MENTER Overview

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UMIACS Contract Review

Laboratory for Telecommunications Science

May 31, 2001

MENTER Goal

- MPLS Event Notification Traffic Engineering and Restoration
- Develop an architecture for managing MPLS domains on a fast timescale to provide
  - efficient utilization of network resources
  - differentiated QoS
  - reliability

Project Components

- Simulator development
  - MPLS (UMD: Phuvoravan, Guven, Sudarsan, Choi)
  - MPLS/Optical (NIST)
- MPLS testbed (based on NISTSwitch) (Landgraf, Bhattacharjee, Gallicchio, Kuo)
- Optical testbed (Chen's group)
- Monitoring and event generation (Bhattacharjee, Kuo, Gallicchio)
- Correlation engine (Landgraf, Jaeger)
- Control algorithms and software implementation (Marcus, Shayman, Lim, Choi, Phuvoravan)

Combining Diffserv with MPLS

- Each LSP corresponds to a diffserv class
  - to conserve experimental bits, signaling used to convey class of service
- Each LSP has provisioned BW
  - permits traffic engineering using constraint-based routing with available link BW (ALB) constraint
    - BW (scheduling weight) per class is configured for each link
    - ALB is calculated per class
- Per-behavior-aggregate queuing
  - more scalable than per-LSP queuing

Diffserv-based SLAs

- Between enterprise network and ISP or between peer ISPs
- SLA parameters can be dynamically renegotiated
- Penalties for SLA violations
- Bandwidth broker (BB) can permit oversubscription of SLAs if conditions permit
- Specification in terms of aggregate traffic for each diffserv class: <u>hose model</u>
  - contains limited egress information
    - SLA specifies an aggregate BW per class entering at each ingress, and possibly how much BW exits at each egress

Traffic Shaping and Policing

- Shaping and policing must be consistent with diffserv SLAs
  - shaping is done at egress of preceding domain on per-class aggregate basis
  - policing is done at ingress applied to aggregate of all traffic of given class from given neighbor domain
- Policing of individual LSPs not permitted
  - may create SLA violations
  - overlimit LSPs not a problem unless links are congested
- Occasional congestion is inevitable unless significant overprovisioning

Bandwidth Broker/Provisioning Server-1

- Diffserv BB
  - Negotiates admission control policy (dynamic SLAs) with BBs in customer networks and peer ISPs
  - Serves as Policy Decision Point (PDP)
  - Instantiates policy in edge routers which serve as Policy Enforcement Points (PEPs)
  - Requires monitoring information to make decisions
    - e.g., how much of the traffic from a customer network is currently going to each egress, are portions of network congested, ….

Bandwidth Broker/Provisioning Server-2

- Provisioning Server (PS) in MPLS
  - BB functionality with extensions to permit management of label switched paths (LSPs)
    - MENTER focus is on on-line management and control
  - Label Edge Routers (LERs) implement LSP setup using CR-LDP or RSVP-TE
  - While some of the route computation can be delegated to LERs and accomplished using constraint-based routing, some resource allocation problems can only be solved by having PS coordinate actions of multiple LERs
    - generally overlooked in MPLS community

Monitoring

- IGP (OSPF, IS-IS) extensions used to flood available link BW (ALB) when thresholds crossed
  - PS as well as ingress LERs receive information
  - threshold spacing can decrease as ALB decreases
- LSRs monitor link BW utilization
- Ingress LER monitors BW utilization of each of its LSPs
- ECN used to alert ingress that LSP experiencing congestion (draft-ietf-shayman-mpls-ecn-00.txt)
- Drops monitored per LSP at each LSR
  - dropping should be regarded as last resort
  - if possible, dropping should be pushed to ingress
- Active techniques can enable dynamically configurable state-based monitoring and event generation

Control

- Off-line control
  - Generate nominal set of provisioned LSPs
    - Off-line optimization
    - Input is traffic matrix giving estimated traffic for each ingress-egress pair
    - Output set of provisioned LSPs
      - may be time-varying

On-line Control

- Concerned with variations of traffic from that predicted by traffic matrix
- On-line slow time-scale control (minutes on up)
  - Concerned with persistent deviations from nominal traffic pattern
- On-line fast time-scale control (seconds on down)
  - Concerned with sudden deviations from nominal traffic pattern
    - action taken only if congestion is observed or imminent
  - Traffic models may enable proactive control.
    - Flow arrival processes
    - Variation of bit rate within flow aggregate
  - Distinguishes MENTER from other MPLS/Diffserv projects

Control Actions

- Modifying the assignment of new flows to LSPs with the same ingress and egress
- Migrating existing flows to alternate LSPs
- Increasing (or decreasing) provisioned BW
- Setting up new LSPs
- Coordinated action involving multiple ingress-egress pairs that have LSPs sharing bottleneck link
- Rate-limiting LSPs at ingress (last resort)
- Reallocate wavelengths in OTN to change BW or network topology
  - issues of time-scale, granularity, and degree of integration of MPLS and OTN management/control planes

Stochastic Control

- Use traffic models for flow arrival process, flow duration and for variation of bit rate within a flow
- Short-range dependent models may be sufficient for predicting performance for real-time traffic
  - Markov modulated fluid (MMF) models obtained by aggregation and "averaging" of DAR models
- Optimization techniques for Markov decision processes may be used to determine policies for dynamic traffic engineering--e.g., conditions under which flow migration should occur
  - Currently developing control policies for voice call migration in response to variations in video traffic

Where VoIP Fits In

- Two models for VoIP
  - aggregate voice governed by SLAs
    - handled like any other Diffserv traffic
  - individual calls subject to admission control
    - require participation of signaling gateway, call agent (CA), provisioning server, media gateway (MG), MPLS ingress
    - VoIP may be designated as separate Diffserv class
    - call blocking replaces congestion and packet drops as trigger for reactive control

Processing of Individual Calls

- Multiple media gateways are directly connected to each LER
- Provisioning server periodically informs call agent of available BW (allocated to VoIP) between each ingress-egress pair of LERs (and hence between each pair of media gateways)
- CA maps dialed number to set of remote MG choices
- CA selects remote MG based on available BW between corresponding ingress-egress LERs
- Ingress LER assigns call to an LSP (dedicated to VoIP) terminating at the appropriate egress LER.

Relationship Between CA and PS

- CA receives resource availability information from PS
- PS receives blocking information from CA
- CA operates on service layer and is specific to the VoIP application
- PS operates on network/MPLS layer and is not specific to VoIP
  - permits PS to coordinate BW needs between VoIP and other types of traffic
    - e.g., if there is a focused overload for VoIP due to a call-in event, video traffic can be temporarily rerouted to accommodate the VoIP
    - e.g., an unexpected number of video sessions between an ingress and egress may require migration of a group of voice calls (may be preferable to migrate low rate voice flows rather than high rate video both to find alternative BW and to minimize migration-induced packet loss)