Addressing robust Next-Generation Networks*
NETWORKS 2008 - Budapest

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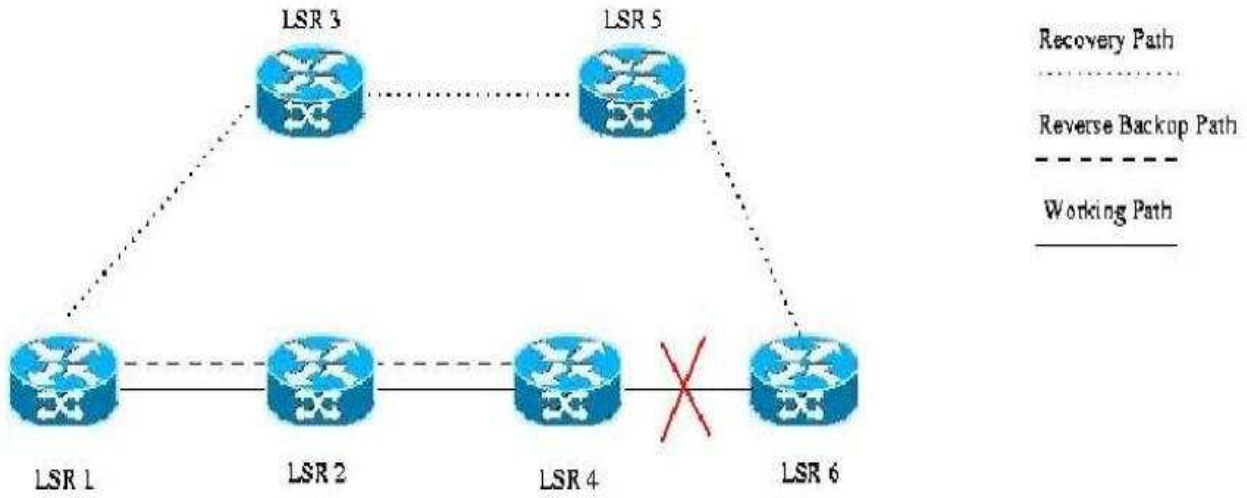
MPLS Protection Tecniques

- Protection against both link and node failures
- Recovery time of some tens of ms
- Efficient and flexible resource utilization
- Protection strategies
  - Global Repair: the issued path protected by an entire backup path from ingress to egress
  - Local Repair: links/nodes nearby protected with a by-passing bacup path segment
  - FRR (Fast-ReRoute) as the reference mechanism

