

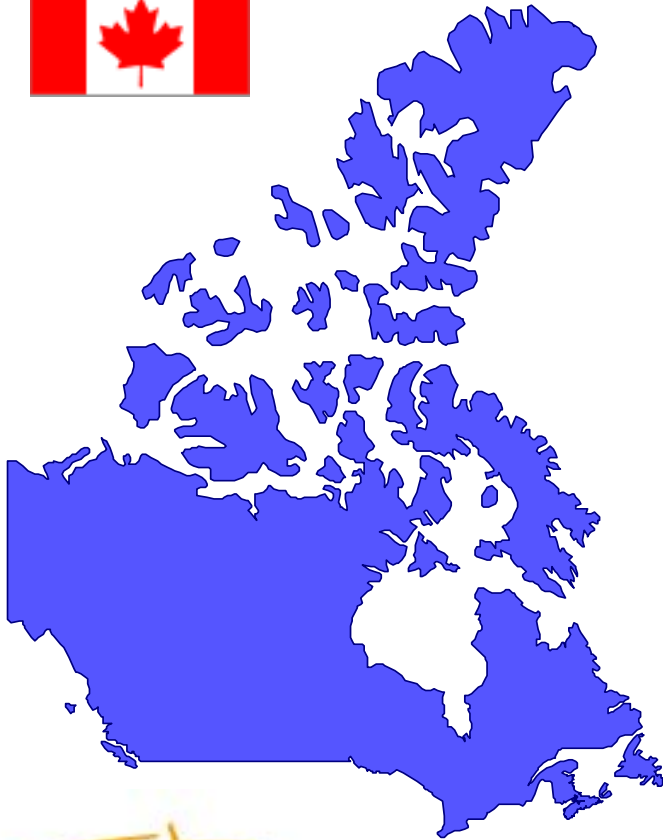
How to alleviate the Diff-Serv TE Network Design Complexity ?

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About Bell Canada



- Bell Canada is the leader in Telecom in Canada for IP Services: Tier 1- Internet Service Provider, Voice over IP, MPLS-VPN (RFC 2547), Ethernet (RPR), Frame & ATM Services.



About WANDL

- ❑ Head office in USA (NJ) with customer support offices in Singapore, UK, Italy and Belgium
- ❑ 19 year expertise in Network Design/Planning Automation/OSS.
- ❑ Technical Partnerships with Cisco, Juniper, Tellabs, Alcatel, Nortel, Lucent,...
- ❑ Customers
 - Telco, PTTs
 - ISPs, Service Providers



Quick reminder about DiffServ-TE

- DiffServ-TE adds the class of service dimension to “regular” MPLS-TE.
 - RSVP Resources in the network are specified on a class basis
 - Call Admission Control is performed per class

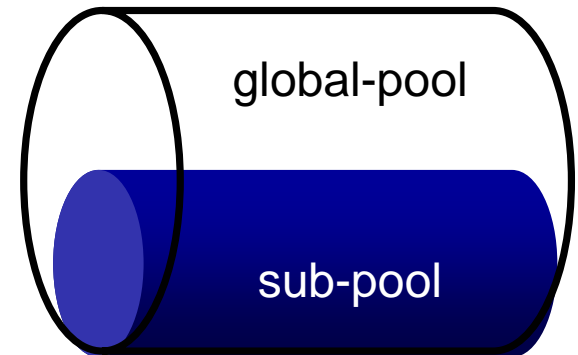
| Feature | Resource reservation | Scope |
|--------------------|---|----------------|
| DiffServ | Queuing reservation (data plane) | point to point |
| MPLS-TE | RSVP bandwidth (control plane) | end to end |
| DiffServ-TE | RSVP bandwidth per IP class (control plane) | end to end |



Cisco DiffServ-TE IOS implementation

- ❑ Two types of tunnels can be defined:
 - “Data tunnels” are constrained by the RSVP Global Pool bandwidth
 - “Voice tunnels” ONLY are constrained by the RSVP Sub Pool bandwidth
- ❑ Cisco current DiffServ-TE is based on Russian Doll Model
- ❑ Sample configuration

```
interface POS5/1
    ip rsvp bandwidth 150000 150000 sub-pool 45000
!
interface Tunnel2000
    tunnel mpls traffic-eng bandwidth sub-pool 50000
!
interface Tunnel3000
    tunnel mpls traffic-eng bandwidth 50000
```



