Simulative Comparison of MPLS Protection Switching vs. OSPF Re-routing

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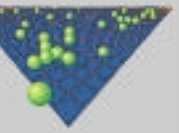
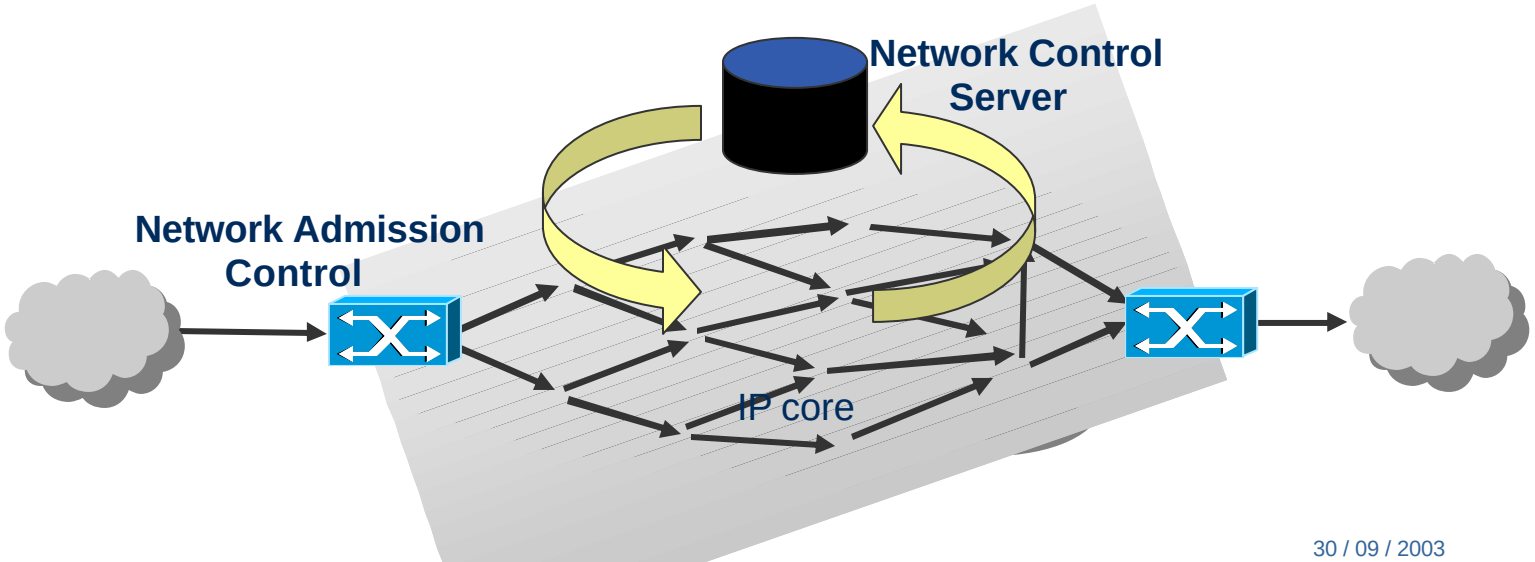
- **Introduction**
- **MPLS**
  - Label switching
  - Recovery
- **OSPF**
  - Base protocol
  - New routing algorithm
  - Recovery
- **Simulation**
  - Framework
  - Scenarios
  - Main results
- **Conclusion**



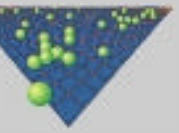
Internet Evolution

- **Issues :**
  - Increasing amount of multimedia flows over IP
  - Need for Quality of Service (QoS)
- **Objectives :**
  - Future and traditional services on a common IP-platform
  - QoS, resilience, scalability



Our objectives

- **Simulate the behaviour of a routing protocol :**
  - Pre-calculated : **MPLS**
  - Dynamic and distributed : **OSPF**
  - Resilience : **speed up failure detection**
    improve rerouting
- **Compare the resulting recovery speed**



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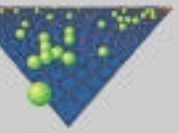
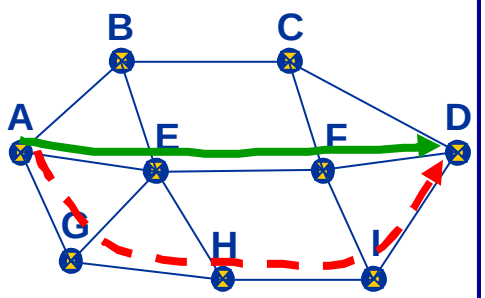
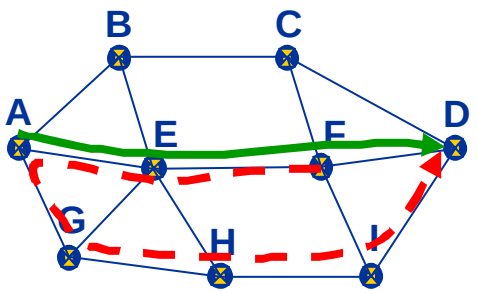
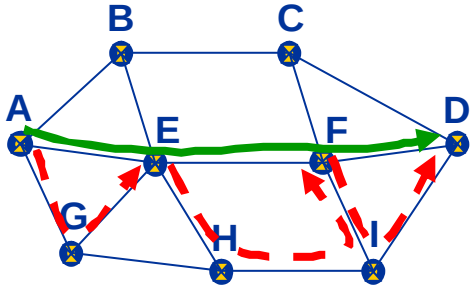
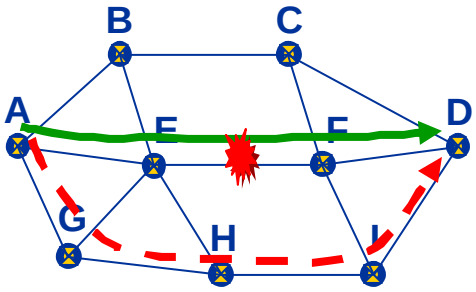
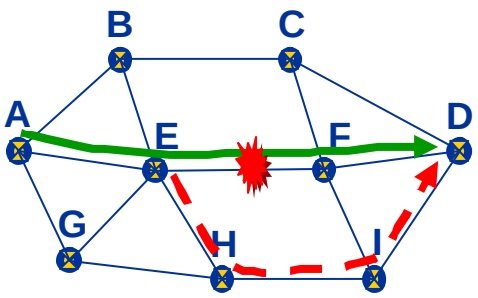
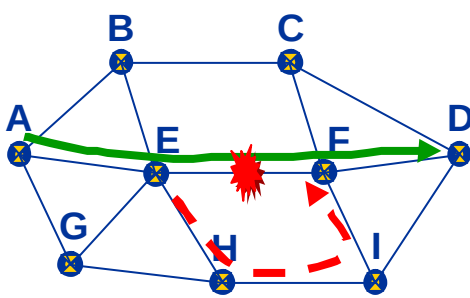
Label Switching

