MPLS Traffic Engineering & Management Issues

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Topics

- MPLS-TE Basics
- MPLS-TE Operational Issues
- MPLS Management Issues
- MPLS-TE Management Solutions

MPLS-TE Basics

What is Traffic Engineering?

- The task of mapping traffic flows onto an existing physical topology to facilitate efficient and reliable network operations

- Check *mpls & tewg* working group documents for more well-versed definitions

  Requirements for Traffic Engineering Over MPLS (RFC 2702)

  A Framework for Internet Traffic Engineering (draft-ietf-tewg-framework-05.txt)

Legacy Internet TE Efforts

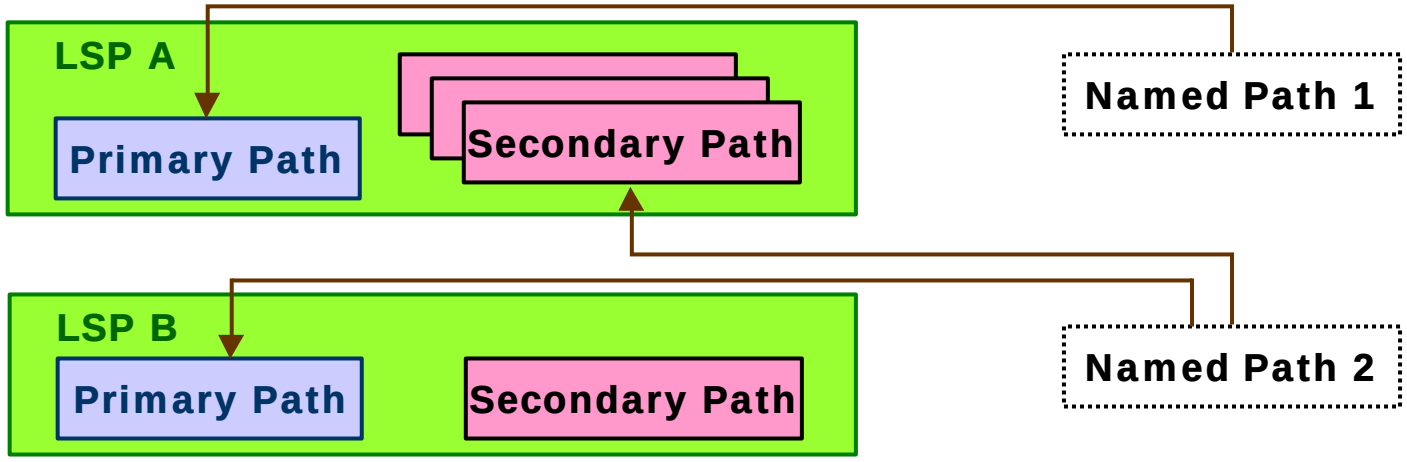
- IGP Metric-Based TE
  - Remember “fish problem?”
  - Drawbacks
    - “Blame Shifting”: only serves to move problem around
    - Lacks granularity
    - Instability
- Overlay Network Approach
  - ATM core ringed by routers & overlaid PVCs on top of it
  - Drawbacks
    - Full mesh overhead
    - Not well integrated
    - Cell Tax
    - ATM SAR speed

MPLS-TE Advantages

- The physical path of the “traffic-engineered path” is not limited to what the IGP would choose as the shortest path to reach the destination
- Variously divisible traffic aggregation and disaggregation
- Maneuvering load distribution
- Stand-by secondary paths and precomputed detouring paths
- Strongly unified measurement and control for each “traffic-engineered path”

Vocabulary

- LSP (Label Switched Path)
  - the “traffic-engineered path”
- Primary and Secondary Paths
  - an LSP can contain a primary path & zero or more secondary paths
- Named Path
  - a sequence of explicit hops



Vocabulary – cont'd

- Traffic Trunk (TT)
  - an aggregation of traffic flows going from an ingress to an egress
  - forwarded through a common path with common TE requirements
  - characterized by
    - its ingress and egress
    - FEC which is mapped to it
    - a set of attributes that determines its behavioral characteristics

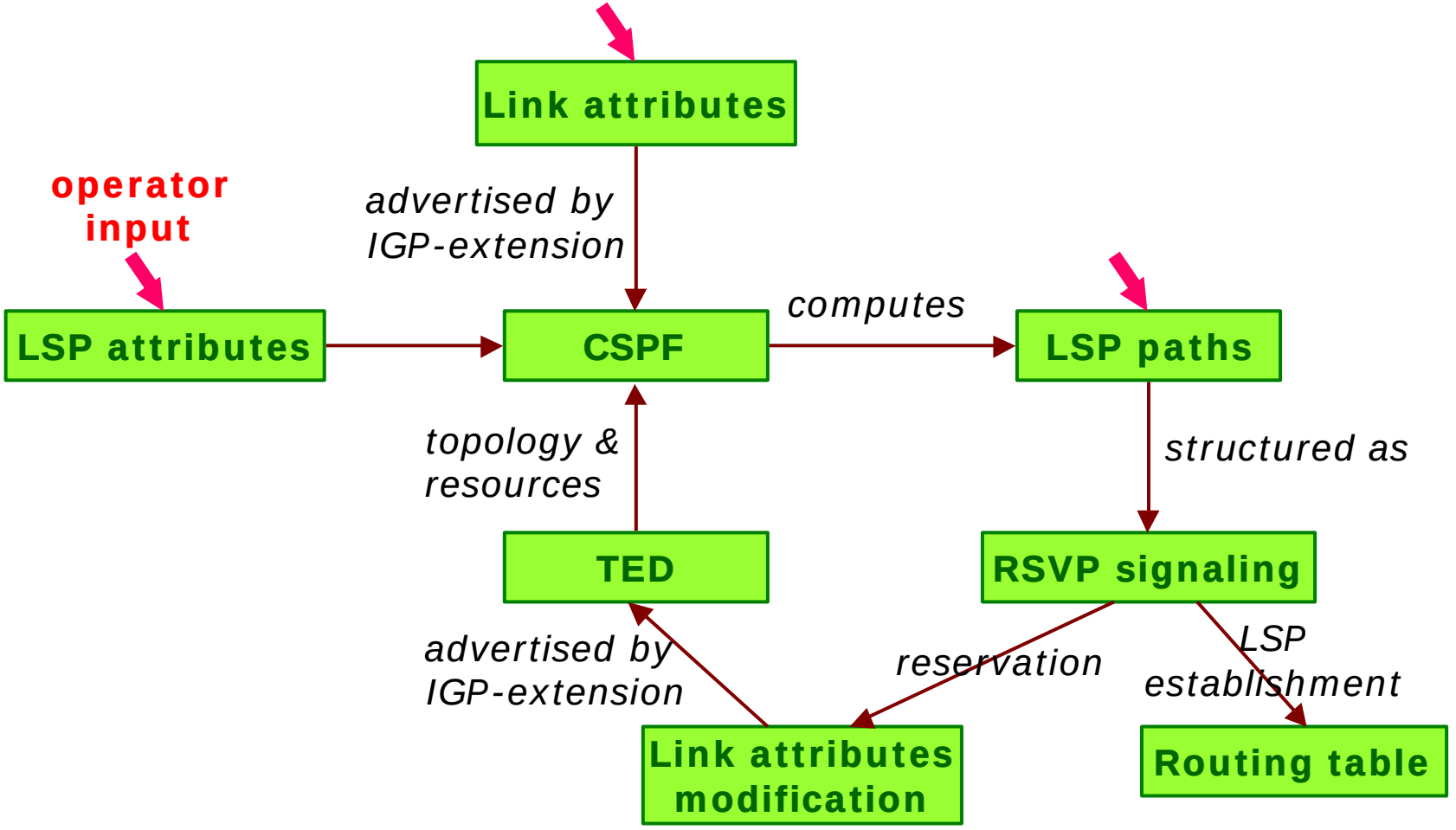
Vocabulary – cont'd

- Types of LSPs
  - Static LSPs
    - no relevance to TE
  - LDP signaled LSPs
    - no relevance to TE
  - RSVP/CR-LDP signaled LSPs
    - Explicit-path LSPs
    - Constrained-path LSPs
    - Note: both of the two above are not mutually exclusive!

Components of MPLS-TE

- Packet Forwarding Component
  - MPLS, label switching itself
- Information Distribution Component
  - IGP (OSPF/IS-IS) extension
- Path Selection Component
  - Constrained Shortest Path First (CSPF) algorithm
- Signaling Component
  - LDP, CR-LDP, and RSVP-TE
- Not all of these required!

How everything fits into?