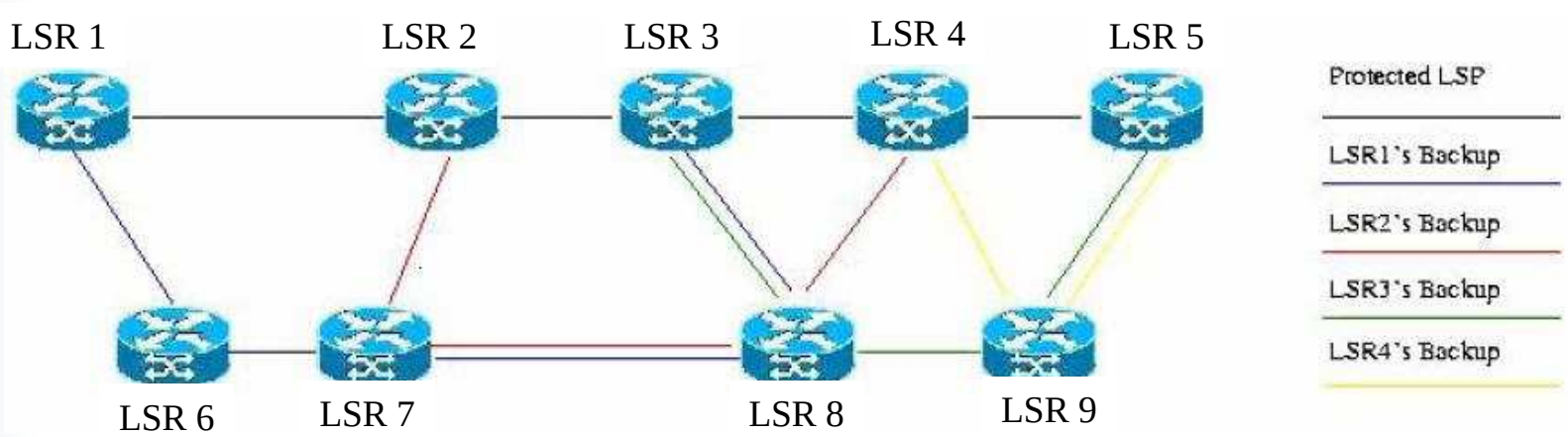
Haskin FRR

- Haskin Fast Re-Route involves the use of a reverse path segment, a shortcut and an entire backup path
- Traffic at POF (Point of Failure) is bounced back onto the Working Path (WP) up to the PSL (Protection Switching LSR) which forwards on the pre-established RP (Recovery Path) through a shortcut



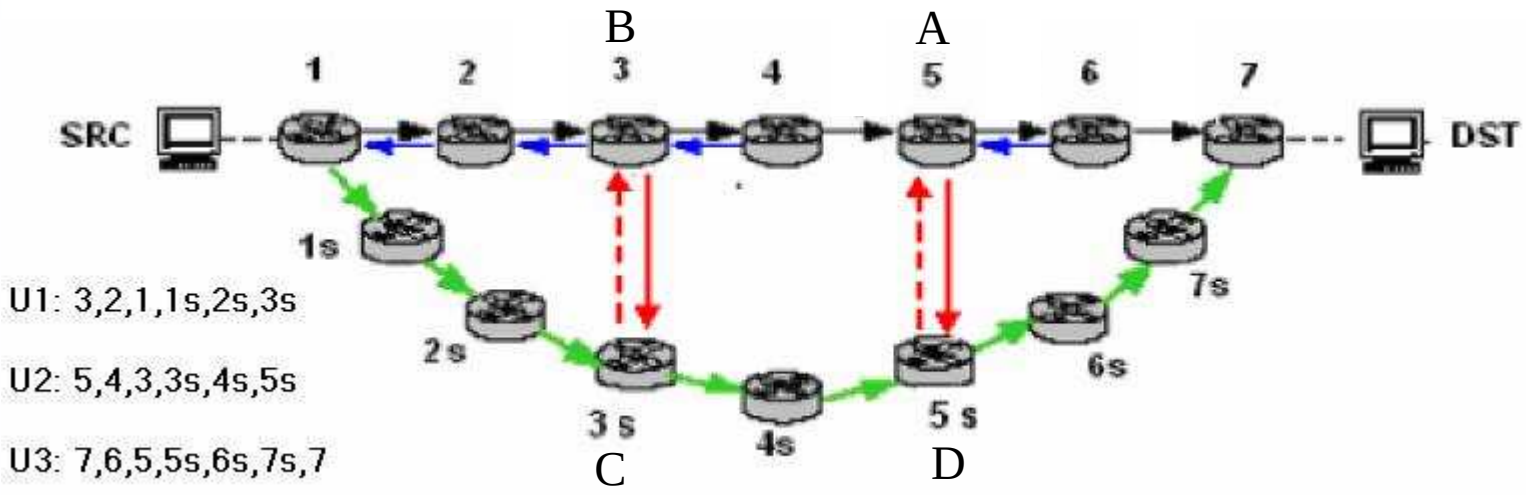
One-to-One Backup FRR

- One-to-One backup Fast Re-Route: a backup path segment, called DP (Detour Path), is (basically) allocated at each LSR of a protected path
- Link/node failure is circumvented by ad hoc pre-established path segment that begins before and ends after the POF



Key concept: the Chained Us

- WP, RP and Detour Paths can be seen (geometrically) as chained Us
- Us determination addresses both the issued FRR schemes
- Constraints on U length imposed by recovery time



