

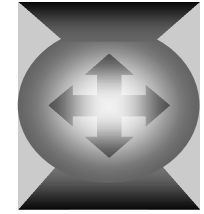
L a n t e r n
Communications

Simulation Results

IEEE 802.17

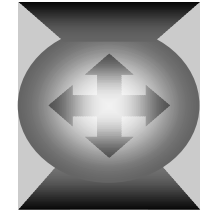
March 12-15, 2001

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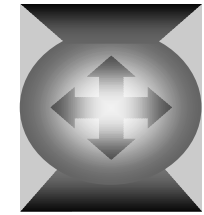
Simulation Objective

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

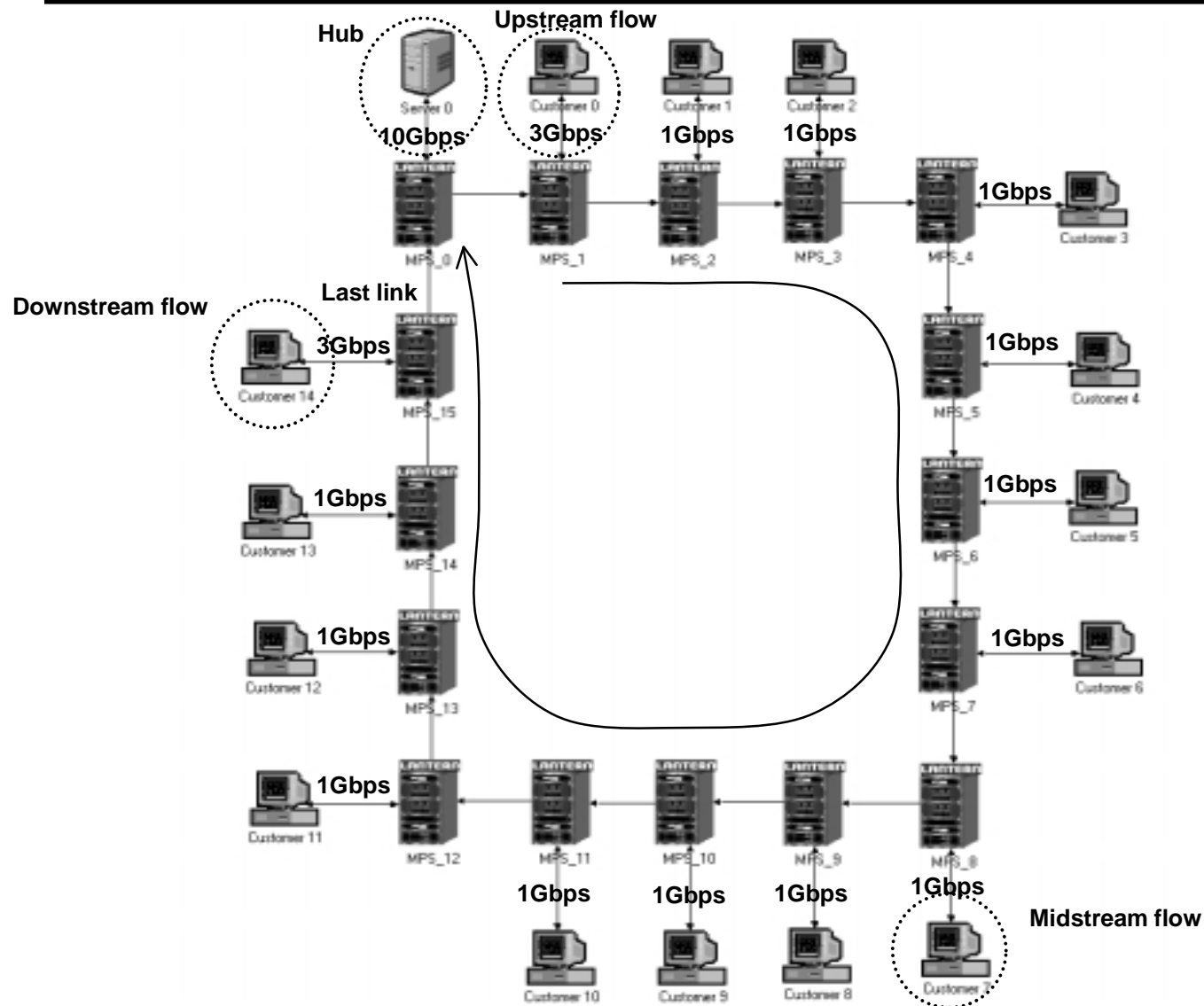


Simulation Setup

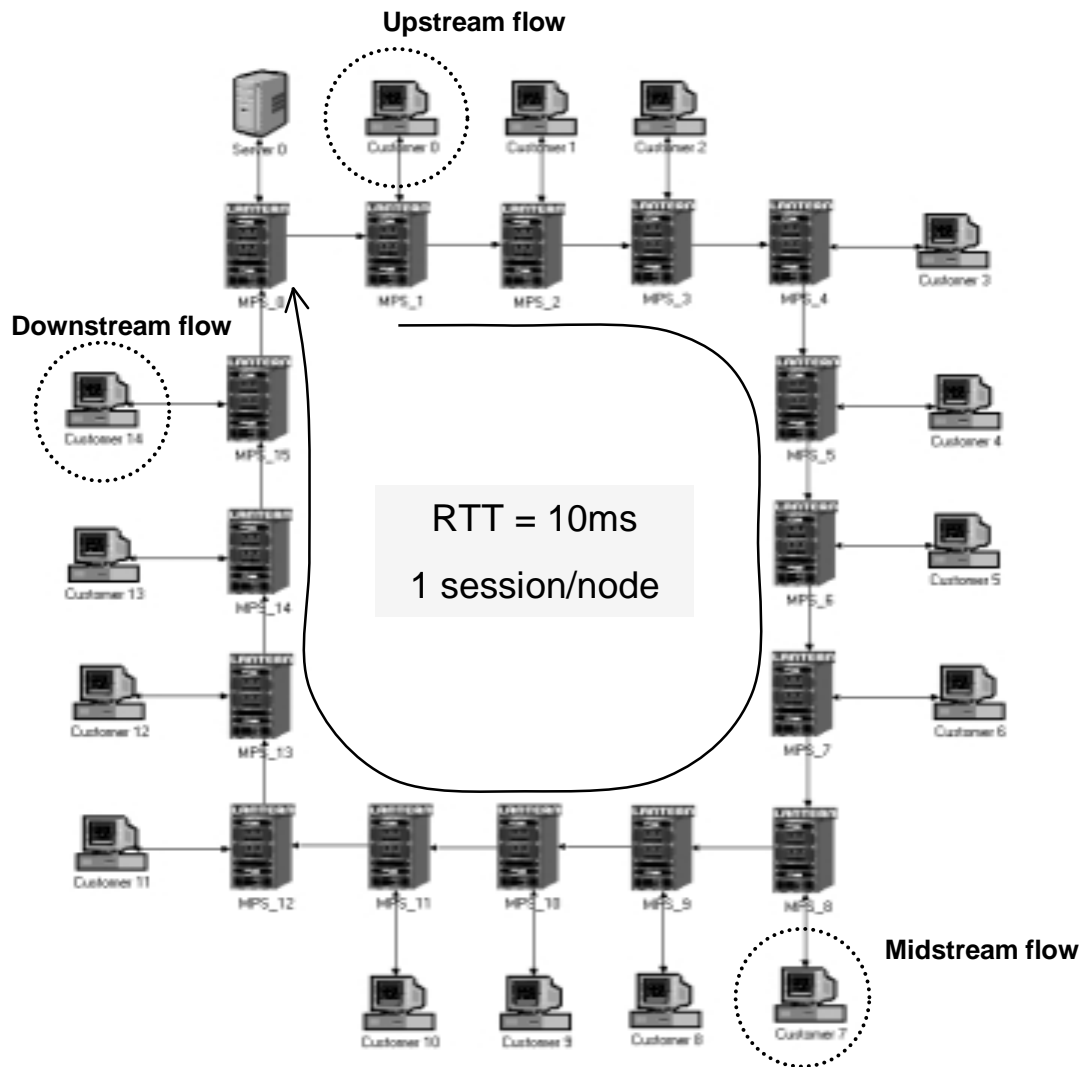
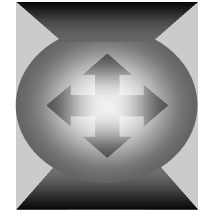
- ◆ Simulation topology
 - Hubbing
- ◆ Scenarios
 - Scenario 1: One TCP flow per customer (Droptail, RED)
 - Scenario 2: Switch-over
 - Scenario 3: UDP (conforming and non-conforming)
 - Scenario 4: Multiple customers/port
- ◆ Performance metrics
 - Throughput
 - Delay and jitter
 - Upstream-downstream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



Topology (hubbing)



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

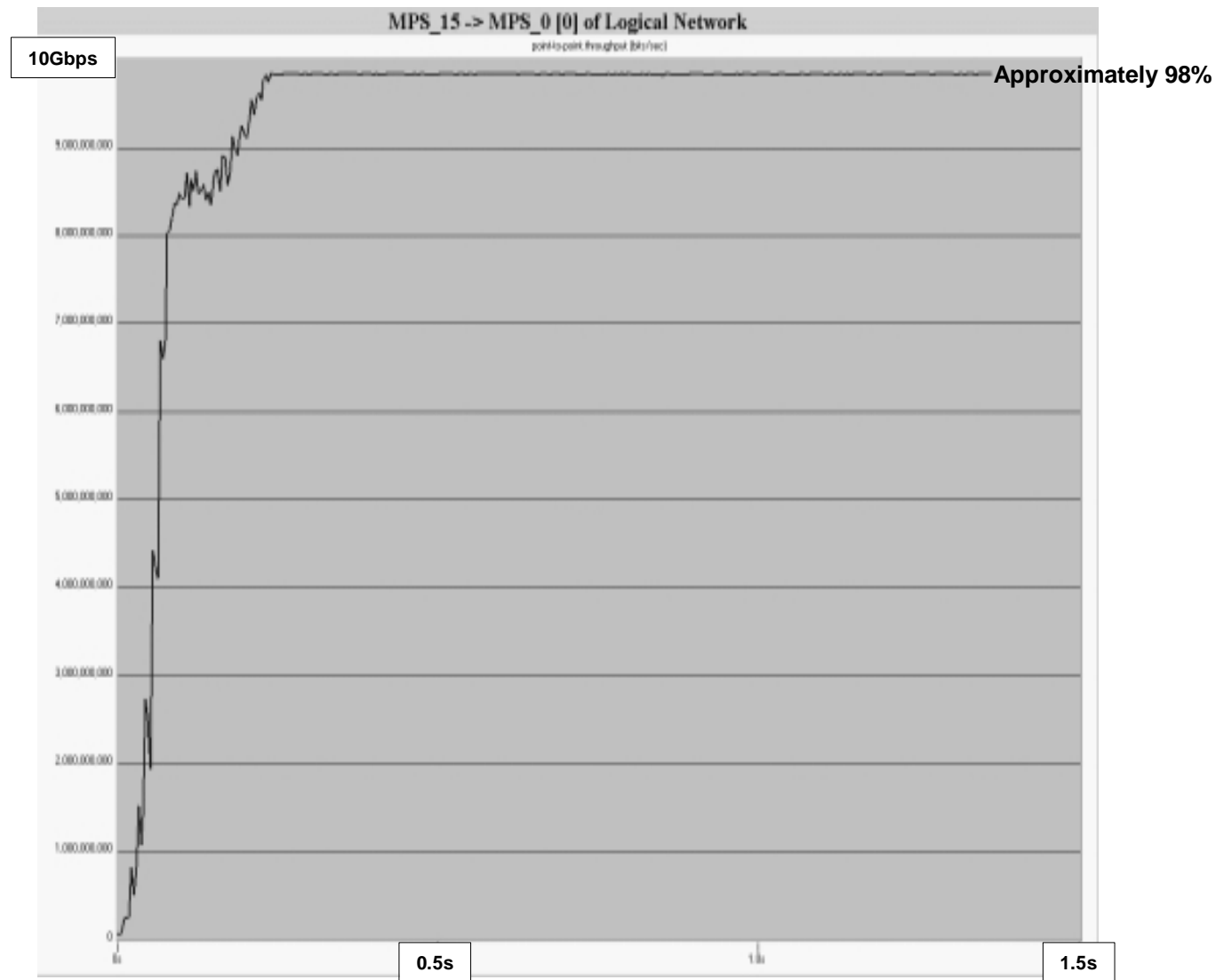
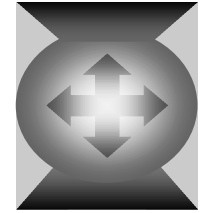
Customer 1 to Customer 13:

Ingress rate (max) = 1Gbps

Reserved rate = 300Mbps

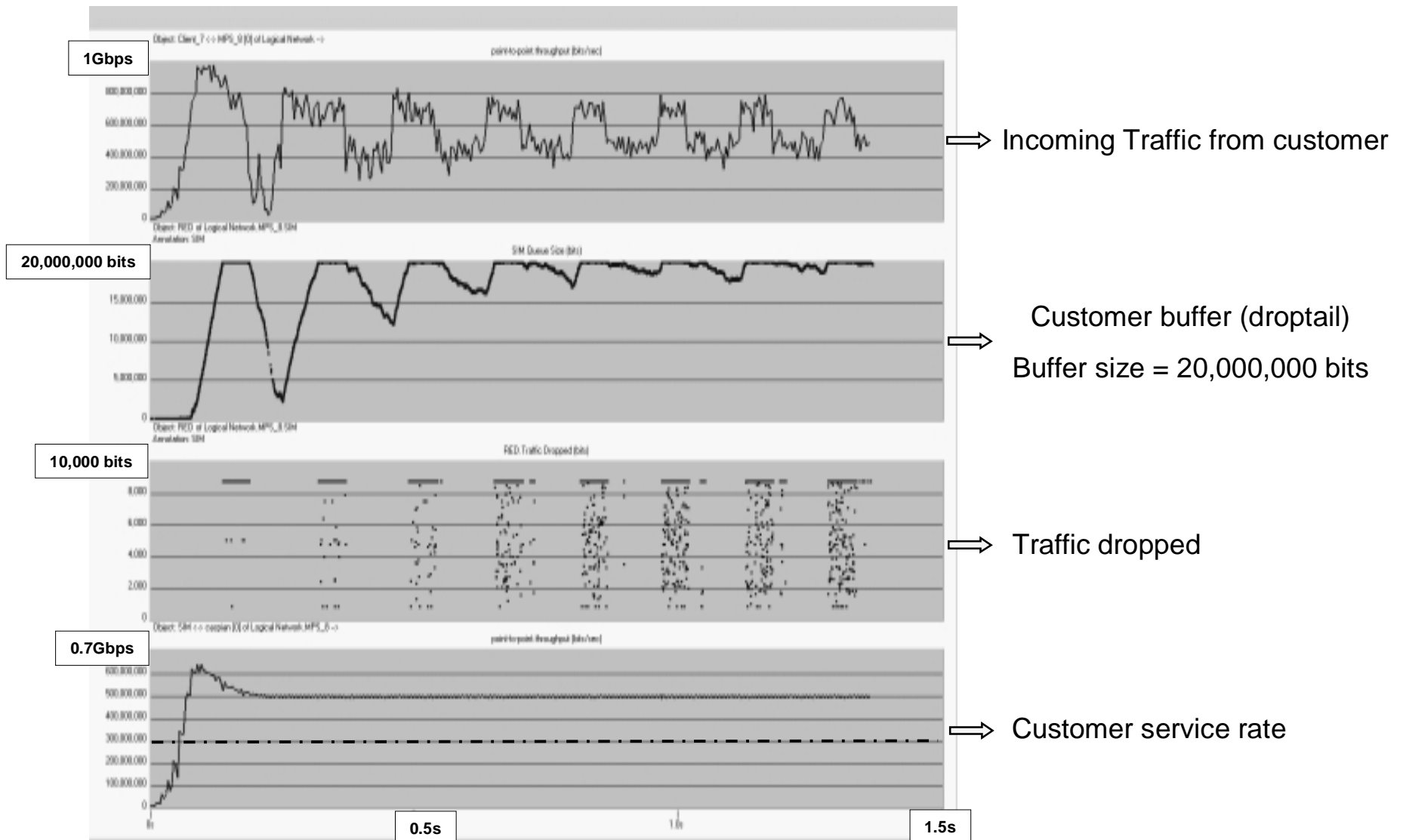
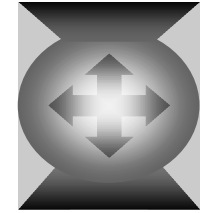
Weight = 1

Utilization (last link)

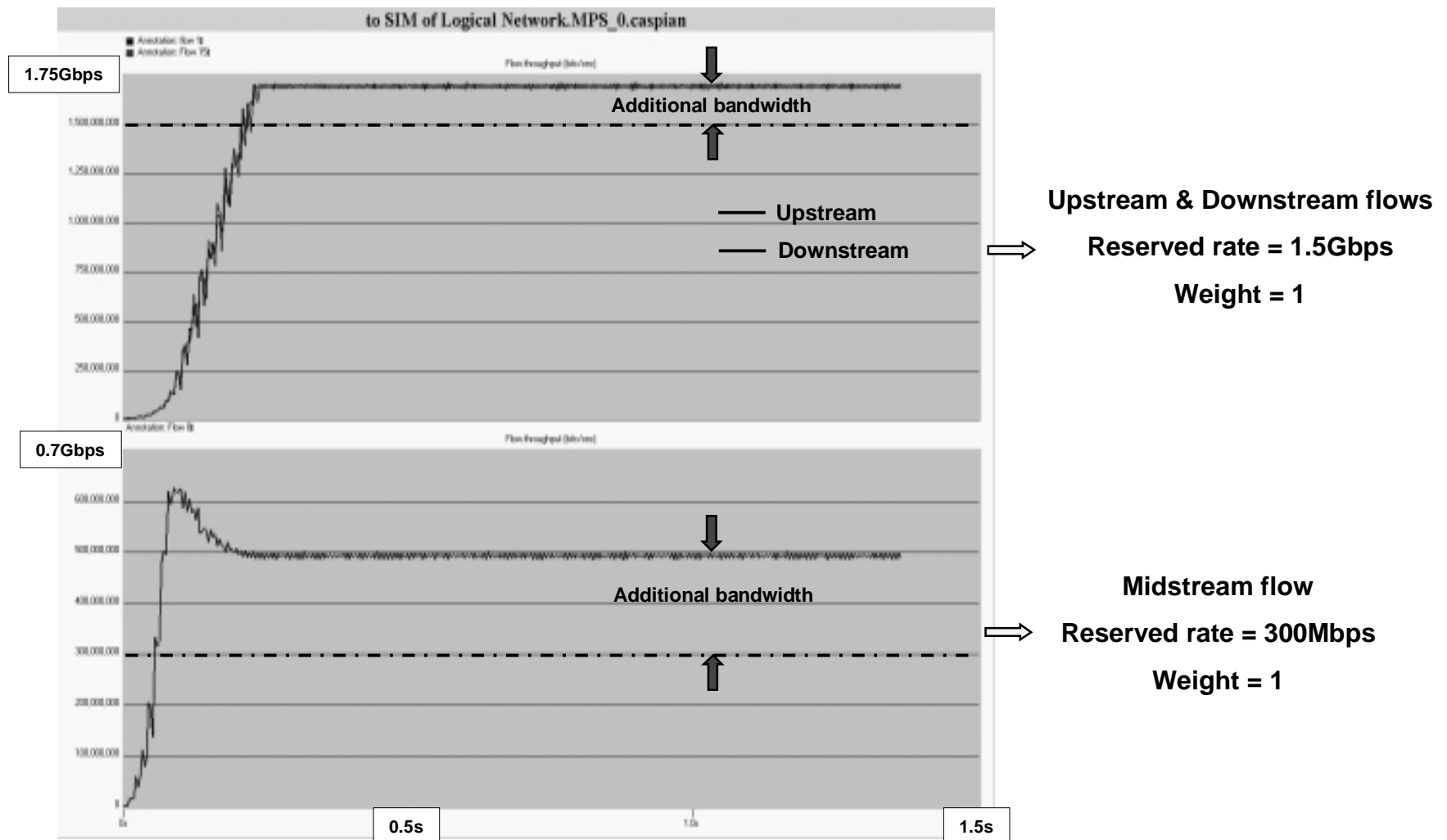
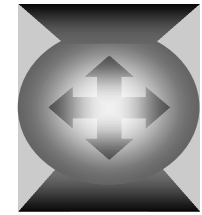


Per customer traffic behavior

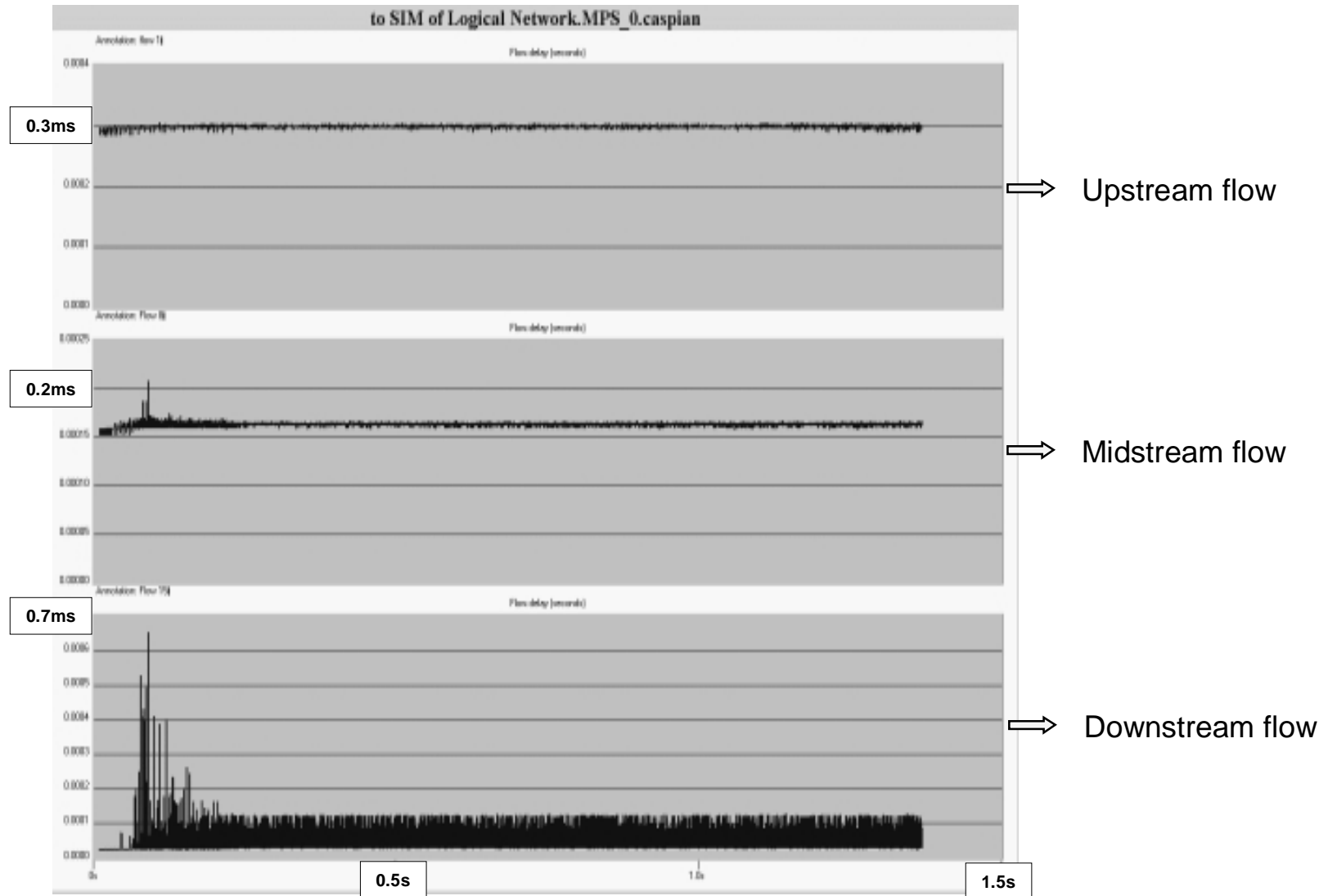
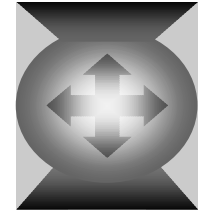
(midstream customer)