- **Attribution of a label**
  - On ingress router (Label Edge Router)
  - Not only destination based
  - Suppression on egress router
- **Packet forwarding**
  - On transient routers (Label Switch Routers)
  - Following a Forwarding Table
  - No analysis of packet's network layer header



MPLS Recovery

	Global	Regional	Local
Protection	 P1: Global Protection	 P2: Regional Protection (by Haskin)	 P3: Local Protection
Restoration	 R1: Global Restoration	 R2: Regional Restoration	 R3: Local Restoration

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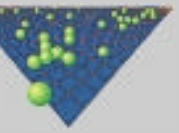


OSPF – Main mechanisms

- **Hello protocol**
  - Topology changes detection
- **Link state advertisements (LSA)**
  - Distribution and storage of the topology
  - Each router maintains its own view

T_{hello}	10s	detection
T_{dead}	$4 * T_{hello}$	
T_{lsa}	0.6 – 1.1ms	propagation
$T_{lsaFlood}$	33ms	

- **Routes calculation**
  - Distributed, shortest path
- **Forwarding information base (FIB)**
  - Router's architecture
  - Updated when routes have changed

T_{SPT}	$O(n.\log n)$, $O(n^2)$	rerouting
$T_{SPTdelay}$	5s	
$T_{SPThold}$	10s	
T_{FIB}	100 – 300ms	

Routes convergence

- **Routes convergence time (RCT)**

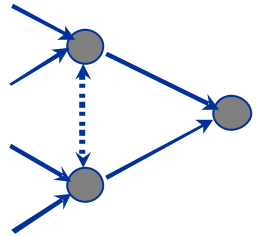
  failure detection, information's propagation, rerouting → **40 – 50s**

- **Possible extensions**
  - Reducing T_{hello}, $T_{SPTdelay}$ et $T_{SPThold}$
  - React faster when resources decrease than when they increase :
    - Multipath routing in order to have at least one backup link
    - When a link fails, react only locally

  → expected RCT **< 500ms**

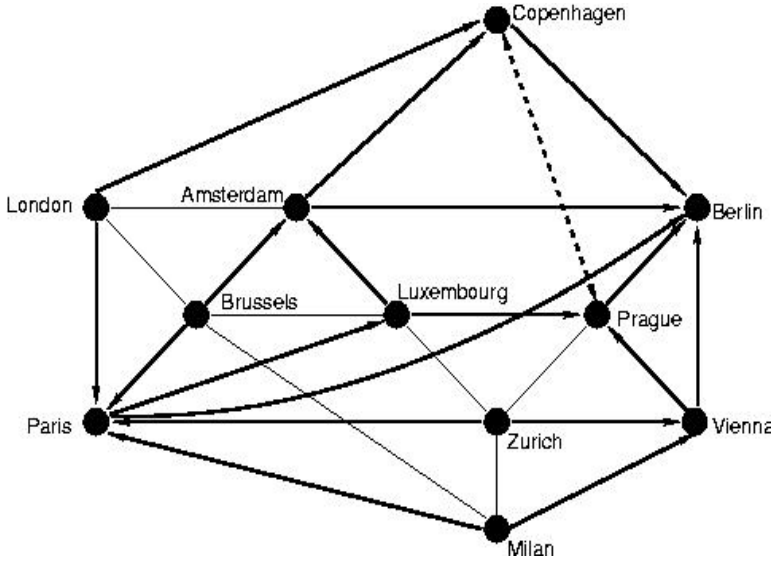
"Outdegree 2" Routing (O_2)

- **At least 2 outgoing links at each node for each destination**
- **No single point of failure**
- **No loops, except "jokers"**
- **Minimize: paths' size/ number of jokers**



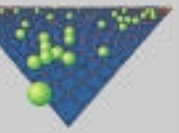
- **Today's IP-network cores are sufficiently meshed**
- **Example : COST 239**

"hammoc set" towards Berlin



Fault tolerance

- **Speed up failure detection**
  - Reduce delays : T_{hello}=100ms, $T_{SPTdelay}$ et $T_{SPThold}$=0
  - Detection at hardware level: 5ms
- **Local reaction** (no propagation delays)
  - Change of routing tables
  - Change of distribution weights
- **Preventive mechanism**
  - After local reaction is completed, recompute routes



