NORTEL NETWORKS

*i*PT Fairness

Controlled Access Protocol

Simulation Report

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Content

- **Simulation Setup**
  - Reference Network
  - Traffic source:
    - TCP: real world traffic profile
    - UDP: for steady state
- **Simulation**
  - Performance metrics
  - Result
- **What's Next**

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Independent Control Messages on the Ring

- **Message only lives within the bound of a ring**
  - Infrequent
    - On demand and soft state
- **Scalable**
  - OC-3 to OC-192 WAN rate
- **Low overhead**
- **Easily Upgradeable**
  - Support CoS
  - Support unfairness
  - Flexible

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Performance Metrics

- **Single Ring Network Performance**
  - Head of Line Delay: head of line delay at the queue output
  - Access Delay: measured from packet accepted into the box
  - Nodal Throughput: average throughput
  - Link utilization: average ring utilization
  - Fair performance: equal behavior for all participants
  - Good Reaction time: ~1 ms response time
  - Stable performance: small oscillation and convergence time time
  - Scalable solution
- **10 us delay per link**

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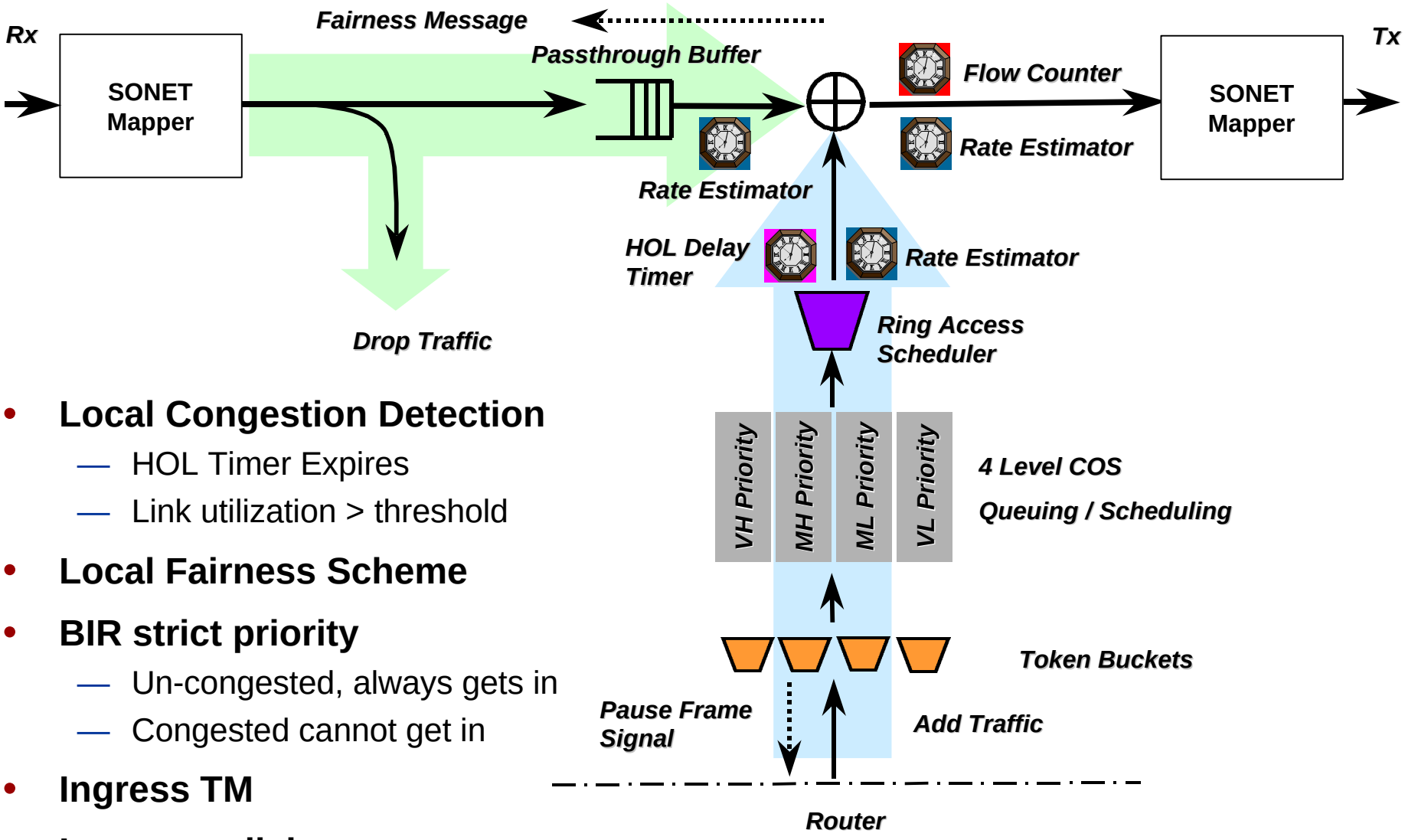
iPT Node Model



- **Local Congestion Detection**
  - HOL Timer Expires
  - Link utilization > threshold
- **Local Fairness Scheme**
- **BIR strict priority**
  - Un-congested, always gets in
  - Congested cannot get in
- **Ingress TM**
- **Ingress policing**

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Nodal Components

- **Rate estimator[10]:**

$$\text{Estimated\_rate (t)} = \text{Estimated\_rate (t-1)} + \frac{\text{Estimated\_rate (t-1)}}{\text{Weight1}} + \frac{\text{Sample\_rate(t-1)}}{\text{Weight2}}$$

- **Estimated_rate(t) is the current estimated rate**
- **Estimated_rate(t-1) is the previous estimated rate**
- **Sample_rate(t) is the current sampled rate over T_{sample}**
- **Weight1 and Weight2 can be independent**
- **Algorithm**
  - Rate measuring and Delay driven
  - Round trip delay
  - Responsive on demand with stability

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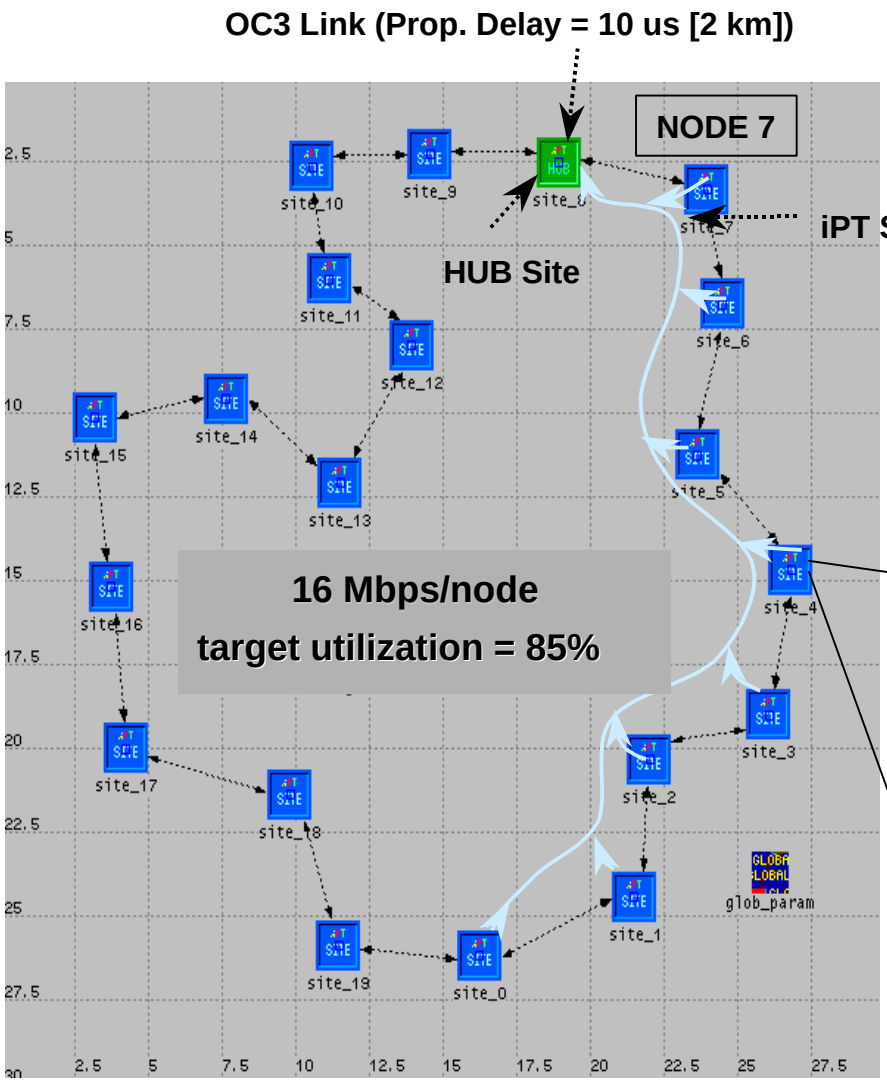
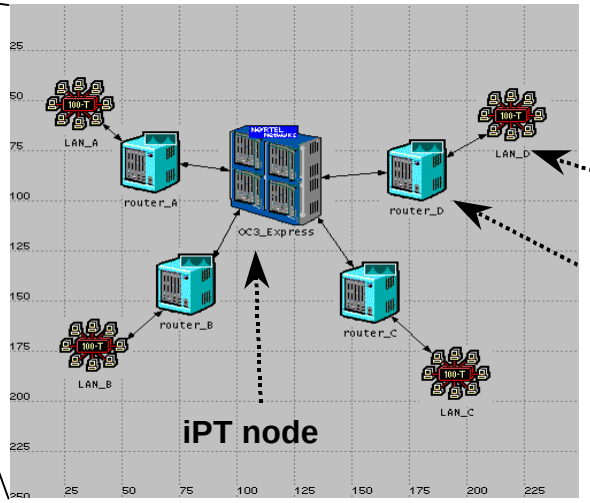
Simulation Network
OC-3: ½ Ring 8 Node Hub; Ingress Policed at 16 Mbps



- **Real networks models**
  - Access Ring
  - Collector Ring
- **Traffic source**
  - 50 simultaneous clients per node
  - Exponential distribution packet arrival
  - HTTP, FTP application > “Pareto”
  - 64, 512, 1500 byte packets
  - 2 MB buffer in Router
  - Best Effort



