

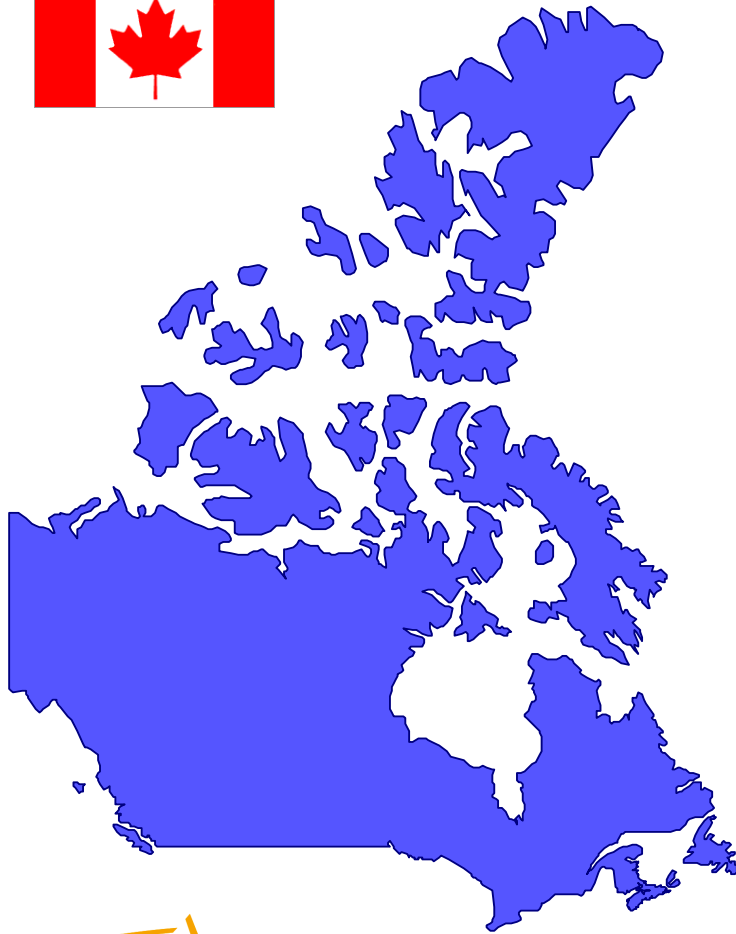
How to alleviate the Diff-Serv TE Network Design Complexity ?

Didier Bousser
dbousser@wandl.com
WANDL System Engineering

Farid Azarani
farid.azarani@bell.ca
Bell Canada Core IP Engineering



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

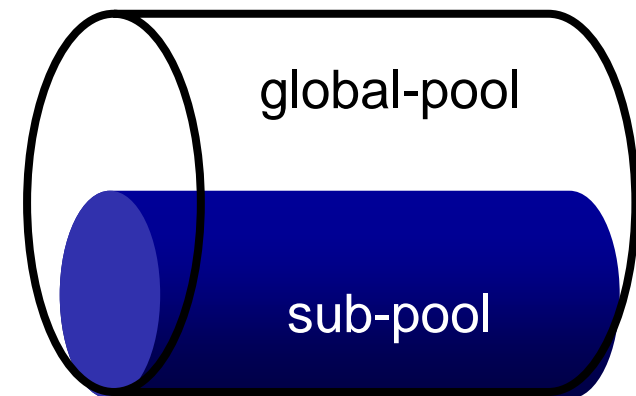
Feature	Resource reservation	Scope
DiffServ	Queuing reservation (data plane)	point to point
MPLS-TE	RSVP bandwidth (control plane)	end to end
DiffServ-TE	RSVP bandwidth per IP class (control plane)	end to end



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...



