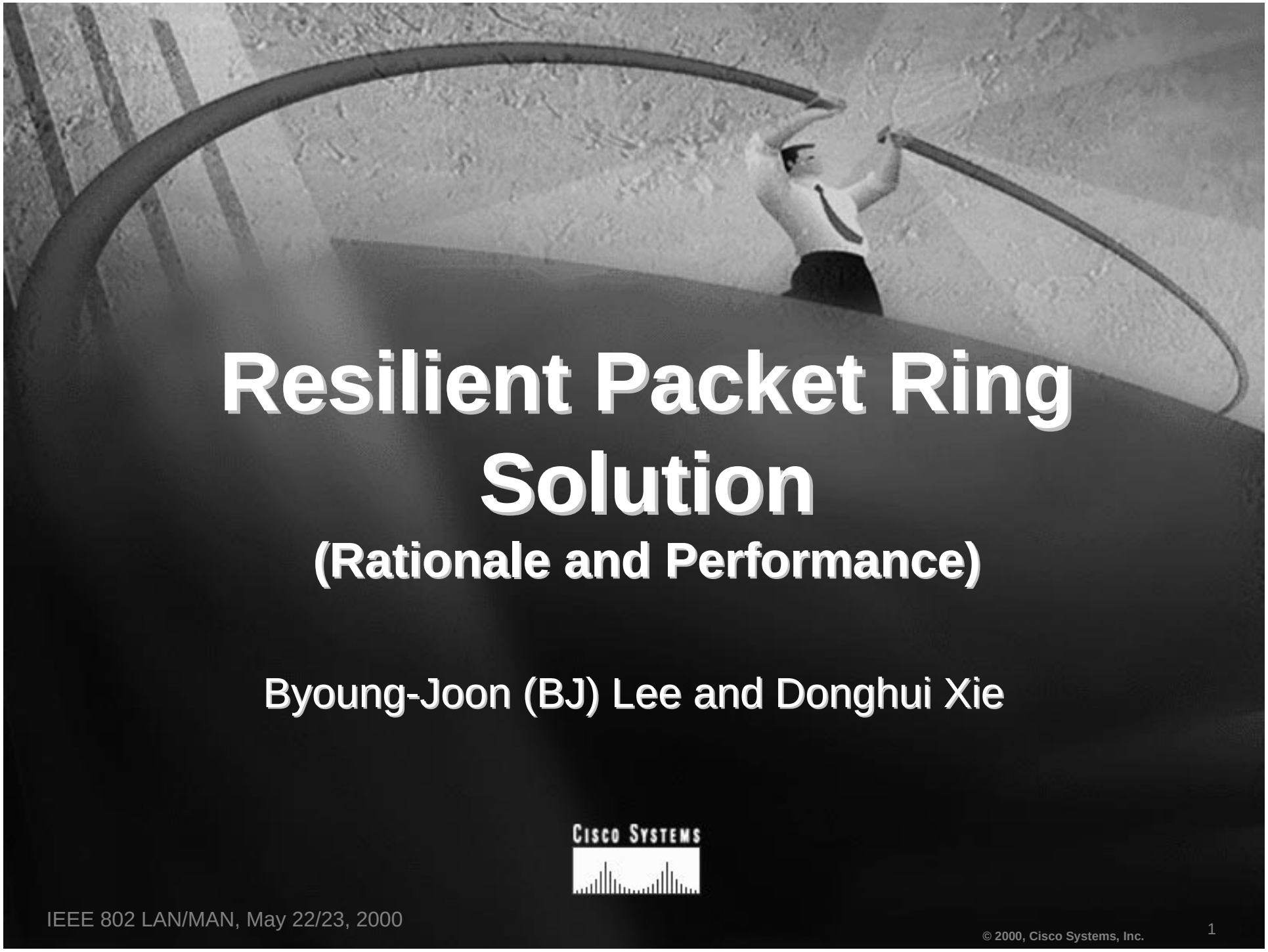

Resilient Packet Ring Solution

(Rationale and Performance)

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Contents

- **Overview**
  - Problem statement
  - Why Resilient Packet Ring?
  - IEEE 802 solutions
- **Example network scenarios**
- **Comparison with L2 Ethernet switched ring**
- **Priority traffic performance**

Problem Statement

- **Provide LAN/MAN/WAN connectivity with the following features:**
  - optimized for packet transfer (statistical multiplexing)
  - bandwidth multiplication
  - fast protection switching
  - dynamic fairness
  - ease and simplicity in multicast
  - media independence (wrt link speed)
  - priority support
  - box and/or layer elimination for economy

Why Resilient Packet Ring?

- **“Ring” is good and necessary**

  - amenable to failure resiliency, port count consolidation, and dynamic fairness over distributed geographical coverage, cabling availability and cost

  - P802.1w D4 (Draft document for Rapid Reconfiguration STP) also shows a switched ring network as an example of “resilient backbone configuration.”