100BT LAN

Router

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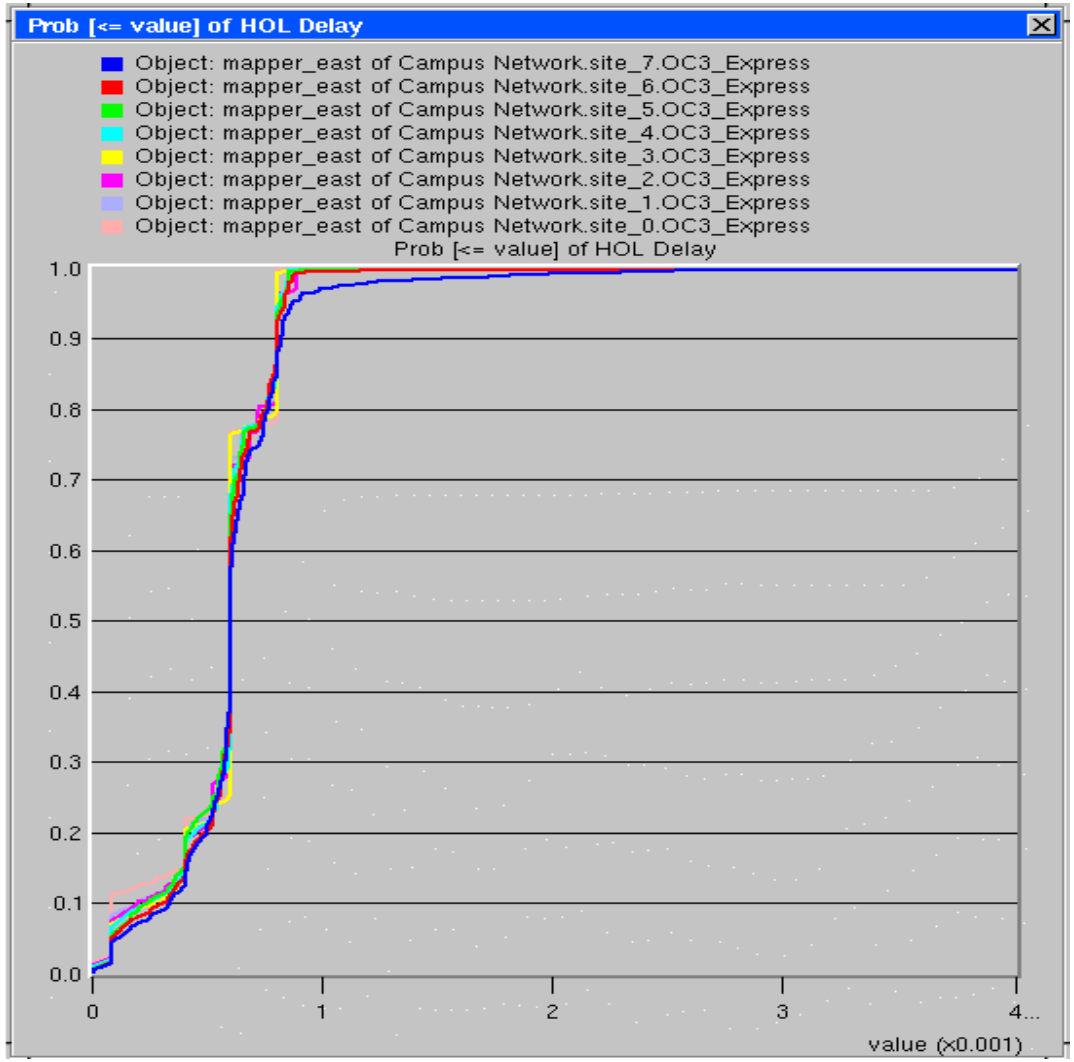
OC-3 Ring Access: Head of Line Delay
85% Utilization Threshold



- **Faster ring access in all ring operating conditions**
- **Head of Line Delay**
  - Head of line delay timer
  - Cummulative Distribution Function
- **95% of all packets have less than 1 ms HOL delay**
- **Fair Access**

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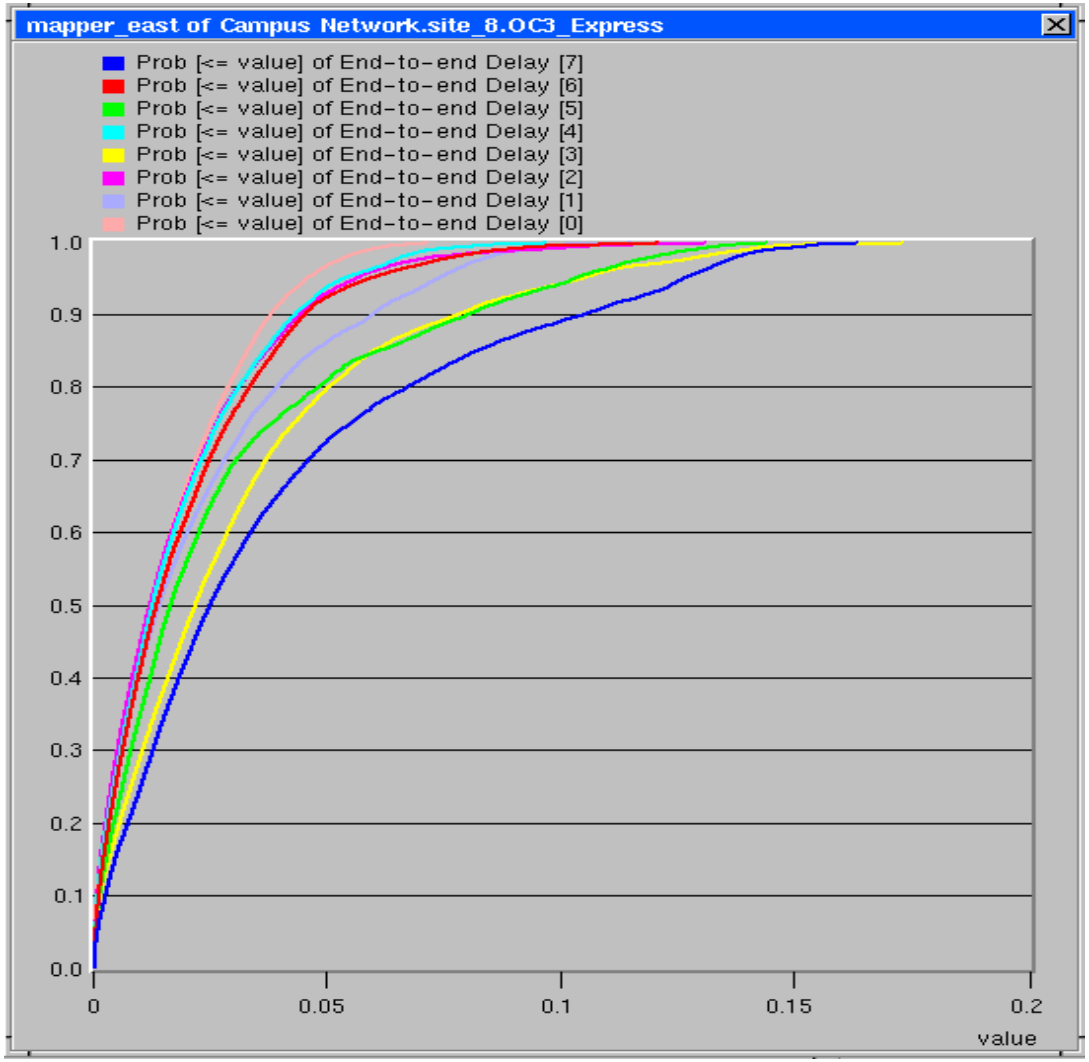
OC-3 End to End Delay
85% Utilization Threshold



- **Sustained Congested state**
- **Fair performance to all nodes**

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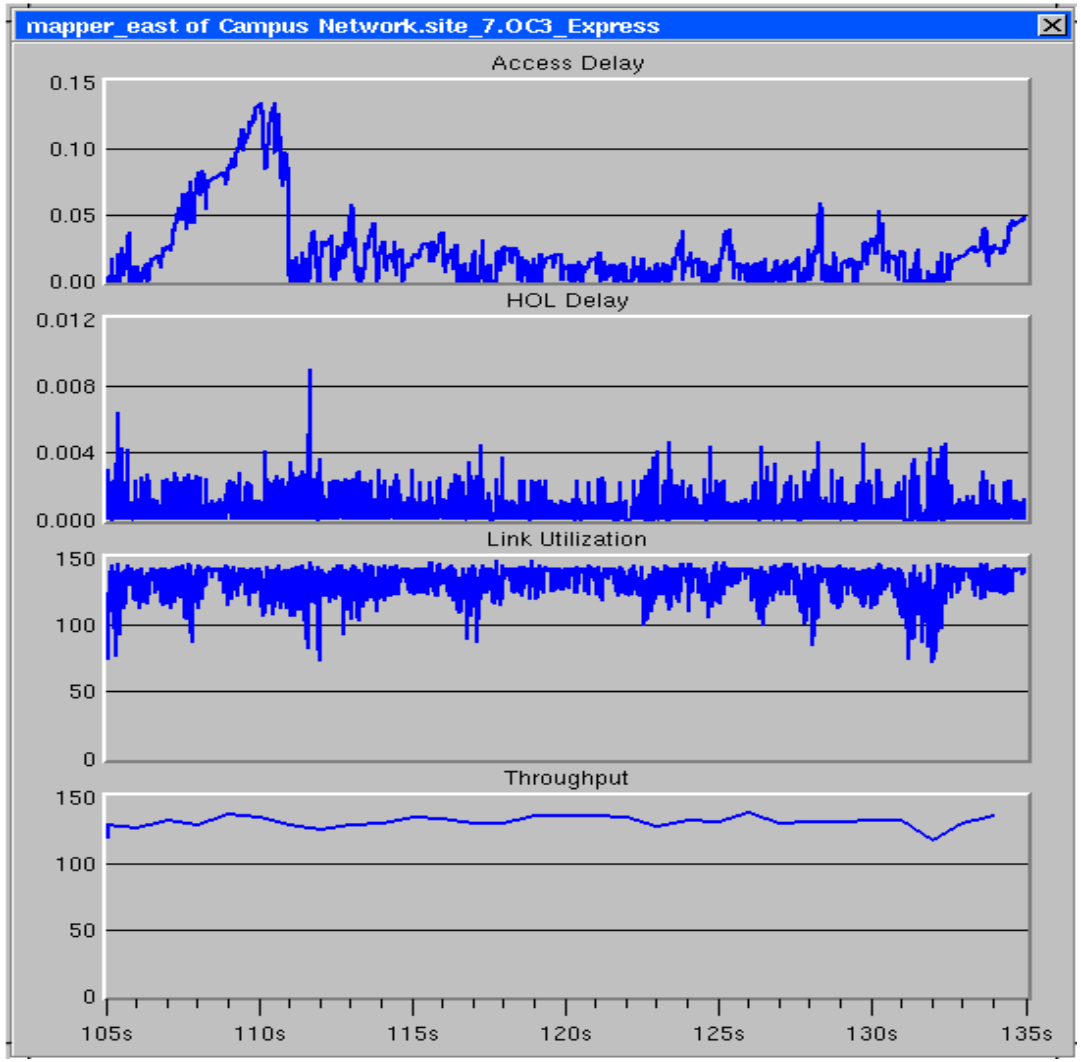
OC-3 Node 7 Internal Performance Characteristics
85% Utilization Threshold