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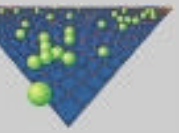
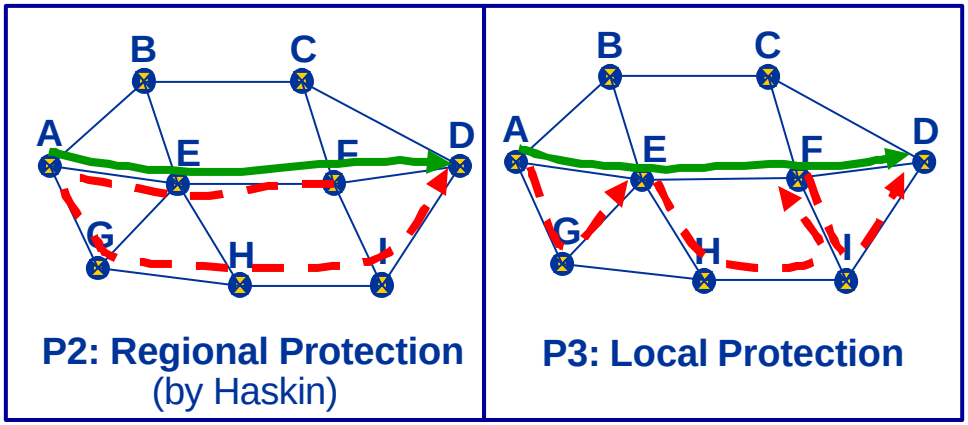
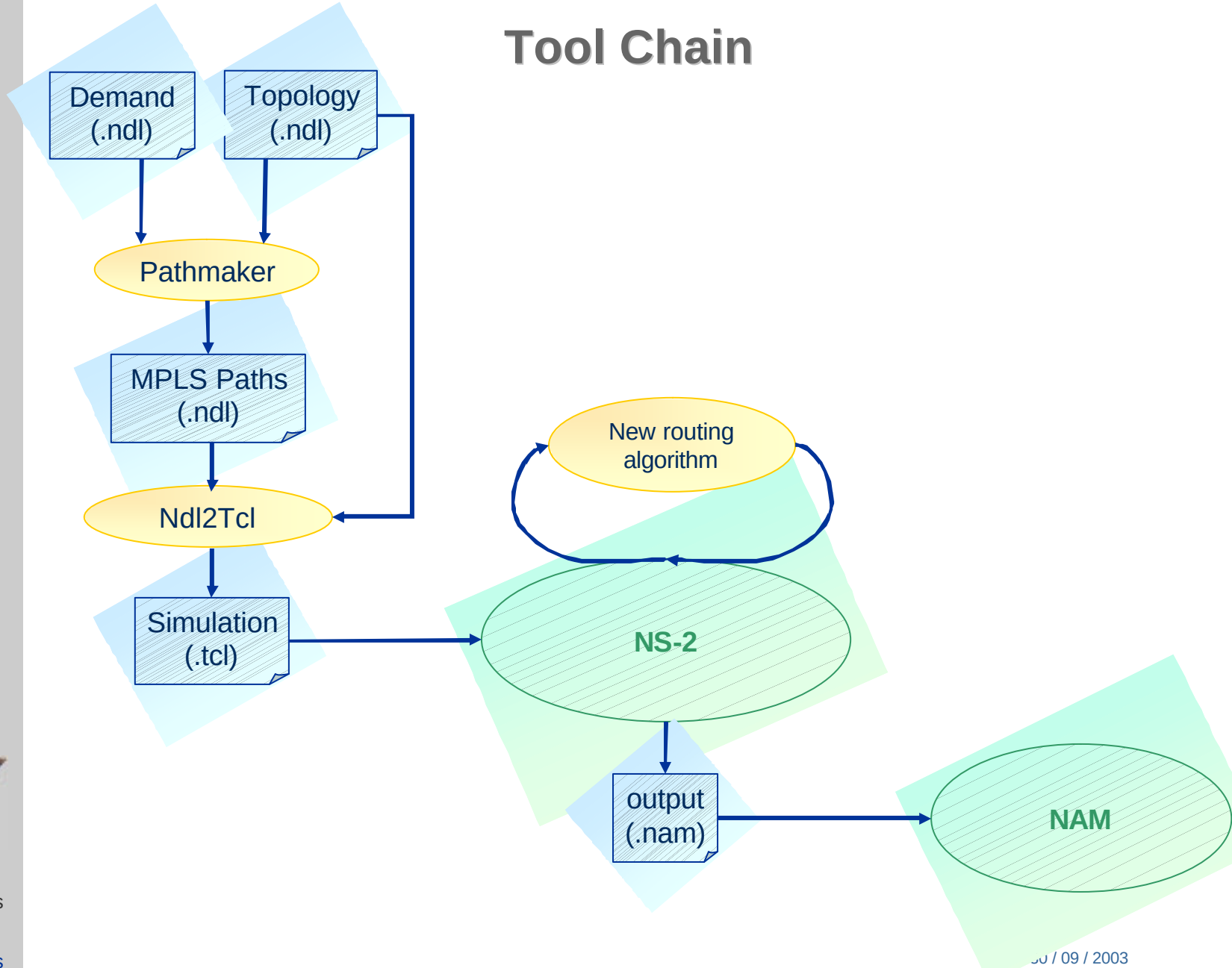


Simulated protocols

- **OSPF**
  - Standard
  - Accelerated (Hello or hardware detection)
  - Accelerated, with O_2 routing and local reaction
- **MPLS**
  - With a detection mechanism equivalent to OSPF Hellos

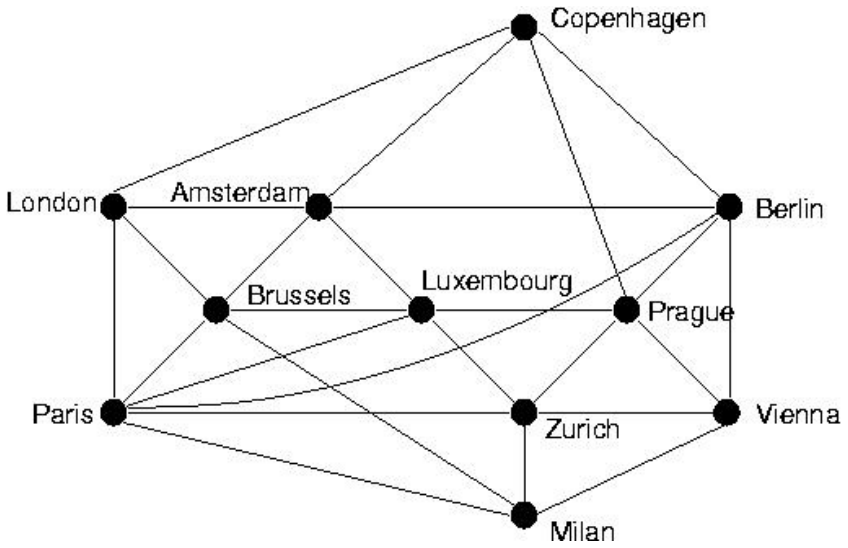


Tool Chain


Demand
(.ndl)
Topology
(.ndl)
Pathmaker
MPLS Paths
(.ndl)
Ndl2Tcl
Simulation
(.tcl)
New routing
algorithm
NS-2
output
(.nam)
NAM

