

September 10, 2001

Traffic and Cost Model for RPR versus 1GbE and 10GbE Architectures

A Carriers' Carrier Perspective

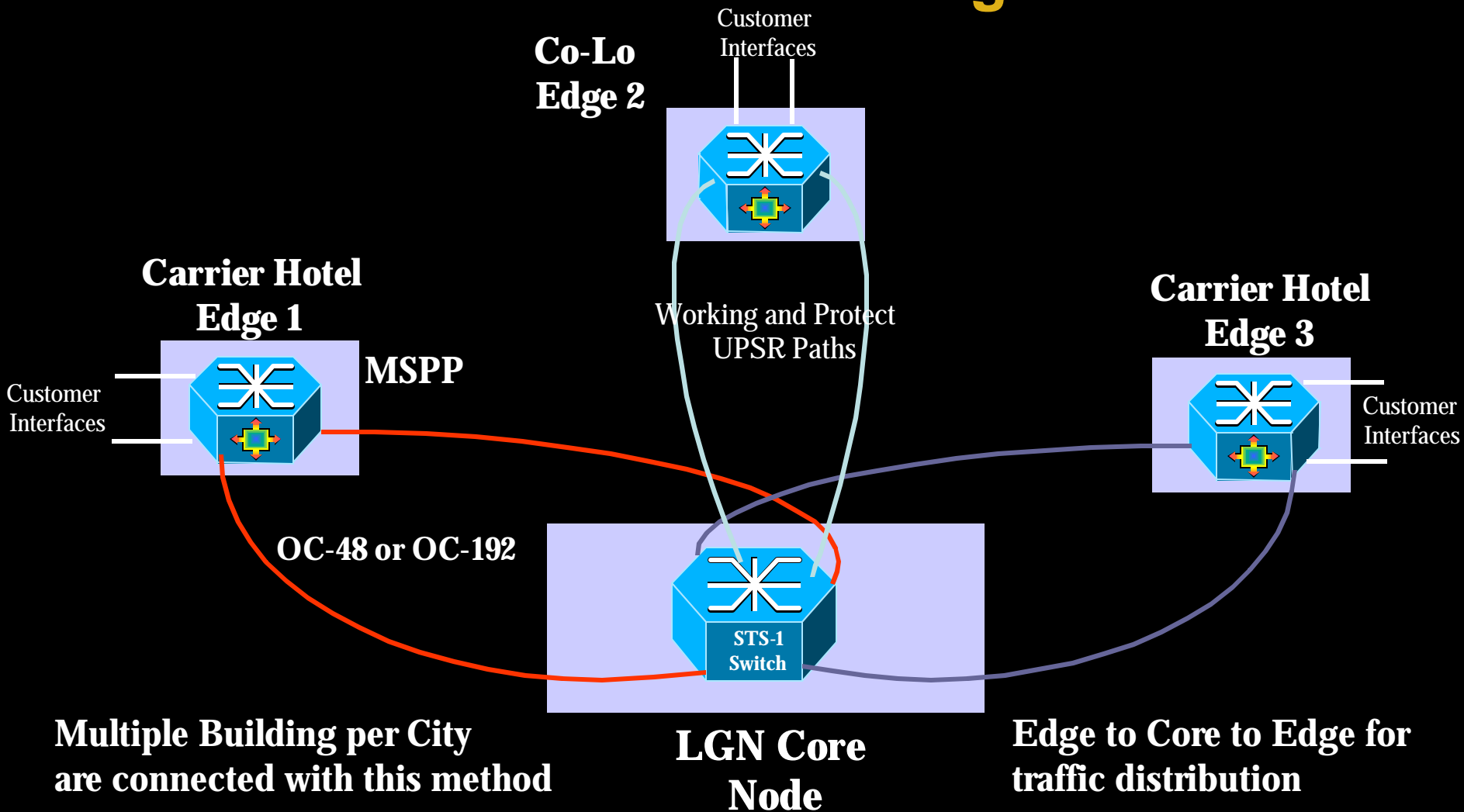
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Director of Technology