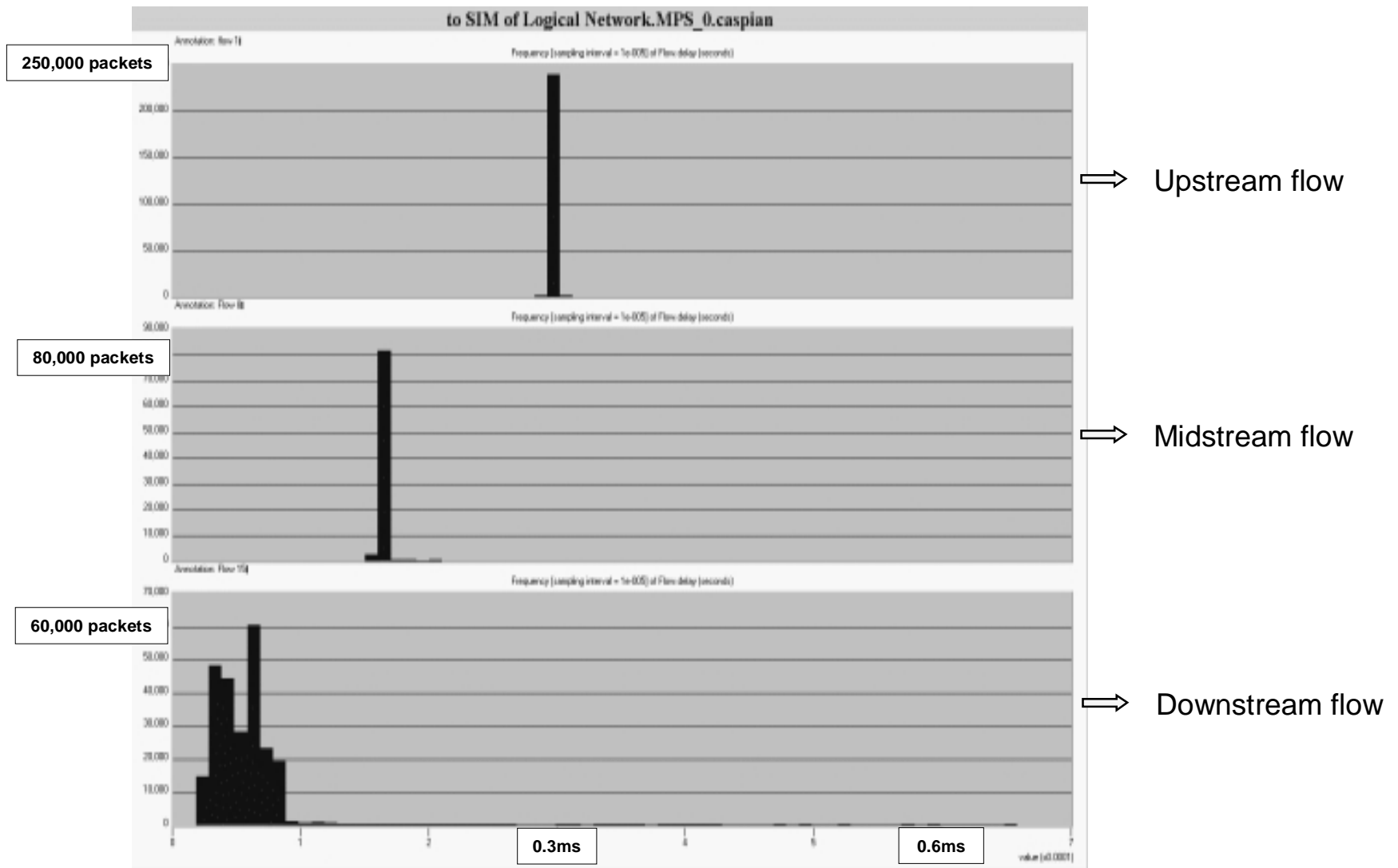
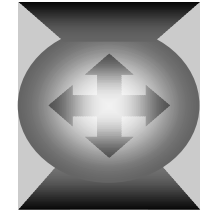
Fairness (bandwidth)



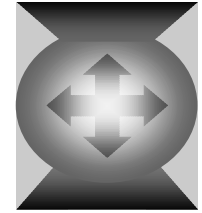
Fairness (delay and jitter)



Histogram (delay)



Scenario 1 (TCP with RED)



RED Parameters:

Buffer size = 2 RTT

Maximum threshold = 2 RTT

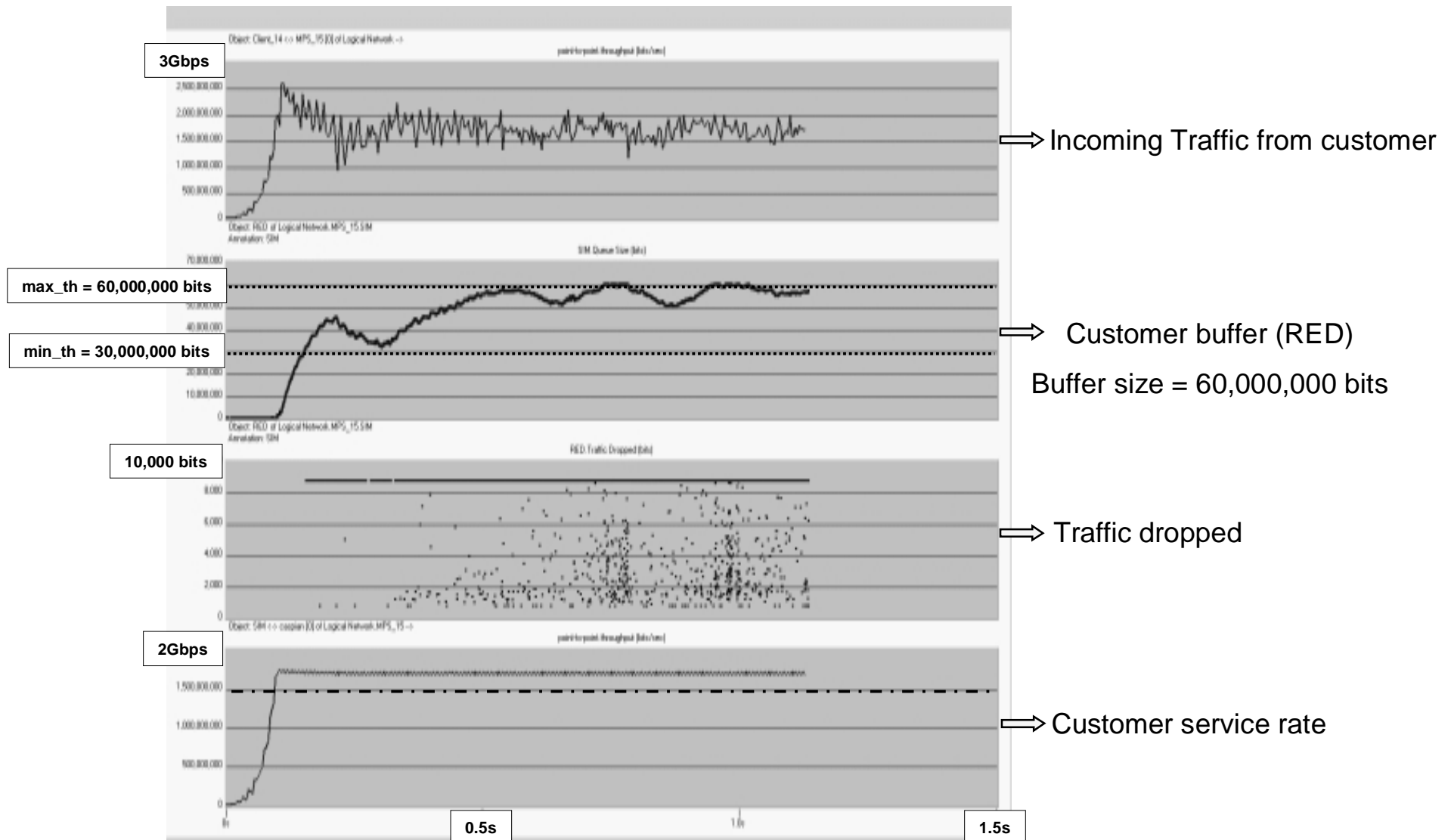
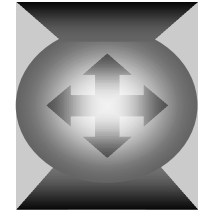
Minimum threshold = RTT

Maximum drop probability = 0.02

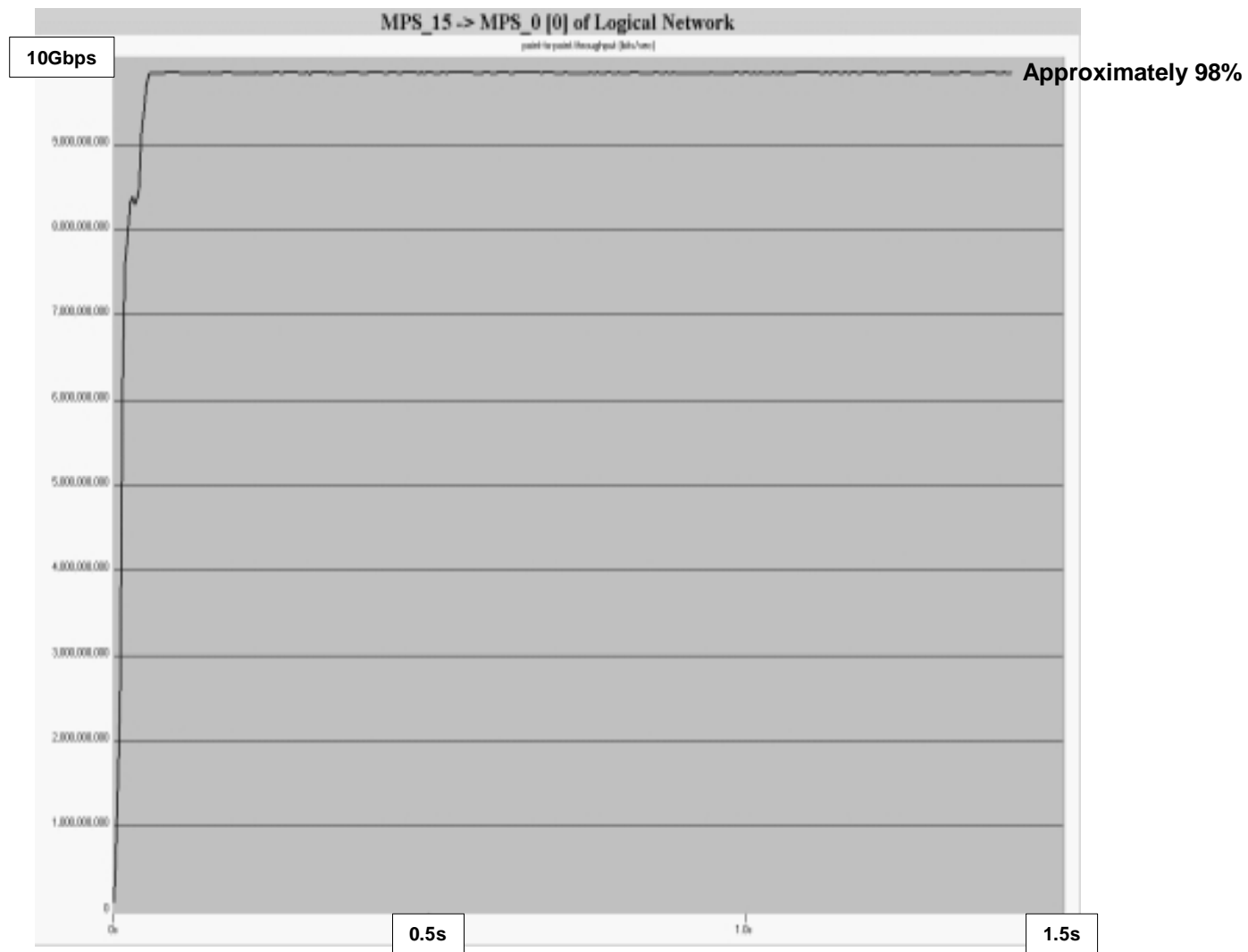
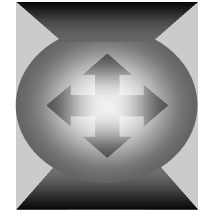
Averaging weight = 1.0

