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Routing Optimization with IP Fast Reroute
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Network Working Group — **M. Menth**
Internet-Draft — M. Hartmann
Intended status: — D. Hock
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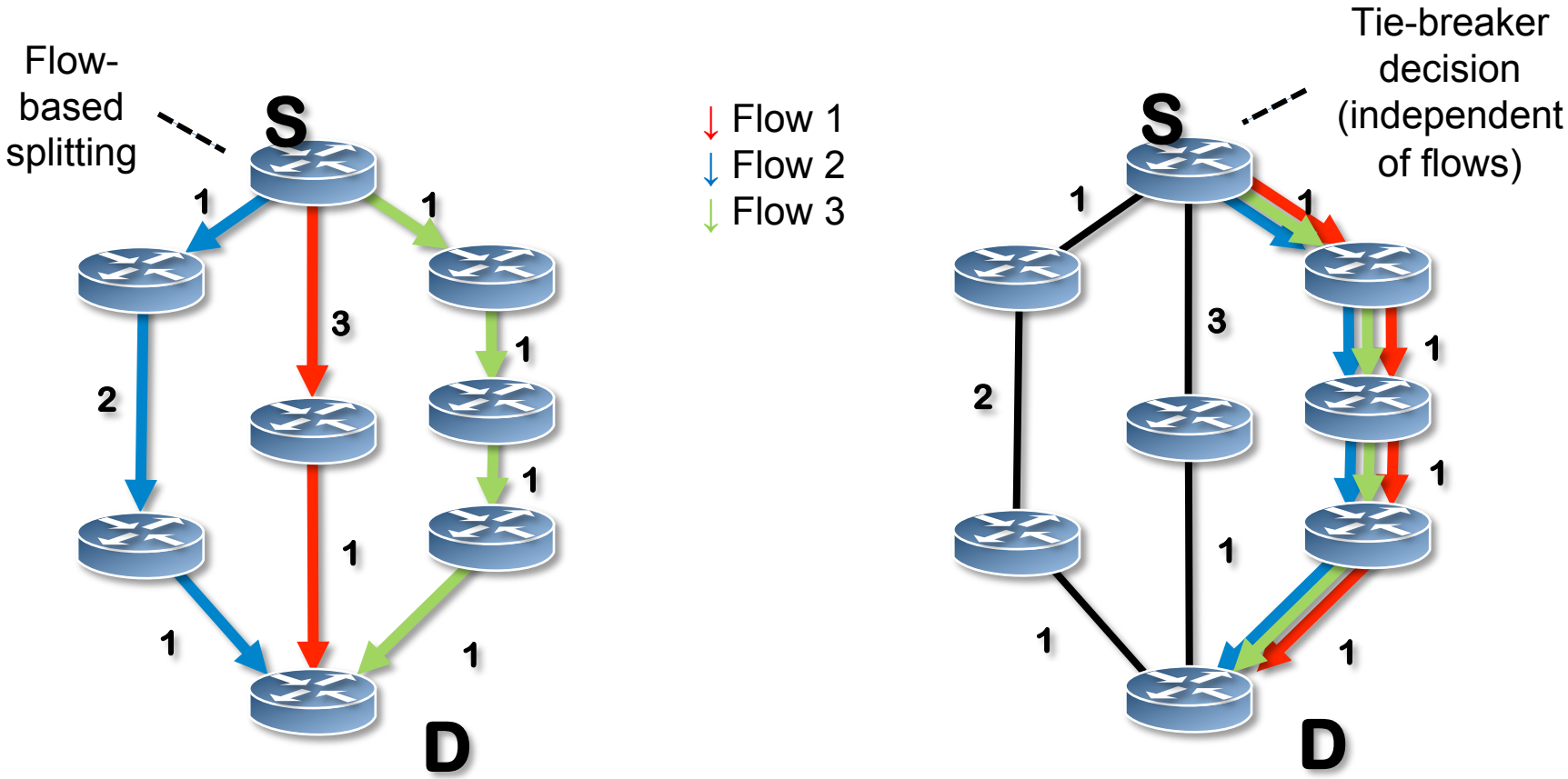
Overview

- Unique Shortest Paths for IP Networks with Not-Via Addresses

- Routing Optimization of Loop-Free Alternates (LFAs): Minimizing Maximum Link Utilization and Maximizing Failure Coverage

