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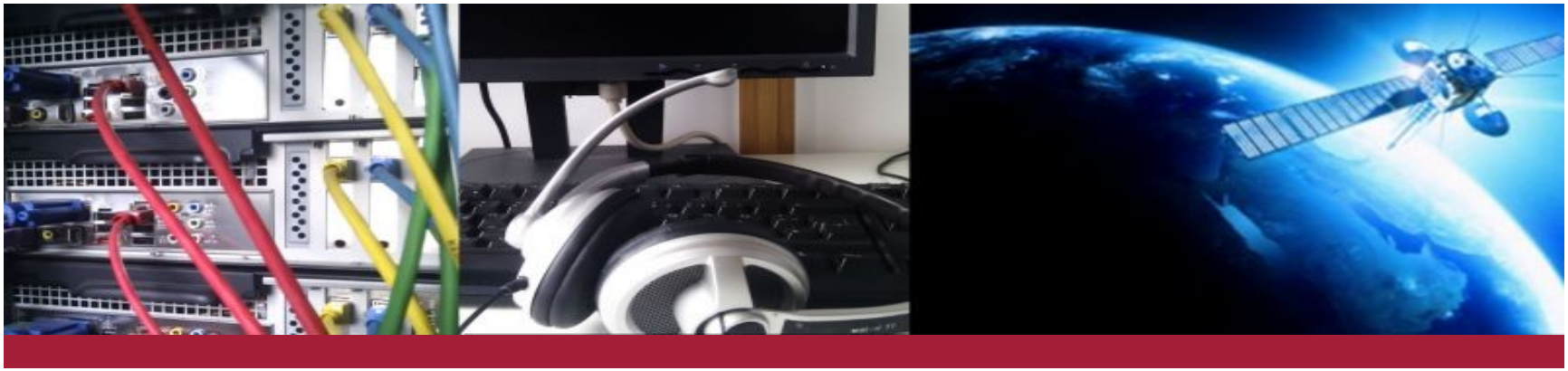
Kommunikationsnetze



Scalable Resilience for Software-Defined Networking Using Loop-Free Alternates with Loop Detection

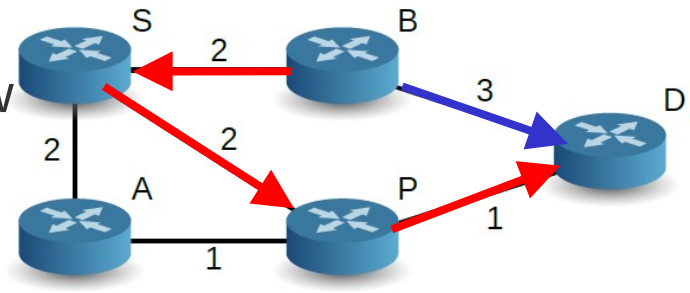
Wolfgang Braun and Michael Menth

http://kn.inf.uni-tuebingen.de

Loop-Free Alternates (LFAs)

- Assumption: destination-based forwarding

- Locally reroute traffic in case of failures
  - Use fast-reroute function in OpenFlow



- Loop-free alternates (LFA)
  - Avoid loops for single link failures
  - But may cause loops for node failures and multiple failures