Per customer traffic behavior

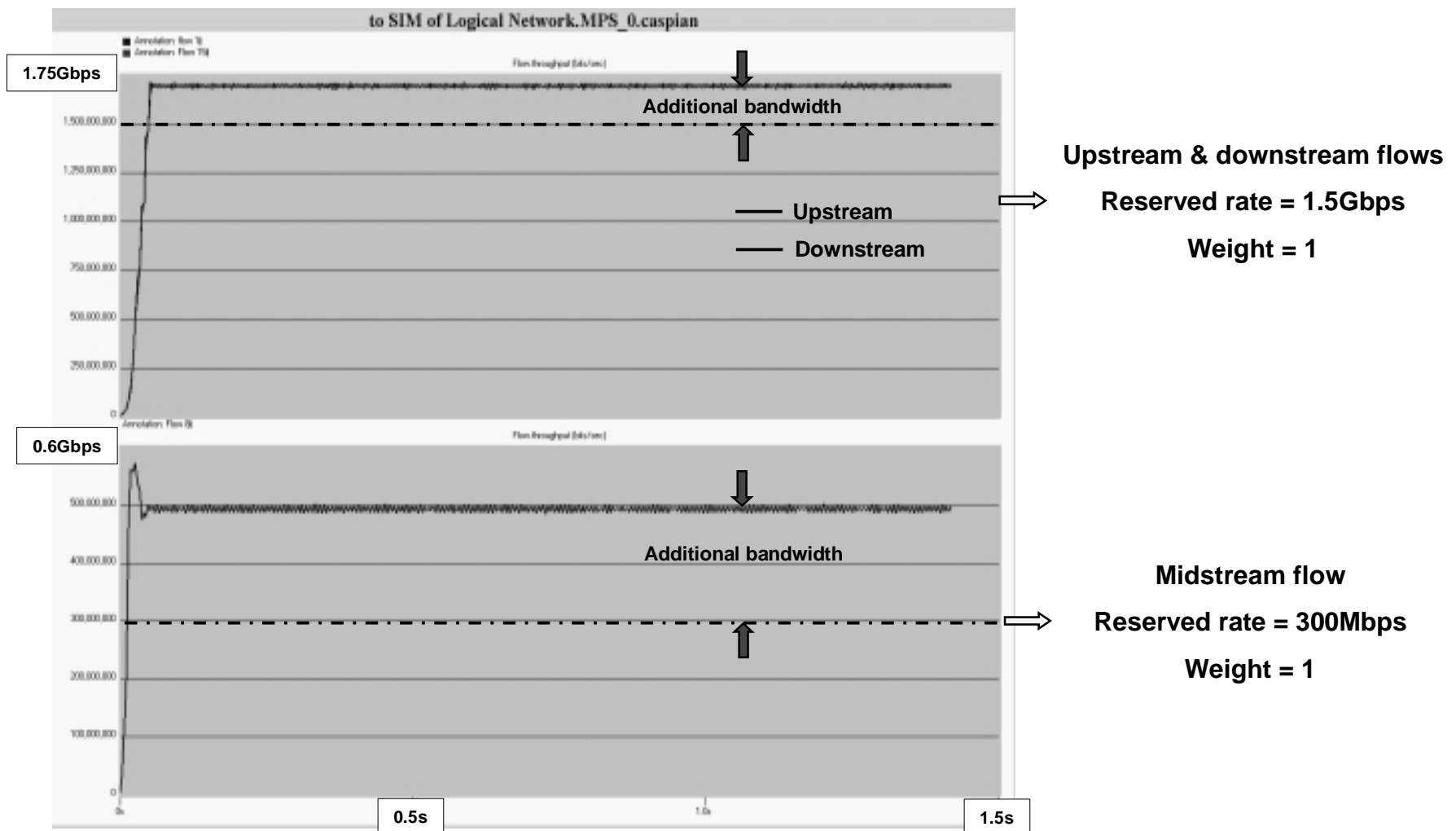
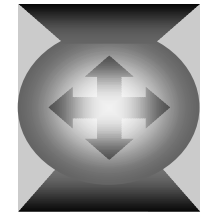
(downstream customer)



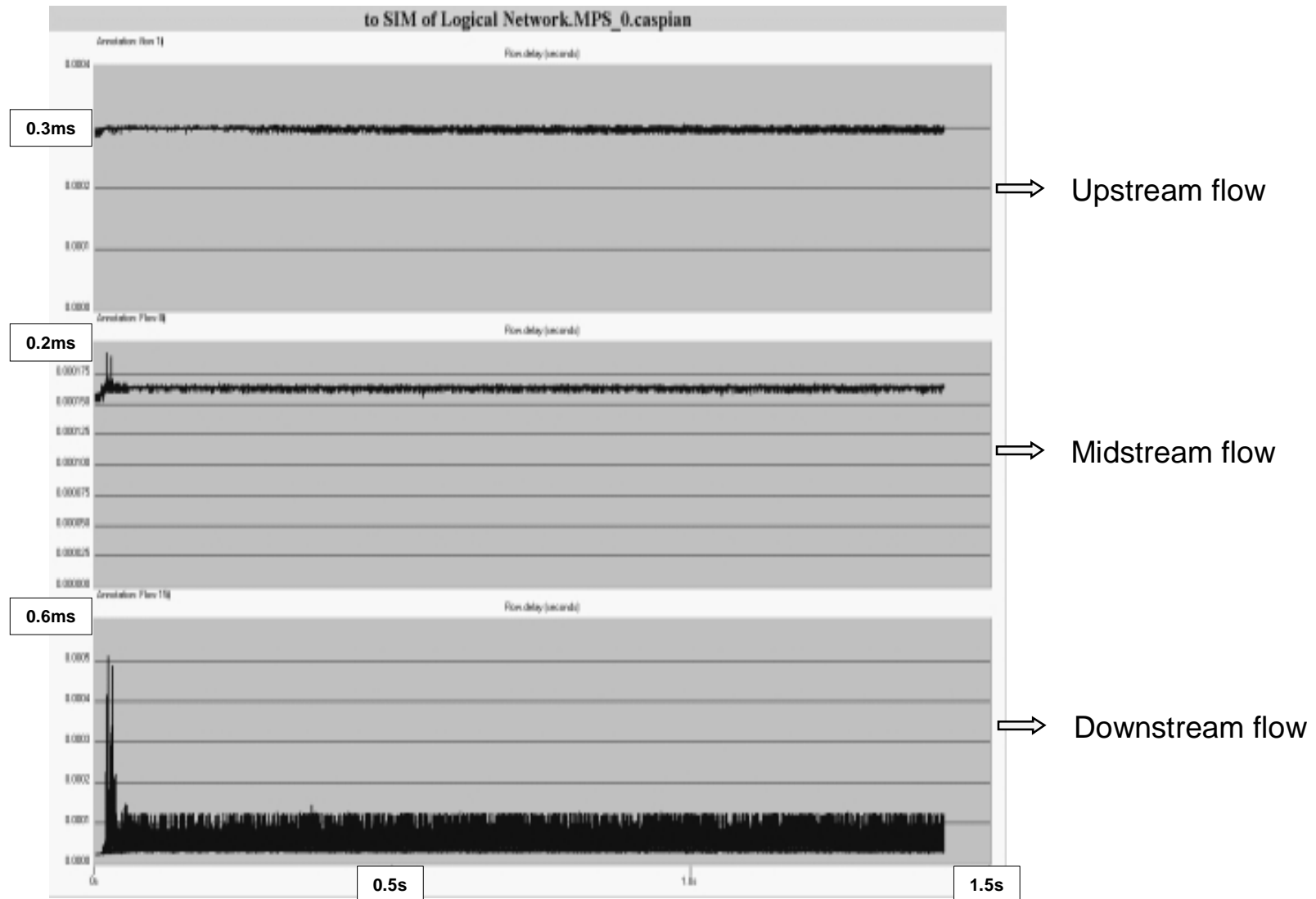
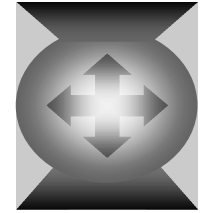
Scenario 1 (RTT = 2ms)



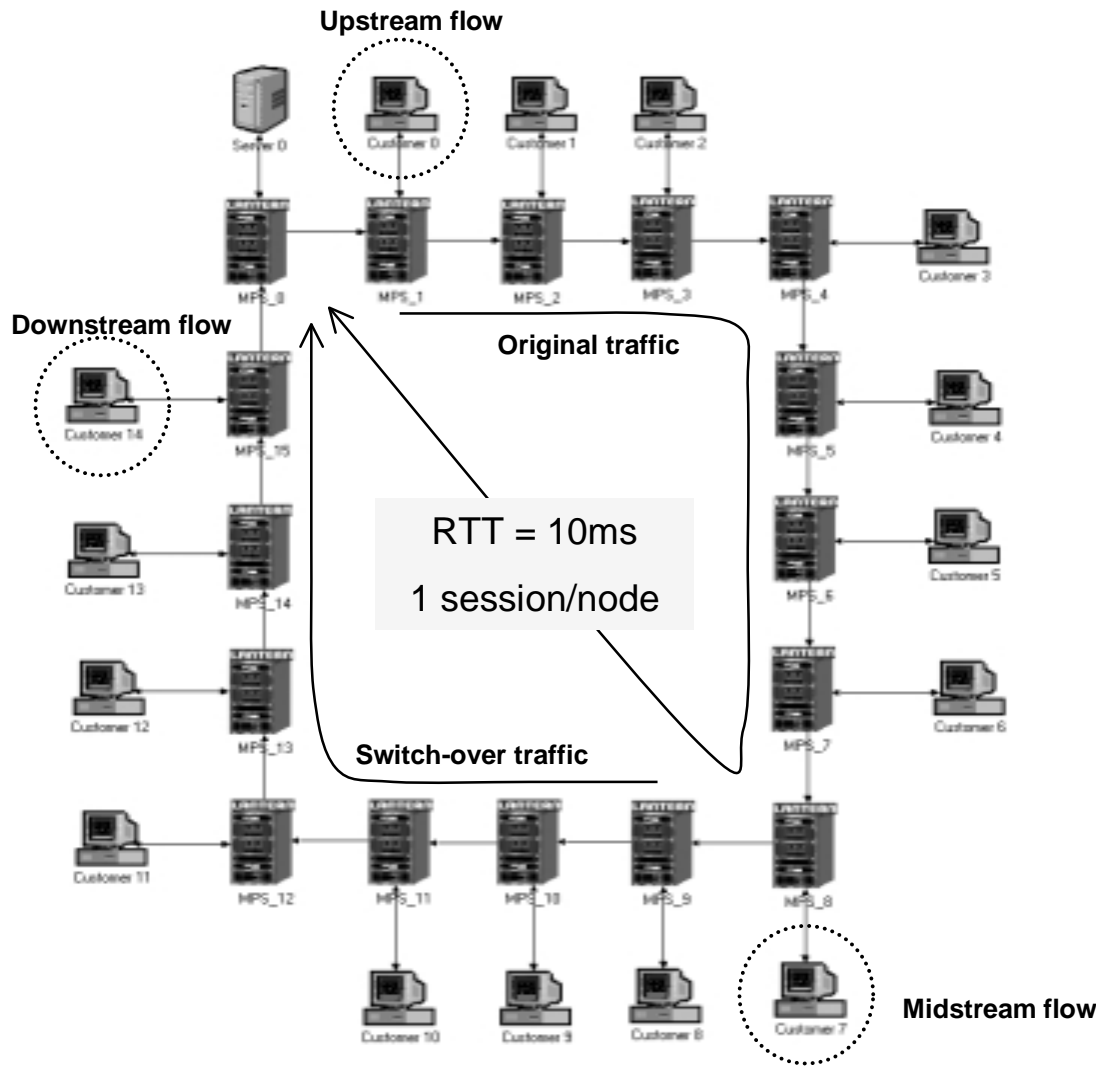
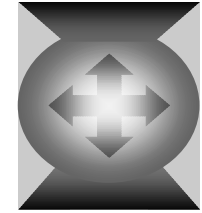
Fairness (bandwidth)



Fairness (delay and jitter)



