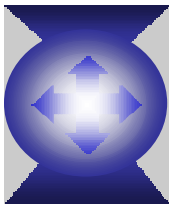


LANTERN COMMUNICATIONS

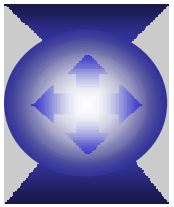
Simulation Results

IEEE 802.17

March 12-15, 2001

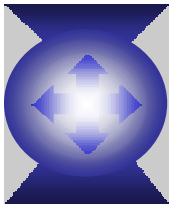
Adisak Mekkittikul
adisak@lanterncom.com

Simulation Objective



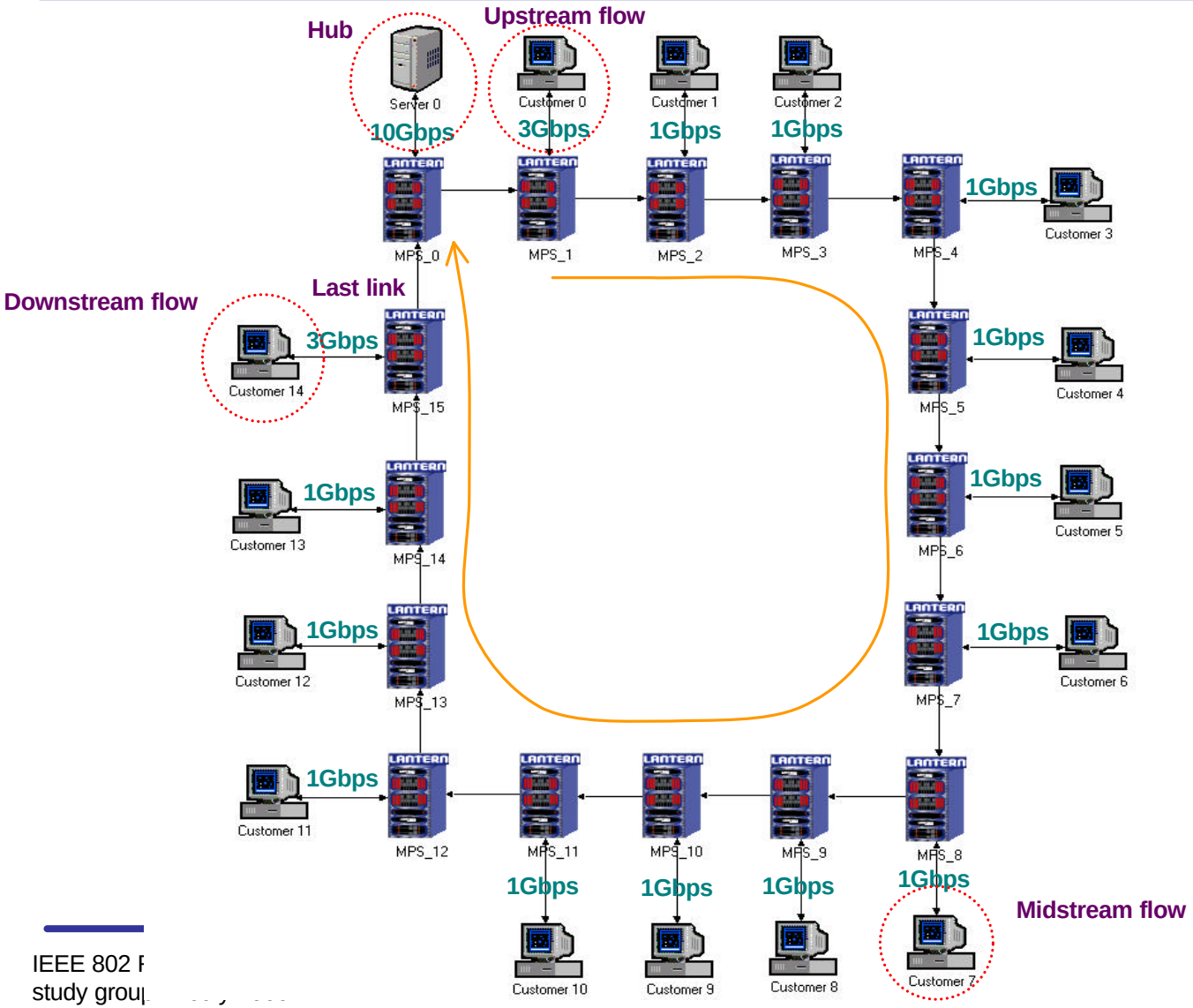
- Investigate any interaction between RPR and end-to-end flow (e.g. TCP) controls
- Quantify the effectiveness of Lantern's RPR flow control under bursty traffic
  - Delay&Jitter
  - Utilization
- Study the effectiveness of RED in reducing burstiness

Simulation Setup



- Simulation topology
  - Hubbing
- Scenarios
  - Scenario 1: One TCP flow per customer (Droptail, RED)
  - Scenario 2: UDP (conforming and non-conforming)
  - Scenario 3: Multiple customers/port
  - Scenario 4: Switch-over
- Performance metrics
  - Throughput
  - Delay and jitter
  - Upstream-downstream fairness
- Tool
  - OPNET

Topology (hubbing)



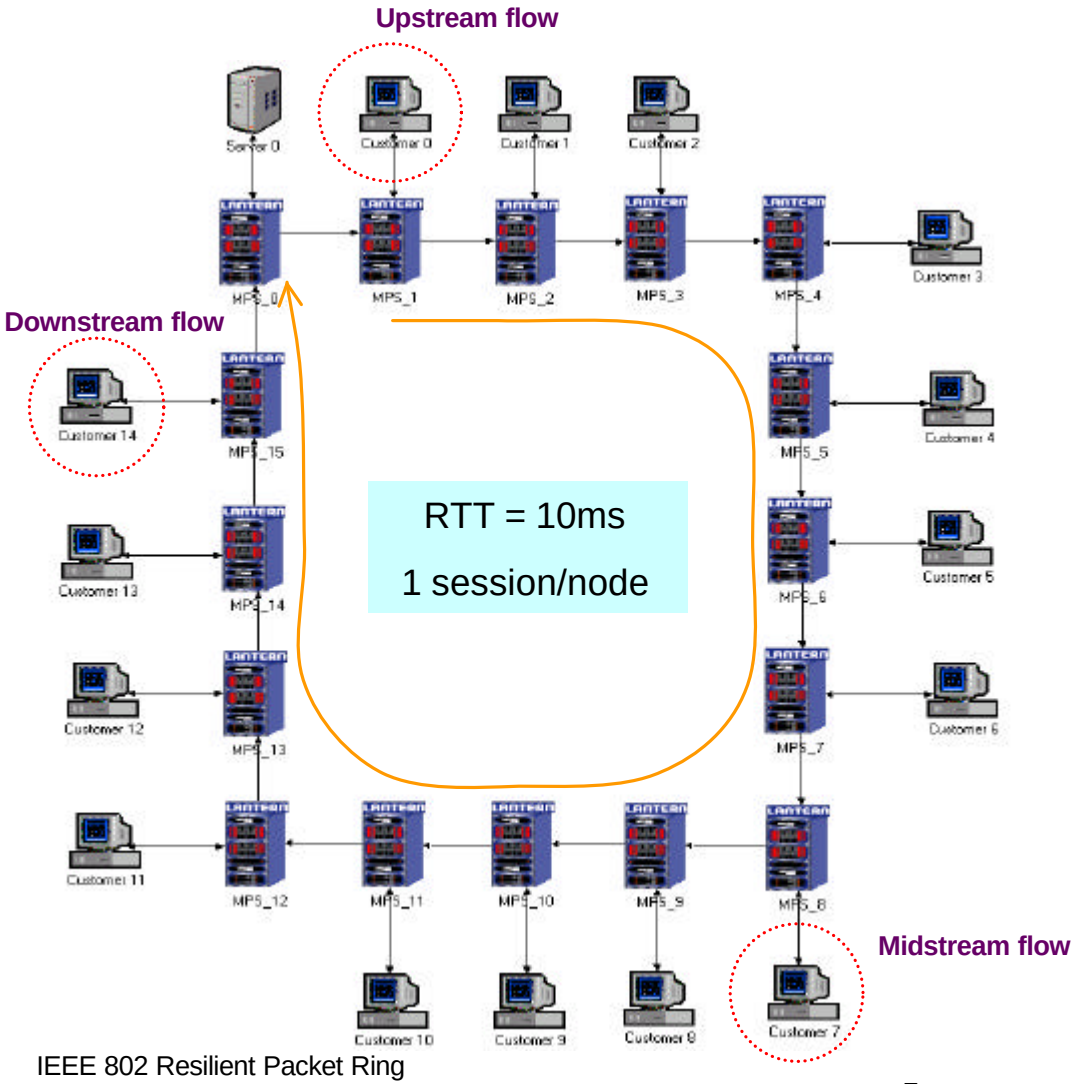
16 nodes

All nodes send to Server 0

10Gbps ring

Ring delay: 300µs (100km)

Scenario 1 (TCP with droptail)



TCP Parameters:

TCP Tahoe

Fast retransmit enabled

Fast recovery disabled

Buffer size = 2 RTT

SLA Parameters:

Customer 0 and Customer 14:

Ingress rate (max) = 3Gbps

Reserved rate = 1.5Gbps

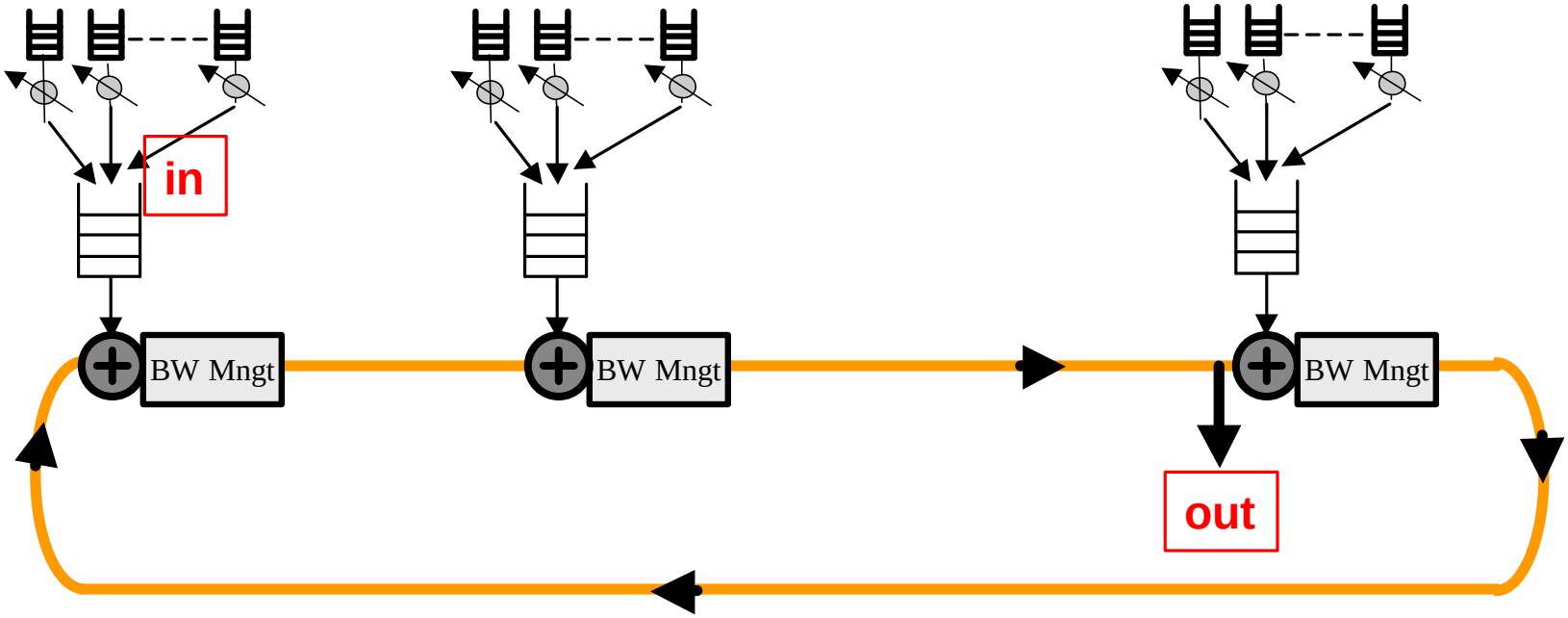
Weight = 1

Customer 1 to Customer 13:

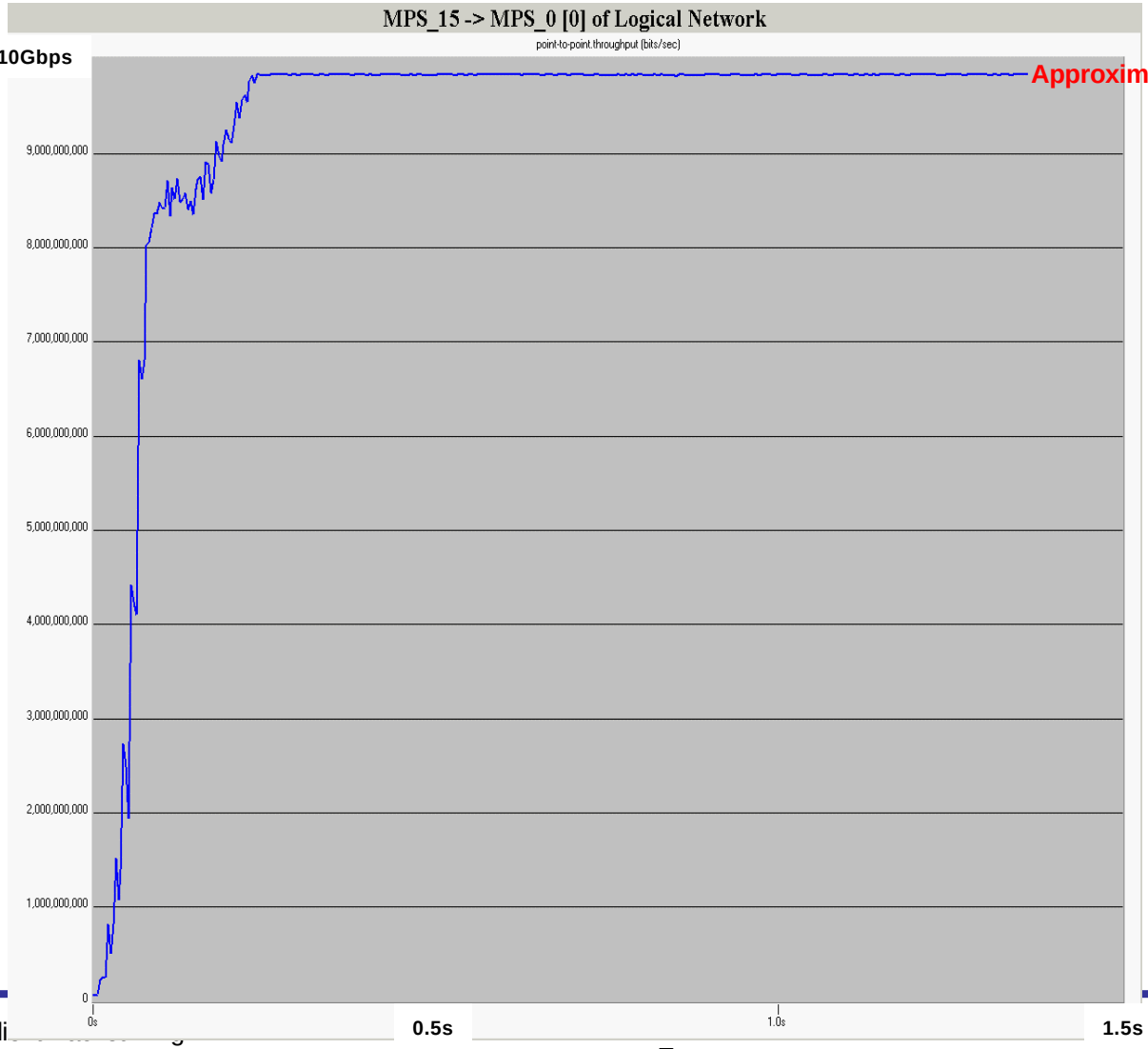
Ingress rate (max) = 1Gbps

Reserved rate = 300Mbps

Weight = 1

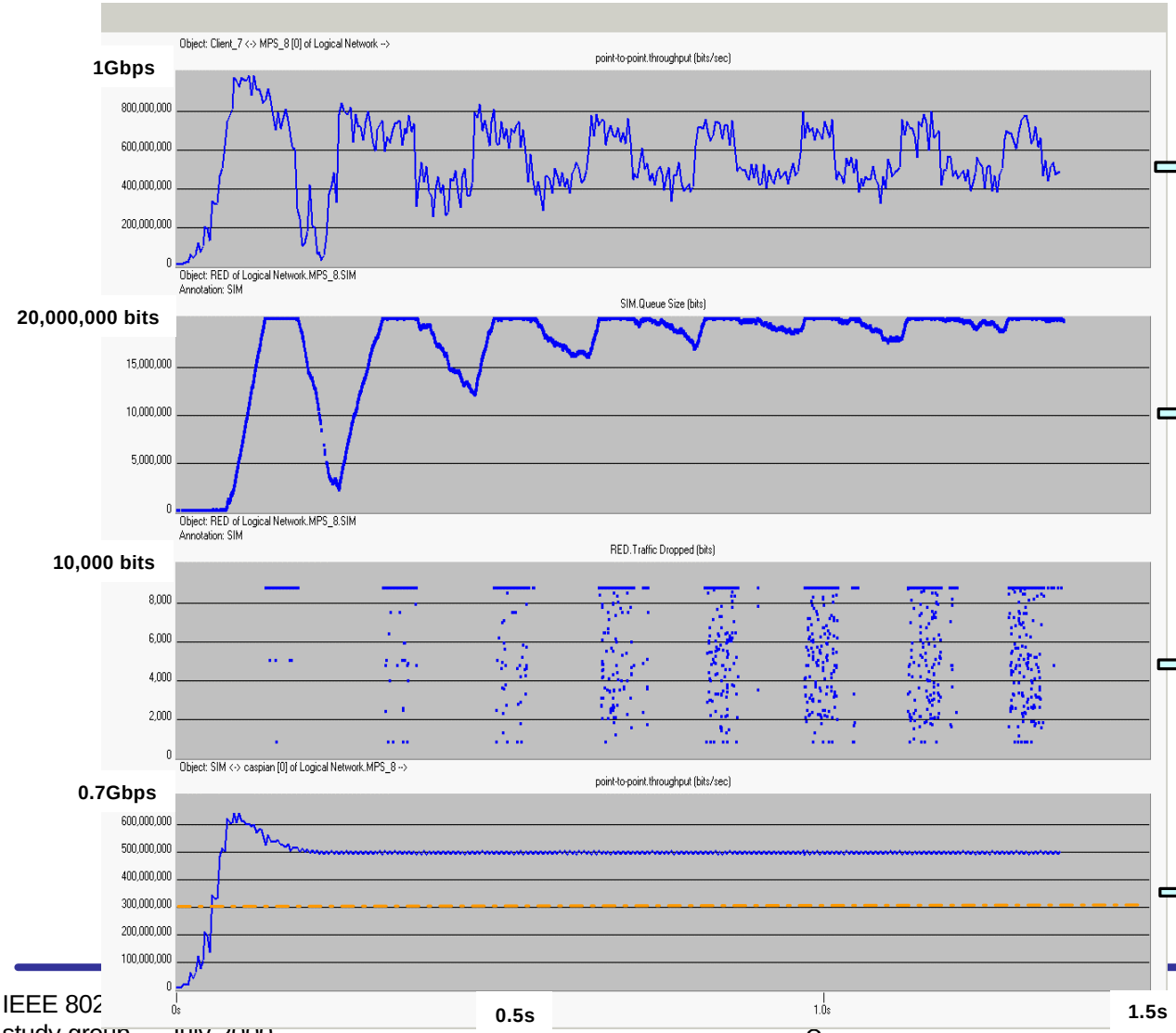

in
BW Mngt
BW Mngt
BW Mngt
out

Utilization (last link)



Per customer traffic behavior

(midstream customer)



⇨ Incoming Traffic from customer

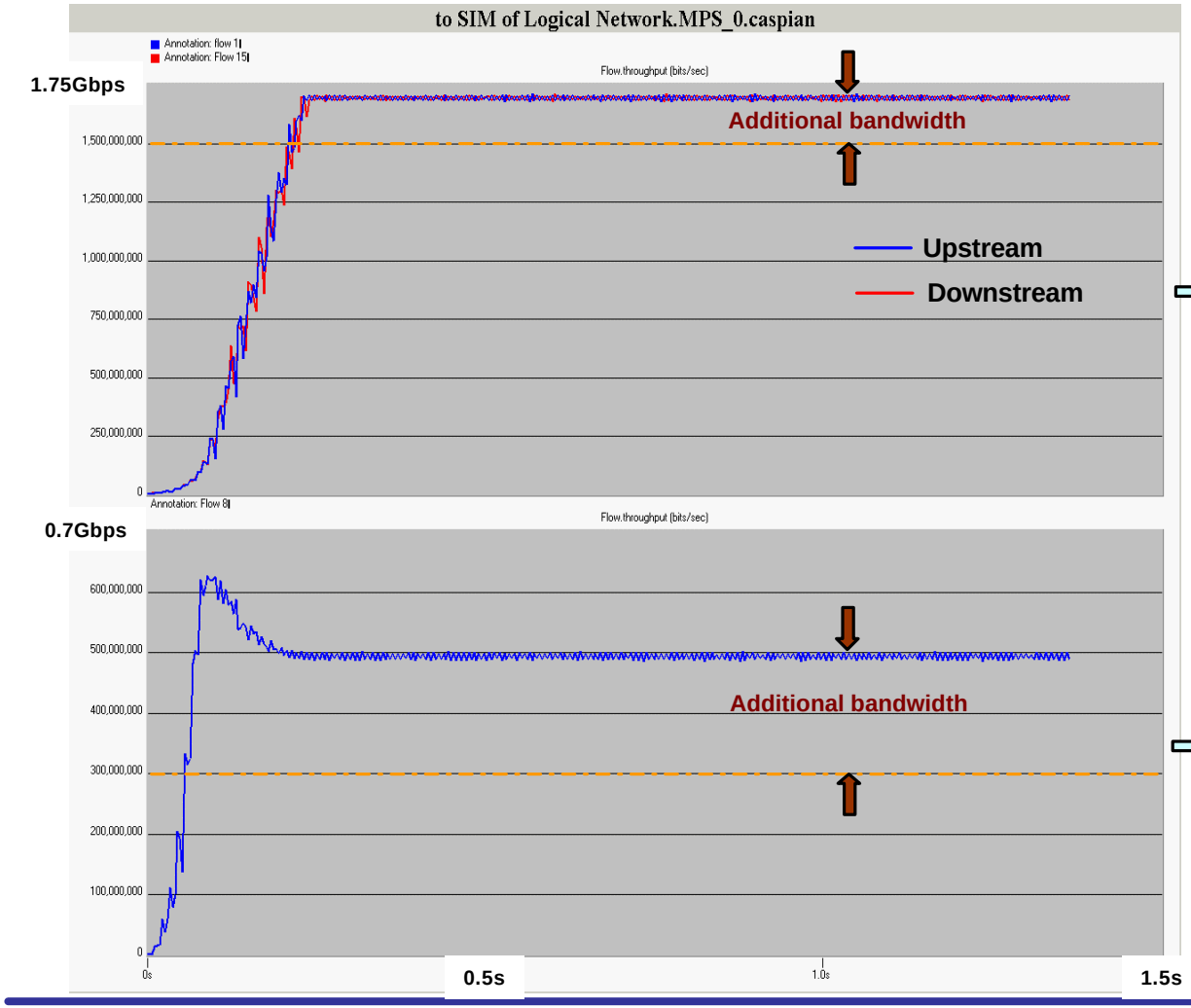
⇨ Customer buffer (droptail)

Buffer size = 20,000,000 bits

⇨ Traffic dropped

⇨ Customer service rate

Fairness (bandwidth)