UNIQUE SHORTEST PATHS FOR IP NETWORKS WITH NOT-VIA ADDRESSES

Motivation - Multiple Shortest Paths in IP Networks



Equal-cost multipath (ECMP)

- Traffic equally load-balanced over all least-cost paths

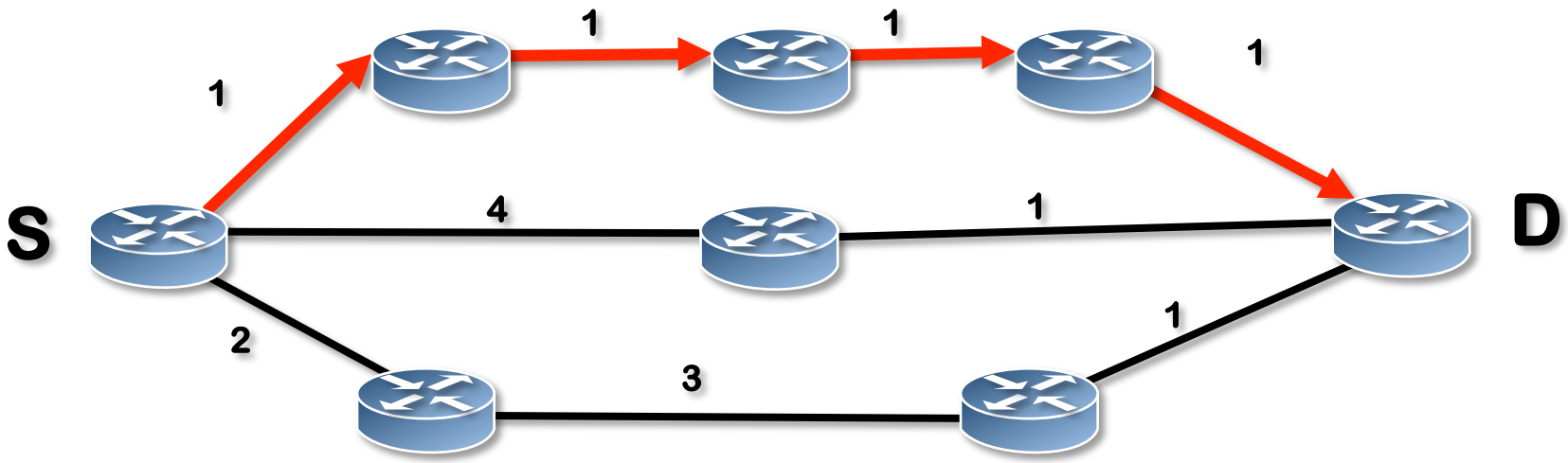
Single shortest path (SSP)

- Tie-breaker criteria not properly standardized
- Unpredictable path layout

Problems with Traffic Engineering

- Link cost optimization
  - Find link costs minimizing maximum link utilization
  - For failure-free case only
  - Also for „considered failure cases“
- Problem with optimized equal-cost paths using SSP
  - Traffic follows in practice different paths compared to assumption in optimization
  - Maximum link utilization up to 200% larger than expected