Juniper DiffServ-TE implementation

- ❑ Two options for Juniper DiffServ TE:
 - Single class LSP
 - Multi-class LSP
- ❑ Two bandwidth models to perform Call Admission Control:
 - Russian Doll Model (RDM)
 - Maximum Allocation Model (MAM)

| | Number of bandwidth constraints | Bandwidth sharing |
|-----------------------------|---------------------------------|-------------------|
| Single class LSP (L-LSP) | 1 | RDM or MAM |
| Multi-class LSP (E-LSP) | Up to 4 | RDM or MAM |

Juniper DiffServ TE configuration

| mpls stanza | class of service stanza |
|---|--|
| <pre>diffserv-te { bandwidth-model mam; } label-switched-path 1-lsp { to 145.255.45.48; bandwidth ct1 10m; } label-switched-path single-class-lsp { to 145.255.45.48; bandwidth ct2 5m; }</pre> | <pre>scheduler-maps { simple-map { forwarding-class AF scheduler fair; forwarding-class BE scheduler fair; forwarding-class NC scheduler fair; forwarding-class EF scheduler fair; } } schedulers { fair { transmit-rate percent 25; buffer-size percent 25; } }</pre> |

Diff-Serv TE complexity

- ❑ DiffServ-TE is a very convenient mechanism for enabling bandwidth guarantees similar to ATM Class Of Service in multimedia networks.
- ❑ Yet DiffServ-TE is complex to manage:
 - Russian Doll Model is not so intuitive when available bandwidth is to be calculated per class
 - Tunnels/LSP for the “smallest doll” need to be assigned a high priority/preemption to get some shares of the bandwidth
- ❑ And because of MPLS-TE intrinsic complexity...



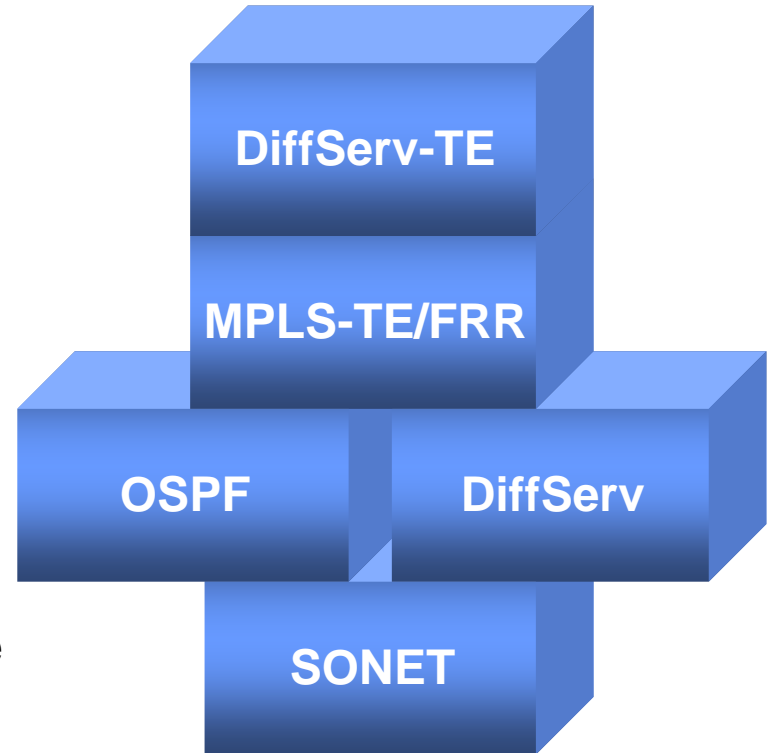
MPLS-TE design: many options...

