INVESTIGATION of MPLS TRAFFIC ENGINEERING CAPABILITIES using CR-LDP

Ensc-833
Project Presentation

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OUTLINE:

- Project Objectives & Scope
- Overview of MPLS & CR-LDP
- Simulation Implementation
- Simulation Results & Discussion

PROJECT OBJECTIVES & SCOPE

Project Rationale: The Internet is excellent best effort network, but long and variable delay make it a poor network for real-time (multi-media) traffic. If the Internet is to evolve into the future "Information Highway", this needs fixing. MPLS is viewed as a potential part of the fix.

Primary Objective: demo MPLS ability to provide traffic engineering in a mixed traffic network

Secondary Objectives:

- adapt available MPLS & LDP "ns-2" modules
- extend the authors' knowledge of MPLS & CR-LDP
- get working knowledge of a network simulation tool

Benefits of MPLS & LDP/CR-LDP

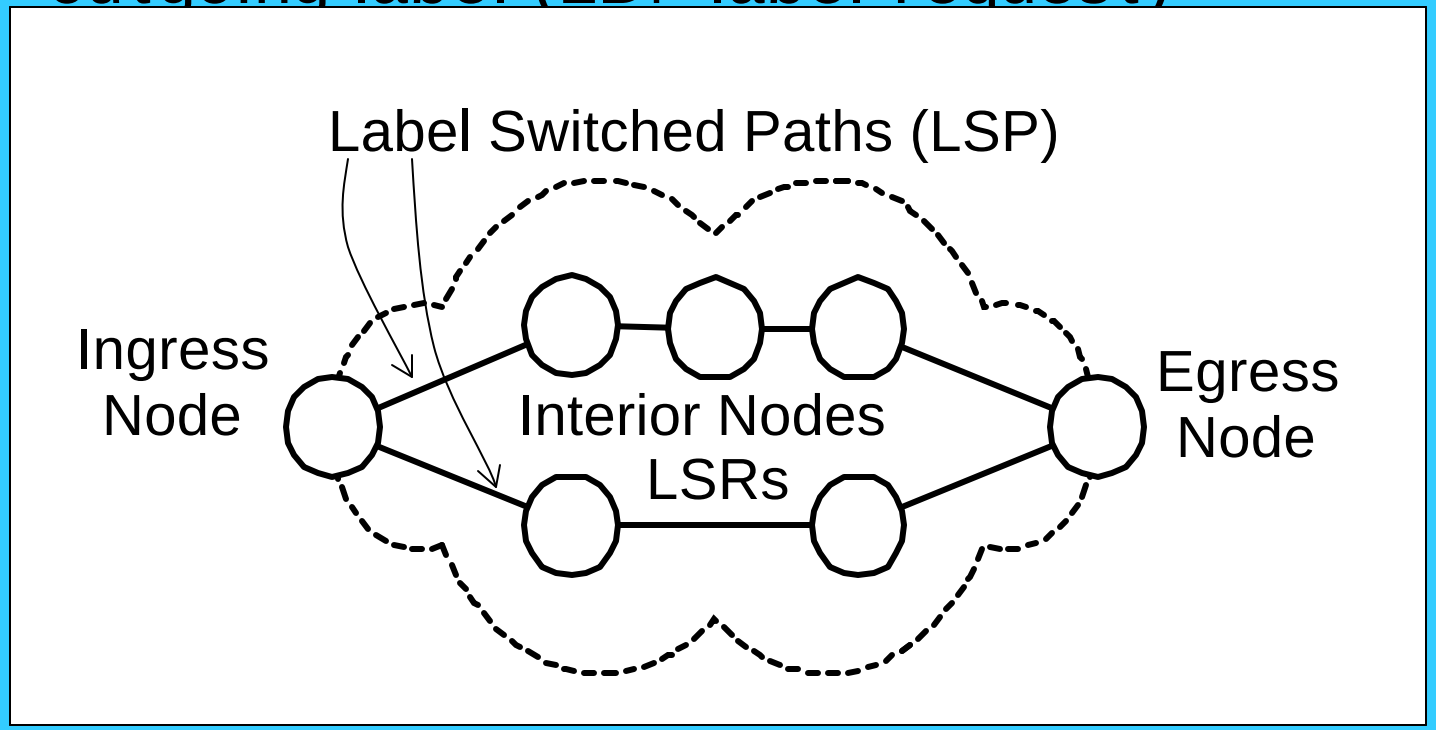
- Multi-Protocol Label Switching (MPLS) is a layer 2 protocol that integrates forwarding and routing
  - Fast: labels are indices into tables
  - Scalable: hierarchical virtual channeling
  - Service: path QoS differentiation
  - Traffic engineering: possible with constraint routing (non-shortest path)
  - Flexible control: data vs control driven & independent vs ordered control etc