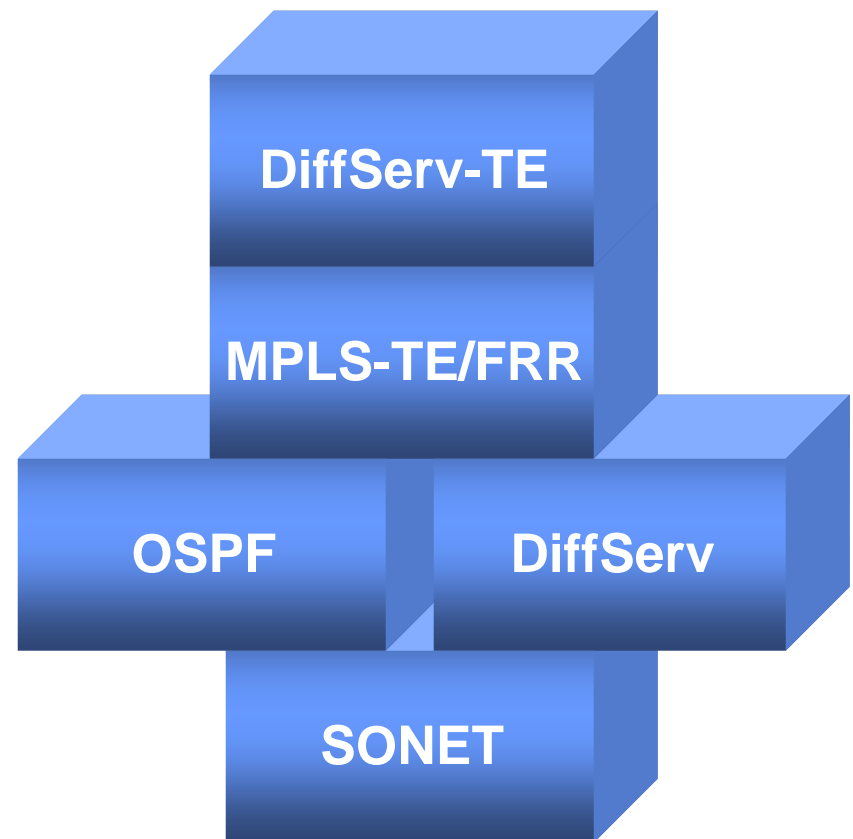
MPLS-TE design: many options...