| | | | |
|---------------------------------|---|--|---|
| Main purpose | <input type="checkbox"/> “Real” Traffic Engineering | <input type="checkbox"/> Network Protection only | <input type="checkbox"/> Deliver Traffic Matrix |
| Tunnel deployment | <input type="checkbox"/> Full mesh | <input type="checkbox"/> One-Hop Tunnel | <input type="checkbox"/> Limited/regional |
| Link colors | <input type="checkbox"/> All links | <input type="checkbox"/> Limited: e.g. only “transcontinental” links | <input type="checkbox"/> No |
| Primary Tunnel Bandwidth | <input type="checkbox"/> 0 BW | <input type="checkbox"/> auto-bandwidth | <input type="checkbox"/> User-defined |
| Backup Tunnel Bandwidth | <input type="checkbox"/> 0 BW | <input type="checkbox"/> % of interface BW | <input type="checkbox"/> % of Primary Tunnel BW |
| Inter-area TE | <input type="checkbox"/> Required | <input type="checkbox"/> Via verbatim path option | <input type="checkbox"/> No |
| Multicast TE | <input type="checkbox"/> Required | <input type="checkbox"/> Only for major sources of traffic | <input type="checkbox"/> No. |



Recommendations for DiffServ-TE roll out

- ❑ DiffServ-TE is usually deployed on top of a multi-layer network.
 - Multi-layer Design requires a good knowledge of the interaction between the various layers.
 - Design of Layer “N” requires that Layer “N-1” is properly engineered
- ❑ Automate the engineering tasks:
 - audit/inventory/analysis of Baseline
 - Network Design
 - Network Provisioning



Real life case study

***How to effectively manage the deployment
and the organic growth of
Toll Voice Trunks in a Multi-Service MPLS-IP
Infrastructure***

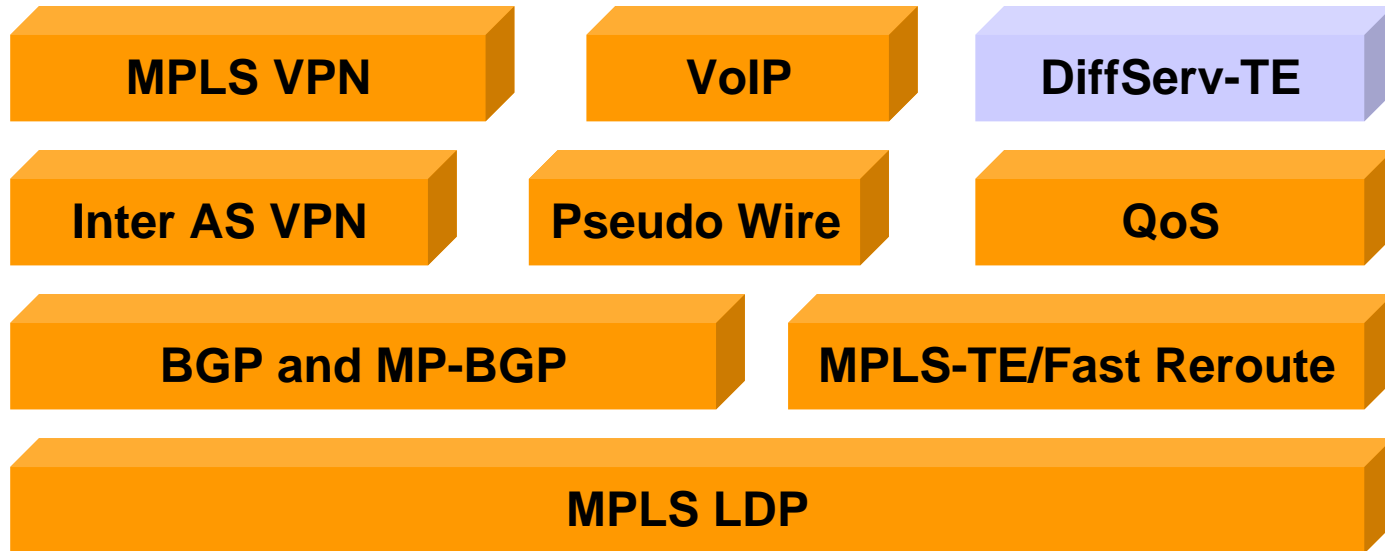


Bell Canada IP Network & Services


- Halifax (Canada) to Palo Alto (USA) ~8000 KM
- Internet Peering & Transit
- MPLS-TE/FRR Tunnels (WAN Consolidation)
- VPN IPSec Service
- VPN 2547 Service
- DSL PPOE Internet Retail & Wholesale Service
- Business Internet Retail & Wholesale Service
- FoMPLS Service
- Inter-AS VPN Service for World Wide Private VPN Connectivity