Looking GlassSM
N E T W O R K S

SONET Architecture - Logical

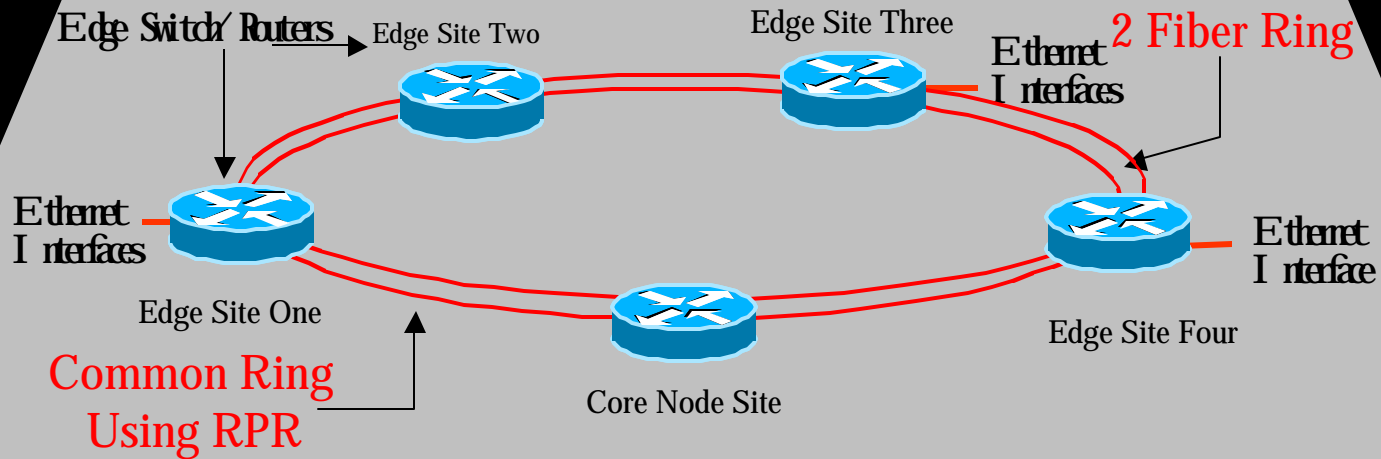


Looking Glass Networks Architecture Overview

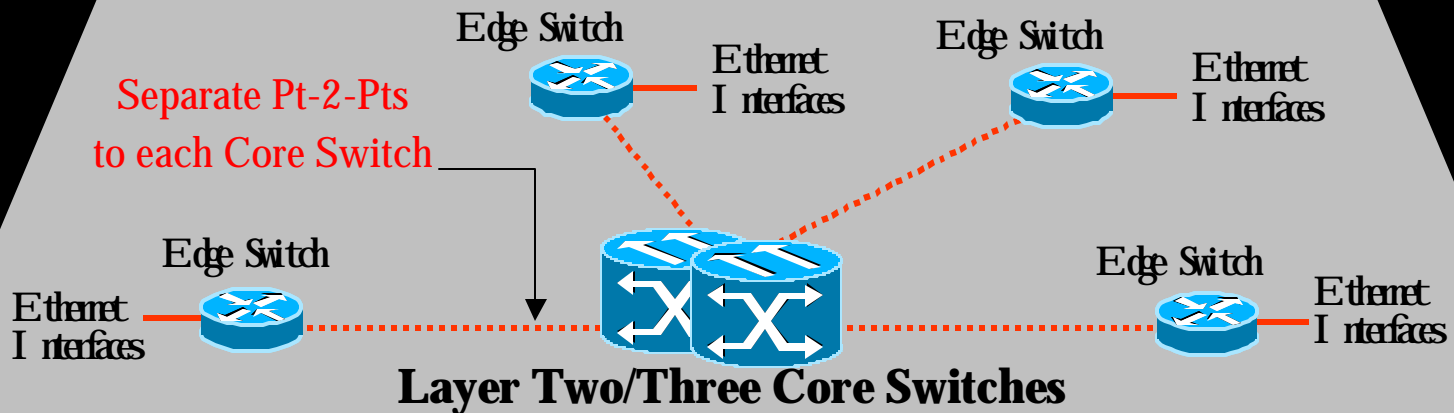
- Metro ring sizes of 11km – 105km; ave. 35km
- Interconnect LEC Co-Lo, Carrier Hotels, Large Enterprises
- Five 9's reliability
- Most GbE connections that Looking Glass transports will be line rate
- No stat muxing capability on the network
- All traffic stays within the metro space

