ENSC 835-3: NETWORK PROTOCOLS AND PERFORMANCE
CMPT 885-3: SPECIAL TOPICS: HIGH-PERFORMANCE NETWORKS
Ljiljana Trajkovic

FINAL PROJECT PRESENTATION

An Analysis of Constraint-based Routing in MPLS

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Road Map

- MPLS Overview
- Constraint-based Routing (CBR)
- Simulation with MNS2.0 in NS-2
- Discussion
- Future work
- Reference

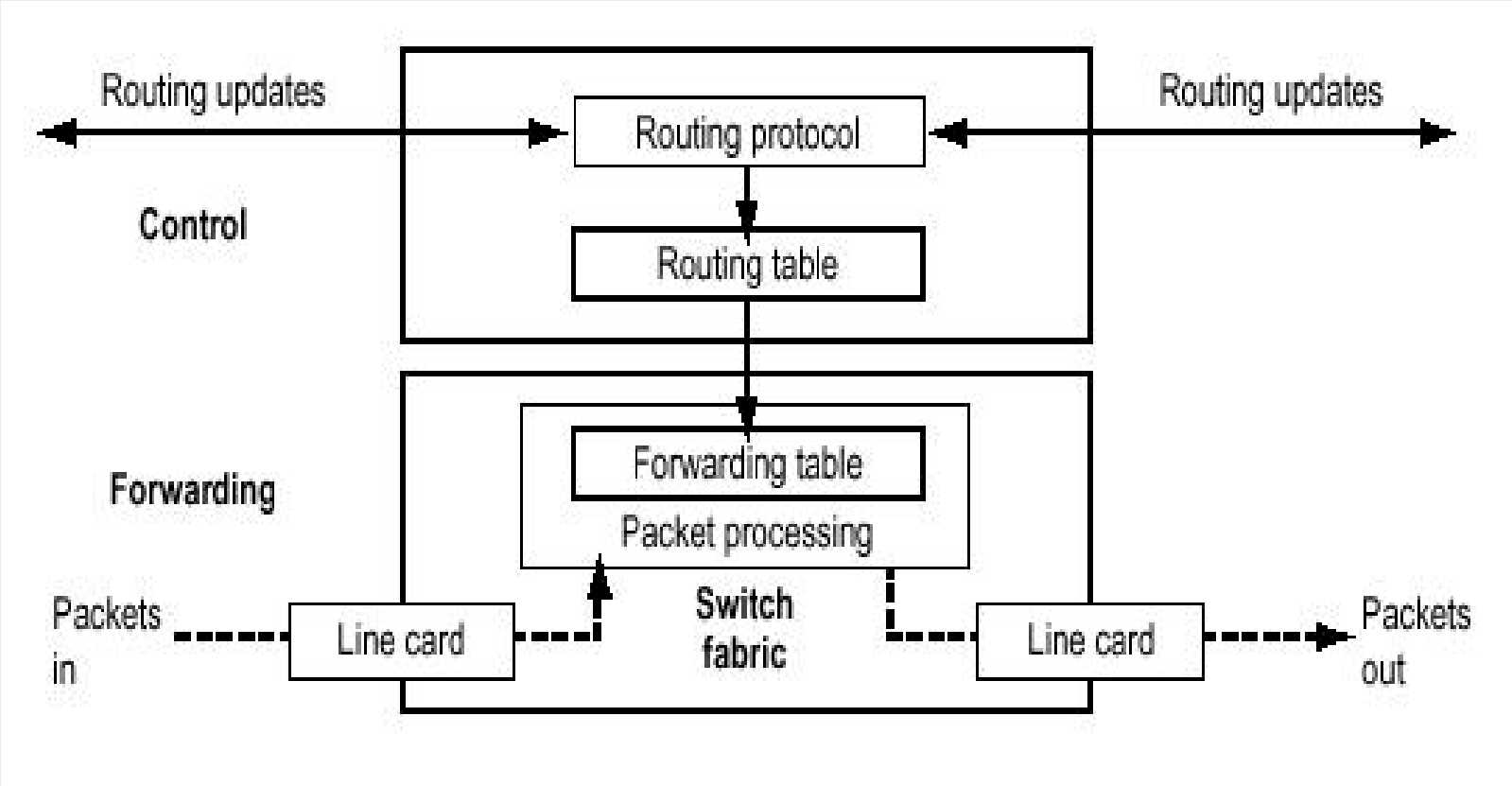
MPLS Overview

Multiple Protocol Label Switching (MPLS) Capabilities

- Traffic Engineering
- Connection-oriented QoS Support
- Multiprotocol Support
- Virtual Private Network (VPN)