MPLS-TE Mechanisms

- LSP Routing
  - with TE attributes (LSP & Link attributes)
  - dynamic vs. explicit
- Traffic Protection (Resilience)
  - secondary paths and fast reroute
- Path Reoptimization (Adaptivity)
- Load Sharing and Balancing
  - LSP-level traffic bifurcation
- LSP Hierarchy
  - forwarding adjacency LSPs, unnumbered links

MPLS-TE Deployment and Operational Issues

MPLS-TE Deployment Issues

- MPLS is proposed as a standard TE solution by IETF, BUT
  - Vendor Interoperability problem
  - Limitation in online path calculation
  - Problems on Traffic Trunks
  - Measurement and Control Issues

Interoperability

- Vendor specific implementation details diverge!
  - Almost everything but signaling standard might be different
  - Using more than two heterogeneous families in a domain may cause unpredictable operational problems
- Need a unified abstraction system to hide, moderate, and arbitrate the differences

Limitation in Online Path Calc.

- Online path calc. considers one LSP at a time
  - undeterministic
  - The order in which an LSP is calculated plays a critical role!
- Global optimization required
  - Optimization tools that simultaneously examine each link's resource constraints and the requirements of each LSPs all together are necessary

Problems regarding to TT

- How to define traffic trunks?
  - No standard
  - Manual classification
    - requires TE policies
    - granularity and scalability concern
    - practically, only dest. prefix based classification supported
    - requires, so called, “policy routing”
  - BGP-based classification
    - Transit traffic whose route updates’ next_hop is identical to the egress of an LSP are routed over the LSP
  - Implicit classification by IGP

Problems regarding to TT – cont'd

- How to map a traffic trunk's attributes onto LSPs' constraints?
  - need a global view
  - must be able to anticipate the effect, to some extent
  - must be able to rationalize
    - by simulations
    - by measurements
    - by policies
    - by intuition?
    - by experience?

Measurement and Control

- Measurement
  - provides rationale and fundamental bases to induce proper TE constraints for TTs and LSPs
    - such as, traffic (demand) matrices, congestion indication, LSP statistics, etc.
  - methods
    - SNMP (various MIBs), CLI, Cisco Netflow and TMS, and/or JUNOS MPLS Statistics, RTFM probes, etc.
- Control
  - manages TE policies
    - policy editing, conflict check, enforcement, withdrawal, etc.
    - customized to service specific policies, such as VPN policies

MPLS-TE Operational Issues

- Prohibitive costs for manual provisioning for multi-node and multi-vendor environment
  - Longer educational curve
  - Single highly skilled operator or multiple vendor specific many operators
  - Tighter and precise communications among them
- Error-prone manual configuration and hard to detect the semantic configuration errors (e.g., typos in path name)
- LSP operations diagnosis (e.g., when LSP setup fails, it is very difficult to pin point the exact reasons. The system doesn't tell much useful info.)

Configurable LSP Attributes

- Can specify the following attributes either for each LSP or for each path belonging to the LSP
  - bandwidth (traffic profile in CR-LDP)
  - constrained (dynamic) vs. explicit path
  - affinity
  - adaptivity
    - reoptimize-timer, reoptimize-event
  - resilience
    - (stand by) secondary paths, fast reroute
  - priority & preemption
    - setup, hold
  - route record
  - hop-limit, cos, etc.

Juniper Example

Minimum MPLS Configuration

- Required of transit routers, as well as the ingress and egress

```
[edit]
interfaces {
   interface-name {
      logical-unit-number {
         family mpls;              # required to enable MPLS on this intf.
      }
   }
}
protocols {
   mpls {
      interface (interface-name | all); # required to enable MPLS on this intf.
   }
   rsvp {
      interface interface-name;         # required for RSVP signaled MPLS only
   }
}
```

Create a Named Path

- Named Path
  - means a physical path from the ingress to the egress
- Named Path and LSP
  - Configuring an LSP may require multiple named paths
    - primary and secondaries
  - can specify the same named path on any number of LSPs
- Syntax

```
[edit protocols mpls]
path path-name {
   address | host name <strict | loose>;
}
```

Create an LSP

- Rough Syntax

```
[edit protocols mpls]
label-switched-path lsp-path-name {
    to address;          # egress address
    from address;        # ingress address

    # lots of statements for setting various LSP attributes;

    primary path-name {

        # lots of statements for setting various path attributes;

    }
    secondary path-name {

        # lots of statements for setting various path attributes;

    }
}
```

Cisco Example

Minimum MPLS Configuration

- Required of transit routers, as well as the ingress and egress

Turn on MPLS tunnels

Turn on CEF

Turn on IS-IS or OSPF

Syntax

- Router(config)# **ip cef**
- Router(config)# **mpls traffic-eng tunnels**
- Router(config-if)# **mpls traffic-eng tunnels**
- Router(config-if)# **ip rsvp bandwidth** ***bandwidth***
- Router(config)# **router ospf** ***process-id***
- Router(config-router)# **mpls traffic-eng area 0**
- Router(config-router)# **mpls traffic-eng router-id loopback0**

Create a Named Path

- Named Path
  - means a physical path from the ingress to the egress
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  - Configuring an LSP may require multiple named paths
    - primary and secondaries
  - can specify the same named path on any number of LSPs
- Syntax

```
Router(config)# ip explicit-path name path-c7204-m5 enable
Router(config)# next-address 10.2.0.29
Router(config)# next-address 10.2.0.34
Router(config)# next-address 10.2.0.33
```

Create an LSP

- Rough Syntax

```
Router(config)# interface tunnel 2003
Router(config-if)# description c7204-m402
Router(config-if)# ip unnumbered Loopback0
Router(config-if)# tunnel mode mpls traffic-engineering
Router(config-if)# tunnel destination 203.255.255.234
Router(config-if)# tunnel mpls traffic-eng autoroute announce
Router(config-if)# tunnel mpls traffic-eng priority 7 7
Router(config-if)# tunnel mpls traffic-eng bandwidth 10000
Router(config-if)# tunnel mpls traffic-eng path-option 1 explicit name path-c7204-m5
Router(config-if)# tunnel mpls traffic-eng record-route
Router(config-if)# exit
Router(config)# router traffic-engineering
Router(config)# traffic-engineering filter 1 egress 10.14.0.111 255.255.255.255
Router(config)# router traffic-engineering
Router(config)# traffic-engineering route 1 tunnel 2003
```

MPLS FCAPS

- MPLS Configuration Management
  - Automating complex MPLS configuration rules (including TE rules)
- MPLS Fault Management
  - MPLS LSP status monitoring
  - MPLS Traffic Trunks/LSP fault analysis
  - Link/Node failure diagnosis
- MPLS Performance Management
  - LSP traffic measurement and analysis
  - MPLS network global optimization
- MPLS Accounting Management
  - Mapping measured traffic data into billing purpose
  - Mapping accounting data into admission control information
- MPLS Security Management

MPLS Service Management

- SLA Provisioning & Monitoring management
  - General MPLS service (e.g., traffic trunk lease) SLA
  - Service specific MPLS service (e.g., MPLS VPN) SLA
- Inter-domain MPLS Management
  - Protocol level distributed solution (e.g. inter-domain signaling such as GMPLS) is one thing
  - and management of this mechanism from network administrator viewpoint is another
- Many issues are still left open

