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Self-Protecting Multi-Paths – A Simple and Efficient Protection Switching Mechanism

Outline

- Overview on resilience options
  - Simplicity
  - Efficiency
  - Derivation of the Self-Protecting Multi-Path (SPM)
- Numerical Results
  - Required backup for the SPM
  - Sensitivity Analysis
    - Impact of network topology
    - Impact of traffic matrix
- Conclusions

Network Resilience

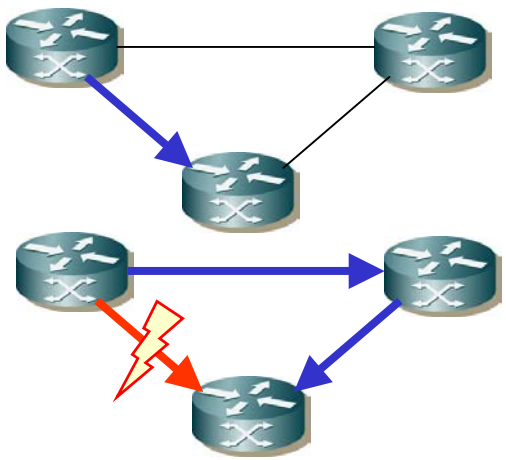
- Reliable communication is business-critical
  - Network outage ⇒ financial loss
  - ISPs give guarantees for network availability

- Telephony system
  - 99.999% (“five nines“) reliability ~ 5 minutes unavailability per year
  - Redundant layout of network entities (links, switching centers, processors, line cards, hot standbys, …)

- Reliability for IP and MPLS networks
  - Network resilience against link and node failures required
  - Traffic rerouting to another path
  - **Backup capacity required for deviated traffic ⇒ cost factor**

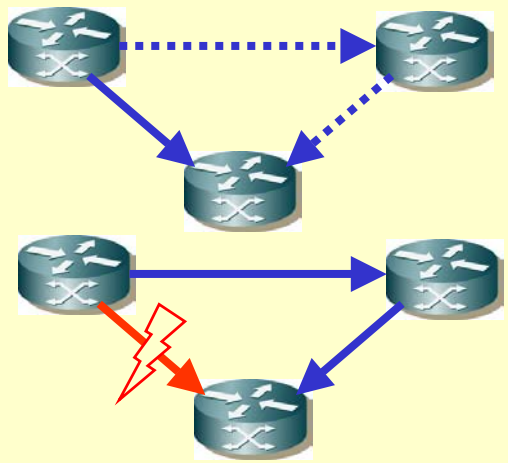
Reaction or Proaction?

- Path restoration
  - IP rerouting
  - Reconfiguration of LSPs
  - Reaction time 400ms – 40s



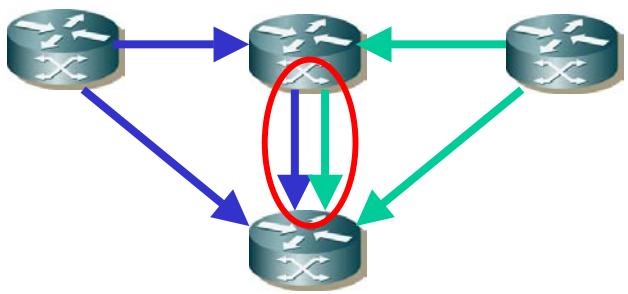
Too slow!

- Protection switching
  - Primary LSP and preconfigured backup LSP
  - Reaction time: <100 ms

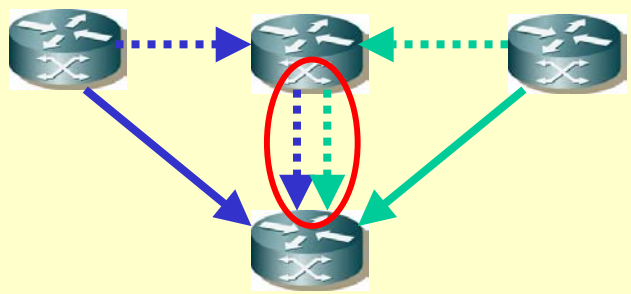


Hot or Cold Standby?