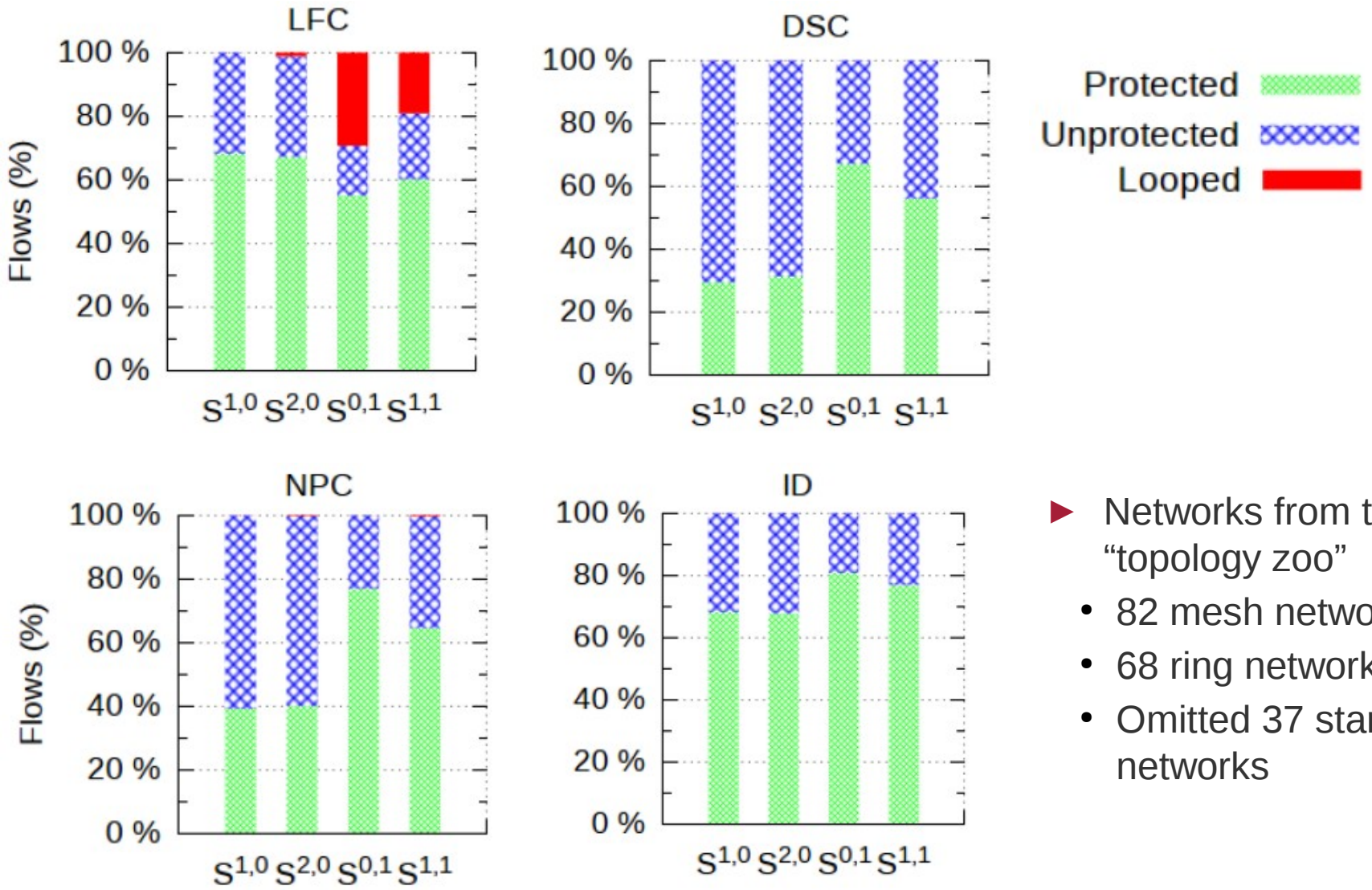
- Classification: LFAs that avoid loops for
  - Link failures (loop-free condition, LFC)
  - Node failures NPC (node-protecting condition, NPC)
  - Multiple failures (downstream condition, DSC)

LFAs with Loop Detection

- Loop detection principle
  - If packet is rerouted, add node ID to packet header
  - Nodes drop arriving packets with their own ID in the header