MPLS TE Management Solutions

KNOM Tutorial 2001

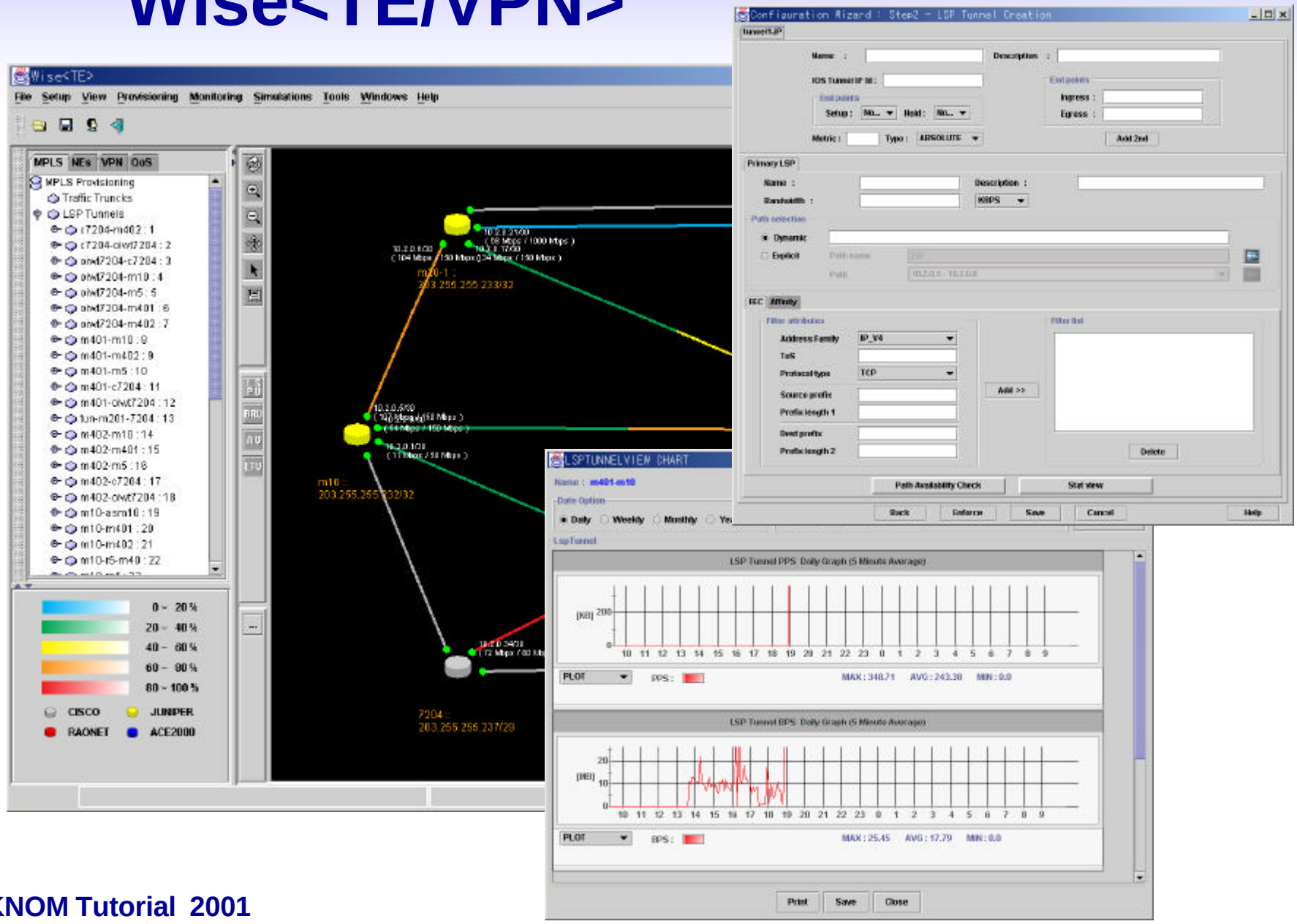
TE Servers: Products Introduction

- WANDL, Inc. - MPLSView ®
  - Automated data collection, layout, event collection and filtering (mainly focused on pre-configured LSPs)
  - A quasi real-time view on the configuration of the network, including LSP set-up & state and per-LSP traffic flow
  - Partnership with Cisco and Juniper
- Makesystems, Inc. - NetMaker ®
  - Network engineering and simulation tool for IP and MPLS
  - Merged to OPNET Technologies, Inc.
- Alcatel GRATE
- ETRI - Wise<TE> ®

VPN Servers: Products Introduction

- Orchaestream
- Cisco's VPN Solution Center
- Dorado
- ETRI - Wise<TE/VPN>

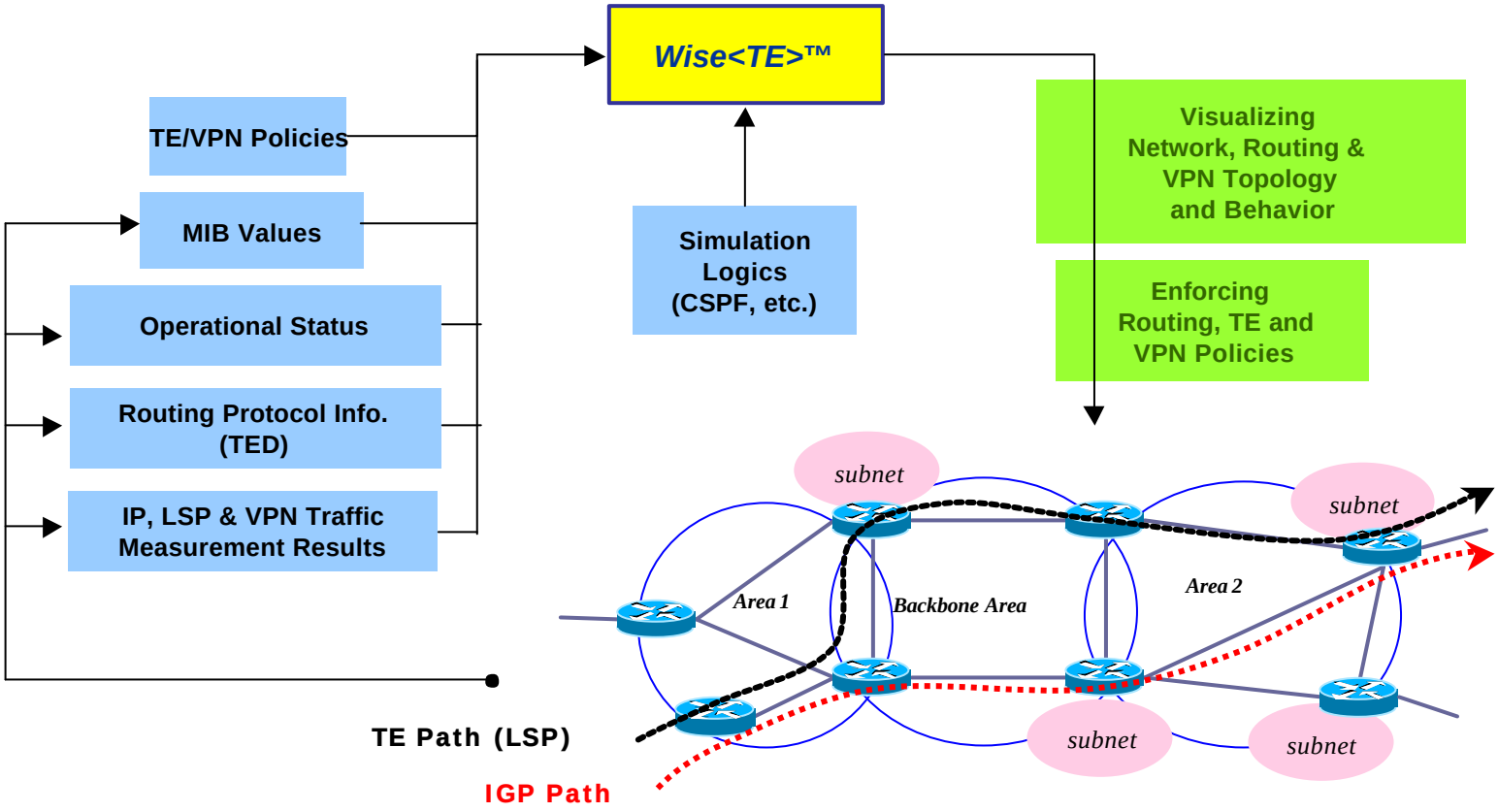
Wise<TE/VPN>


Wise<TE>
File Setup View Provisioning Monitoring Simulations Tools Windows Help
MPLS NEs VPN QoS
MPLS Provisioning
Traffic Trunckis
LSP Tunnels
0 ~ 20 %
20 ~ 40 %
40 ~ 60 %
60 ~ 80 %
80 ~ 100 %
CISCO
JUNIPER
RAONET
ACE2000
Configuration Wizard : Step2 - LSP Tunnel Creation
Primary LSP
Path Availability Check
Start view
Back
Enforce
Save
Cancel
Help
LSPTUNNELVIEW CHART
LSP Tunnel PPS Daily Graph (5 Minute Average)
LSP Tunnel BPS Daily Graph (5 Minute Average)
PLOT
Print
Save
Close

Wise<TE> addresses Questions

- How are packets routed in our network, and how are routing protocols configured ?
- Why is this link so congested, while others are underutilized ?
- Which path is the best fit for an LSP to serve a new VPN flow without QoS degradation ?
- Why is this LSP's operational / signaling state down?
- How much would it be worse if this node (link) fails?
- How much would it be better if our MPLS network is globally optimized by recomputing all LSPs together?
- Can we achieve some traffic engineering goals by global LSP reoptimization, routing metric optimization, or a totally new capacity planning process?