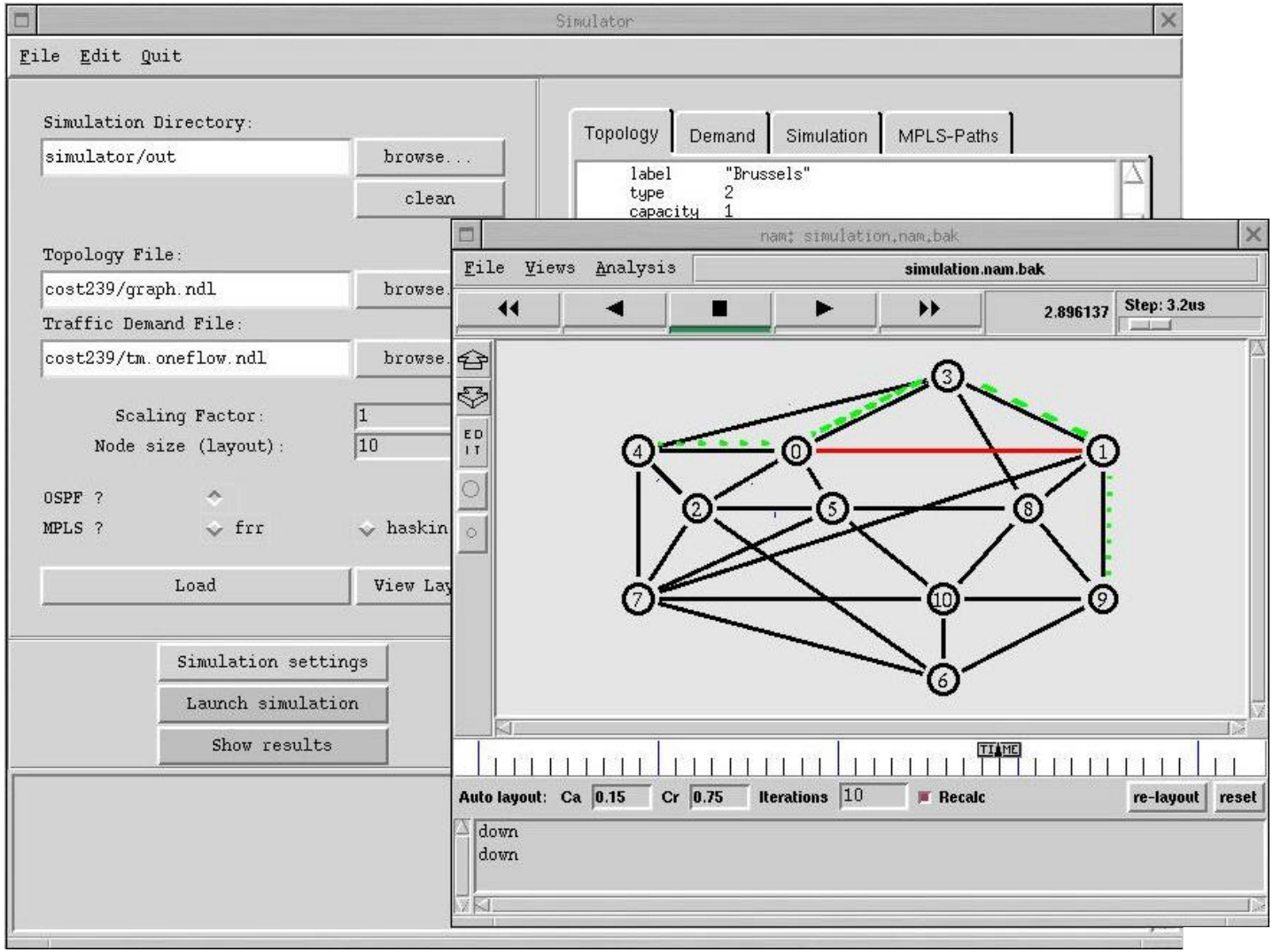
Simulation Scenarios

- **Characteristics**
  - COST 239 topology
  - Fully-meshed traffic
  - One link failure



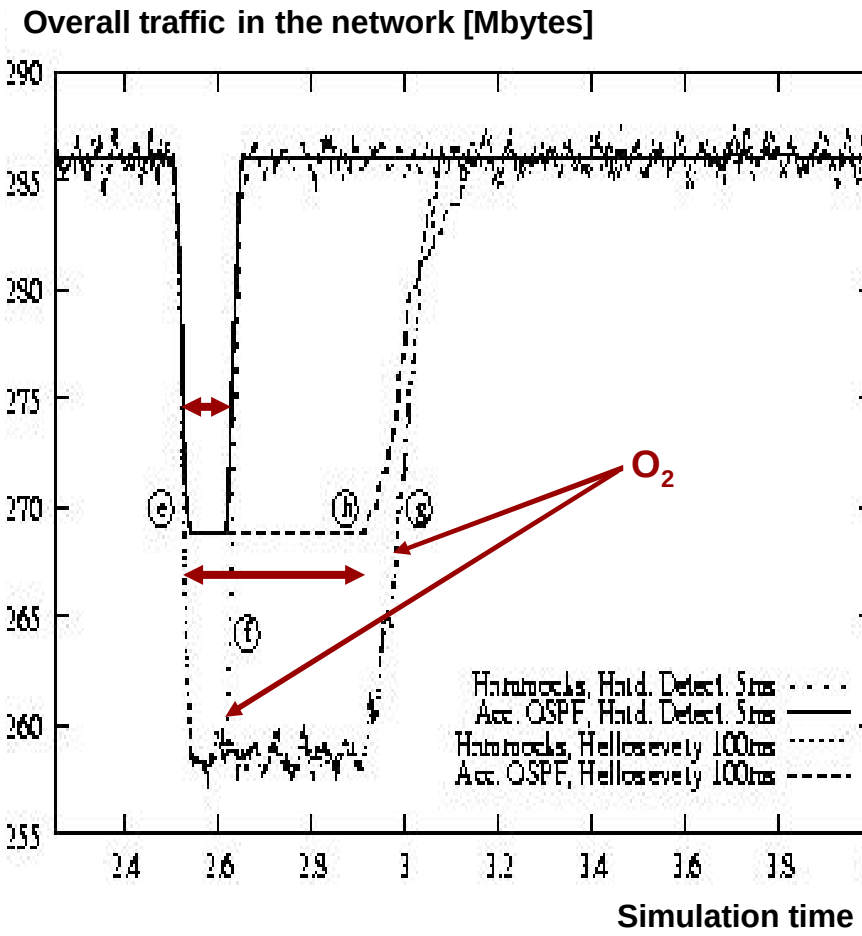
- **Measures**
  - Sum of all incoming traffic
  - Mean of values for each possible link failure