- **“Ring” complements other topologies**

  - complements the current effort in IEEE 802.3

- **Evolution from classical IEEE rings**

  - calls for standardization effort for scalable ring solution

IEEE 802 Solutions

- **Ethernet, Token ring, and *FDDI***

  LAN connectivity at 4-16 Mbps, and 100 Mbps
  shared medium bus and ring

- **DQDB**

  LAN/MAN connectivity at 155 Mbps
  shared medium dual-bus

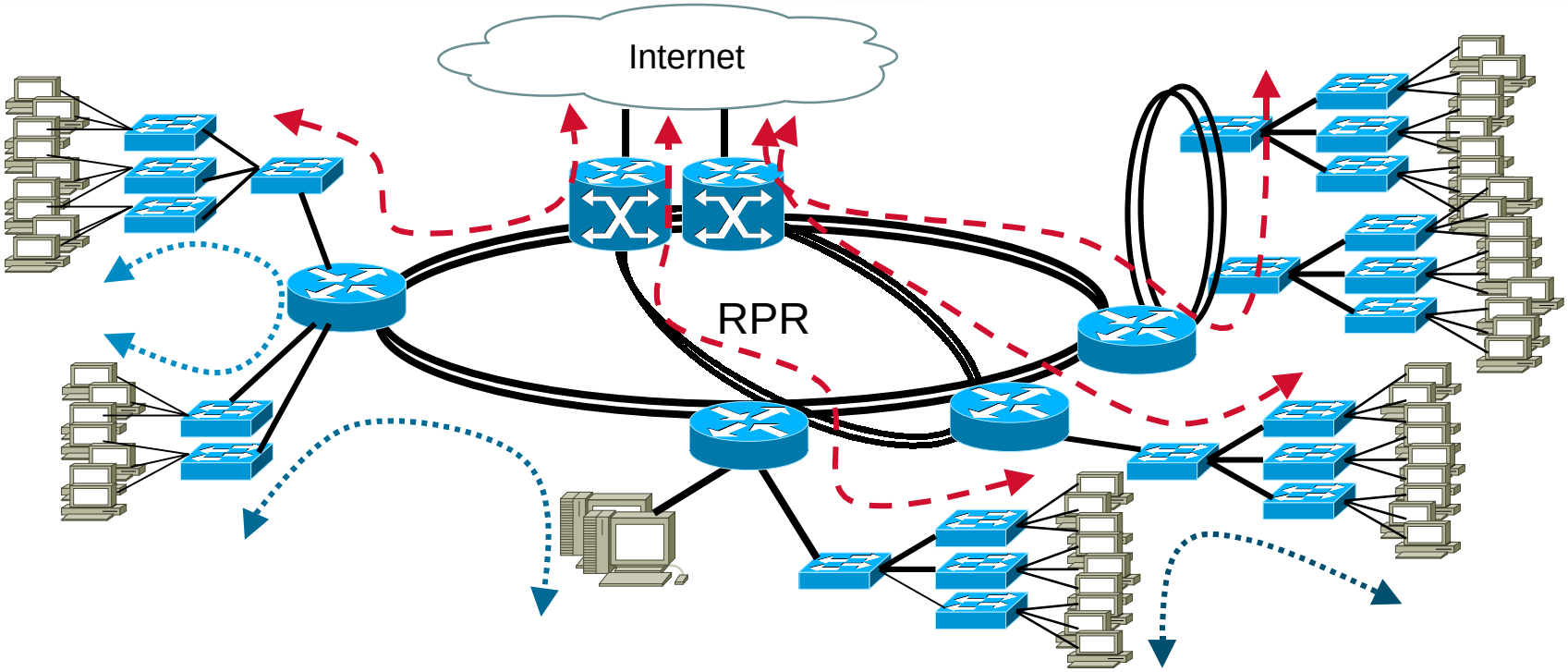
- **Fast/Gig Ethernet**

  LAN/MAN/WAN connectivity at 100M - 10Gbps
  half/full-duplex pt-to-pt star or tree topology networks