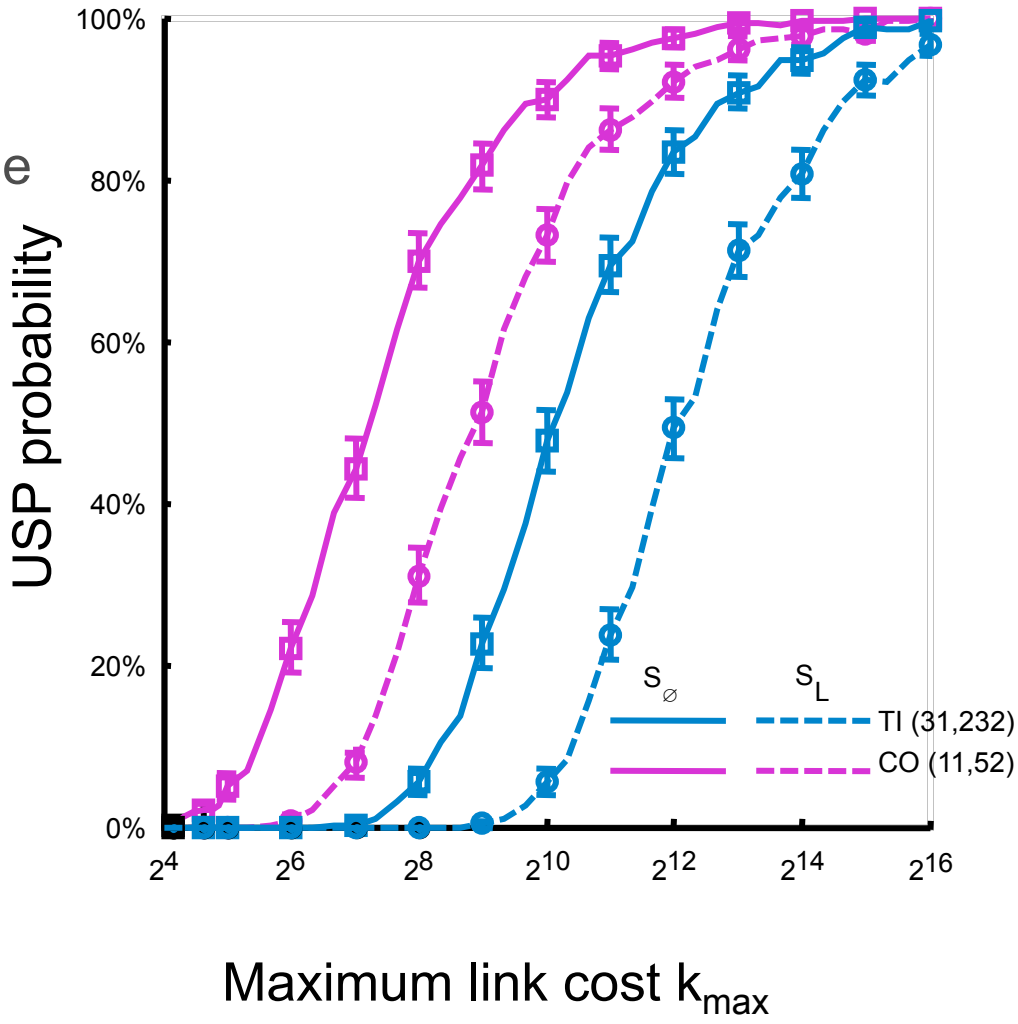
Solution: Unique Shortest Paths (USP)



- Unique shortest paths (USP)
  - All shortest paths are unique
  - Appropriate link costs required
- Need for USP in
  - Failure-free scenario $S_{\varnothing}$
  - Set of protected failure scenarios S, e.g., single link failures S_L

