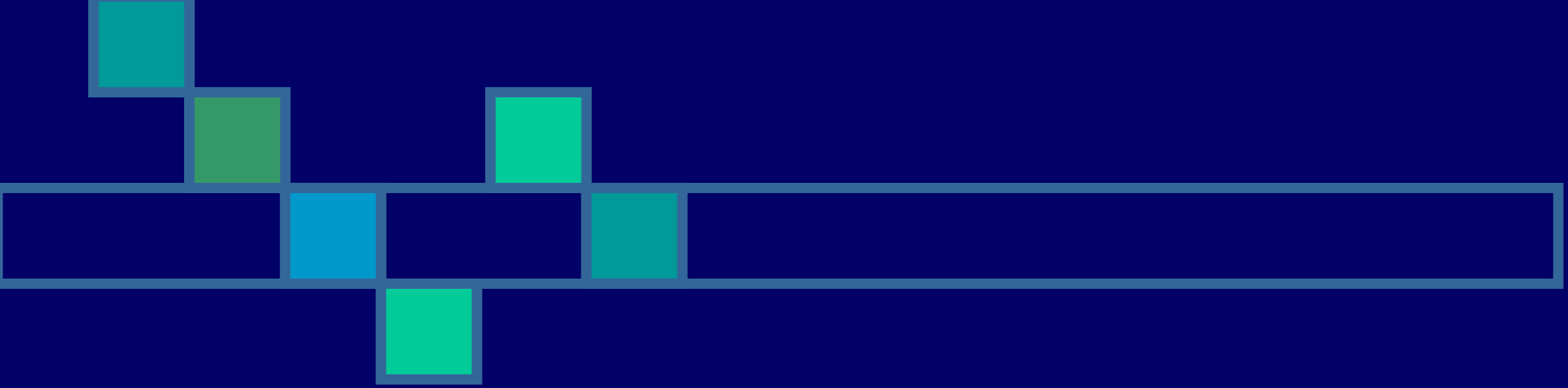

Trends in MPLS TE/FRR and QoS

Dave Wang, Ph.D.
WANDL, Inc.

Agenda

- Overview of MPLS TE
  - Case Studies
  - Trends
- Overview of FRR
  - Case Studies
  - Trends
- Overview of QoS
  - Case Studies
  - Trends
- Questions

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- As MPLS continues to mature, more carriers are beginning to use MPLS-TE/FRR for improving real-time applications and QoS for prioritizing IP traffic. We will discuss ways in which these technologies are commonly used in various practical situations.

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Before MPLS TE

- How do you solve congestion in a plain IP network?
  - Modify IGP metrics
    - Not scalable
  - Overprovision your network (set a threshold and order additional bandwidth when reached)
    - Poor bandwidth utilization
    - Expensive

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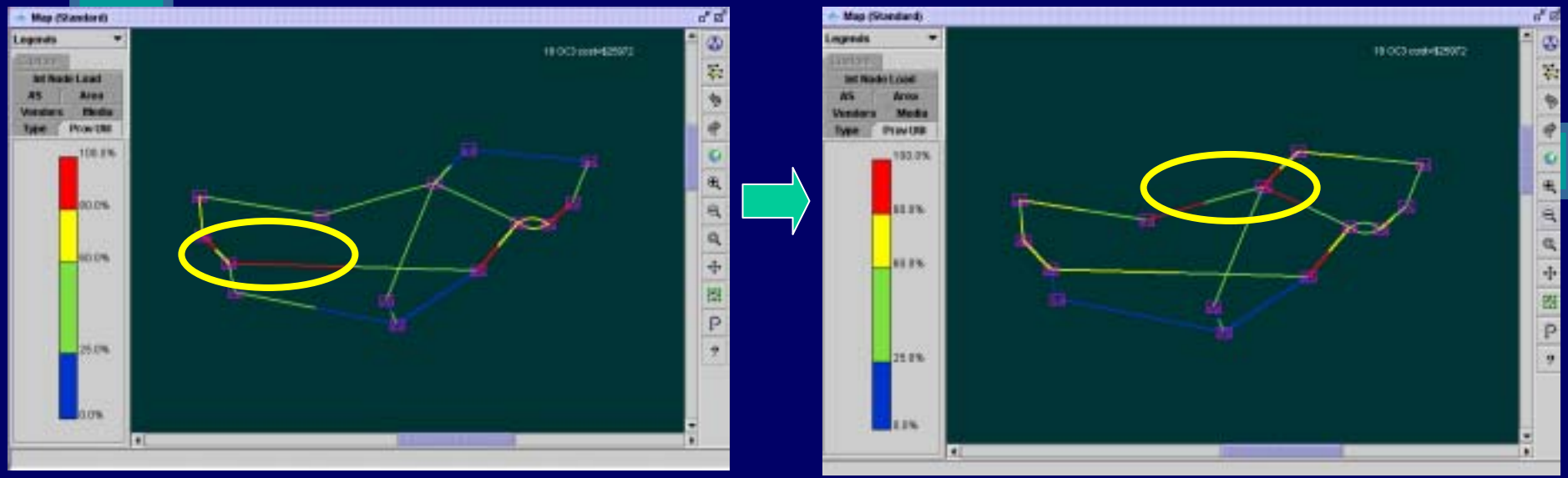
Before MPLS TE (cont'd)