User Interface

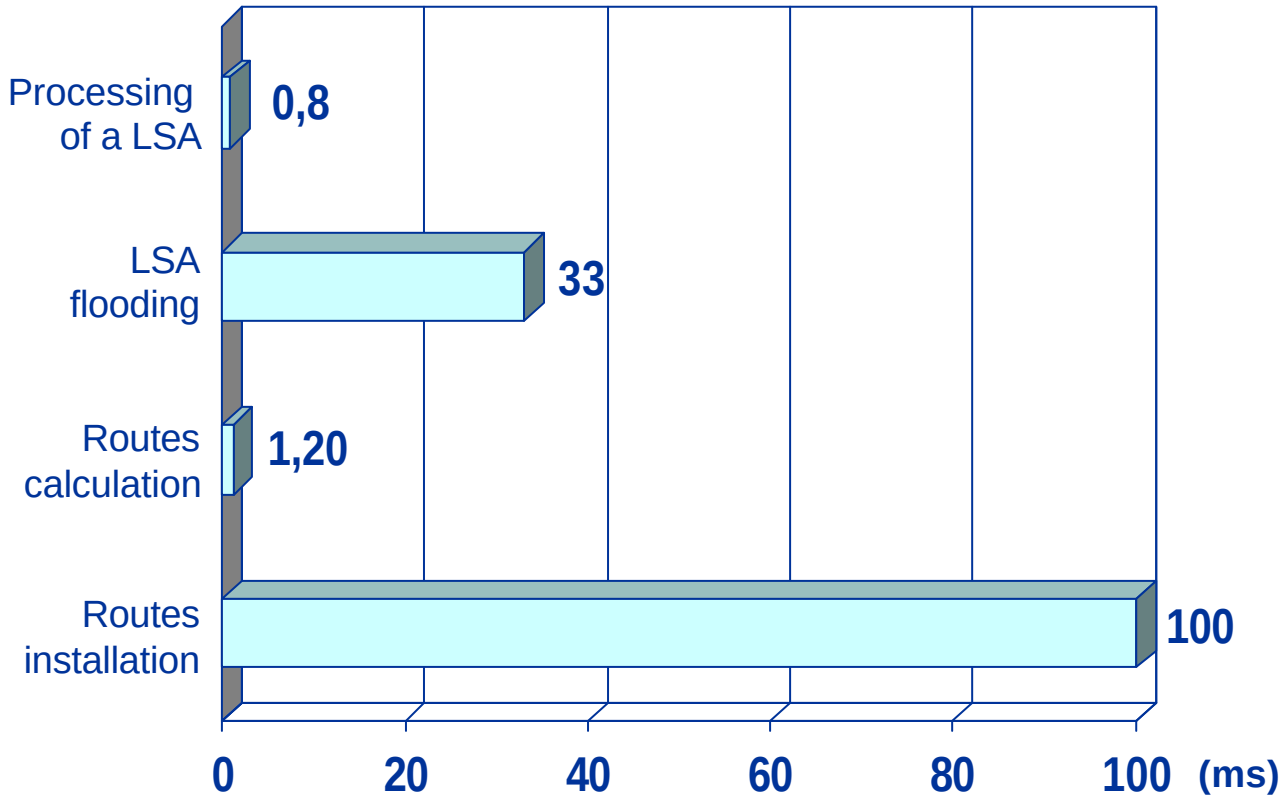


Comparison of SPF / O_2 routing

- **Just after the failure (2.5s)**
  - Overall traffic decreases
- **Similar behaviour but**
  - More traffic is affected in O_2 case
- **With equal detection times**
  - Equal reaction times

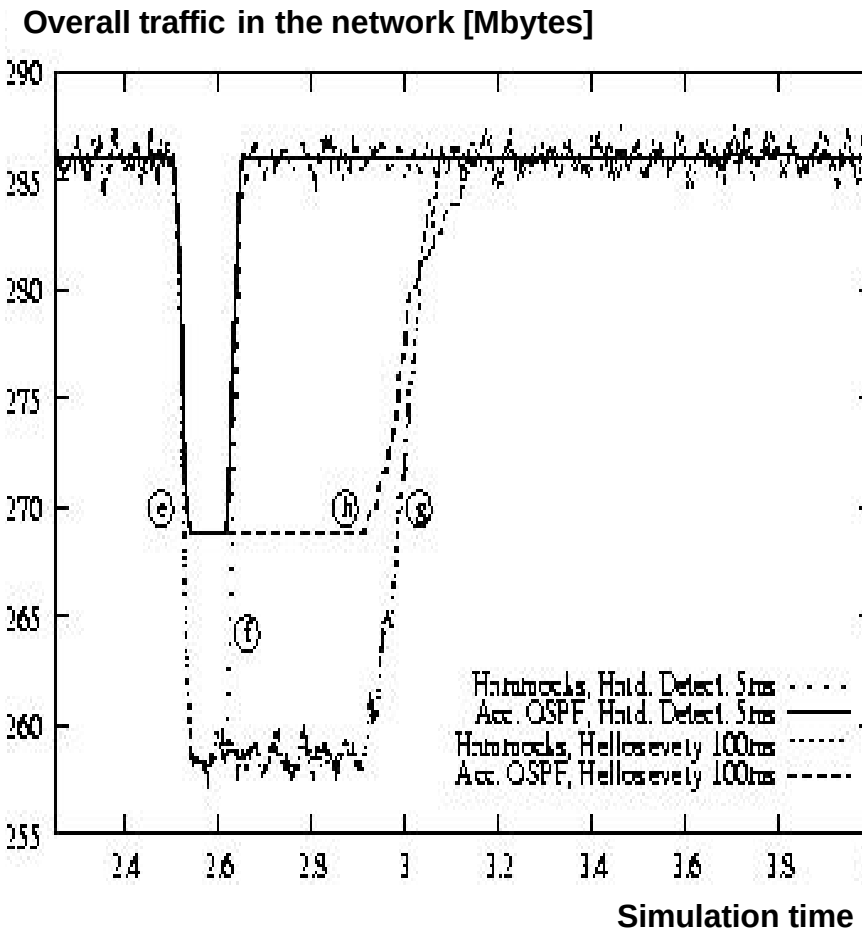


Restoration time



Comparison of SPF / O_2 routing

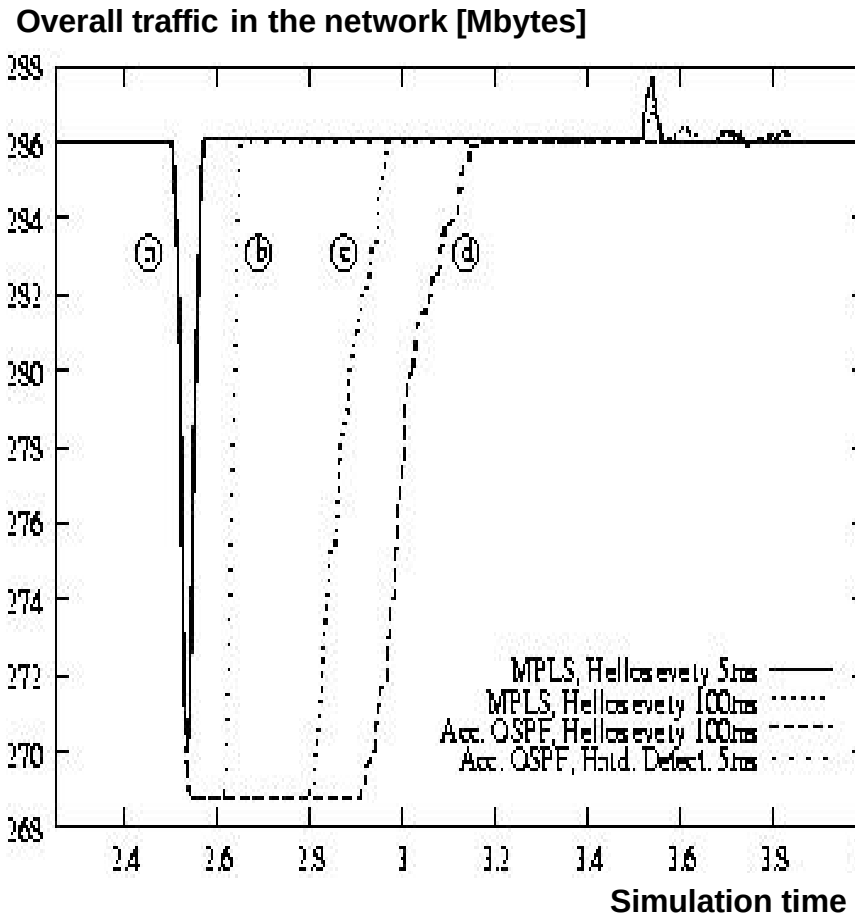
The time saved thanks to O_2 routing and local reaction is hidden by T_{FIB}



Comparison of MPLS / OSPF

- **MPLS protection is always faster**
  - In general (curve ⓐ, standard MPLS)
  - With equivalent detection times
    (pairs ⓐⓑ, and ⓒⓓ)
    100ms less than OSPF