1st 5 seconds of simulation

Access Delay

- **Accumulative effect on access delay for burst**

HOL Delay

- **Second**

Link Utilization

- **150Mb/s = OC-3**

Throughput

- **150Mb/s = OC-3**

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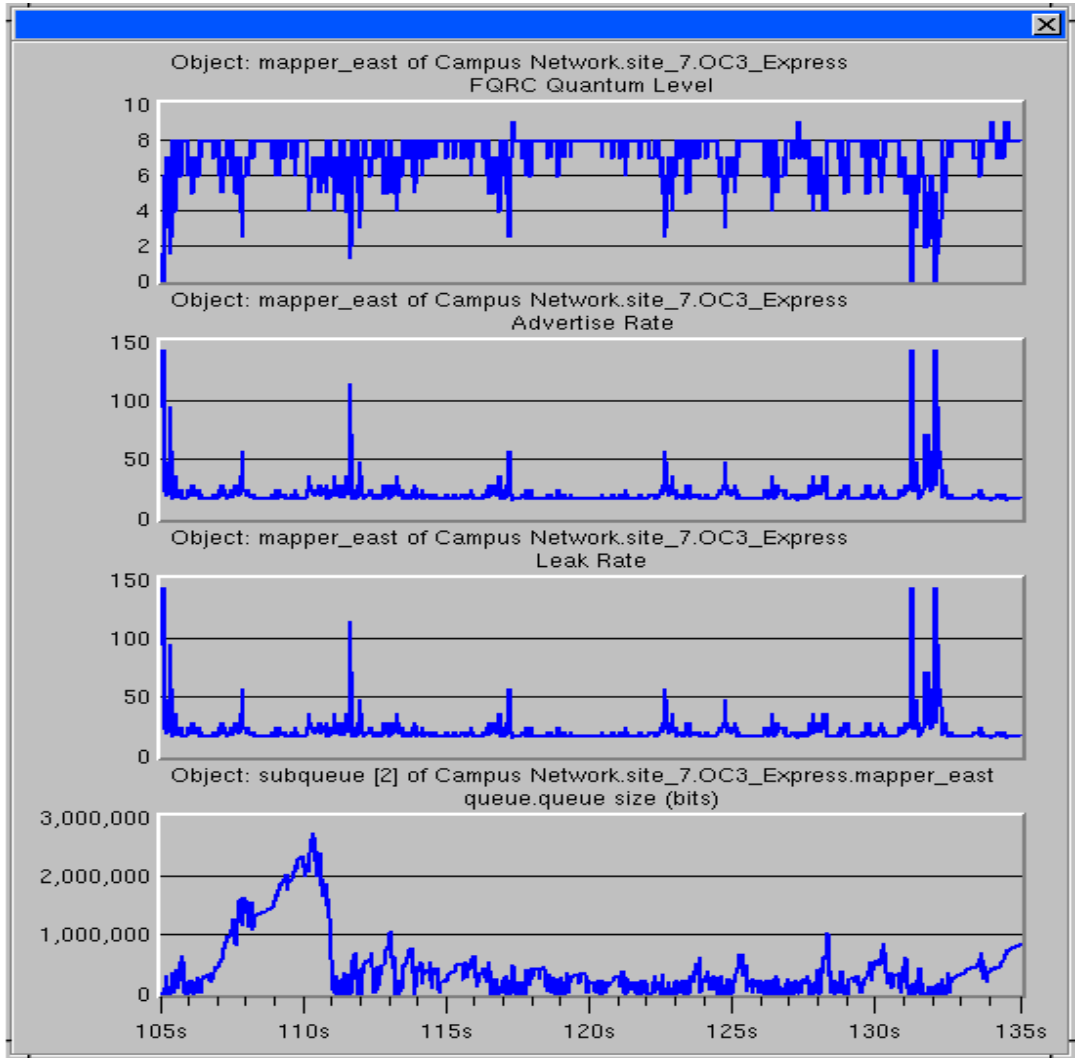
OC-3 Node 7 Internal Performance Characteristics 85% Utilization Threshold (Cont'd)



1st 5 seconds of simulation

Fairness State

- **Number of nodes in congestion span**

Advertised Rate

- **150 Mb/s**

Leak/ Add Rate

- **150Mb/s = OC-3**

iPT Node Queue Occupancy

- **3 Mb**
- **Bursty input**

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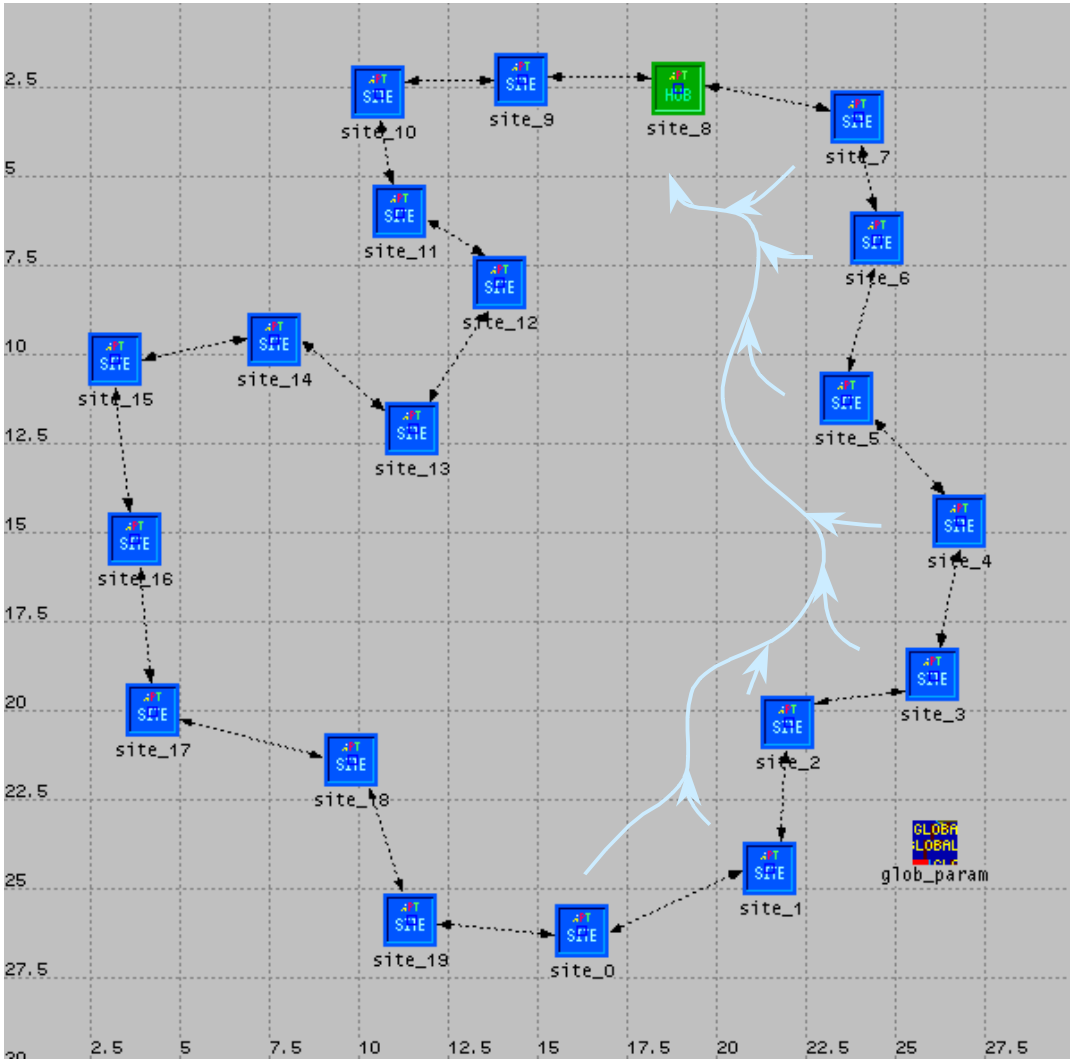
OC-3: ½ Ring 8 node Hub
Ingress Policed at 18 Mbps



- **Ingress policing set at 18 Mbps**
- **Traffic source still set at 16 Mbps**
- **Excess burst capability**

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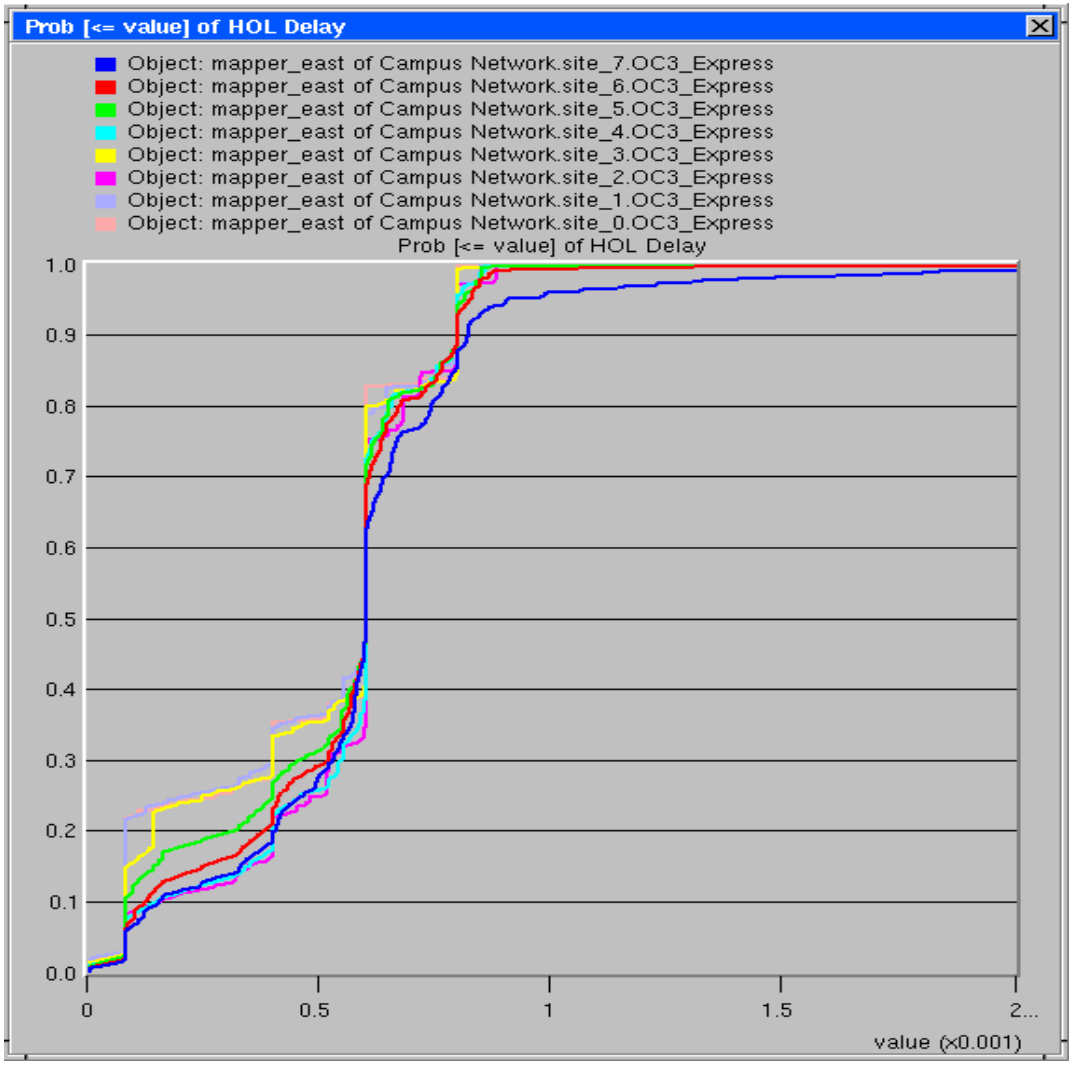
OC-3: 8 node Hub