- Modifying the IGP metric just moves the congestion elsewhere

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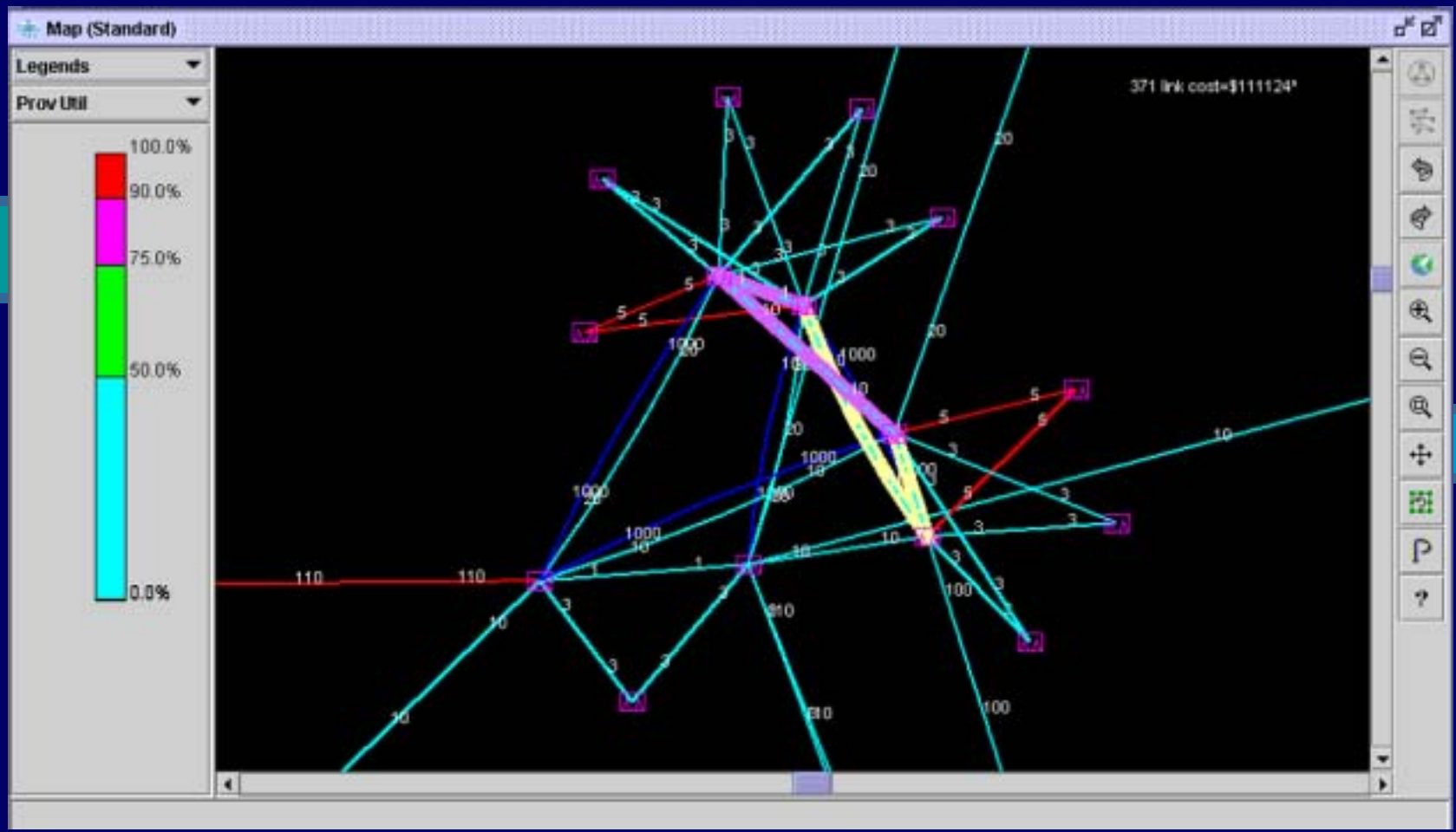
Case Study: Link Utilization



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MPLS Today

- MPLS VPN with IP CoS
  - No ATM cell tax
  - Easier for carrier's to build a business case
  - Dominant in Europe and Asia
- MPLS TE
- FRR protection
  - Shared Risk Link Groups (SRLG)