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***

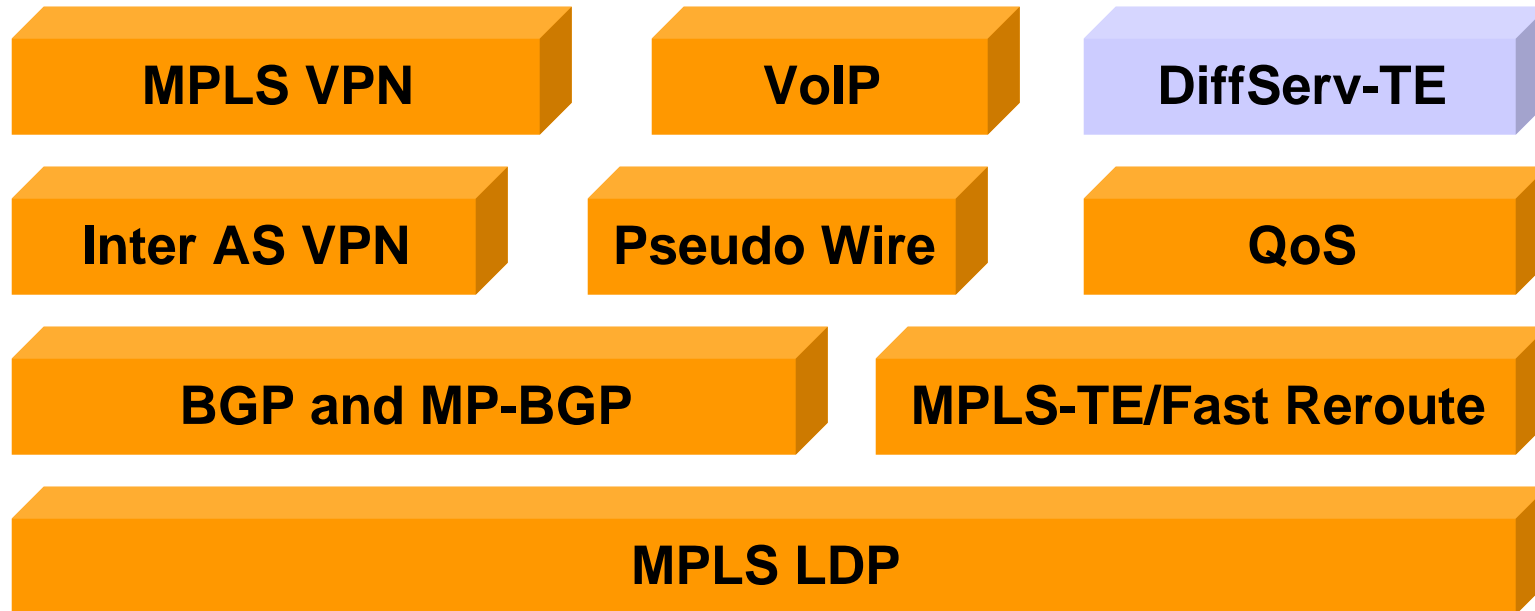


Bell Canada IP Network & Services

- 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

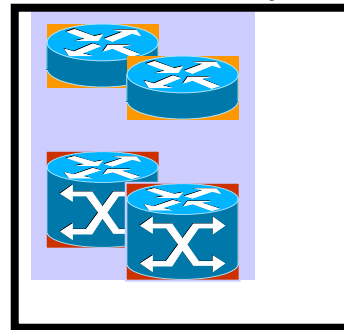
 OC48

 OC12

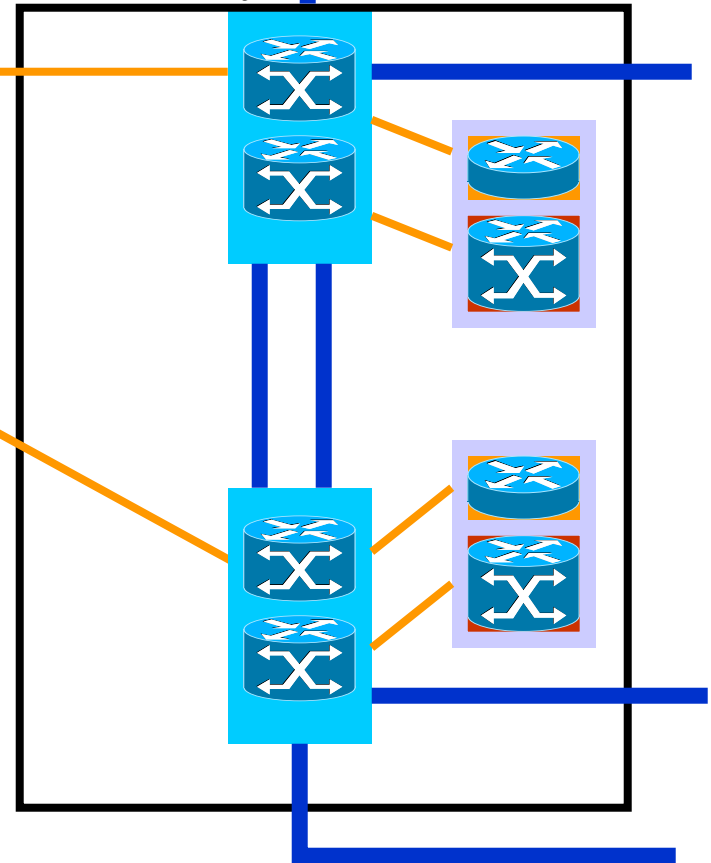
Core PoP

Access PoP

Tier 2 City





Tier 1 City



Bell Canada Fast Reroute Deployment

Primary TE tunnels
(Full mesh) 