- 1+1 protection
  - Live backup path carries traffic simultaneously



- 1:1 protection
  - Backup path carries traffic only if primary path fails

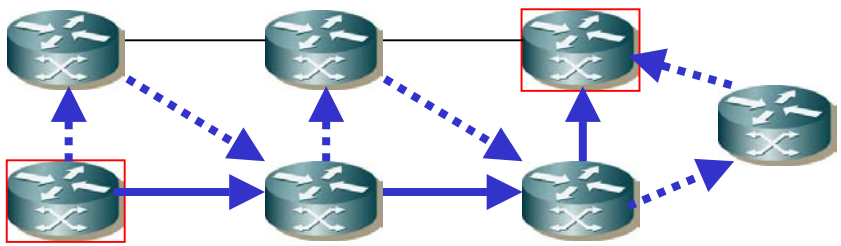


Inefficient!

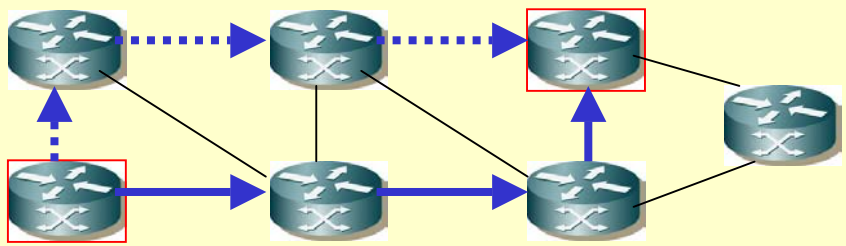
Reduction of backup capacity possible

Local or End-to-End Protection?

- Local protection
  - One backup path per aggregate and link
  - Local repair keeps all traffic nearby



- End-to-end protection
  - One backup path per aggregate
  - Distant traffic deviation by end-to-end repair

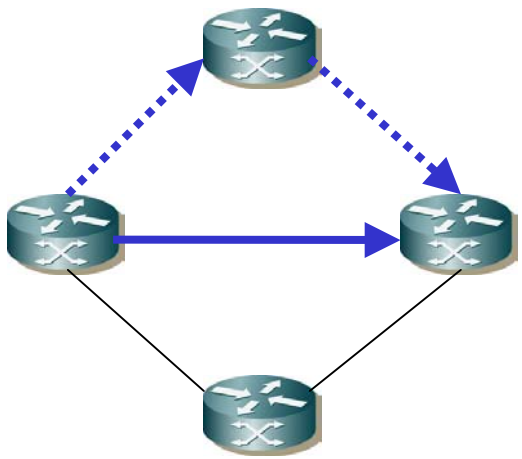


Too complex!

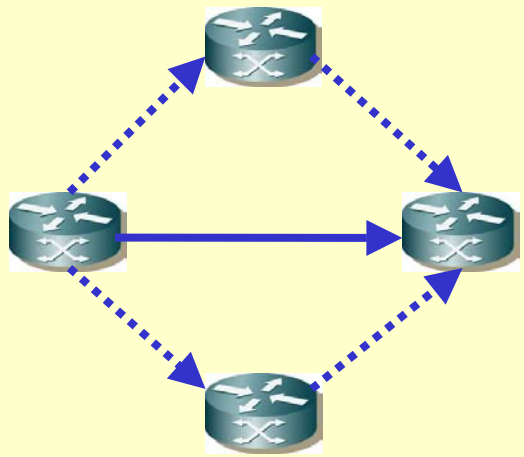
Additional reduction of backup capacity?

Single- or Multi-Path Protection?

- Single backup path
  - Load balancing not possible
  - ≥ 100% backup capacity per backup link required

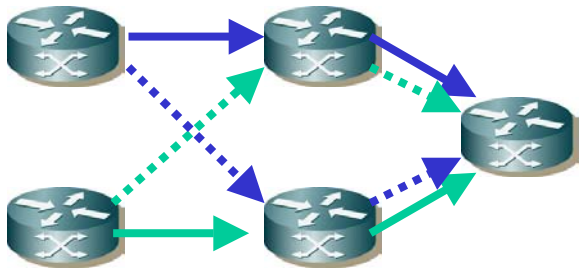


- Multiple backup paths
  - Load balancing possible
  - ≥ (100/n)% backup capacity per backup link required

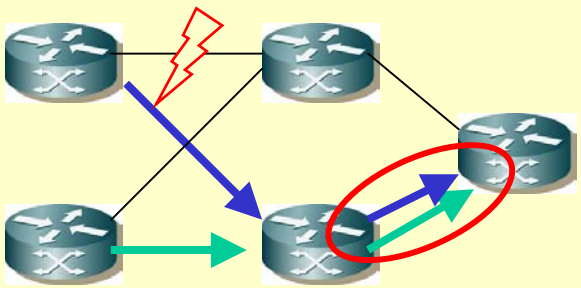


Additional reduction of backup capacity?