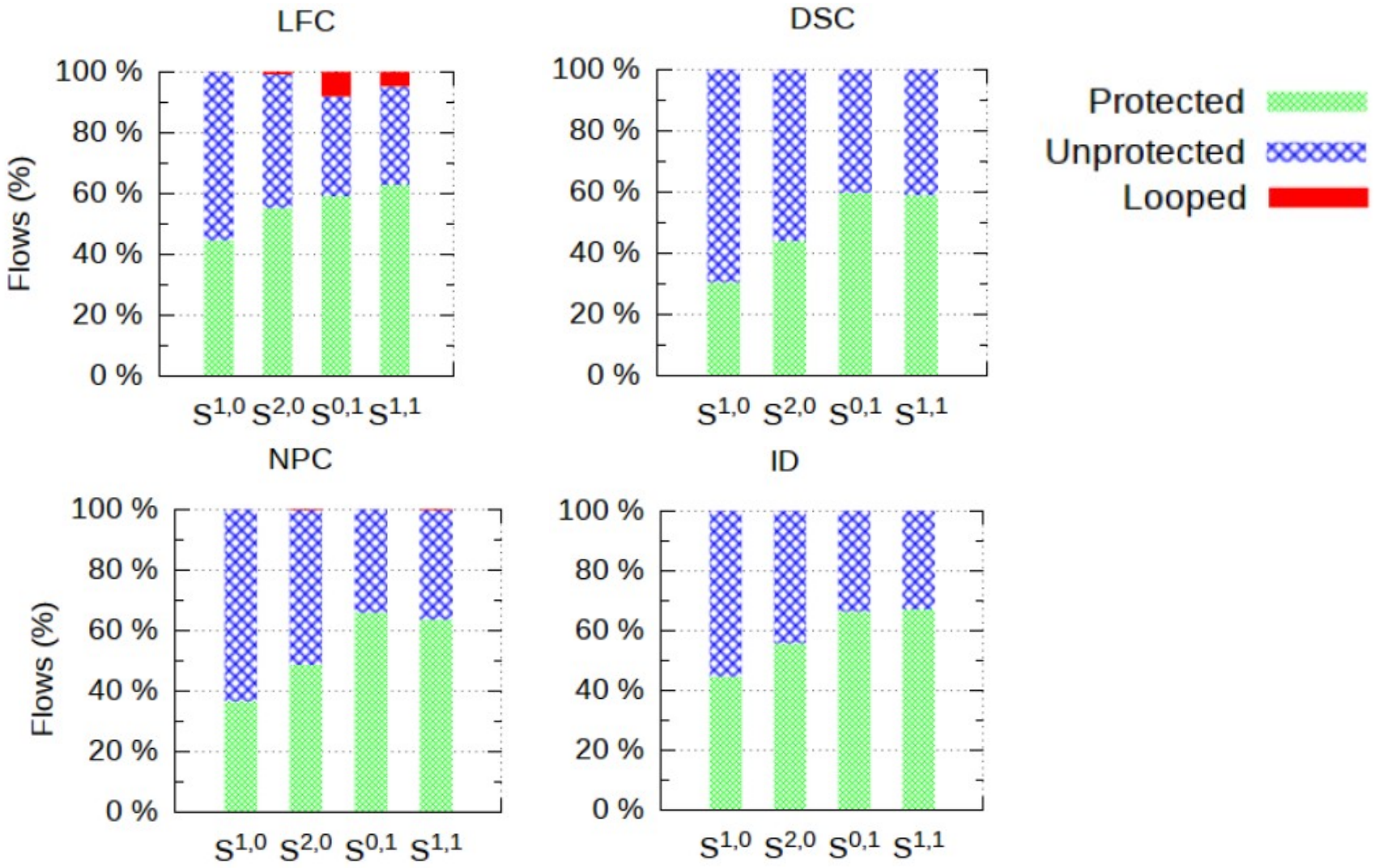
- Implementation in OpenFlow (LFA-ID)
  - Assign IDs to nodes
  - Add ID label to packet header
  - Each bit in the ID label stands for a node ID
  - If pkt is rerouted, set node‘s bit in ID label
  - Add one flow entry to switch that
    - Drops pkts with own node ID in pkt hdr

LFAs in Mesh Topologies



- Networks from the "topology zoo"
  - 82 mesh networks
  - 68 ring networks
  - Omitted 37 star networks