T_{FIB}



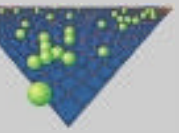
Conclusion

- **Resilience based on traditional OSPF is slow**
- **Accelerated OSPF :**
  - reaches sub-second recovery
  - improving restoration speed ?
    - speed up failure detection
    - but FIB update still an issue
- **MPLS protection has superior resilience :**
  - faster recovery
  - but more complex operation, and more bandwidth consuming

Pre-planned LSP restoration with resource sharing

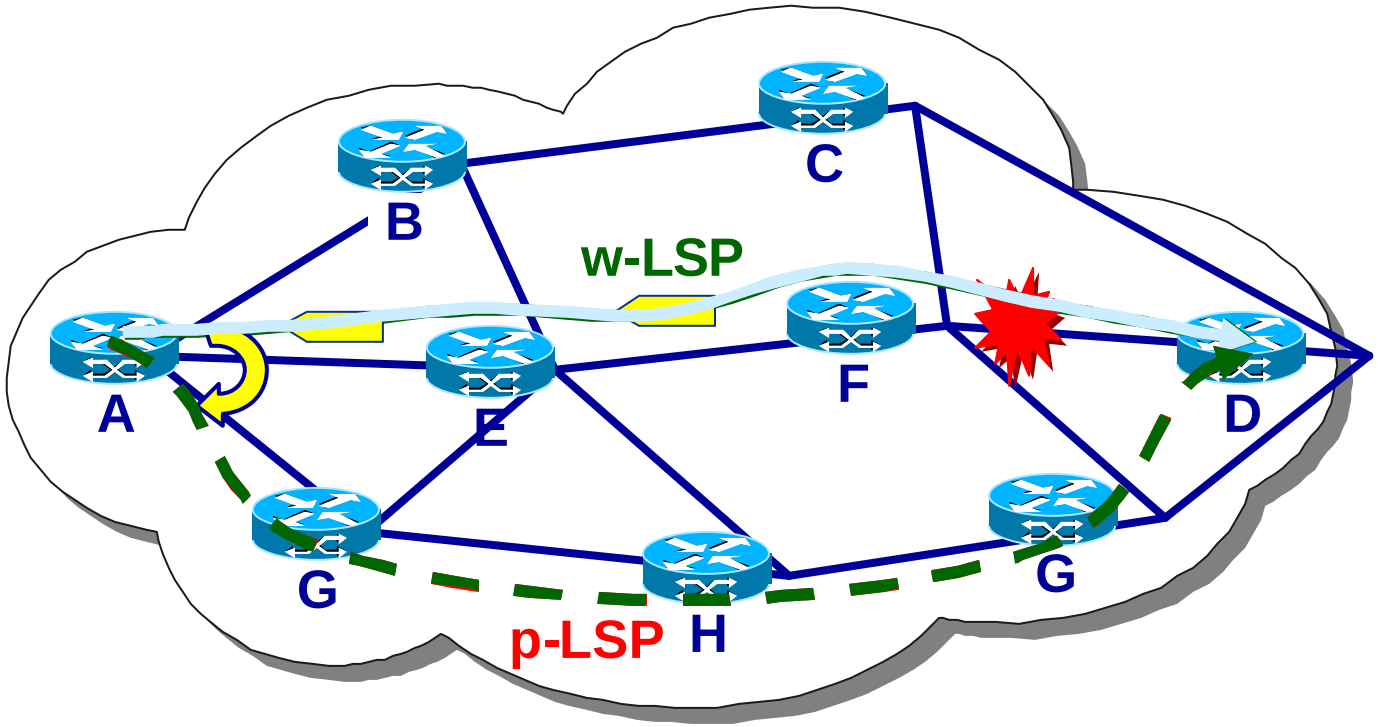
Thank you for your attention

Questions ?



Global Protection

Protection switching, pre-established alternate LSP, global scope



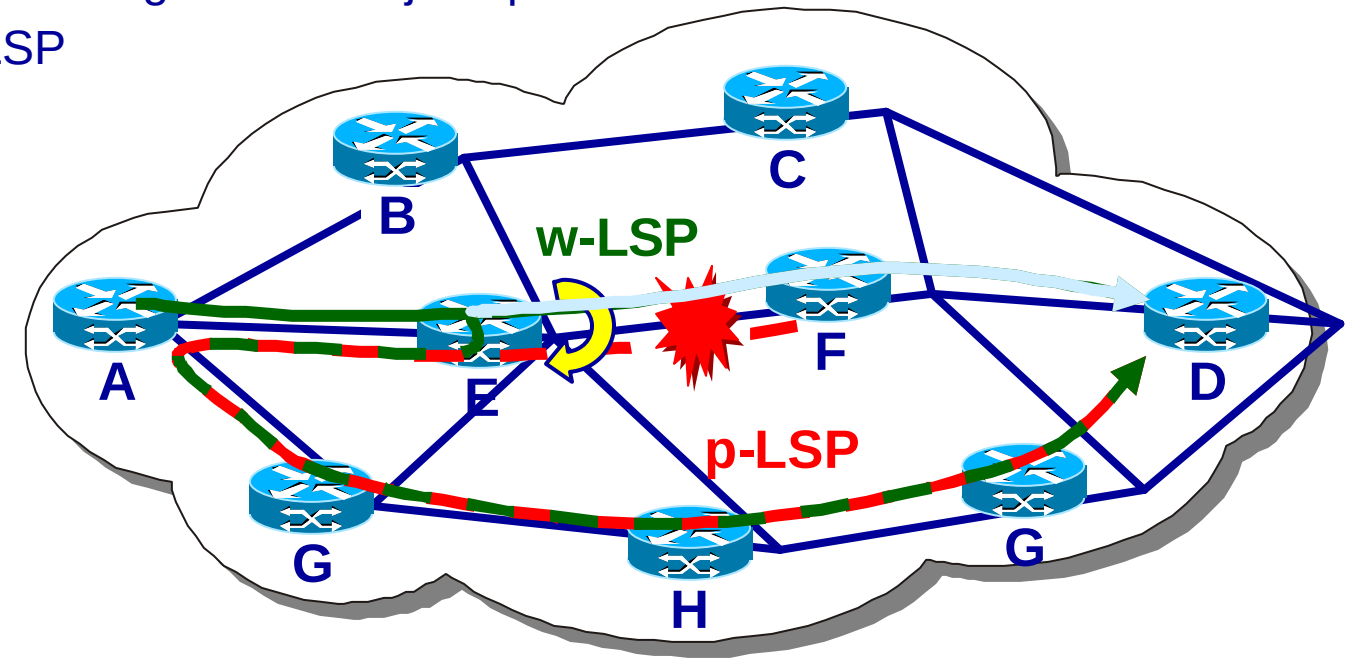
+ Single backup LSP per working LSP
– Failure signaling required
+ Node failures covered

Fast Reroute [Haskin]