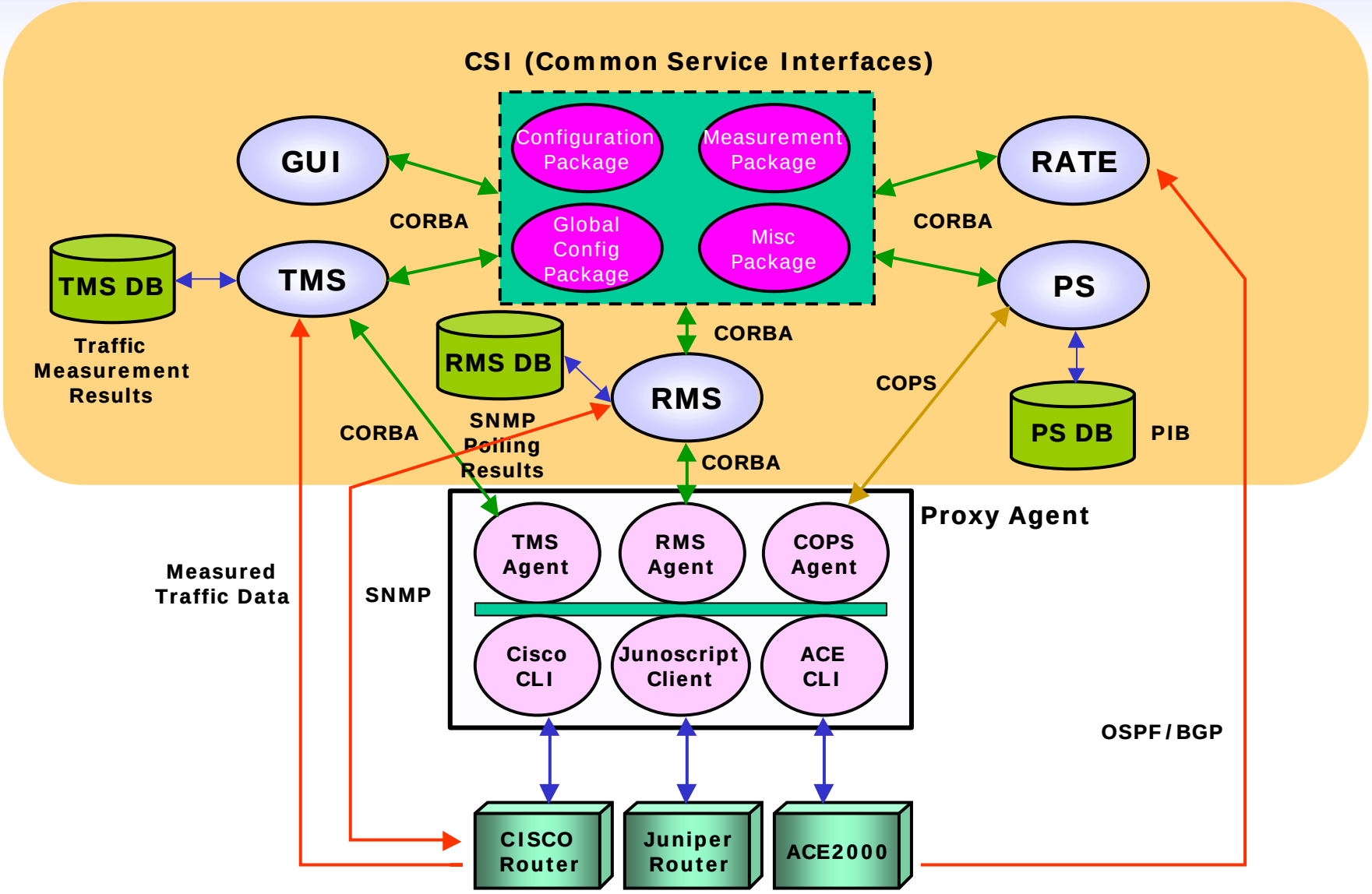
How!


Wise<TE>™
TE/VPN Policies
MIB Values
Operational Status
Routing Protocol Info. (TED)
IP, LSP & VPN Traffic Measurement Results
Simulation Logics (CSPF, etc.)
Visualizing Network, Routing & VPN Topology and Behavior
Enforcing Routing, TE and VPN Policies
subnet
subnet
subnet
subnet
Area 1
Backbone Area
Area 2
TE Path (LSP)
IGP Path

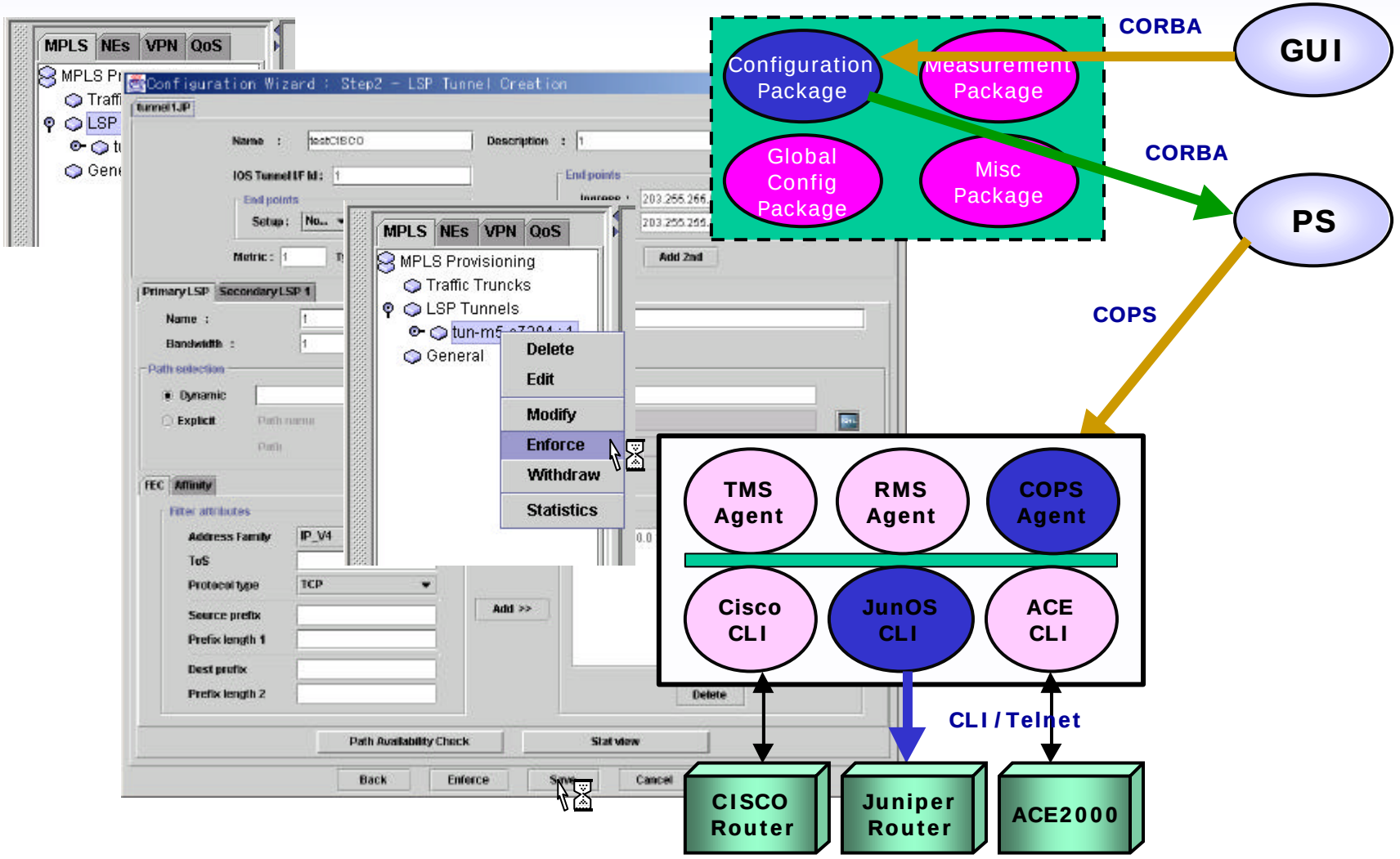
Main Functionality

- LSP / VPN Configuration Management and Quasi-realtime Monitoring
- Versatile Views of IP, MPLS, Routing (OSPF and BGP), and VPN Topology
- TE and VPN Policy Management
- IP Traffic Measurement and Analysis for MPLS-TE and VPN Management
- Intelligent Path Computation, Recommendation, and Various Simulations