Benefits of MPLS & LDP/CR-LDP (cont'd)

- Flow can be aggregated based on FEC
- Ability to detect & stop loop flow
- Works with any link/network layer protocols
- Multicast is supported

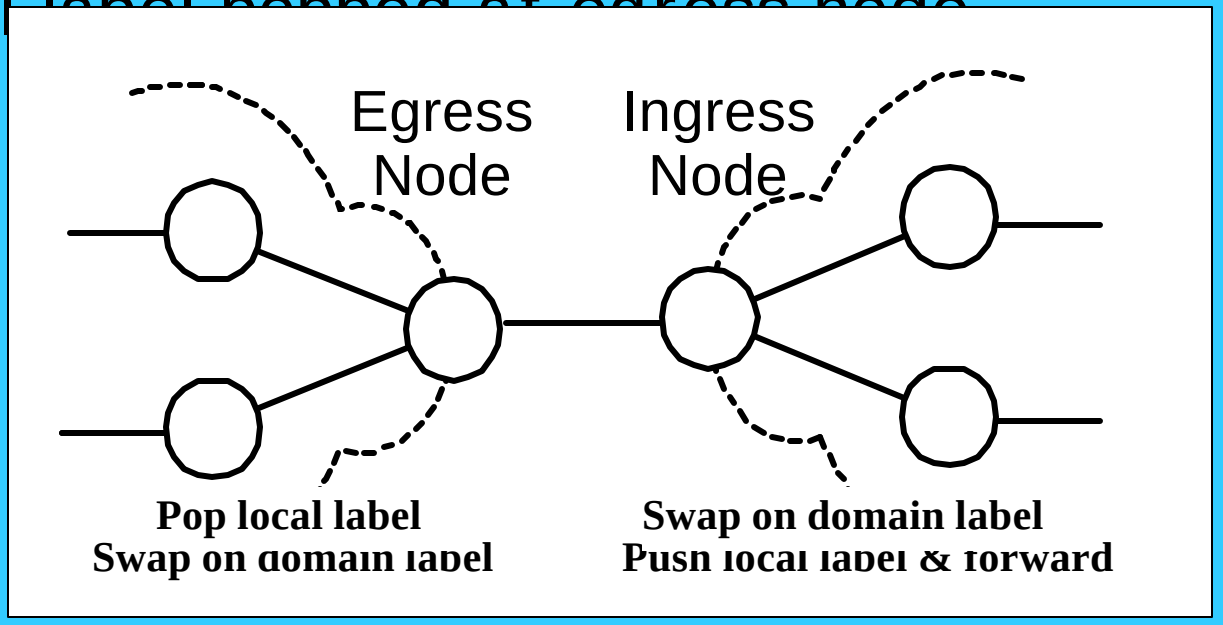
Intradomain MPLS/LDP Route Setup

- OSPF must come up with routing table first
- Next hop based on OSPF
- MPLS database requires at least 5 entries:
  - FEC & next hop & interfaces
  - incoming label (local binding - no initiation req'd)
  - outgoing label (LDP label request)



Interdomain MPLS Route Setup

- Next hop based on BGP routing only & not OSPF
- Egress and Ingress nodes send LDP messages via intradomain MPLS paths
- Label stack used - no limit to stack depth
- Lookup always performed on label at the stack top
- Local label pushed on interdomain entry
- Local label popped at egress node



Interdomain MPLS Advantages

- LSRs don't have to maintain interdomain routes
- Results in faster convergence
  - interdomain changes border routing tables only
  - interior LSR restart faster
- Better fault isolation between domains

Label Distribution Protocol (LDP)