Protection switching, pre-established, pre-reserved,

local switching, global recovery

Alternative recovery LSP set up from the last-hop LSR in reverse direction to the ingress LSP and along a node-disjoint path to the egress LSP

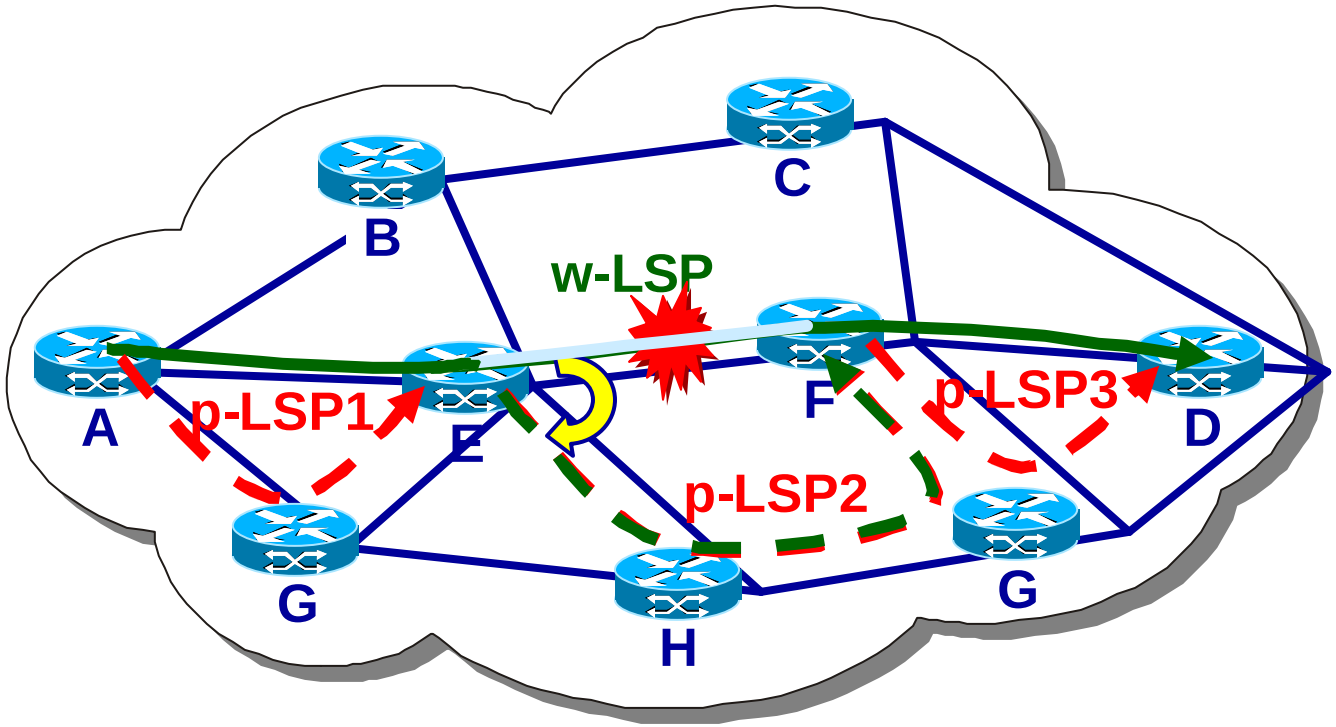


+ Single backup LSP per working LSP
– No failure signaling required
+ Node failures covered
– High spare capacity requireme

Source: [draft-haskin-mpls-fast-reroute-01.txt]

Local Protection

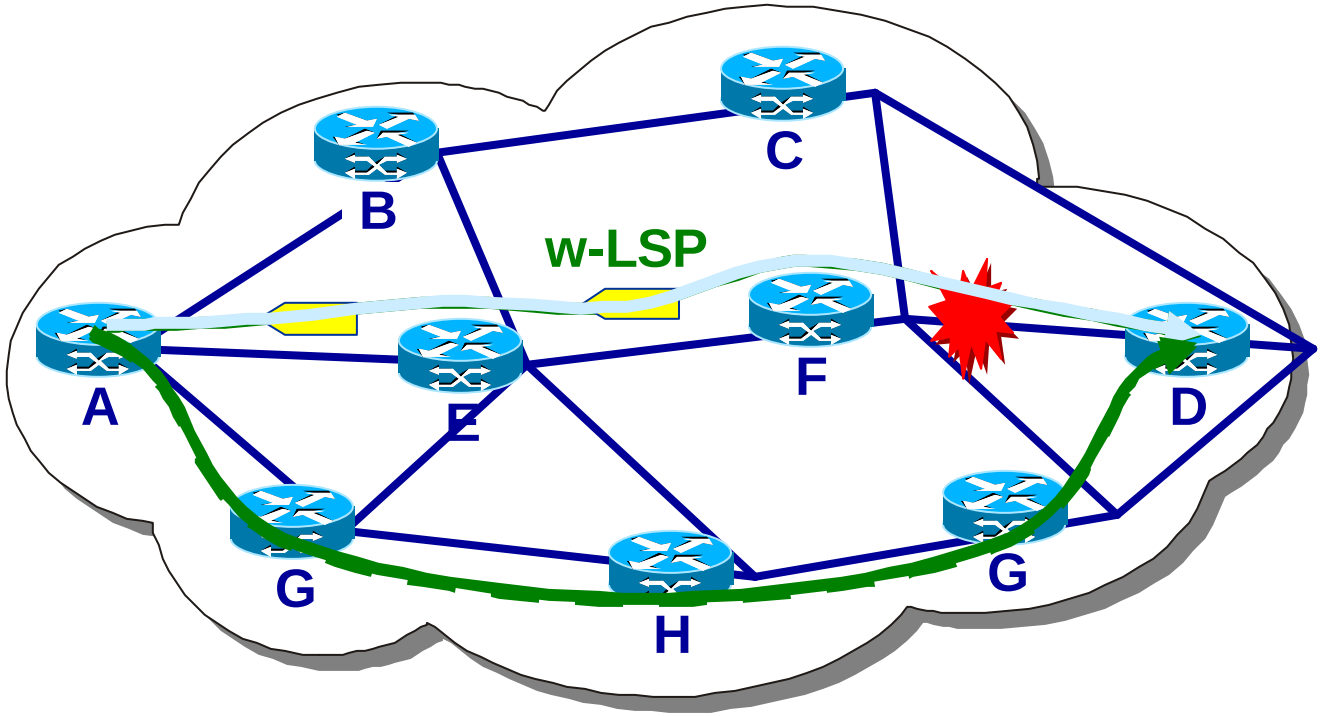
Protection switching, pre-established, **local scope,** pre-reserved



– **Multiple backup LSPs per working LSP**
\+ **No failure signaling required**
– **Node failures not covered**