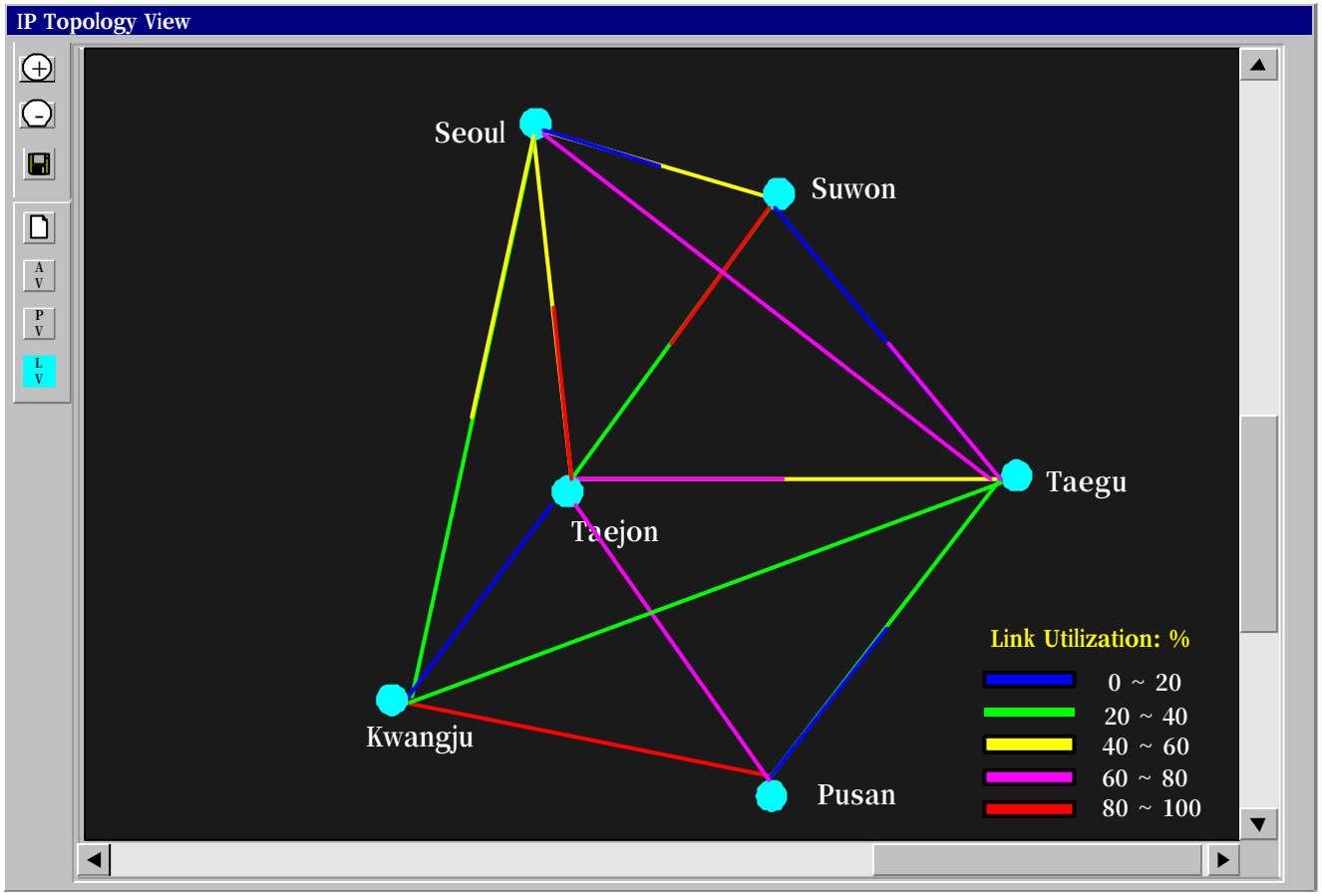
Wise<TE> Architecture



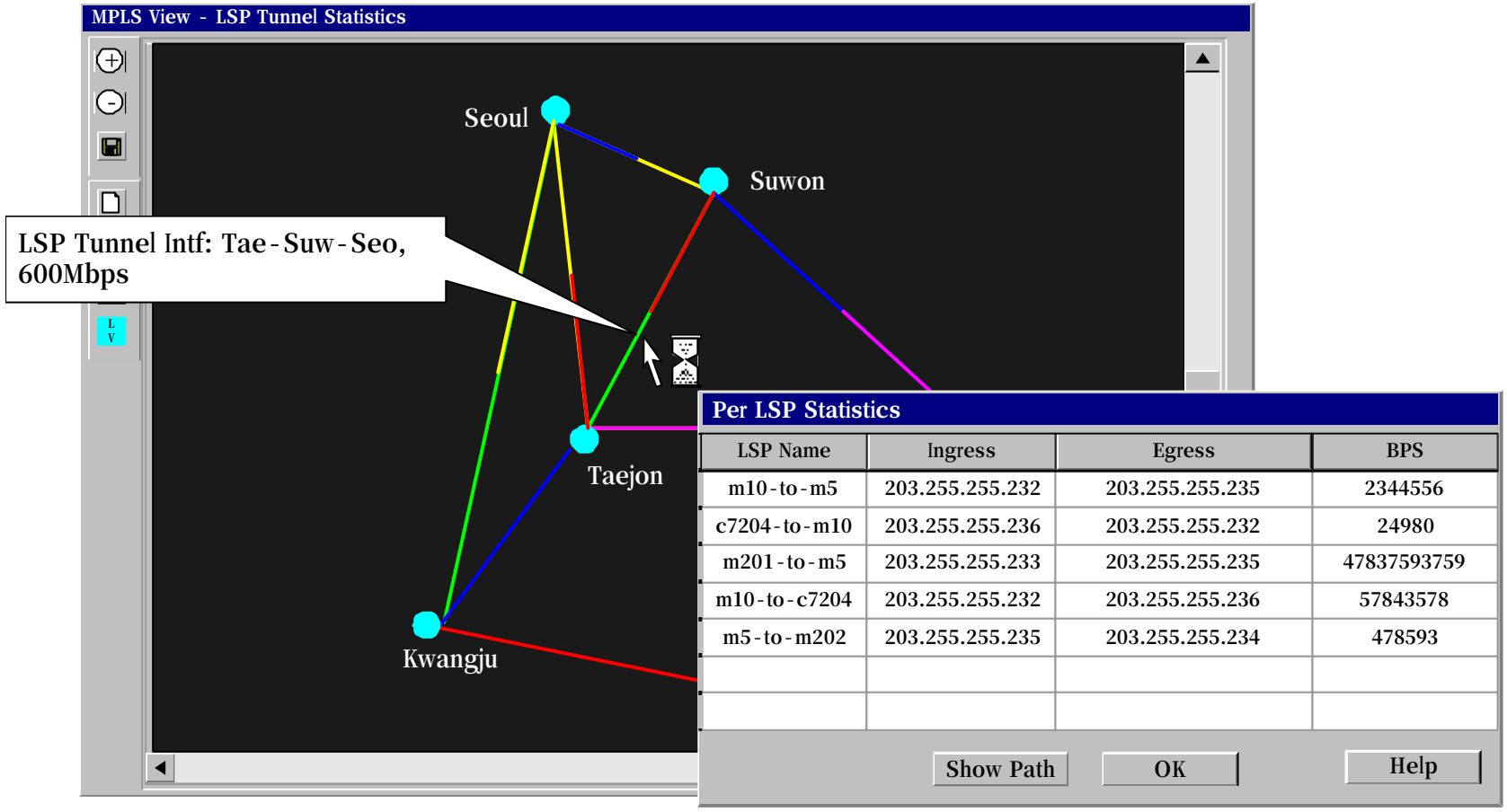
Easy Steps to create LSP Tunnels and VPNs