Scenario 2 (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

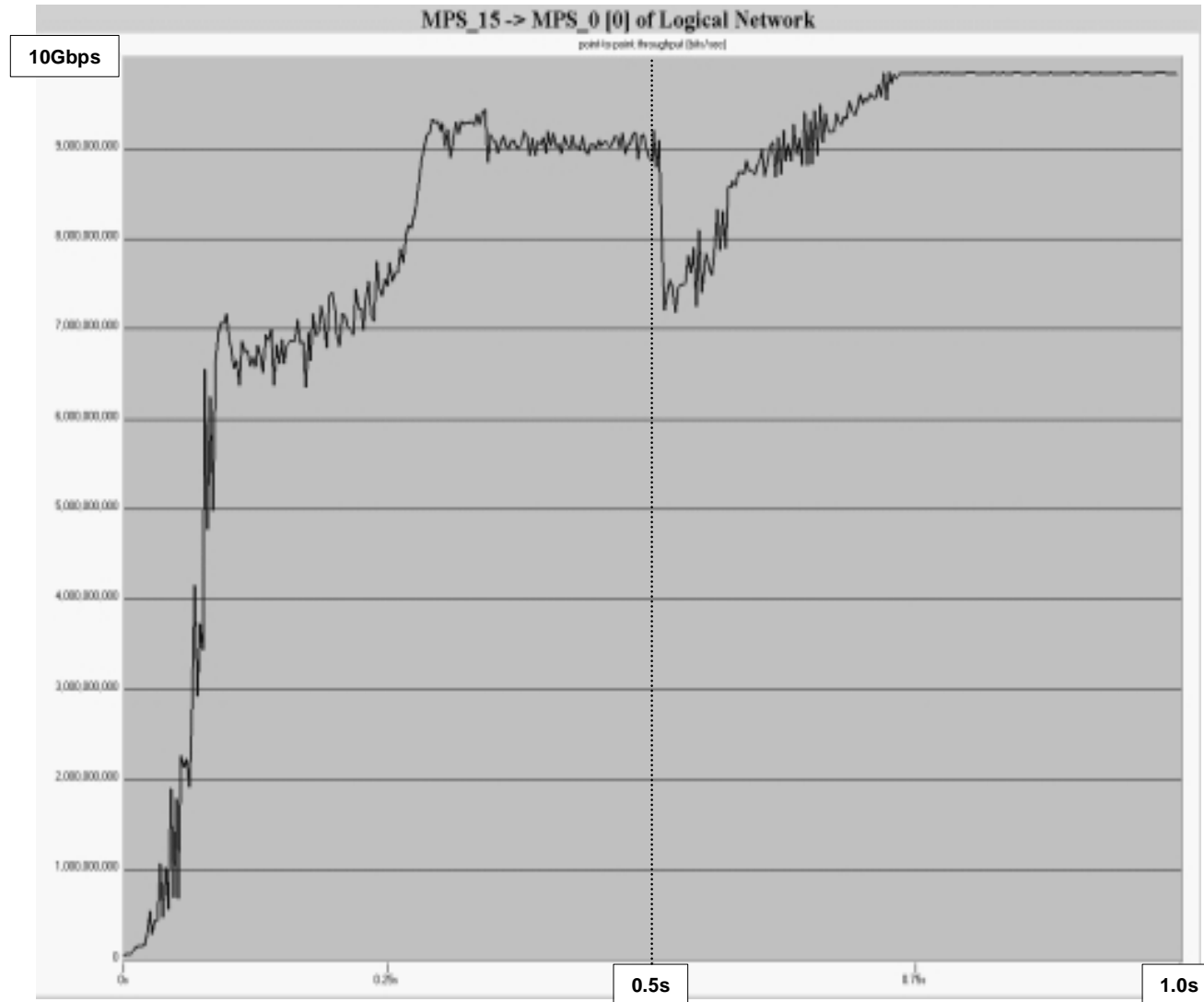
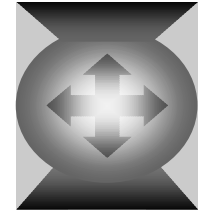
Reserved rate = 300Mbps

Weight = 1

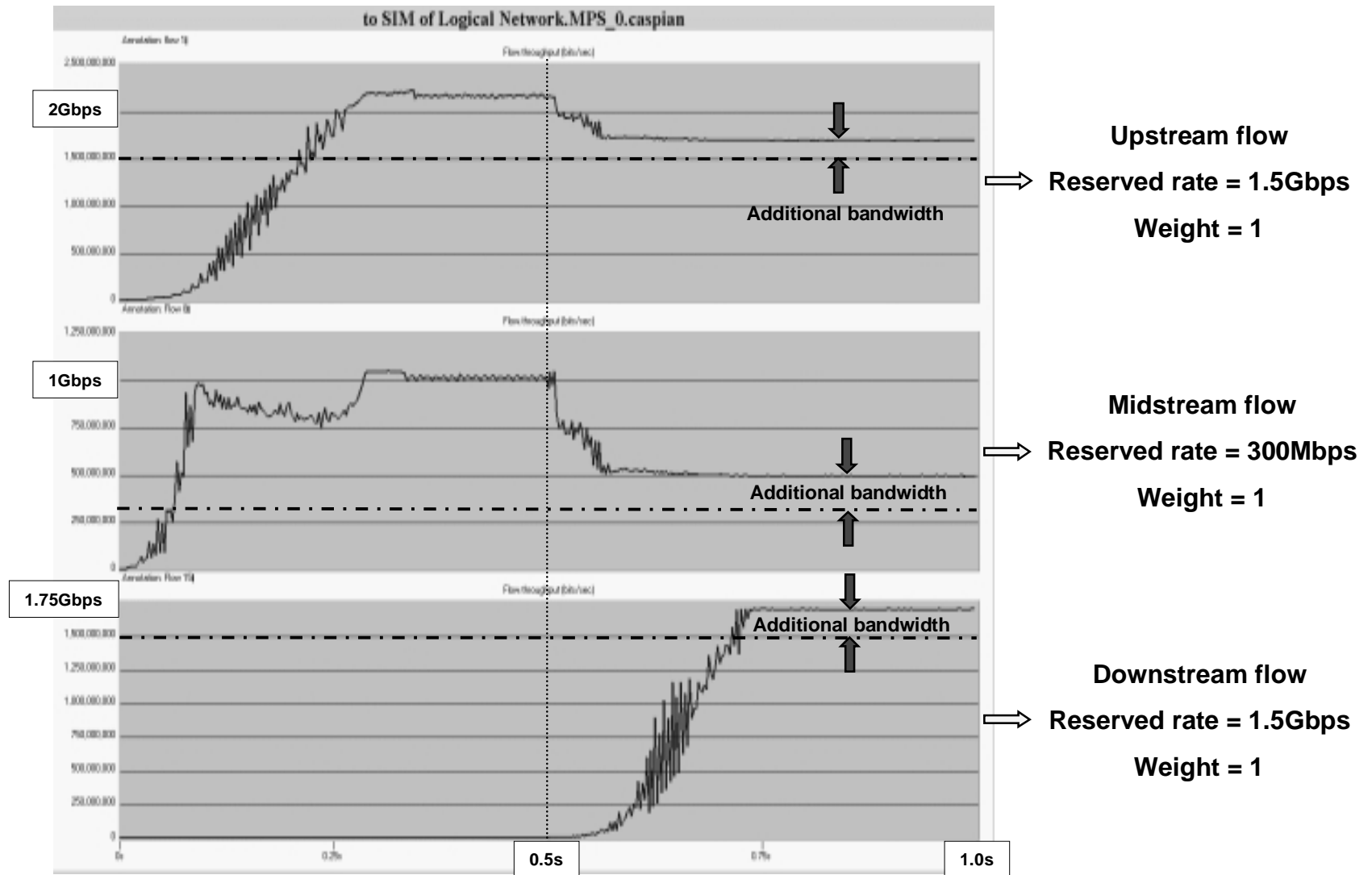
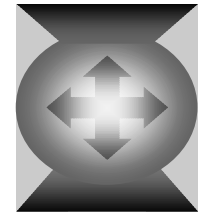
Switch-over traffic:

Customers 8-14, start at 0.5s

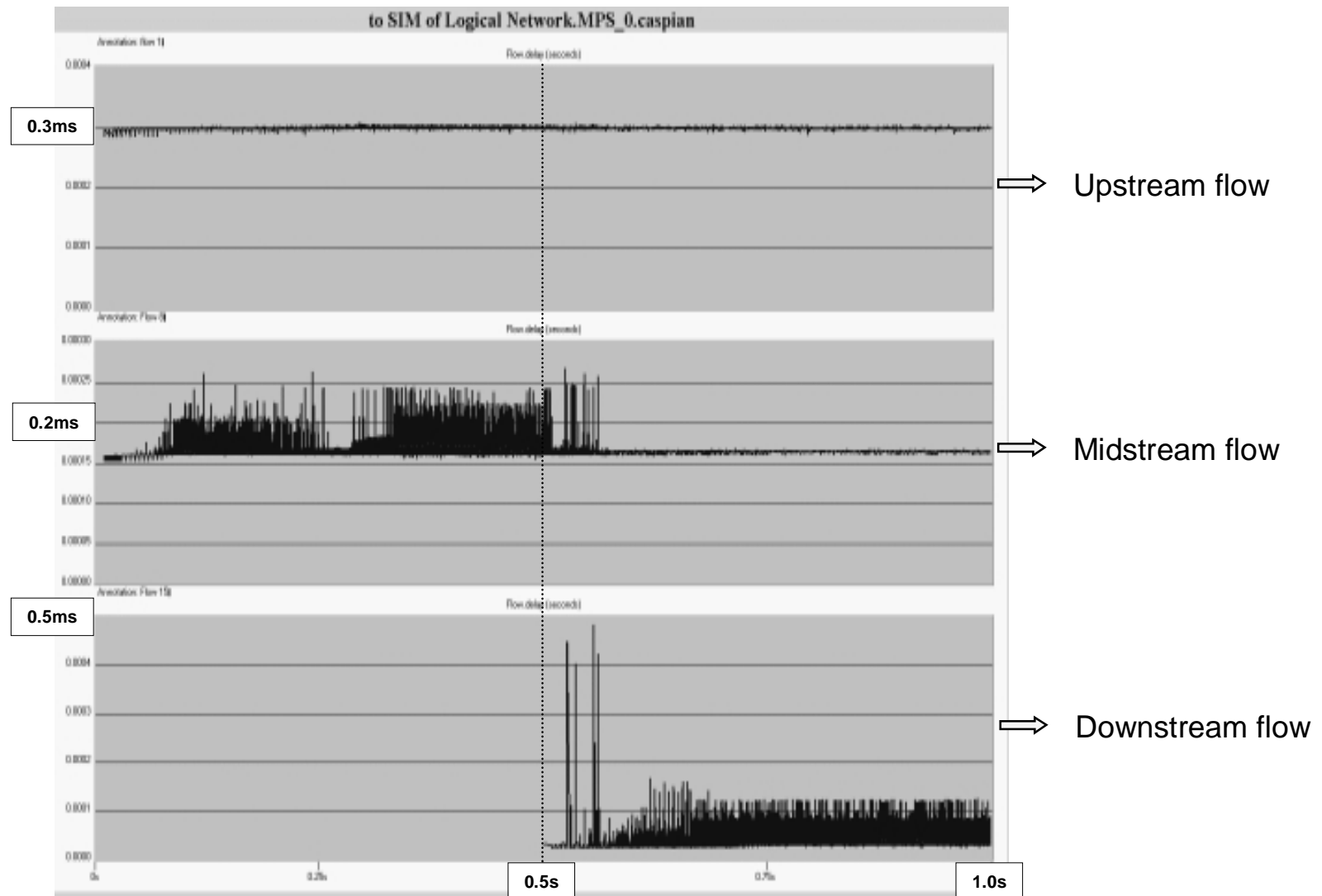
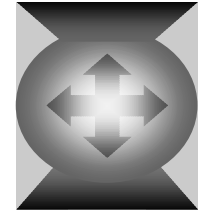
Utilization (last link)



