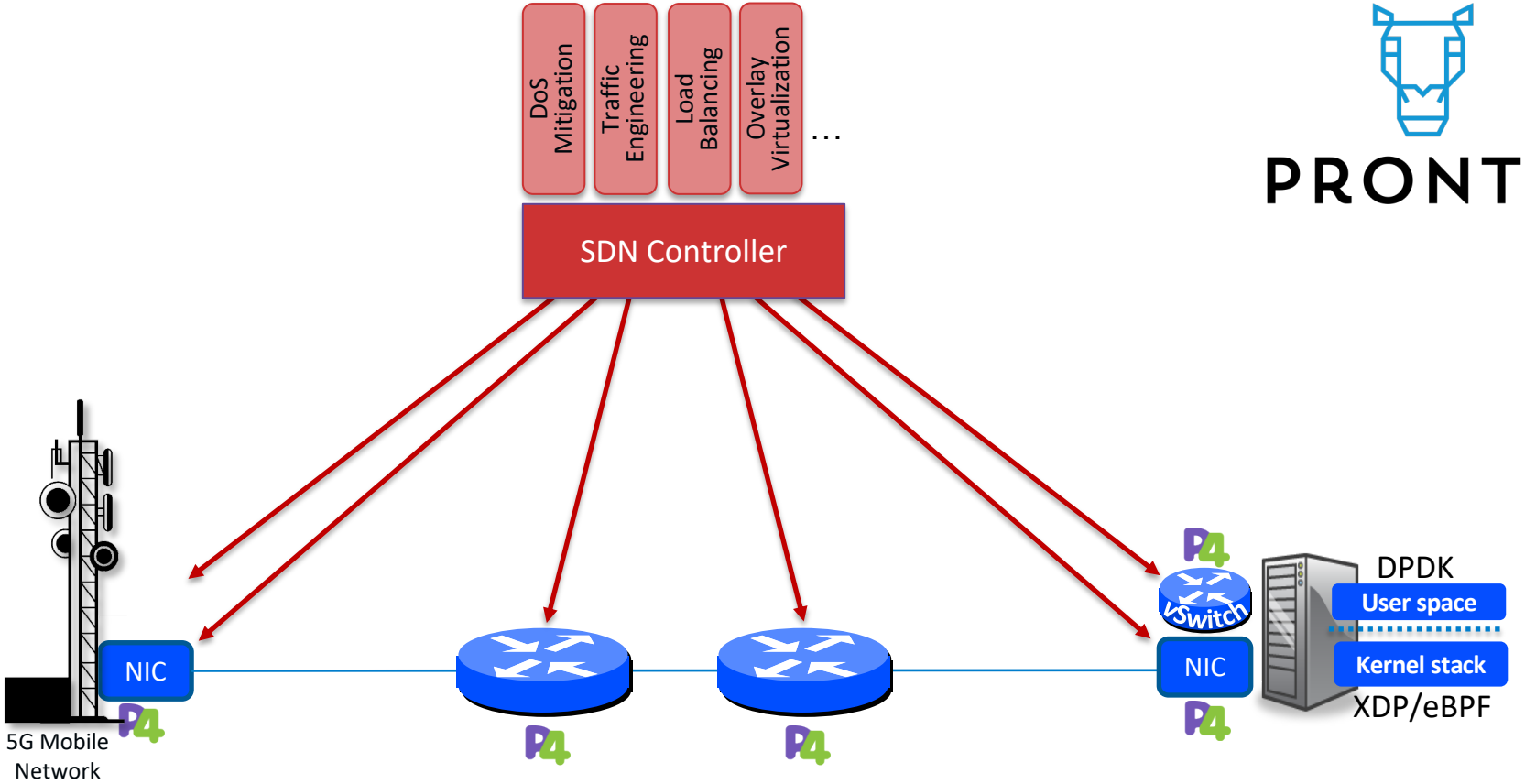
5G Connected Edge Cloud for Industry 4.0 Transformation

Closing the Network Control Loop

Jennifer Rexford, Princeton University

2020

Programmability From Top-to-Bottom and End-to-End



What Will Network Owner's Do?

- What will network owners *do* with this new flexibility?

- We believe they will want to run their networks better!