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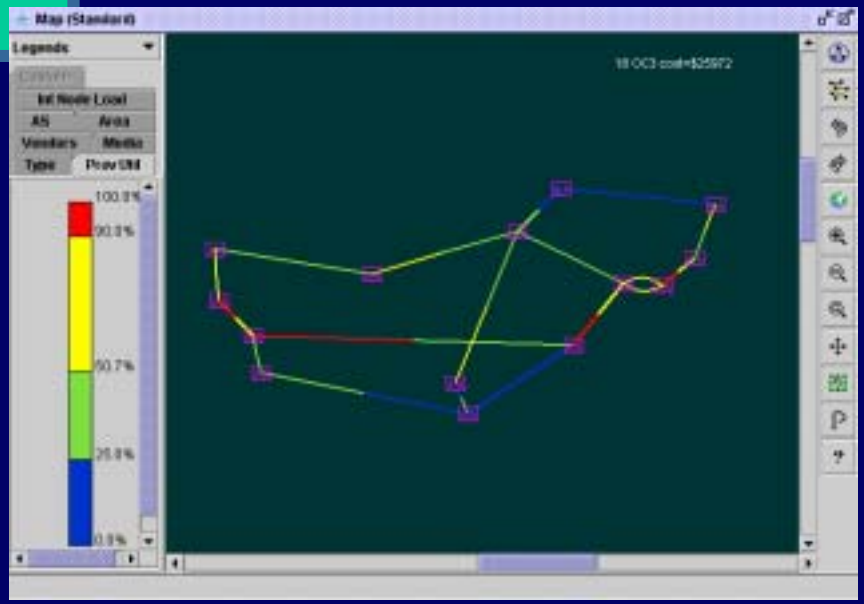
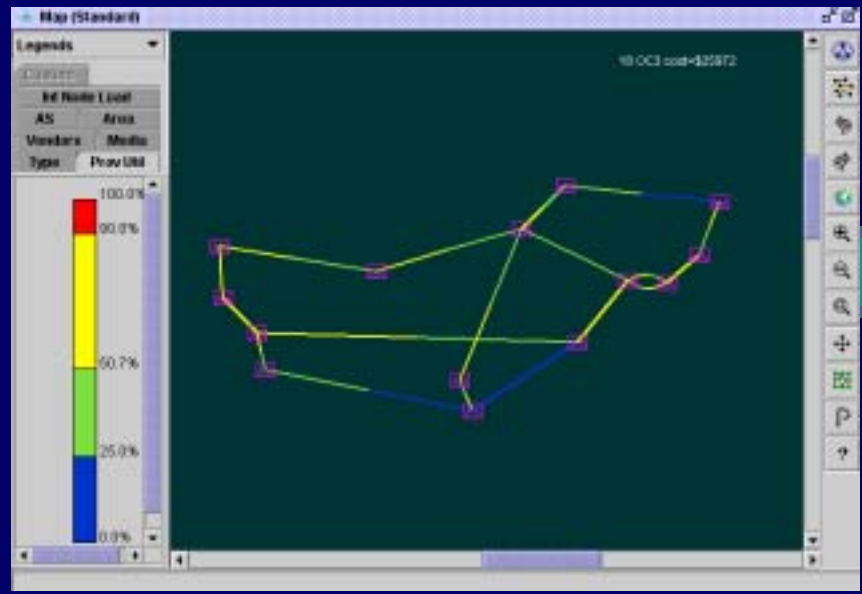
MPLS TE Today





- Traffic rebalanced without spending additional $$$ for BW.

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Routing for Layer 3 Traffic

- OSPF, ISIS, BGP4
- Forwarding Equivalence Classes
- Dijkstra Algorithms
- Influenced by LSP Tunnels
- New Shortest Path Tree