- Runs over TCP
- LDP uses the OSPF to setup up intradomain LSPs
- Labels exchanged between adjacent LSRs
- Label Binding Distribution Methods:
  - Unsolicited (ex initialization)
  - On demand (ex route changes)
- Label Control Modes:
  - Independent control (faster but less robust)
  - Ordered control (from border nodes)
- Label retention modes
  - Conservative
  - Liberal

LDP Messages

- Discovery Messages
  - Hello
- Adjacency Messages
  - Initialization, keep alive, & shutdown messages
- Advertisement Messages
  - Label mapping & label request
  - Label withdrawal & label release
- Notification Messages
  - for error signaling & advisory information

CR-LDP

- Extension of ordinary LDP
- Provides
  - explicit routing &
  - reservation of resources along routes
- RSVP is a possible alternative
- How it works:
  - (1) list of MPLS nodes is constructed & sent
  - (2) Label Request issued on forward sweep
  - (3) Label Mapping issue on backward return

CR-LDP Traffic Parameter Packet

- Provides means of communicating QoS parameters:
  - Peak data rate & burst size define bucket characterizing max expected rate of traffic
  - Committed data rate & burst size define bucket characterizing average expected rate of traffic
  - Excess burst size defines a bucket characterizing the amount by which bursts exceed the committed burst size

SIMULATION IMPLEMENTATION

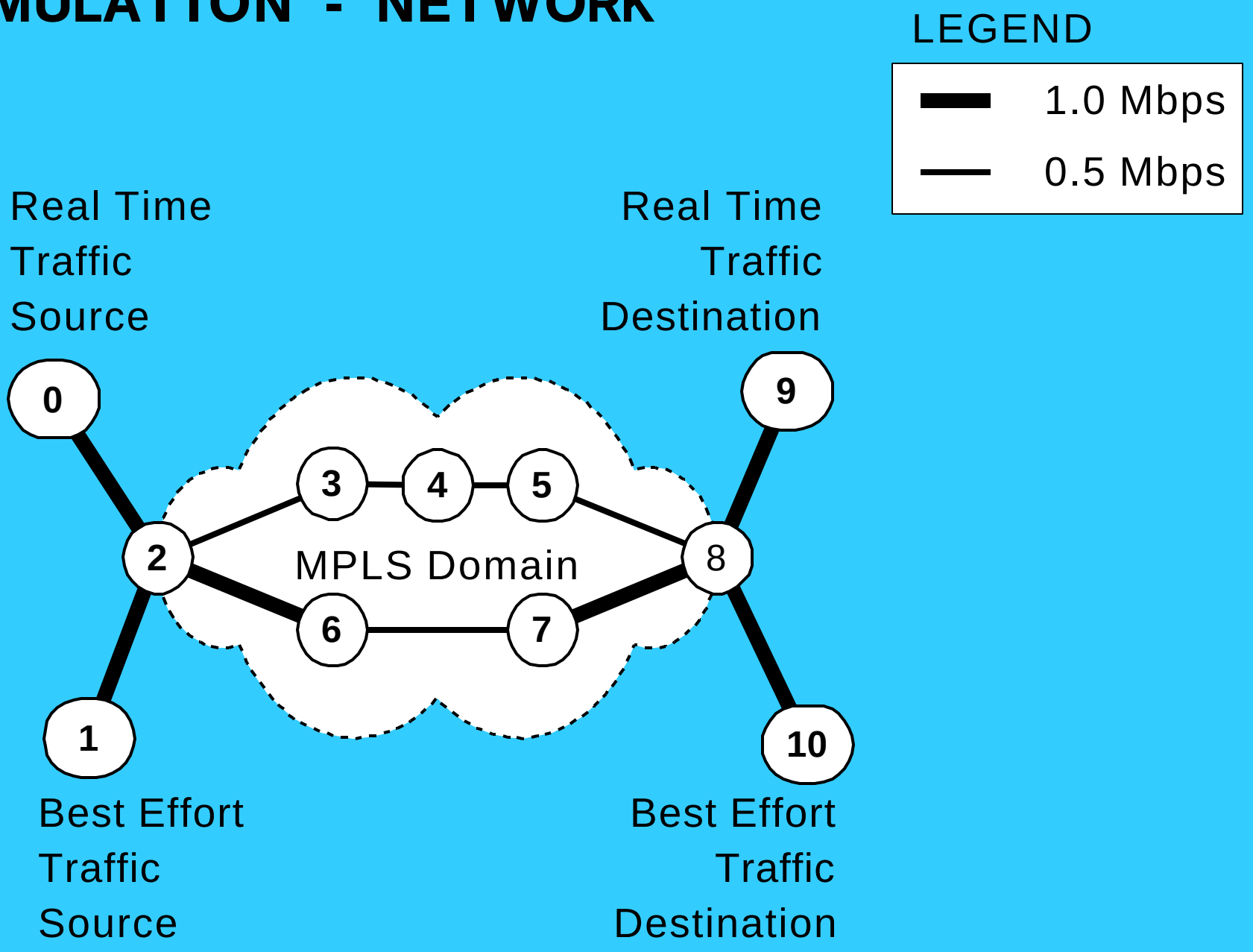
- used “ns-2”
  - http://www.isi.edu/nsnam/ns/
- MPLS nodes & CR-LDP modules
  - http://www.raonet.com

