



Transit Buffer Implementations for 3 Classes of Service in RPR

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- Node Model
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- Conclusion



Objectives



- Provide 3 priority classes in the ring:
- High Priority
 - Guaranteed bandwidth (provisioned)
 - Bounded delay and bounded jitter
- Medium Priority
 - Committed bandwidth (provisioned), best effort for excess traffic
 - Bounded delay and (loosely) bounded jitter
- Low Priority
 - No guarantees
 - Best effort for bandwidth, delay and jitter



Why 3 Priorities?



- 3 traffic types with very specific behavior
- Mapped from Diffserv/MPLS/802.1Q CoS (3 bits)
- Good compromise between the types of services and the implementation
- Further classification performed by higher layers
- RPR MAC divides unprovisioned bandwidth fairly among nodes



Node Model



Mapped from Diffserv/MPLS/802.1Q (3 bits)

If Priority < "Med Prio Threshold" then Low Priority

Else if Priority < "High Prio Threshold" then Med Priority

Else High Priority

- Committed Access Rate (CAR) for MP
 - MP Traffic only when exceeds CAR is subject to fairness algorithm control
- Number of transit buffers configurable
 - 2Tb: MP gets buffered in LTb
 - 3Tb: MP gets buffered in a separate queue

DATA PROCES

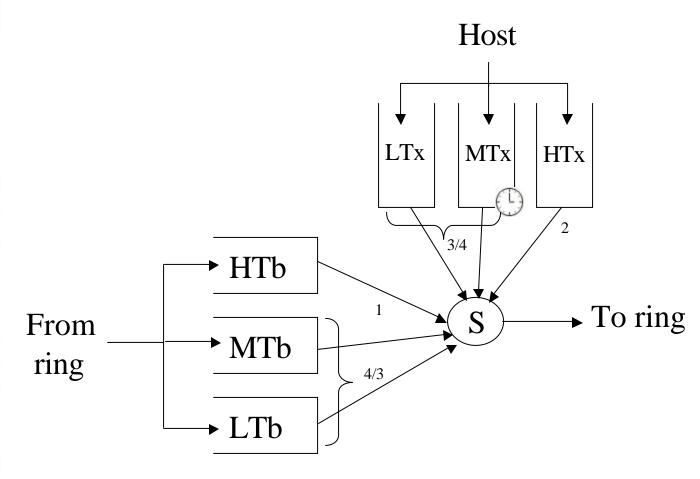
Node Model (cont)



Network Coo

Optica Speeds

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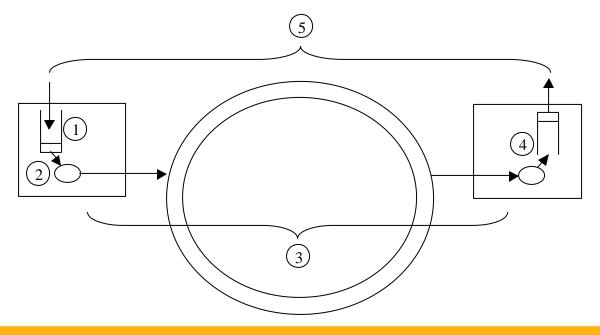
Important Statistics



MAC ETE = Queuing Delay + Medium Access Delay +
Ring ETE Delay (+Receive Buffer Delay)

Ring ETE = Pkt Tx + PropDelay + Transit Node Delay

Transit Node Delay = Pkt Handling Time + (Insertion/Tb) Buffer Delay



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DATA PROCES

Scenarios



- 16 node, 100Km OC192 dual ring
- Packet size: 64B(%60), 512B(%20), 1518B(%20)
- Buffers:

$$-$$
 HTb = 32KB

$$-$$
 MTb = 256KB

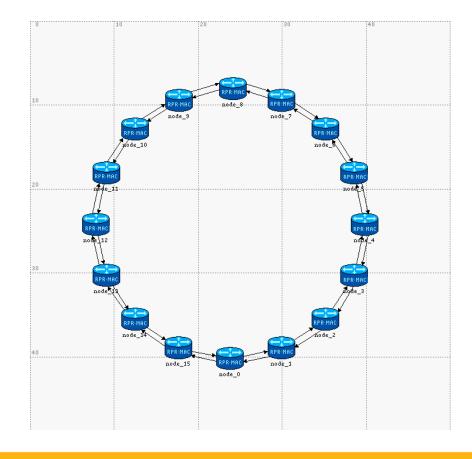
$$-$$
 LTb = 256KB

$$-LTx = 256MB$$

$$- MTx = 512 KB$$

$$-$$
 HTx = 256KB

Store and forward





Hub Traffic Scenario



- Node 7,6,5,4,3,2,1 to Hub (Node 0):
 - HTx: 430Mbps CBR
 - 1 tri-modal source per node
 - LTx: 1.15Gbps bursts
 - 1 tri-modal source per node, on 1msec, off 1msec, exponential distribution
 - total of ~570Mbps LTx per node
 - MTx: 860Mbps bursts
 - 1 tri-modal source per node, on 1msec, off 1msec, exponential distribution
 - total of ~430Mbps MTx per node
 - CAR per node 430Mbps
- In addition, Nodes double their MP traffic at 1sec
- Total traffic destined at Hub: ~10Gbps
 - 0.1-1 sec: %30HP, %30MP, %40LP
 - 1-2 sec: %30HP, %60MP, %10LP
 - Total simulation run-time: 2sec

Throughput Comparison

■ 100Hub_2TB_3TX ■ 100Hub_3TB_3TX Traffic.6lobal Traffic Destined (bits/sec)

1.0s

0.5s

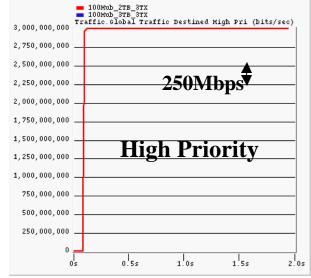


9,000,000,000 1Gbps 8,000,000,000 7,000,000,000 6,000,000,000 5.000.000.000 4,000,000,000 3,000,000,000