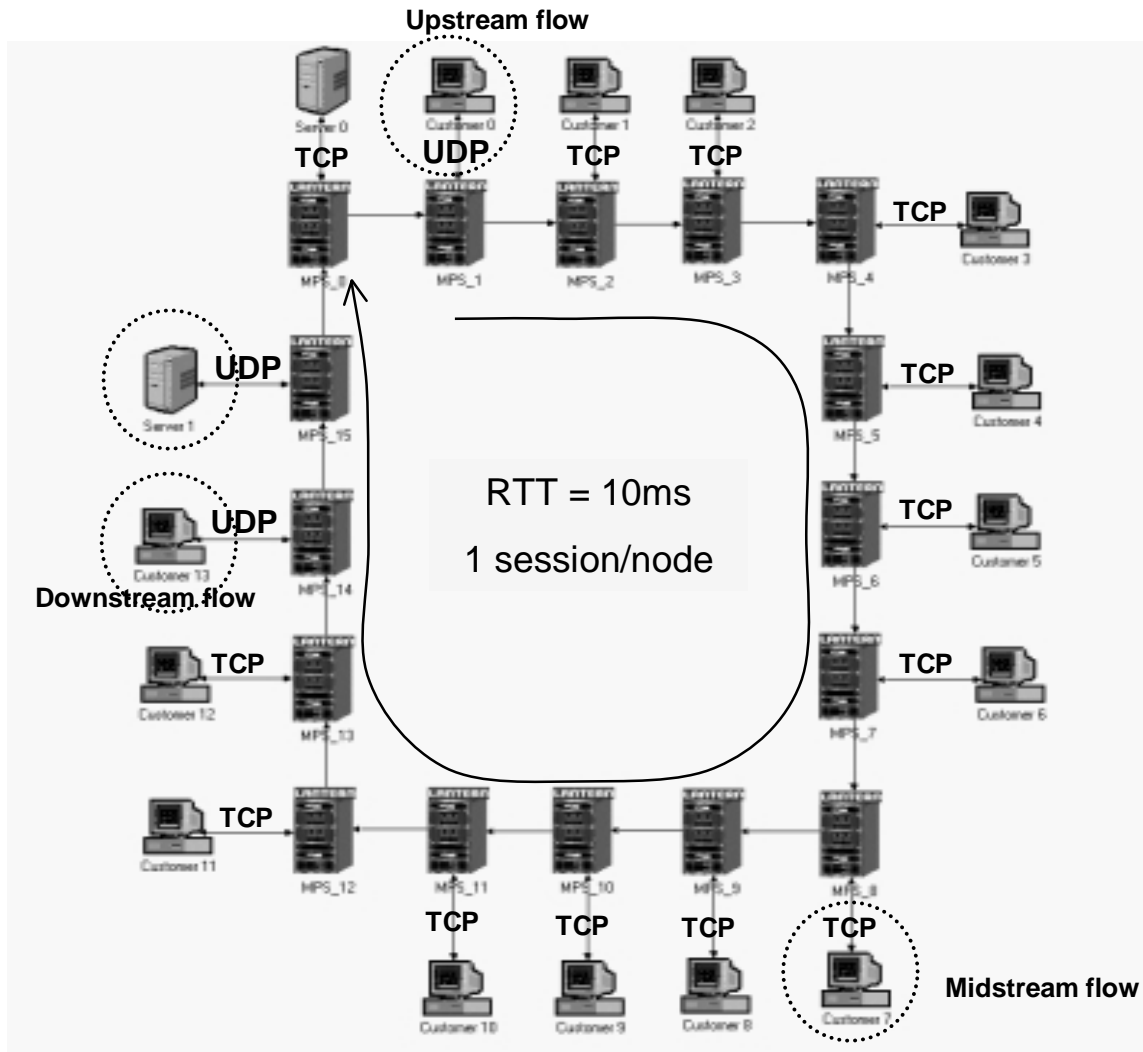
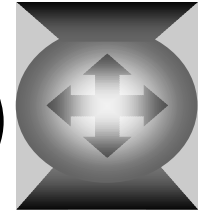
Fairness (bandwidth)



Fairness (delay and jitter)



Scenario 3 (UDP with bursty TCP)



TCP Parameters:

TCP Tahoe

Fast retransmit enabled

Fast recovery disabled

Buffer size = 2 RTT, $\frac{1}{4}$ RTT, $\frac{1}{8}$ RTT

SLA Parameters:

Customer 0 and Customer 13:

Ingress rate = 1.5Gbps (UDP)

reserved rate = 1.5Gbps

Weight = 1

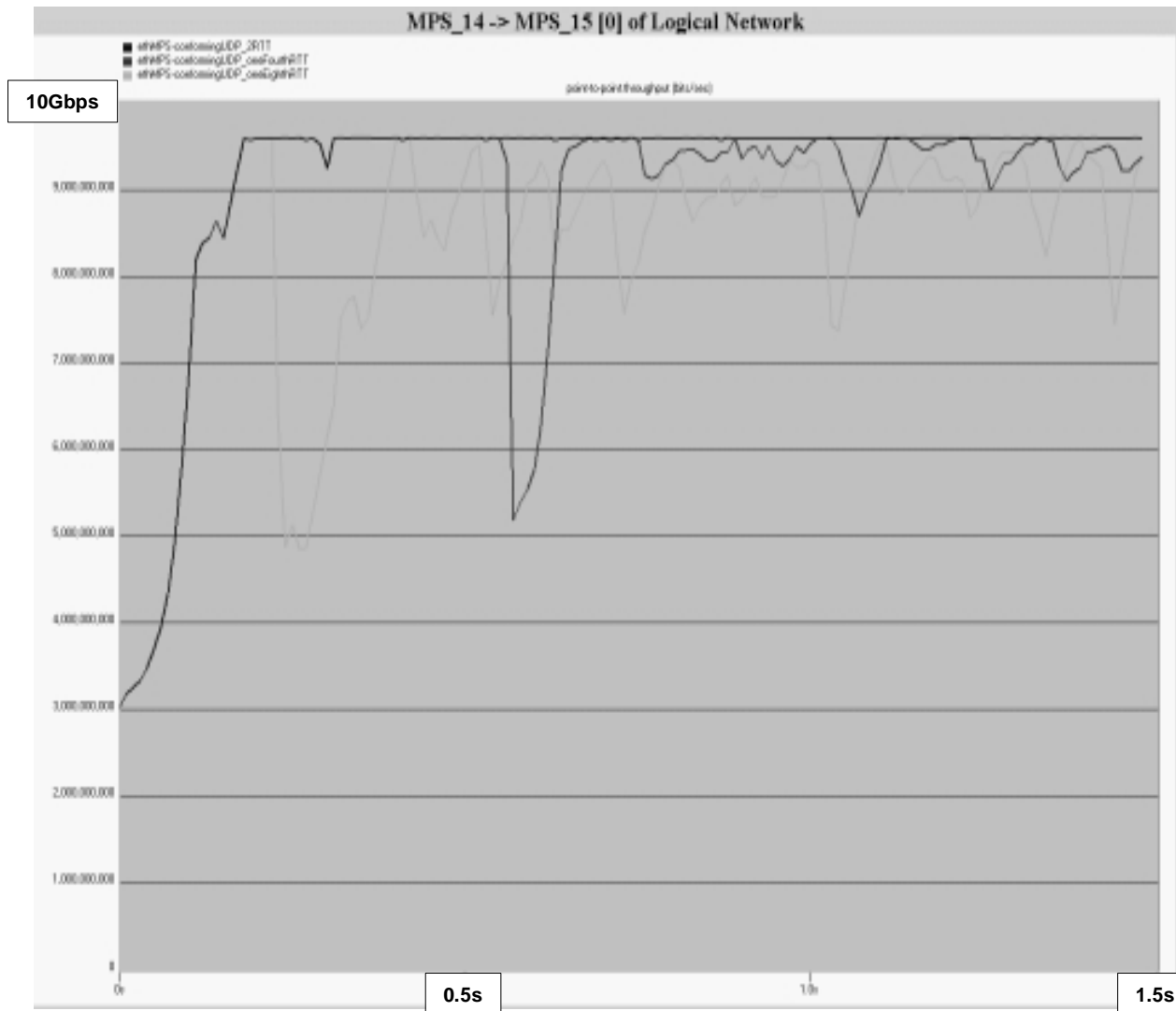
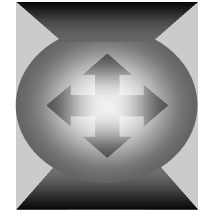
Customer 1 to Customer 12:

Ingress rate (max) = 1Gbps (TCP)

Reserved rate = 300Mbps

Weight = 1

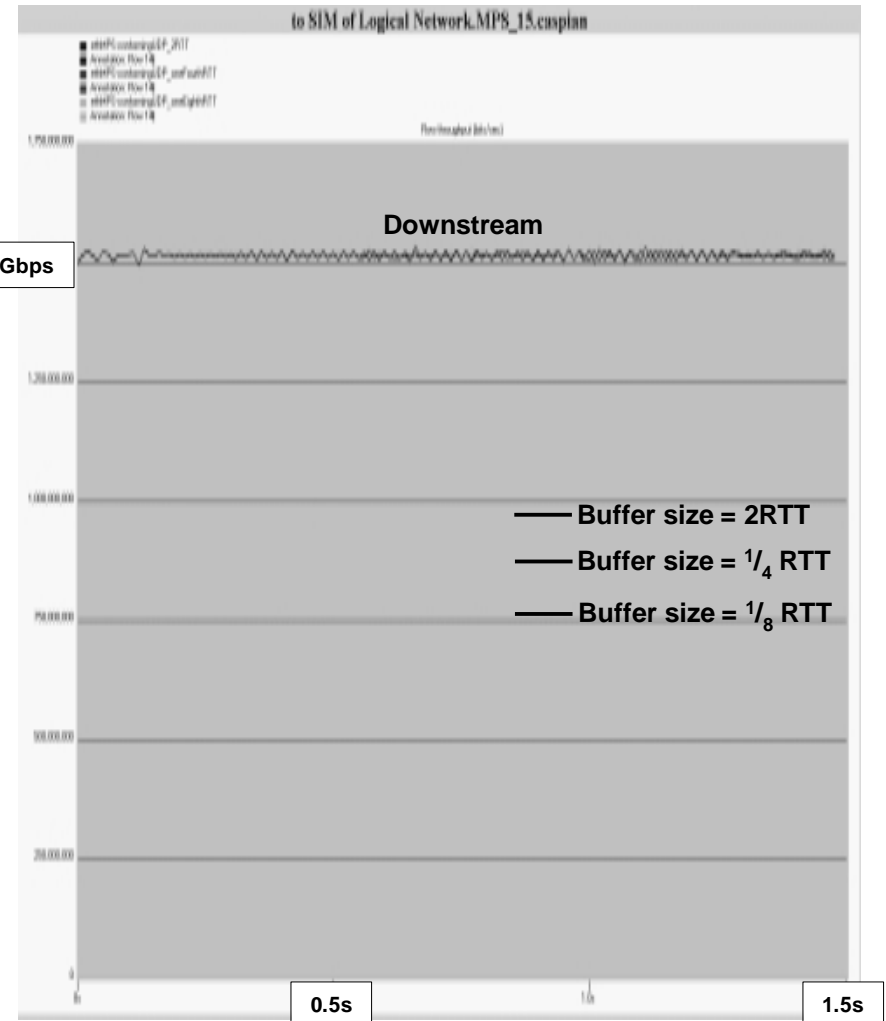
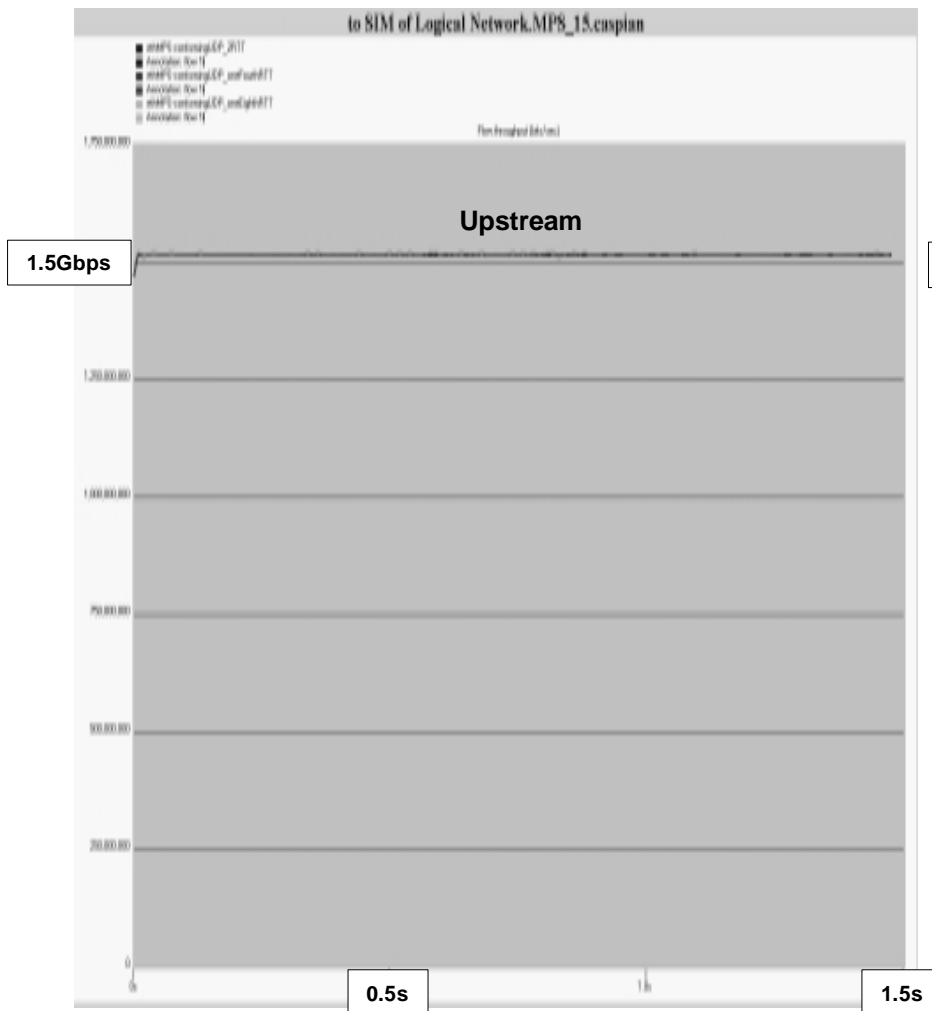
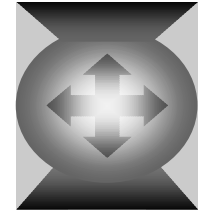
Utilization (last link)