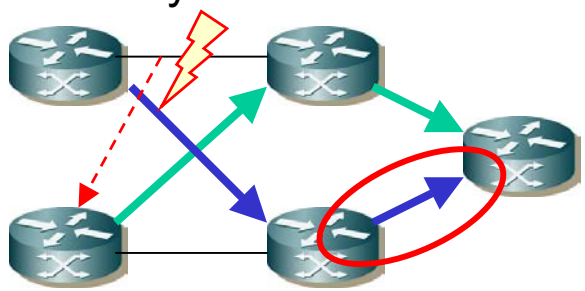
Triggering of Traffic Redistribution: Locally by Path Failure Recognition or Globally by Signalling?



- Traffic redistribution only if source recognizes path failure
  - Only relocation of affected paths possible



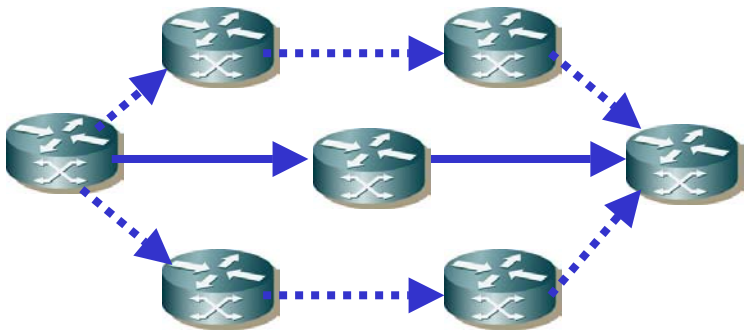
- Traffic redistribution triggered by failure signalling
  - Relocation of any paths possible
  - Possibly more efficient



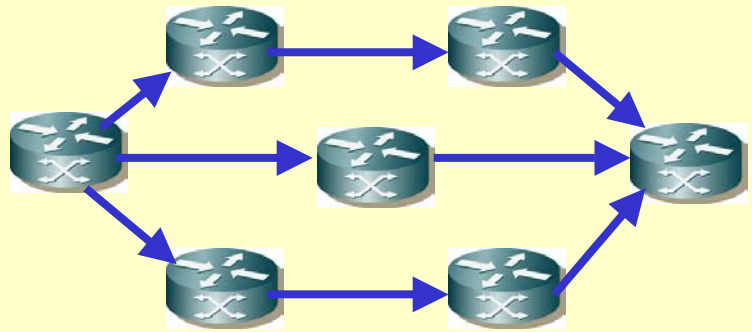
Too complex!

Path Protection or Self-Protecting Multi-Path (SPM)?

- Path Protection
  - Single primary paths
  - Multiple (disjoint) backup paths



- Self-Protecting Multi-Paths
  - No distinction between primary and backup paths
  - Multiple (disjoint) paths

