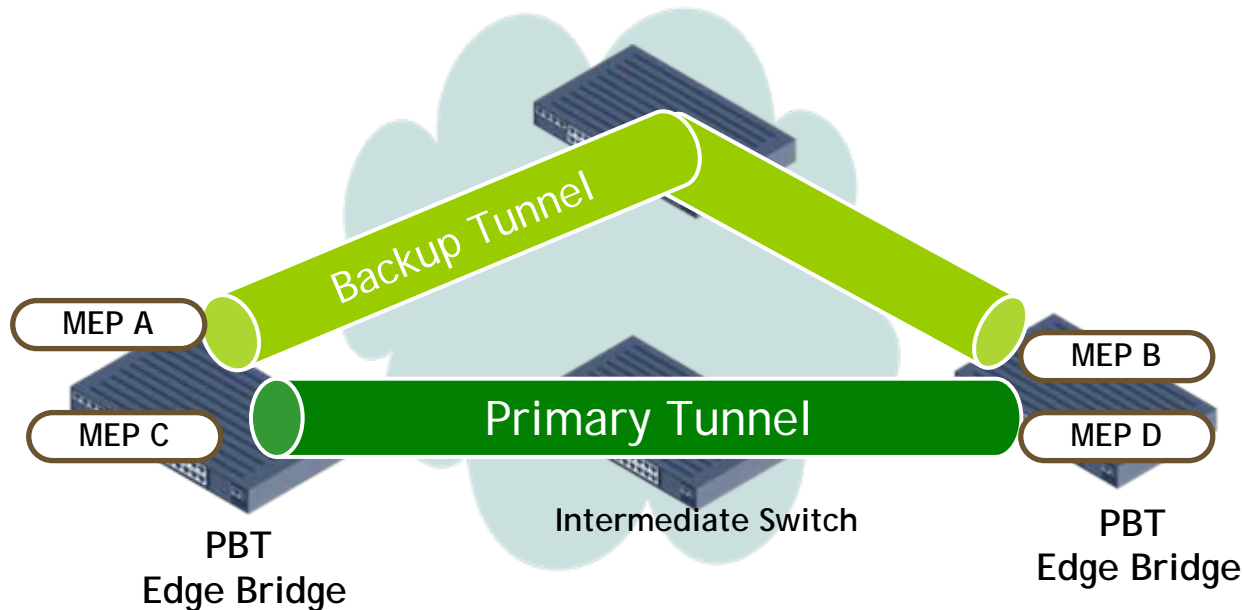


Encapsulation

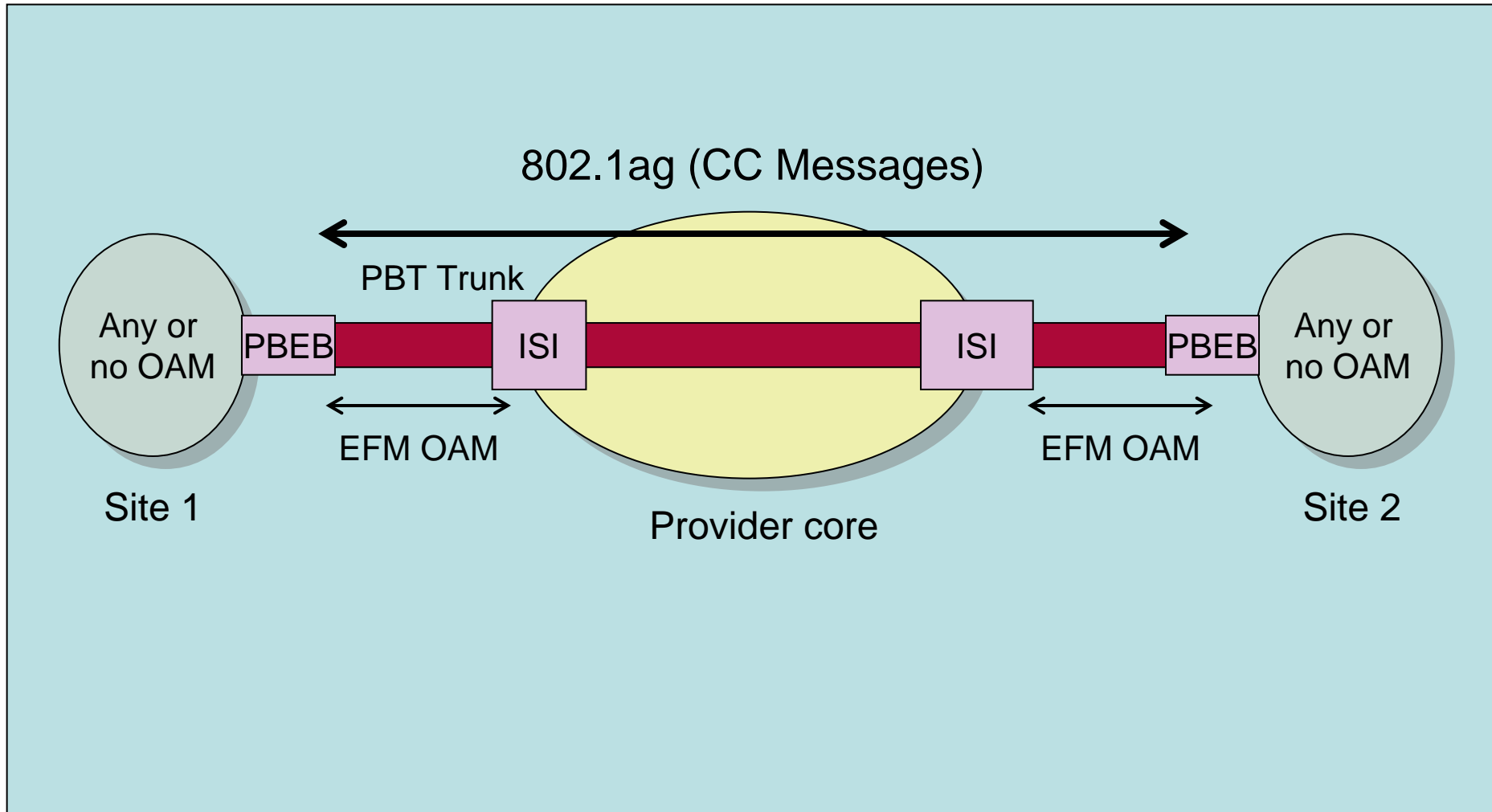


PBB-TE Tunnel Monitoring & Failover

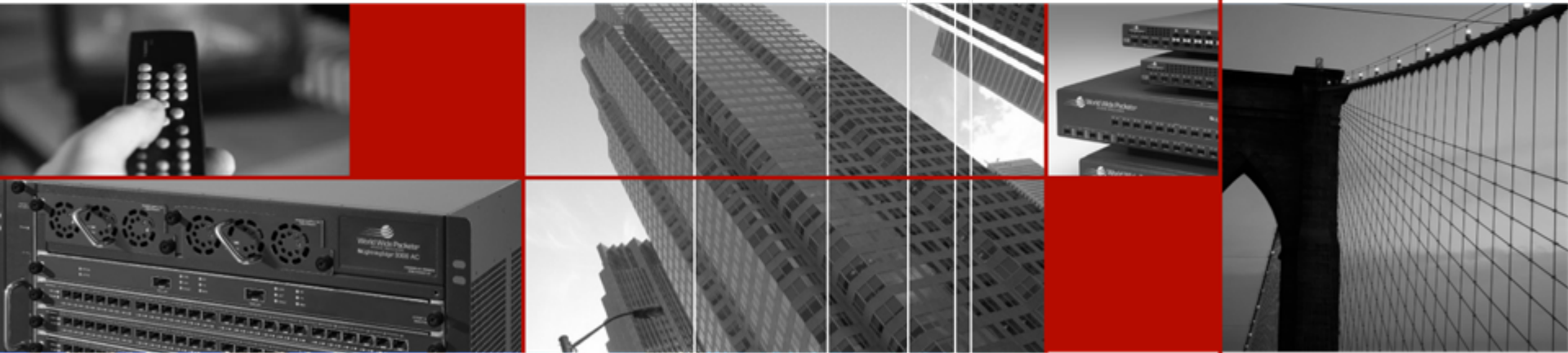
- PBT leverages 802.1ag CFM (Connectivity Fault Management)
- Primary & backup tunnels monitored via 802.1ag CCMs
 - CCMs are exchanged on both tunnels all the time
 - CCM interval time configurable at 3.3ms, 10ms, 100ms, 1s, 10s, 1m, 10min
 - Using 802.1ag model 3 CCMs have to be lost before failure signalled
 - High frequency of CCM is resource and bandwidth intensive
- Immediate switchover to backup tunnel when failure detected on primary