- Buffer size = 2RTT
- Buffer size = $\frac{1}{4}$ RTT
- Buffer size = $\frac{1}{8}$ RTT

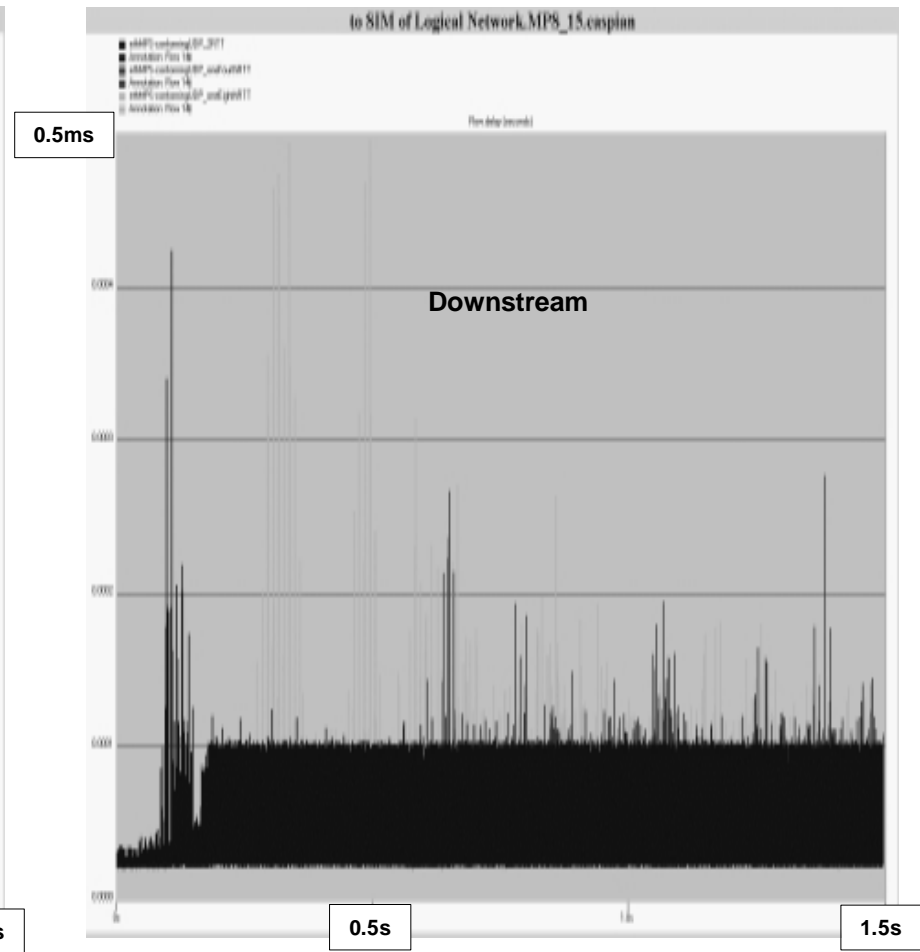
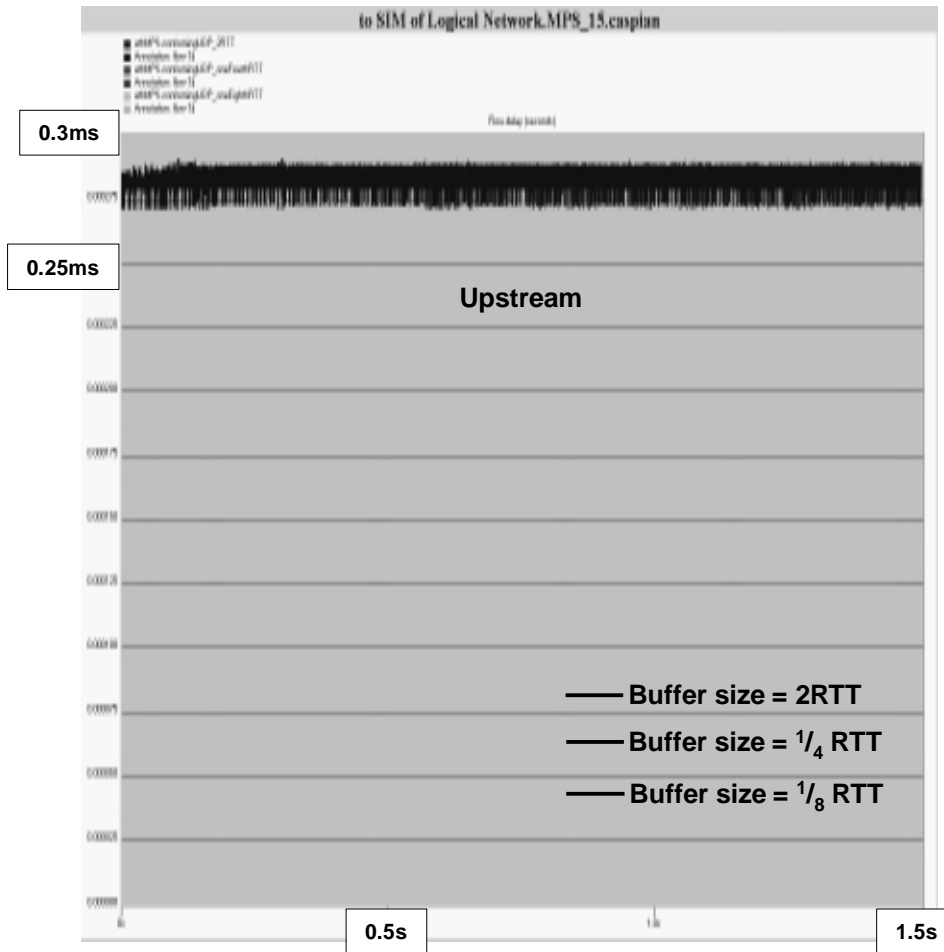
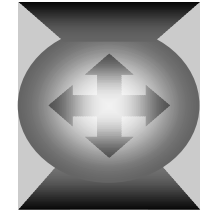
Fairness (bandwidth)

(Upstream and downstream conforming UDP flows)



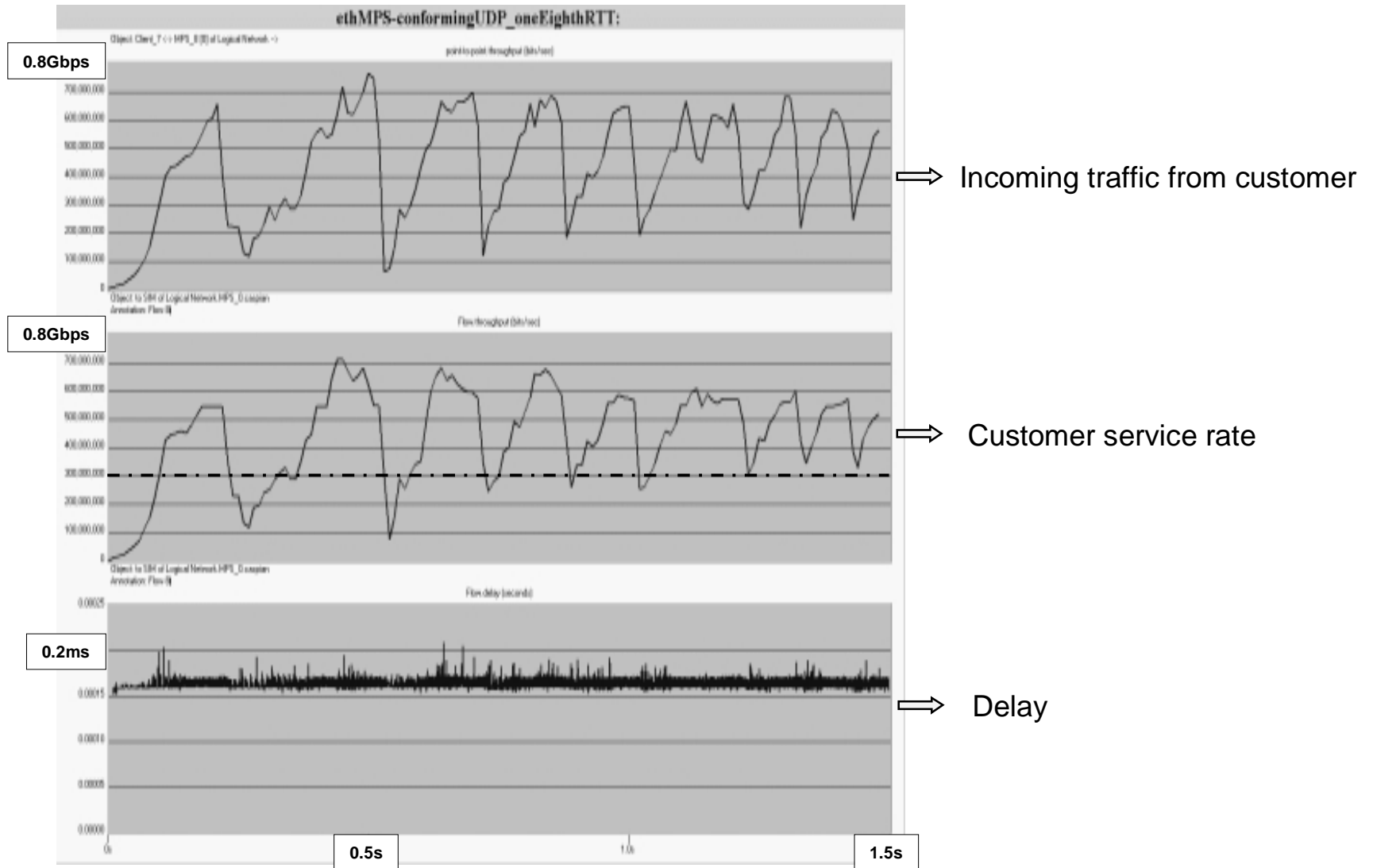
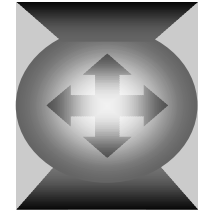
Delay

(Upstream and downstream conforming UDP flows)