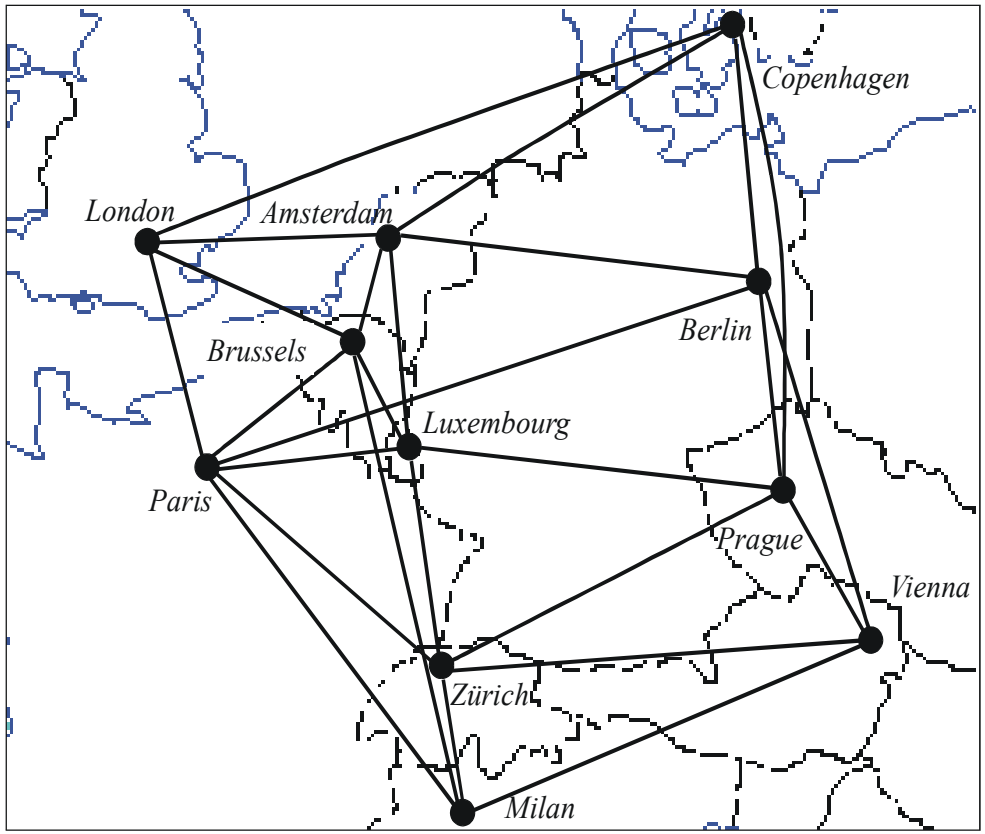


- Action in a failure case
  - Source recognizes (set of) failed paths
  - Traffic deflection to working paths according to failure specific load balancing function

Can be mimicked by SPM

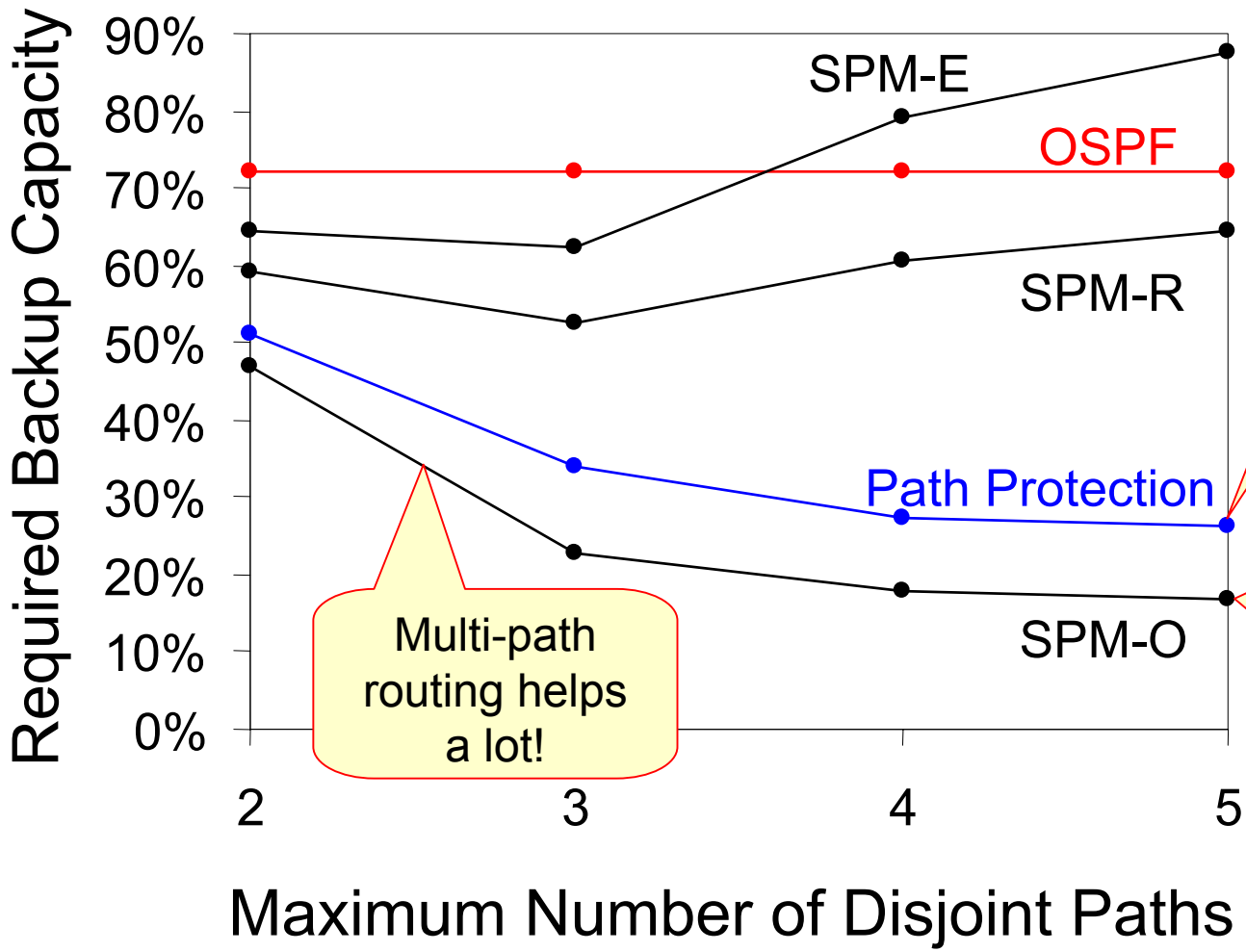
Additional reduction of backup capacity?