- **Resilient Packet Ring** *(in proposal)*

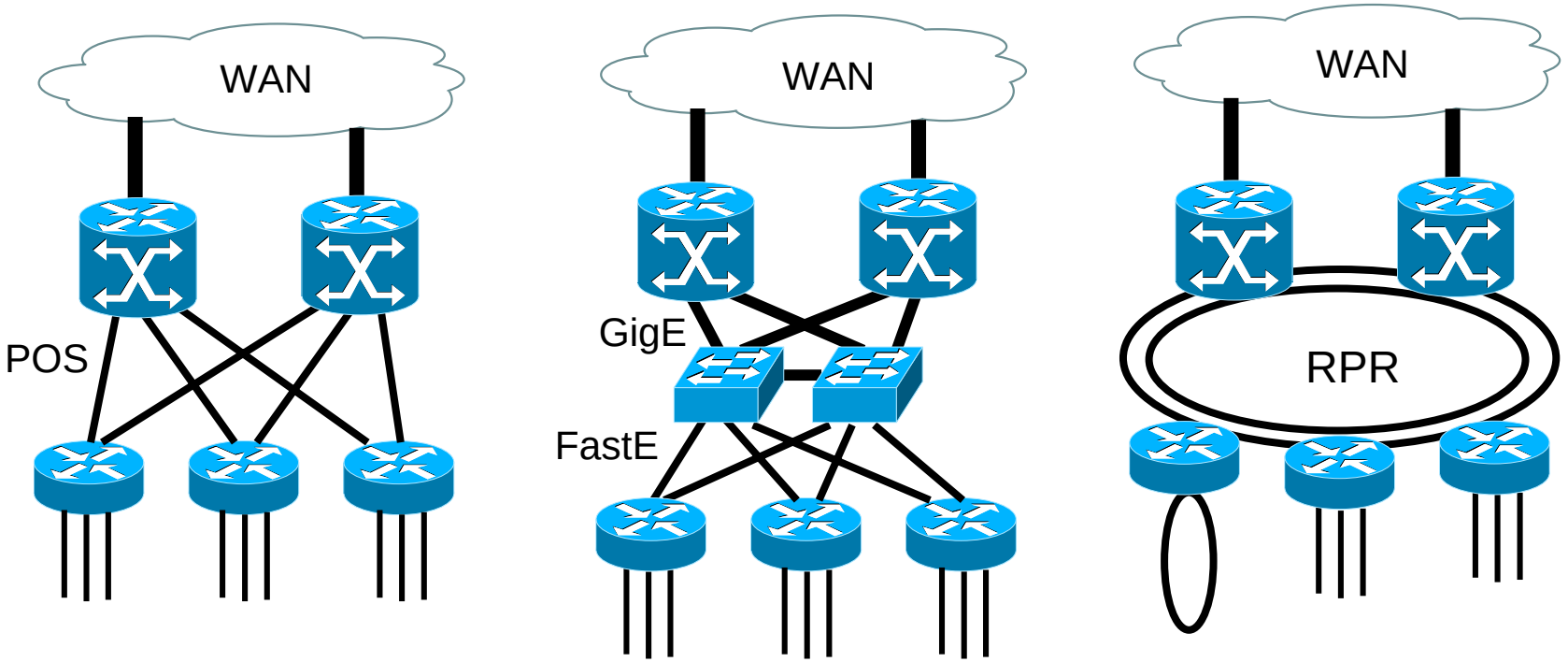
  LAN/MAN/WAN connectivity at 622M - 10Gbps *(and more)*
  shared bandwidth with distributed switching

Example: Building/Campus/Metro/Wan Backbone



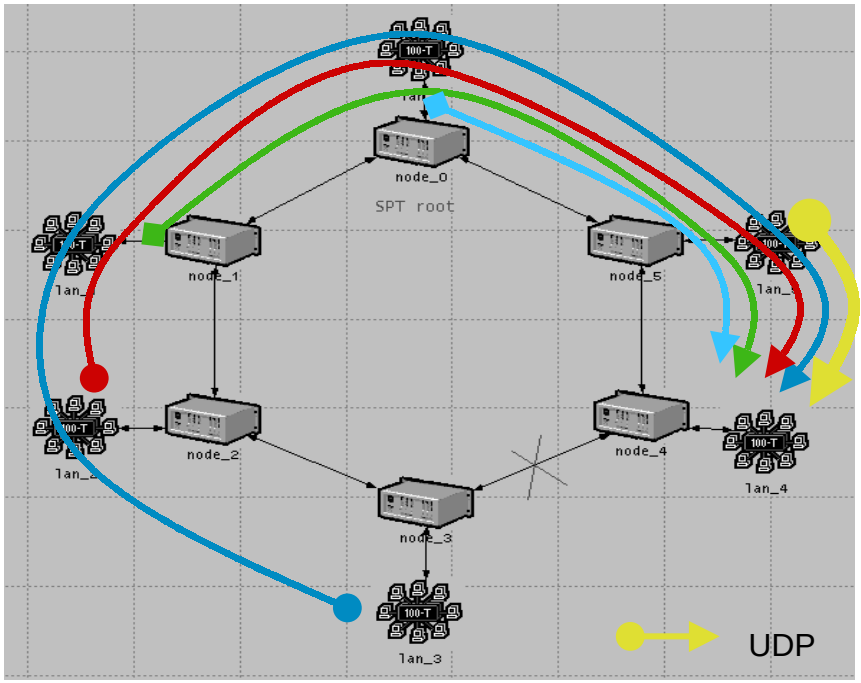
- While pt-to-pt switched networks provide dedicated port b/w (thus greater aggregate capacity), RPR provides resiliency, port count consolidation, ease of multicast, and dynamic fair access control. Cabling constraint and cost are also the determining factors.
- Spatial reuse property further enables b/w multiplication, and effects distributed switching.
- If required, the counter-rotating dual ring implementation can readily be extended into multi-dimensional connectivity providing higher network capacity and less hop count.