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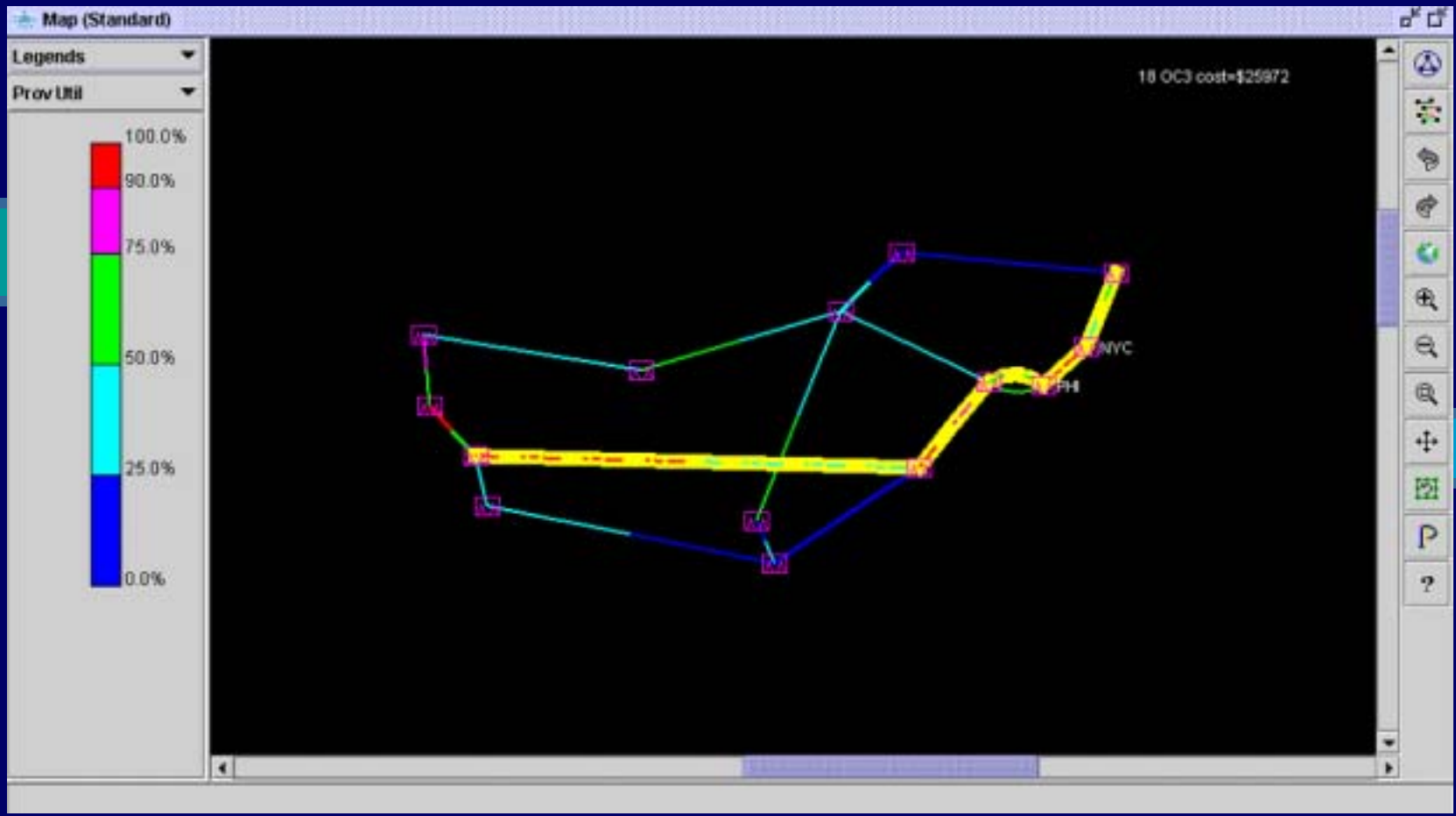
Forwarding Equivalence Classes



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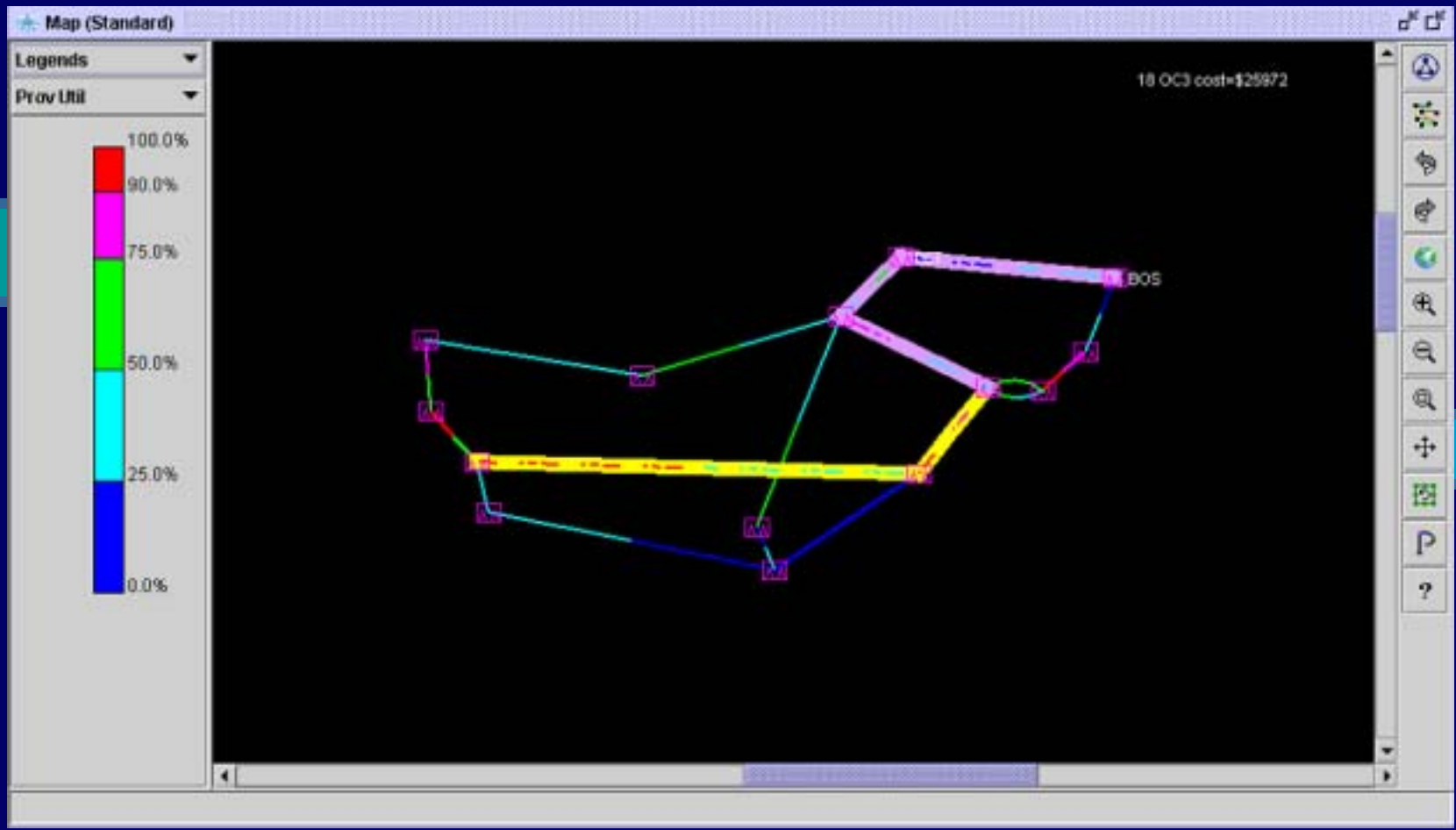
Forwarding Equivalence Classes



