Performance Simulation of Nortel OPE-RPR Ring

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Agenda

- Objectives
- Simulation setup
- Transient simulation results
- Steady-State simulation results
- Conclusions
- What’s next
Objectives

- Phase I
  - Simulation environments follow the specifications by 802.17 performance ad-hoc group
  - Examine the transient performance of OPE-RPR ring under raw traffic model
  - Examine the steady-state performance of OPE-RPR ring under bursty raw traffic model
Simulation setup: Node model
Simulation setup: Ring model
Definitions

- **MAC end-to-end delay**: Time between the arrival of an end of packet at the MAC transmit buffer of the source node and the time that this packet is completely delivered to the next protocol layer of the destination node on the same ring.

- **Medium access delay**: Time required for a head-of-the-line packet in the MAC transmit buffer to gain access to the medium. This delay is only caused by the medium competition and the fairness mechanism, not by the node's own traffic. This delay does not include the packet transmission time.

Note: definitions same as “Terms and Definitions” by Harmen R. van-As
Trigger conditions of fairness algorithm

- Two trigger conditions:
  - triggered by high utilization
    - controlled by target utilization and weights
    - tandem and add-in rate estimator
      \[
      \text{ESTIMATEDrate}(t) = \text{ESTIMATEDrate}(t-1) - \frac{\text{ESTIMATEDrate}(t-1)}{\text{WEIGHT1}} + \frac{\text{CURRENTrate}}{\text{WEIGHT2}}
      \]
  - triggered by high HOL delay
    - controlled by HOL timer
Traffic description

- The packet interarrival distribution is exponential (Poisson traffic)
- Packet size distribution is trimodal (60% 64B, 20% 512B, 20% 1518B)
- The mean packet size is 444.4B
- Hub application
  - Node 0 is the hub node
  - Node 1 to 15 send traffic to node 0 along counter-clock direction
Simulation scenarios for transient performance study

- Two types of scenarios:
  - nonoverloading
  - overloading

- Common parameters:
  - Link Utilization Max Threshold: 0.9
  - HOL Delay Threshold: 1,000us
  - Sample Window: 200 us
  - Token Size: 1,000 bits
  - Token Bucket Size: 15,000 bits
  - Tandem Rate Min Threshold: 0.0001
  - Add Rate Min Threshold: 0.0001
  - Link rate: 10 G bps
  - Propagation delay: 70 us (20 KM)
## Scenarios in detail

<table>
<thead>
<tr>
<th>Scenario 1 - 1</th>
<th>Data rate per node (mean value)</th>
<th>Weight for Tandem rate and Add rate Estimators</th>
<th>Simulation duration</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%*10G/15 bps (0 &lt; t &lt;= 5 ms)</td>
<td>32</td>
<td>45 ms</td>
<td>Mean utilization of the link between Node_1 and Node_0 jumps from 50% to 100% at time t = 5 ms following the input load jumps.</td>
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<tr>
<td></td>
<td>100%*10G/15 bps (t&gt;5 ms)</td>
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<tr>
<td>Scenario 1 - 2</td>
<td>50%*10G/15 bps (0 &lt; t &lt;= 5 ms)</td>
<td>64</td>
<td>45 ms</td>
<td>Mean utilization of the link between Node_1 and Node_0 jumps from 50% to 100% at time t = 5 ms following the input load jumps.</td>
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<td>100%*10G/15 bps (t&gt;5 ms)</td>
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<tr>
<td>Scenario 2 - 1</td>
<td>100%*10G/15 bps (0 &lt; t &lt;= 5 ms)</td>
<td>32</td>
<td>45 ms</td>
<td>Mean utilization of the link between Node_1 and Node_0 jumps from 100% to 150% at time t = 5 ms following the input load jumps.</td>
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<tr>
<td></td>
<td>150%*10G/15 bps (t&gt;5 ms)</td>
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<tr>
<td>Scenario 2 - 2</td>
<td>100%*10G/15 bps (0 &lt; t &lt;= 5 ms)</td>
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<td>150%*10G/15 bps (t&gt;5 ms)</td>
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<tr>
<td>Scenario 2 - 3</td>
<td>100%*10G/15 bps (0 &lt; t &lt;= 5 ms)</td>
<td>32</td>
<td>45 ms</td>
<td>Mean utilization of the link between Node_1 and Node_0 jumps from 100% to 200% at time t = 5 ms following the input load jumps.</td>
</tr>
<tr>
<td></td>
<td>200%*10G/15 bps (t&gt;5 ms)</td>
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<tr>
<td>Scenario 2 - 4</td>
<td>100%*10G/15 bps (0 &lt; t &lt;= 5 ms)</td>
<td>64</td>
<td>45 ms</td>
<td>Mean utilization of the link between Node_1 and Node_0 jumps from 100% to 200% at time t = 5 ms following the input load jumps.</td>
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<td>200%*10G/15 bps (t&gt;5 ms)</td>
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</table>
Selective results

Scenario 1-1 vs. Scenario 1-2

5/22/2001
Selective results (cont’d)

Scenario 2-1 vs. Scenario 2-2
Selective results (cont’d)

Scenario 2-3 vs. Scenario 2-4
Fully distributed algorithm in operation

Node Status:
0 Normal
1 Chain
2 Head1
3 Head2

Scenario 2-4
(CBR traffic)
Steady state results with bursty traffic

Bucket size: 2000bits
Utilization: 97%

Enter steady state after 40ms
Bucket size: 150000 bits
Utilization: 97%

BIR effects.
Enter steady state after 40ms.
Statistical results of steady state

HOL delay at 97% target utilization and 97% load

Blue line: 2,000 bits token bucket size.
Red line: 150,000 bits token bucket size.

Probability

Head of Line Delay (us)
Statistical results (cont’d)

HOL delay at 98% target utilization and 98% load

Blue line: 2,000 bits token bucket size.
Red line: 150,000 bits token bucket size.
Statistical results (cont’d)

HOL delay at 99% target utilization and 99% load

Blue line: 2,000 bits token bucket size.
Red line: 150,000 bits token bucket size.
Statistical results (cont’d)

HOL delay at 100% target utilization and 100% load

Blue line: 2,000 bits token bucket size.
Red line: 150,000 bits token bucket size.
Statistical results (cont’d)

![Graph showing Average HOL delay versus Load (%) and Target utilization (%)]

- **Blue line**: 2,000 bits token bucket size.
- **Red line**: 150,000 bits token bucket size.
Statistical results (cont’d)

Max HOL delay

Blue line: 2,000 bits token bucket size.
Red line: 150,000 bits token bucket size.

Max Head of Line Delay (us)

Load (%) and Target utilization (%)
Statistical results (cont’d)

Target utilization 100% and load 100%
Statistical results (cont’d)

Target utilization 100% and load 100%

Throughput (bits/us) (Token bucket size: 2,000 bits)
Conclusions

- OPE-RPR ring can achieve more than 95% utilization and low MAC end-to-end delay with **single insertion buffer**
  
  - OPE-RPR fairness algorithm is stable under steady and bursty traffic
  - OPE-RPR fairness algorithm is fair to all nodes under congestion
  - OPE-RPR fairness algorithm works effectively as predicted
What’s next

- Distributed applications (multiple servers)
- Multiple classes
- BW unfairness services
- TCP applications