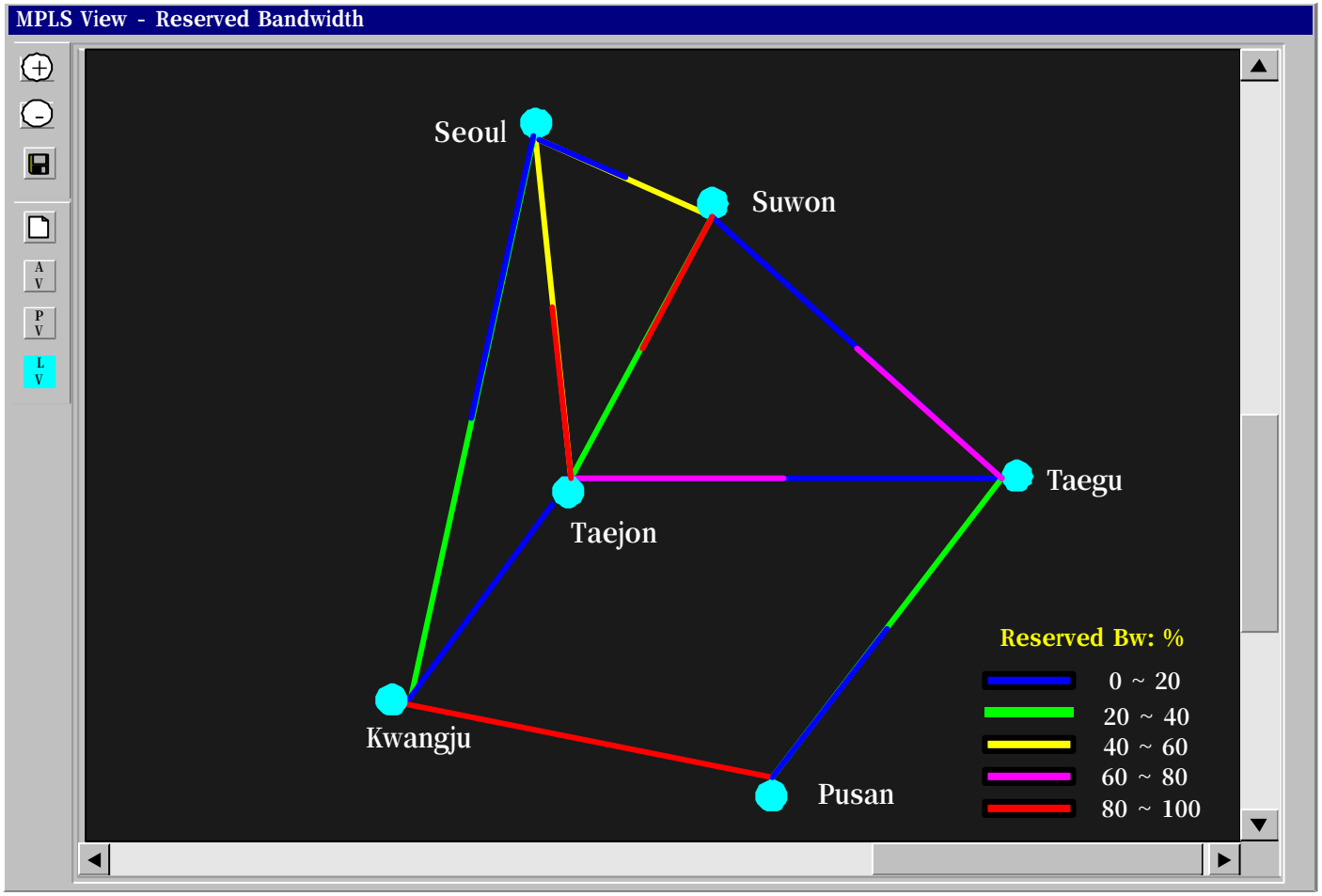
Versatile Topology Views: IP



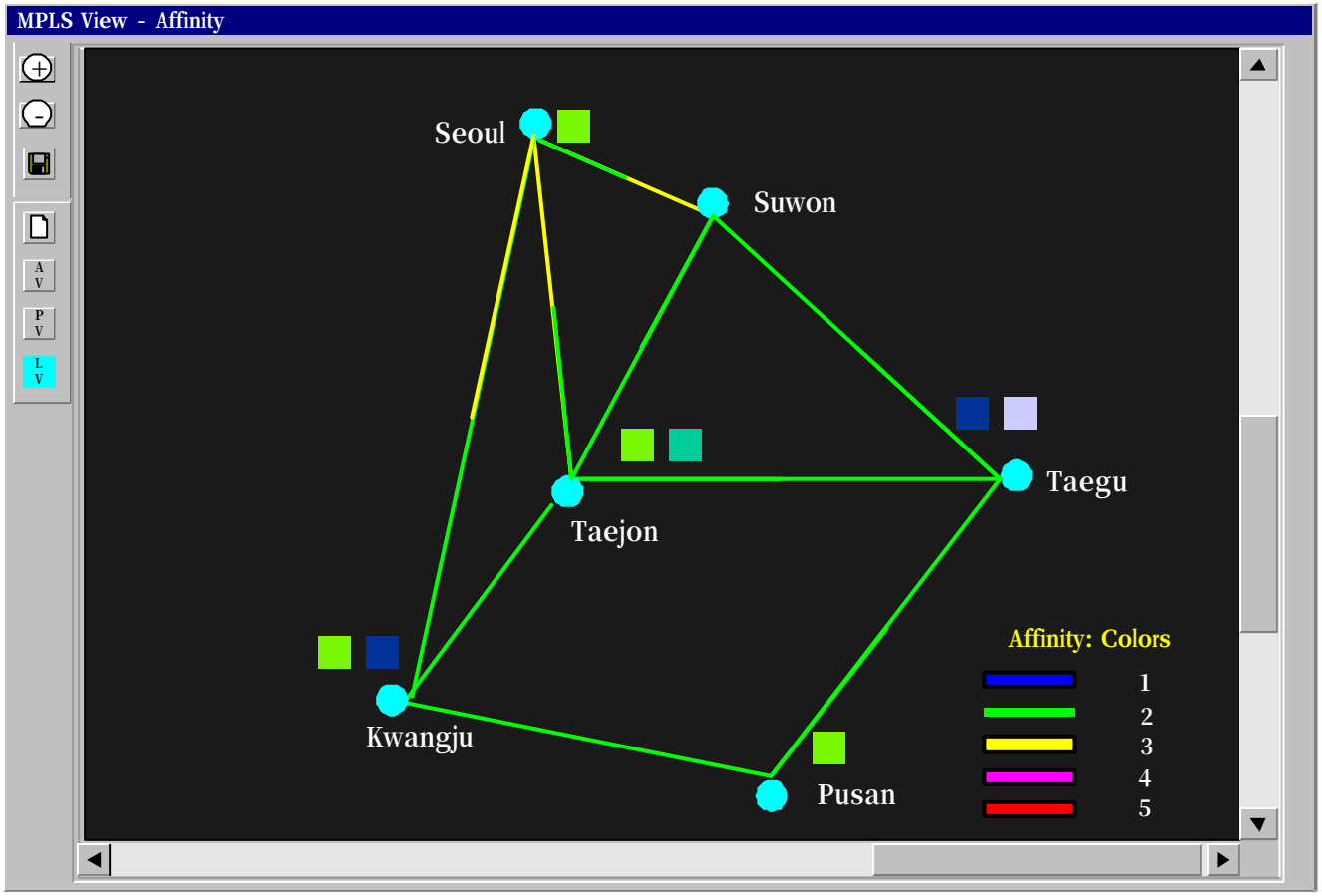
Versatile Topology Views: MPLS LSP Traffic



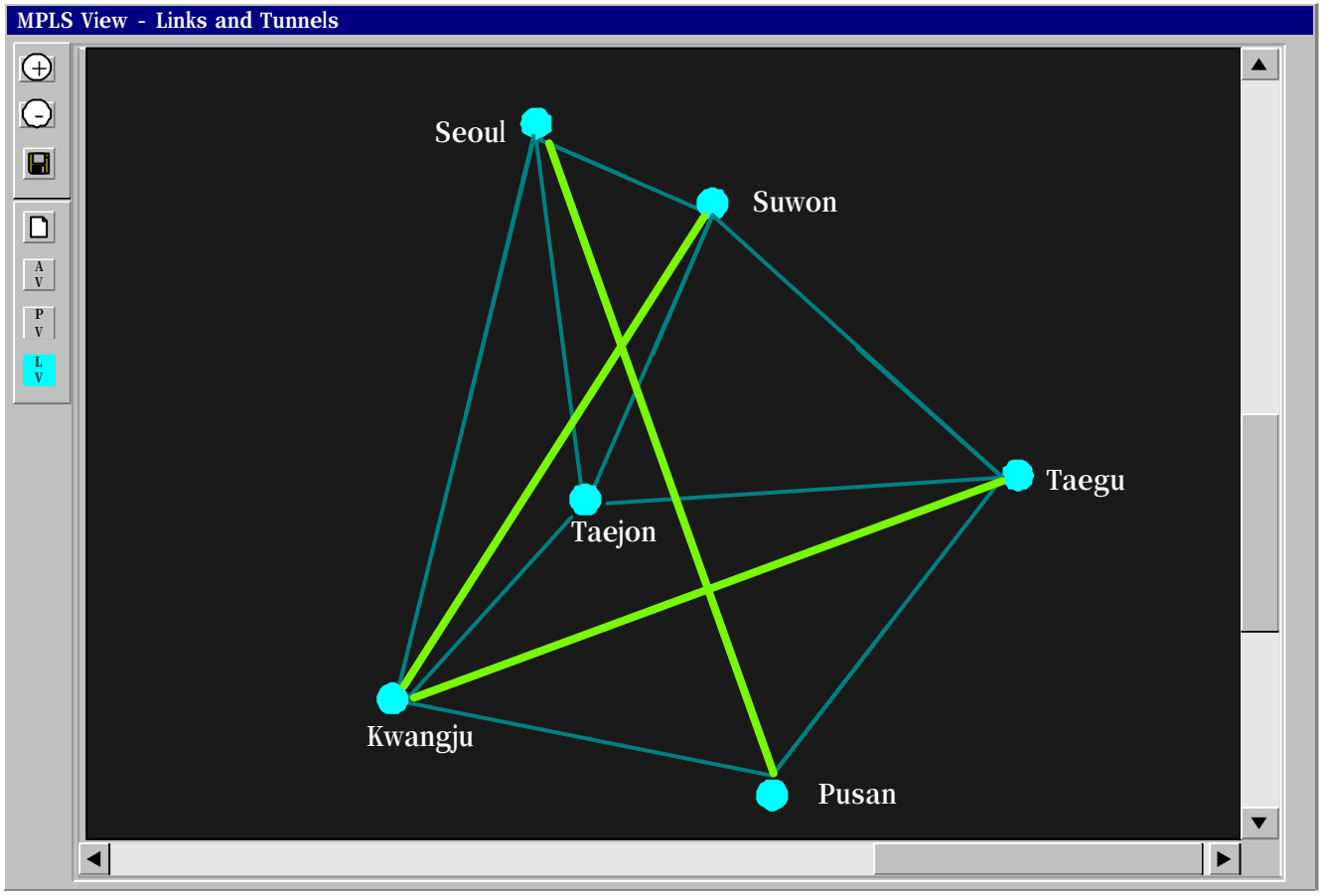
Versatile Topology Views: MPLS Reserved Bw