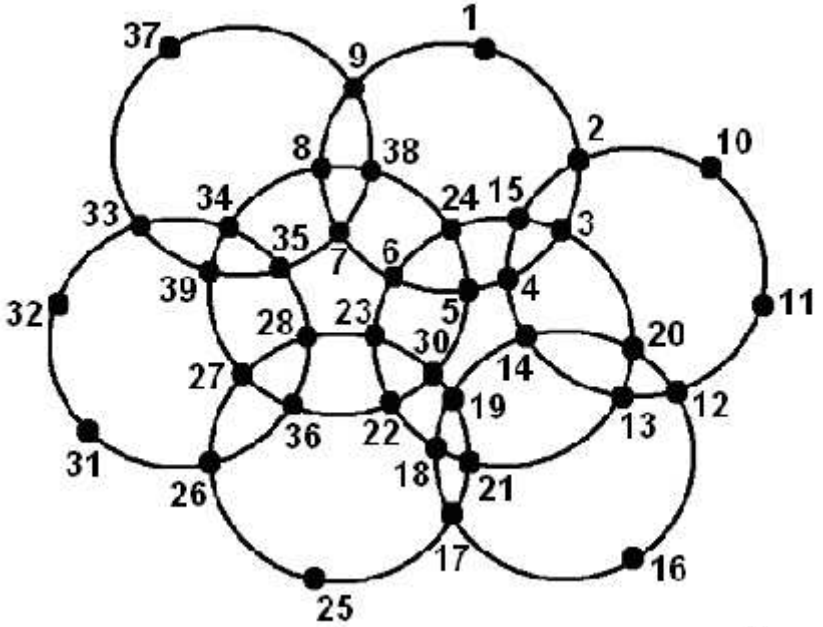
Network Engineering System Specification

- Problem definition:
  - Protection constraint: every WP must be totally protected against single node and link failures
  - Capacity constraint: the allocated bandwidth cannot exceed the available capacity in every link
  - Time constraint: recovery time of the same order as in SONET/SDH (i.e. maximum length for the U first segment)
  - Objective: to optimize the allocated capacity or the overall switching time seen by the user

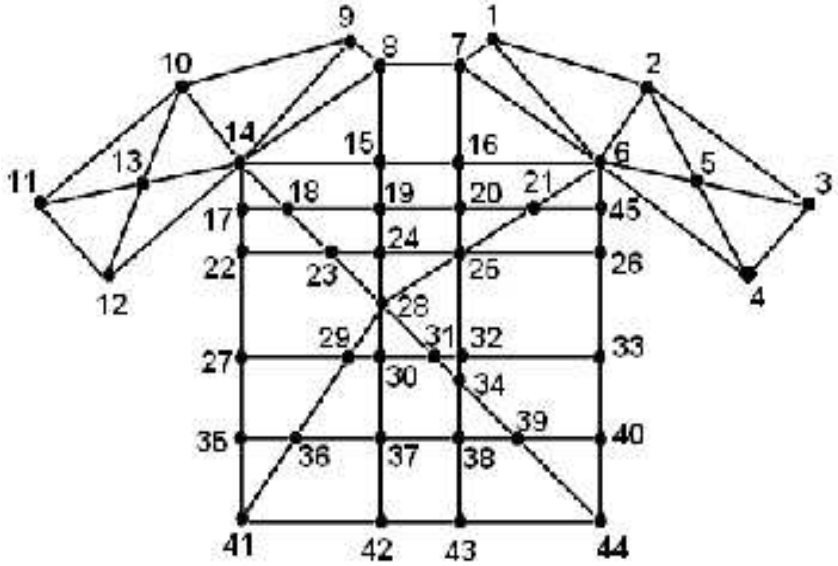
Network Engineering System Design

- First, shorthest paths (employing REA) between every couple of ingress and egress bourder routers calculation, with equal cost links or not
- All Us determination: considering either fixed-length Us or variable-length Us
- Chained Us selection (for the accepted traffic requests), as output of the resolution of a ILP model. Capacity allocation optimized by applying the SP (Shared Protection)
- Objective funtion minimizing either the allocated bandwidth or the overall switching time
- Addressing of both the issued FRR schemes