MPLS Overview

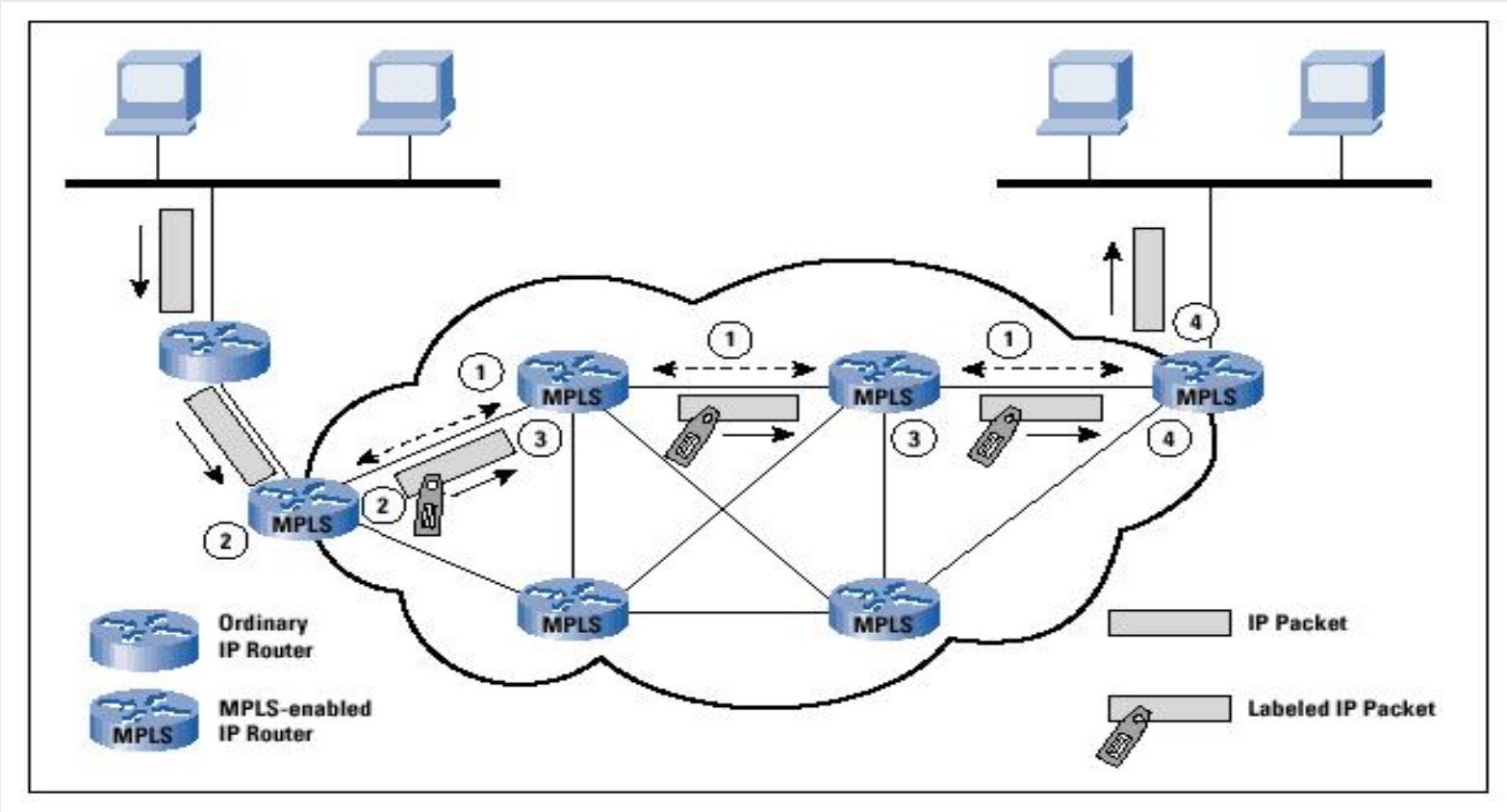
Separation of Control and Forwarding Components



MPLS Overview

- Packet Forwarding

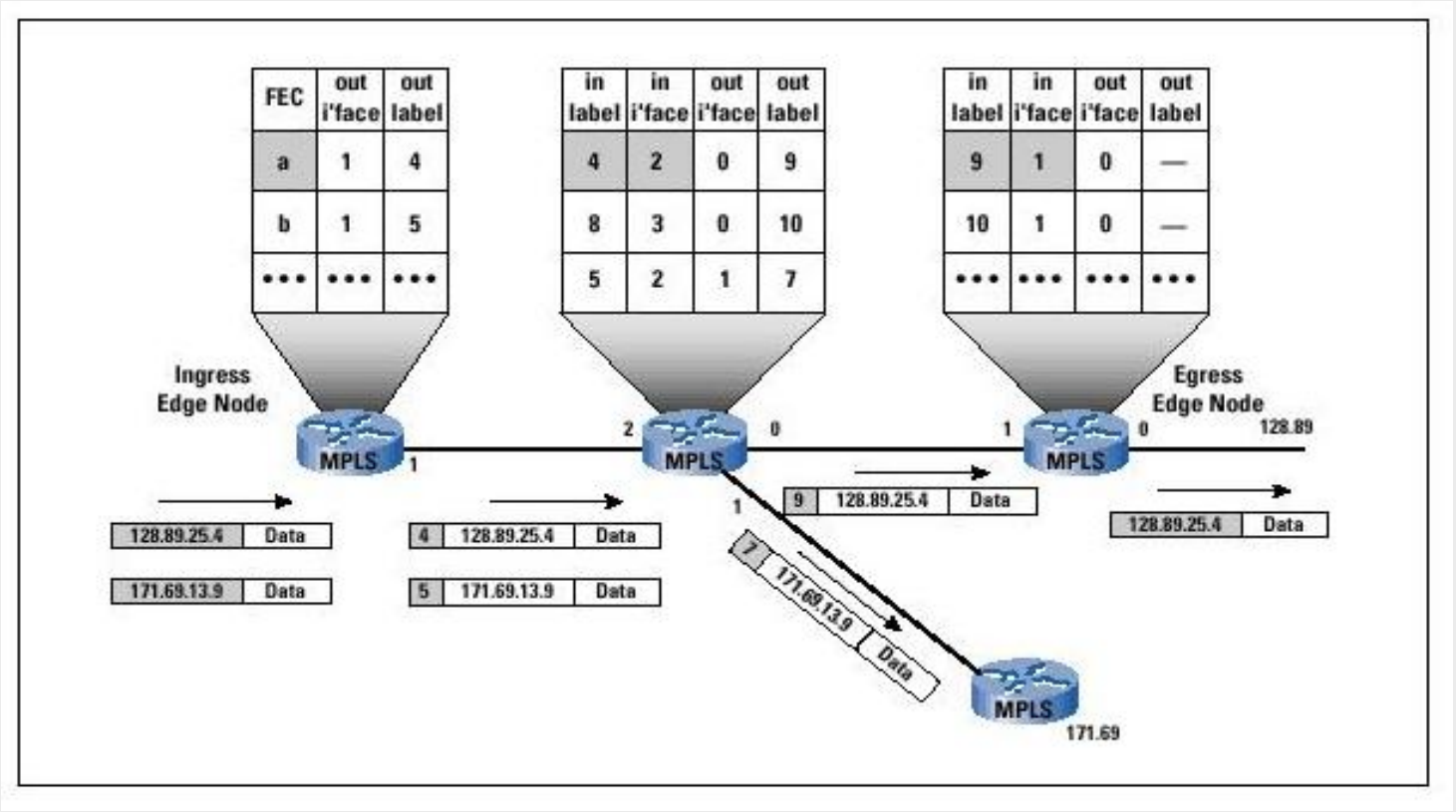
An MPLS Label Switched Path (LSP) set up between two Label Switched Routers (LSR) is similar to an ATM VC



