EBERHARD KARLS UNIVERSITÄT TÜBINGEN

MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT

Kommunikationsnetze

Hardware-Based Evaluation of Scalable and Resilient Multicast with BIER in P4

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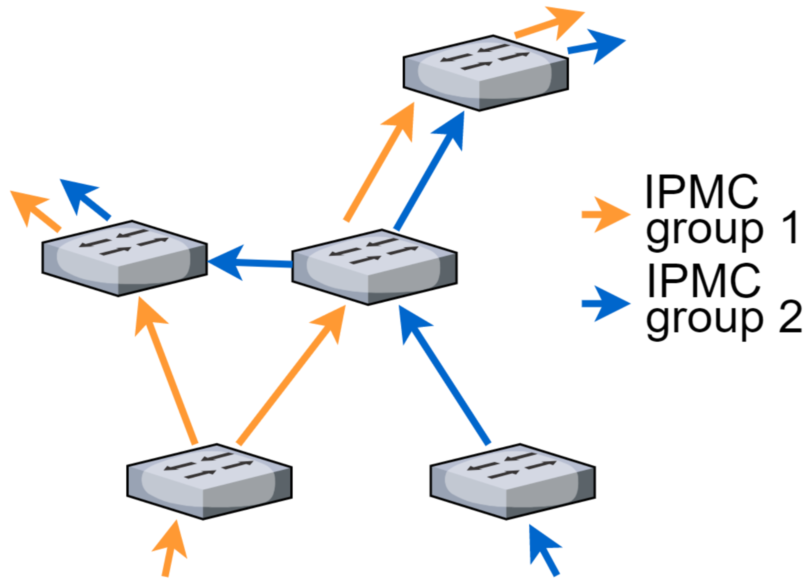
Outline

- Traditional IP multicast
- BIER
- Implementation of BIER in P4
- BIER Fast Reroute

IP Multicast (IPMC)

- IP multicast (IPMC) efficiently distributes one-to-many traffic



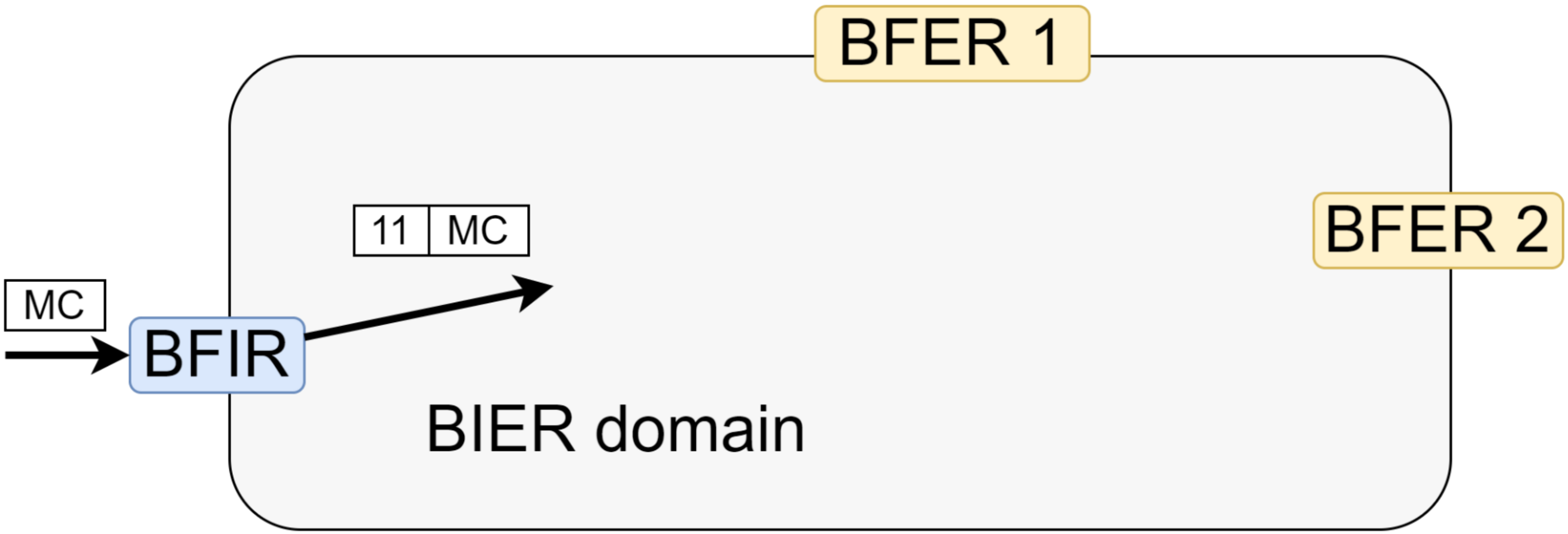
⇒ Traditional IPMC core network requires

1. State per multicast group to know next-hops (NHs) of a packet
2. Signaling in core network when Group subscriptions change

⇒ Scalability of traditional IPMC is limited

Bit Index Explicit Replication (BIER)

- Efficient transport mechanism for IPMC traffic
  - Domain concept
  - Core routers do not require state per IPMC group