Testbed

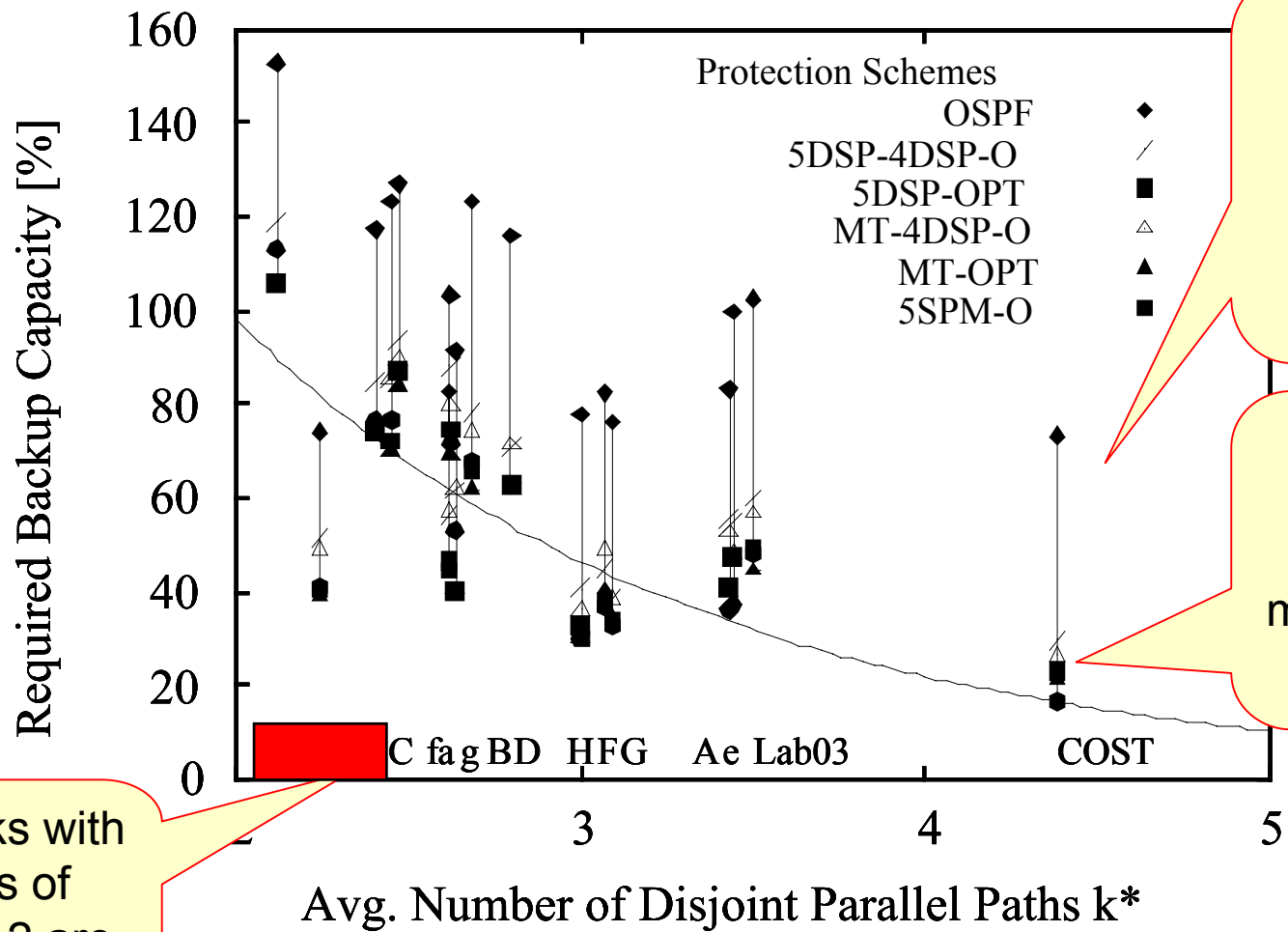


- Topology of optical core network of COST239 (European research network)
- Homogeneous traffic matrix
- Protected failure scenarios $\mathcal{S}$: all single link and node failures
- Performance metric: required backup capacity