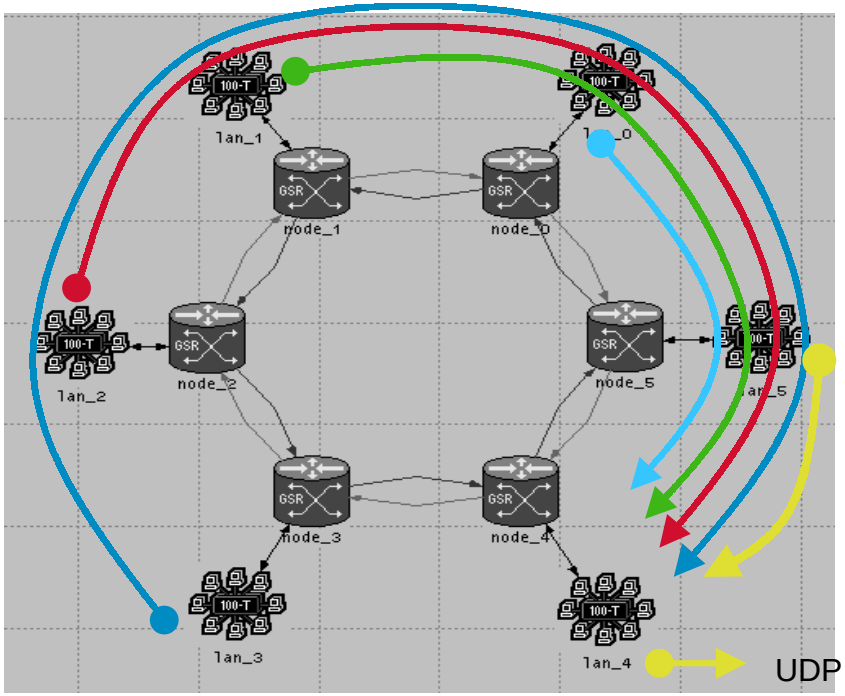
Example: Intra-POP Aggregation



- Direct POS aggregation incurs complex policy need on backbone routers, and port counts.
- L2 Switched solution relieves of policy need from backbone routers, but incurs box and port count explosion. Thus more susceptible to failures.
- RPR aggregation enables elimination of additional boxes and policy elements. It also provides simpler network management.