Data Architecture Options

1



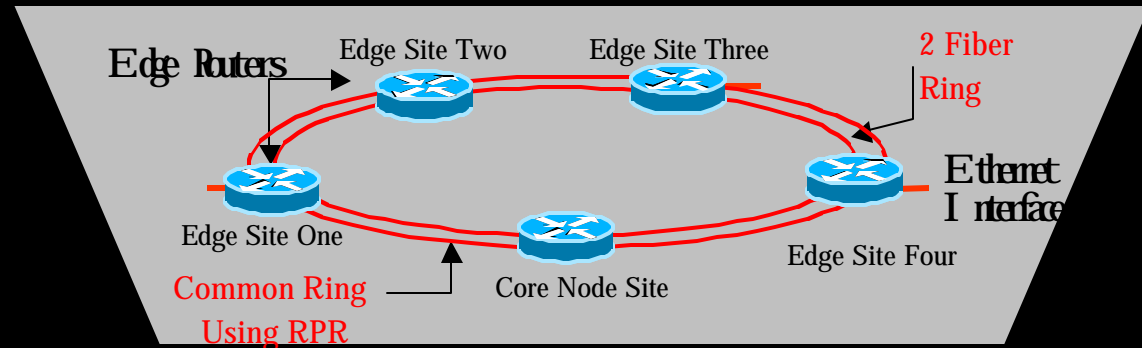
2



Preliminary RPR Points

• Pros

- Fiber conservation
 - No Core connect required for each edge location
- Equipment cost
 - Core cost will be cheaper
 - Edge cost will rise
 - Significant saving by not using long haul (ZX) optics and XX times fewer GBICs
- Bandwidth provisioning
 - It is Ethernet
 - LGN will not have to oversubscribe the ring
 - Spatial reuse has economic benefits
 - Looking Glass can oversubscribe a segment of the ring and use priority to allocate bandwidth
 - Overall benefits of over-subscription



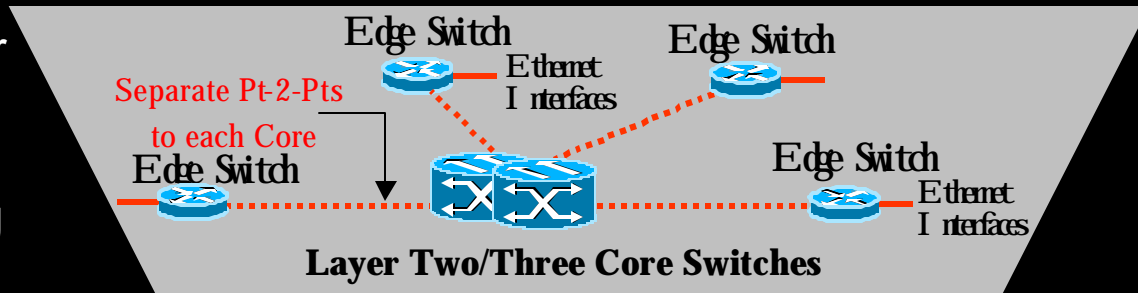
• Cons

- No delivery guarantee for Private line service
- Multi-node ring fiber topology
 - Operational impact on fiber, maintenance, record keeping
- Testing and monitoring
 - Multi-node ring requires RMON test access and monitoring
 - Pt-2-Pt plan monitors and tests at the core.