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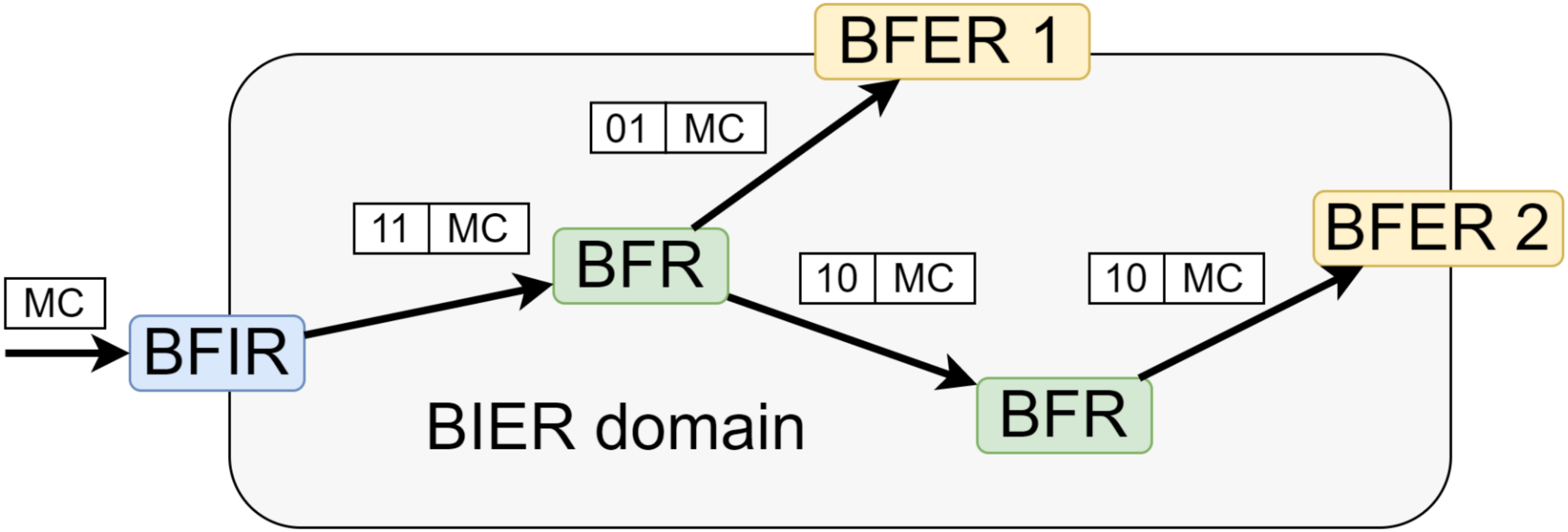