Bell Canada MPLS-IP Core Network Features



Bell Canada IP Network POP Architecture

 DSL Aggregation
72XX, JNPR-E Series

 LER Routers
75XX, 12XXX

 LSR Routers
12XXX

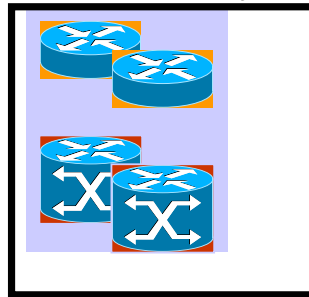
 OC48

 OC12

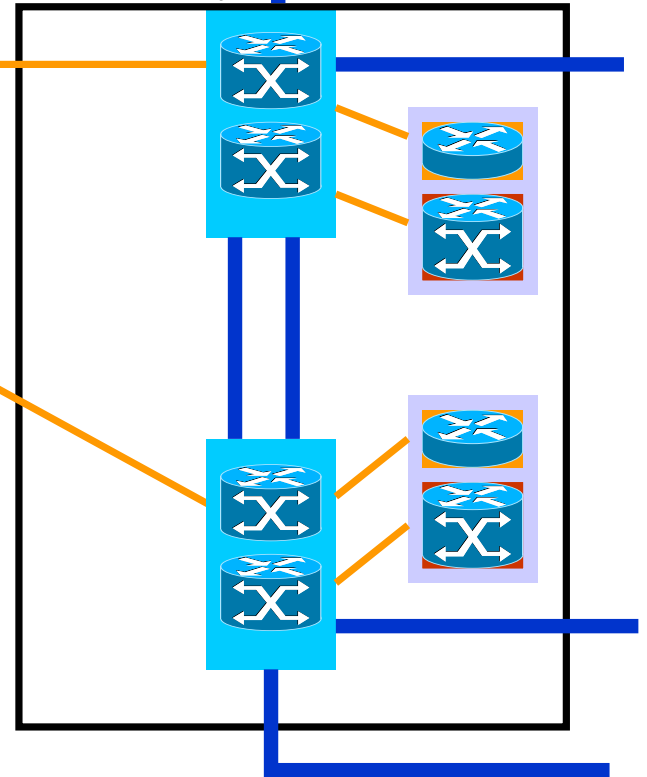
Core PoP

Access PoP


Tier 2 City





Tier 1 City



Bell Canada Fast Reroute Deployment

Primary TE tunnels
(Full mesh) 

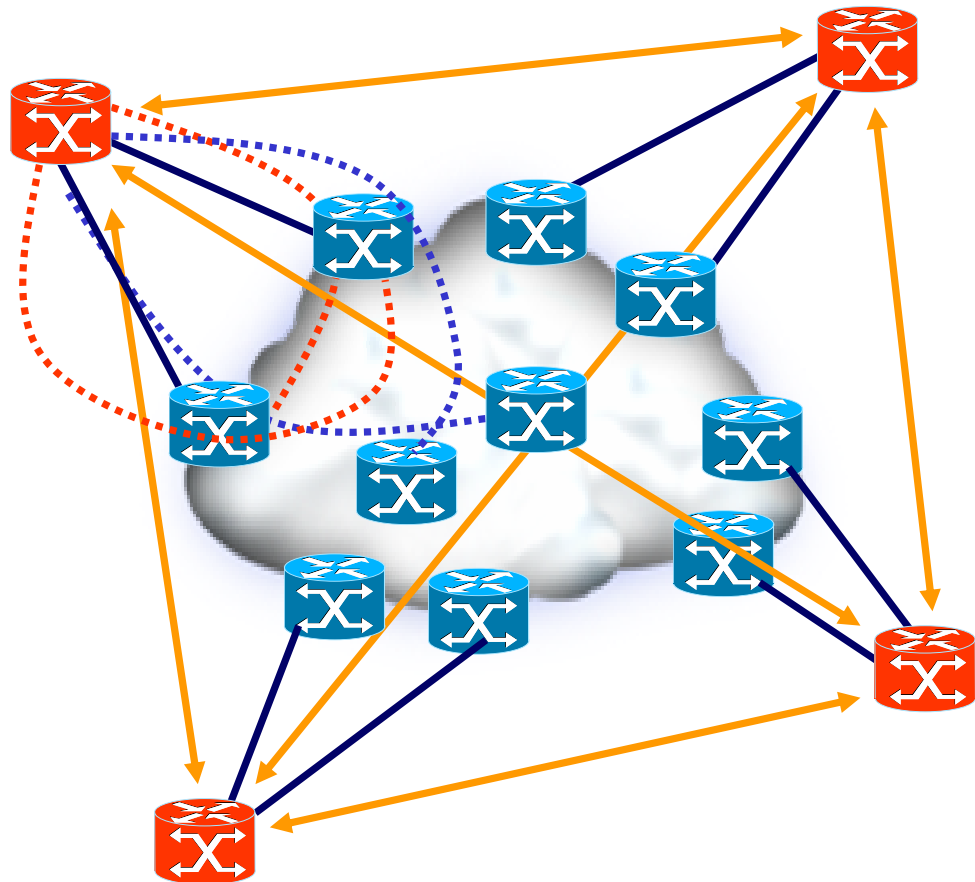
FRR node
Protection NNHOP
(for all Core routers) 