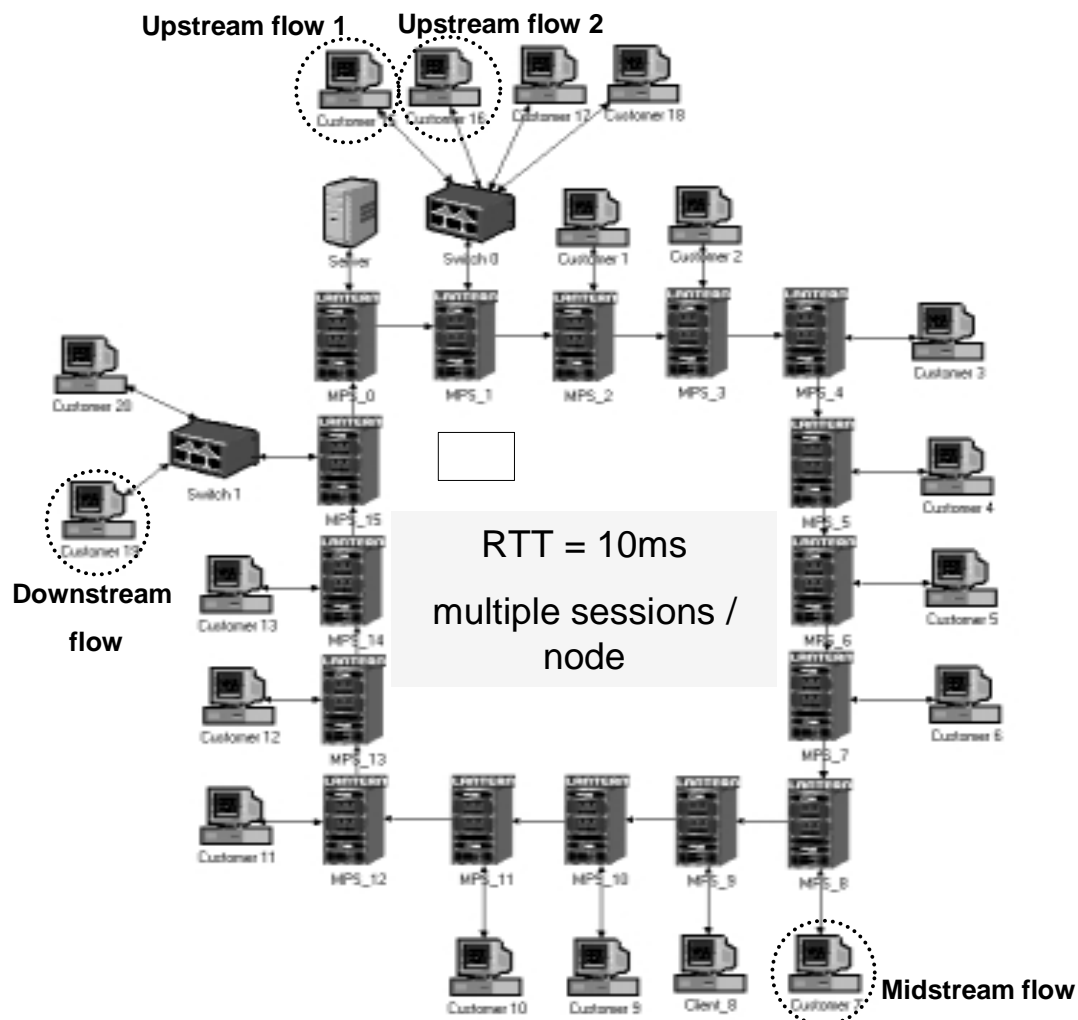
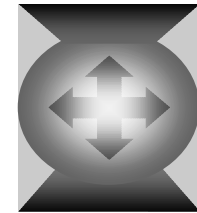


Fairness

(Midstream bursty TCP flow)



Scenario 4 (multiple flows)



TCP Parameters:

TCP Tahoe

Fast retransmit enabled

Fast recovery disabled

Buffer size = 2 RTT

SLA Parameters:

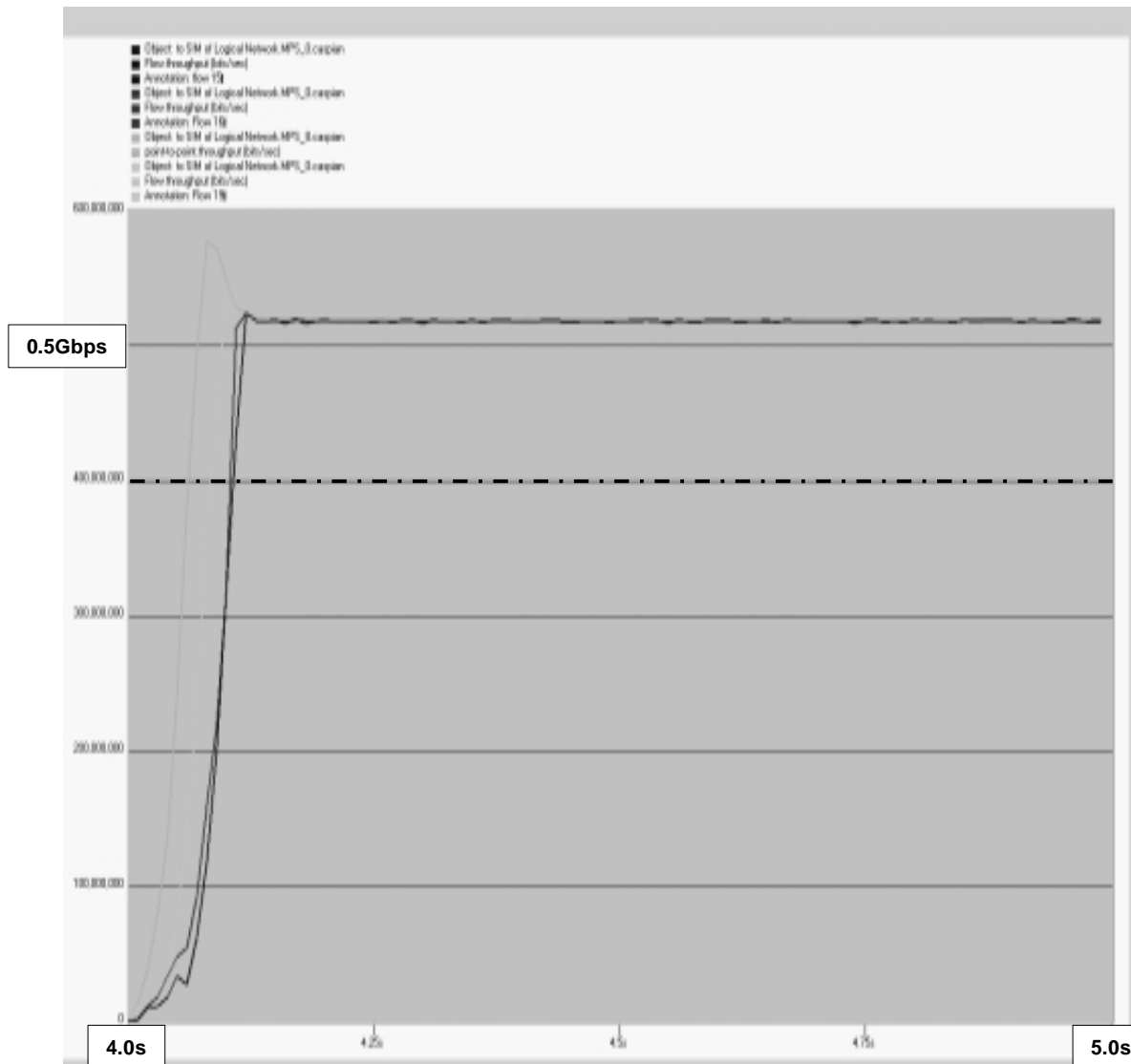
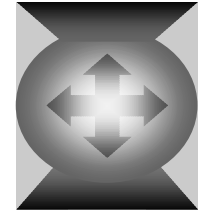
Customer 1 and Customer 20:

Ingress rate (max) = 10Gbps

Reserved rate = 0.4Gbps

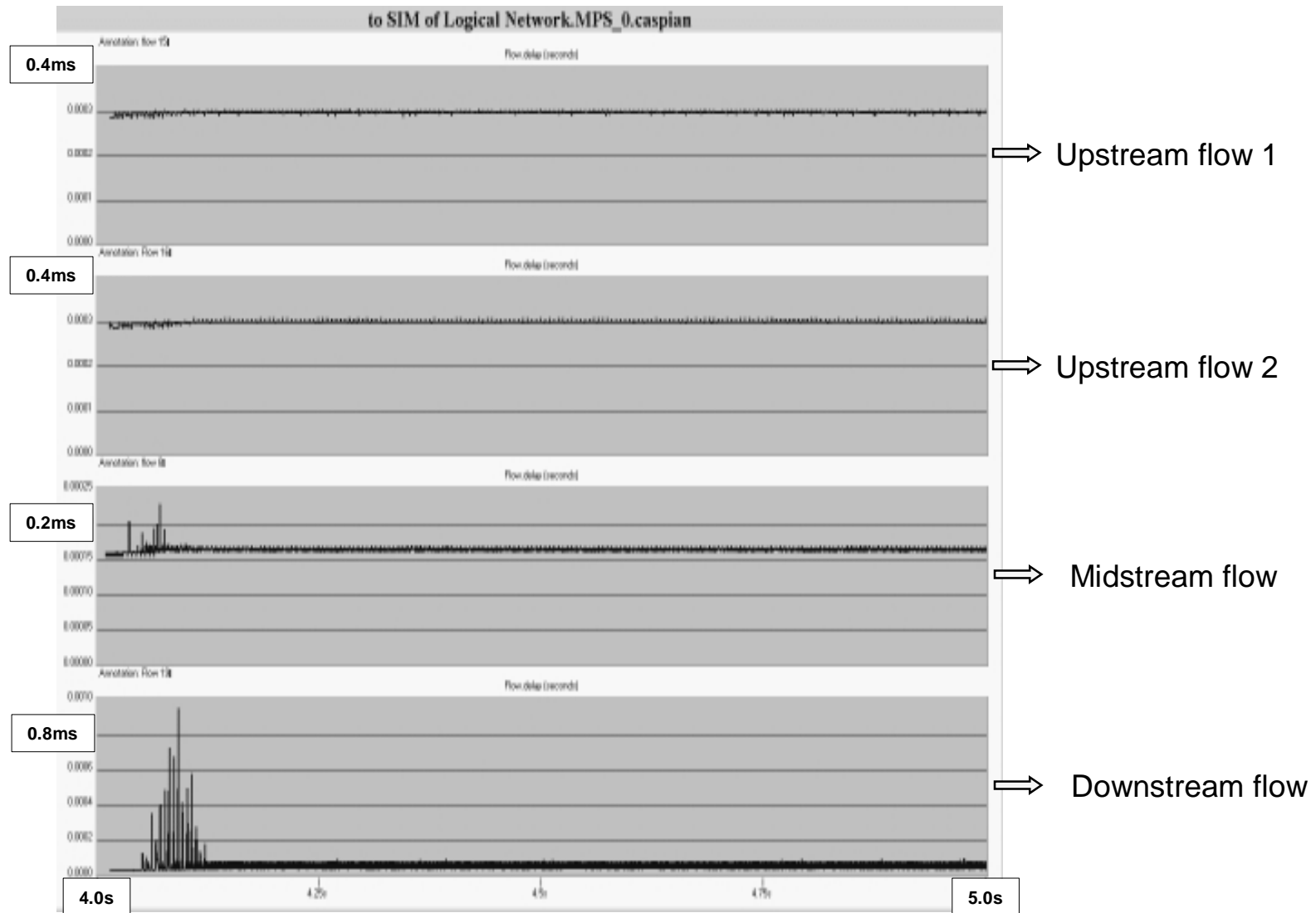
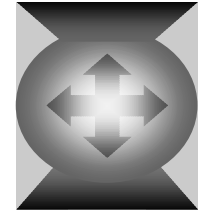
Weight = 1

Fairness (bandwidth)

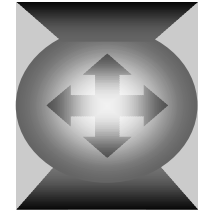


- Upstream flow 1
- - Upstream flow 2
- Midstream flow
- Downstream flow

Fairness (delay and jitter)



Observation



- ◆ Fast converging flow control can prevent interaction with TCP end-to-end flow control.
- ◆ 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