Engineering End-to-End IP Resilience Using Resilience-Differentiated QoS

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Introduction

- Traffic-engineering methods that allow the provisioning of network resilience are a requirement for future Internet architecture
- Recovery at the lower layer (e.g. SDH) v.s. recovery at IP or MPLS layer
- Existing QoS architecture so far do not allow signaling of resilience requirement

RD-QoS Architecture

- Extends the existing QoS architecture
  - Resilience requirements are included in QoS signaling between application and network
  - Packet belonging to a certain resilience class are marked accordingly at network boundary
- Maintain QoS level in case of a net failure
  - Careful bandwidth and resource management
  - Traffic conditioning takes the resilience requirements of service class into account

Resilience Classes

Service class	RC1	RC2	RC3	RC4
Resilience requirements	High	Medium	Low	None
Recovery time	10–100 ms	100 ms–1 s	1 s–10 s	n.a.
Resilience scheme	Protection	Restoration	Rerouting	Preemption
Recovery path setup	Pre-established	On-demand immediate	On-demand delayed	None
Resource allocation	Pre-reserved	On-demand (assured)	On-demand (if available)	None
QoS after recovery	Equivalent	May be temporarily reduced	May have reduced QoS	None

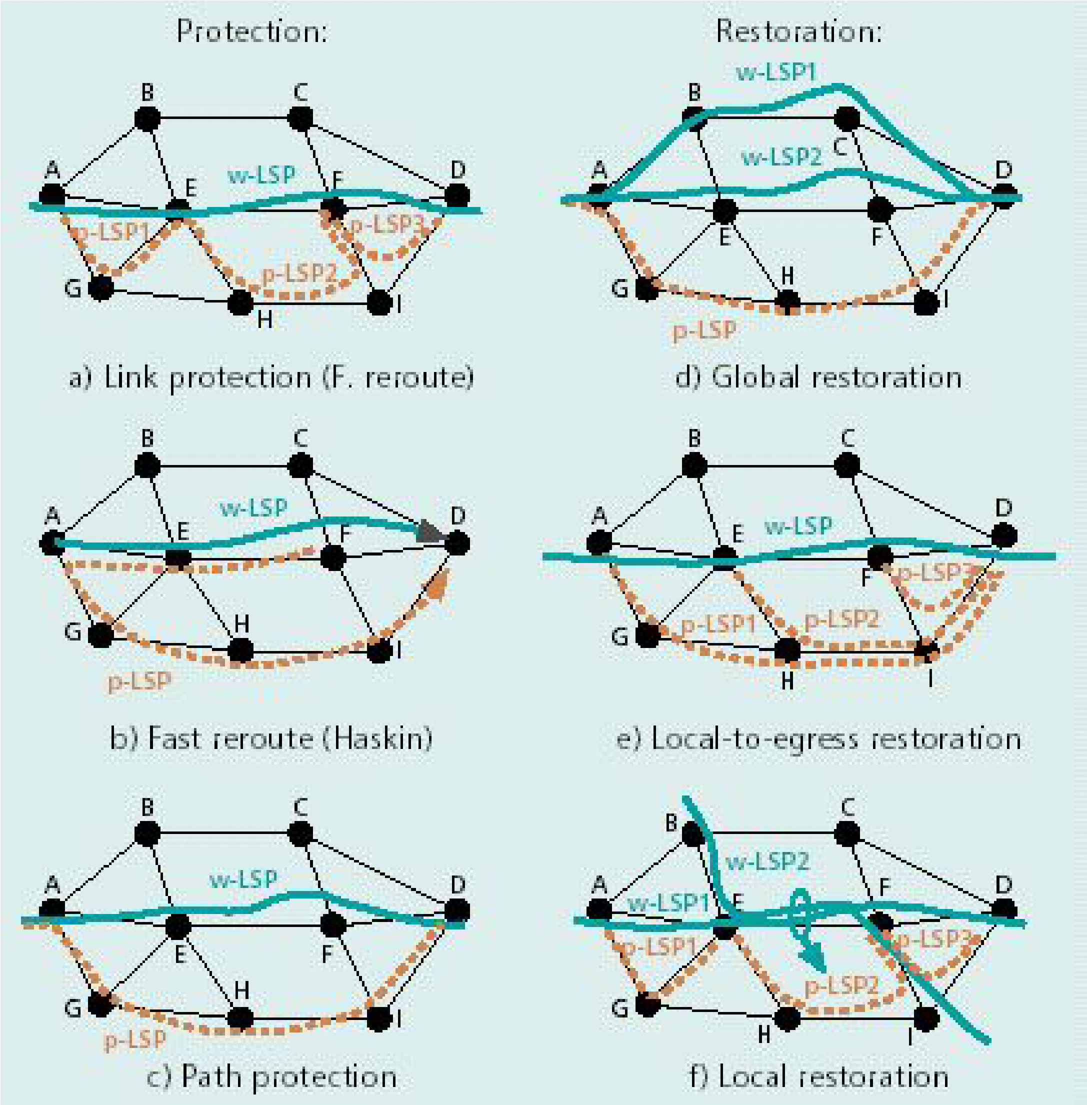