FRR link
Protection NHOP
(for all POS interfaces
In Area 0.0.0.0) 

OC48 POS
Interfaces 

VoIP
Gateways 

Core
Routers 

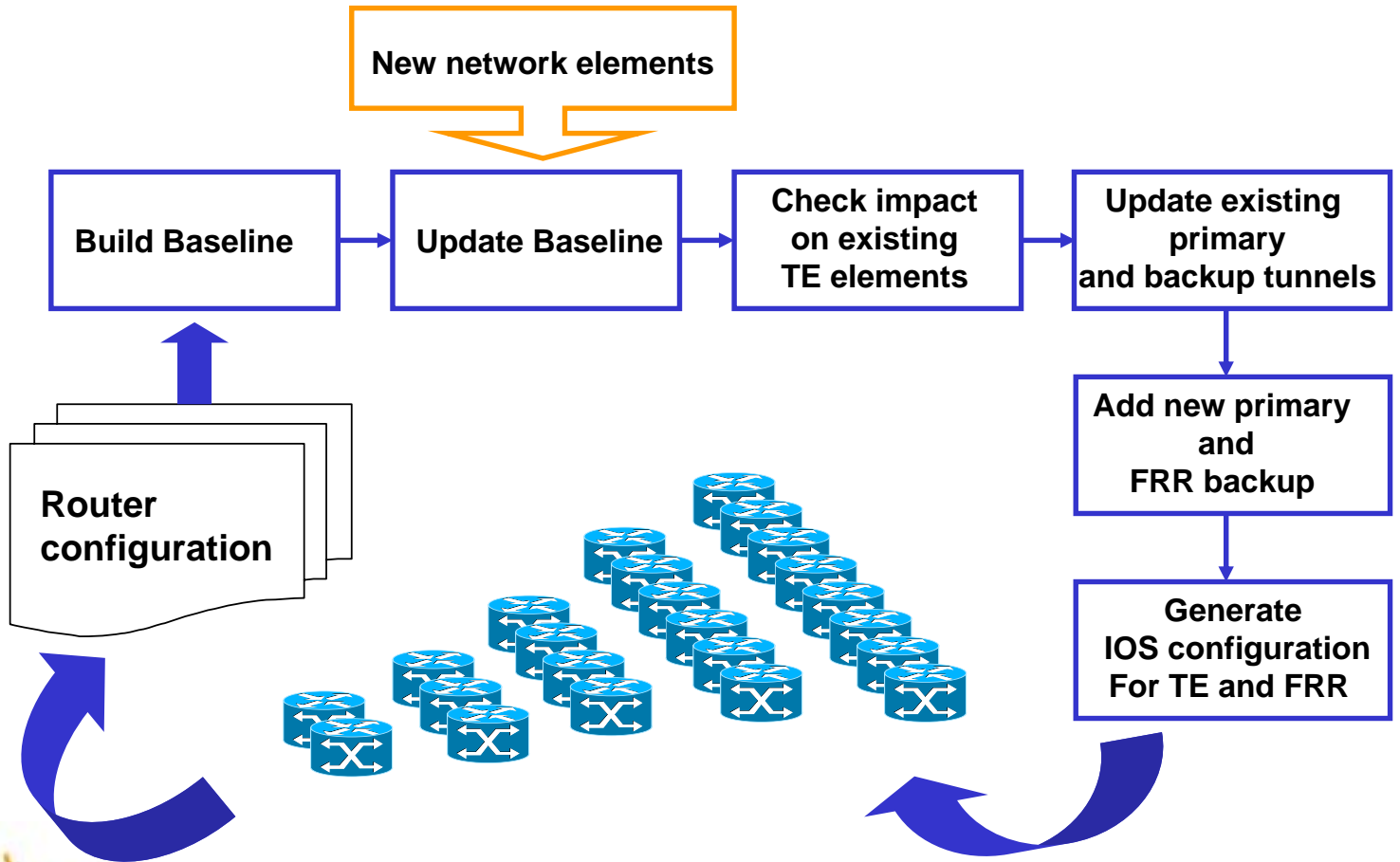


Network Investment & Growth

- ❑ One of the major challenge for Bell IP Network Designers is to manage the ongoing investment/growth in the MPLS-IP Infrastructure of new Service Areas (i.e. POP build out) while managing the MPLS TE/FRR as Core Network Service Offering.
- ❑ Example of network impact when a site is added:
 - New POS links
 - Re-use existing IP addresses
 - Optimize/Update routing path for existing primary and backup tunnels
 - Design Fast Reroute plan for new network elements
- ❑ Bell Canada chose WANDL IP/MPLSview to automate its MPLS TE/FRR Design and Engineering challenges