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Using TE

- End-to-End Traffic Matrix Collection
- Load Balancing without Equal Cost Multiple Paths (ECMP)
  - ECMP may not balance traffic in all cases
- Virtual Trunks
- CCC, AToM

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Industry Practices

- Fully meshed Tunnels
  - With / without FRR per LSP protection
  - With / without RSVP BW
  - With / without color/affinity/admin group
- Dynamic versus Explicit Routes
  - Primary and backup path computations for explicit routes
- Advertise LSP in IGP

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Survey of FRR Implementations

- FRR is an enabler for TE
  - Need TE to deploy FRR
- Link, Node, or LSP Protection
  - Configure detour path to exclude SRLG
  - Dynamic or Manual configuration of bypass routes. Explicit routes needs maintenance
  - Sometimes deployed with 0 Kbit/s tunnel
    - BW not really checked
    - Hybrid between best effort IP and SDH restoration

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Cisco TE/FRR Example

```
!
interface Tunnel0
 description HK->LA
ip unnumbered Loopback0
 no ip directed-broadcast
 tag-switching ip
 tunnel destination 12.34.56.129
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 3 3
 tunnel mpls traffic-eng bandwidth  1000
 tunnel mpls traffic-eng path-option 1 explicit name hk2la
 tunnel mpls traffic-eng path-option 5 dynamic
 tunnel mpls traffic-eng record-route
 tunnel mpls traffic-eng load-share 1
 tunnel mpls traffic-eng fast-reroute
!
ip explicit-path name hk2la enable
 exclude-address 12.34.56.78
!
```

Notes:

- If priority is missing, the default is 7,7
- If Autoroute announce missing, this is a private tunnel

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Juniper TE/FRR Example

```
traffic-engineering shortcuts;
    admin-groups {
        transit 1;
        content 2;
        voip 3;
        L2vpn 4;
    }
    label-switched-path HK2LA {
        to 12.34.56.78;
        metric 430;
        fast-reroute;
        primary path1 {
            bandwidth 125m;
            no-decrement-ttl;
            optimize-timer 300;
        }
        priority 3 3;
        adaptive;
        admin-group {
            include transit;
            exclude content;
        }
    }
```

Notes:

- if priority is missing, the default is 7,0
- Shortcut is same as Cisco's Autoroute announce