Global Restoration

Restoration, established on-demand, reserved on-demand, global scope



– Failure signaling required

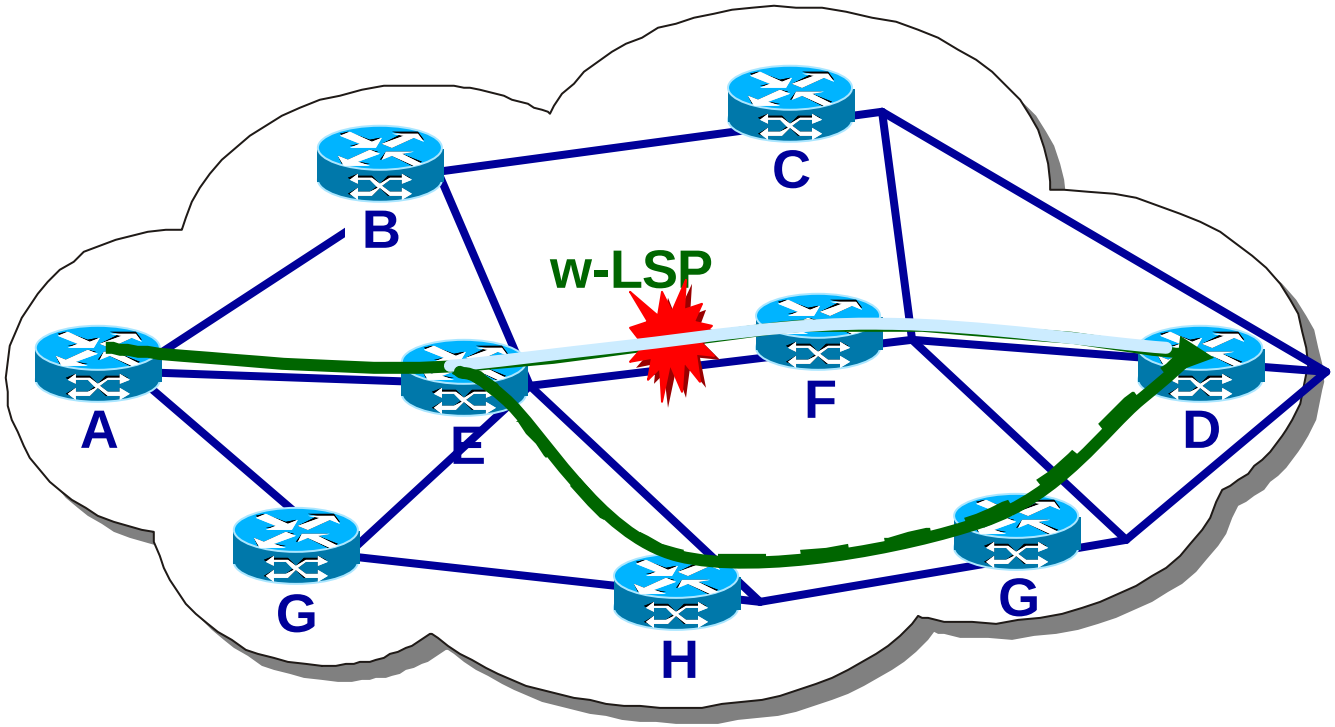
+ Node failures covered

+ Alternative LSPs distributed over netwo
=> high spare capacity efficiency

Failure to Egress Restoration

Restoration, pre-established, pre-reserved,

local switching, global recovery



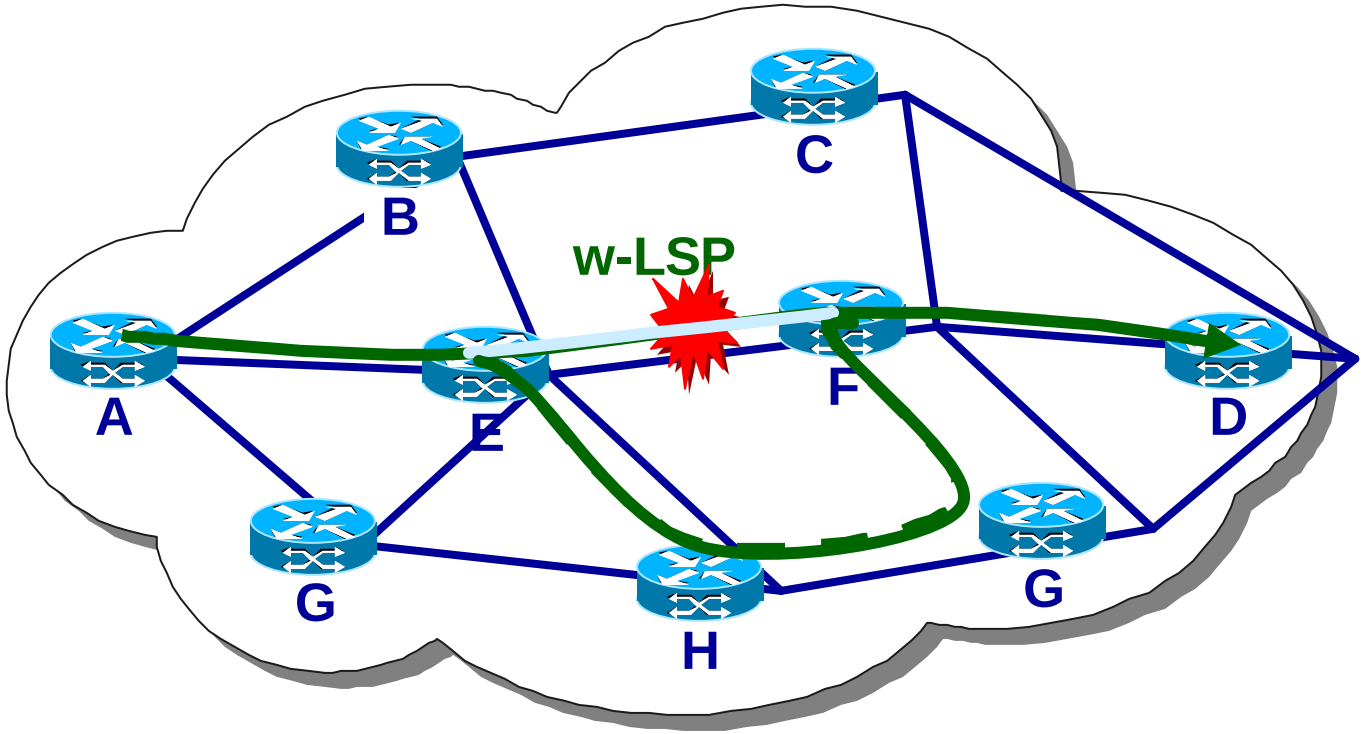
+ No failure signaling required

+ Node failures covered

o Between local and global routing
=> average spare capacity efficien

Local Restoration

Restoration, established on-demand, reserved on-demand, **local scope**



+ No failure signaling required **– Alternative LSPs locally routed**

– Node failures difficult to cope with => lower spare capacity efficiency