Bell IP Engineering Change Management Process



Step 1: Build and Crosscheck Baseline

- ❑ Baseline is built via router configuration files as input.
- ❑ OSPF and RSVP settings need to be verified for Quality Assurance as they can have a major impact on the tunnel routing

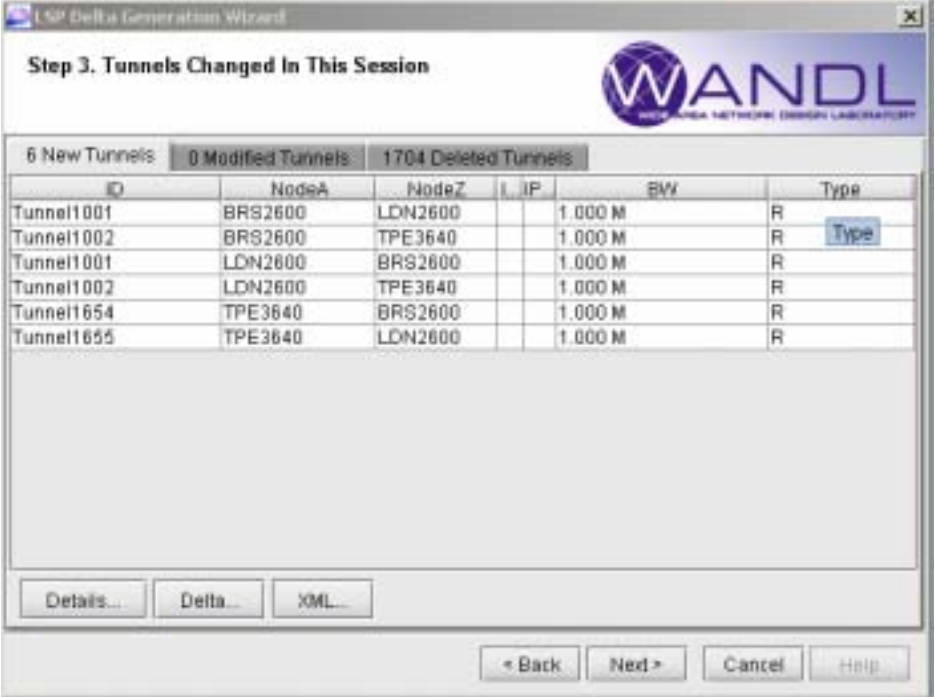
The screenshot shows the IP/MPLSView software interface. The 'Report Manager' window is open, displaying a table of configuration errors. The table has columns for Category, Severity, Message, Count, and InqID. The errors are categorized by protocol (MPLS, OSPF, IP, BGP, Static Route, Access List, VPN) and severity (HIGH, MEDIUM, LOW). The total count of errors is 111.