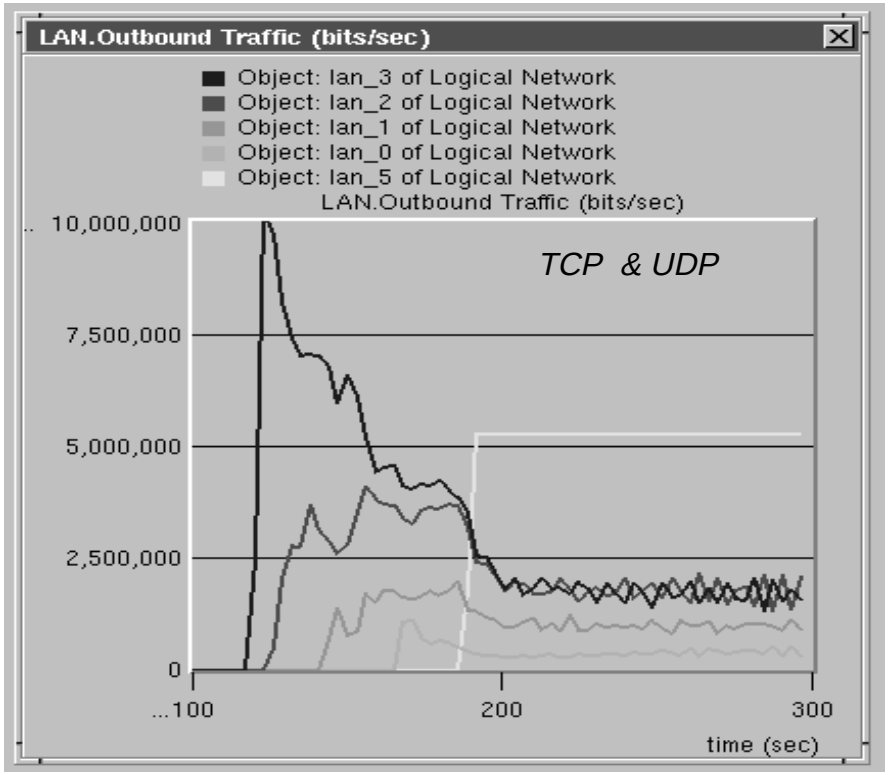
Comparison: Ethernet Ring vs SRP

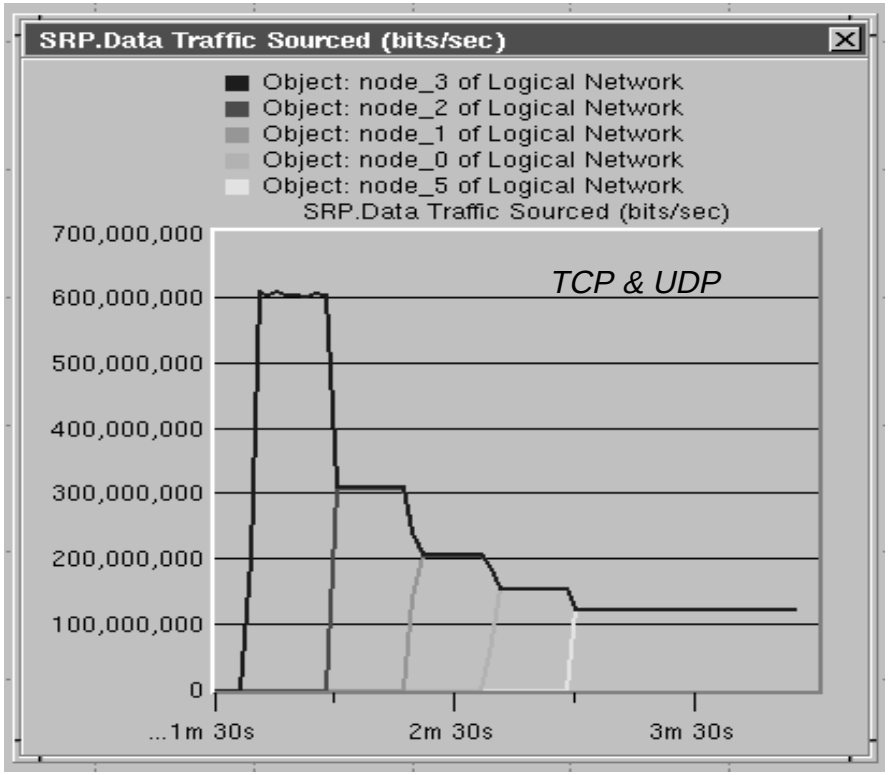




- STP blocks link segment between switch nodes 3 and 4, thus forcing unnecessary multi-hop path and reduced b/w multiplication
- SRP chooses inner/outer ring to ensure minimum-hop path, increasing BW multiplication
  (above example forces to use outer ring for fair comparison with Ethernet ring)

Comparison: Ethernet Ring vs SRP
(cont'd)





- Due to lack of L2 access control in the Ethernet Ring, fairness is non-existent in the presence of unresponsive UDP traffic
- On the other hand, dynamic b/w sharing mechanism of SRP ensures fairness and fast convergence.