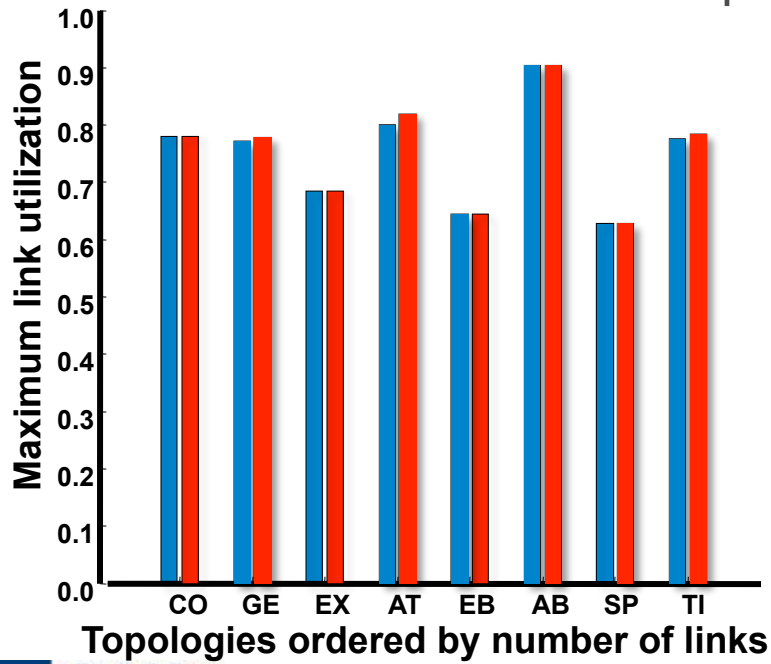
Existence of USP Solutions

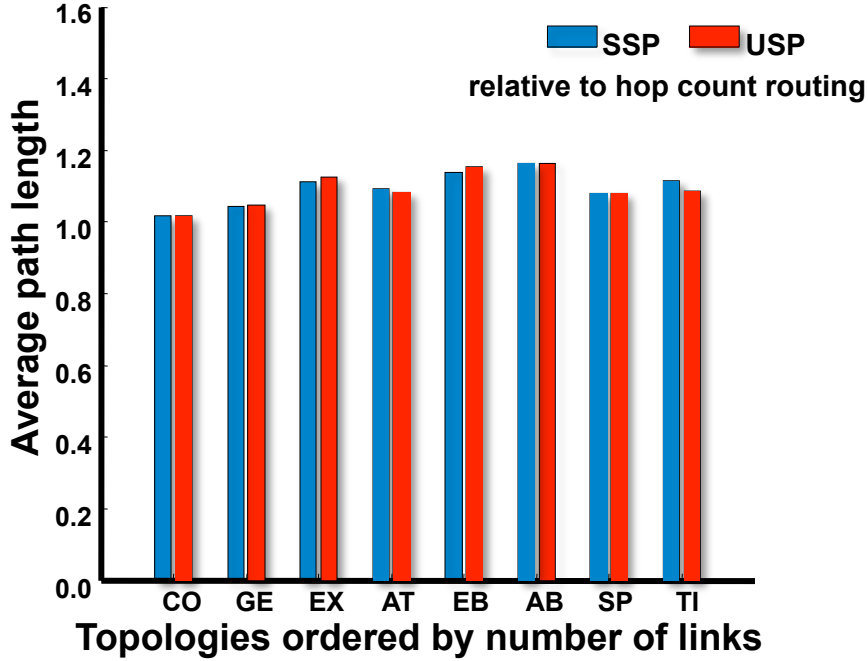
- USP probability dependent on the
  - allowed link cost range
  - failure scenarios
  - network size



Comparison of Optimized USP and SSP Routing

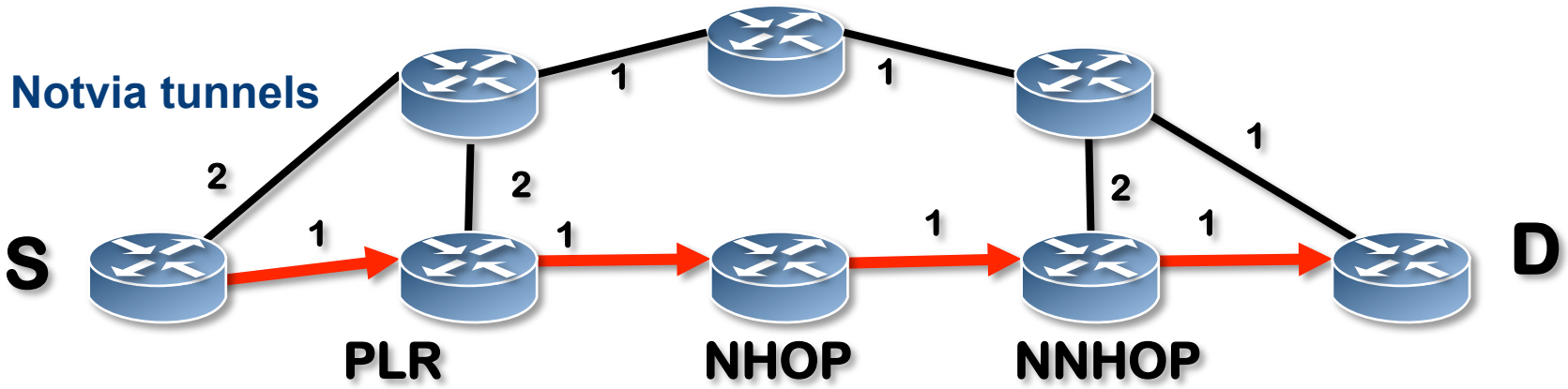
- Considered performance measures
  - Maximum link utilization
  - Average path length
- Similar results for
  - Optimized USP and SSP
  - Failure-free case and protected failure scenarios





Application of USP for Fast Reroute

- Pure IP networks
  - SSP and ECMP as forwarding options
  - USP required for traffic engineering with SSP