Upstream & Downstream flows

Reserved rate = 1.5Gbps

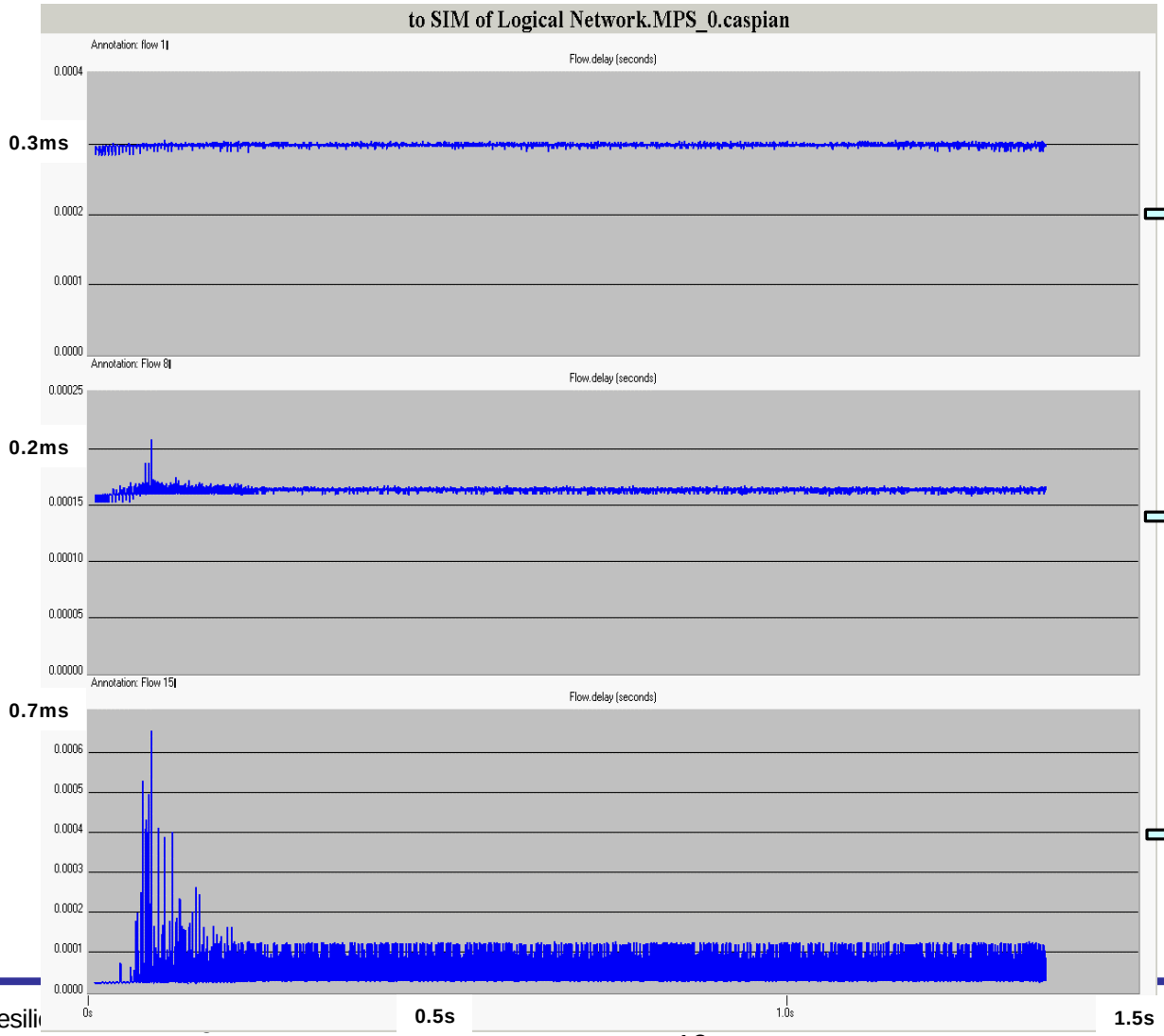
Weight = 1

Midstream flow

Reserved rate = 300Mbps

Weight = 1

Fairness (delay and jitter)

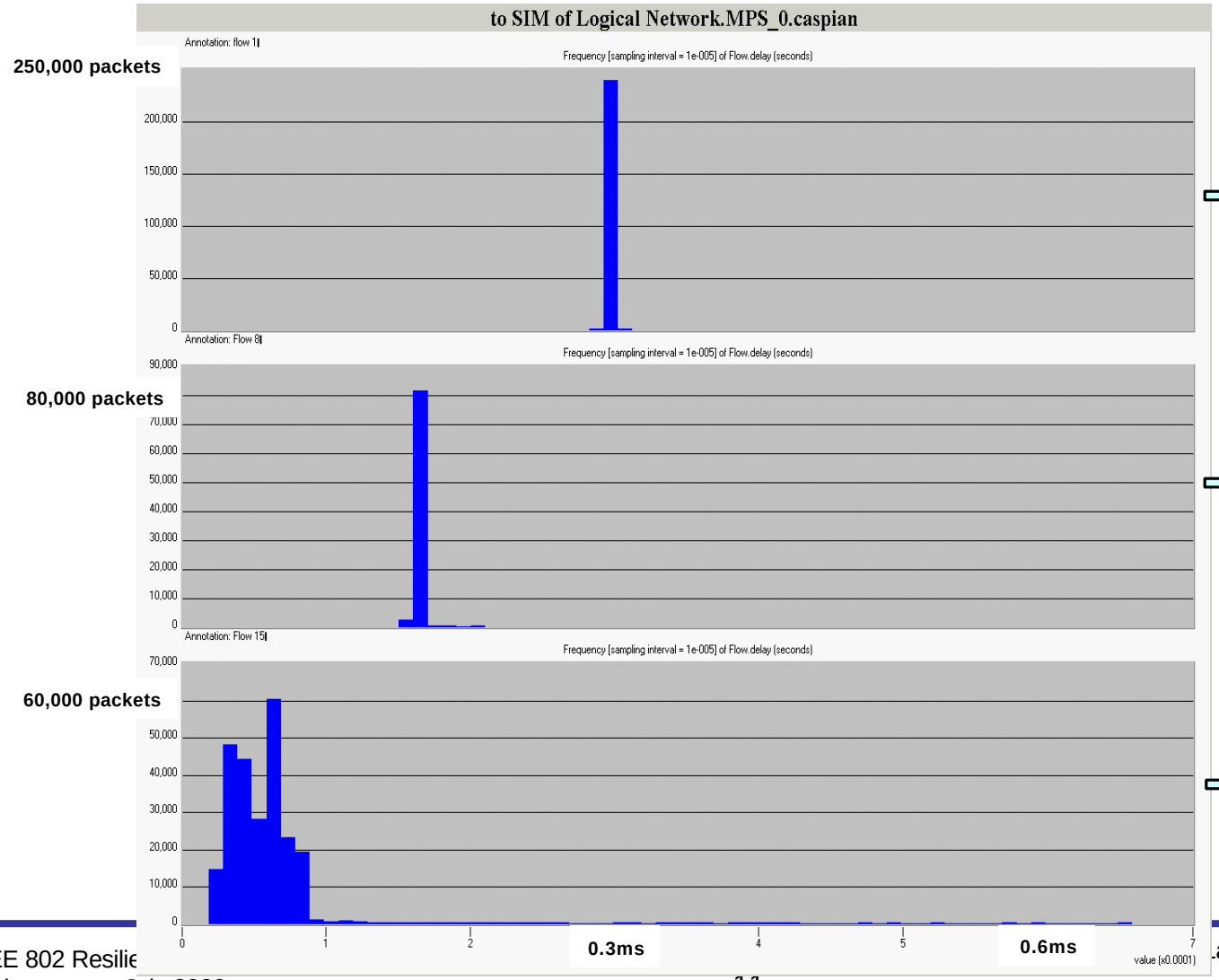


⇨ Upstream flow

⇨ Midstream flow

⇨ Downstream flow

Histogram (delay)

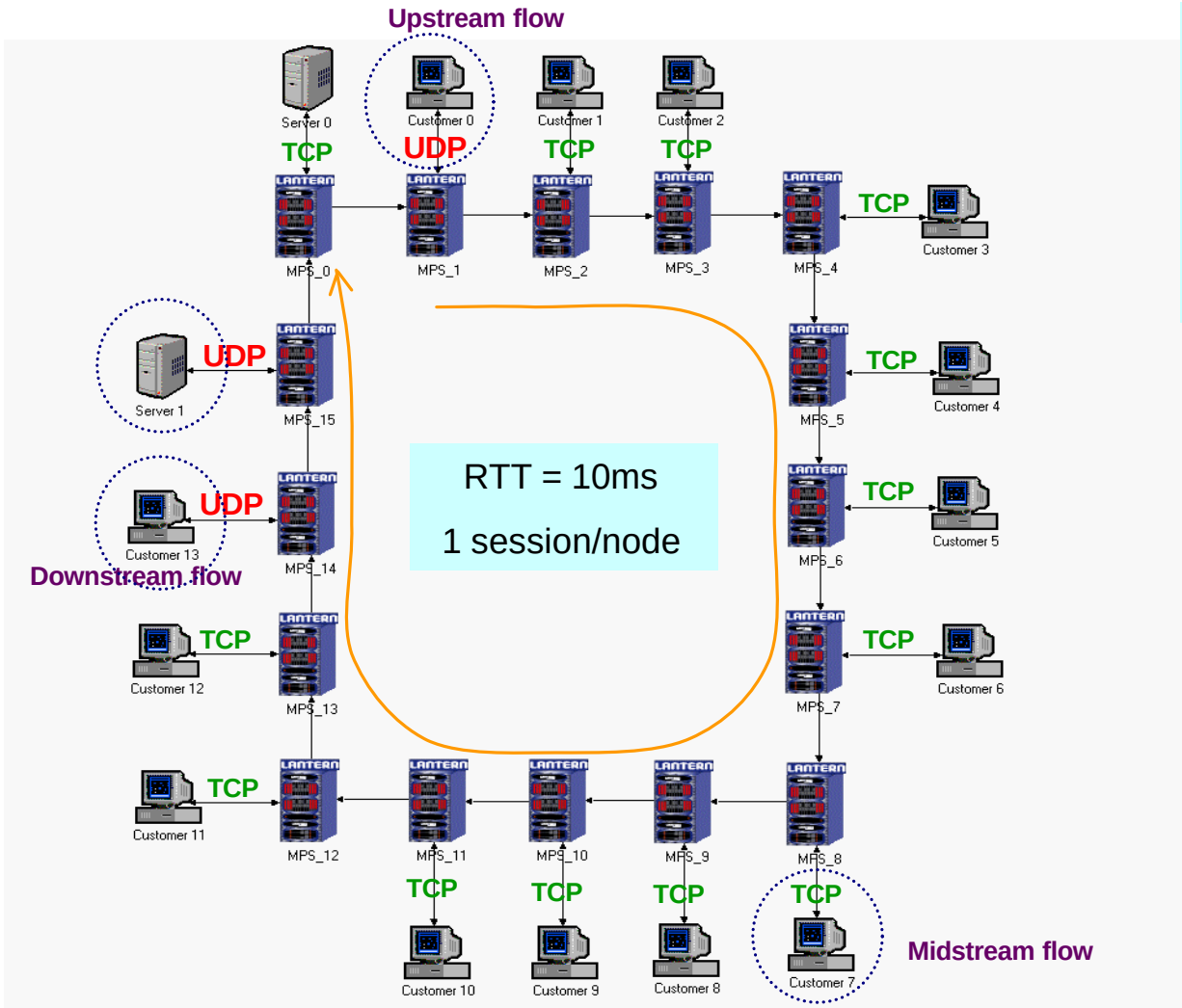


⇨ Upstream flow

⇨ Midstream flow

⇨ Downstream flow

Scenario 2 (UDP with bursty TCP)



TCP Parameters:

TCP Tahoe

Fast retransmit enabled

Fast recovery disabled

Buffer size = 2 RTT, ¼ RTT, $^1/_8$ RTT

SLA Parameters:

Customer 0 and Customer 13:

Ingress rate = 1.5Gbps (UDP)

reserved rate = 1.5Gbps

Weight = 1

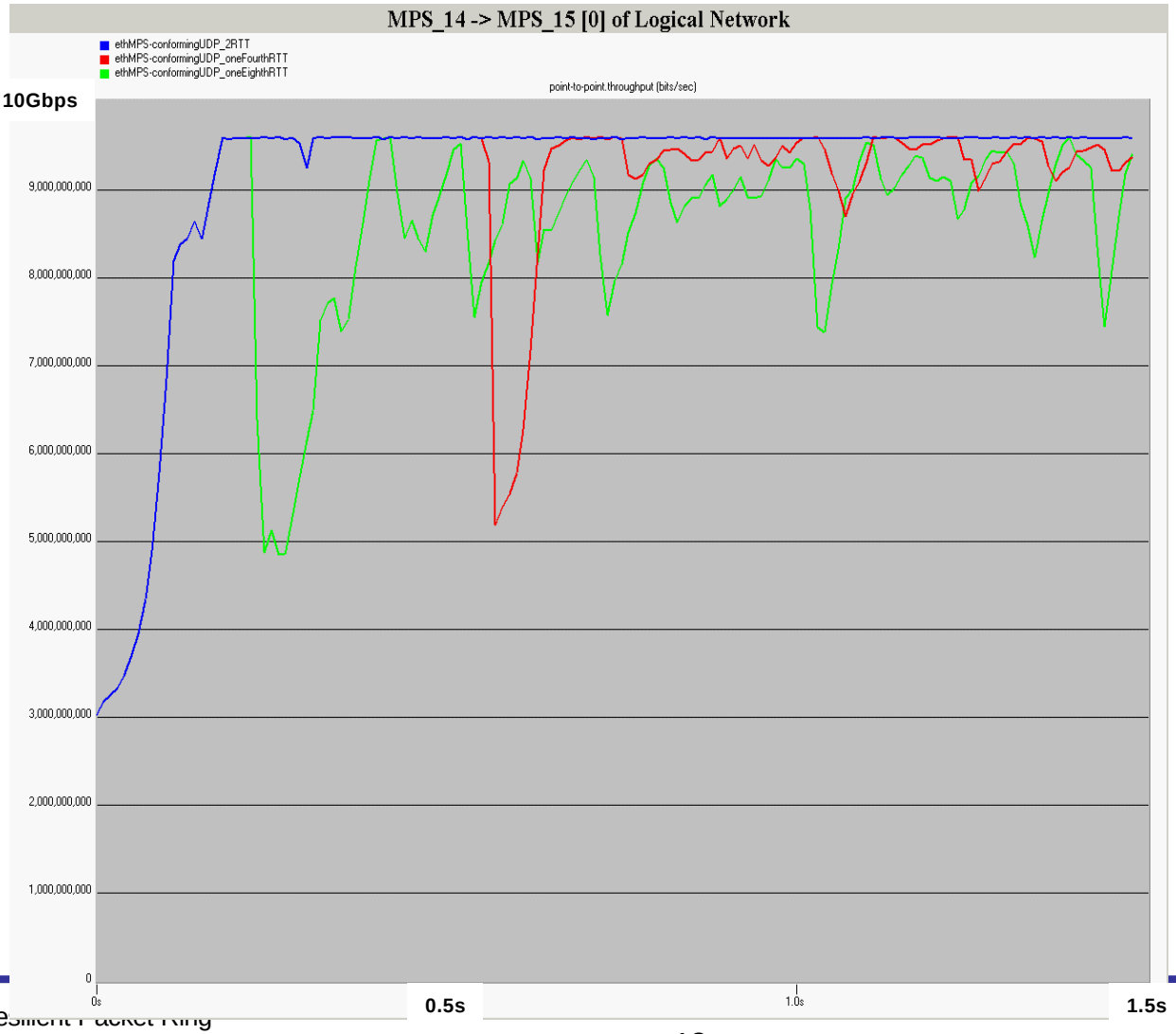
Customer 1 to Customer 12:

Ingress rate (max) = 1Gbps (TCP)

Reserved rate = 300Mbps

Weight = 1

Utilization (last link)



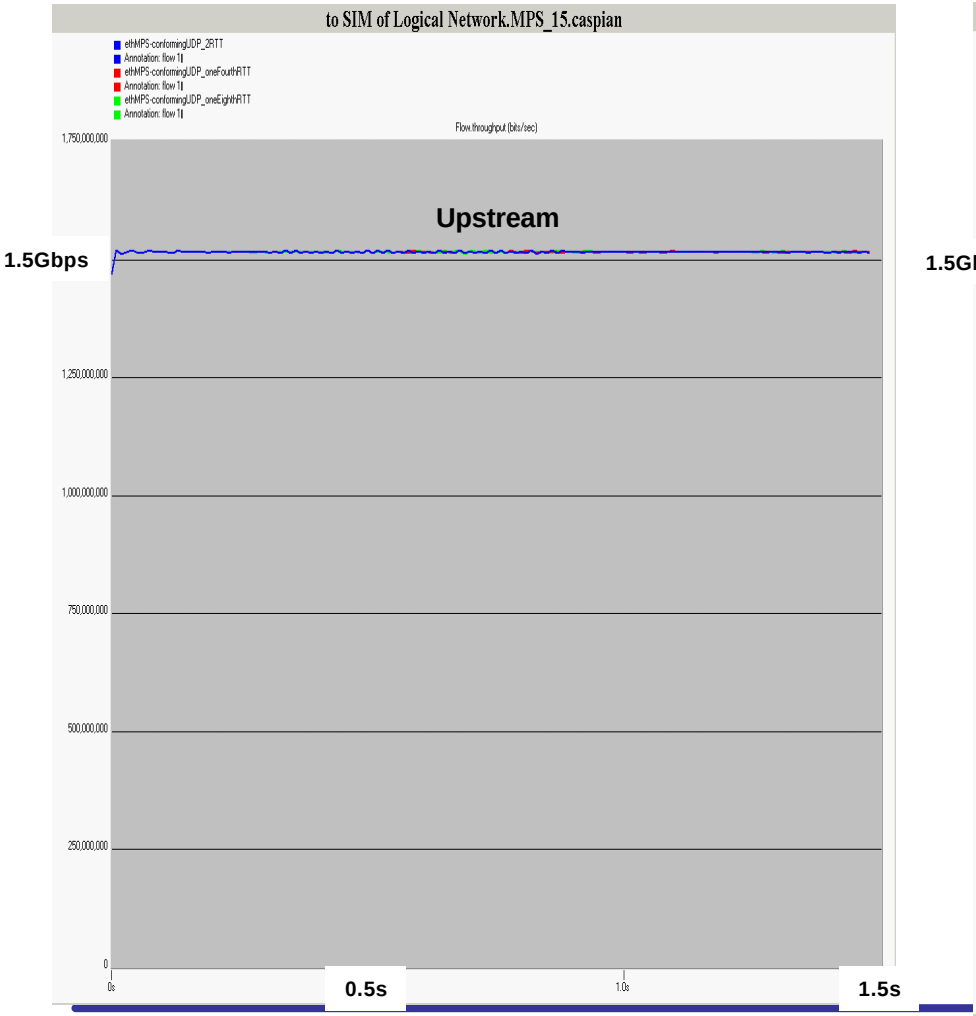
Buffer size = 2RTT

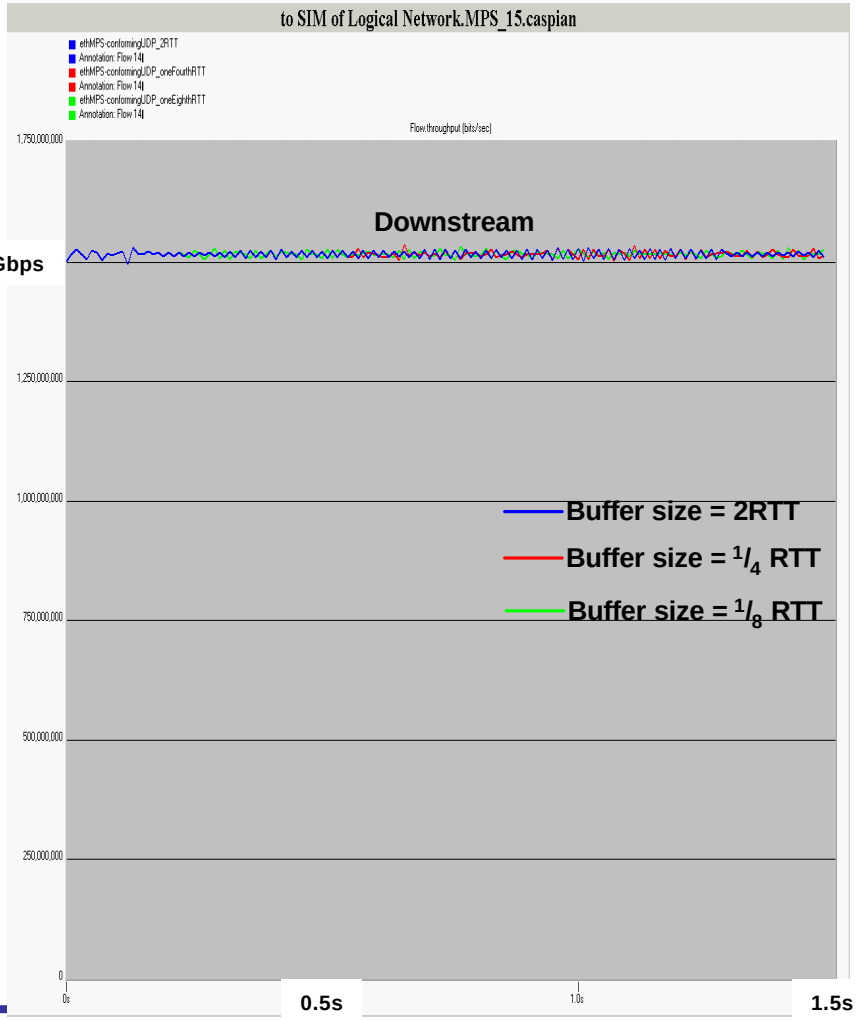
Buffer size = $^1/_4$ RTT

Buffer size = $^1/_8$ RTT

Fairness (bandwidth)

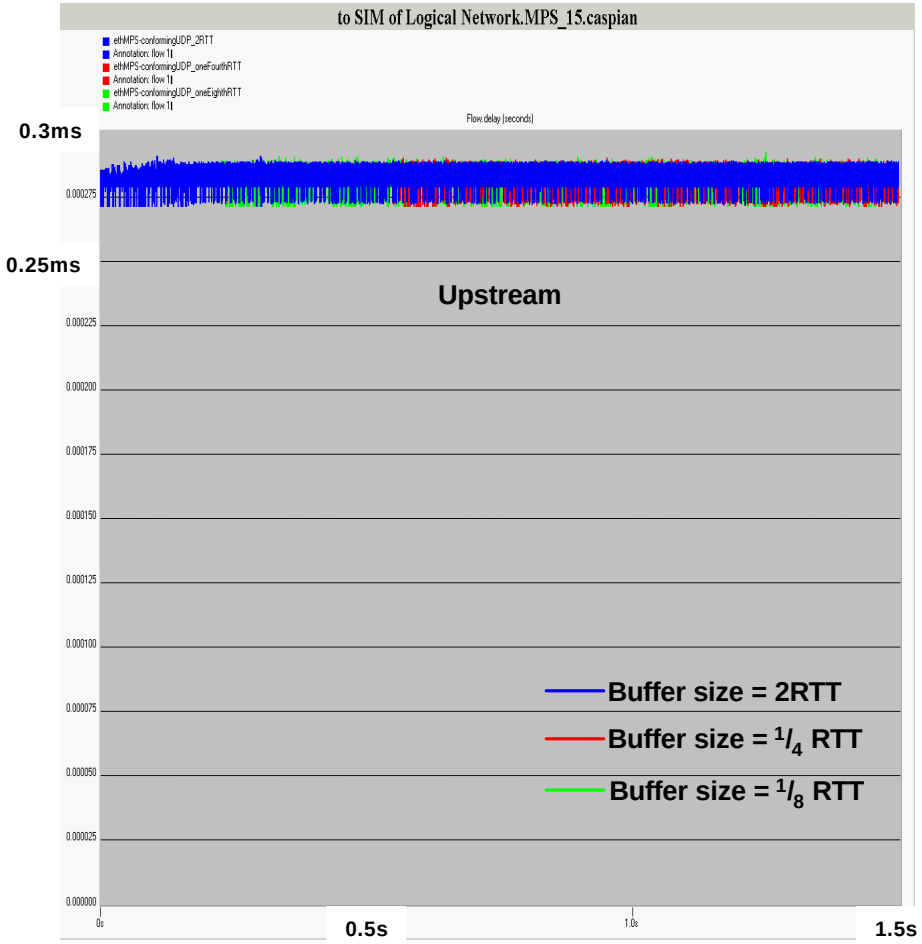
(Upstream and downstream conforming UDP flows)