10,000,000,000

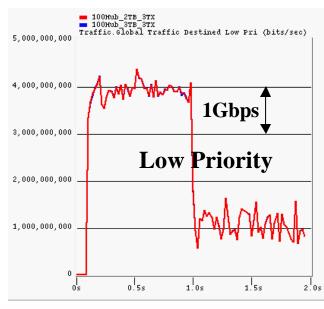
2,000,000,000

1,000,000,000

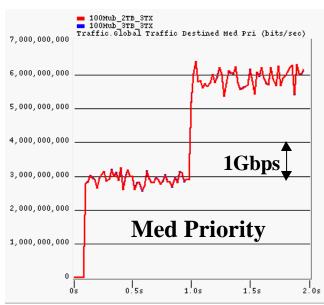


2TB

3TB



1.5s



DAT PROCES

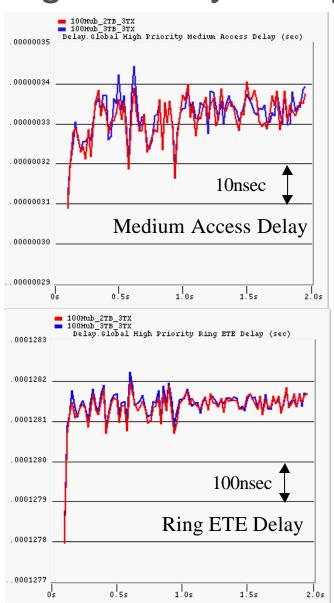
High Priority Delay Comparison

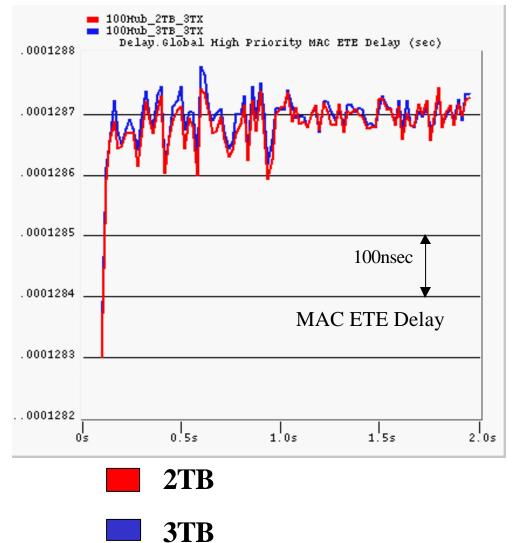


Network Co unications

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PROCES

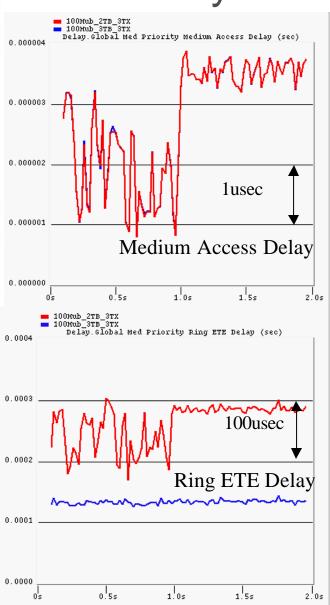
Med Priority Delay Comparison

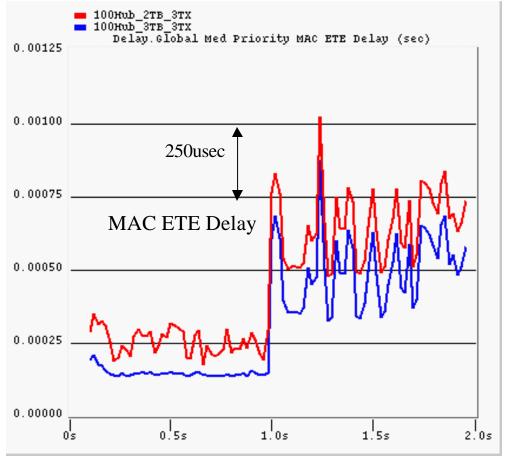






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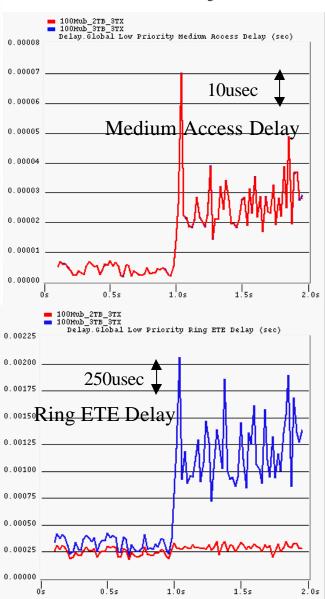