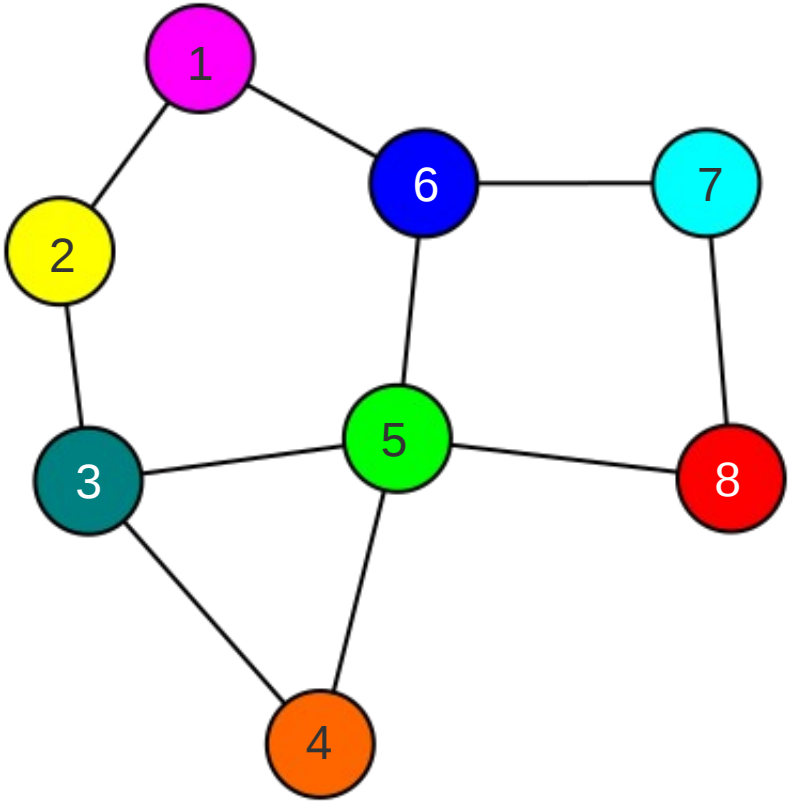
LFAs in Ring Topologies



How to deal with large networks?