Recovery Options

<table>
<tr><td>Recovery models</td><td colspan="2">Protection switching</td><td colspan="4">Restoration (MPLS rerouting)</td><td colspan="2">(IP) rerouting</td></tr>
<tr><td>Resource allocation</td><td colspan="4">Pre-reserved</td><td colspan="4">Reserved-on-demand</td></tr>
<tr><td>Resource use</td><td colspan="2">Dedicated resources</td><td colspan="4">Shared resources</td><td colspan="2">Extra-traffic-allowed</td></tr>
<tr><td>Path setup</td><td colspan="2">Pre-established</td><td colspan="4">Pre-qualified</td><td colspan="2">Established-on-demand</td></tr>
<tr><td>Recovery scope</td><td>Local repair</td><td colspan="2">Global repair</td><td colspan="2">Alternate egress pair</td><td colspan="2">Multi-layer repair</td><td>Conc. prot. domain</td></tr>
<tr><td>Recovery trigger</td><td colspan="4">Automatic inputs (internal signals)</td><td colspan="4">External commands (OAM signaling)</td></tr>
</table>

Application to Existing QoS Architectures

- Extension to RSVP/RSVP-TE
  - The proposed method is to include resilience requirement in the Resource Spec of RSVP
  - The three IntServ classes are combined with a two-bit resilience attribute
- Extension to Diff-Serv
  - Packets marking with resilience requirement is done using DSCP values for individual behavior aggregates (BAs)