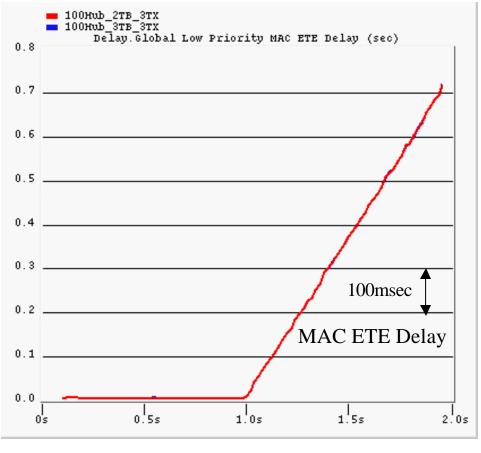


Low Priority Delay Comparison











High Pri MAC ETE Delay Histogram

2 Transit Buffers

100usec

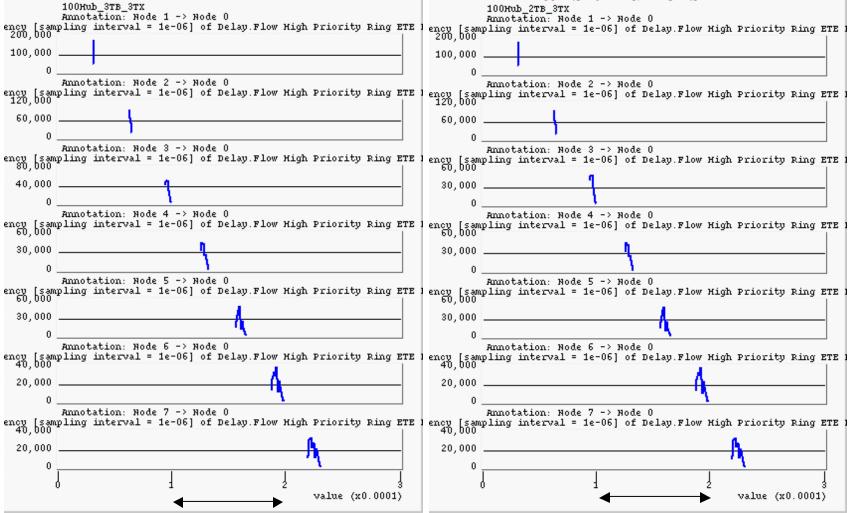
3 Transit Buffers

100usec

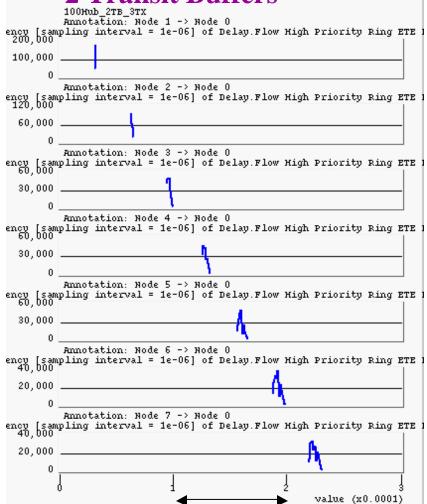
100Hub_3TB_3TX Annotation: Node 1 -> Node 0 Annotation: Node 1 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 100,000 _ 100,000 | Annotation: Node 2 -> Node 0 Annotation: Node 2 -> Node 0 tenop [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 80,000 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 80.000 40,000 ___ 40,000 . Annotation: Node 3 -> Node 0 Annotation: Node 3 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 30,000 __ 30,000 __ Annotation: Node 4 -> Node 0 Annotation: Node 4 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 60,000 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 30,000 ____ 30,000 _ Annotation: Node 5 -> Node 0 Annotation: Node 5 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 60,000 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 60,000 30,000 _ 30,000 ___ Annotation: Node 6 -> Node 0 Annotation: Node 6 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 40,000 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 20,000 _ 20.000 ____ Annotation: Node 7 -> Node 0 Annotation: Node 7 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D ency [sampling interval = 1e-06] of Delay.Flow High Priority MAC ETE D 40,000 20,000 _ value (x0.0001) value (x0.0001)