- **Fair HOL Delay**
- **Slightly better than 16 Mbps ingress policing**

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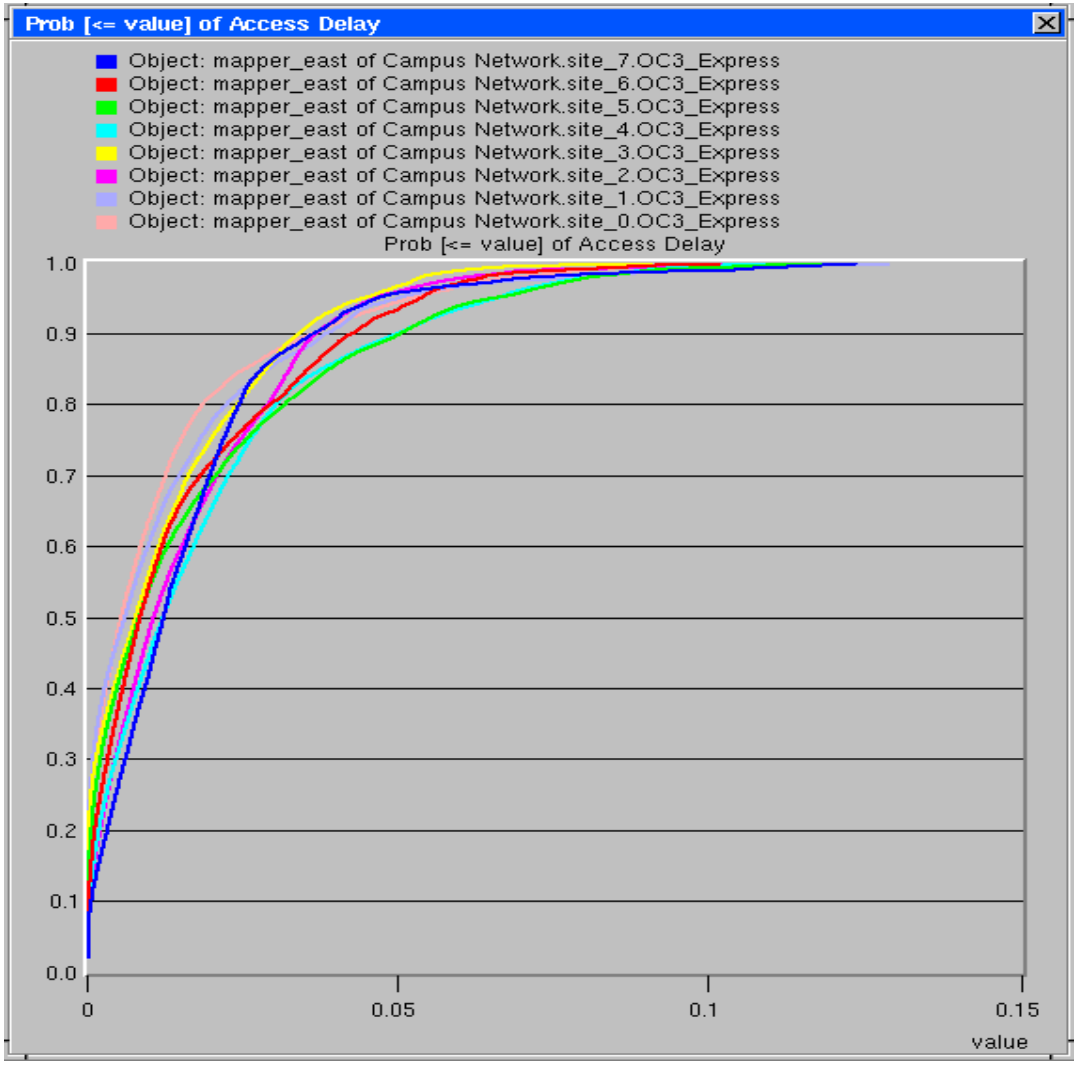

- **Fair Access Delay**
- **Much better than 16 Mbps ingress policing**

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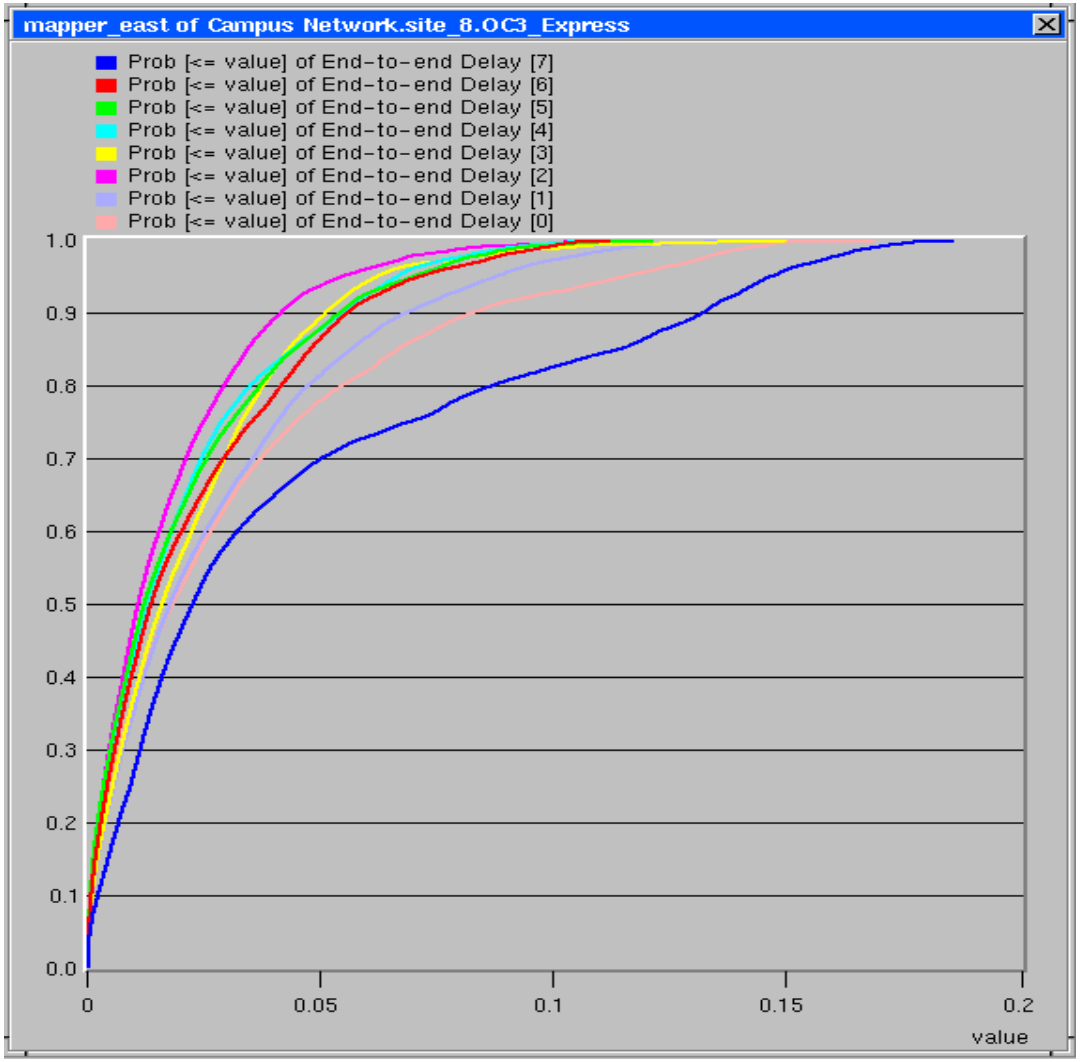