MPLS Overview

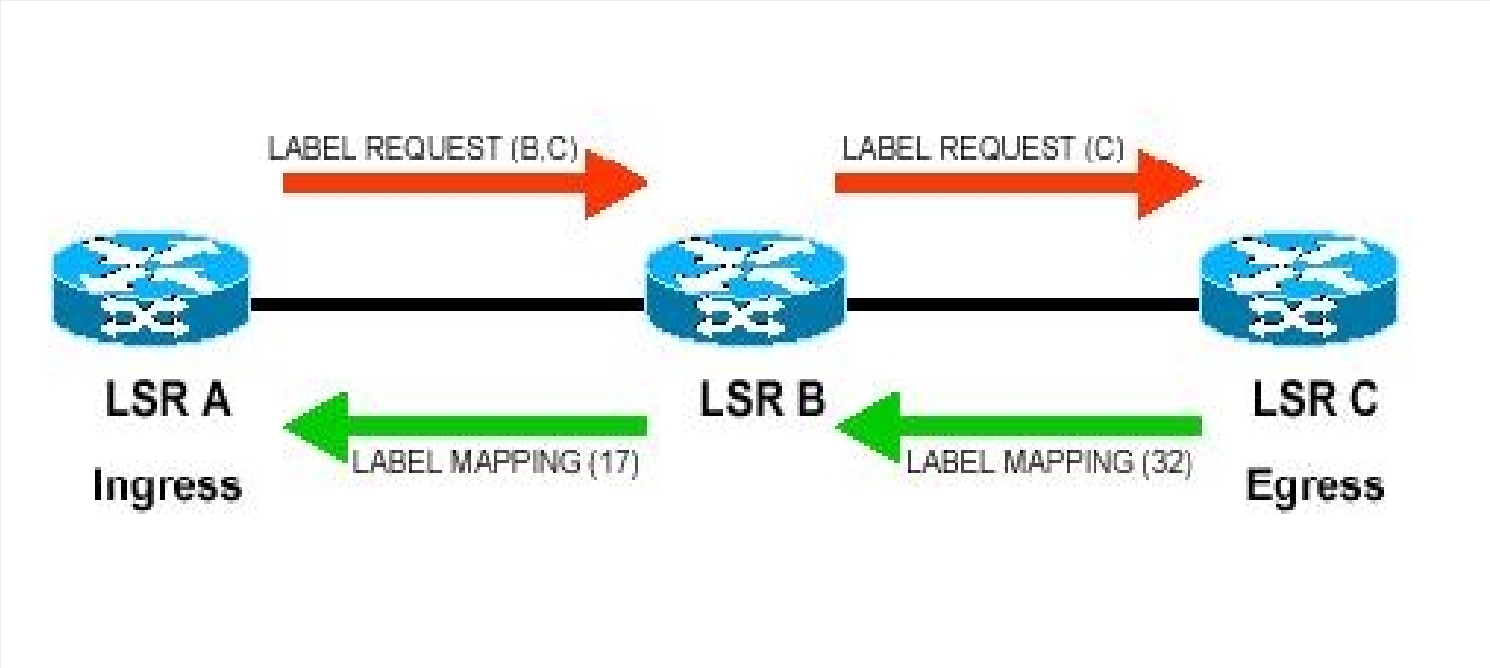
- Packet Forwarding (cont.)