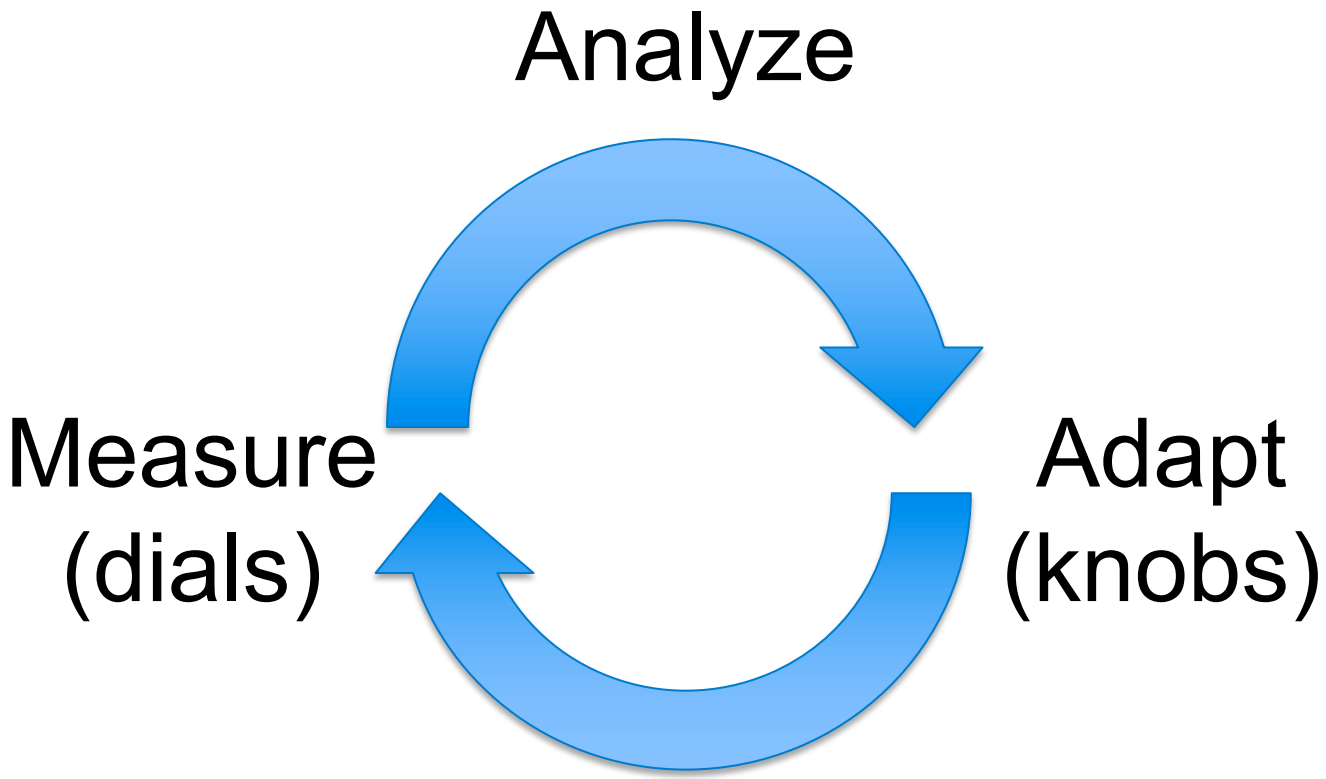
Adding New “Dials”

- Traffic
- Performance
- Cyberattacks
- Failures
- Signal strength
- <Your measurement here>

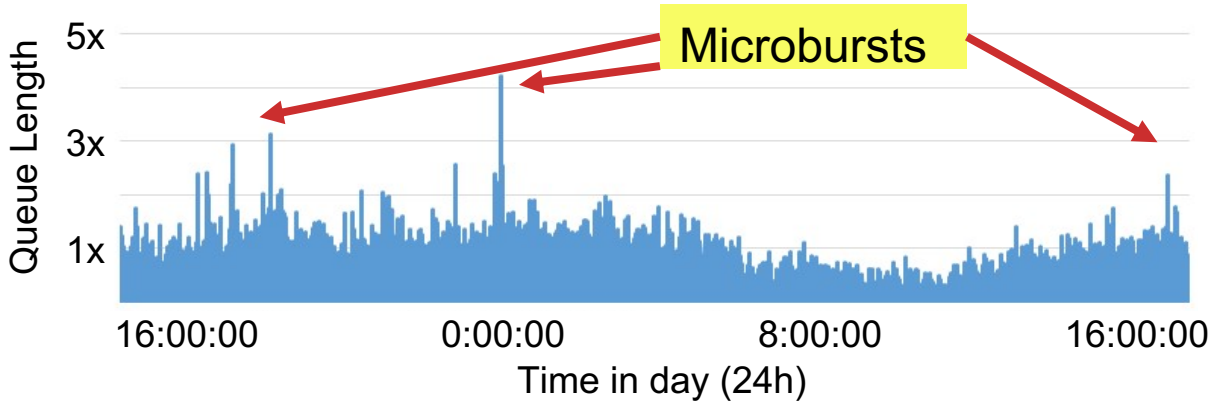
Adding New “Knobs”