Recovery Schemes

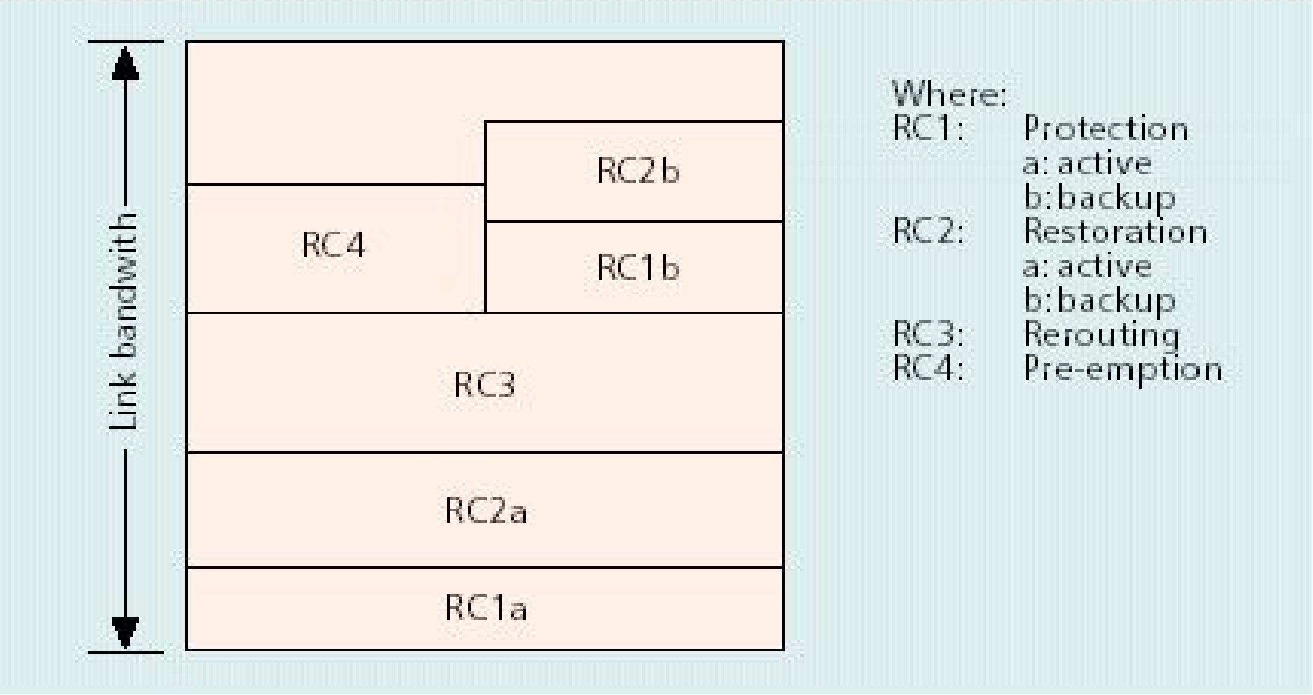


Integration of RD-QoS with MPLS Recovery

- RC1: two disjoint LSPs are setup for protection
- RC2: a single LSP is setup but resource management must reserve enough spare resource
- RC3: no MPLS recovery and no additional resource reservation. After a failure, network tries to recover affected traffic when the recovery of RC1 and RC2 is completed
- RC4: can be transported as extra traffic using the protection and spare resources of higher RC

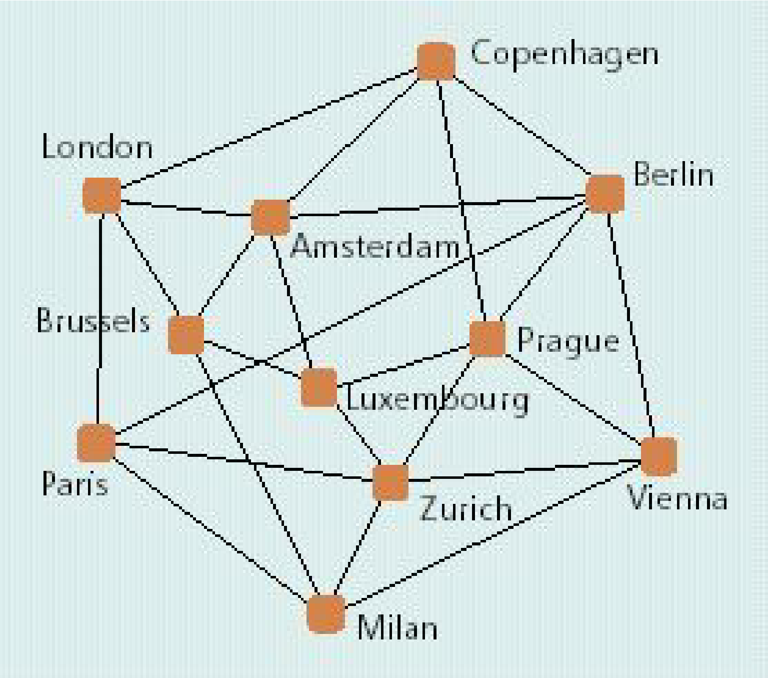
Traffic Engineering for RD-QoS

- In the RD-QoS TE process the used resource for the RCs on each link must be calculated