- Networks with IP and MPLS fast reroute

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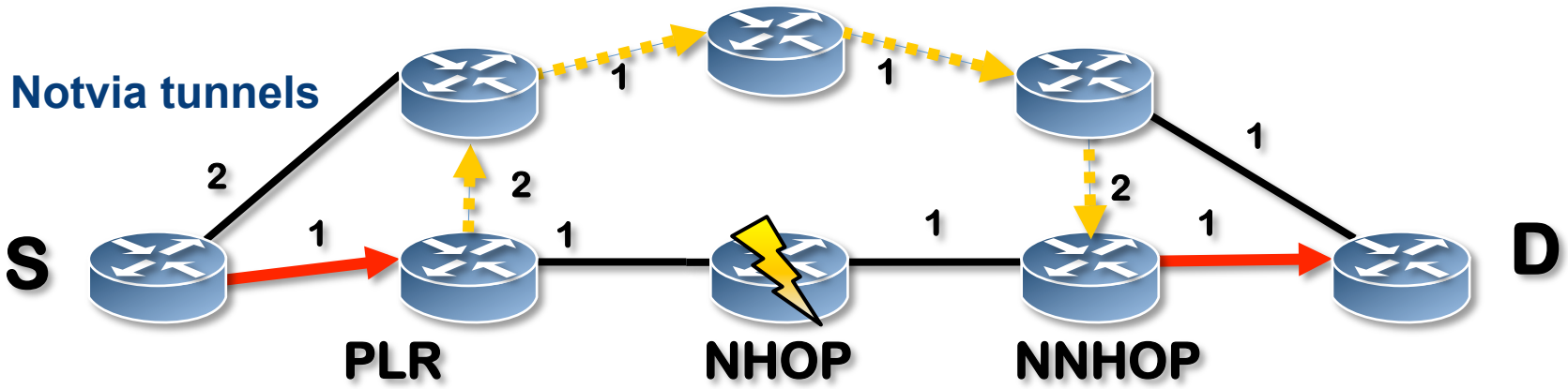

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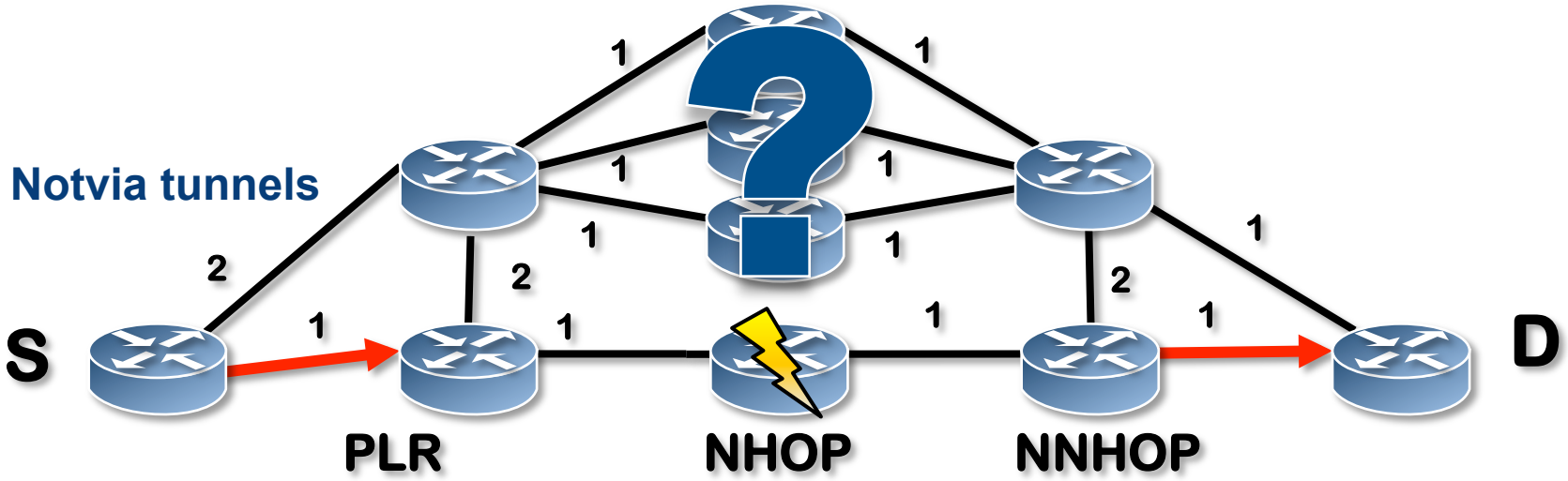