  One or more Forwarding Equivalence Class (FEC) may be mapped to a single LSP



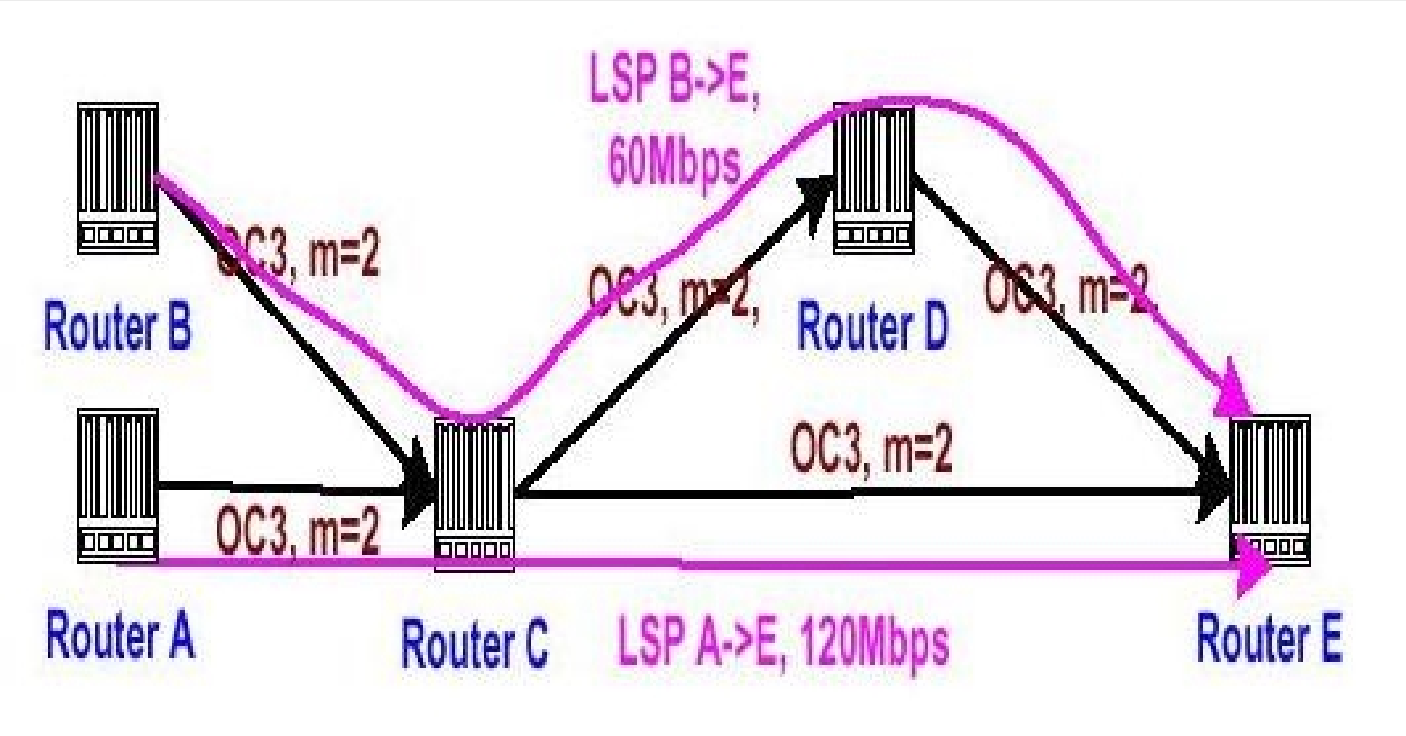
MPLS Overview

Control component-Label distribution protocol (LDP)



Constraint-based Routing

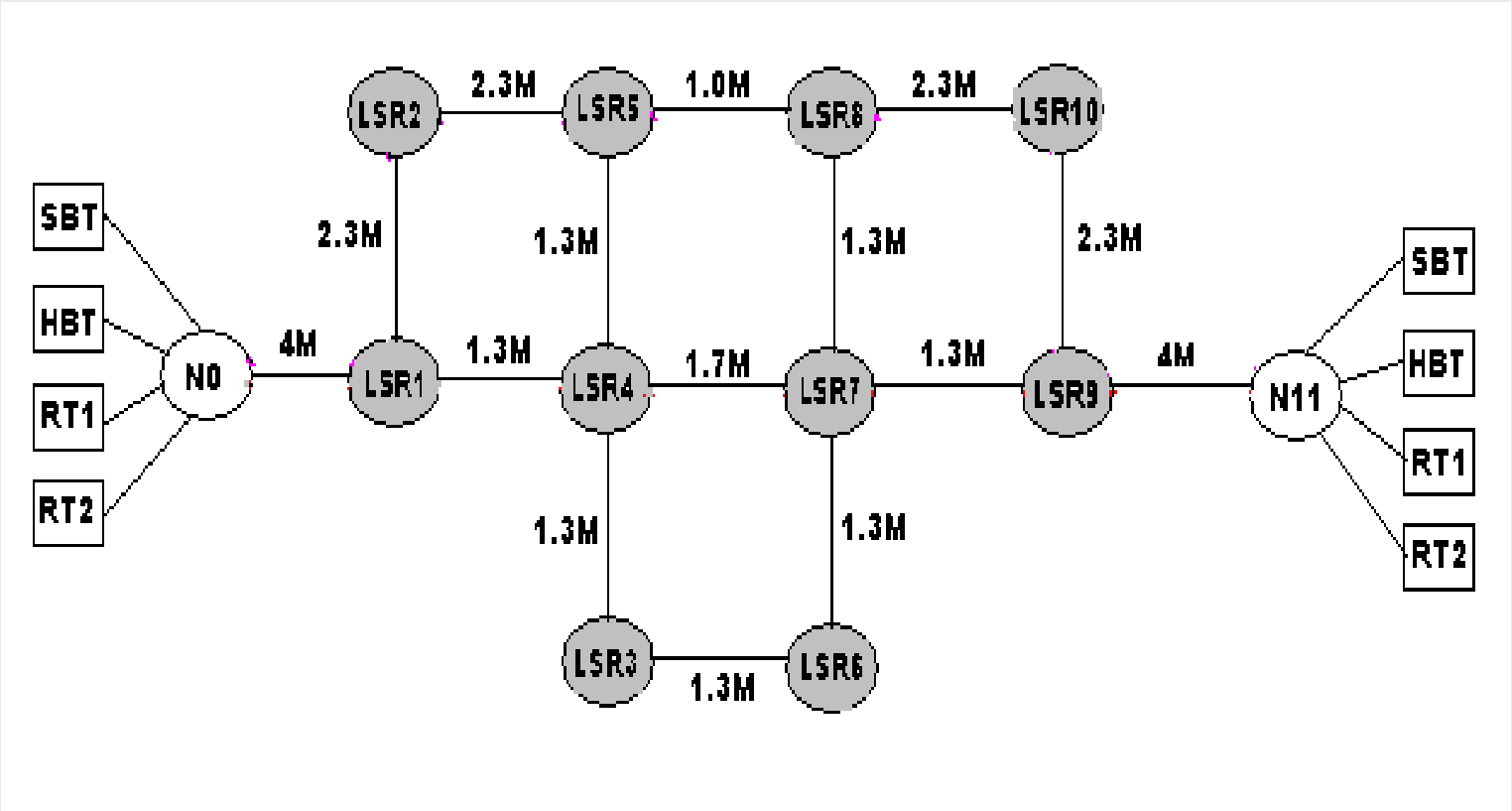
CR-LDP consider not only network topology, but also other constraints-link bandwidth, delay, etc.