SIMULATION IMPLEMENTATION

Demonstrate “traffic engineering”... STEPS:

- Set up network carrying mixed traffic
  - Real-time (RT)
  - Best-effort
- Operate without traffic engineering
  - measure delay to the RT traffic
- Use CR-LDP explicit route capability to dedicate network resources to RT traffic
  - measure & compare delay

SIMULATION - NETWORK



SIMULATION IMPLEMENTATION - TRAFFIC

- Constant Bit Rate (CBR) traffic over UDP
  - 48 byte packets every 3 ms
  - Ex. 2 64kbps channels
- Best effort Ethernet trace over TCP
  - From Bellcore ethernet trace
  - Provides “noise” for our Quality of Service simulation
  - Default TCP implementation is “Tahoe”
  - ns trace starts at random point

PERFORMANCE MEASUREMENTS

- used “nam” animation with queue monitors
- measured end-to-end delay of real time packets
  - dump simulator trace to an output file
  - run custom “Perl” script to filter data
  - imported and plotted in Excel

SIMULATION IMPLEMENTATION ISSUES

- compiling & getting MPLS nodes & LDP code working
- converting traces to “ns” form
- capturing & filtering data

SIMULATION RESULTS

- By default, MPLS defers to higher layer for routing function.
- Default IP routing is Distance Vector (DV), so both flows through the network follow the same path through which has the fewest hops between source and destination.
- Shared route has a slow link which builds up queue depth.