- **Fair Access Delay**
- **Better than 16 Mbps ingress policing**

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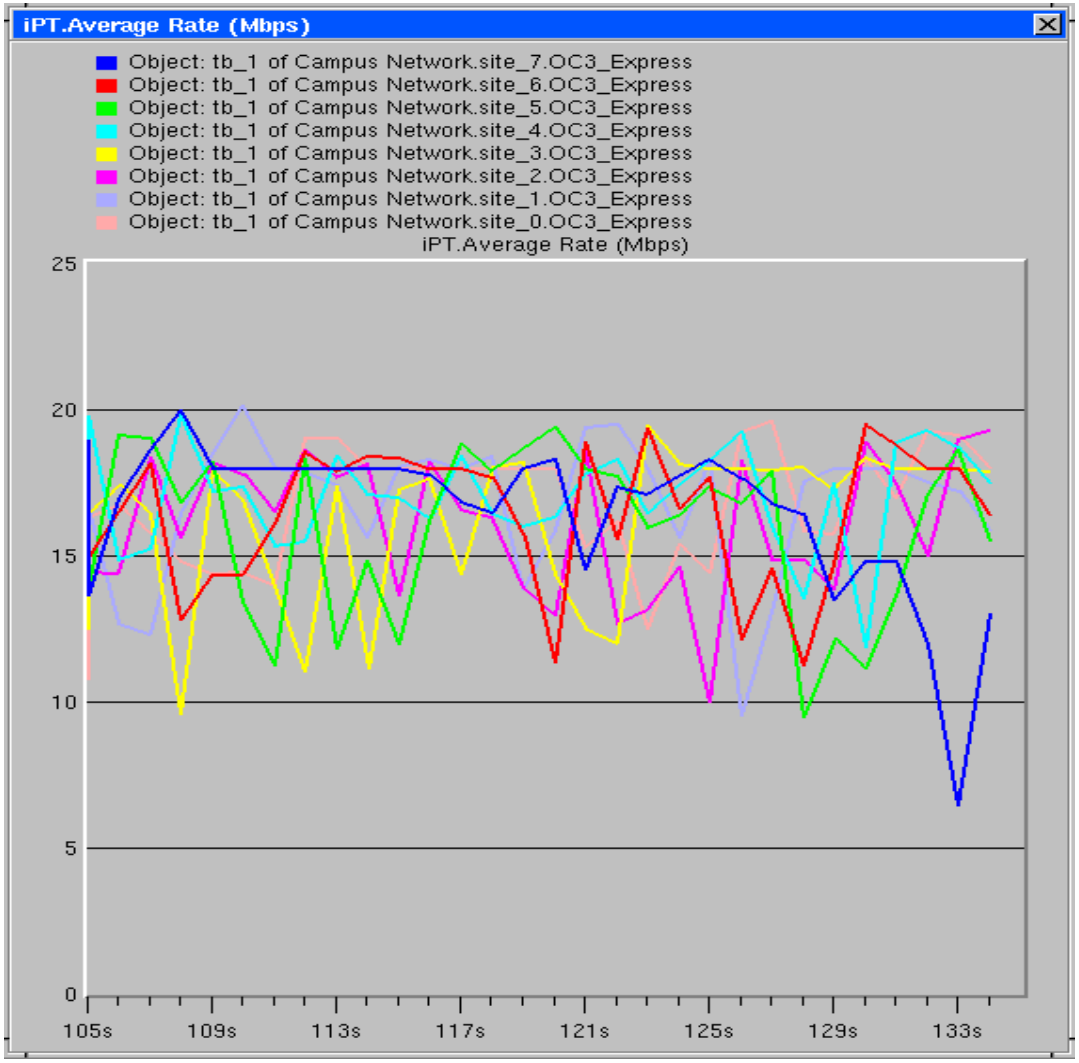

- **Ingress Average rate**
- **Target is 16 Mbps**

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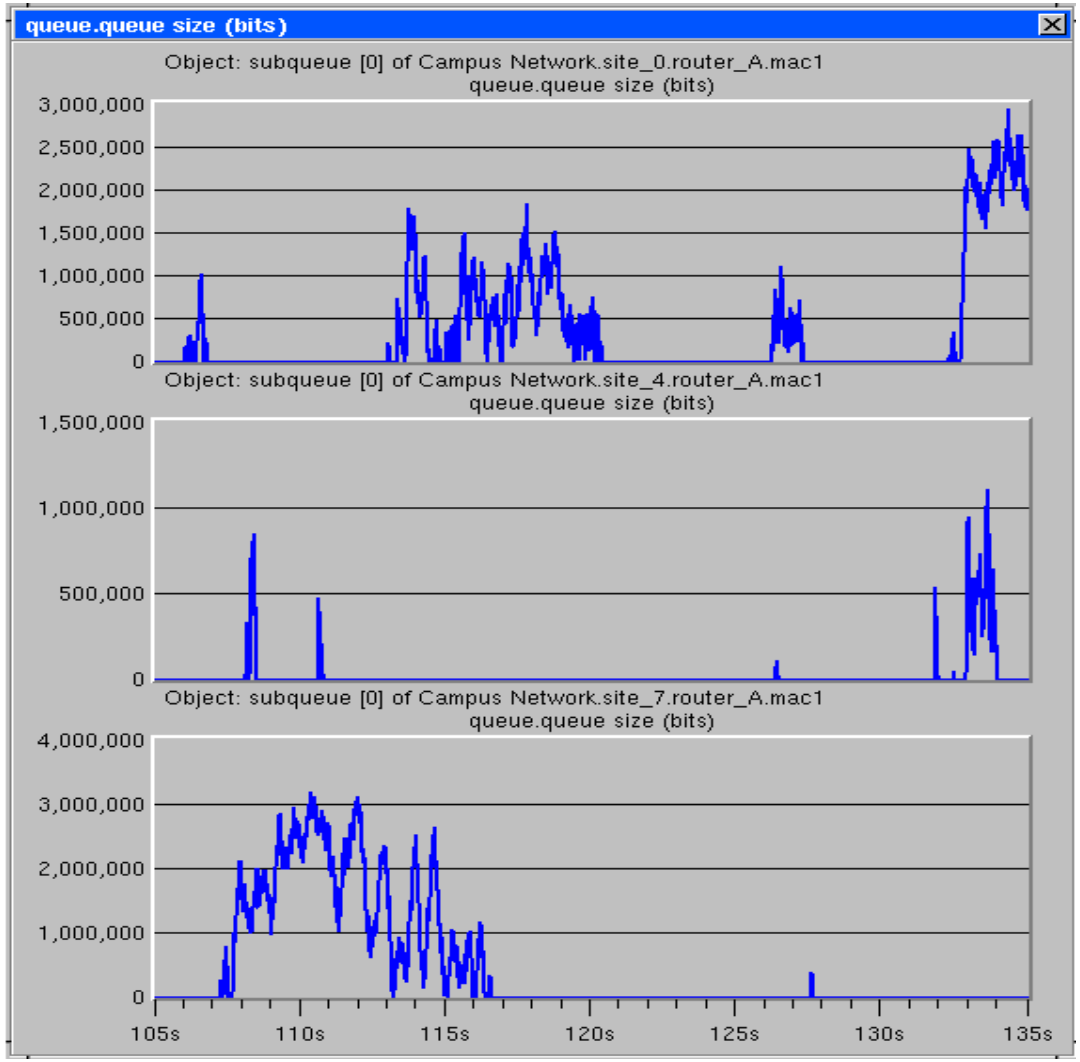
Insight into Traffic profile is bursty



1st 5 seconds of simulation

Queue Occupancy; Node 0

Queue Occupancy; Node 4

Queue Occupancy; Node 7

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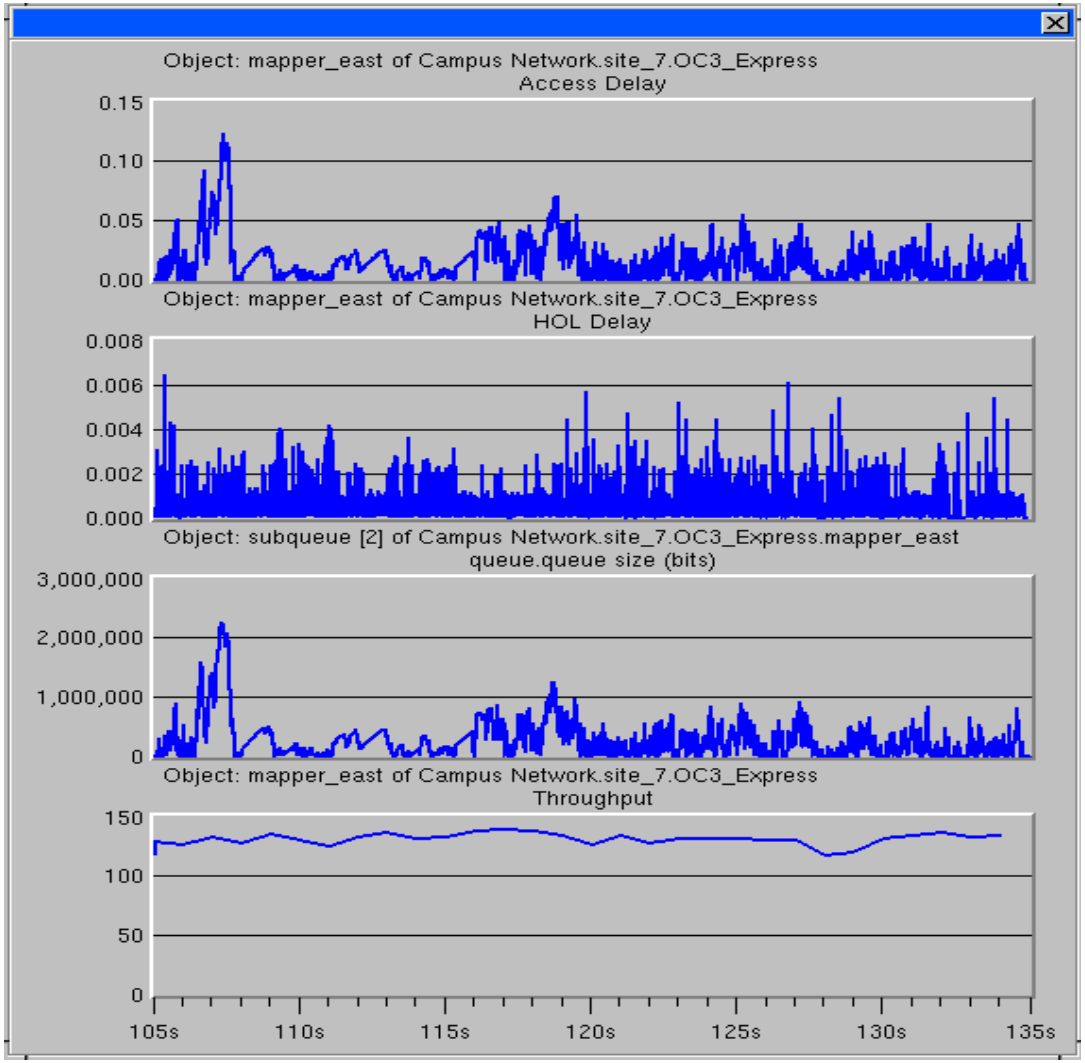