Preliminary L2/L3 Points

- **Pros**

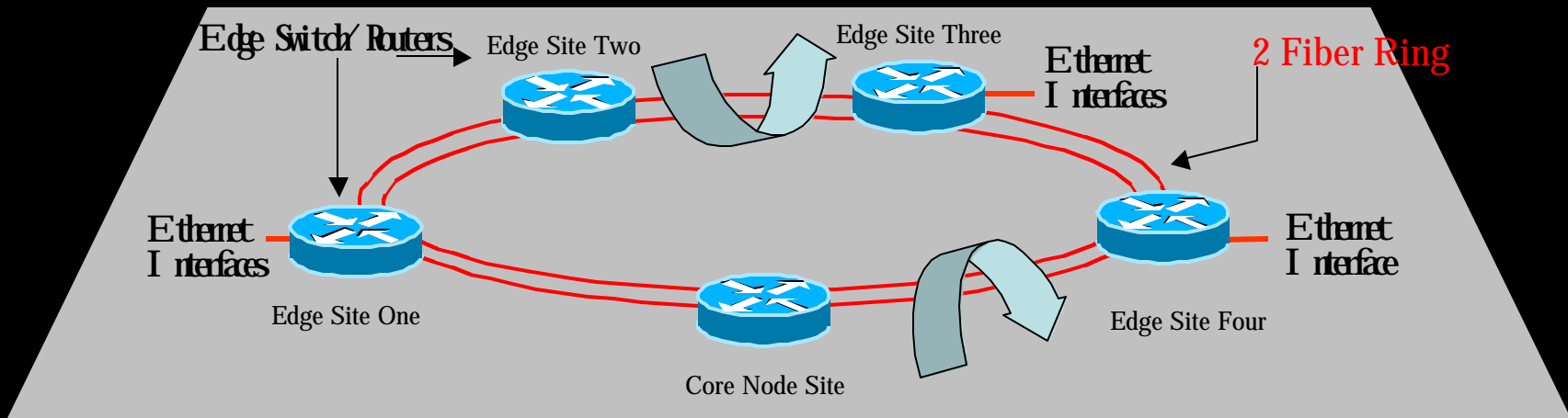
- Maintains current Star fiber topologies
 - No fiber operational impact, record keeping
- Equipment cost
 - Edge cost is lower
- Bandwidth provisioning
 - Pt-2-Pt allows you to oversubscribe any trunk on the network as well as any access Edge
- Testing and monitoring
 - Supports monitoring and test at the core.
- Core router supports peering
 - Looking Glass can connect to anyone else at layer 3



- **Cons**

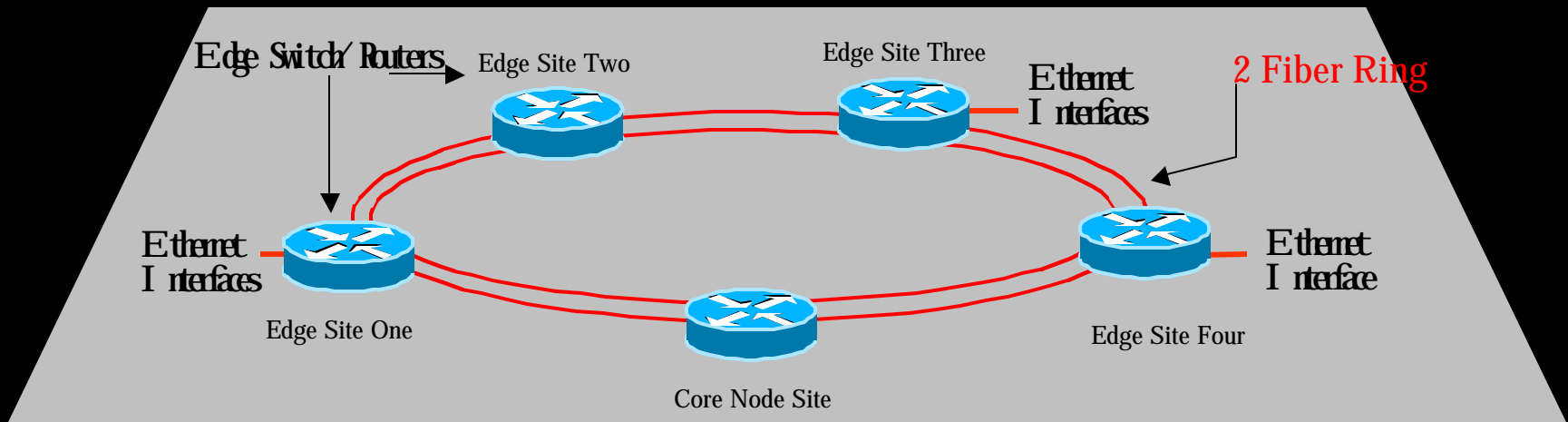
- Excessive fiber usage
- Equipment cost
 - Cost impact of long haul (ZX) optics
 - Core costs are higher
- Need for a core router
 - Additional equipment installation, maintenance and management

Model – Analysis



- Use 10 Gbps RPR interfaces versus Ten 1Gbps Pt2Pt connections per Edge
 - LX/LH GBICs for RPR model and ZX GBICs for Pt2Pt model
- Assumed 100% bandwidth reuse on each segment of ring
 - 80 fiber pairs for pt2pt vs 2 fiber pair for RPR
- Model a max fiber cost using a fully loaded, amortized cost for each pair
 - Increment cost of using each pair in a deployed cable
- Fiber cost difference: 40X less with RPR