- Drop
- Mark
- Rate-limit
- Reroute
- Hand-off
- <your knob here>

Closed-Loop Control



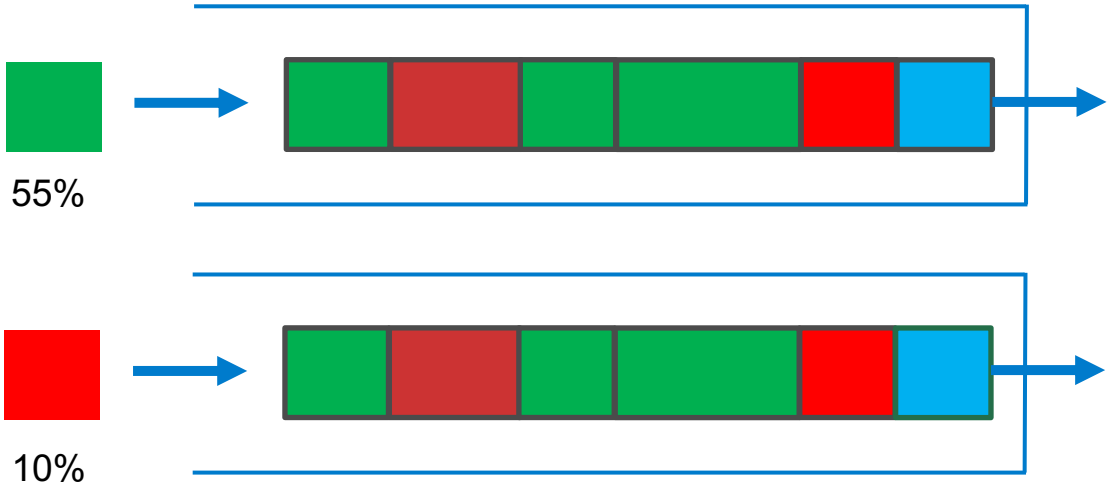
Example #1: Microbursts



- Small timescale traffic bursts
  - Long queues caused by incast, attacks, etc.
  - Lead to high packet delay and loss
  - … despite low average link utilization

Example #1: Microburst Measurement

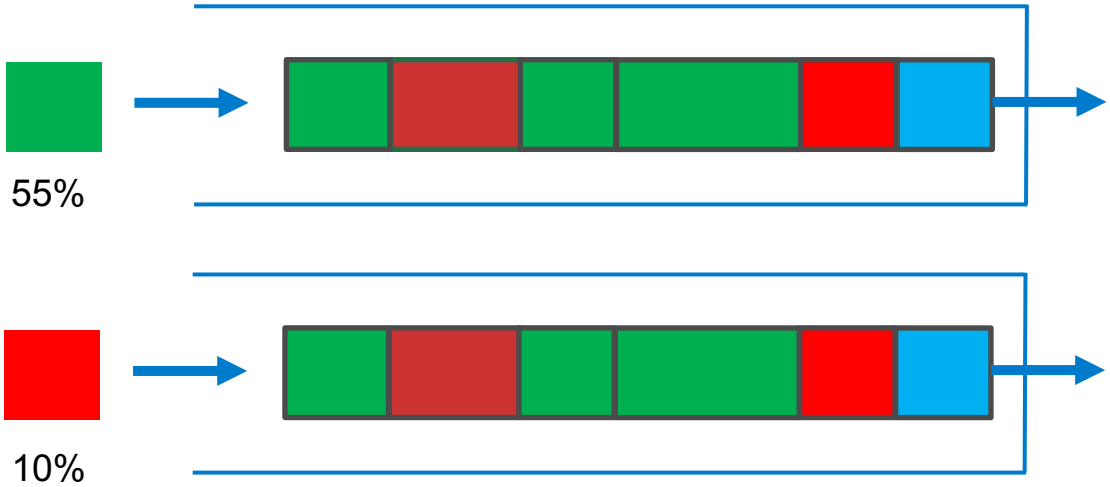
- Data-plane measurement and analysis
  - Backlog in the queue
  - A flow's own contribution to the queue



ConQuest: "Fine-grained queue measurement in the data plane" in CoNEXT'19.