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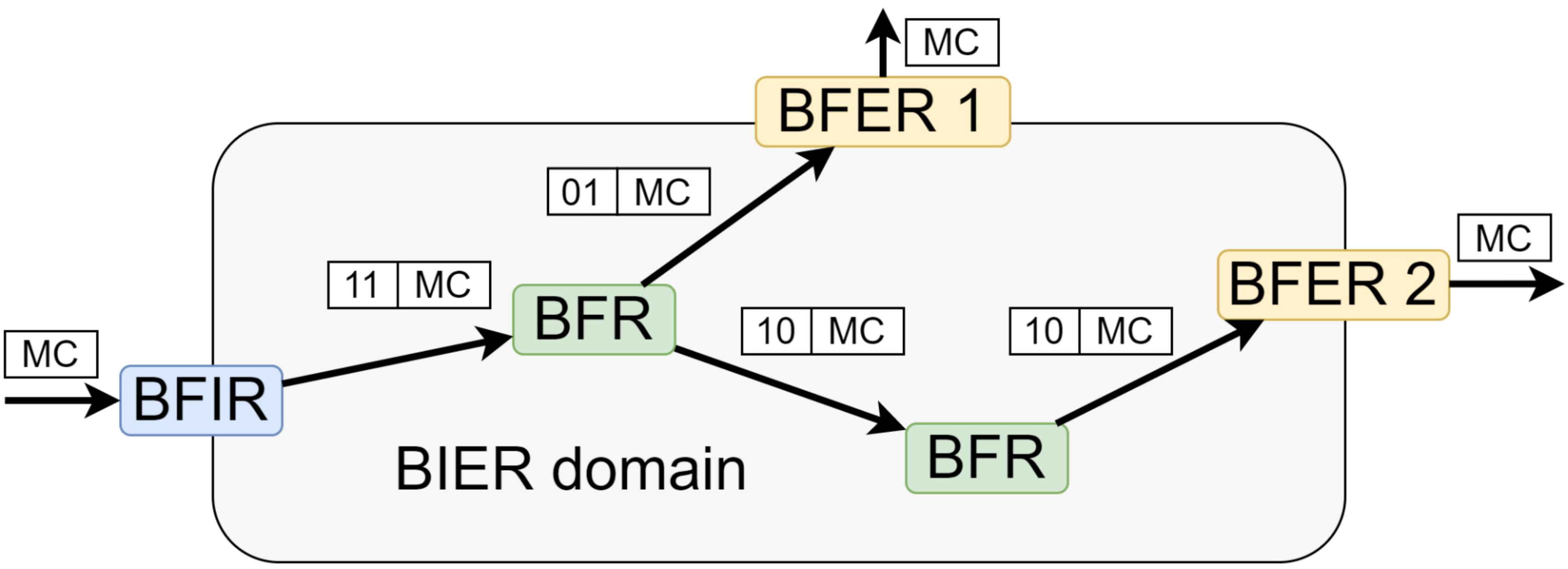
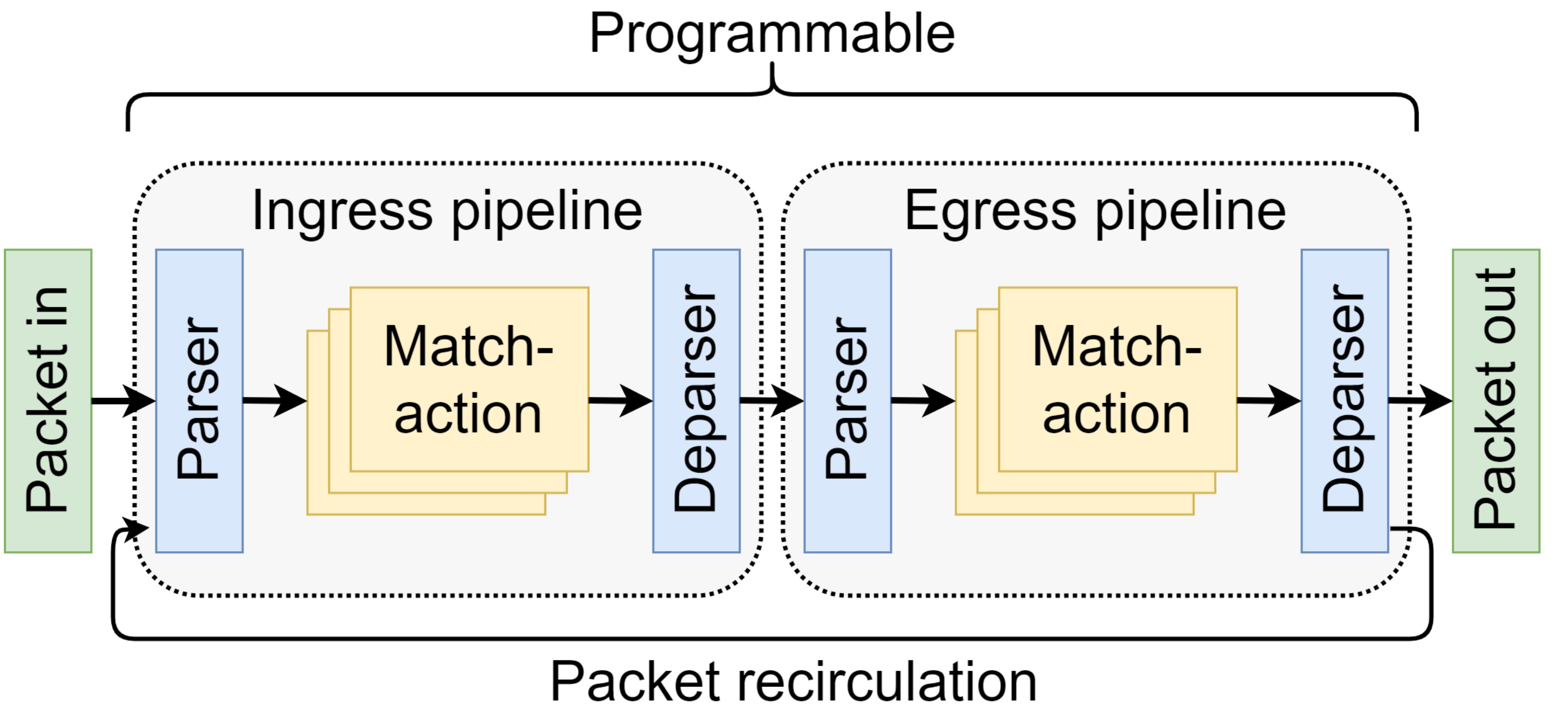
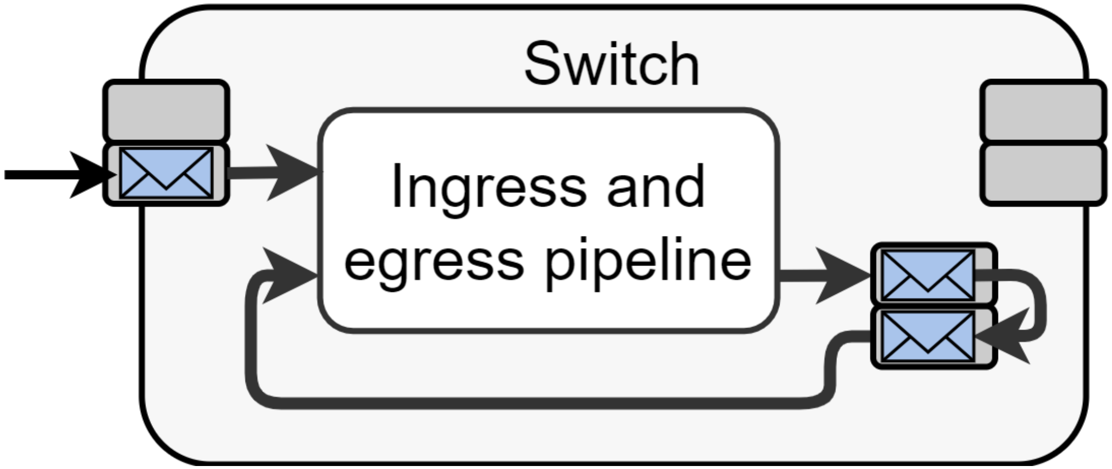


- High-level programming language to describe data plane
  - Compiler maps P4 program onto programmable pipeline of target