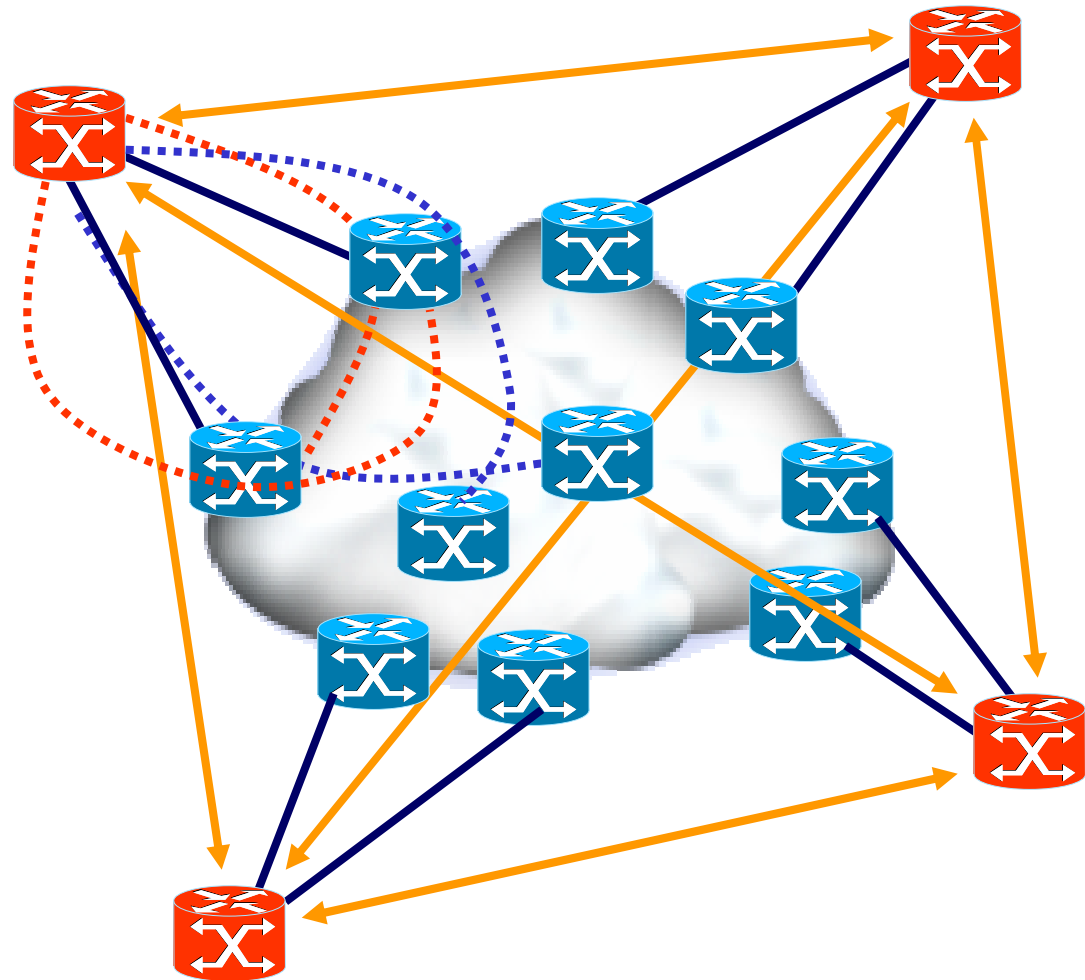
FRR node
Protection NNHOP
(for all Core routers) 