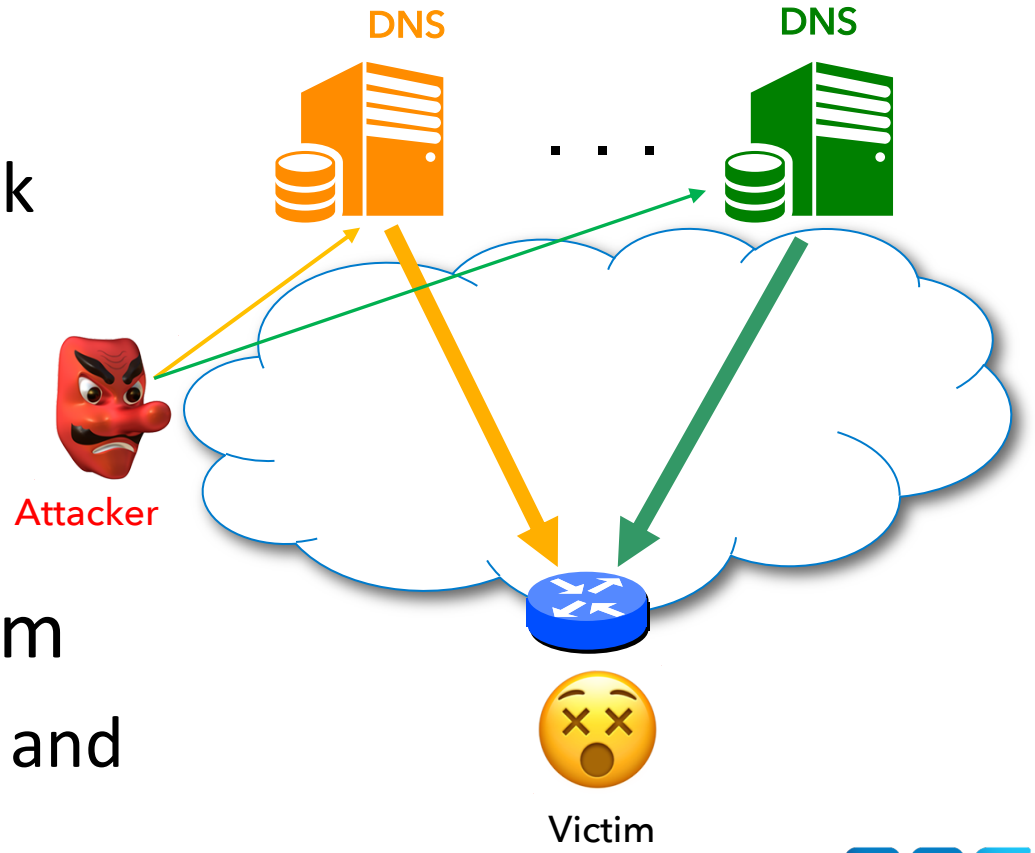
Example #1: Microburst Mitigation

- Data-plane adaptation
  - Drop or mark an arriving packet probabilistically
  - Based on its flow's contribution to the queue



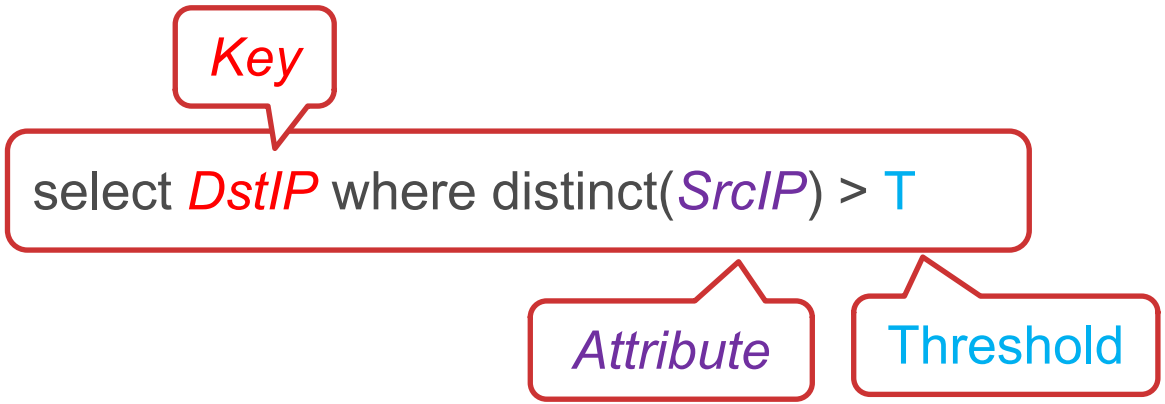
Example #2: Distributed Denial-of-Service Attacks