Simulation with MNS-2 in NS

- Install MNS-v2.0 (Written by Gaeil Ahn)
- Create a network topology
- Attach traffic agents of multiple service classes
- Measure performance of packet delay, packed loss and network utilization of the following two scenarios:
  - Scenarios 1
    - Set up CR-LSPs in the ascending order of importance
  - Scenarios 2
    - Set up CR-LSPs in the descending order of importance

Network topology



Traffic Type

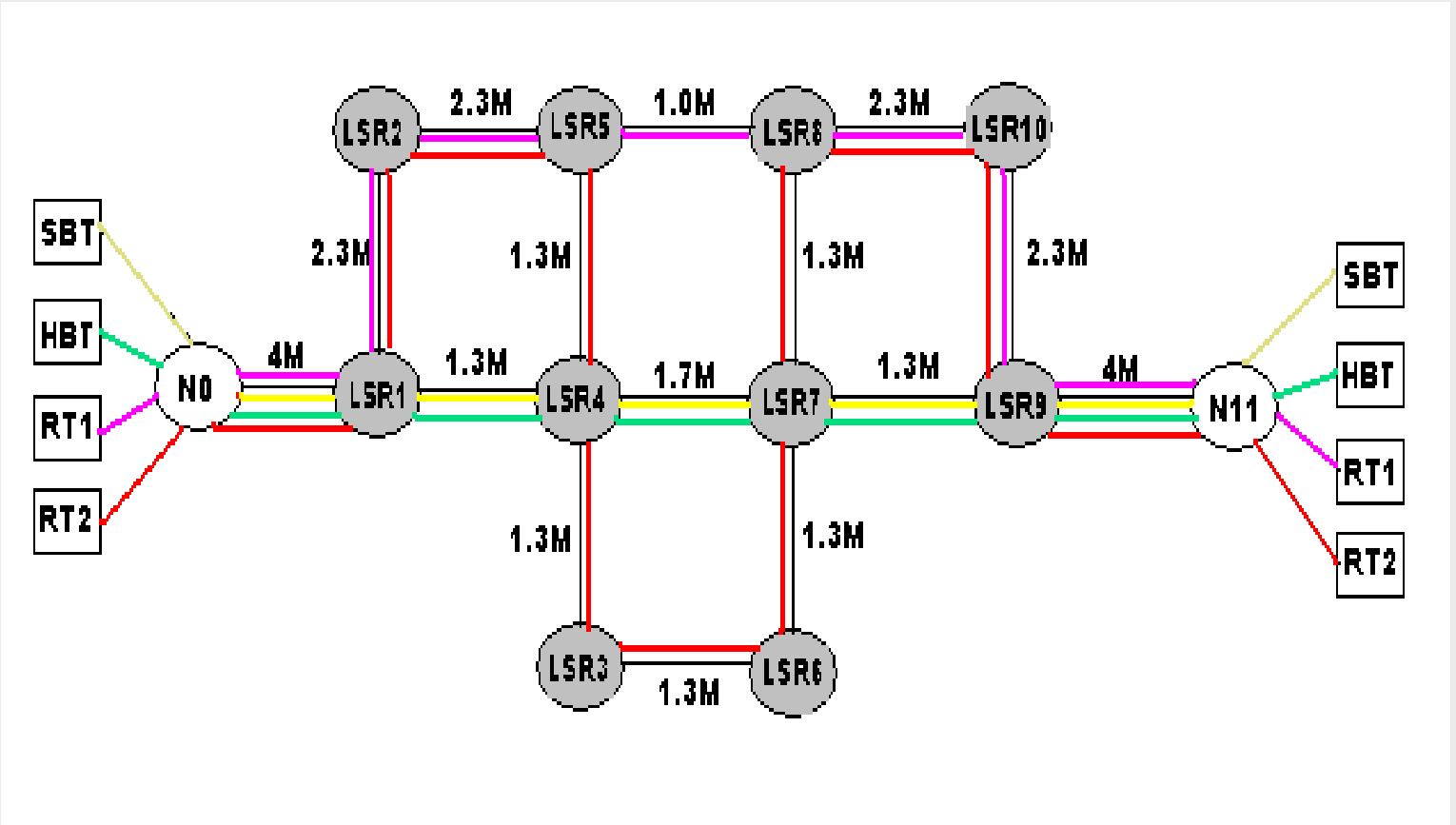
- Real-time2
  - CBR traffic: Packet Size 200b, Bandwidth 1000k
- Real-time1
  - CBR traffic: Packet Size 200b, Bandwidth 800k
- High priority Best Effort
  - Exponential on/off traffic: Packet Size 200b, Burst time 500ms, Idle time 500ms, Bandwidth 300k
- Simple Best Effort
  - Exponential on/off traffic: Packet Size 200b, Burst time 200ms, Idle time 800ms, Bandwidth 100k