- Networks with IP and MPLS fast reroute
  - ECMP cannot load-balance traffic from PLR to NNHOP
  - Unique shortest paths needed for unambiguous backup paths
  - Adaptation of USP routing optimization to not-via addresses

Summary (USP)

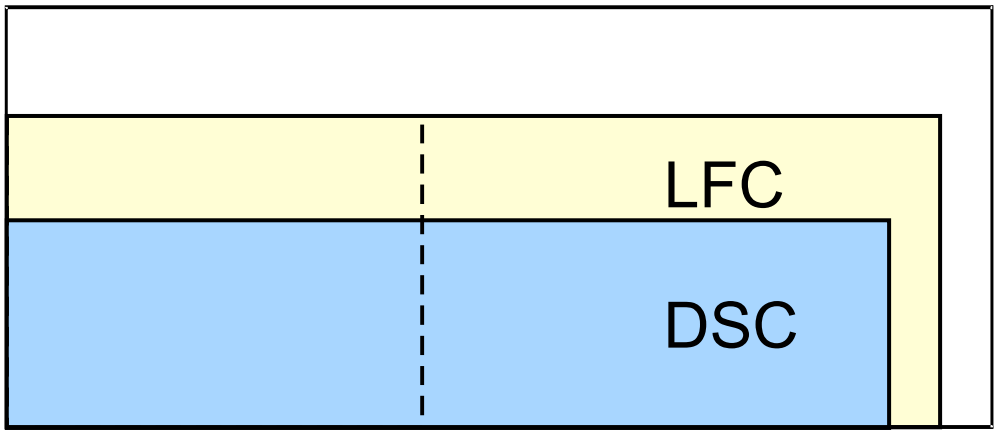
- Problem
  - Ambiguous path layout for equal-cost paths in IP networks
  - Optimized routing results might not work in practice
  - ECMP avoids this problem for pure IP networks
  - Problem remains for not-via addresses and MPLS fast reroute
- Solution
  - IP link costs for unique shortest paths (USP)
- Our contribution
  - Heuristic algorithm
  - Efficiency studies
  - Adaptation to not-via and MPLS fast reroute
- More: http://www.menth.net/Publications/papers/Menth10g.pdf
  IEEE NOMS, 2010, Osaka, Japan

ROUTING OPTIMIZATION OF LOOP-FREE ALTERNATES (LFAS)

IP-FRR: Loop-Free Alternates (LFAs)

- Idea
  - Node S has multiple neighbors
  - Next hop on shortest path towards destination D is down
  - Node S forwards packet to alternate neighbor N
    - Requirement: traffic forwarded to N does not loop back to S (LFA)

Classification of Neighbor Nodes as LFAs wrt a Destination



All neighbors

General LFAs

Downstream LFAs:
avoid loops with
multiple failures

Link-protecting:
may cause loops
with node failures

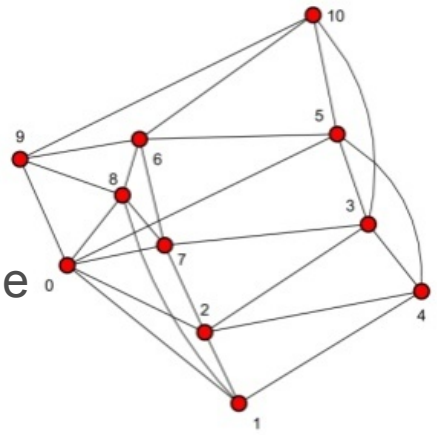
Node-protecting:
avoid loops with
node failures

Motivation

- LFAs ready to use with current hardware
- Problem: LFAs do not always offer 100% failure coverage
- Idea: use IP link cost optimization to maximize the percentage of destinations protected by LFAs
- Related work
  - Ho Trong Viet, Pierre Francois, Yves Deville and Olivier Bonaventure: „Implementation of a Traffic Engineering Technique that Preserves IP Fast Reroute in COMET", http://hal.inria.fr/docs/00/38/38/16/PDF/article_Algotel_No59.pdf
  - Only link-protecting LFAs and optimization for failure-free routing