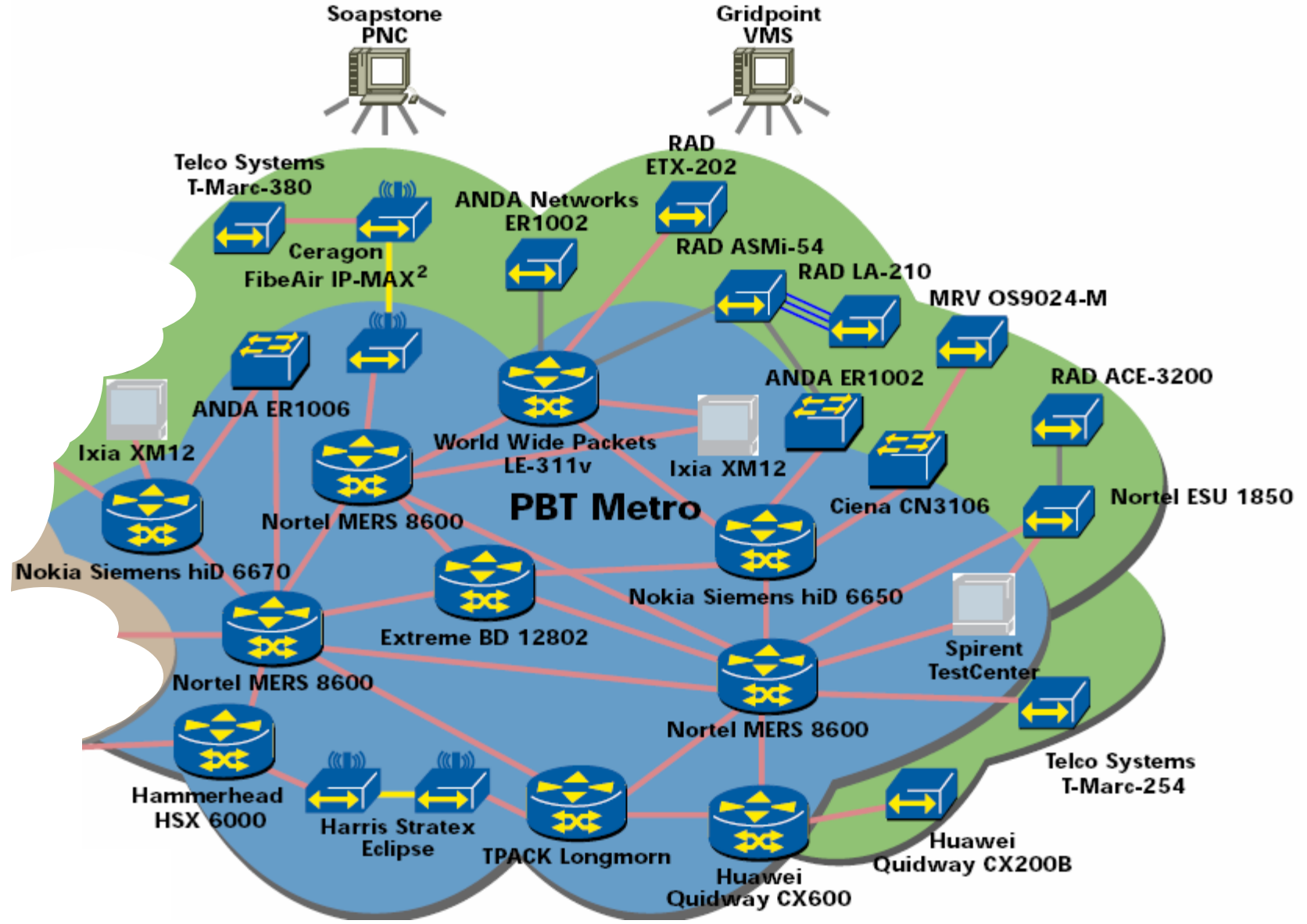
Multi-Stage OAM



EANTC Testing for Carrier Ethernet World Congress 2007



Carrier Ethernet World Congress - PBT Test Network



WWP Interoperability with PBB-TE Vendors

		PBB-TE Transport Trunks	PBB-TE Control Plane		
			CFM interop	Auto failover	50 ms failover
<i>ANDA</i>	ER100x	Yes*	Yes*	Yes*	No
<i>Extreme</i>	12802	Yes*	Yes*	N/A	N/A
<i>Hammerhead</i>	HSX6000	Yes*	Yes*	N/A	N/A
<i>Huawei</i>	Quidway CX600	Yes*	Yes*	Yes*	No