Performance Comparison of Resilience Mechanisms



Comparison in Sample Networks

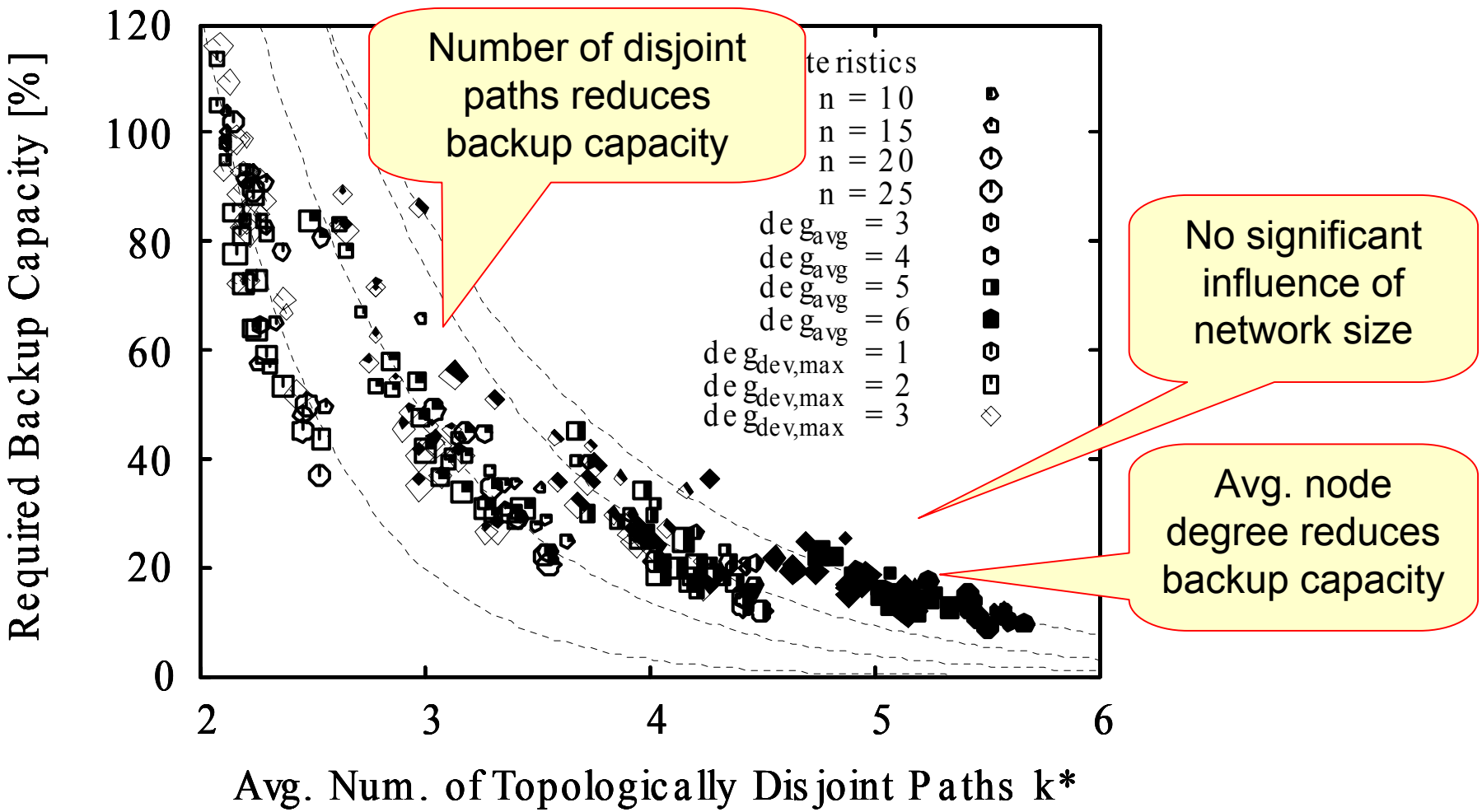


Backup capacity depends strongly on network topology.