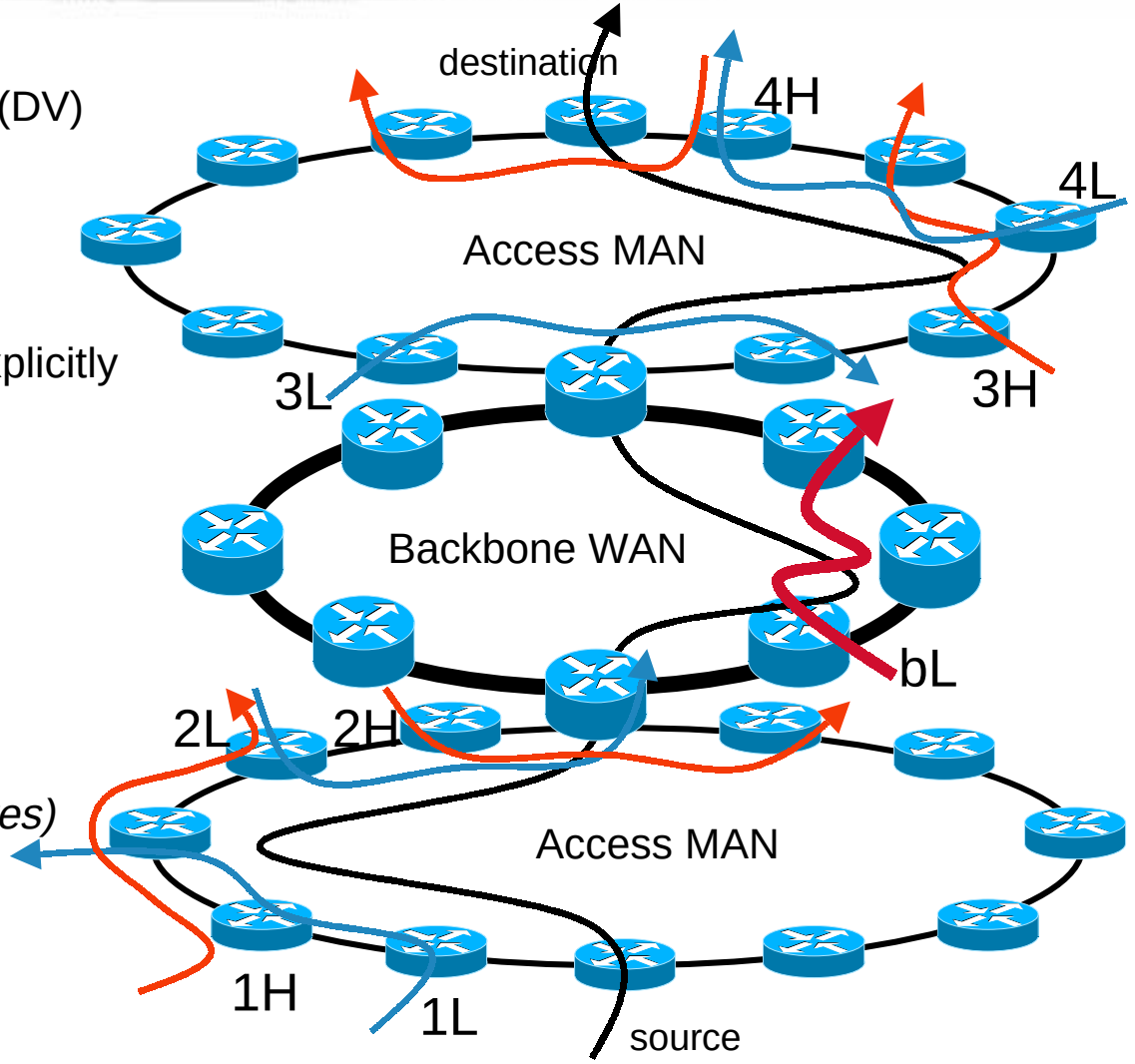
More Comparisons

	RPR	EtherRing	POSRing
BW multiplication (spatial reuse)	Very good (with min hop)	Good (no min hop, lost segment due to STP)	Very good (with shortest path)
Fairness	Very good	Difficult	Difficult
Policy queueing and forwarding	Only at access, at access rate	At every hop, at full ring rate	At every hop, at full ring rate
Transit delay	L2 only (with min hop)	L2 only (without min hop)	L2/L3 queueing and forwarding
Packet loss within the ring	No	Yes	Yes
Protection	L2 IPS (50 ms)	L2 STP (10's of sec) *L2 RSTP (sub-second)*	L3