- DDoS attacks
  - DNS reflection attack
  - SYN flooding
  - HTTP flooding
  - Slowloris attack
- Overwhelm the victim
  - Exhausting network and server resources



Example #2: DDoS Detection

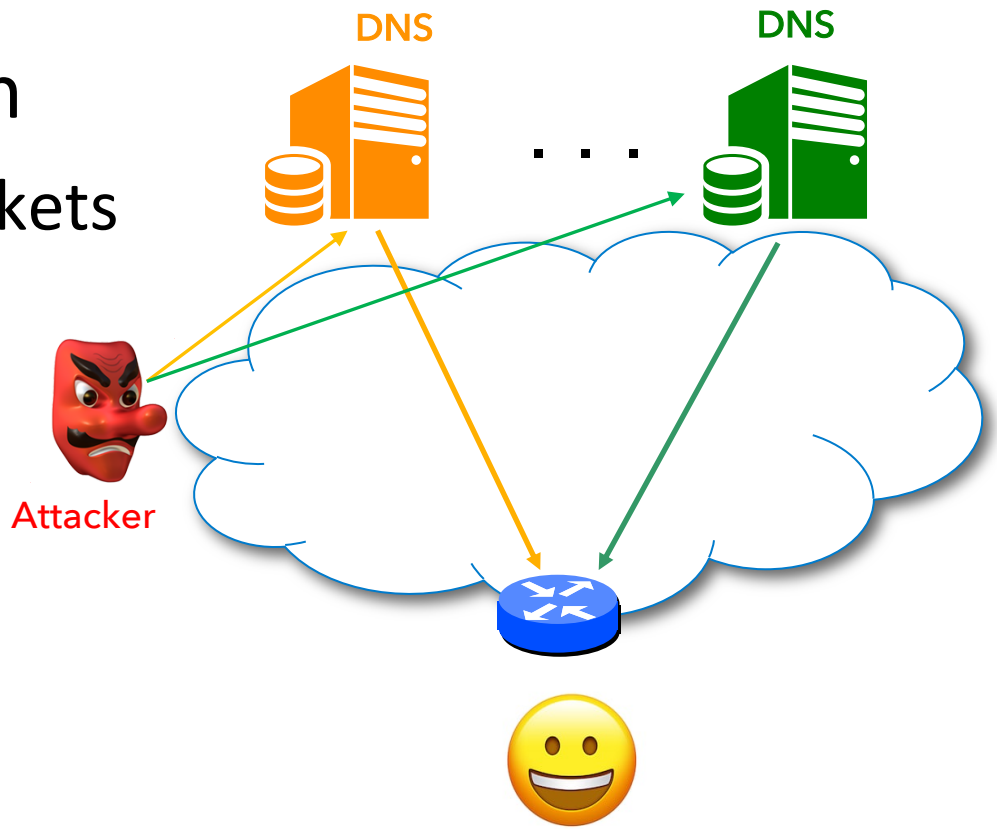
- Data-plane measurement and analysis
  - Identify suspected victim destinations (key DstIP)
  - … receiving traffic from distinct senders (attribute SrcIP)
  - … in excess of a threshold (threshold T)



BeauCoup: "Answering many network traffic queries, one memory update at a time" in SIGCOMM'20

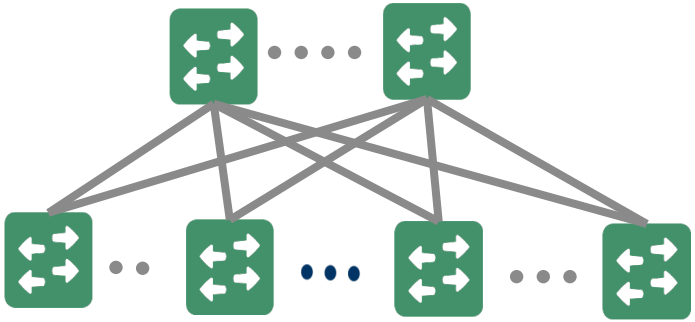
Example #3: DDoS Mitigation

- Data-plane adaptation
  - Drop or rate-limit packets to suspected victims
  - Run stateful firewall for suspected victims
  - Pushback upstream toward the senders