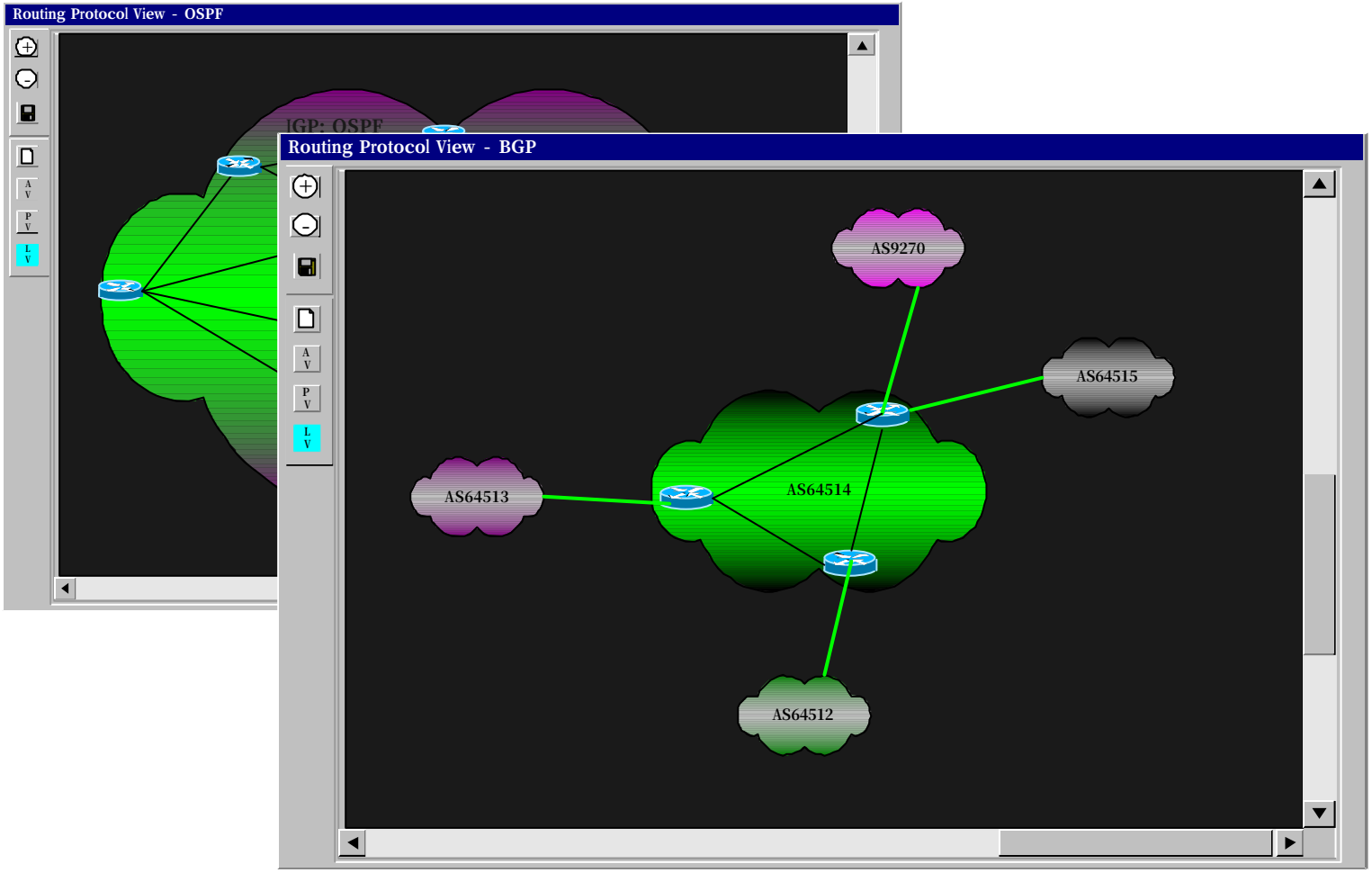
Versatile Topology Views: MPLS Affinity



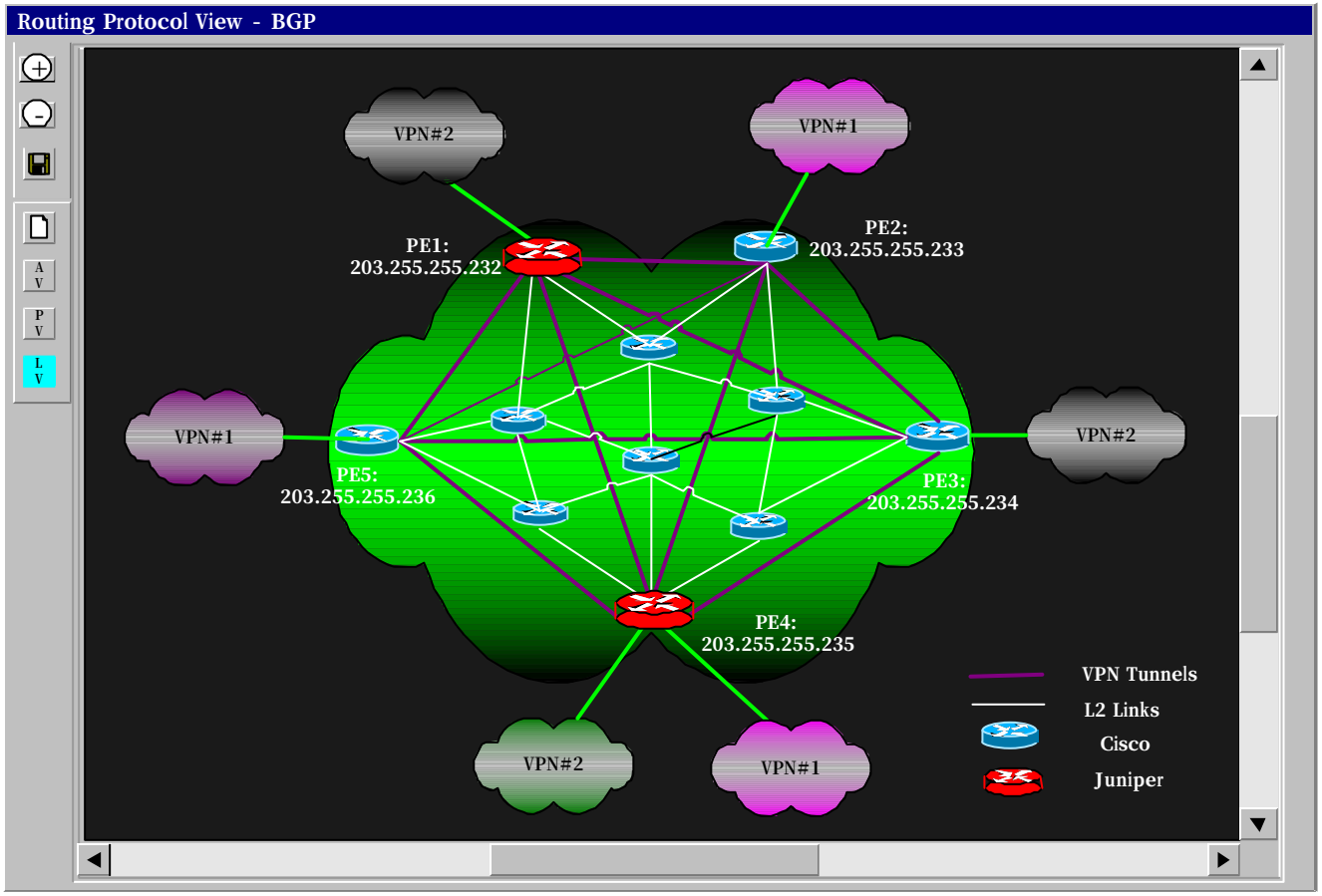
Versatile Topology Views: MPLS Link & Tunnels