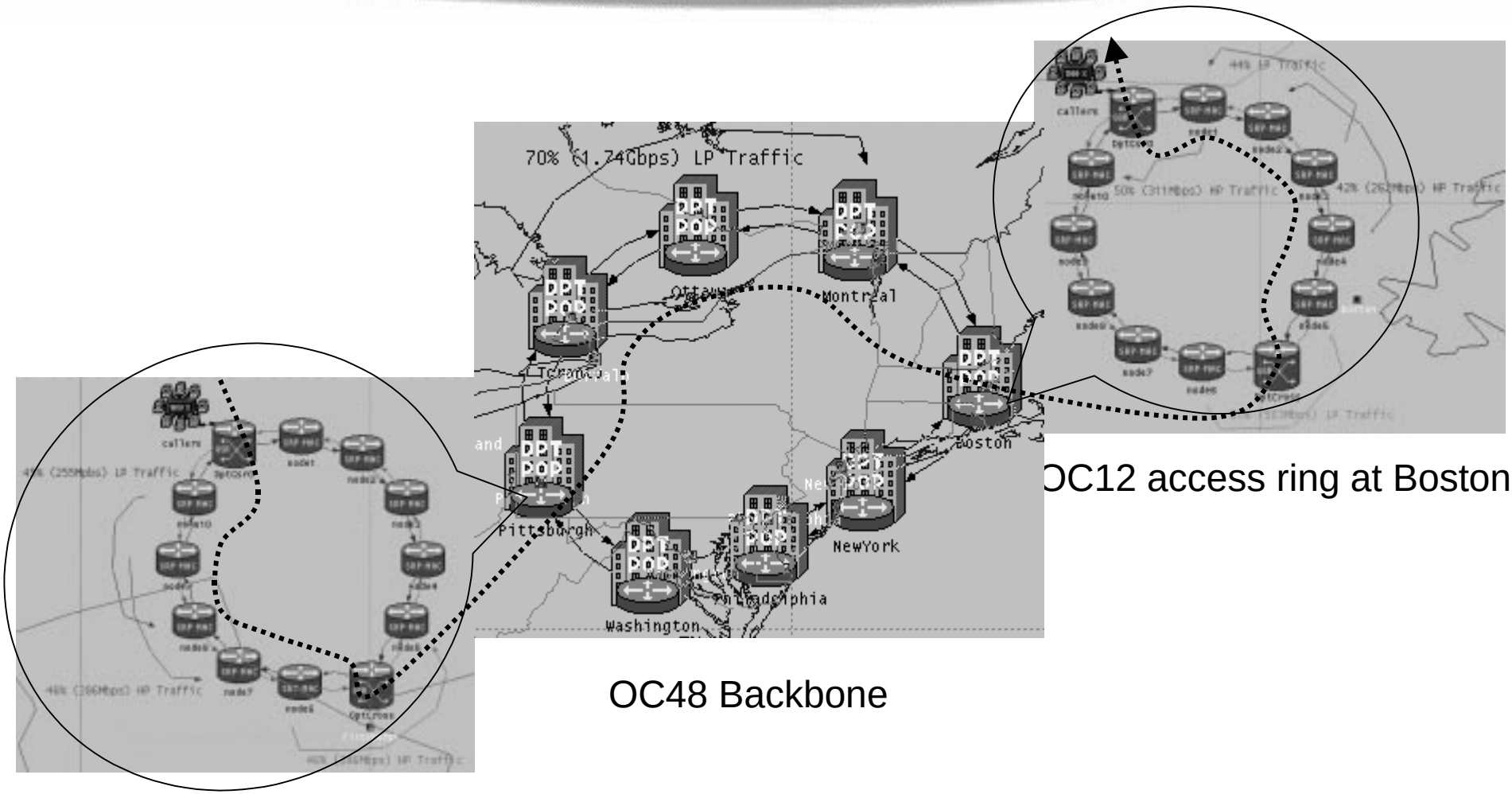
High Priority Traffic Performance

- End-to-end delay and delay variation(DV)
  - per-packet measurement
  - CDF (cumulative distribution function) plot
- Reference voice traffic is modeled explicitly (G.711)
- Total of 9 background traffic streams
  - bursty on/off traffic
    - 4 low priority w/ 4K byte pkts
    - 4 high priority w/ 128 byte pkts
    - 1 low priority w/ 4K byte pkts

  (3 runs with 1.5K, 4K, and 9K bytes)
- 45% of OC-12 for both low and high interference traffic stream



High Priority Traffic Performance *(cont'd)*



High Priority Traffic Performance *(cont'd)*

(Call Generation Parameters) Table

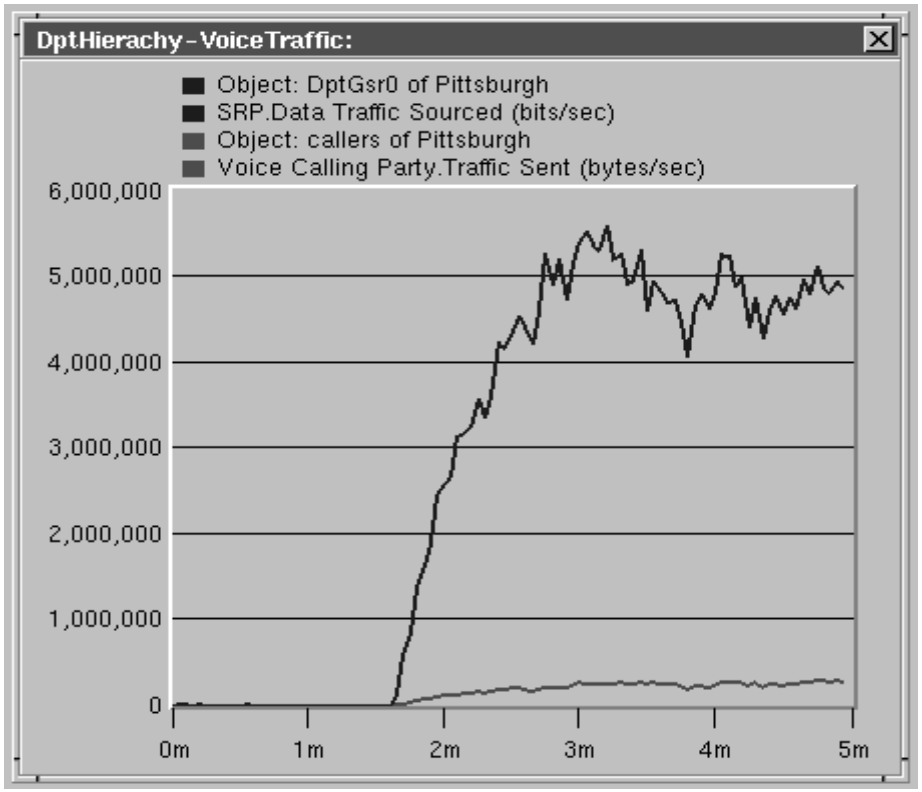
Attribute	Value
Call Rate (Calls/Hour)	120
Call Rate PDF	exponential
Call Duration (Minutes)	0.5
Call Duration PDF	exponential

(Talk Spurt Length) Table

Attribute	Value
Incoming Talk Spurt Length (sec)	0.352
Incoming Talk Spurt Length PDF	exponential
Outgoing Talk Spurt Length (sec)	0.352
Outgoing Talk Spurt Length PDF	exponential