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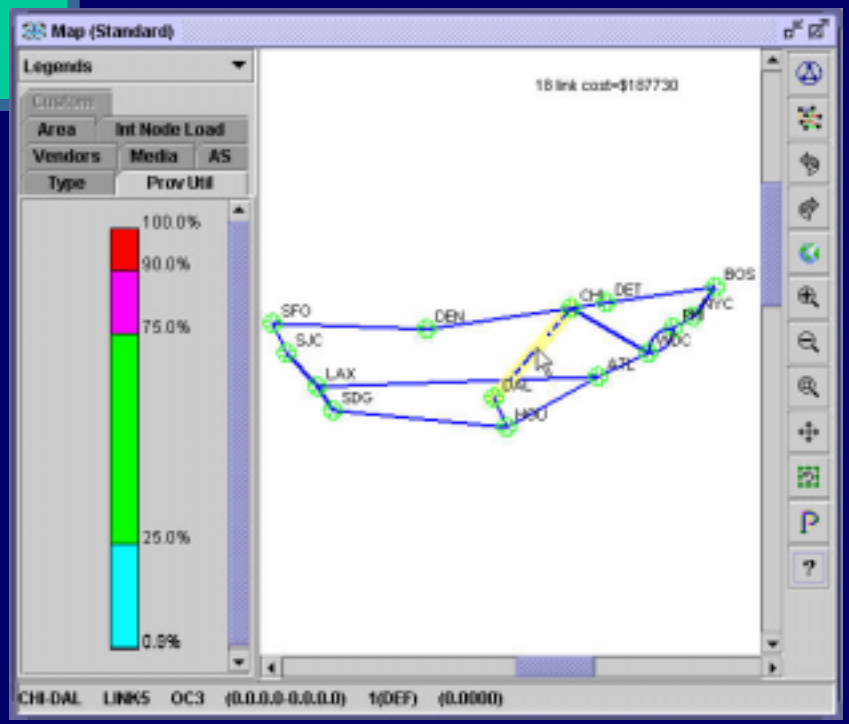
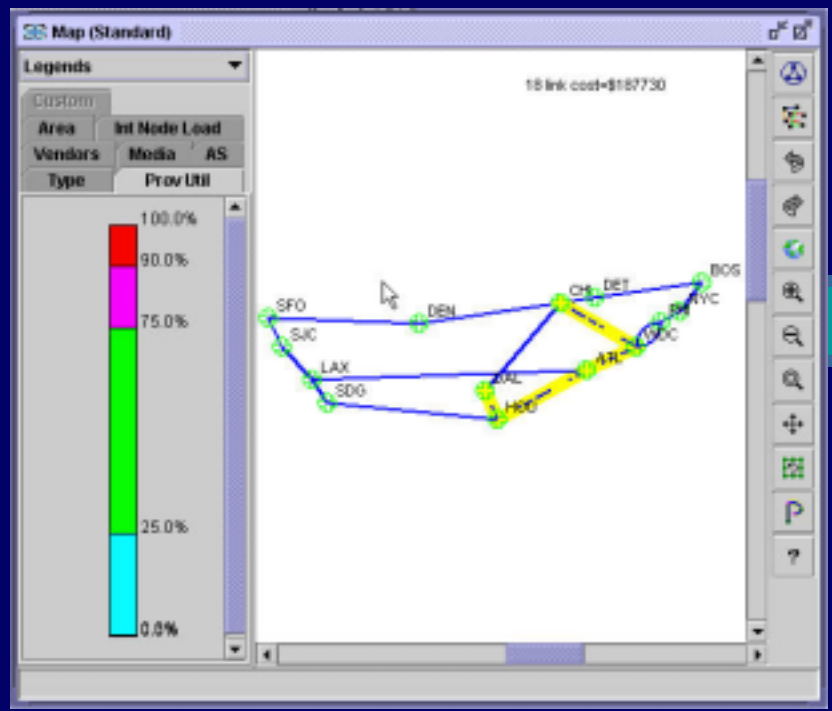
FRR Link Protection Modeling





- Can see backup routes CHI-WDC-ATL-HOU-DAL
- Not Facility Diverse

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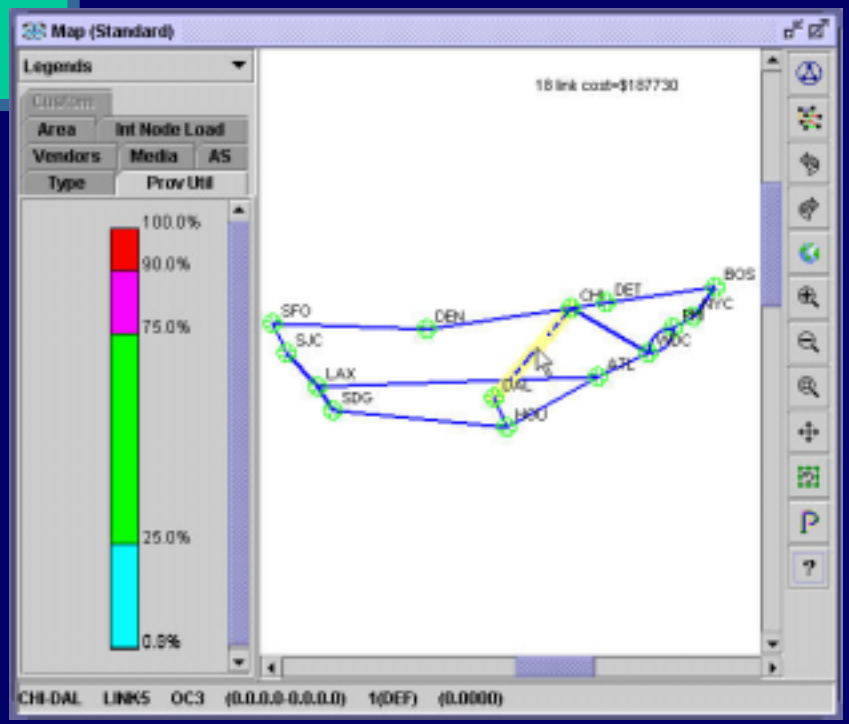
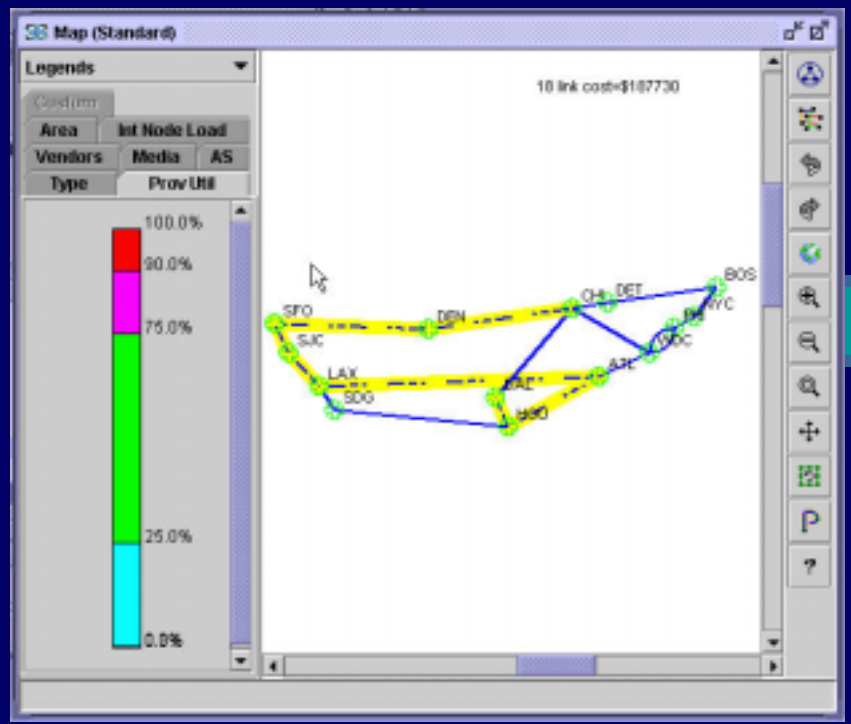
FRR Modeling