Example #3: Path Performance

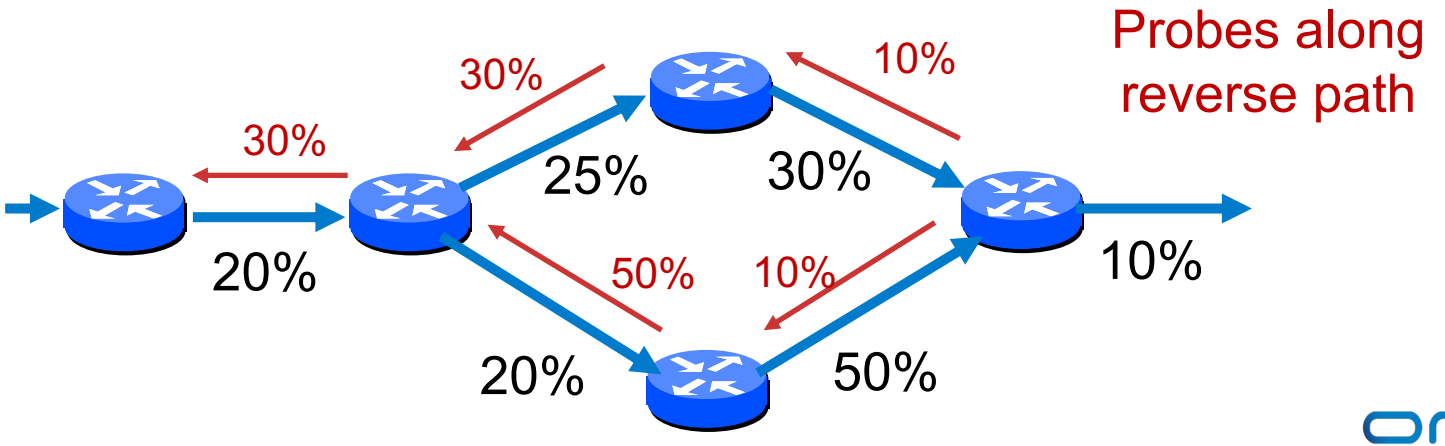
- Network path diversity



- Load balancing to achieve good performance
  - Track the performance (load, loss, delay) of paths
  - Split traffic effectively over the multiple paths

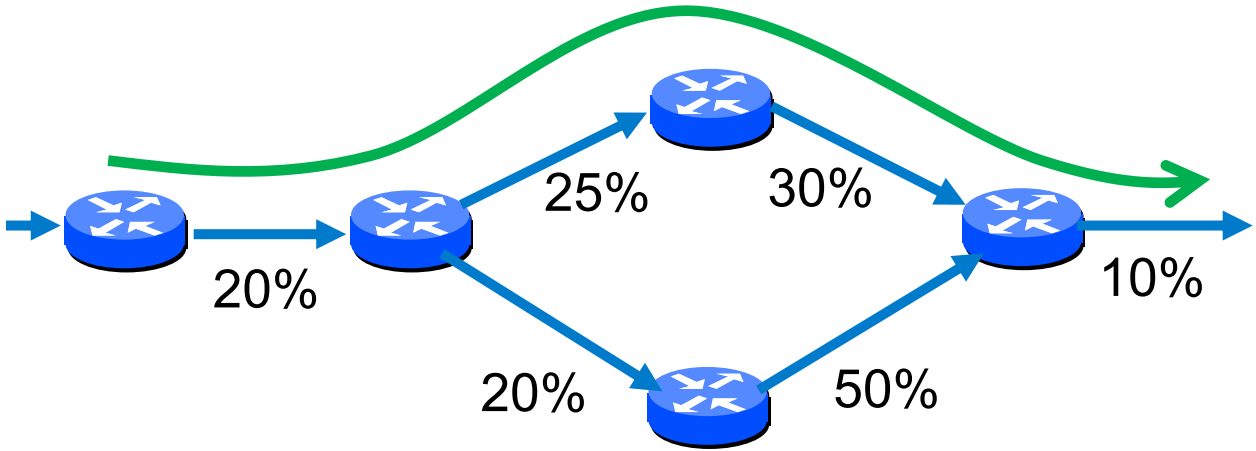
Example #3: Path Performance Monitoring

- Tracking the best path by some metric
  - E.g., lowest maximum link utilization
  - E.g., minimum end-to-end latency or loss