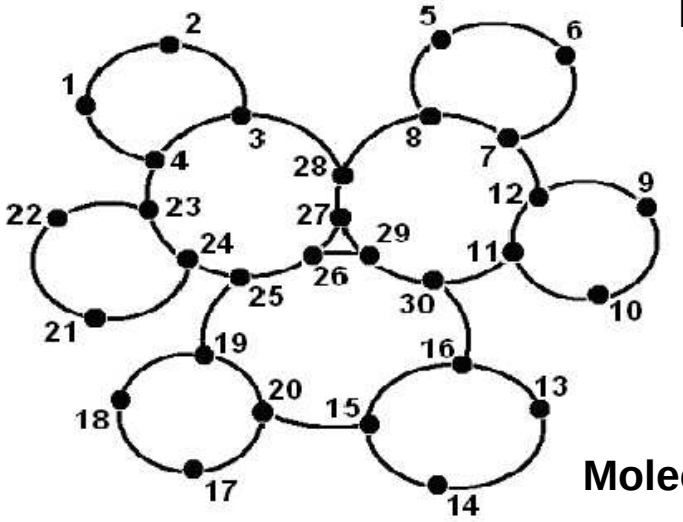
Simulation analysis: Network Topologies



Maze



Mesh



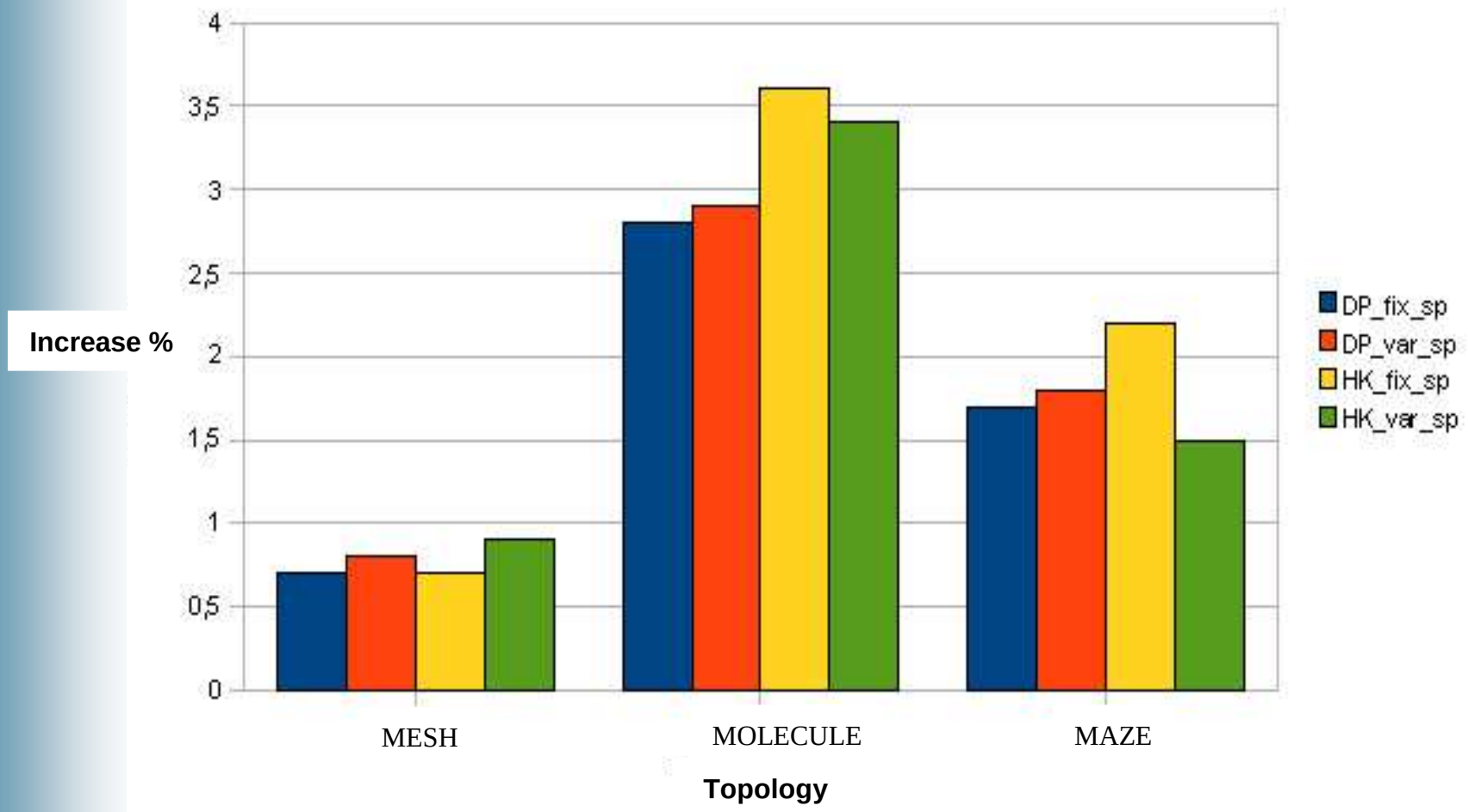
Molecule

Simulation analysis: Testbed specification and Performance