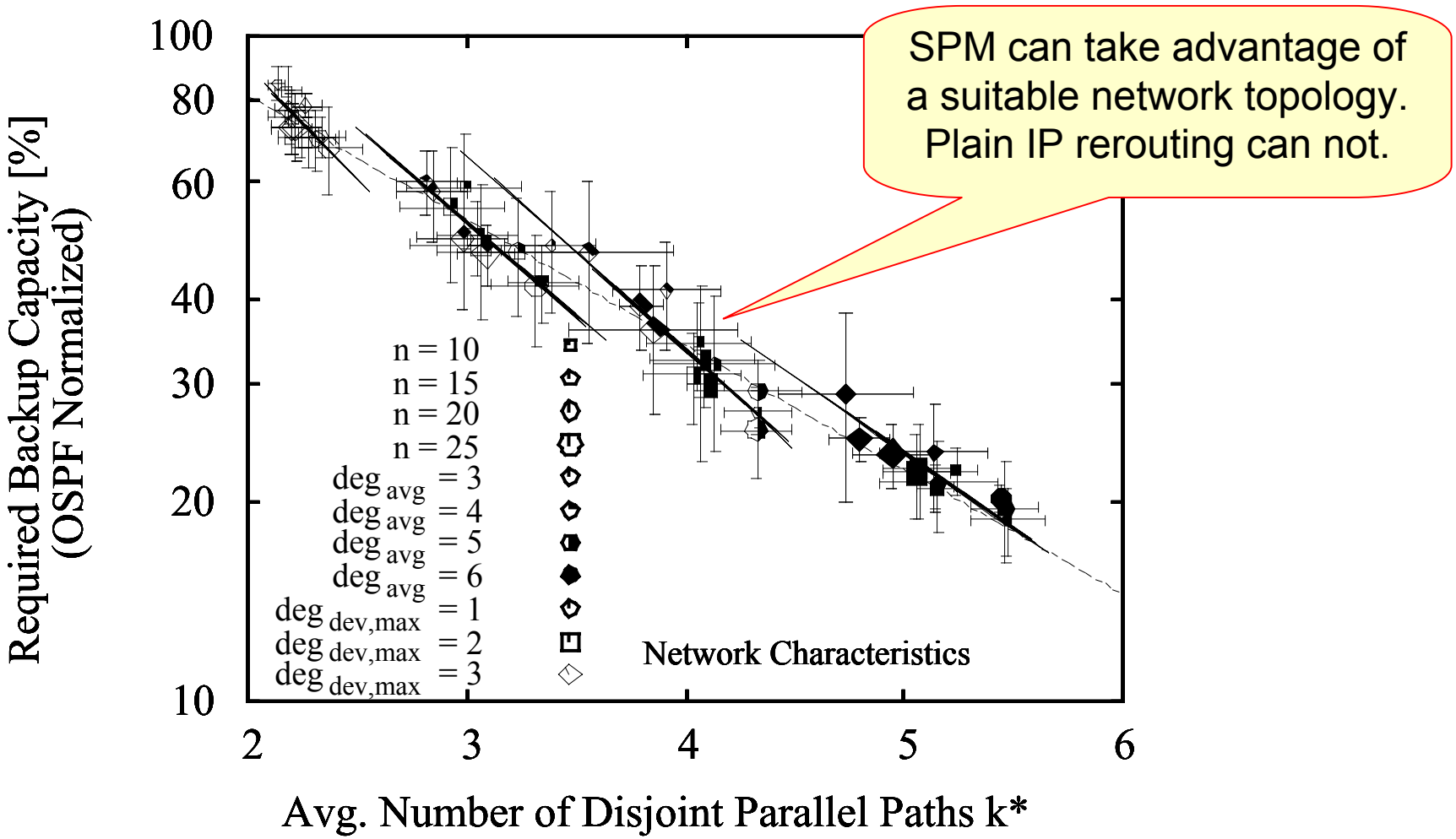
SPM outperforms all feasible methods by at least 10%.

Networks with nodes of degree 2 are not suitable!