Scenario 1 (w/o OCPC)

- Simulation Schedule
  1. At 0.0, Set up CR_LSP (with lspid 1100) for SBT
  2. Right after CR_LSP 1100 is set up, SBT start
  3. At 0.2, Set up CR_LSP (with lspid 1200) for HBT
  4. Right after CR_LSP 1200 is set up, HBT start
  5. At 0.4, Set up CR_LSP (with lspid 1300) for RT1
  6. Right after CR_LSP 1300 is set up, RT1 start
  7. At 0.6, Set up CR_LSP (with lspid 1400) for RT2
  8. Right after CR_LSP 1400 is set up, RT2 start
  9. At 3.0, Stop traffic sources
  10. At 3.1, Stop simulation

Scenario 1 (w/o OCPC cont.)

- CR_LSP set-up diagram



Scenario 1 (w/o OCPC cont.)

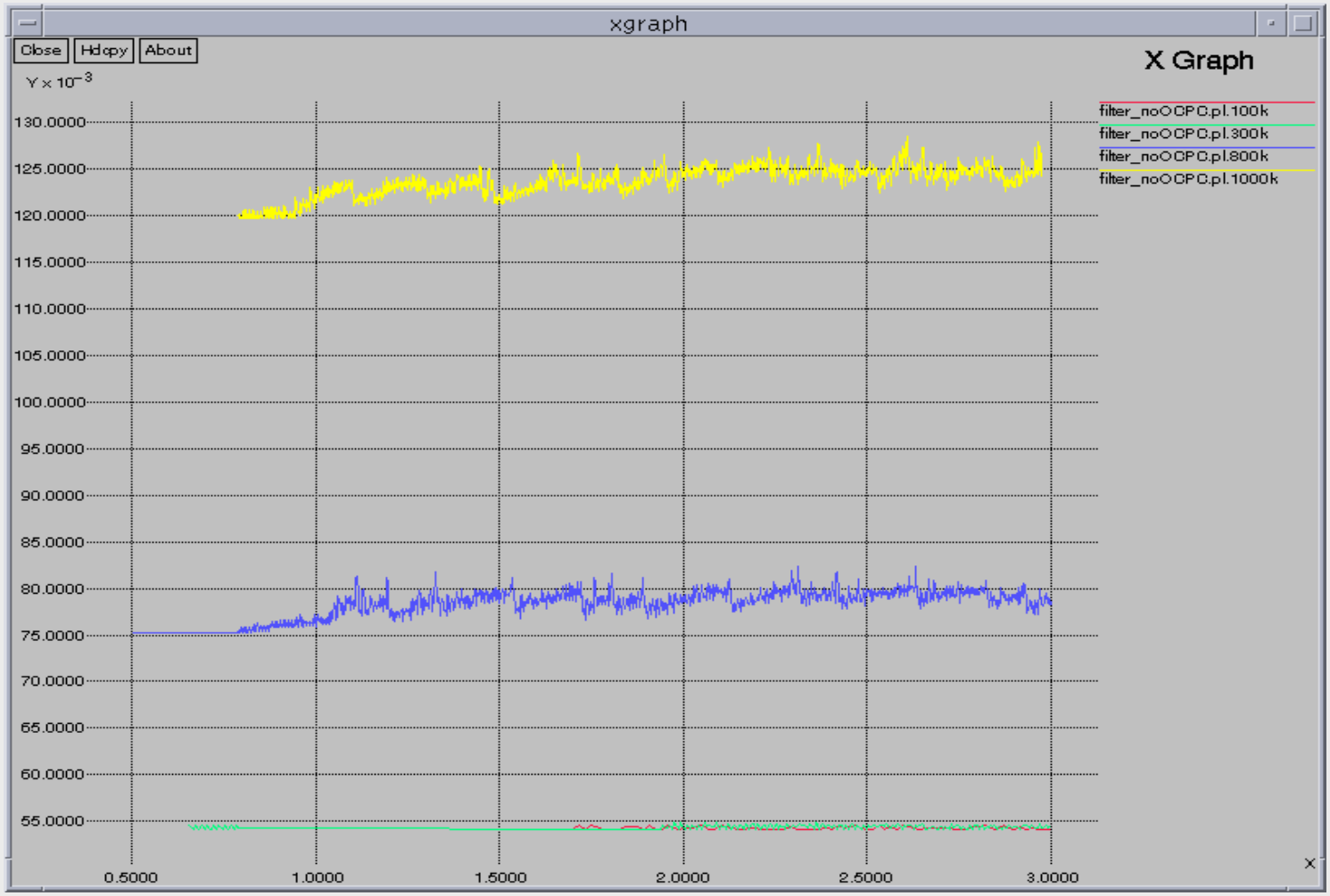
•Network Performance Statistics

Traffic Type	Bandwidth (kbps)	Packets Sent	Packet Dropped	Packet Lost Rate	Average Delay (ms)
SBT	100	82	0	0	54.3
HBT	300	224	0	0	54.4
RT1	800	1248	13	1.04%	78.2
RT2	1000	1381	35	2.53%	123.7

Overall Delay : 96.89 ms

Scenario 1 (w/o OCPC cont.)