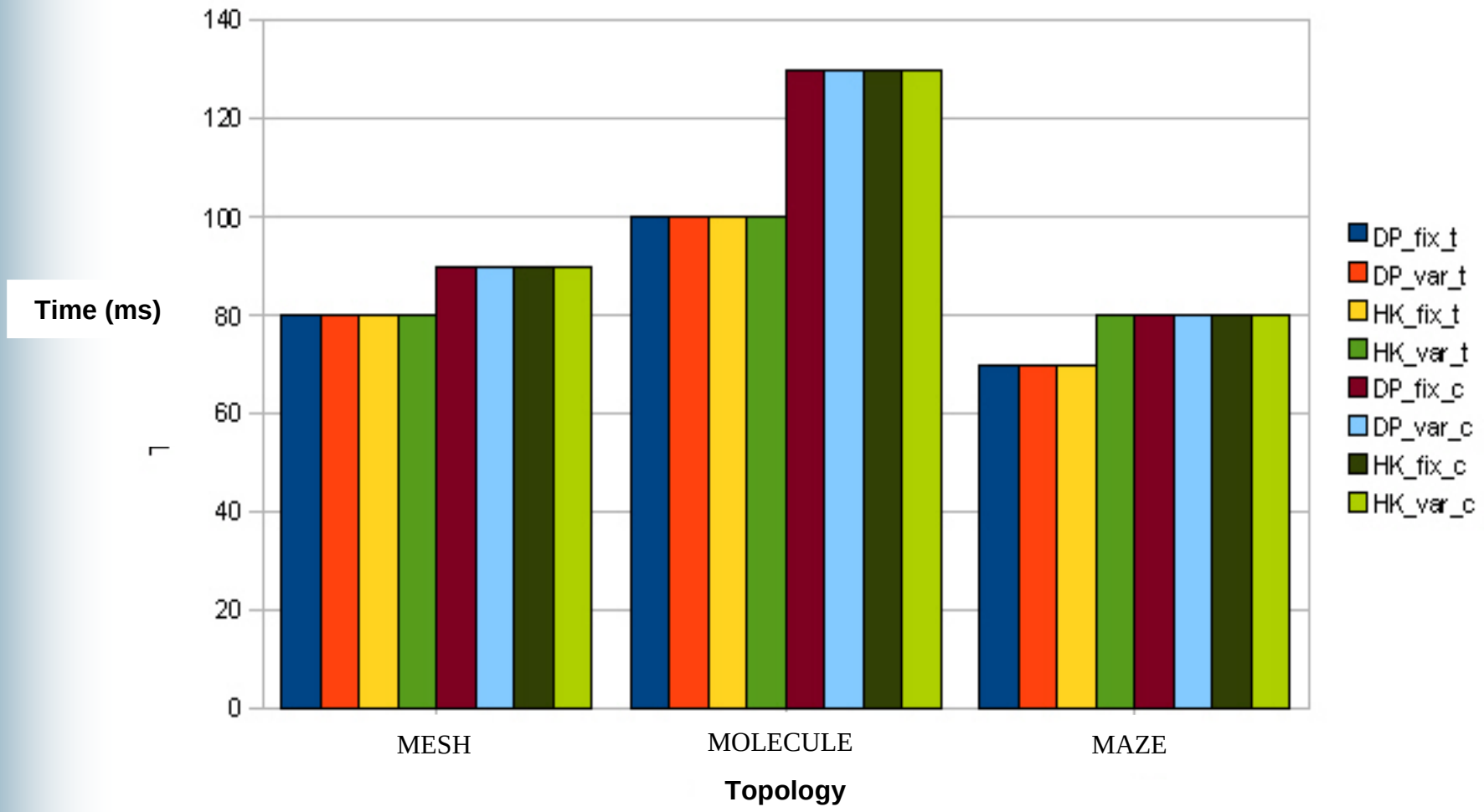
- The simulations were run on a laptop PC equipped with Intel Core Duo T2250 1.73 GHz and 2 GB of RAM, and version 4.9 of GLPSOL (solver LP / MIP standalone GPLK) over Linux Debian 4.0r3 OS