Packet Recirculation in P4

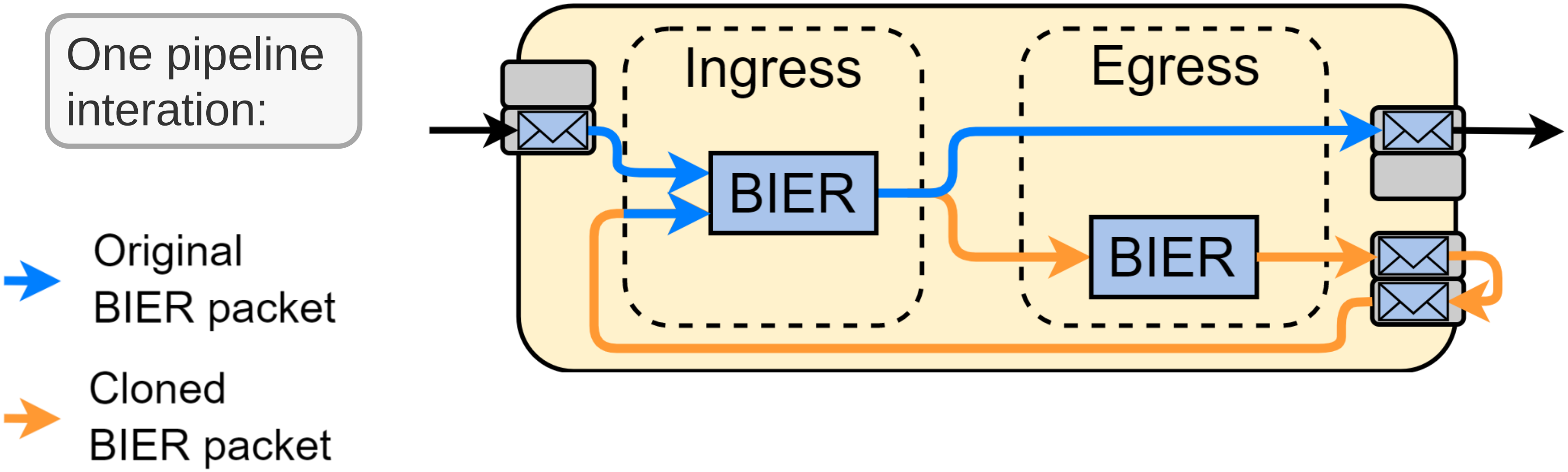
- Paket is sent to switch-intern recirculation port



- Port can be overloaded if to many packets are recirculated

⇒ Additional physical ports in loopback mode

- Create packet clones and forward them to all relevant next-hops



BIER in P4

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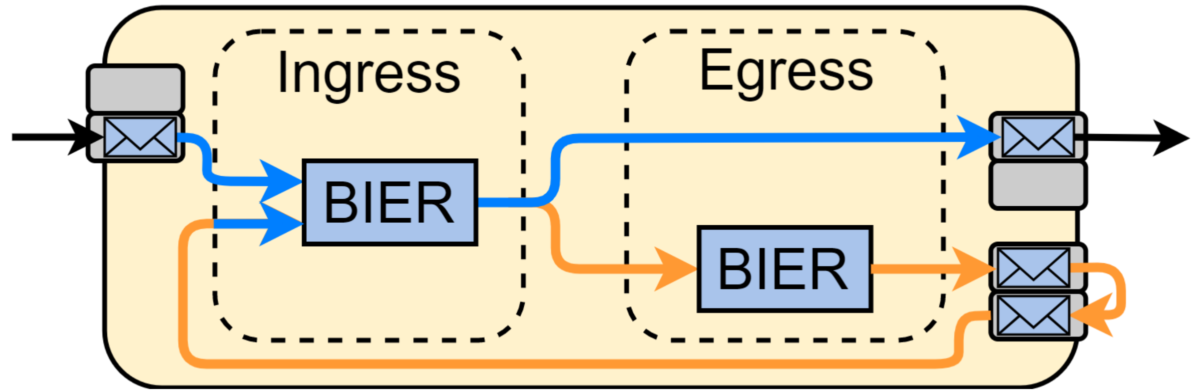
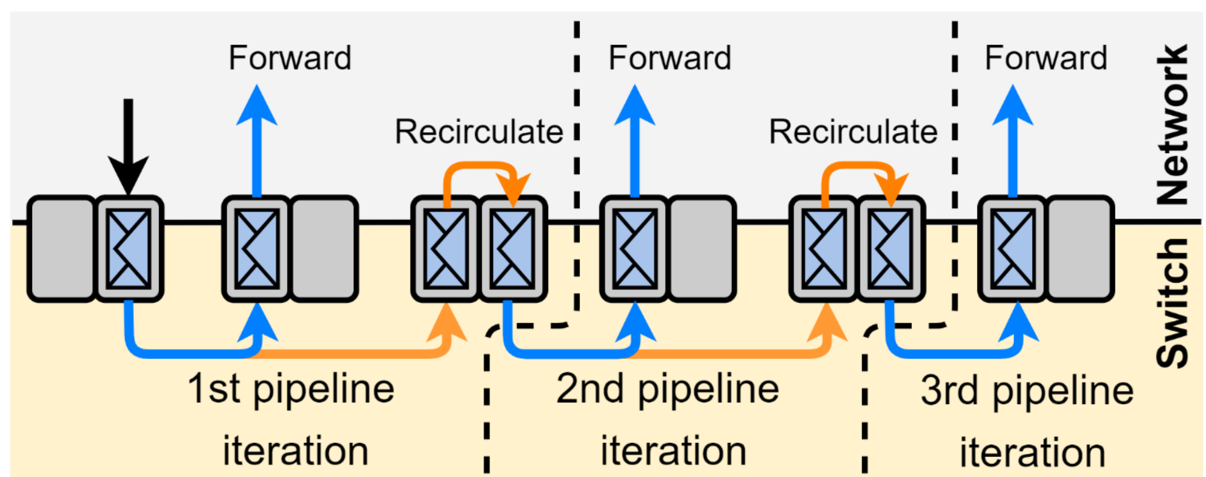
One pipeline interation:



Original BIER packet

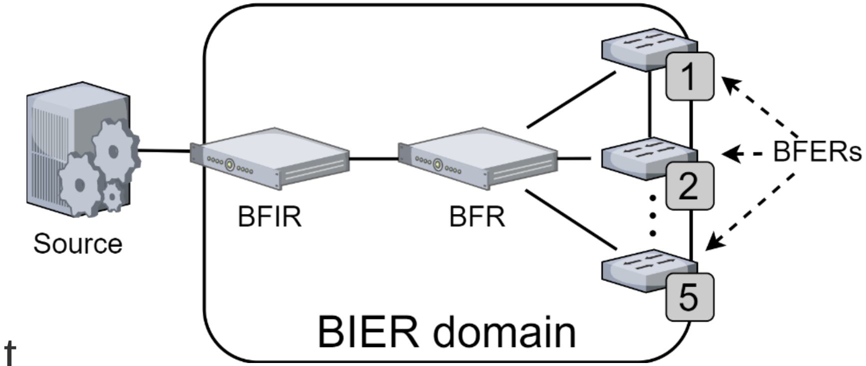
Cloned BIER packet

Entire packet processing:



Throughput Measurements: Setup

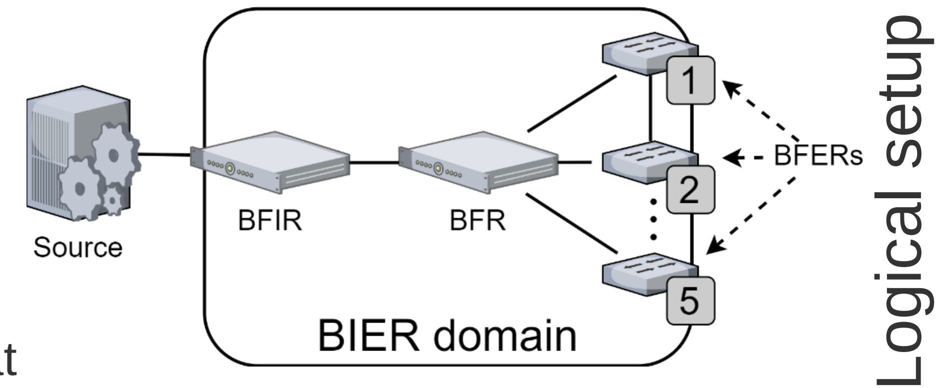
- Measure end-to-end throughput
  - Change amount of recirculation traffic
    - Number of next-hops
  - Measure throughput always at last next-hop!