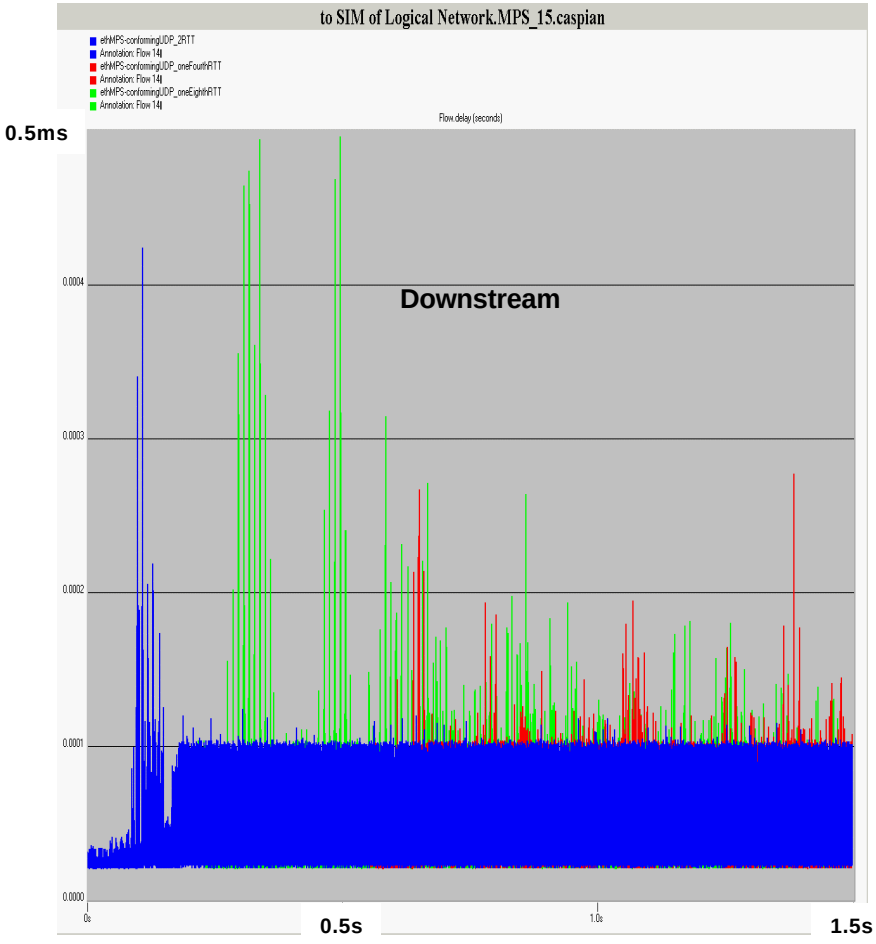




Delay

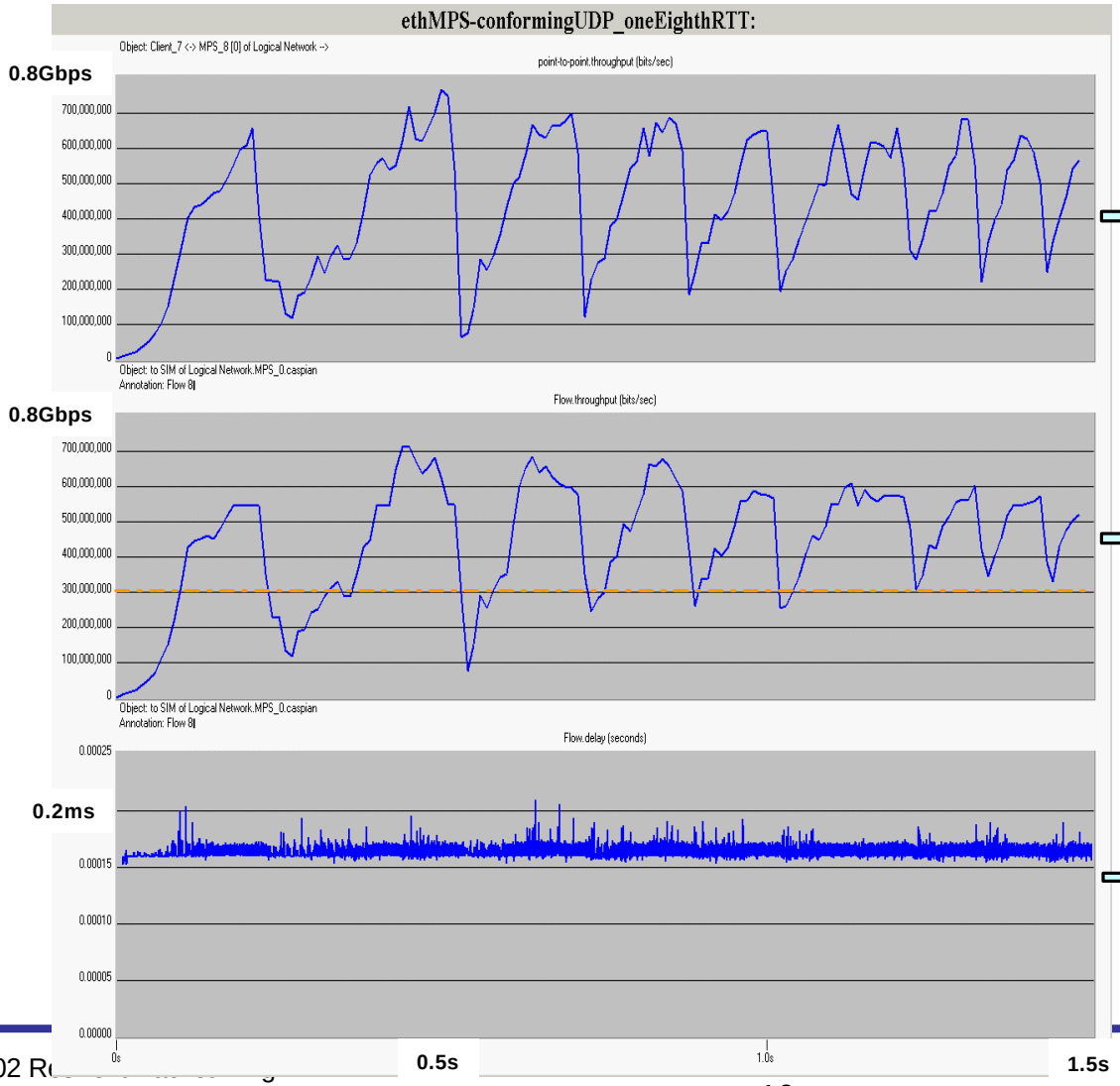
(Upstream and downstream conforming UDP flows)





Fairness

(Midstream bursty TCP flow)

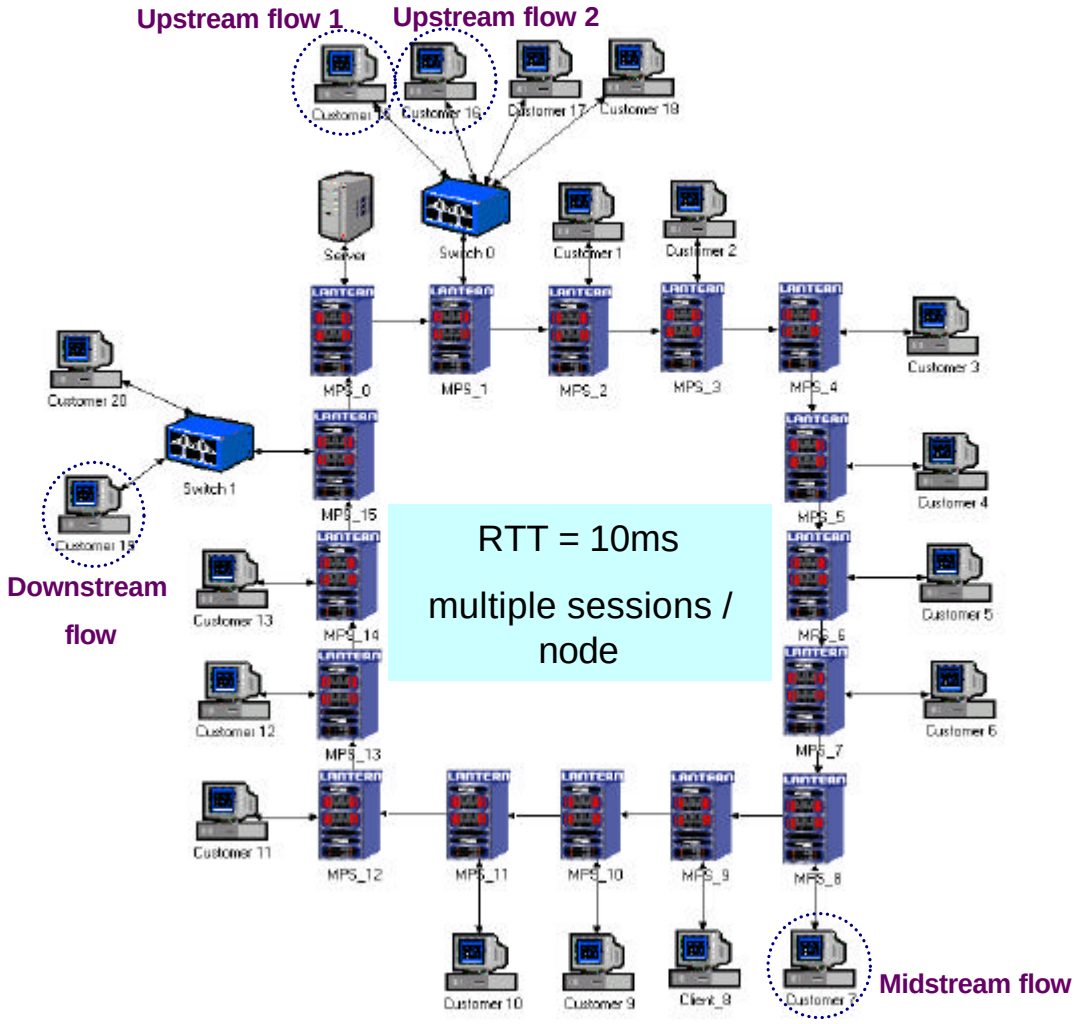


Incoming traffic from customer

Customer service rate

Delay

Scenario 3 (multiple flows)



TCP Parameters:

TCP Tahoe

Fast retransmit enabled

Fast recovery disabled

Buffer size = 2 RTT

SLA Parameters:

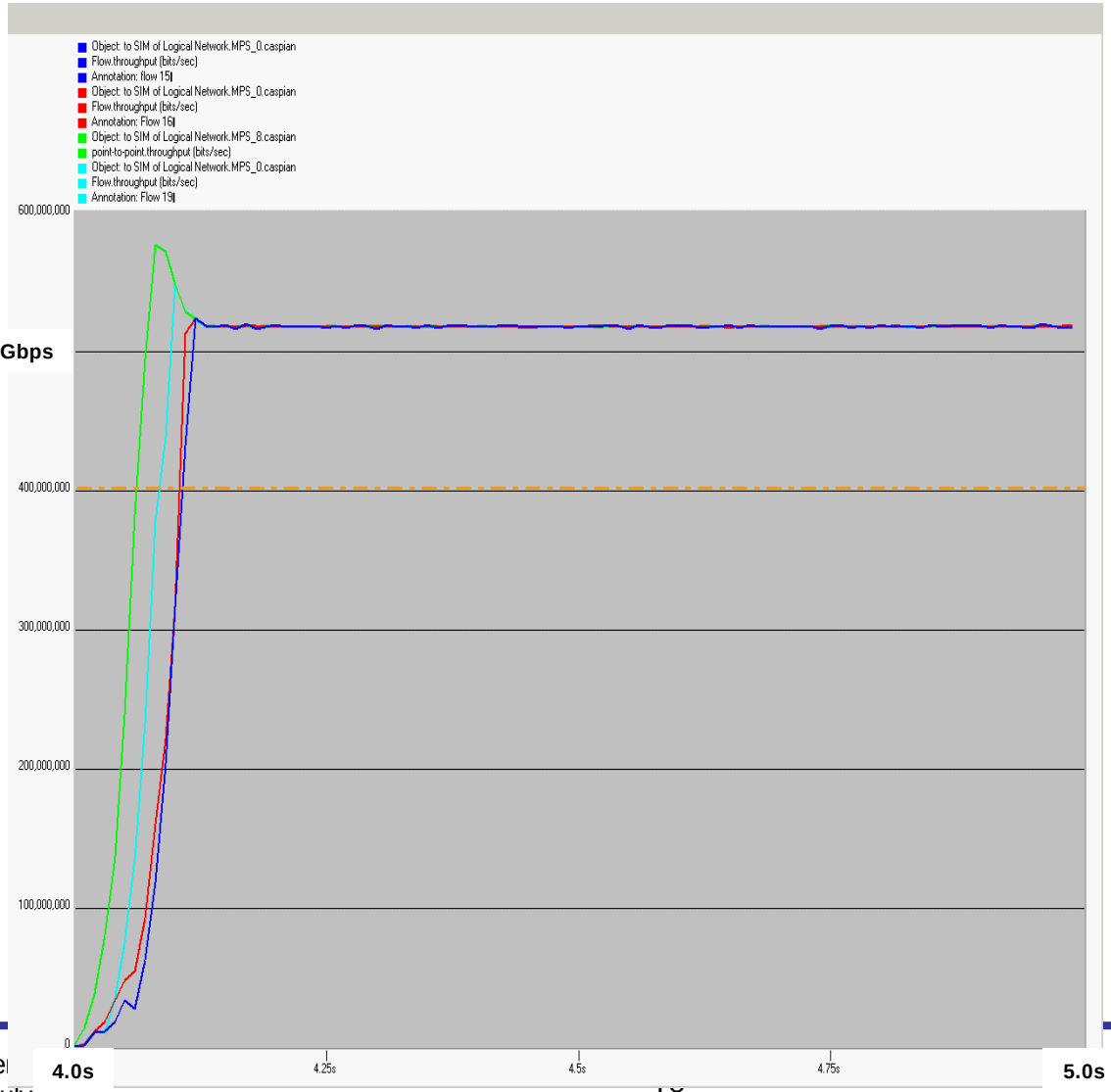
Customer 1 and Customer 20:

Ingress rate (max) = 10Gbps

Reserved rate = 0.4Gbps

Weight = 1

Fairness (bandwidth)



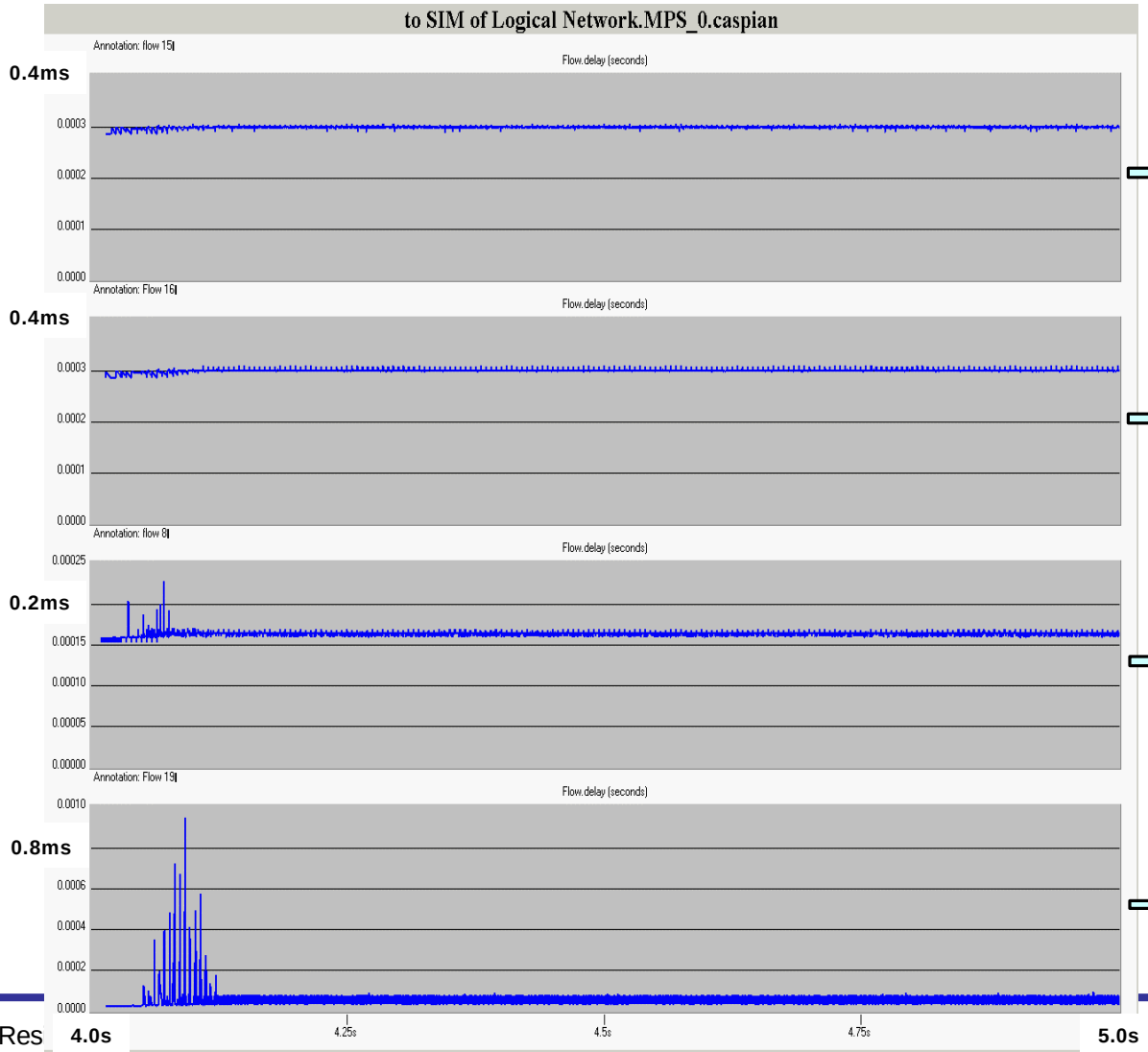
Upstream flow 1

Upstream flow 2

Midstream flow

Downstream flow

Fairness (delay and jitter)



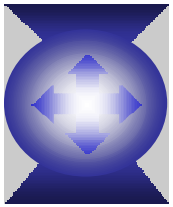
⇨ Upstream flow 1

⇨ Upstream flow 2

⇨ Midstream flow

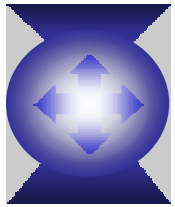
⇨ Downstream flow

Results Highlight

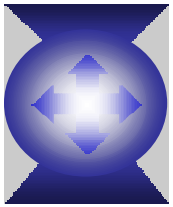


- Lantern's flow control does not interfere with TCP
- QoS guarantee still holds under bursty traffic.
- Fairness strictly maintained even when traffic is bursty.
- High link utilization (95-98%) is achieved with no compromise on QoS performance.
- No locality dependency (upstream/downstream, sharing node/port, etc)

Observation

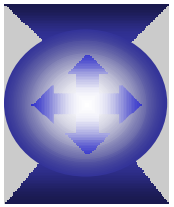


- Lantern's flow control converges much faster than TCP end-to-end flow control, so there is no interference between them.
- Fast converging flow control also minimizes the impact of bursty traffic on the other conforming traffic (delay&jitter).
- RED and/or more buffer space help absorb burst



Additional Slides

Scenario 1 (TCP with RED)



RED Parameters:

Buffer size = 2 RTT

Maximum threshold = 2 RTT

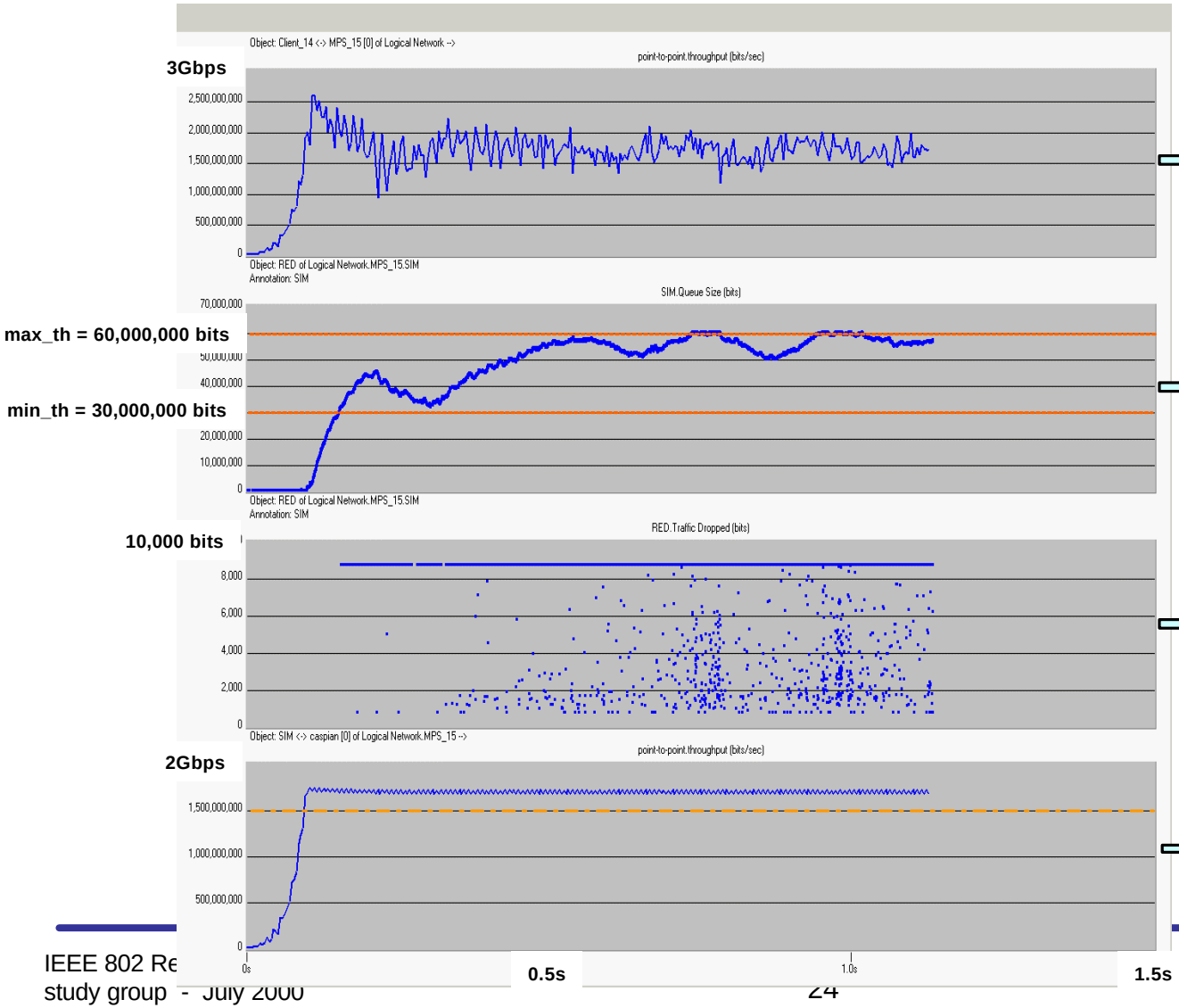
Minimum threshold = RTT

Maximum drop probability = 0.02

Averaging weight = 1.0

Per customer traffic behavior

(downstream customer)



⇨ Incoming Traffic from customer

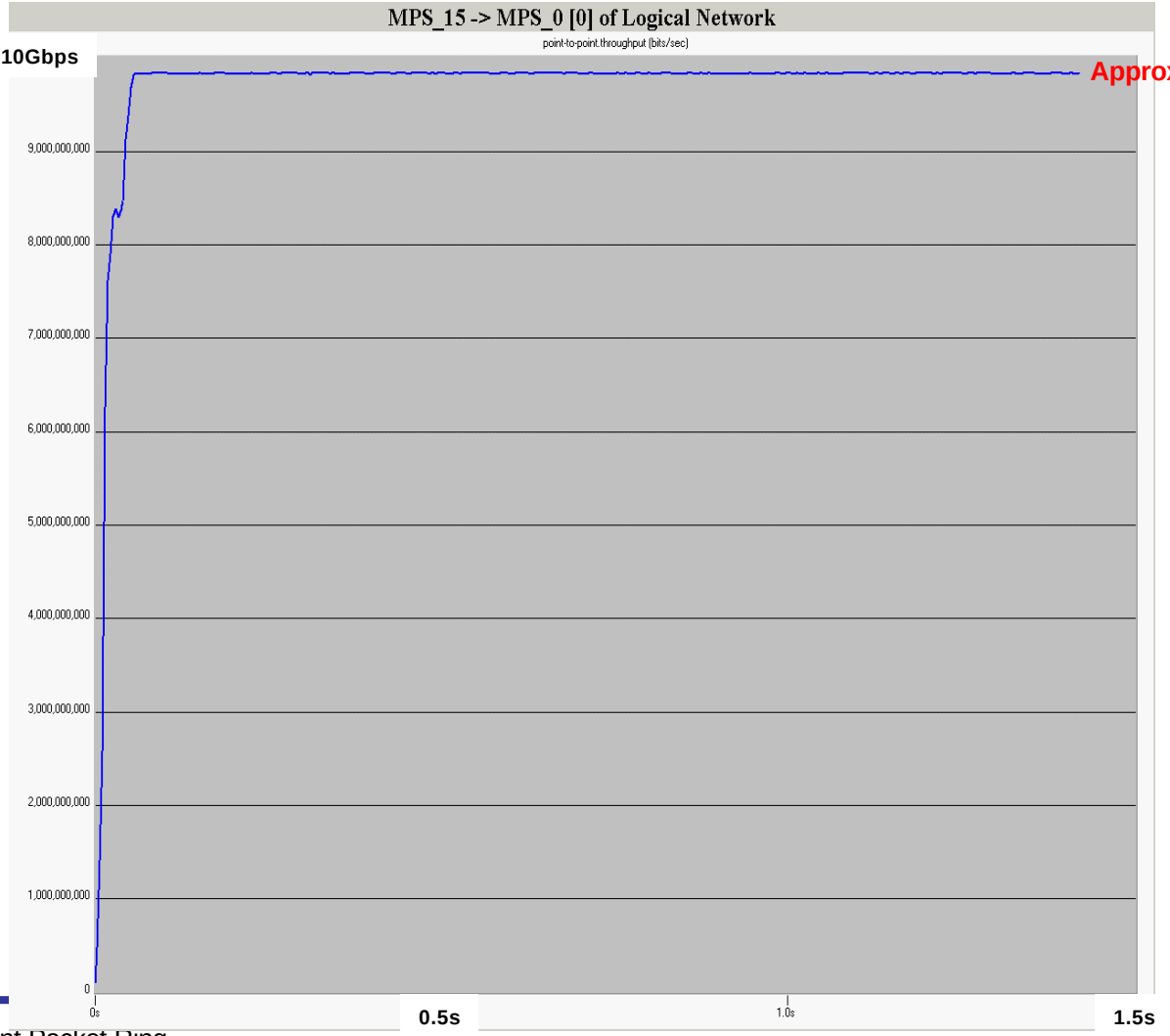
⇨ Customer buffer (RED)