Model – Analysis (con't)



- Hardware cost delta EDGE/CORE: 19% less with RPR @100% reuse
- Hardware cost delta EDGE/CORE: 15% less with Pt2Pt @ 50% reuse
- Overall cost delta: 37% lower at Max fiber cost with RPR@100% reuse
- Extended Analysis
 - 8 EDGE sites per ring has 80X less fiber cost and 42% lower total cost with RPR

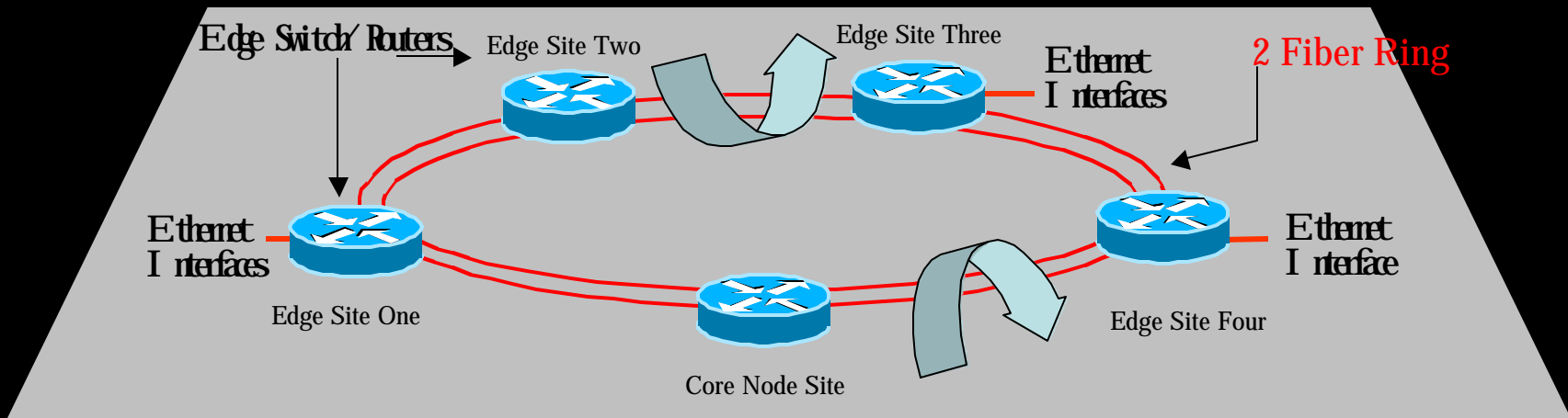
Model Disclaimers

- The numbers on the following slides are not “true” costs
- Common control and access interfaces are similar in all model cases.
- The trunk side interface differences are the usage of ZX vs LX GBICs based upon assumed span distances
- The trunk side interfaces are priced relative to each other: 1GbE 10GbE and 10Gb RPR
- The fiber costs are also arbitrary but relative to each other based upon a 35KM ring

Looking Glass Model Summary

Model	Hardware Cost	Fiber Cost	Total Cost
LGN Ring 4	\$1,620,305	\$14,308	\$1,634,613
LGN Star 4	\$2,007,370	\$572,331	\$2,579,701
LGN Star 4@50	\$1,407,050	\$286,166	\$1,693,216
LGN Ring 8	\$2,936,145	\$14,308	\$2,950,453
LGN Star 8	\$3,911,790	\$1,144,662	\$5,056,452
LGN Star 8@50	\$2,591,180	\$572,331	\$3,163,511
Cost Delta Compare	H/W Delta Costs	Fiber Cost Delta	Total Cost Delta
4 Node Ring vs Star	19%	98%	37%
4 Node Ring @50 vs Star	-15% Star less	95%	3%
8 Node Ring vs Star	25%	99%	42%
8 Node Ring @50 vs Star	-13% Star less	98%	7%