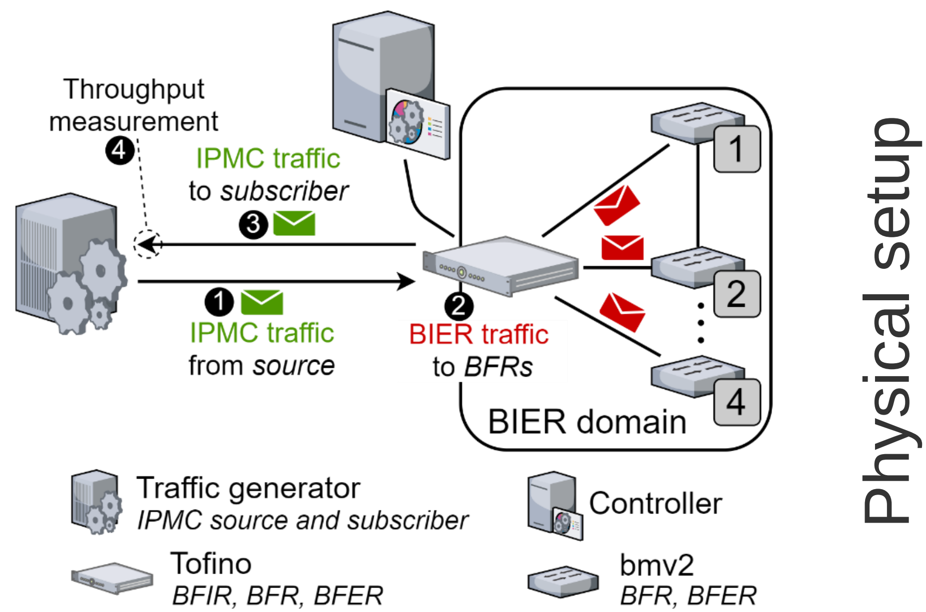


Logical setup

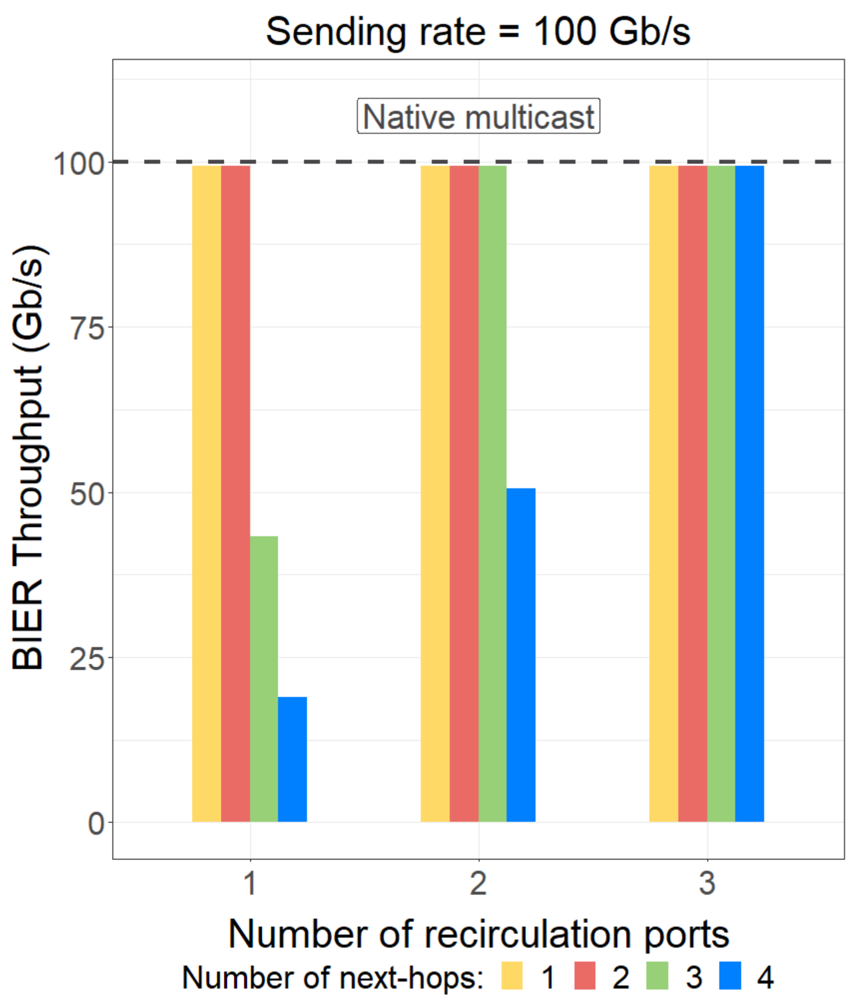
Throughput Measurements: Setup

- Measure end-to-end throughput
  - Change amount of recirculation traffic
    - Number of next-hops
  - Measure throughput always at last next-hop!
- Tofino
  - P4 programmable high-performance switch ASIC
  - In Edgecore Wedge 100BF-32X
- 100 Gb/s traffic generator