Buffer size = 60,000,000 bits

⇨ Traffic dropped

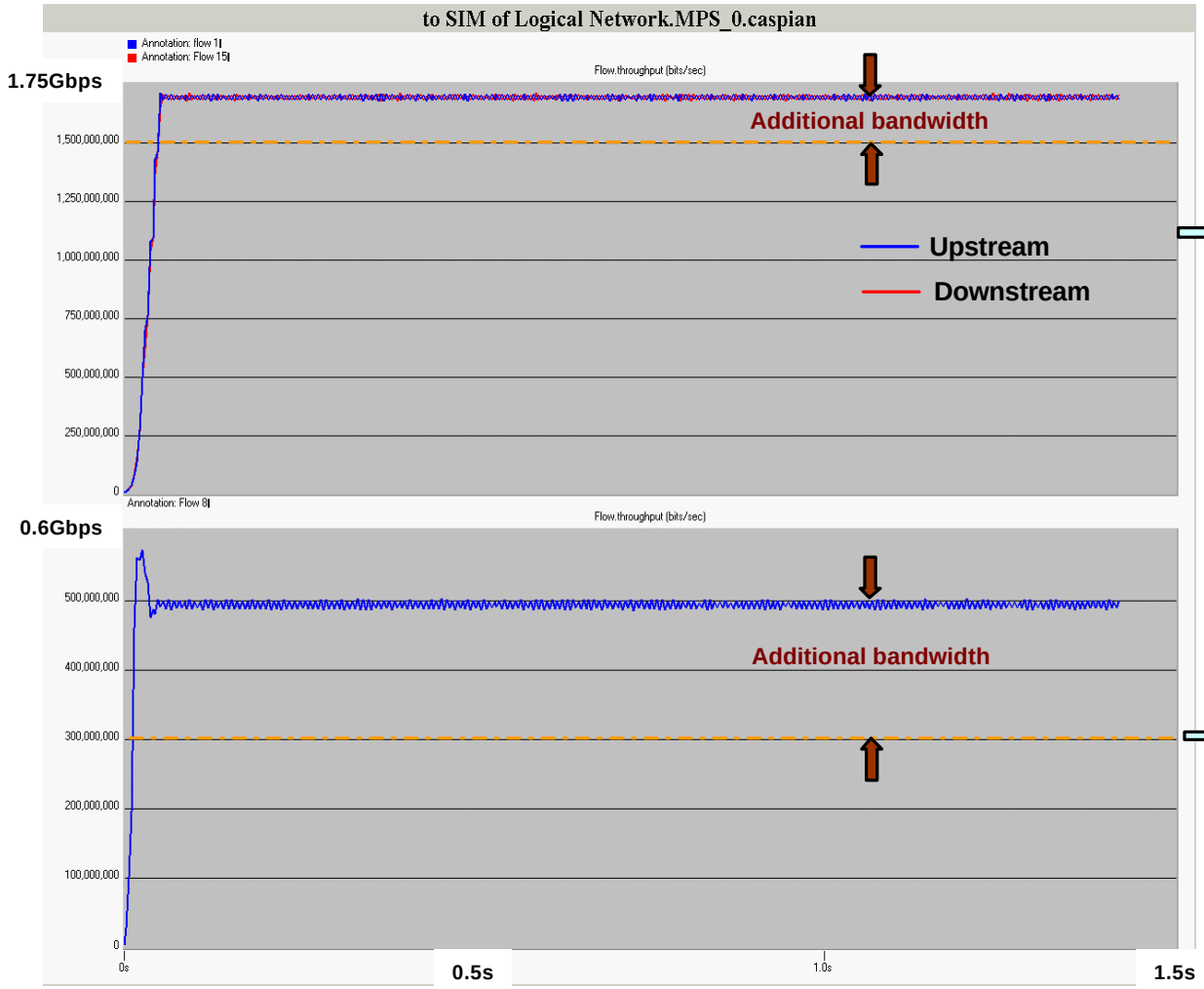
⇨ Customer service rate

Scenario 1 (RTT = 2ms)



Approximately 98%

Fairness (bandwidth)



Upstream & downstream flows

Reserved rate = 1.5Gbps

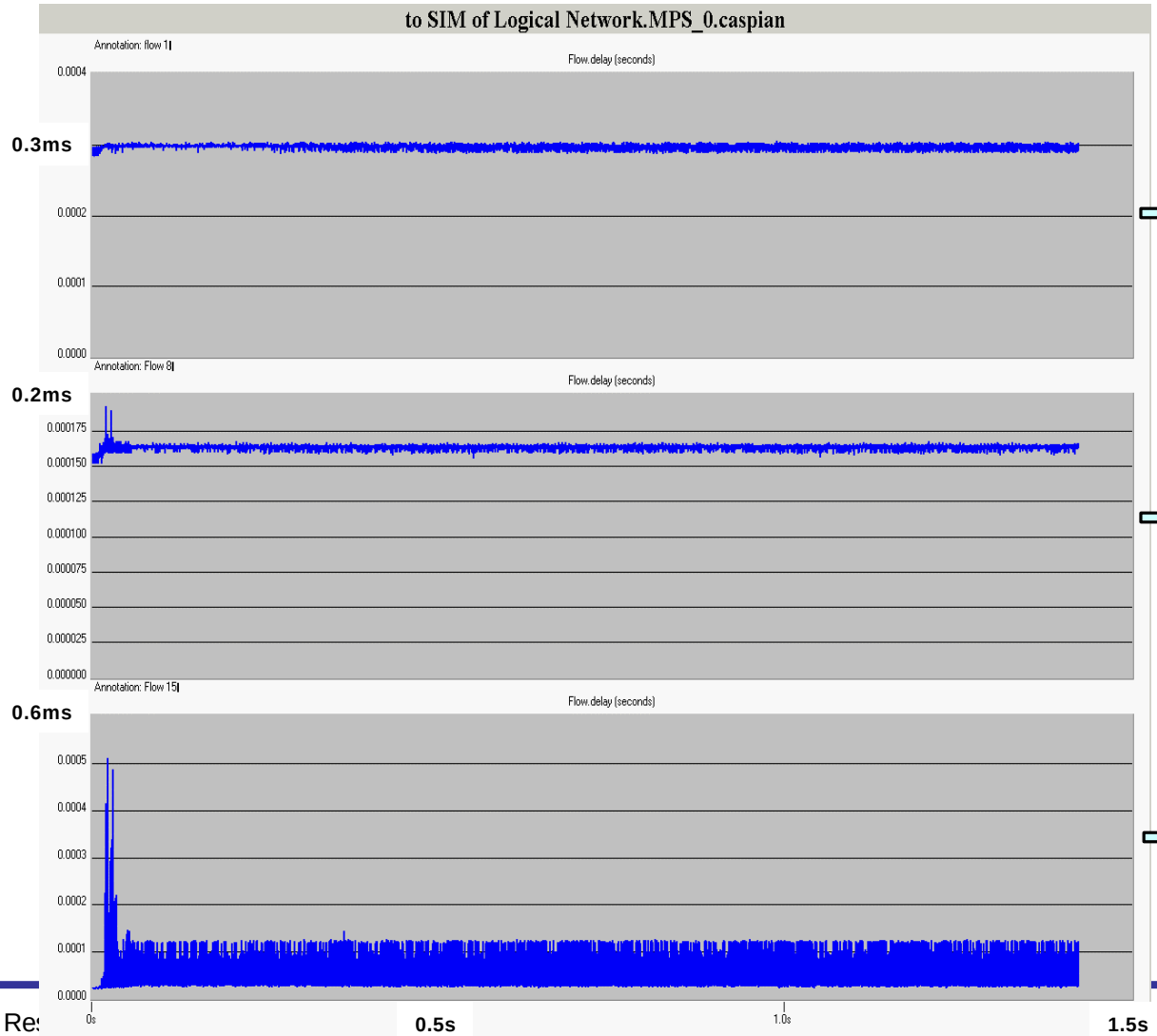
Weight = 1

Midstream flow

Reserved rate = 300Mbps

Weight = 1

Fairness (delay and jitter)

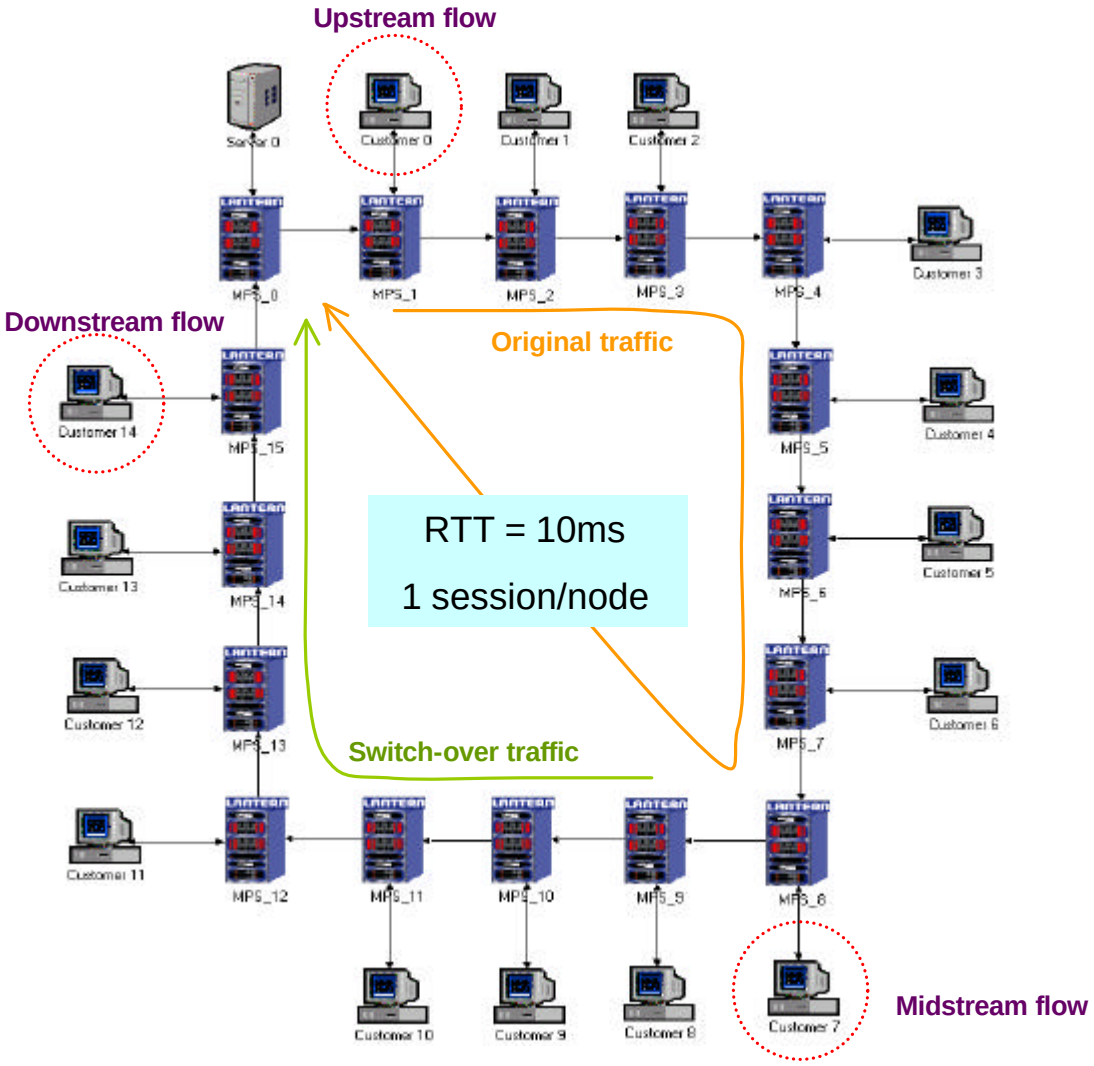


⇨ Upstream flow

⇨ Midstream flow

⇨ Downstream flow

Scenario 4 (switch-over)