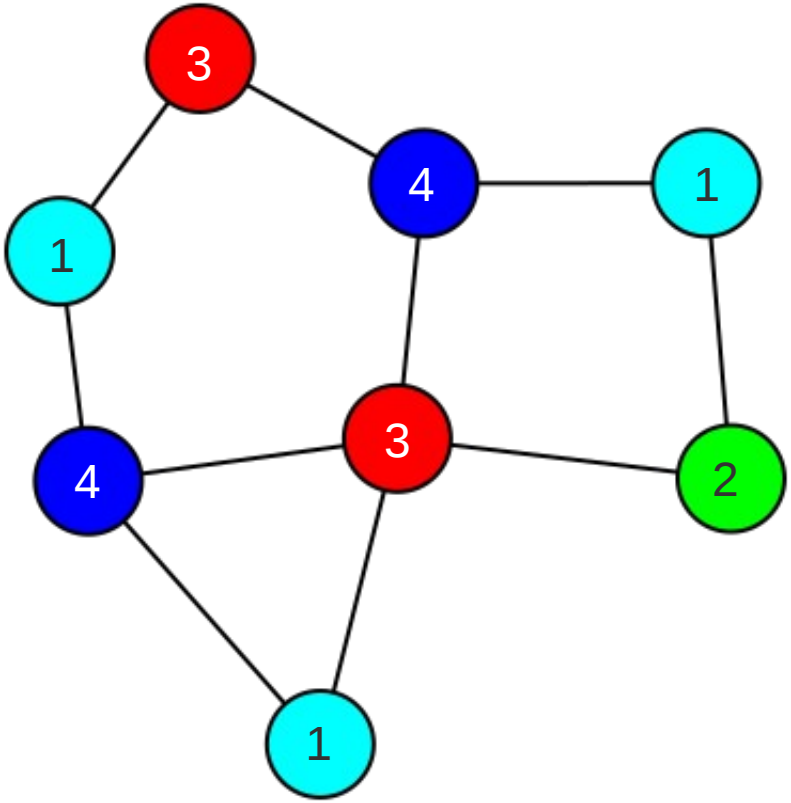
- Use large ID labels

⇒ Large overhead

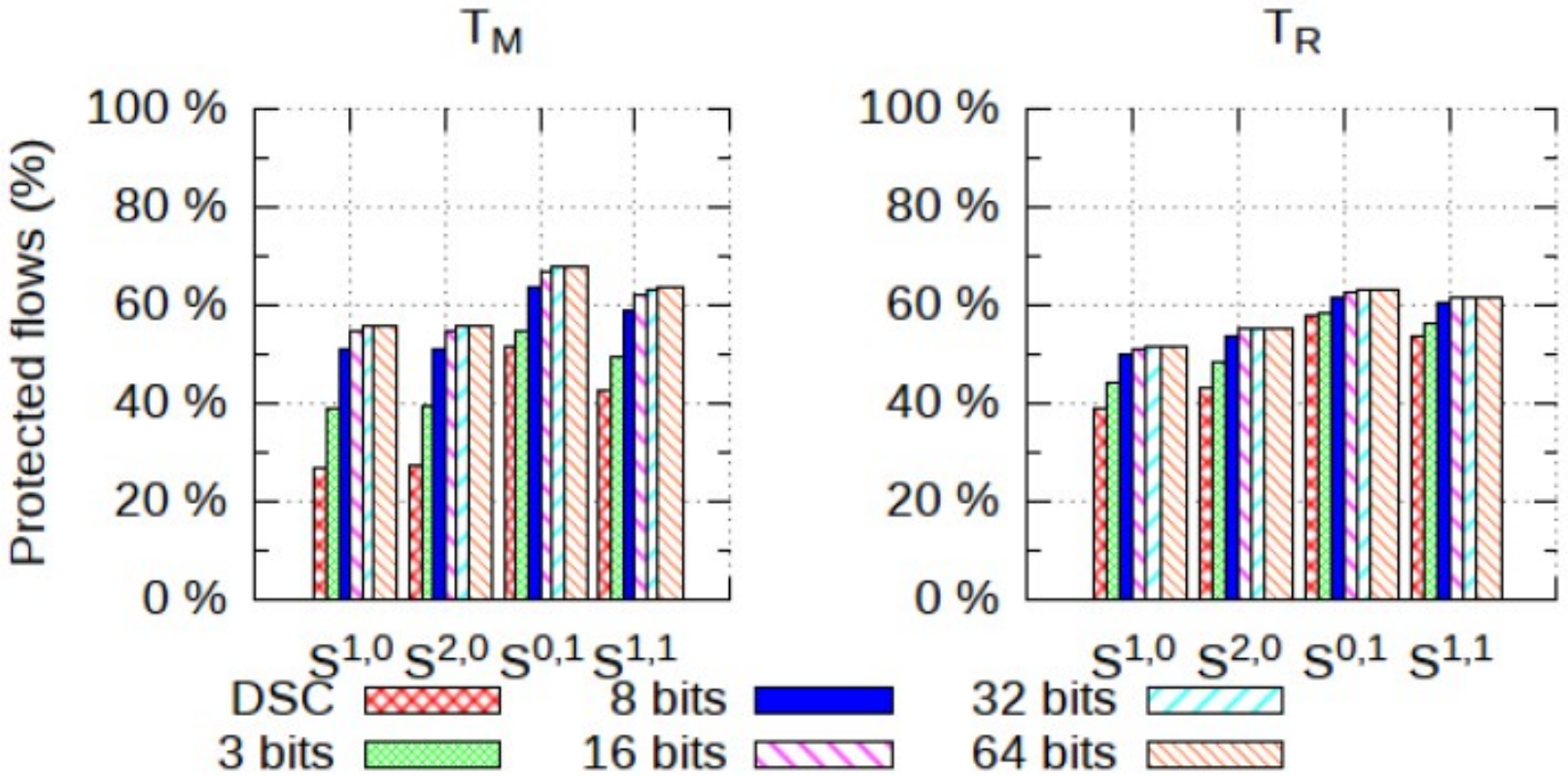


- Use small ID labels and map one bit to multiple nodes

⇒ Packets may be dropped unnecessarily