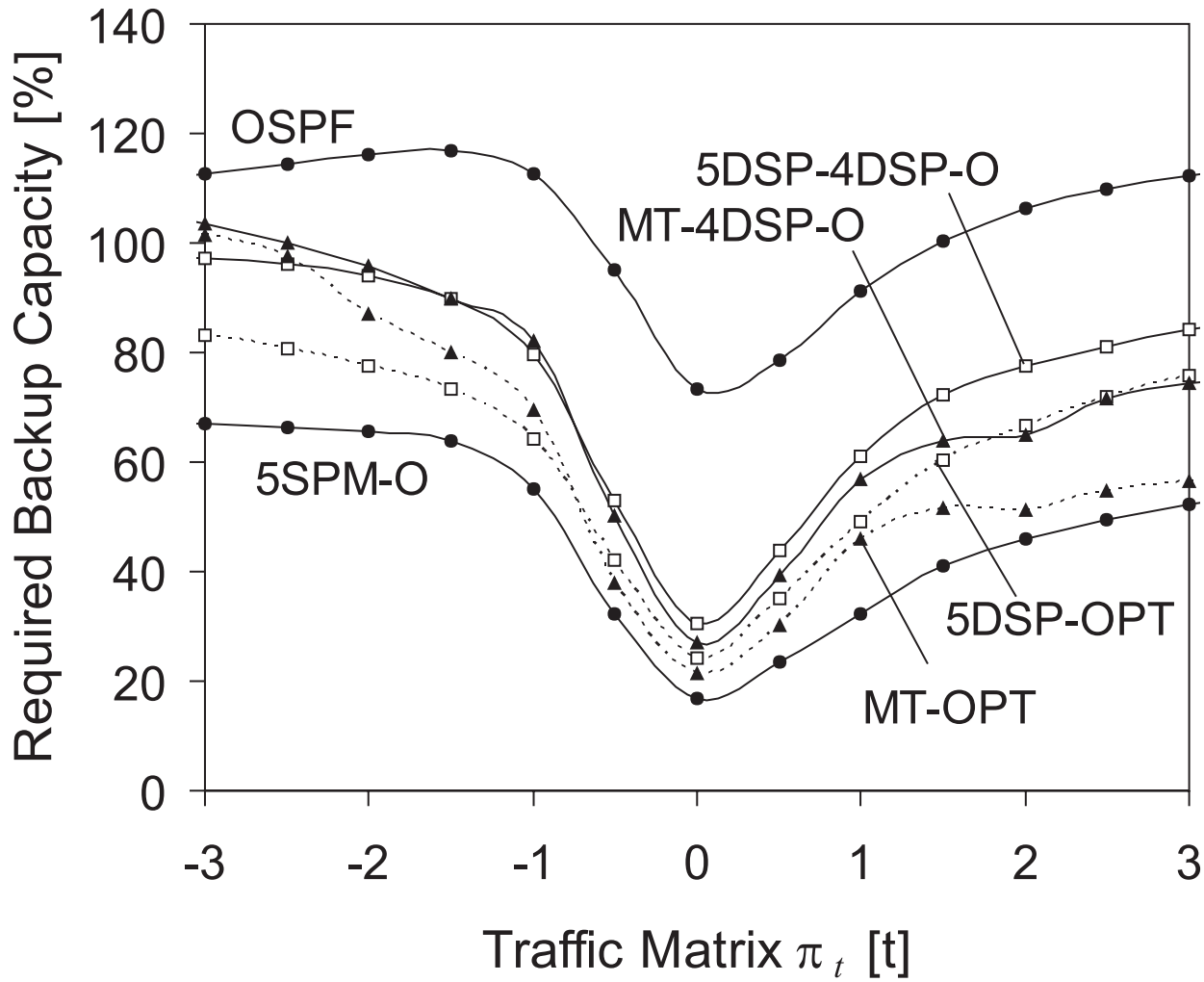
Impact of Network Characteristics

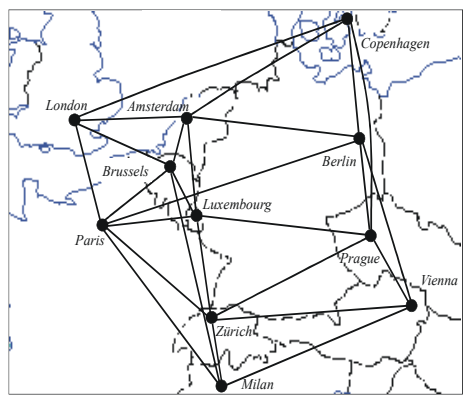


Comparison of SPM and IP Rerouting



Impact of Traffic Matrix on the Required Backup Capacity (COST239)





Conclusions

- Self-Protecting Multi-Path (SPM)
  - Traffic distribution over disjoint multiple paths
  - Optimization of the load balancing function
- Simplicity
  - Little path configuration: one structure fits all scenarios.
  - Load balancing only at the ingress LSP
  - No signalling: local recognition of partial path failures sufficient
- Efficiency
  - 17% backup capacity required for COST239 network (OSPF: 72%)
    $\Rightarrow$ 1/3 of network capacity can be saved!
  - Takes advantage of suitable resilient network topologies
- Outlook: configuration of SPM in networks with given link capacities