| Category | Severity | Message | Count | InqID | Info |
|--------------|----------|---|-------|-------|------|
| MPLS | - | Total | 106 | - | Yes |
| MPLS | HIGH | - Unknown interface | 8 | 93 | Yes |
| MPLS | WARNING | - RSVP not defined on MPLS enabled interface | 69 | 118 | Yes |
| MPLS | MEDIUM | - Inconsistent LDP/TEP definition | 99 | 23 | Yes |
| OSPF | - | Total | 47 | - | Yes |
| OSPF | HIGH | - Unknown interface | 6 | 93 | Yes |
| OSPF | WARNING | - ABR not in Area 0 | 2 | 119 | Yes |
| OSPF | MEDIUM | - Inconsistent OSPF definition | 12 | 26 | Yes |
| OSPF | WARNING | - Asymmetric OSPF peers | 27 | 113 | Yes |
| IP | - | Total | 873 | - | Yes |
| IP | WARNING | - Inconsistent interface media with same subnet address | 79 | 19 | Yes |
| IP | WARNING | - Duplicate IP address (private) | 52 | 111 | Yes |
| IP | WARNING | - Duplicate IP address (public) | 22 | 9 | Yes |
| IP | HIGH | - Overlapped subnet addresses | 703 | 50 | Yes |
| IP | LOW | - Inconsistent bandwidth | 17 | 29 | Yes |
| BGP | - | Total | 7 | - | Yes |
| BGP | HIGH | - Unknown VRF | 5 | 85 | Yes |
| BGP | WARNING | - Shutdown BGP neighbor | 2 | 51 | Yes |
| Static Route | - | Total | 281 | - | Yes |
| Static Route | WARNING | - Next hop not in local subnet | 179 | 47 | Yes |
| Static Route | MEDIUM | - Shutdown interface is static route | 102 | 52 | Yes |
| Access List | - | Total | 299 | - | Yes |
| Access List | WARNING | - Unreferenced access-list | 230 | 100 | Yes |
| Access List | HIGH | - Unknown access-list | 52 | 86 | Yes |
| Access List | HIGH | - Non-sliced access-list rule | 17 | 106 | Yes |
| VPN | - | Total | 153 | - | Yes |
| VPN | HIGH | - missing route distinguisher | 6 | 120 | Yes |
| VPN | INFO | - | 147 | 121 | Yes |



Step 2&3: Update Baseline and review the impact of new network elements

- ❑ New network elements contain new tunnels. They may also turn the existing FRR backup tunnels obsolete.
- ❑ IP/MPLSview Delta LSP feature can automatically identify the existing Primary and FRR tunnels that need to be modified or are now redundant.



LSP Delta Generation Wizard

Step 3. Tunnels Changed In This Session

6 New Tunnels | 0 Modified Tunnels | 1704 Deleted Tunnels

| ID | NodeA | NodeZ | L. IP | BW | Type |
|------------|---------|---------|-------|---------|------|
| Tunnel1001 | BRS2600 | LDN2600 | | 1,000 M | R |
| Tunnel1002 | BRS2600 | TPE3640 | | 1,000 M | R |
| Tunnel1001 | LDN2600 | BRS2600 | | 1,000 M | R |
| Tunnel1002 | LDN2600 | TPE3640 | | 1,000 M | R |
| Tunnel1654 | TPE3640 | BRS2600 | | 1,000 M | R |
| Tunnel1655 | TPE3640 | LDN2600 | | 1,000 M | R |

Details... Delta... XML...

< Back Next > Cancel Help

Step 4: Provisioning new primary tunnels

- Primary tunnels are configured with two path options.

The screenshot displays the Packet Tracer interface with the configuration for a primary tunnel on router BR/2600. The configuration is as follows:

```
interface Tunnel1001
description from BR/2600 to LDN2600
ip unnumbered Loopback0
tunnel destination 10.1.1.1
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng autroute announce
tunnel mpls traffic-eng bandwidth 1000
tunnel mpls traffic-eng path-option 10 explicit name Tunnel1001.p0
tunnel mpls traffic-eng path-option 20 dynamic
!
!
ip explicit-path name Tunnel1001.p0 enable
next-address 192.10.20.120
!
```

The interface also shows a table of tunnels and a summary of records:

| ID | Source ID | Destination ID | Bandwidth |
|------------|-----------|----------------|-----------|
| Tunnel1001 | BR/2600 | LDN2600 | 1.000 |
| Tunnel1002 | BR/2600 | TPC3640 | 1.000 |
| Tunnel1001 | LDN2600 | BR/2600 | 1.000 |
| Tunnel1002 | LDN2600 | TPC3640 | 1.000 |
| Tunnel1004 | TPC3640 | BR/2600 | 1.000 |
| Tunnel1005 | TPC3640 | LDN2600 | 1.000 |

Summary: Total # of records: 6 records (stat: 6, indexed: 1-6)

Step 5: Provisioning Bell FRR backup tunnels

- ❑ Fast Reroute backup tunnels are calculated for both Node and Link Protection.
 - ❑ FRR backup path does not share any router/site with primary tunnel path
- ⇒ best in class network protection.