(Silence Length) Table

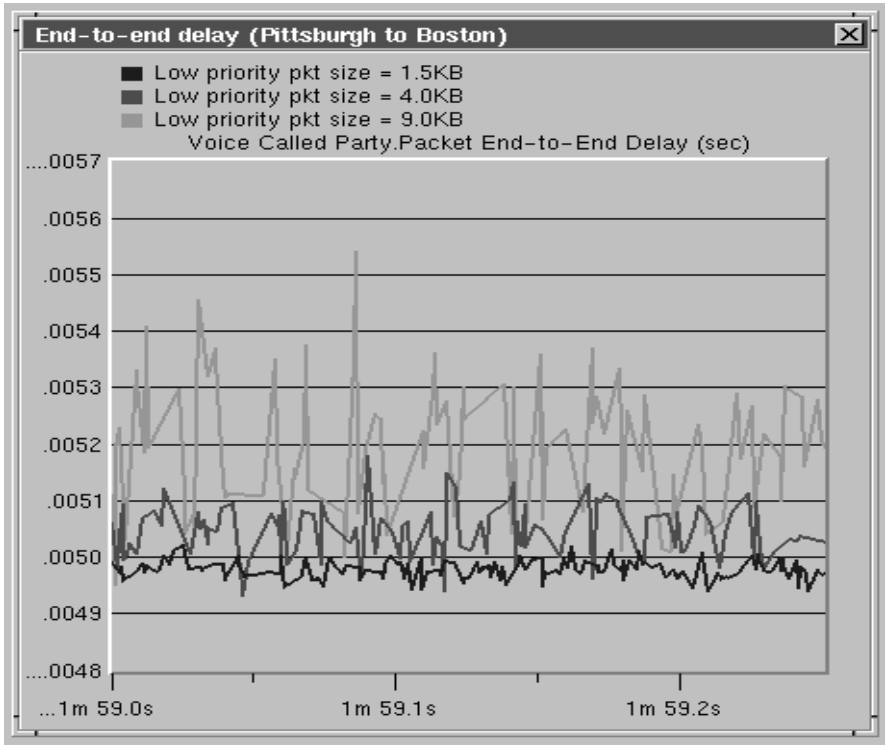
Attribute	Value
Incoming Silence Length (sec)	0.650
Incoming Silence Length PDF	exponential
Outgoing Silence Length (sec)	0.650
Outgoing Silence Length PDF	exponential

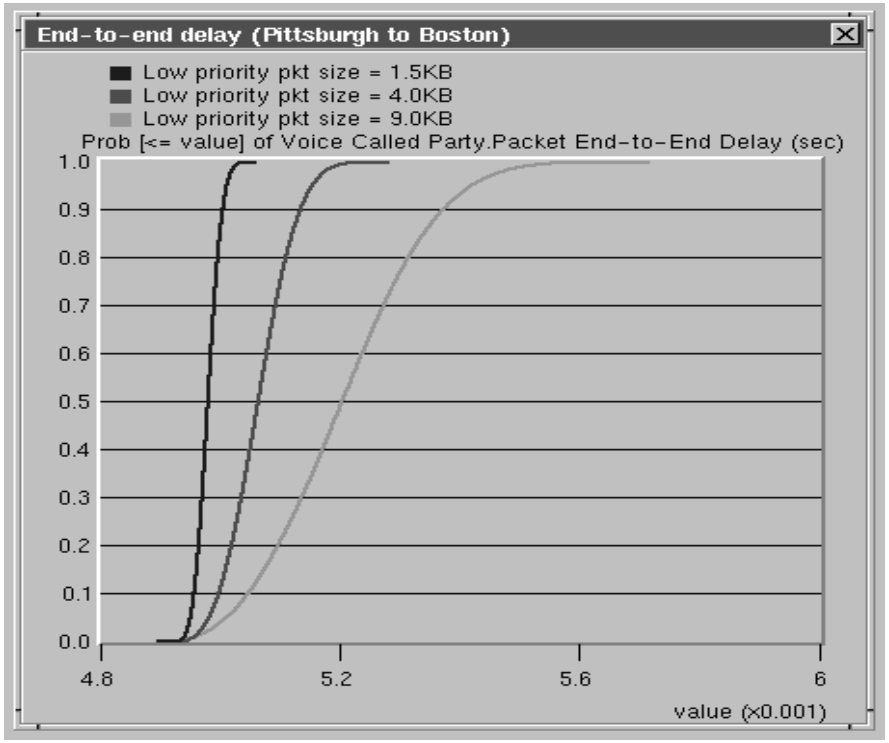


- G.711 voice encoding
- 200 callers in the LAN

- Voice traffic profile: aggregate and individual

High Priority Traffic Performance *(cont'd)*





- Shows instantaneous end-to-end delay measurements and CDFs for 1.5K, 4K, and 9KB low priority background packet sizes
- Delay variations are bounded within 160, 270, and 800 uS, respectively

Summary

- “Ring” is good and necessary, complementing other topological approaches (such as IEEE 802.3 Gigabit Ethernet).
- RPR (Resilient Packet Ring) is a unique and scalable solution for providing LAN/MAN/WAN connectivity with fast protection switching and dynamic fairness.
- Simulation study results and field experience with candidate RPR implementation demonstrate technical feasibility and intended performance.