High Pri Ring ETE Delay Histogram

3 Transit Buffers



100usec

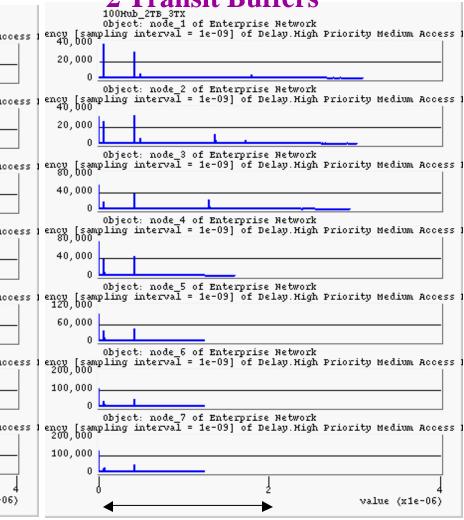


100usec

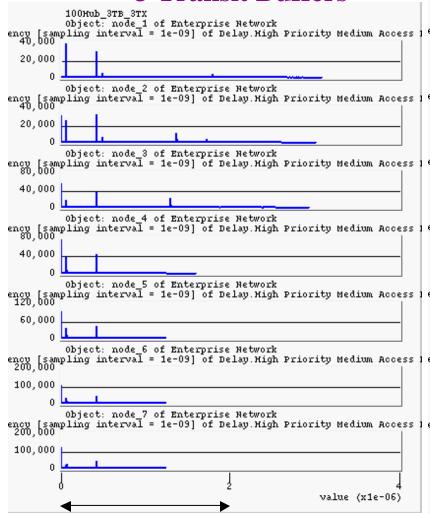
High Pri MedAcc Delay Histogram



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2usec

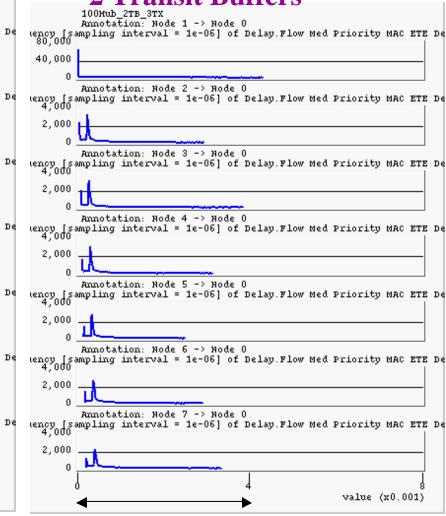


2usec

40,000

Med Pri MAC ETE Delay Histogram

2 Transit Buffers



100Hub_3TB_3TX Annotation: Node 1 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De

3 Transit Buffers

tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De 20,000 Annotation: Node 3 -> Node 0

tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De 20,000 10,000 Annotation: Node 4 -> Node 0

tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De 20,000 10,000

tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De 20,000 10,000

tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De 20,000 10,000 Annotation: Node 7 -> Node 0

Annotation: Node 6 -> Node 0

tency [sampling interval = 1e-06] of Delay.Flow Med Priority MAC ETE De 12,000 6,000 value (x0.001)

4msec

4msec

value (x0.001)

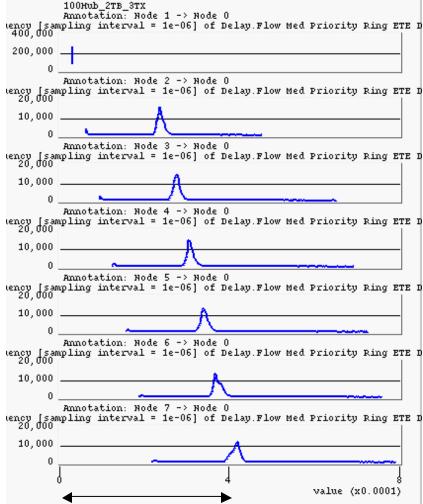
Med Pri Ring ETE Delay Histogram



3 Transit Buffers

100Hub_3TB_3TX Annotation: Node 1 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 200,000 Annotation: Node 2 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 60.000 _ Annotation: Node 3 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 80,000 Annotation: Node 4 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 30,000 _ Annotation: Node 5 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 30,000 _ Annotation: Node 6 -> Node 0 ency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 40,000 20,000 _ Annotation: Node 7 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Med Priority Ring ETE D 20,000 value (x0.0001)