Topology/Methods	MESH	MOLECULE	MAZE
DP_FIX [s/MB]	1/4,1	1,8/5,9	1,7/5,8
DP_VAR [s/MB]	2/6,3	2,6/6,7	3,5/7,5
HK_FIX [s/MB]	1,2/4,2	2/6,4	1,9/6,2
HK_VAR [s/MB]	2,1/6,4	2,8/6,9	3,9/7,8

Improvements by SP in optimizing the allocated capacity



Extra delay optimizing the allocated capacity or the overall switching time



Results optimizing the allocated capacity with links of different cost

- Some links are assigned to a cost lower than 1
  - Different set of initial shortest paths by REA
  - Different weights for the residual capacity of the network links in the objective function
- The values of allocated capacity are significantly worse in all the topologies (costs of 0.2-0.6) in comparison with the former /i.e. equal cost case
  - Less optimal chained Us selected

Final remarks

- Comparing the two FRR schemes: Haskin achieves better resource allocation, while One-to-One Backup could lead to shorter overall switching Times
- Variable-length Us allow for a greater flexibility (i.e. improved optimization function), except for some cases of ring topology
- A non-uniform distribution of spare capacity withing the network has a cost to pay (i.e. lower objective funtion)
- The model optimizing the overall switching Time is more likely to be used in networks with wide resource availability and/or stringent constraints on QoS
- The designed tool addresses robustness to single node and link failure with:
- Recovery time as in SONET/SDH
- Efficient resource allocation (SP)
- Low computational cost

Future work: Multicast support

- A Multicast tree can be seen as multiple overlapping Unicast paths (from the same ingress border router), each characterized by a pair (WP, RP)
  - Accurate resource counting is needed
- The multicast tree is protected from the root to every leaf (by Haskin or One-to-One Backup FRR)
- A link/node failure induces a change in the multicast topology (on the basis of the Us activated for protection)
  - Resulting in a different set of branching points
- The ILP model should be enhanced to consider both unicast and multicast traffic requests simultaneously
  - New constraint for SP
  - Optimization of either the allocated capacity or the overall switching time

Future work: Mobility management

- The leaves of the multicast tree are the active set of Base-Stations (BSs) the users of the service are attached to
- User mobility can lead to a different active set
  - Resulting in a change in the multicast tree topology
  - New (WP, RP) pairs calculation is needed
- The addition or removal of new (WP, RP) pairs should be transparent to the users
  - The old (WP, RP) pairs remain the same
  - The ILP model enhanced to allow for fixed, pre-calculated (WP, RP) pairs
- Periodic re-optimization could be required (transparent to the user)
- Optimization of either the allocated capacity or the overall switching time

IST FP7 OPTIMIX system architecture