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

OC48 POS
Interfaces 

VoIP
Gateways

Core
Routers

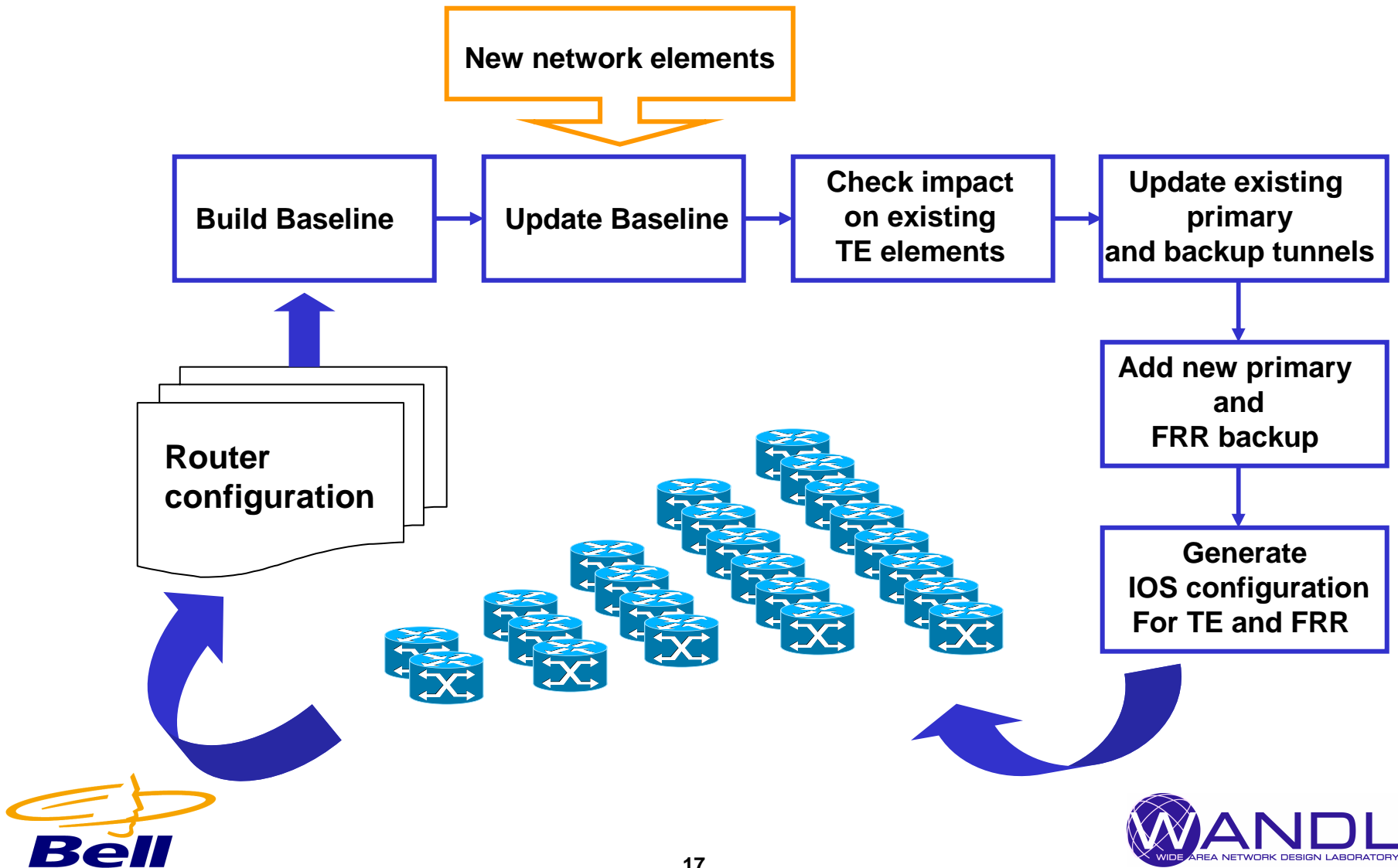


Network Investment & Growth

- ❑ 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

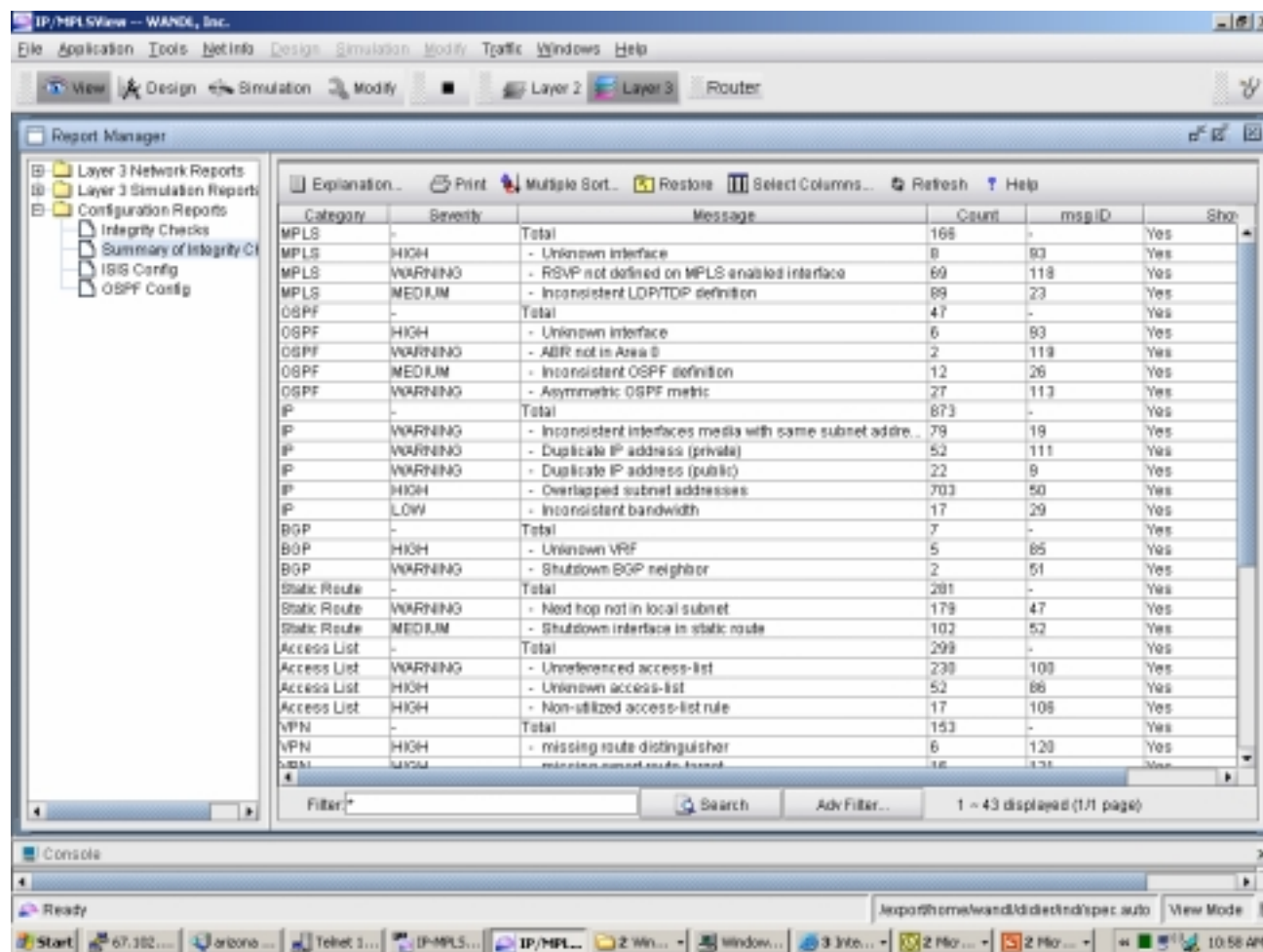


Bell IP Engineering Change Management Process



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



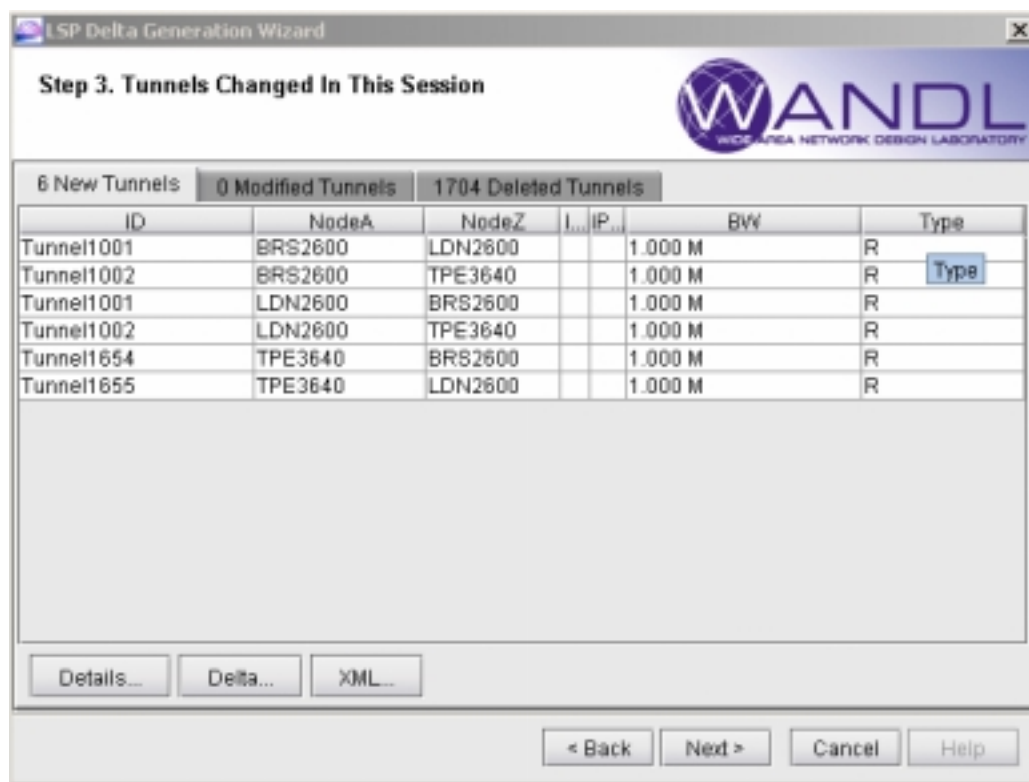
The screenshot displays the IP/MPLSView application interface. The 'Report Manager' window is open, showing a table of configuration errors. The table has columns for