SIMULATION RESULTS

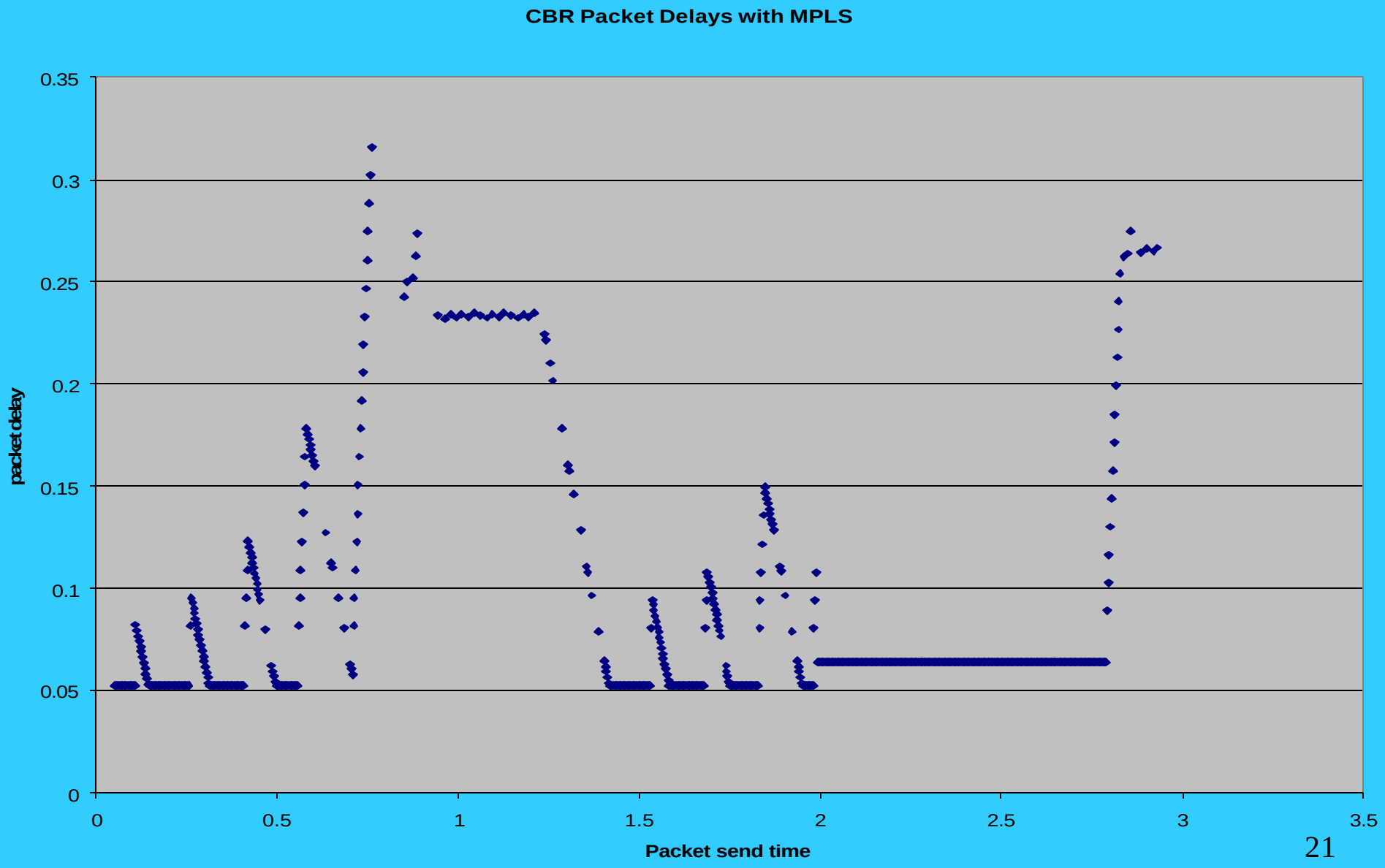
- TCP steals available bandwidth, so CBR traffic gets stuck in the queue.
- Result: high delay variation for CBR traffic and poor Quality of Service.

- After explicitly routing CBR traffic, CBR traffic no longer shares slow link with TCP traffic, and delay variation becomes very small.

SIMULATION RESULTS

- CR-LDP “withdraw” message at 1.6 sec
  - Marks LSP to node 9 to be withdrawn
  - Prevents circular routing once explicit route is setup
- CR-LDP explicit route setup at 1.9 sec
  - Add routing for LSP to node 9 to LDP stack
- At 2.0 sec “install” directive at node 2 causes CBR flow to switch to new route

SIMULATION RESULTS



DISCUSSION

- MPLS with CR-LDP can provide superior Quality of Service when compared with IP alone or MPLS with LDP.
- Methodology demonstrated here requires intervention in the network.
  - Traffic engineer must notice that there is a better route for the high QoS traffic to follow, and set up that route.
  - CR-LDP specifies protocol of explicit route planning.

DISCUSSION

- Best to set up explicit routes before sending channel traffic
  - Packets arrive out of order following re-route
  - RTP (Real Time Protocol) running over UDP could re-order or drop late packets

FUTURE WORK

- We've looked at explicit routing, but MPLS with CR-LDP offers other tools for implementing quality of service.
  - Flow aggregation
  - Policy based CR-LDP

REFERENCES

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[7] E. Lim, H. Shin, Y. Kim, "Implementation of the Simulation Model for the MPLS Signaling Protocol and OAM Functions With OPNET", [http://www.mil3.com/products/modeler/biblio.html]

QUESTIONS?

Credits

- Chris
  - Obtained MPLS code and ported it into ns-2.6b
- Duncan
  - Constructed the network and did most of the tcl work
- Dave
  - Converted trace to ns format and analyzed results
- All
  - Debugged and ran simulations over 3 weekends