- Now have a backup route for LP that is link & facility diverse

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FRR detour Design Challenges

- Consider SRLG
- Bandwidth setting of FRR backup tunnels
- Difficult to protect 100 % of link BW especially with tunnels already deployed.
  - Should focus on a subset of tunnels such as VoIP
  - No need to protect all links with FRR. Some links could be SONET protected so no need to protect them twice.

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FRR Design Challenges (cont'd)

- One Implementation
  - Primary tunnels (to be protected) marked as fast-reroute. If link is down and backup tunnel is implemented on the link, then all primary tunnels passing through the link are detoured.
  - BW overlap of paths used by the FRR backup tunnels.
  - If enough BW, configure backup tunnel BW to be >= primary tunnel bandwidth (on the link). Otherwise, tunnels may need to be configured with smaller BW. Offline simulation is needed to insure "performance impact" acceptable during failure.

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Deploying FRR

- Voice over IP (VoIP)
  - Link/Node detours
  - FRR sometimes used as a SONET/SDH “killer”
    - Trying to remove a layer from the network
- Delay Sensitive video and voice
- Transit Service Provider

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IP Class Of Service

- Real life implementations:
  - A few classes in the core (e.g. among Ps).
    - Near real time (e.g. voice or video)
    - Premium (e.g. top VPN customers)
    - Best effort (basically everybody else)
  - Possibly more class definition at the edge (e.g. PEs) but mapping is performed into “core classes”

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IP Class Of Service (cont'd)

- Main advantages:
  - Easy to configure: does not require any signaling process
  - Based on straight forward packet tagging process (TOS, precedence,...)
- Limitations:
  - Not Proactive
  - Only used to decide who should be dropped during congestion

Works when <u>average</u> utilization is not high

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Quality of Service (QoS)

- Use WFQ to differentiate 3-4 classes
  - LLQ Voice
  - First Class/Business Class
  - Best Effort Class
- Extract MPLS tunnel traffic data in QoS
  - SNMP does not yet report per QoS
- If tunnel sizing correct (can route/re-route) then QoS problem will not occur

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Quality of Service (QoS) cont'd

- Global Pool / SubPool RSVP BW partition
  - SubPool used to be called guaranteed bandwidth traffic engineering
- SubPool Tunnel need to have high setup and holding priority and high QoS