Category, Severity, Message, Count, msg ID, and Show. The errors are categorized by protocol (MPLS, OSPF, IP, BGP, Static Route, Access List, VPN) and severity (HIGH, MEDIUM, WARNING, LOW). The total count of errors is 165.

Category	Severity	Message	Count	msg ID	Show
MPLS	-	Total	165	-	Yes
MPLS	HIGH	- Unknown interface	8	83	Yes
MPLS	WARNING	- RSVP not defined on MPLS enabled interface	60	118	Yes
MPLS	MEDIUM	- Inconsistent LDP/TDP definition	89	23	Yes
OSPF	-	Total	47	-	Yes
OSPF	HIGH	- Unknown interface	6	83	Yes
OSPF	WARNING	- ABR not in Area 0	2	118	Yes
OSPF	MEDIUM	- Inconsistent OSPF definition	12	26	Yes
OSPF	WARNING	- Asymmetric OSPF metric	27	113	Yes
IP	-	Total	873	-	Yes
IP	WARNING	- Inconsistent interfaces media with same subnet addre..	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	178	47	Yes
Static Route	MEDIUM	- Shutdown interface in static route	102	52	Yes
Access List	-	Total	298	-	Yes
Access List	WARNING	- Unreferenced access-list	238	103	Yes
Access List	HIGH	- Unknown access-list	52	86	Yes
Access List	HIGH	- Non-utilized access-list rule	17	108	Yes
VPN	-	Total	153	-	Yes
VPN	HIGH	- missing route distinguisher	6	120	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

