MPLS
Traffic Engineering
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What is Traffic Engineering

Taking control of how traffic flows in your network in order to -

- Improve overall network performance
- Offer premium services
- As a tactical tool to deal with network design issues when the longer range solution are not deployed
Voice Traffic Engineering

- Telco’s noticed that demands vary widely by time of day
- Began “engineering the traffic” long ago
- Evolved over time
- Now fully automated
Reasons for Traffic Engineering

- Economics – more packets, fewer $$$
- Address deficiencies of IP routing
- Tactical tool for network operations
- Class-of-service routing
“The efficacy with which one uses the available bandwidth in the transmission fabric directly drives the fundamental ‘manufacturing efficiency’ of the business and its cost structure.”

Mike O’Dell, UUnet

Savings can be dramatic. Studies have shown that transmission costs can be reduced by 40%.
The “Fish” Problem
a deficiency in IP routing

IP uses shortest path destination based routing
Shortest path may not be the only path
Alternate paths may be under-utilized while the shortest path is over-utilized
Deficiencies in IP Routing

- Chronic local congestion
- Load balancing
  Across long haul links
- Size of links
  Difficult to get IP to make good use of unequal size links without overloading the lower speed link
Overlay Motivation

Separate Layer 2 Network (Frame Relay or ATM)

“The use of the explicit Layer 2 transit layer gives us very exacting control of how traffic uses the available bandwidth in ways not currently possible by tinkering with Layer 3-only metrics.”

Mike O’Dell
UUnet, November 17, 1996
The Overlay Solution

• Layer 2 network used to manage the bandwidth

• Layer 3 sees a complete mesh
Overlay Drawbacks

- Extra network devices (cost)
- More complex network management
  - Two-level network without integrated NM
  - Additional training, technical support, field engineering
- IGP routing doesn’t scale for meshes
  - Number of LSPs generated for a failed router is $O(n^3)$; $n = \text{number of routers}$
• MPLS fuses Layer 2 and Layer 3
• Layer 2 capabilities of MPLS can be exploited for IP traffic engineering
• Single box / network solution
An LSP Tunnel

Labels, like VCIs can be used to establish virtual circuits

- Normal Route: R1->R2->R3->R4->R5
- Tunnel: R1->R2->R6->R7->R4
LSP Tunnel Setup

Setup: Path (R1→R2→R6→R7→R4→R9) Tunnel ID 5, Path ID 1

Reply: Communicates Labels and Label Operations
Reserves bandwidth on each link
Multiple Parallel Tunnels

- Automatically load shared
- Weighted by bandwidth to nearest part in 16
- Traffic assigned by either Source-Destination hash or Round robin
Additional Features

• Adjusting to failures
  Requires rapid notification
• Adjusting to improvements
• Need to account for
  Global optimality
  Network stability
Protection Strategy

Two pronged approach:

• Local protection
  Repair made at the point of failure us to keep critical applications going
  Fast - $O(\text{milliseconds})$
  Sub-optimal

• Path protection
  An optimized long term repair
  Slower - $O(\text{seconds})$
Local Protection via a Bypass Tunnel

- R1
- R2
- R3
- R4
- R5
- R6
- R7
- R8
- R9
- R10

Bypass Tunnel
Primary Paths
Backup Paths
Path Protection

Primary Path

Backup Path
Summary

Traffic engineering provides the means to

- Save transmission costs
- Address routing deficiencies
- Attack tactical network engineering problems
- Provide better QoS
  - Making sure resource are available
  - Minimizing disruption