1st 5 seconds of simulation

Access Delay

- **Accumulative effect on access delay for burst**

HOL Delay

- **Order of ms**

Queue Occupancy Node 7

- **3 Mb**

Throughput

- **150Mb/s = OC-3**

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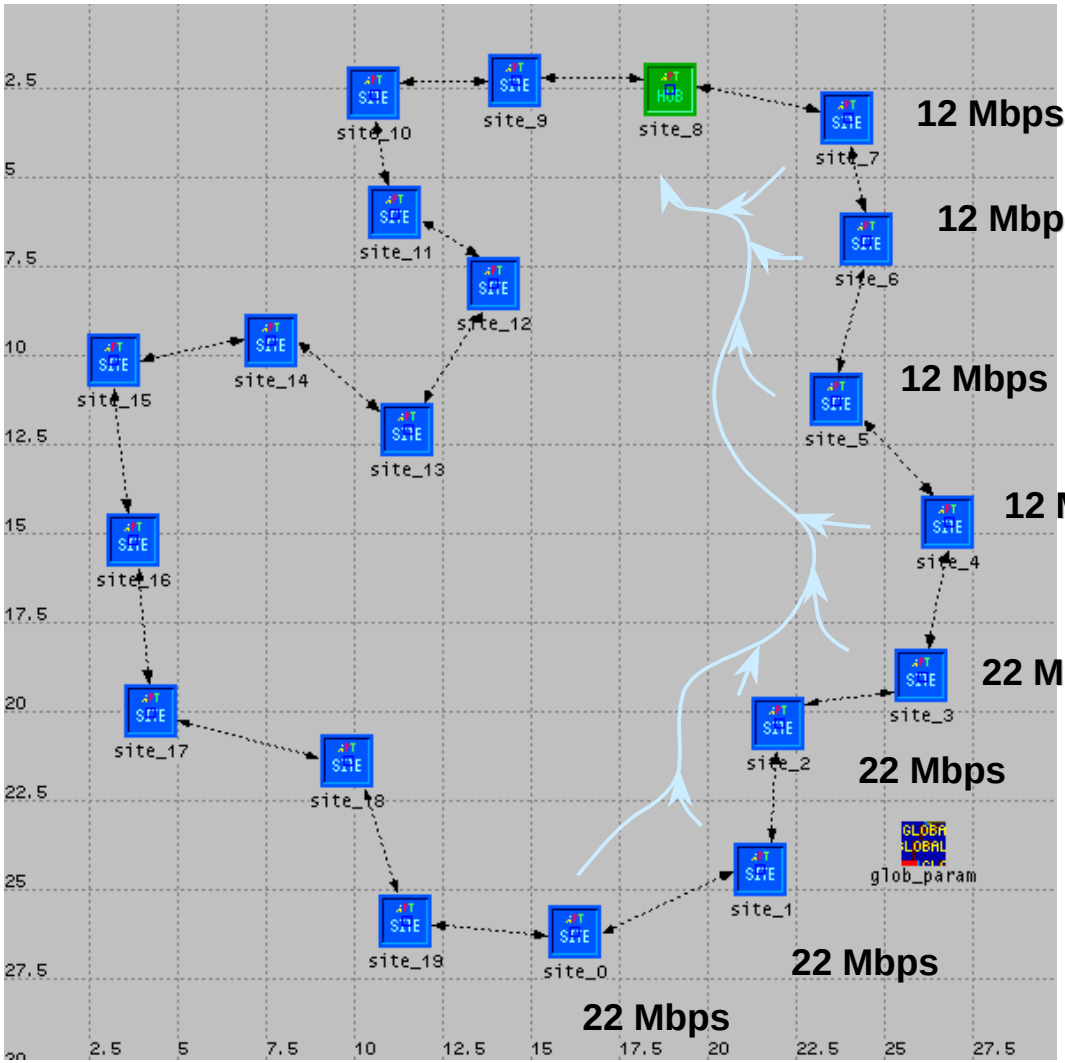
OC-3
90% Utilization Threshold



- Target Utilization 90%
- 8 nodes

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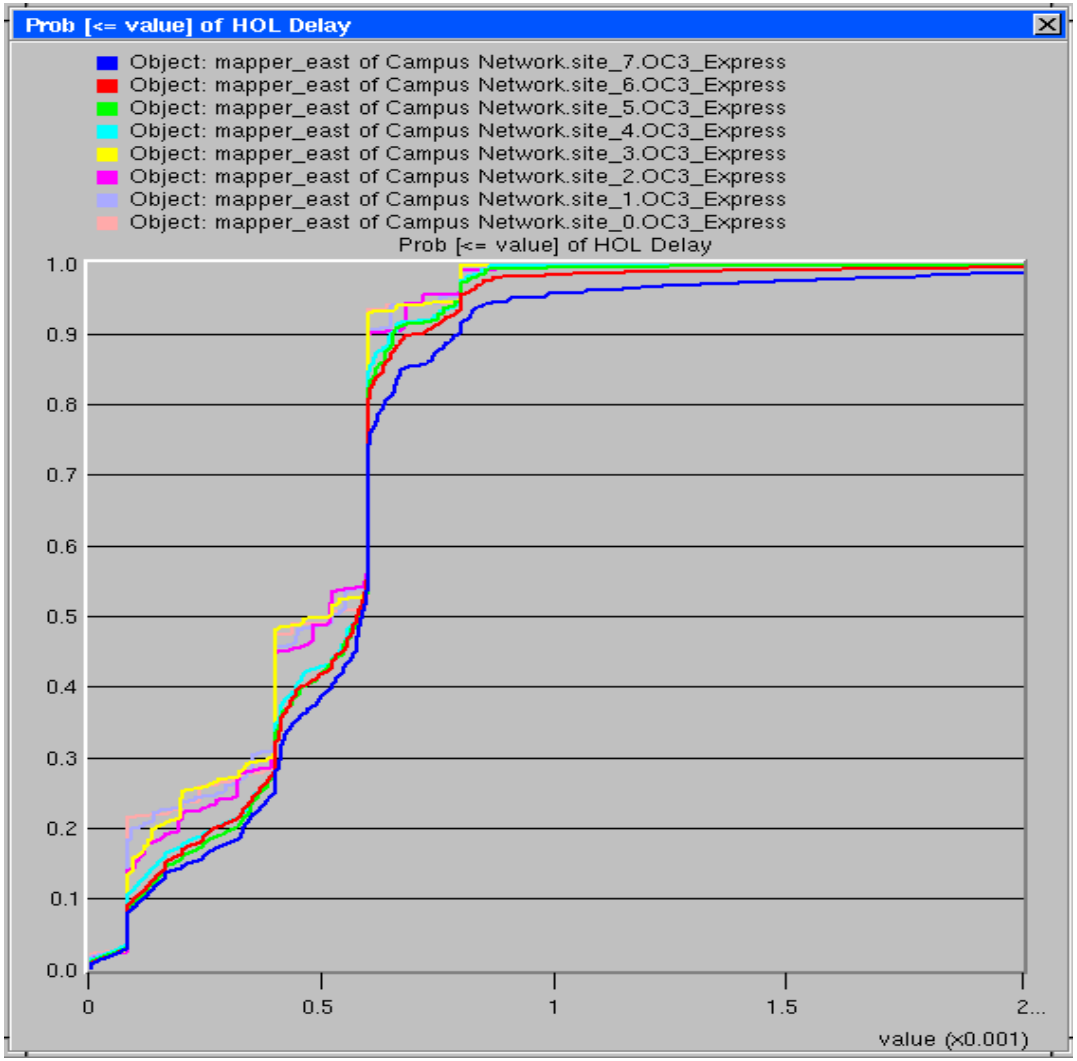
OC-3 Head of Line Delay
90% Utilization Threshold



- **Fair and equal performance**

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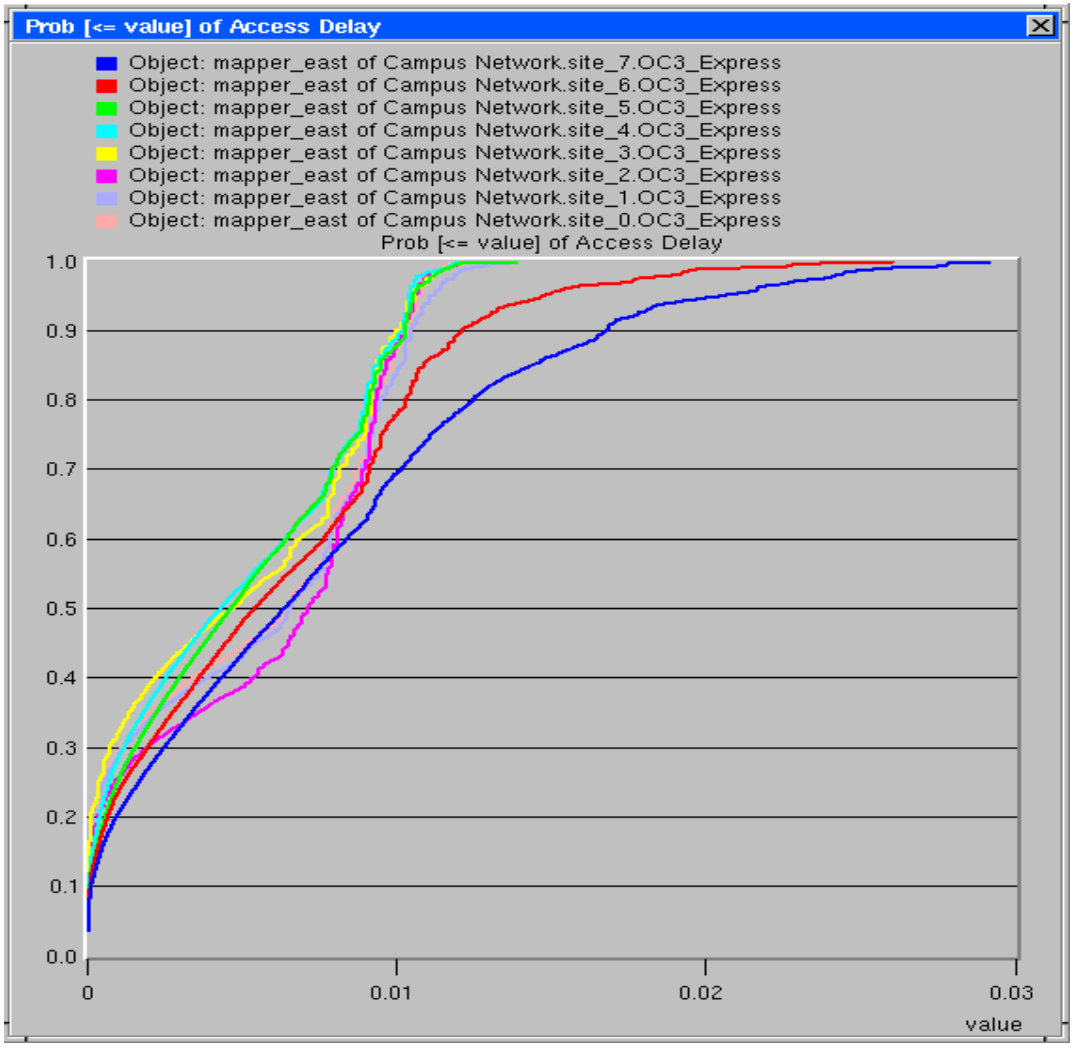
OC-3 Access Delay
90% Utilization Threshold