The screenshot shows the 'FRR Design' configuration window. It is divided into several sections:

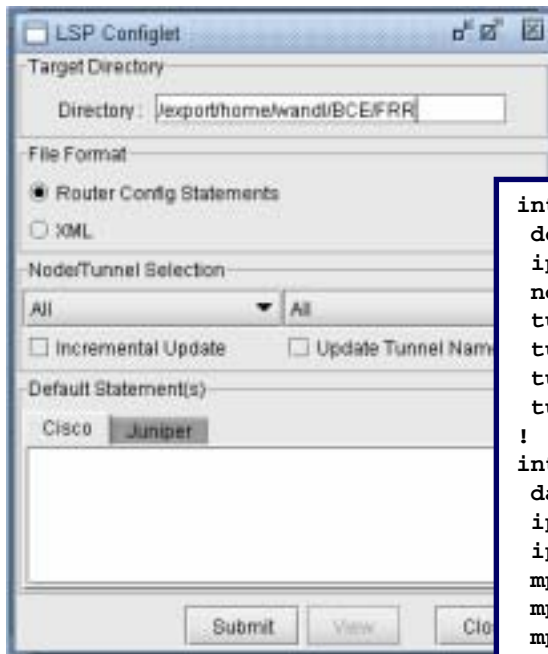
- Protection Type:** Radio buttons for 'Link' (selected) and 'Node'.
- Diversity Level:** Radio buttons for 'Facility', 'Link', and 'Site' (selected).
- Protected Tunnel Type:** Radio buttons for 'Global-Pool', 'Sub-Pool', and 'Any' (selected).
- Backup BW:** Radio buttons for 'Limited' and 'Unlimited' (selected).
- Allocate backup BW using:** Radio buttons for 'Global-Pool' (selected) and 'Sub-Pool'.
- Design BW (for Design/Placement):**
 - Design BW = RefBW * % + Fixed
 - % RefBW:
 - Fixed BW:
 - Reference BW Source: Radio buttons for 'Link BW' (selected), 'Sub-Pool BW', and 'Sum of FRR Primary Tunnel BW'.
- Advanced Options:**
 - Set signaling BW to design BW value
 - Prompt to view FRR design report

Buttons at the bottom: 'ViewTune Paths...', 'Auto Design', 'Close', and 'Help'.



Step 6: Support FRR provisioning

- ❑ Best vehicle/language to communicate a TE/FRR Design to our Operations team is in form of router commands.
- ❑ Wandl assists us in generating the related commands in a configlet.



```
interface Tunnel4
  description from TORONTO to MONTREAL; protected link=TORONTO_POS0/0
  ip unnumbered Loopback0
  no ip directed-broadcast
  tunnel destination 192.168.96.20
  tunnel mode mpls traffic-eng
  tunnel mpls traffic-eng path-option 10 explicit name Tunnel4.p0
  tunnel mpls traffic-eng path-option 20 explicit name exclude_ 10.1.103.130
!
interface POS0/0
  dampening
  ip address 10.1.103.130 255.255.255.252
  ip ospf cost 500
  mpls label protocol both
  mpls traffic-eng tunnels
  mpls traffic-eng backup-path Tunnel4
```

Conclusion

- ❑ DiffServ-TE is a complex powerful mechanism to transport multimedia tunnels with many knobs to tune.
- ❑ DiffServ-TE networks tend to be large and multi-layer: usually MPLS-TE, FRR are also deployed
- ❑ Hence manual configuration is very tedious and not scalable.
- ❑ The objective for Bell Canada IP Engineering Team is to automate (i.e. OPEX Management) the MPLS-TE layer Design/Management , there by using intelligent and complementing Software from vendors such as WANDL.



Acknowledgement

We would like to acknowledge the following persons for their contributions with implementing the MPLS TE in the Bell Canada network:

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