Model – Analysis



- Use 10 Gbps RPR interfaces versus 10 Gbps Pt2Pt connections per Edge
 - LX/LH GBICs for RPR model and ZX GBICs for Pt2Pt model
- Assumed 100% bandwidth reuse on each segment of ring
 - 8 fiber pairs for pt2pt vs 2 fiber pair for RPR
- Model a max fiber cost using a fully loaded, amortized cost for each pair
 - Increment cost of using each pair in a deployed cable
- Fiber cost difference: 4X less with RPR

Looking Glass Model 10Gb I/F

Model		Hardware Cost	Fiber Cost	Total Cost
4 Node Ring		\$1,620,305	\$14,308	\$1,634,613
4 Node Star		\$2,007,370	\$572,331	\$2,579,701
4 Node Star @50		\$1,407,050	\$286,166	\$1,693,216
4 Node Star@10G I/F		\$1,213,304	\$57,233	\$1,270,537
4 Node Ring 10G I/F		\$1,070,305	\$14,308	\$1,084,613
8 Node Ring		\$2,936,145	\$14,308	\$2,950,453
8 Node Star		\$3,911,790	\$1,144,662	\$5,056,452
8 Node Star @50		\$2,591,180	\$572,331	\$3,163,511
8 Node Star@10G I/F		\$2,203,688	\$114,466	\$2,318,154
8 Node Ring 10G I/F		\$1,946,145	\$14,308	\$1,960,453
Cost Delta Compare		H/W Delta Costs	Fiber Cost Delta	Cost Delta
4 Node Ring vs Star		19%	98%	37%
4 Node Ring @50 vs Star		-15% Star less	95%	3%
4 Node Ring vs Star@10G		12%	75%	15%
				*
8 Node Ring vs Star		25%	99%	42%
8 Node Ring @50 vs Star		-13% Star less	98%	7%
8 Node Ring vs Star@10G		12%	88%	15%

*** 10G RPR priced
@ 2X 10 GbE**

Looking Glass Model Update for 10GbE

Model	Hardware Cost	Fiber Cost	Total Cost
4 Node Ring	\$1,620,305	\$14,308	\$1,634,613
4 Node Star @10G I/F	\$1,213,304	\$57,233	\$1,270,537
4 Node Ring @10G I/F	\$820,305	\$14,308	\$834,613
4 Node Star	\$2,007,370	\$572,331	\$2,579,701
4 Node Star @50	\$1,407,050	\$286,166	\$1,693,216
8 Node Ring	\$2,936,145	\$14,308	\$2,950,453
8 Node Star @10G I/F	\$2,203,688	\$114,466	\$2,318,154
8 Node Ring @10G I/F	\$1,496,145	\$14,308	\$1,510,453
8 Node Star	\$3,911,790	\$1,144,662	\$5,056,452
8 Node Star @50	\$2,591,180	\$572,331	\$3,163,511
Cost Delta Compare	H/W Delta Costs	Fiber Cost Delta	Total Cost Delta
4 Node Ring vs Star	19%	98%	37%
4 Node Ring @50 vs Star	-15% Star less	95%	3%
4 Node Ring vs Star@10G	<u>32%</u>	<u>75%</u>	<u>34%</u>
8 Node Ring vs Star	25%	99%	42%
8 Node Ring @50 vs Star	-13% Star less	98%	7%
8 Node Ring vs Star@10G	<u>32%</u>	88%	35%

* 10G RPR priced @ Parity

Recommendations

- 10Gb RPR at a Premium to 10Gb ENET does not win
- RPR has to be as cheap as Ethernet. Fiber gain is not a big enough advantage
 - RPR shows cost advantages vs Pt-to-Pt due to fiber and ZX connectors
- At ring bandwidth less than 10Gbps - RPR does not prove in
 - Not enough ring bandwidth at 2.5Gbps to justify RPR and multiple nodes on a ring; even with bandwidth reuse in a non-oversubscribed ring
- Private line traffic reliability has to be proven on RPR
 - Overlay SONET network for restoration guarantee

Recommendations (con't)

- As we move to over-subscription models, and if RPR costs more than Ethernet; the cost advantage for RPR shrinks and Carriers should look at Pt-to-Pt
 - Over-subscription means fewer fibers and ZX connectors in Pt-to-Pt architectures
 - Higher node counts reduce the probability of 100% spatial reuse on RPR ring; less advantage versus Core switching
 - RPR reliably guarantees TDM service delivery
- Network Management interfaces must support CORBA
 - Carriers require TMN architectures
 - Typical EMS layer