- Network Performance Statistics graph

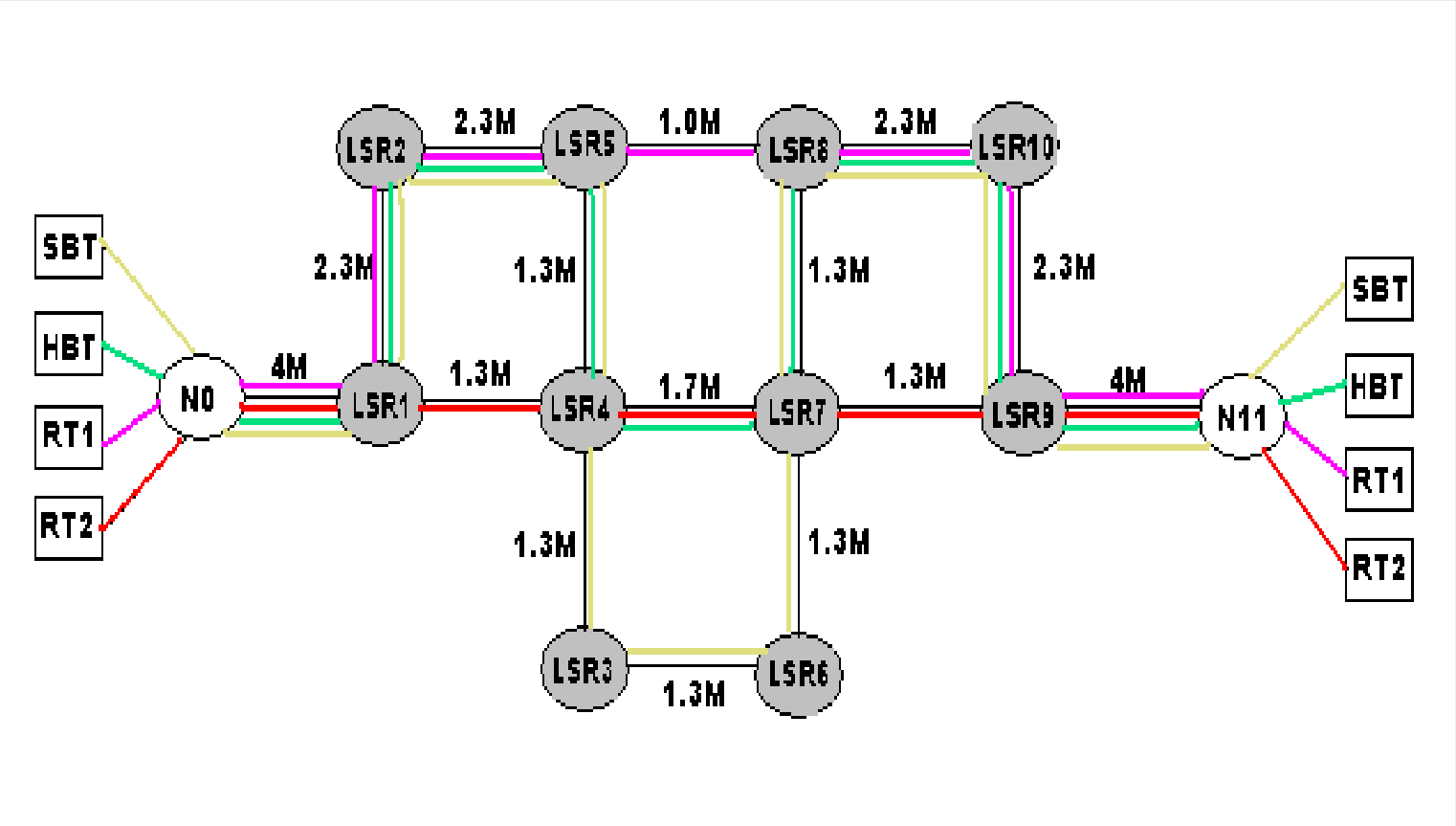


Scenario 2 (with OCPC)

- Simulation Schedule
  1. At 0.0, Set up CR_LSP (with lspid 1100) for RT2
  2. Right after CR_LSP 1100 is set up, RT2 start
  3. At 0.2, Set up CR_LSP (with lspid 1200) for RT1
  4. Right after CR_LSP 1200 is set up, RT1 start
  5. At 0.4, Set up CR_LSP (with lspid 1300) for HBT
  6. Right after CR_LSP 1300 is set up, RT1 start
  7. At 0.6, Set up CR_LSP (with lspid 1400) for SBT
  8. Right after CR_LSP 1400 is set up, RT2 start
  9. At 3.0, Stop traffic sources
  10. At 3.1, Stop simulation

Scenario 2 (with OCPC cont.)

- CR_LSP set-up diagram



Scenario 2 (with OCPC cont.)