WANDL
WIDE AREA NETWORK DESIGN LABORATORY

6 New Tunnels | 0 Modified Tunnels | 1704 Deleted Tunnels

ID	NodeA	NodeZ	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 IP/MPLSView interface. The 'Tunnels' window shows a table of tunnel configurations:

ID	NodeAID	NodeZID	Bandwidth
Tunnel1001	BRS2600	LDN2600	1.00
Tunnel1002	BRS2600	TPE3640	1.00
Tunnel1001	LDN2600	BRS2600	1.00
Tunnel1002	LDN2600	TPE3640	1.00
Tunnel1654	TPE3640	BRS2600	1.00
Tunnel1655	TPE3640	LDN2600	1.00

Below the table, it indicates 'Total # of records: 6 records (start-end indices): 1 - 6'. The console window shows the configuration for Tunnel1001:

```
interface Tunnel1001
description from BRS2600 to LDN2600
ip unnumbered Loopback0
tunnel destination 10.1.1.1
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng autoroute 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 console output at the bottom shows: '--- Iteration: 6 Tunnels (6 placed, 0 unplaced, 0 deactivated)'. The status bar indicates 'Ready' and 'Design Mode'.



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 with the following settings:

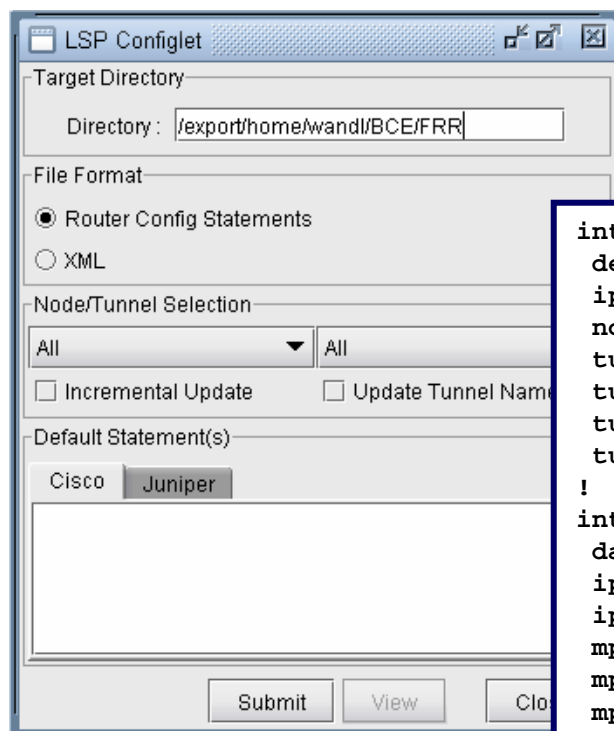
- Protection Type:** Link, Node
- Diversity Level:** Facility, Link, Site
- Protected Tunnel Type:** Global-Pool, Sub-Pool, Any
- Backup BW:** Limited, Unlimited
- Allocate backup BW using:** Global-Pool, Sub-Pool
- Design BW (for Design/Placement):**
 - Design BW = Ref BW * % + Fixed
 - % Ref BW:
 - Fixed BW:
 - Reference BW Source: Link BW, Sub-Pool BW, 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, 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:

Tim Lam	Bell Canada	Technology Development
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Terry Snatinsky	Bell Canada	Core Operations Support
Hao-Hsin Huang	WANDL	System Engineering