Example #3: Performance-Aware Load Balancing

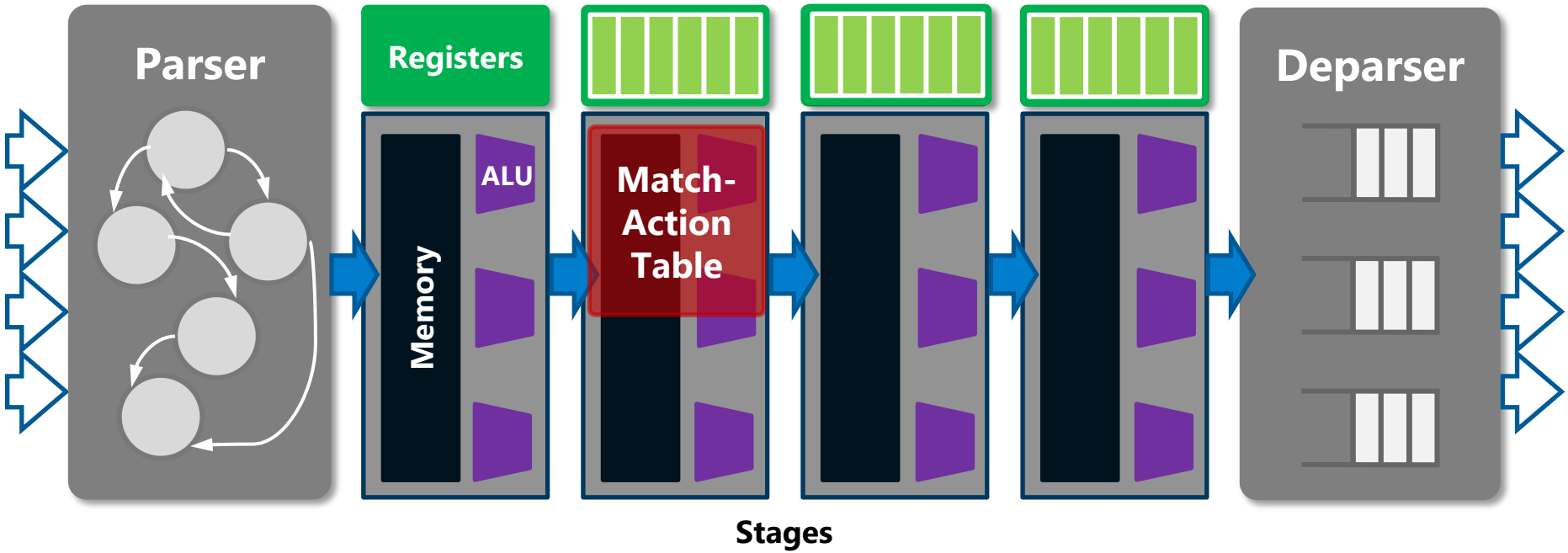
- Directing traffic over the best path
  - Sending packets in the forward direction
  - … along the path with the best performance



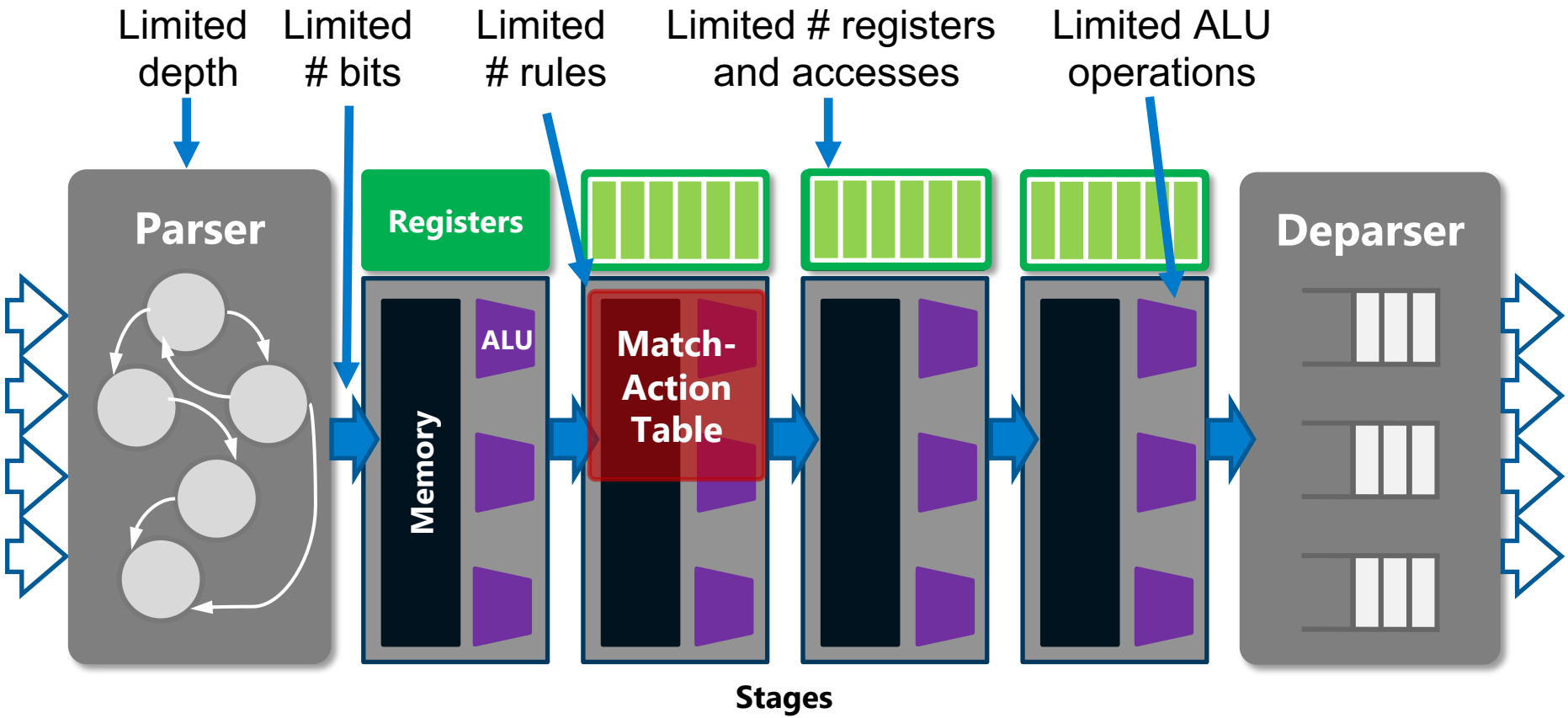
Contra: "A programmable system for performance-aware routing" (NSDI'20)