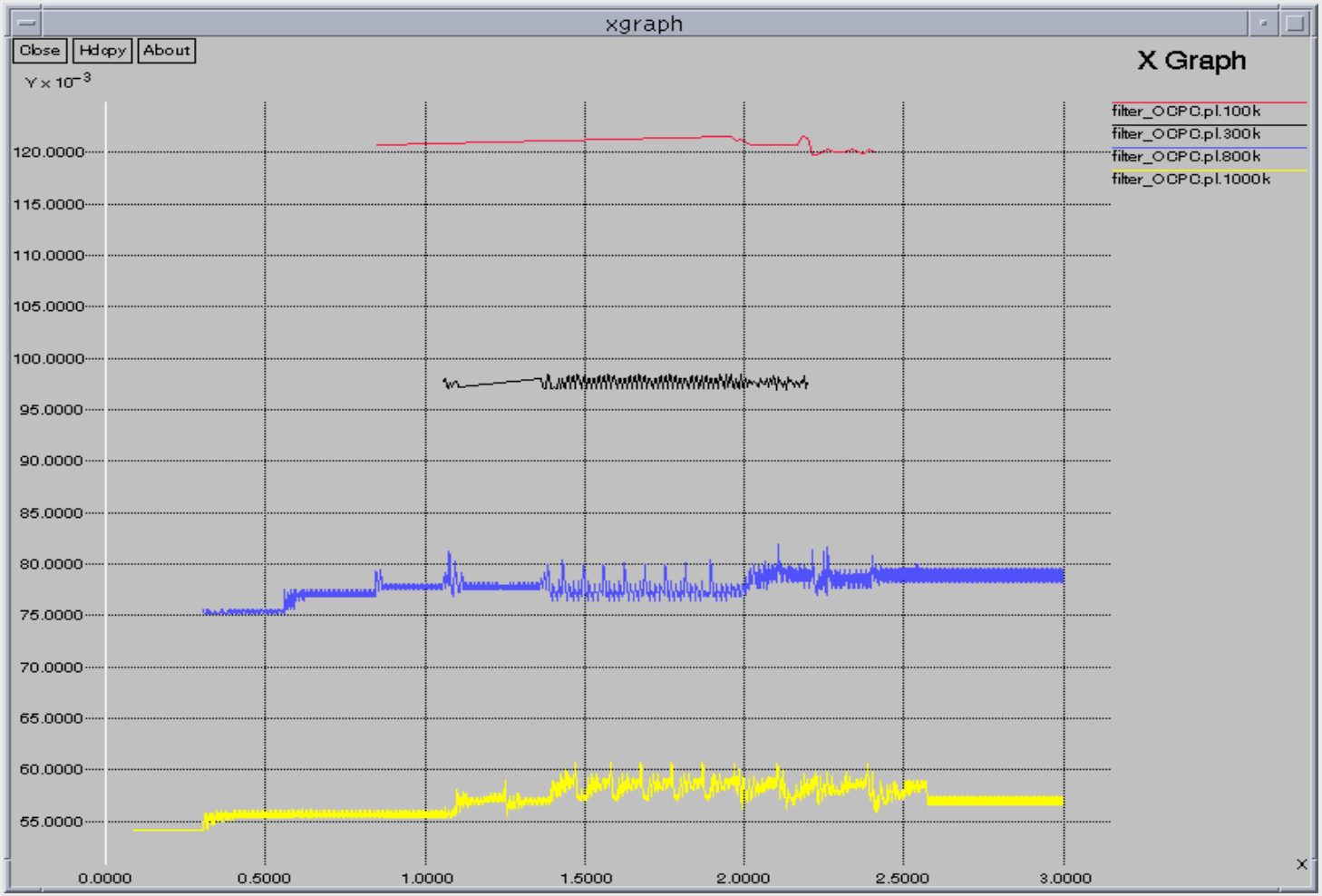
- Network Performance Statistics

Traffic Type	Bandwidth (kbps)	Packets Sent	Packet Dropped	Packet Lost Rate	Average Delay (ms)
SBT	100	30	0	0	120.5
HBT	300	166	0	0	97.7
RT1	800	1348	11	0.82%	77.8
RT2	1000	1823	15	0.82%	56.9

Overall Delay : 67.88 ms

Scenario 2 (with OCPC cont.)

- Network Performance Statistics graph



Discussion

- Constraint-based Routing in MNS2 succeeded in routing the traffic around the unsatisfied links
- LSPs set up order has great effect on the overall packet delay
  - From 96.89 ms to 67.88 ms
- The paths for the LSPs can be computed by some offline Constraint-based Routing algorithm[1].

Future Work

- Use some real traffic trace such as the *Star War* trace file
- Expend the Network topology and upgrade the link bandwidth
- Implement an Offline Constraint-based Routing Algorithm as a application on an offline server.

References 1

- [1] XiPeng Xiao, A. Hannan, B. Bailey, S. Carter, L. M. Ni, "Traffic Engineering with MPLS in the Internet", IEEE Network magazine, pp. 28-33, March 2000. http://www.cse.msu.edu/~xiaoxipe/papers/mplsTE/mpls.te.pdf
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Reference 2

- [5] David Culley, Chris Fuchs, Duncan Sharp, “ An Investigation of MPLS traffic engineering capabilities using CR-LDP”, http://www.ensc.sfu.ca/~ljilja/ENSC833/Projects/ENSC833.projects.html, Spring 2001
- [6] XiPeng Xiao, Thomas Telkamp, Lionel M. Ni, "A Practical Approach for Providing QoS in the Internet Backbone", Aug. 2001
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- [10] E. Rosen, A. Viswanathan, R. Callon, IETF RFC 3031 “Multiprotocol Label Switching Architecture”. January 2001.

Thank You !