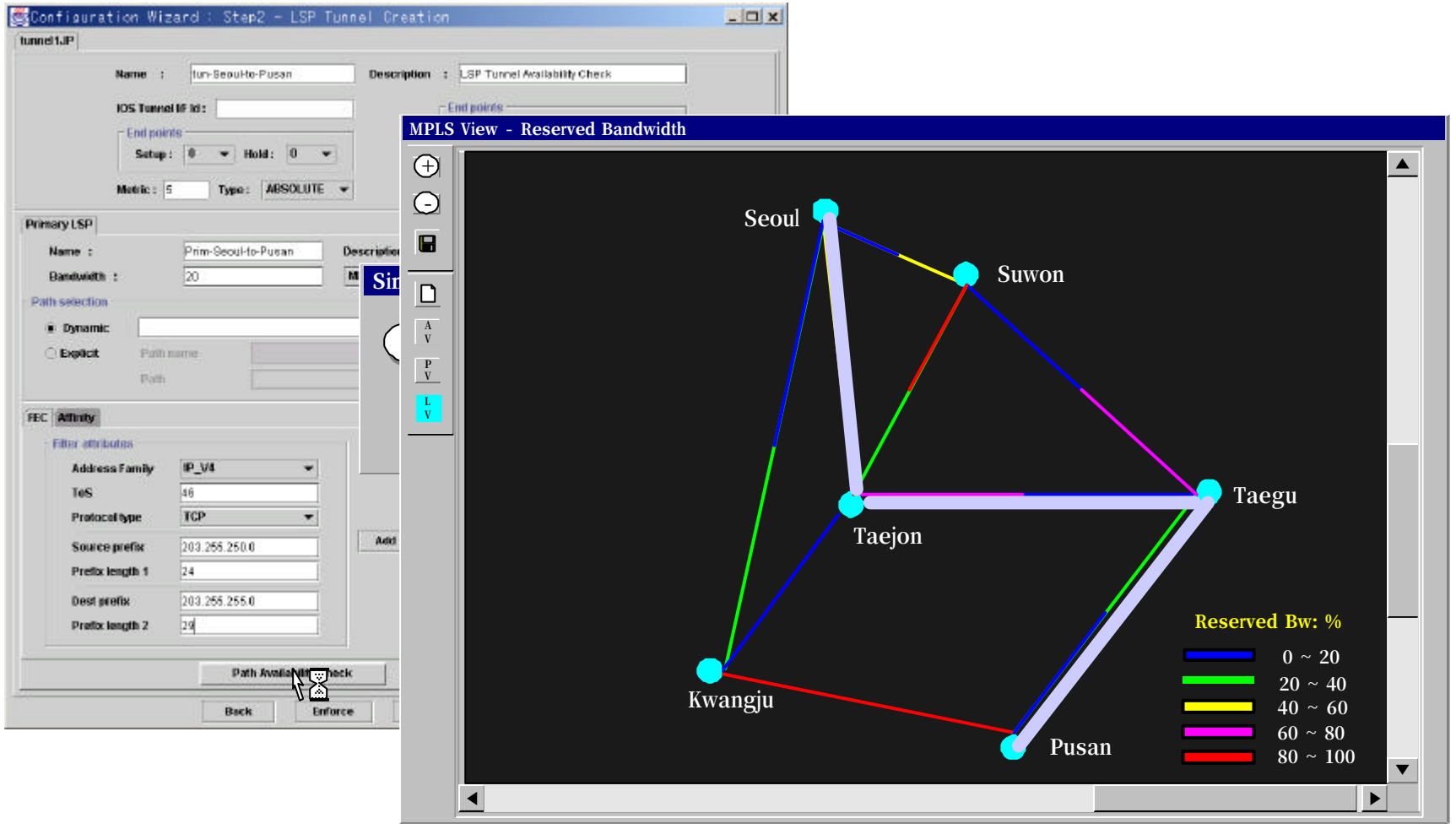
Versatile Topology Views: Routing Protocols



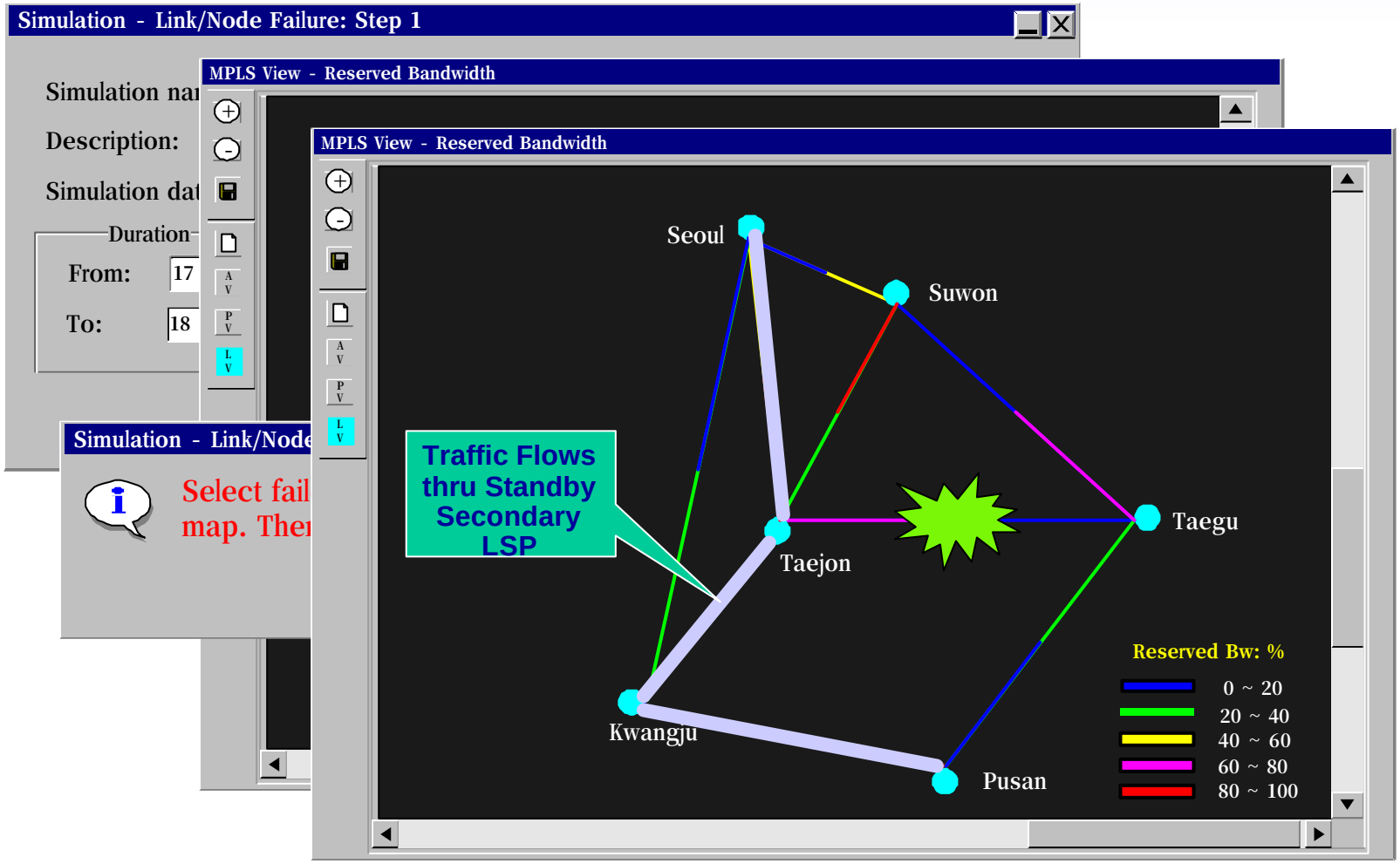
Versatile Topology Views: MPLS/BGP VPN



Various Simulations: Path Availability Check



Various Simulations: Link/Node Failure



LSP/Network Traffic Measurement and Analysis