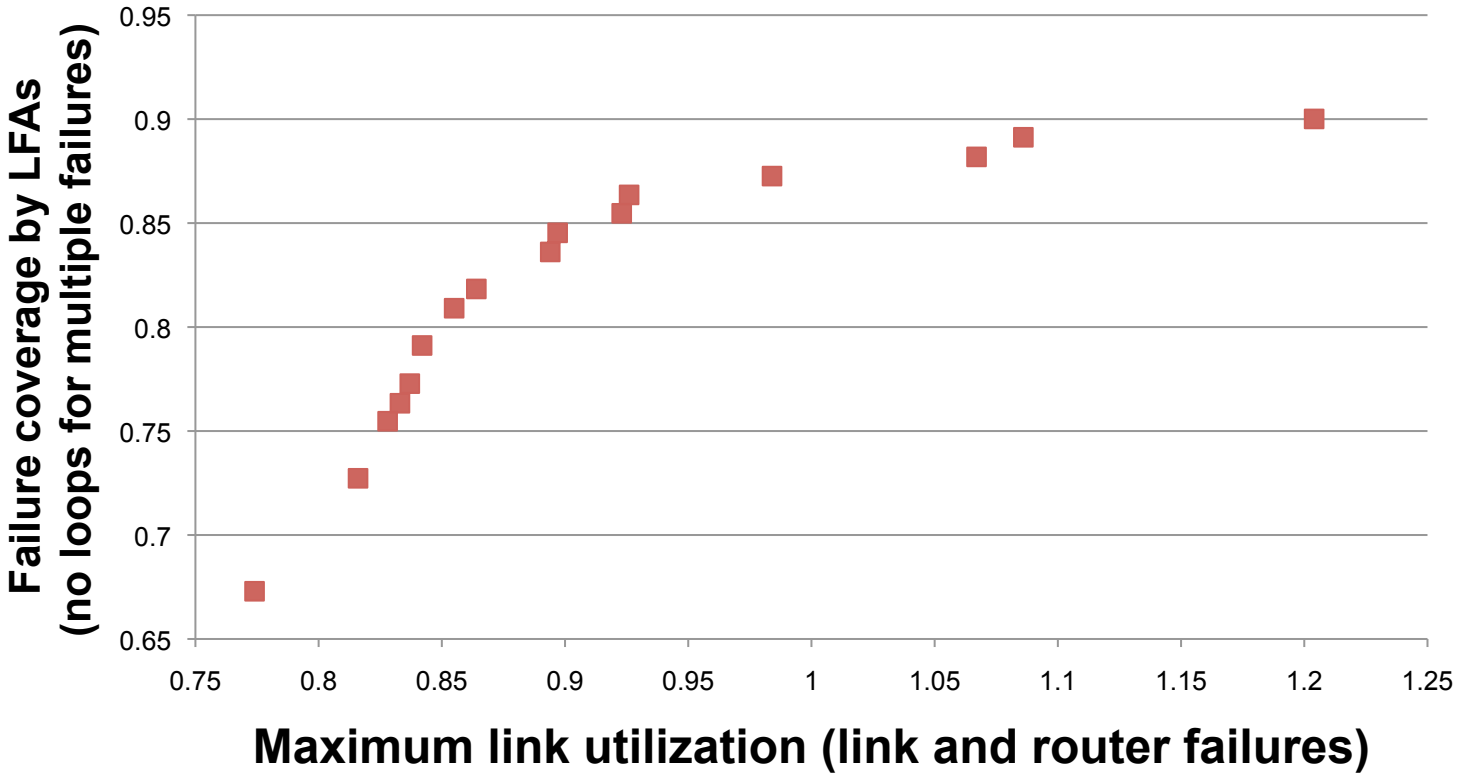
Maximum Link Utilization and LFA Coverage

- COST239 network
- Performance metrics
  - MaxUtil: maximum link utilization (failure-free and single link failures)
  - FailCov: percentage of protected destinations per node (different protection requirements)
- Different optimization goals



Cell entries: MaxUtil / FailCov	none
Link-protecting	100% / 98%
Node-protecting	100% / 53%
Downstream + node-protecting	100% / 38%

Pareto-Optimization for Loop-Avoidance with Multiple Failures



- Pareto-optimality: no other point is better in both dimensions
- Contrary goals: maximum link utilization and failure coverage?
- Which is most important for ISPs?

Summary (LFAs)

- Problem
  - LFAs do not always offer 100% failure coverage
  - But: link cost optimization improves failure coverage
- What protection is important?
  - Link-/node-protecting?
  - No extra-loops with multiple failures?
- Future work
  - Improve optimization algorithms
  - What network structures prohibit good failure coverage by LFAs?