<i>Ixia</i>	IX12 tester	Yes*	Yes*	N/A	N/A
<i>NSN</i>	hiD 66x0	Yes*	N/A	N/A	N/A
<i>Nortel</i>	MERS 8600	Yes*	Yes*	Yes*	Yes [†]
<i>RAD</i>	ETX-202	No	Yes*	N/A	N/A
<i>T-PACK</i>	Longmorn	Yes*	Yes*	Yes*	No
<i>Telco Systems</i>	T-Marc-254	No	Yes*	N/A	N/A

- * Tested in EANTC, Berlin hot-staging for CEWC
- † Only WWP and Nortel demonstrated 50 ms resiliency

Overview of PBB-TE

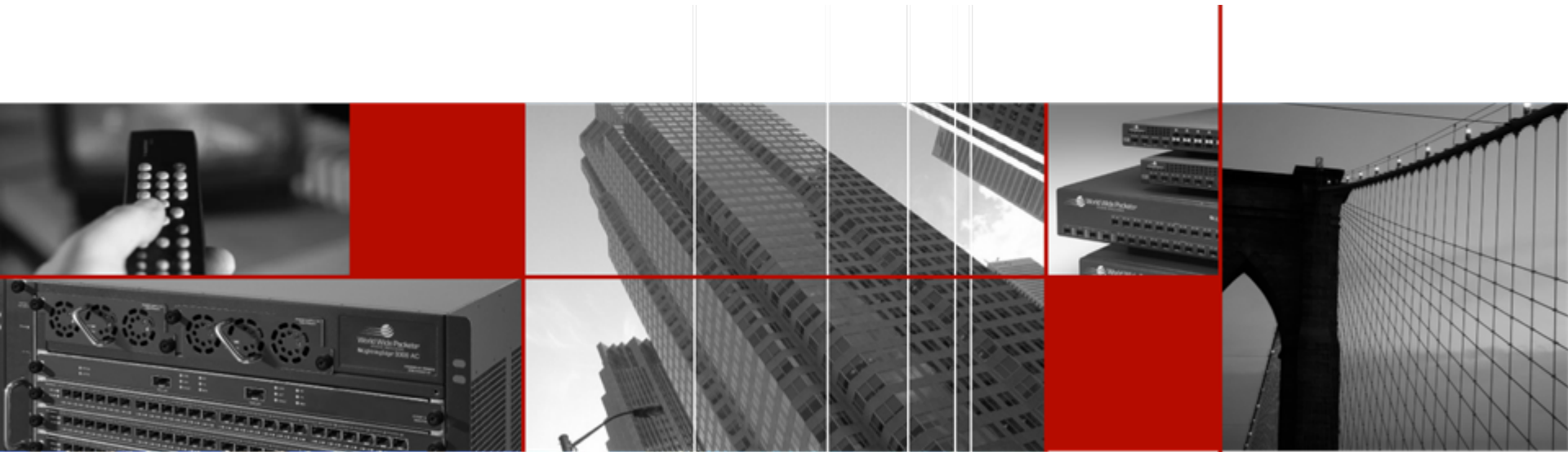
■ Advantages:

- True traffic engineering
 - Enhanced QoS (CIR, CBS, etc.)
 - Site will have primary and backup paths and bandwidth explicitly defined
- Predictable failover
 - No need to walk the network post-change
- No learning or flooding in transit network
 - Each site will only need to learn MACs attached to it (not transit MACs)
 - Only core switch terminating PBB-TE tunnels must learn customer MACs
- More bandwidth -> more connections
 - No complex load balancing
 - No worrying about LAGs not distributing
 - No blocked paths
- IEEE 802.1 standards-based solution

■ Disadvantages:

- Traffic Engineering requires a lot more thinking first
 - Design/Provisioning tools need structure and rules
 - More configuration
 - Needs good record keeping
- Less flexible than H-VPLS or xSTP
 - Fewer degrees of freedom for redundant connectivity
 - Not suited to highly dynamic traffic patterns
- Clearly not suited for backbones

Wireless Backhaul Overview



Requirements of Wireless Backhaul Solutions

- Stable architecture optimizing
 - Physical topology
 - Ring, Hub-and-Spoke or any combination thereof
 - Resilience
 - Predictable failover, with minimal interaction with other devices
 - Network resources
 - Traffic planned, since significant use of microwave for backhaul
 - Cost
- Flexibility offering high degree of scalability
 - Must handle arbitrary numbers of MAC addresses, customers, sites
- Comprehensive management system for provisioning
 - Need for rapid integration with existing systems whilst not losing flexibility of a standalone EMS
 - Devices and EMS must support open interfaces

Wireless Backhaul Reference Design



■ Base station

- IEEE 802.16 WiMAX
- (3) 120° radios per tower
- (1) LE-311v per tower
- Microwave shots between towers

■ POP

- (1) LE-3300 at POP
- Terminates tunnels

■ PBB-TE tunnels over microwave

Wireless backhaul: Tunnel connectivity



■ Topological view:

- Rings constructed to provide diverse paths to POP
- LE-311v's serve as transit nodes

■ Scalability

- Each LE-311v only learns Customer MACs for local base station
- Each LE-311v tunnels C-MACs for transiting tunnels
- LE-3300 learns all C-MACs for POP

Wireless backhaul: Logical connectivity, protection



Logical view:

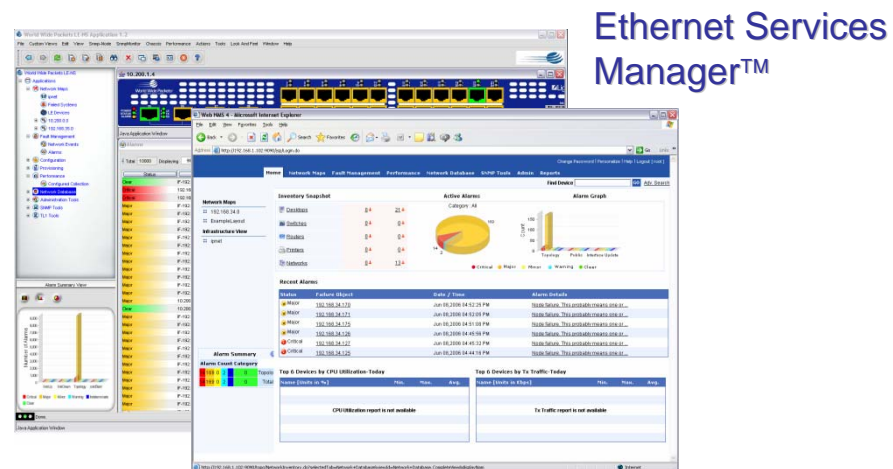
- Each base station has primary and backup PBB-TE tunnel pair for resiliency
- LE-3300 terminates tunnels and hands off to service router