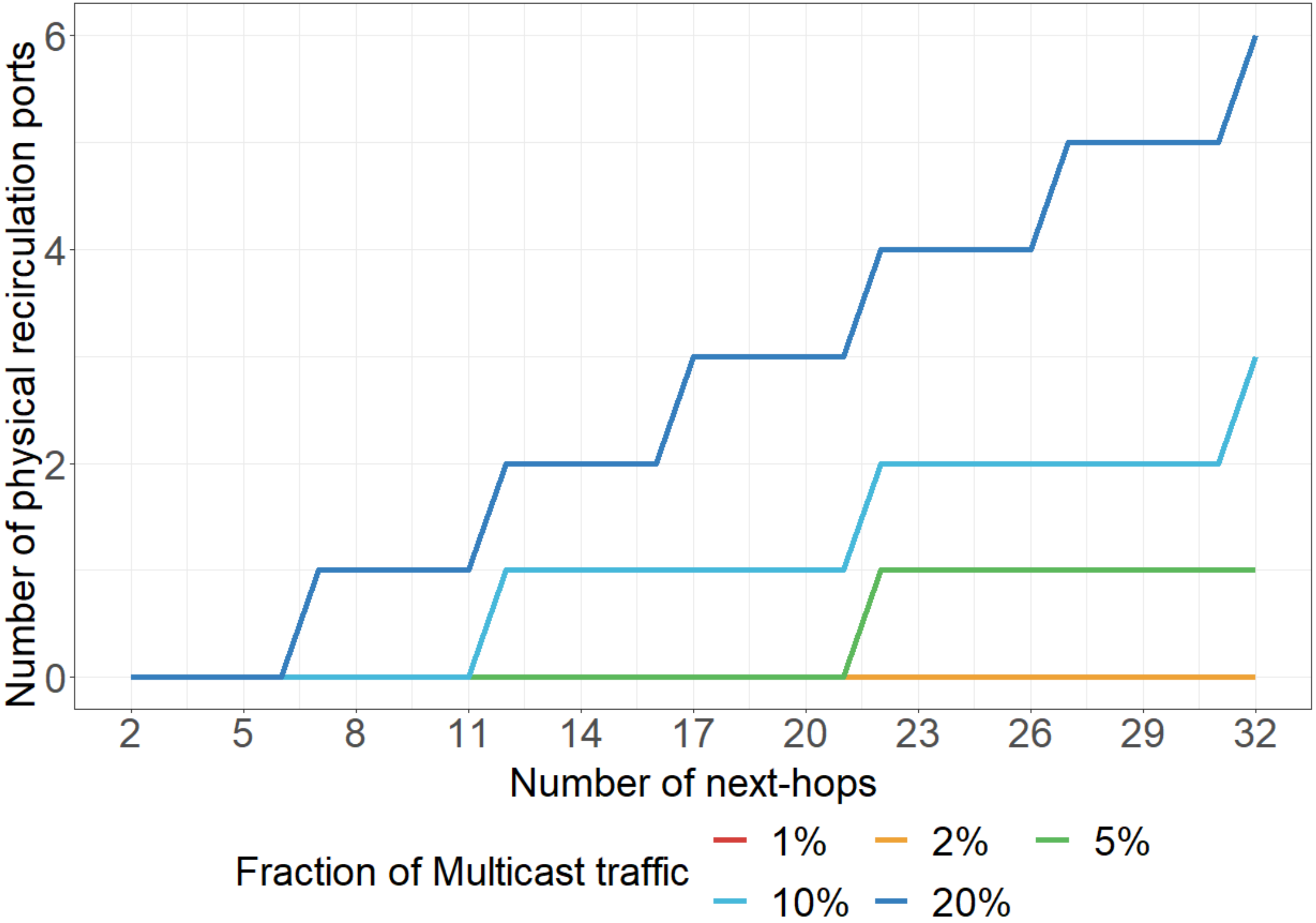




Throughput Measurements: Results



Provisioning of Recirculation Ports



BIER Fast Reroute (BIER-FRR)

- BIER patent mentions fast reroute (FRR) for BIER based on loop-free alternates
  - LFAs cannot guarantee full coverage for single link failures [1] [2]
  - LFAs may cause microloops [1] [2]
  - Sometimes multiple BIER packets are sent over the same link [3]

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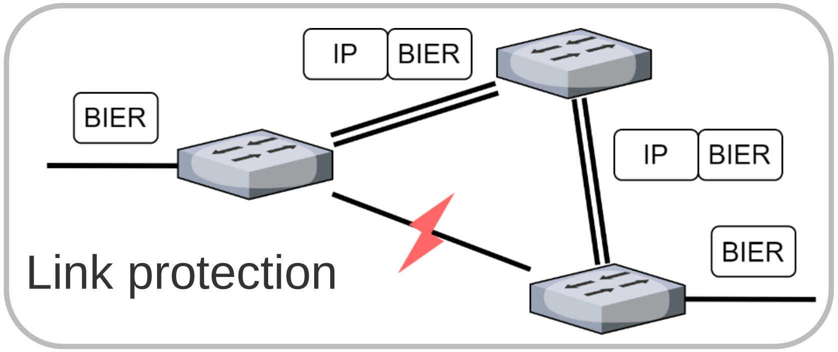
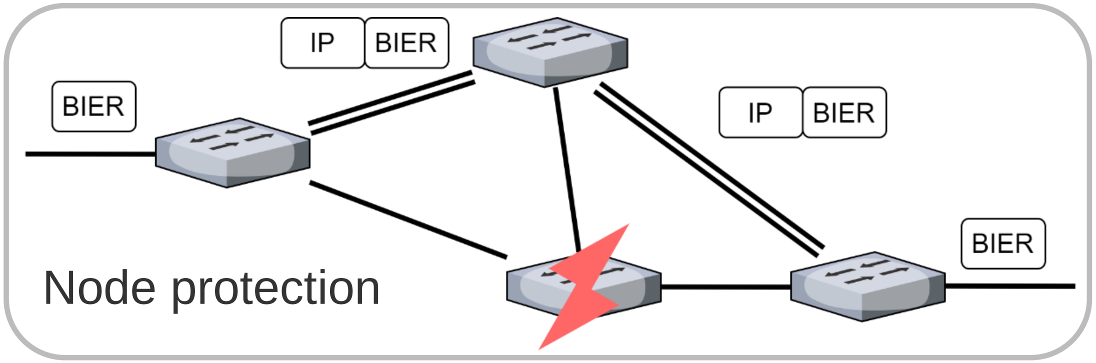


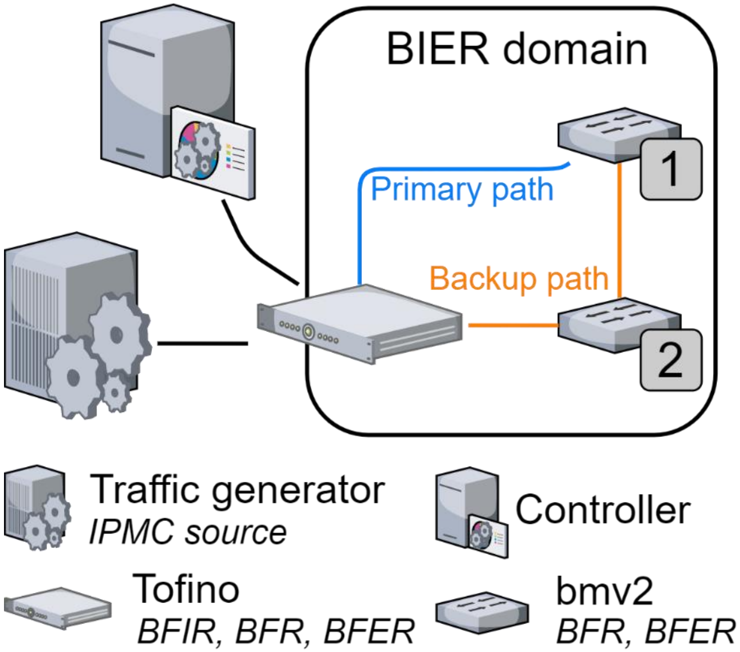
- Tunnel-based BIER-FRR [4]
  - Connectivity is restored faster in routing underlay
    - Unicast FRR
    - Faster recomputation