- **Fair and equal performance**

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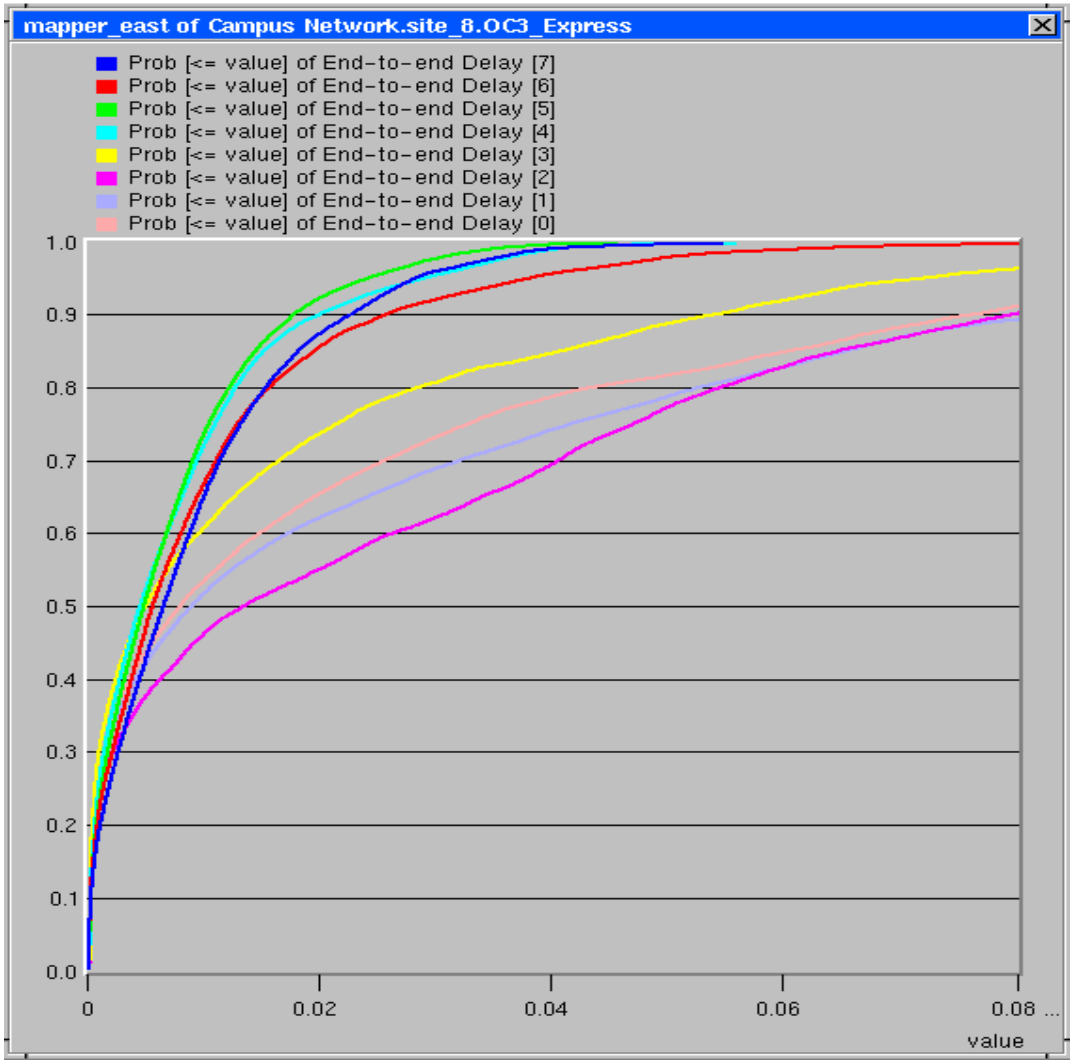
OC-3 End to End Delay
90% Utilization Threshold



CDF plot for End to End Delay

Node 0 to 3 suffers BIR effect

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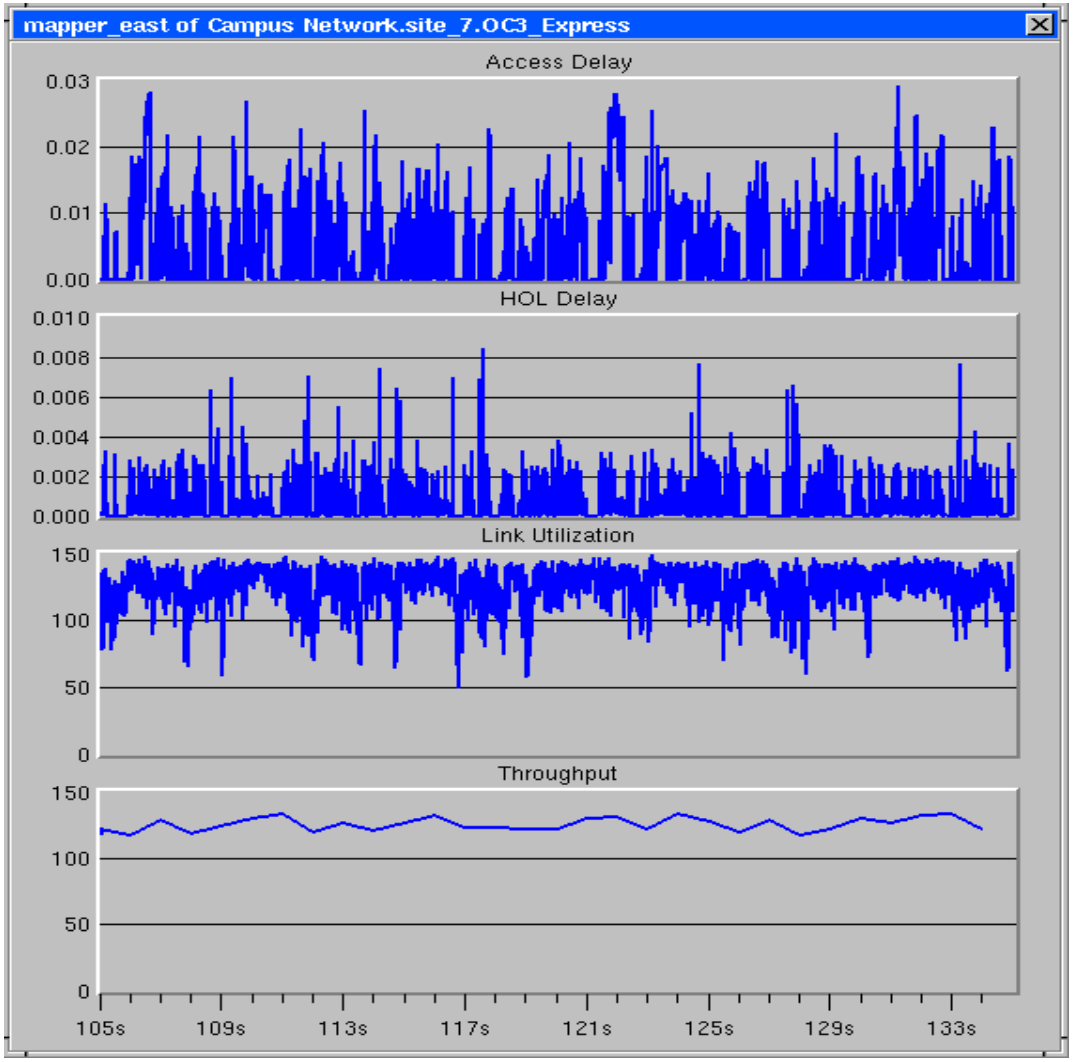
OC-3 Node 7 Internal Performance Characteristics 90% Utilization Threshold



1st 5 seconds of simulation

Access Delay

- **Accumulative effect on access delay for burst**

HOL Delay

- **Second**

Link Utilization

- **150Mb/s = OC-3**
- **High utilization**

Throughput

- **150Mb/s = OC-3**
- **Estimated**

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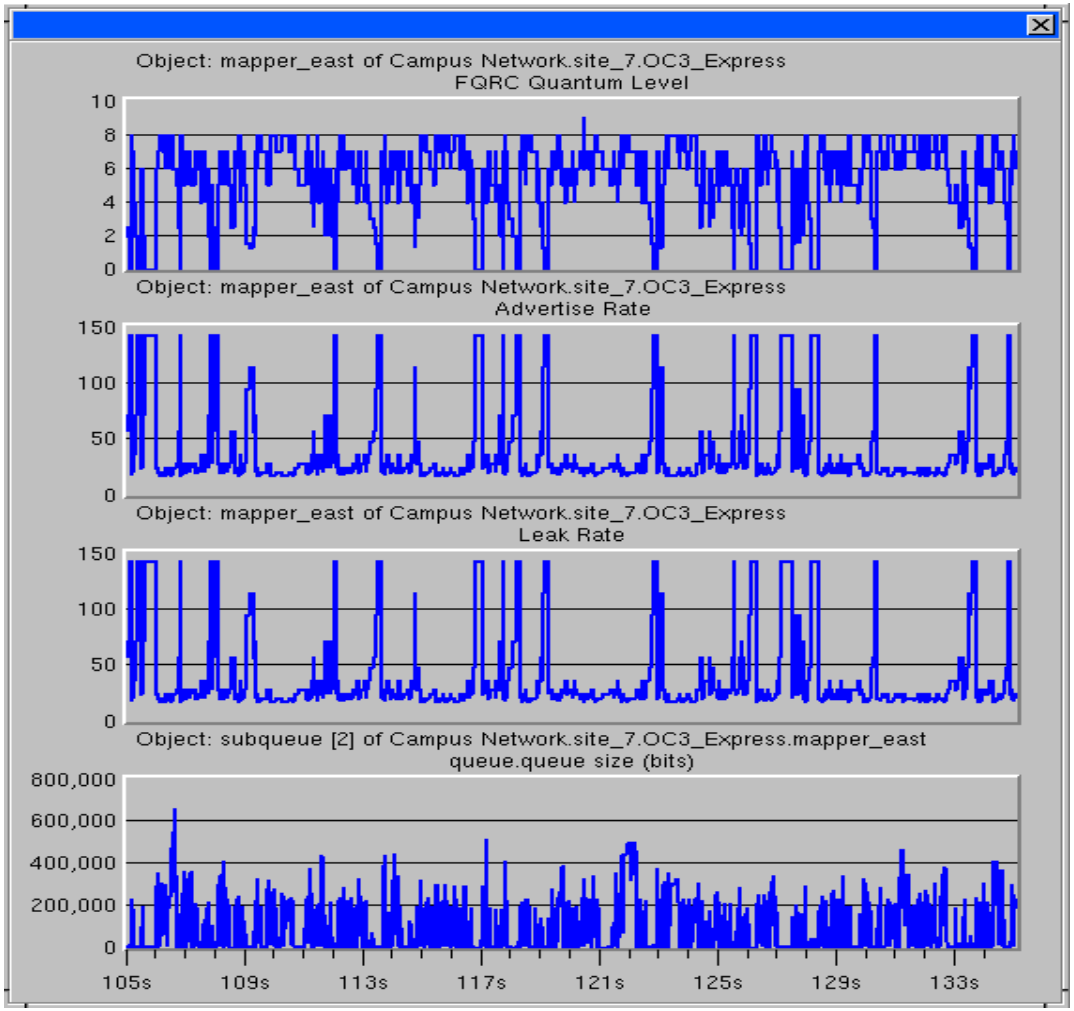
OC-3 Node 7 Internal Performance Characteristics 90% Utilization Threshold (Cont'd)