Benefits:

- Improved resiliency
- Predictable failover
- Connection-oriented traffic engineering, provisioning
- Increased MAC scalability

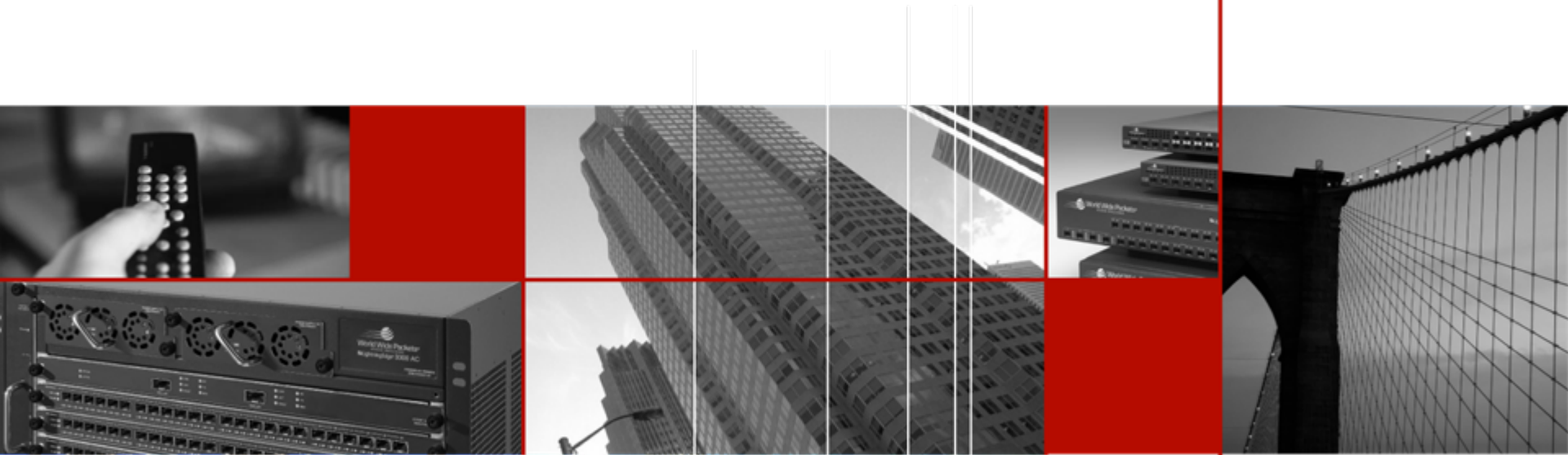
WWP's PBT solution for Wireless Backhaul

- PBB-TE enabled equipment and Ethernet Services Manager™
 - PBB-TE engineered transport
 - Preserves physical rings, removes problematic logical rings
 - Improved stability
 - Optimum network utilization
 - Resilient tunnels for protection
 - Support 250K+ MACs per L2 domain
 - PBB-TE encapsulation for customer MAC transparency on all transit nodes
 - IEEE 802.1ag CFM for service monitoring of all access points
 - ESM for discovery and provisioning to ease operations

The screenshot shows the Ethernet Services Manager™ software interface. The top part displays a network map with various nodes and connections. Below the map, there are several panels: 'Network Maps' with a table of statistics, 'Subscriber View' showing a list of subscribers, and 'Alarm Summary' with a table of active alarms. The interface is complex and provides detailed monitoring and management capabilities for the network.

Engineered.
Deployed.
Proven.



Eric Davison
Technical Director, EMEA
+44-7773-429-723 mobile
eric.davison@wvp.com