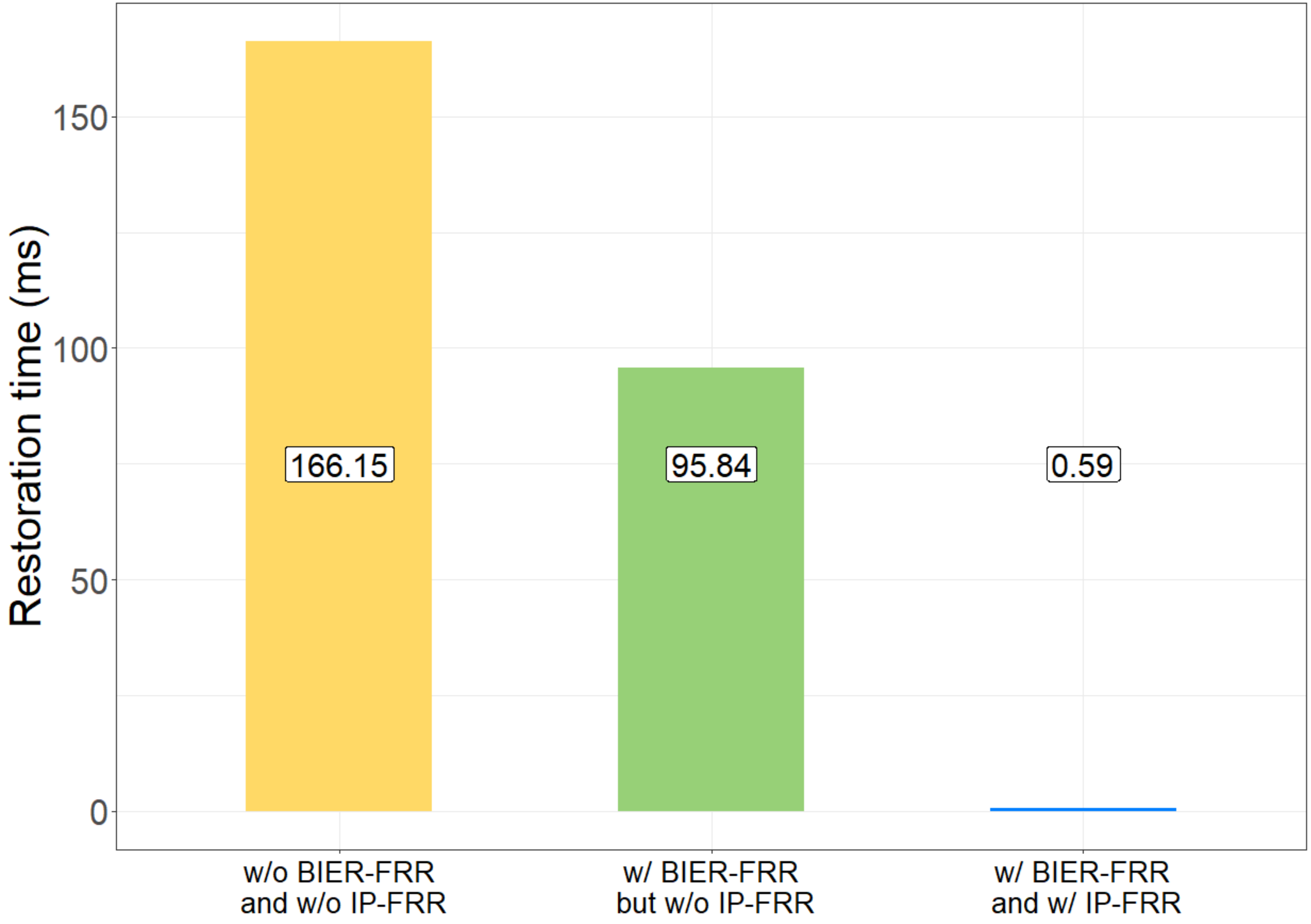
- Comparison in [3]

Restoration Time: Setup

- Time measurement until bmv2 1 receives traffic again after failure of primary path
- Controller is directly connected to Tofino



Restoration Time: Results



Conclusion

- Hardware-based P4 implementation of BIER for 100G hardware
  - Depending on amount of recirculation traffic, physical ports in loopback mode may be necessary to prevent packet loss
  - In realistic scenarios only very few physical recirculation ports are sufficient
- Tunnel-based BIER-FRR significantly reduces restoration time in case of failures

References

[1] D. Merling, W. Braun, and M. Menth, “Efficient Data Plane Protection for SDN,” in IEEE NetSoft, 2018.

[2] W. Braun and M. Menth, “Loop-Free Alternates with Loop Detection for Fast Reroute in Software-Defined Carrier and Data Center networks,” JNSM, vol. 24, 2016.

[3] D. Merling, S. Lindner, M. Menth, “Comparison of Fast-Reroute Mechanisms for BIER-Based IP Multicast”, in SDS, 2020

[4] D. Merling and M. Menth, BIER Fast Reroute, https://tools.ietf.org/html/draft-merling-bier-frr-00, Mar. 2019.