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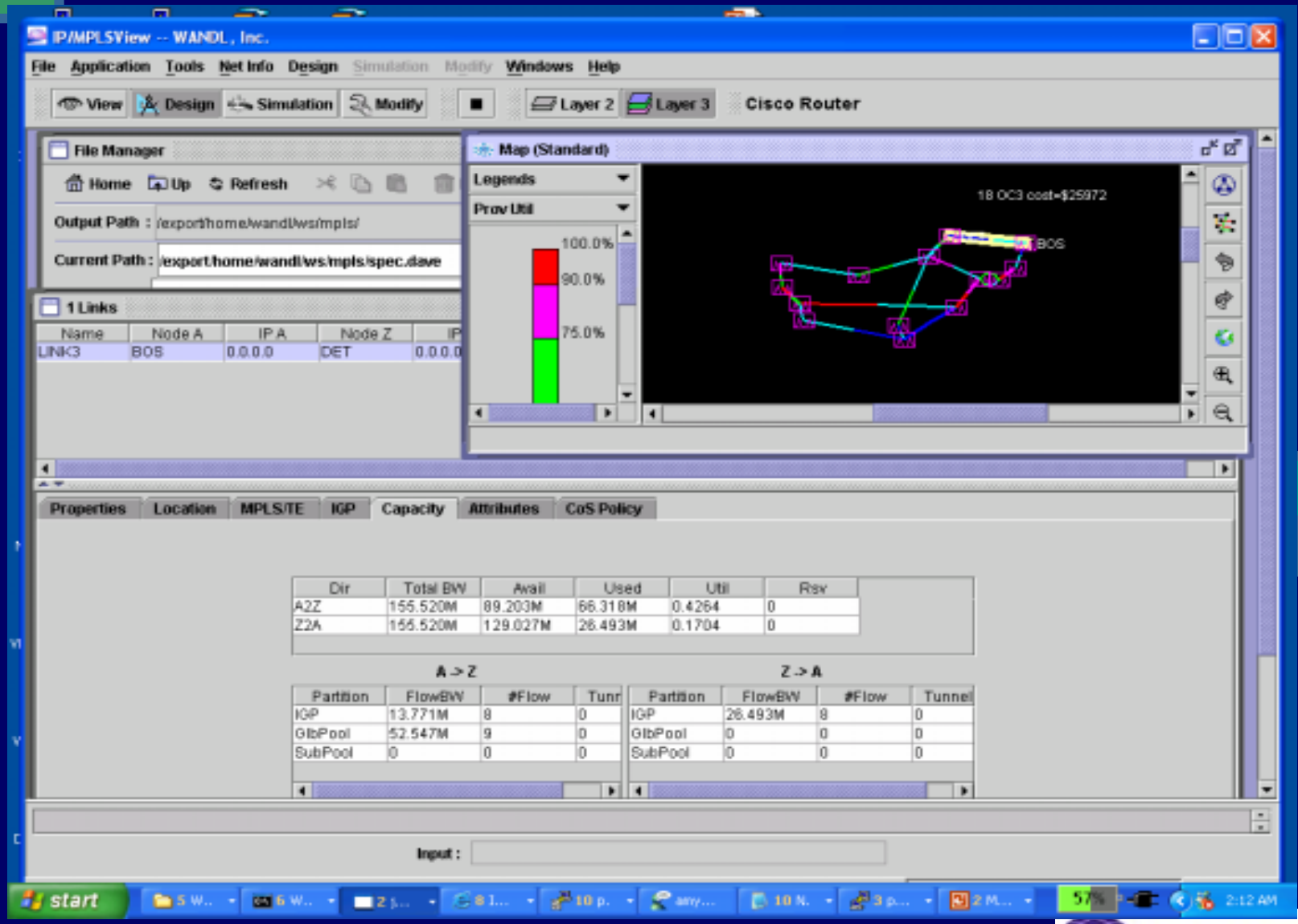
Global Pool vs SubPool



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Quality of Service (QoS) cont'd

- Diffserv with MPLS TE
  - L-LSP
  - E-LSP
- Granularity versus Scalability
- No Hard commitment without bandwidth reservation
- Not yet popular.

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Quality of Service (QoS) cont'd

- Current solution is still to simply throw bandwidth at the problem.
- Best solution is to configure LSP tunnel bandwidth correctly.

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Multiple Vendor Environments

- Lab testing for Interoperability
- Use only compatible features
- Need vendor support to resolve issues

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Importance of Processes

- Calculate the worst case for each link and build in appropriate redundancies
- TE is very difficult to simulate manually and it is not intuitive
  - Color logic and tunnel attributes
  - Load balancing

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Importance of Processes (cont'd)

- Primary/backup path computation
- Verify QoS configuration
- Offline simulation of traffic growth
  - Even with overprovisioning, traffic growth may still surpass network capacity
- Multiple vendor network modeling
- Inventory management and reconciliation

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Capacity Planning Approaches

	Point to point (e.g. MRTG)	End to End (widely used in voice, ATM)
PRO	■Very easy to implement ■Low upfront investment	■Accurate picture of traffic to troubleshoot congestion ■Minimizes over-provisioning
CONS	■Can lead to poor design if the sources of traffic change over time ■May artificially increase backbone filling ratio due to too many hops	■Complex to manage in a connectionless environment

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Industry Direction

- Convergence of IP/ATM/FR
- L3 MPLS
- L2/L3 VPN and TPLS
- FRR for Link/Node/LSP Protection
- TE acceptance will be driven by increased demand for bandwidth from high-speed Internet access like DSL and Cable.

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Questions?

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