TCP Parameters:

TCP Tahoe

Fast retransmit enabled

Fast recovery disabled

Buffer size = 2 RTT

SLA Parameters:

Customer 0 and Customer 14:

Ingress rate (max) = 3Gbps

reserved rate = 1.5Gbps

Weight = 1

Customer 1 to Customer 13:

Ingress rate (max) = 1Gbps

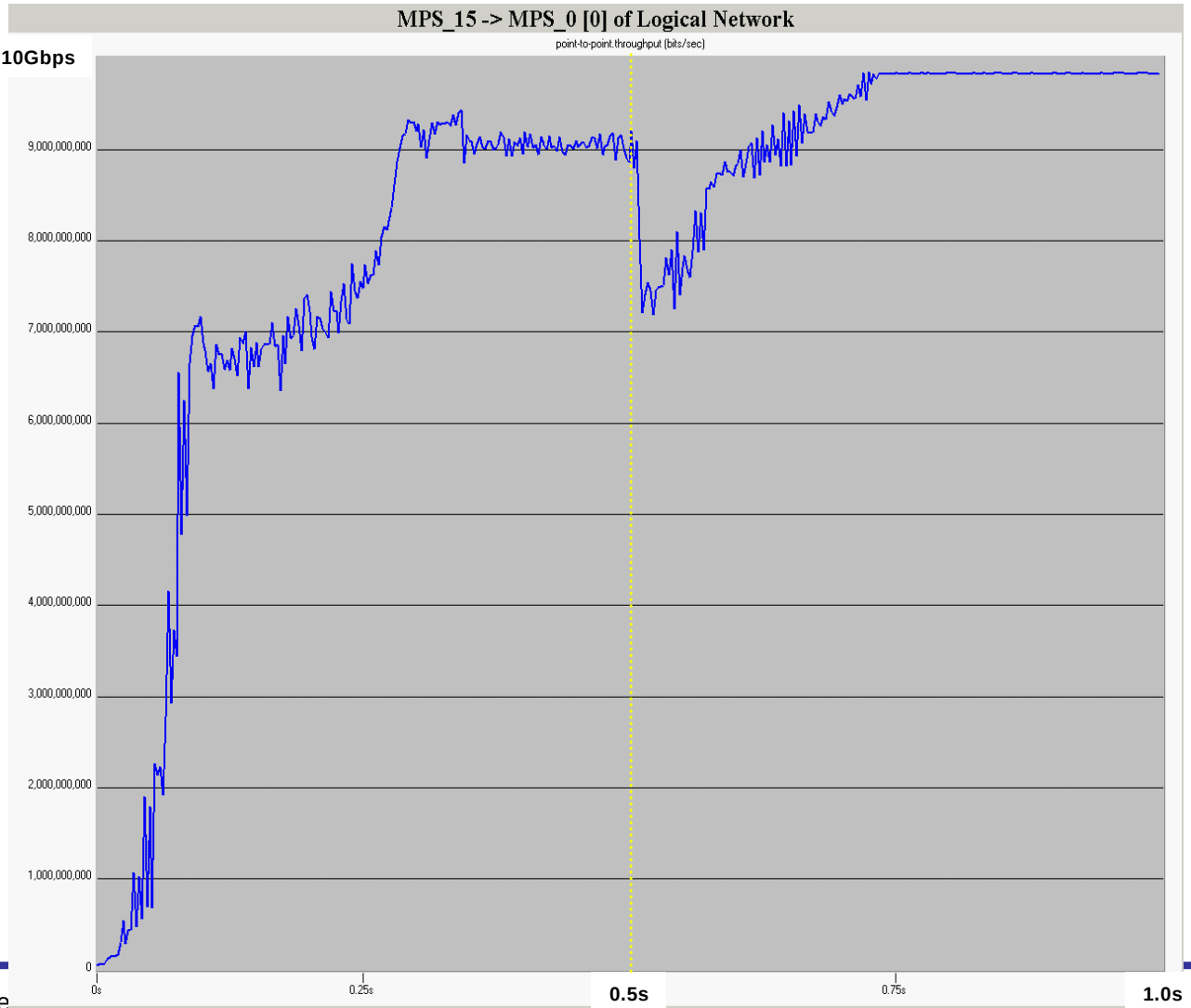
Reserved rate = 300Mbps

Weight = 1

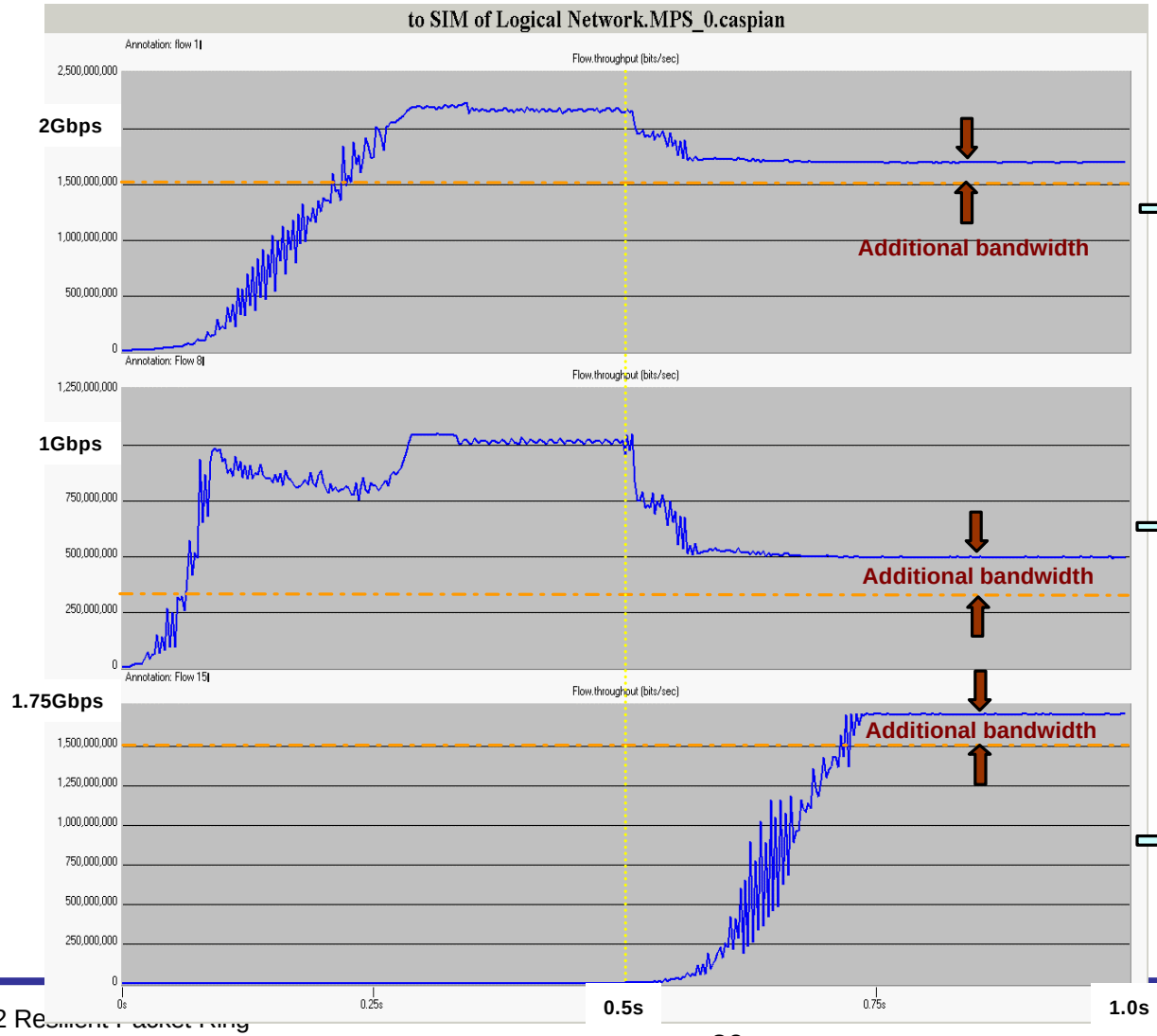
Switch-over traffic:

Customers 8-14, start at 0.5s

Utilization (last link)



Fairness (bandwidth)



Upstream flow

⇨ **Reserved rate = 1.5Gbps**

Weight = 1

Midstream flow

⇨ **Reserved rate = 300Mbps**

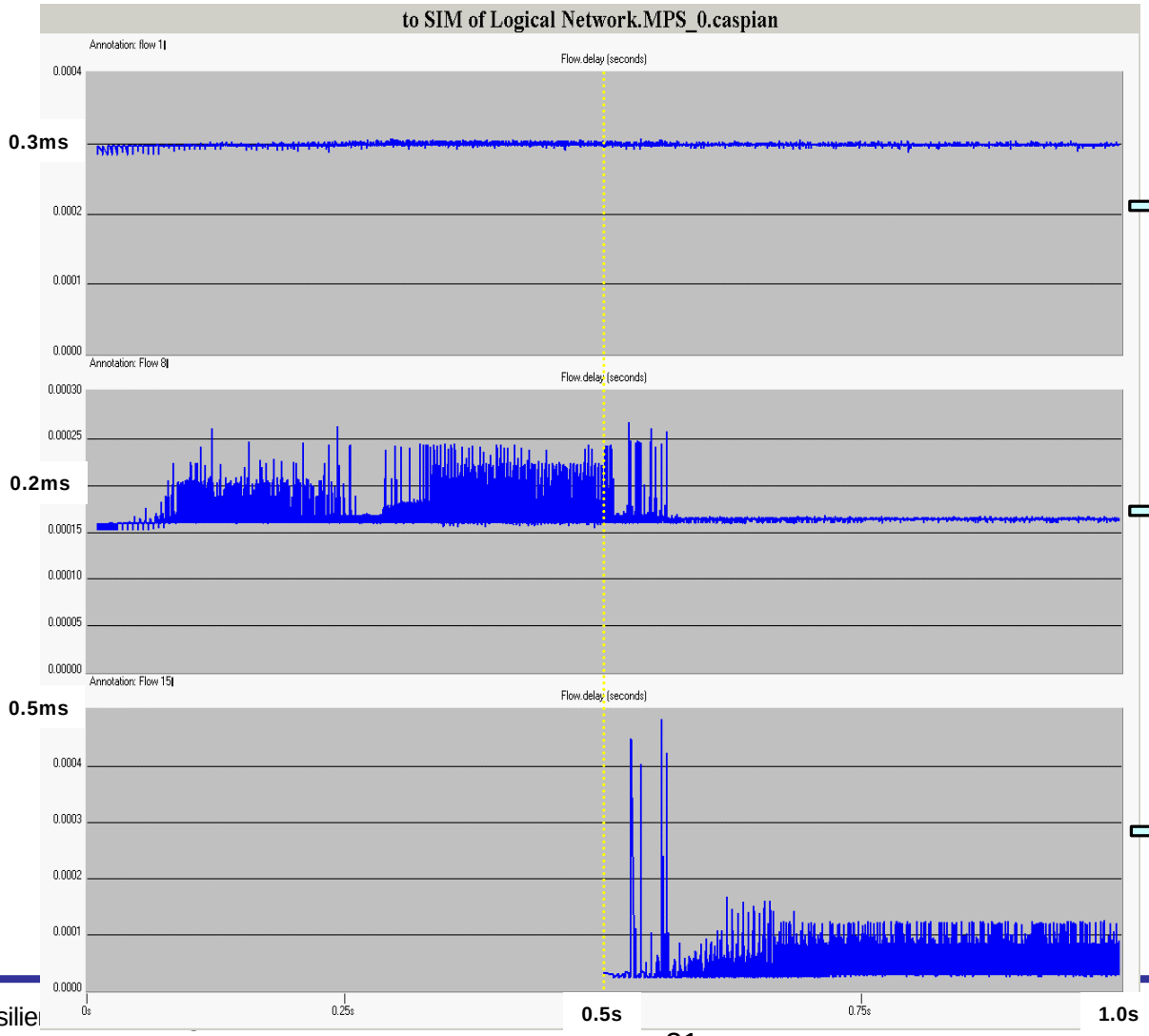
Weight = 1

Downstream flow

⇨ **Reserved rate = 1.5Gbps**

Weight = 1

Fairness (delay and jitter)



⇨ Upstream flow

⇨ Midstream flow

⇨ Downstream flow