Enabler: Programmable Data Planes

p4.org

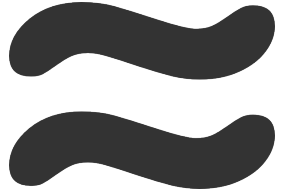


Challenges: Resource Limitations



Solution: Compact Data Structures

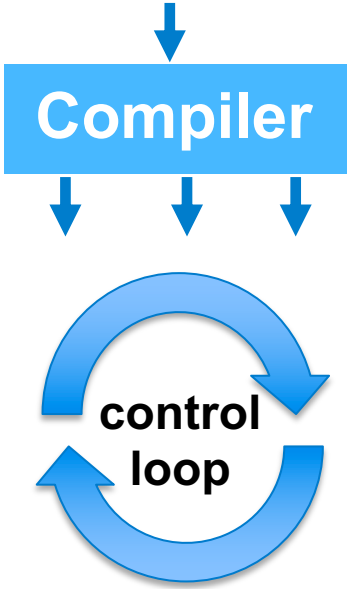
- Approximate analysis is fine
  - Microbursts: size estimate for just the large flows
  - DDoS: rough count for large #s of distinct sources
  - Path performance: rough estimates for best paths



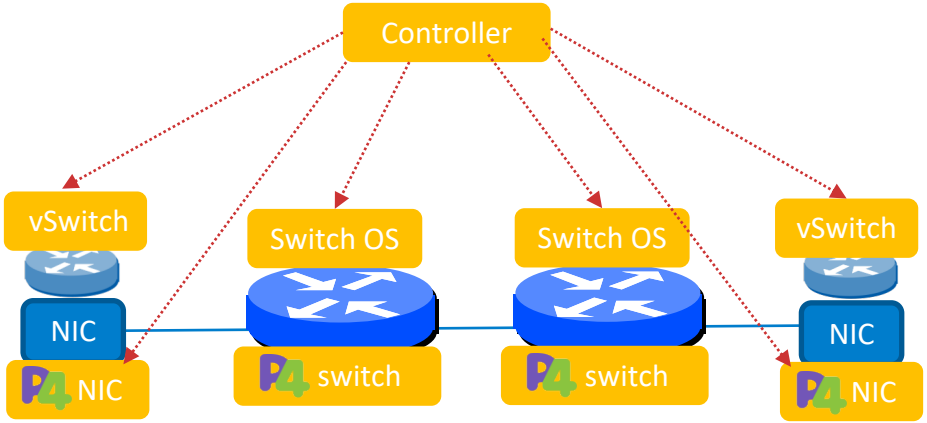
- Data structures can fit in data-plane registers
  - Sketch (e.g., Bloom filter, count-min sketch, etc.)
  - Small hash table (e.g., cache of the popular keys)

Grand Challenge

High-level goals



Distributed software



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Thank You

jrex@cs.princeton.edu
https://www.cs.princeton.edu/~jrex/

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