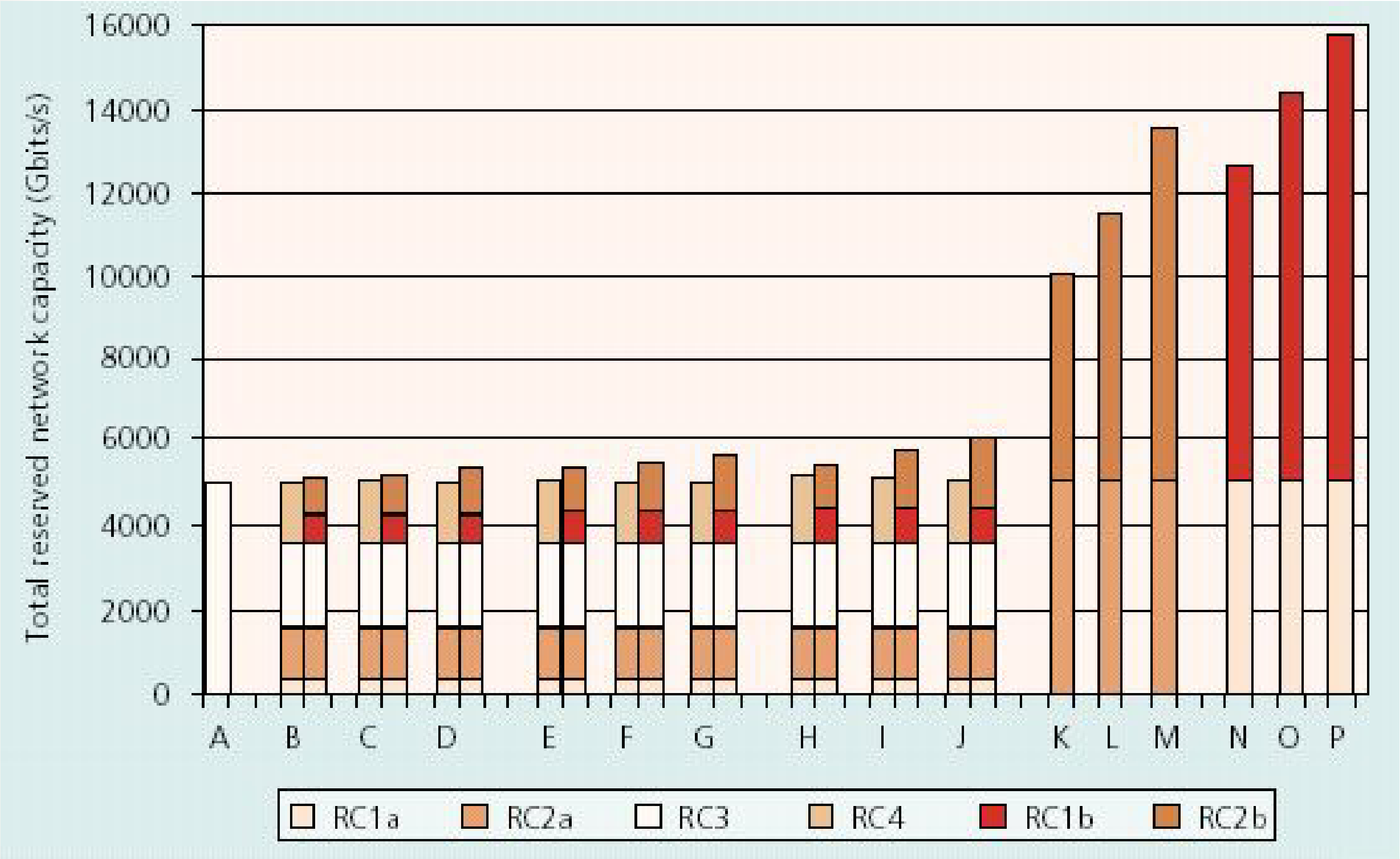
Case Study

- Demands: 10~110Gb/s
- Link capacity: 40 Gb/s for each direction
- Routing: was done on demand unit of 1Gb/s
- Multi-RC scenario: RC1:RC2:RC3:RC4 =1:2:4:3



- RC1 recovery: link protection, Haskin, path protection
- RC2 recovery: path restoration, link restoration, local-to-egress restoration

Results (1/2)



Total reserved network capacity (Gbits/s)
16000
14000
12000
10000
8000
6000
4000
2000
0
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
RC1a
RC2a
RC3
RC4
RC1b
RC2b

Results (2/2)

	Recovery options		Used resources per resilience class						Total
	RC1	RC2	RC1a	RC2a	RC3	RC4	RC1b	RC2b	
A	-	-	0	0	5126	0	0	0	5126
B	Path protection	Global rest.	507	1014	2028	1521	750	811	5464
C	Path protection	Local-to-egress	507	1014	2028	1521	750	1028	5712
D	Path protection	Local rest.	507	1014	2028	1521	750	1160	5949
E	Haskin	Global rest.	507	1014	2028	1521	909	831	5668
F	Haskin	Local-to-egress	507	1014	2028	1521	909	1041	5880
G	Haskin	Local rest.	507	1014	2028	1521	909	1205	6080
H	Link protection	Global rest.	507	1014	2028	1521	1056	805	5926
I	Link protection	Local-to-egress	507	1014	2028	1521	1056	1107	6209
J	Link protection	Local rest.	507	1014	2028	1521	1056	1350	6531
K	-	Global rest.	0	5121	0	0	0	4861	9982
L	-	Local-to-egress	0	5121	0	0	0	6371	11492
M	-	Local rest.	0	5121	0	0	0	8429	13550
N	Path protection	-	5089	0	0	0	7540	0	12629
O	Haskin	-	5081	0	0	0	9141	0	14222
P	Link protection	-	5070	0	0	0	10849	0	15919

Conclusion

- RD-QoS architecture is presented integrating the signaling of resilience requirements with the traditional QoS signaling of IP services
- Discussion
  - Are the resilience requirements really orthogonal to the classical QoS requirements?
  - Failure detection is a key component to the success of recovery mechanisms—not only recovery time should be concerned
  - RC2 needs an NMS to manage the network resource, its operation is inconsistent with other RCs