1st 5 seconds of simulation

Fairness State

- **Number of nodes in congestion span**

Advertised Rate

- **150 Mb/s**

Leak/ Add Rate

- **150Mb/s = OC-3**

iPT Node Queue Occupancy

- **0.6 Mb**
- **Bursty input**

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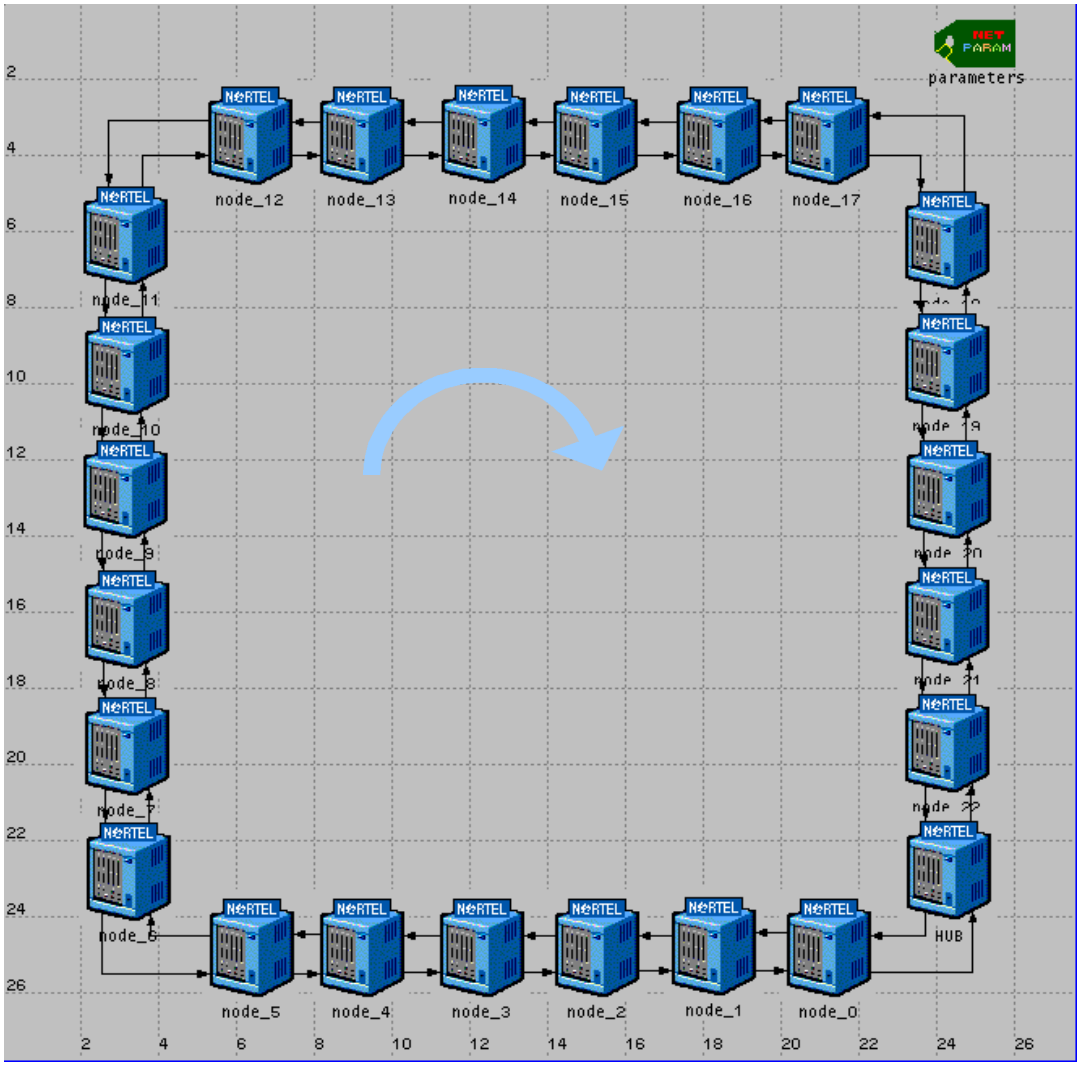
Stability Evaluation



- A simple UDP model was developed and used for a higher simulation efficiency. (models a completely congested network).
- Simulates a single routing domain.
- 24 node OC3/12c hub ring
- Node_0 starts at 5s. Each node (from node_1 to node_22) starts at every half second.
- Packet size distribution used for the UPD generator
  - 50% 64 bytes, 20% 536 bytes, 30% 1500 byte
- Message Timer Interval = 100 µs

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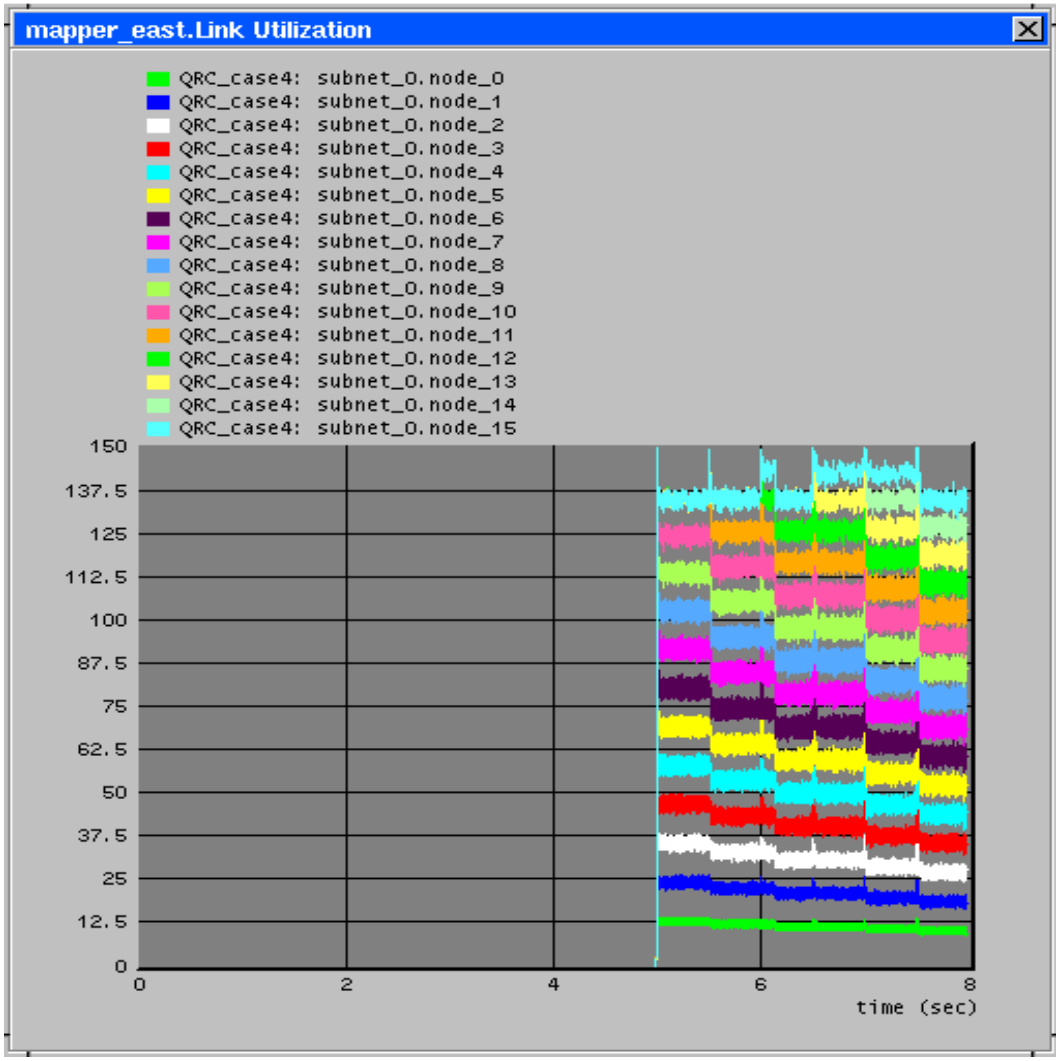
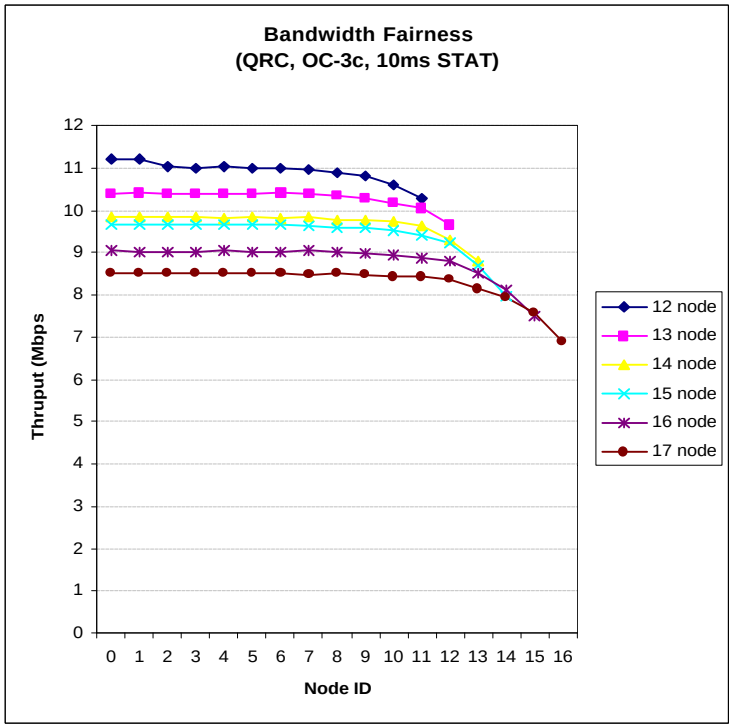
Stable for Large number of nodes and scalable





- **OC-3c link utilization**
- **Bursty leaky bucket**
- **Explicit rate control scales better (12 nodes) than the Adoptive rate.**

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Summary

- **Performance effected by**
  1. Buffer Insertion Ring Effect.
     - Head node slightly worse performance
  2. Bursty traffic pattern.
     - Heavy Tail Effect.
- **Trade-off between stability, responsiveness, delay**
  - HOL timer
  - Rate estimator
- **Scalable with WAN BW, using explicit rate advertising**
  - Better performance with fewer number of nodes
- **Achieve Fairness on real network topology.**

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What's Next

- **Higher BW simulation**
  - OC-48
  - OC-192
- **QoS support**
  - 4 ingress priorities
  - iPT CoS Fairness messages
- **Meshed traffic flow**

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