Impact of ID Label Size

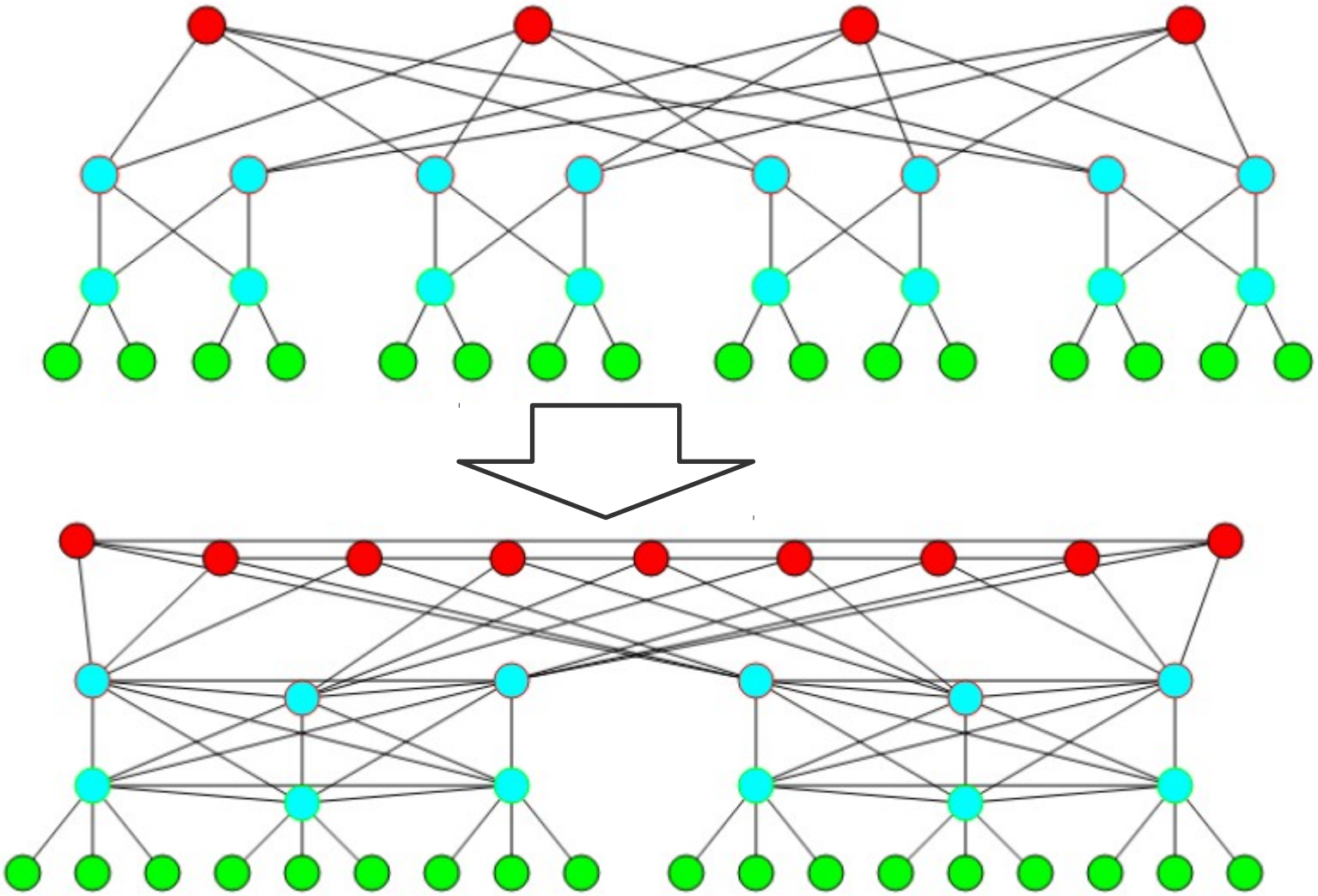


- Results for 14 networks with 50 or more nodes
- Label size of 8 to 16 bits can be sufficient for large networks
  - MPLS labels may be used