400usec



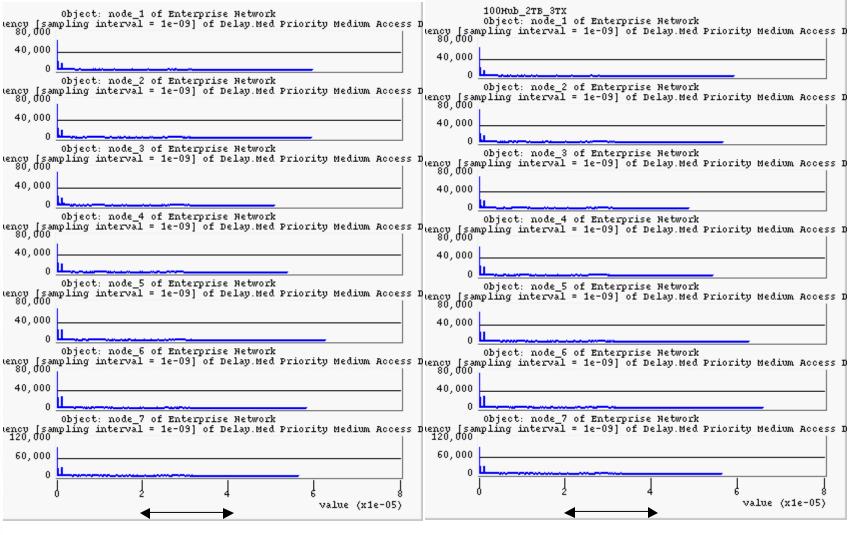
400usec

Med Pri MedAcc Delay Histogram
3 Transit Buffers
2 Transit Bu

20usec

2 Transit Buffers urora Netics, Inc.

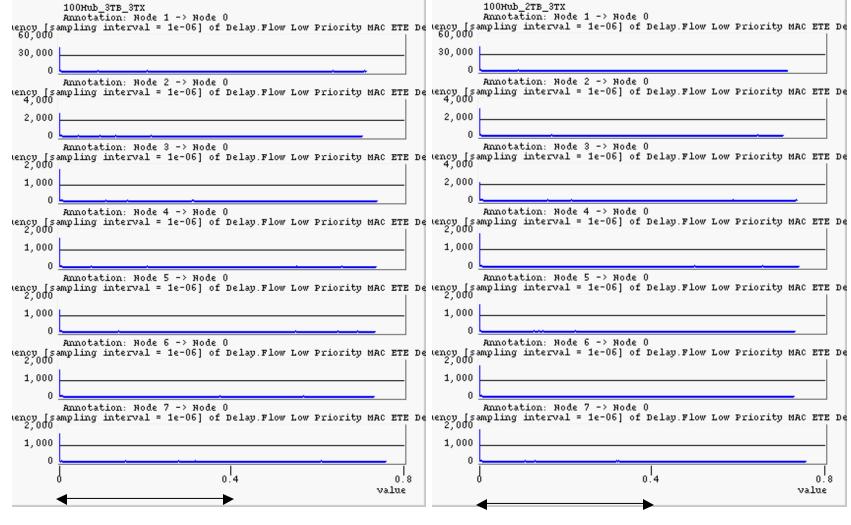
20usec



7/11/2001

Low Pri MAC ETE Delay Histogram

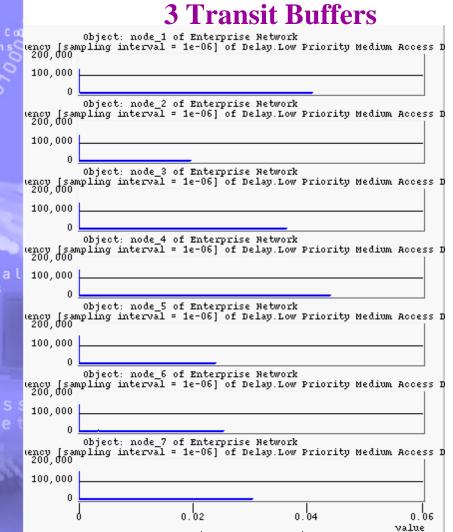
2 Transit Buffers 3 Transit Buffers



Low Pri Ring ETE Delay Histogram 3 Transit Buffers 100Hub_3TB_3TX Annotation: Node 1 -> Node 0 Annotation: Node 1 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D 200,000 tency [sampling interval = 1e-06] of Delay Flow Low Priority Ring ETE D 200,000 100,000 100,000 Annotation: Node 2 -> Node 0 Annotation: Node 2 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D 3,000 Annotation: Node 3 -> Node 0 Annotation: Node 3 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D
4.000 2,000 Annotation: Node 4 -> Node 0 Annotation: Node 4 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D 1,000 Annotation: Node 5 -> Node 0 Annotation: Node 5 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D 4,000 1,000 Annotation: Node 6 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Low Priority Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Ring ETE D (ency [sampling interval = 1e-06]) of Delay.Flow Ring ETE D (ency [sampling interval = 1e-06]) of 1,000 Annotation: Node 7 -> Node 0 Annotation: Node 7 -> Node 0 tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D tency [sampling interval = 1e-06] of Delay.Flow Low Priority Ring ETE D 4,000 1,000 value (x0.001) value (x0.001) 4msec 4msec

Low Pri MedAcc Delay Histogram





20msec



20msec



Conclusion



- With 3 transmit buffers and a rate limiter for MP, we can provide guaranteed bandwidth to MP
- 2 transit buffers perform just as well in terms of throughput, delay and jitter for provisioned traffic as 3 transit buffers
- Delay and jitter guarantees are compromised with single transit buffer for provisioned traffic

(http://grouper.ieee.org/groups/802/17/documents/presentations/may2001/nu_ctvst_02.pdf)







Thank you!

Q & A