LFAs in Data Center Topologies

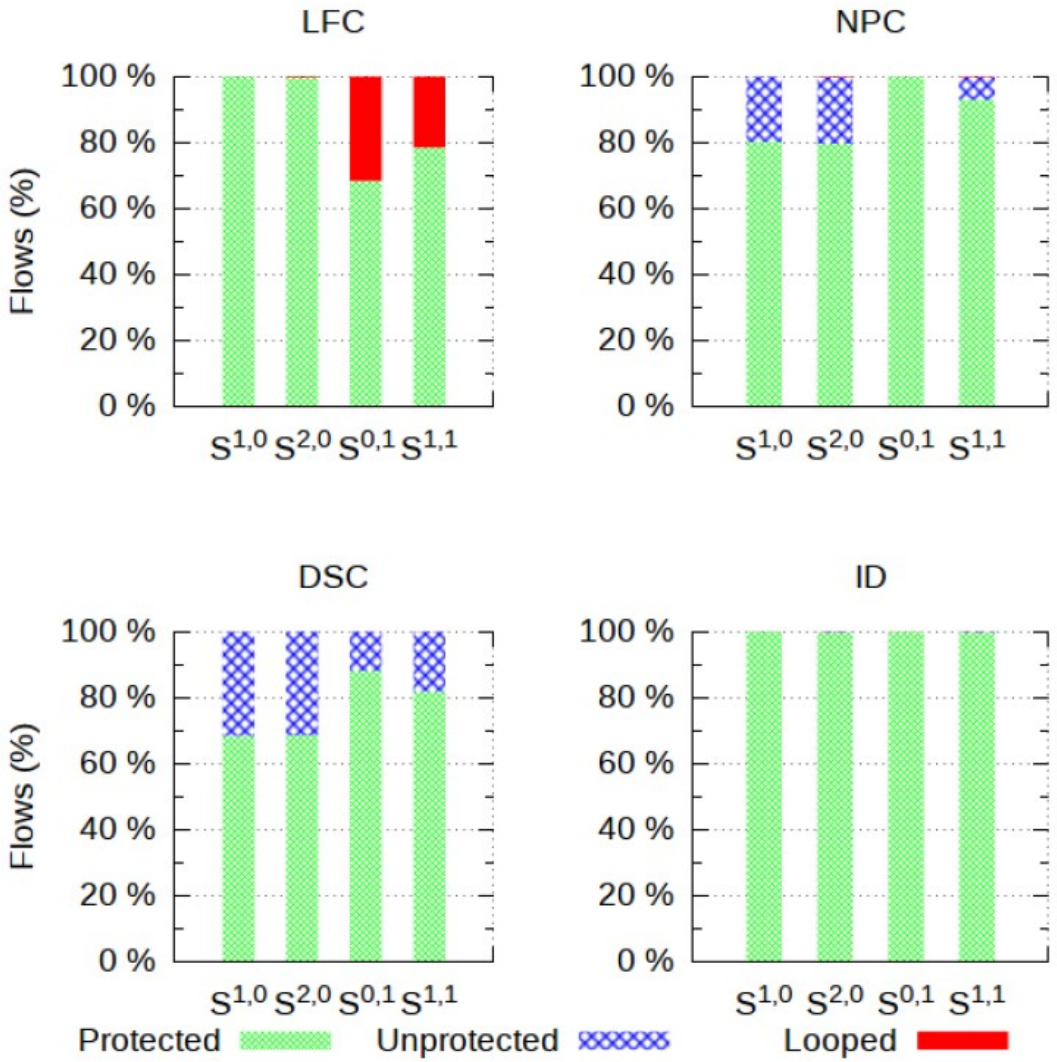
	Fat-tree	BCube	DCell
LFC	70.8% - 81.9%	18.8% - 19.1%	21% - 50%
LFC-NPC	70.8% - 81.9%	18.8% - 19.1%	21% - 50%
LFC-DSC	70.8% - 81.9%	18.8% - 19.1%	0% - 28%
LFA-ID	70.8% - 81.9%	18.8% - 19.1%	21% - 50%

Link-Augmented Fat-Tree



LFAs in Link-Augmented Fat-Tree

- Full protection for single link failures with LFC
- But many loops in case of node failures and multiple failures
- LFA-ID almost protects 100% even for multiple failures (< 0.3% of flows cannot be protected)



Conclusion & Future Work

- LFAs for OpenFlow-based SDN with loop detection
  - ID label
  - 1 flow entry per switch

- Coverage depends on network topology
  - Almost full failure coverage in link-augmented fat-tree topologies

- Future work: add remote LFAs
  - Complete coverage
  - Keep overhead low