



Tracking the QUIC Spin Bit on Tofino

Ike Kunze, Constantin Sander, Klaus Wehrle, and Jan Rüth

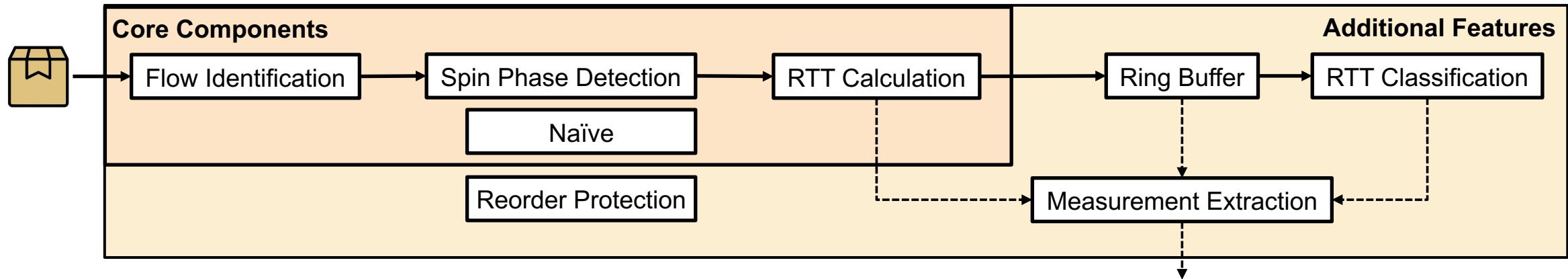
- Network monitoring essential for network management
 - ▶ Growing trend of leveraging programmable networking hardware
- TCP-based measurements leverage protocol semantics
 - ▶ RTT: Handshake or SEQ/ACK [1], [2]
 - ▶ Loss: SEQ/ACK [2]
- QUIC protects semantics
 - ▶ Explicit measurement signal: optional spin bit (RTT)
 - Simpler logic, but susceptible to reordering

[1] Chen et al.: Measuring TCP Round-Trip Time in the Data Plane; <https://doi.org/10.1145/3405669.3405823>

[2] Apostolaki et al.: Performance Driven Internet Path Selection; <https://doi.org/10.1145/3482898.3483357>

Our contribution

- Spin Bit Tracker implementation in P4 for Tofino



- Goals
 - ▶ Evaluate QUIC-specific challenges for monitoring
 - ▶ Propose additional post-processing steps

The Match-Action Pipeline of Tofino

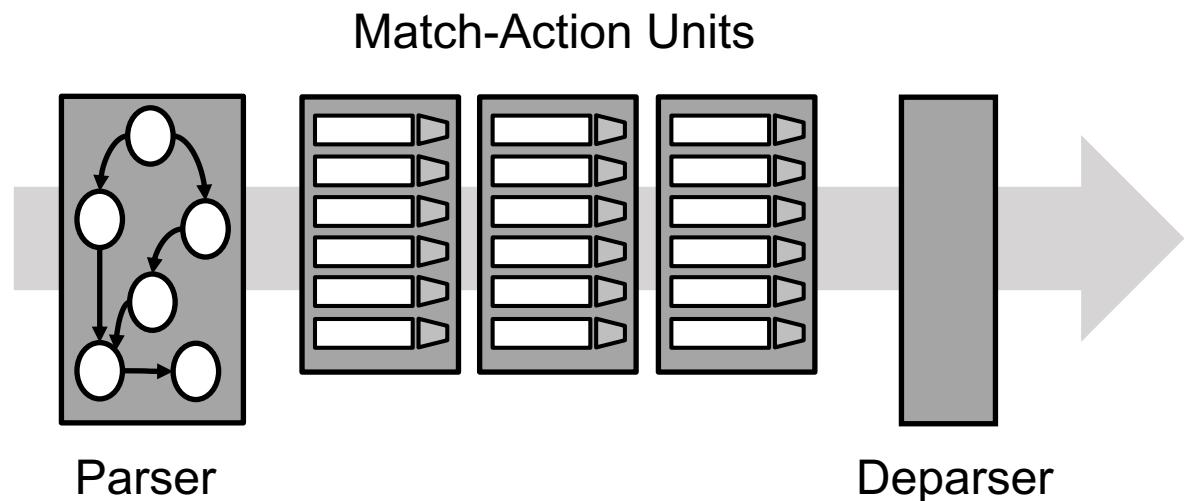
- Simplified Tofino architecture

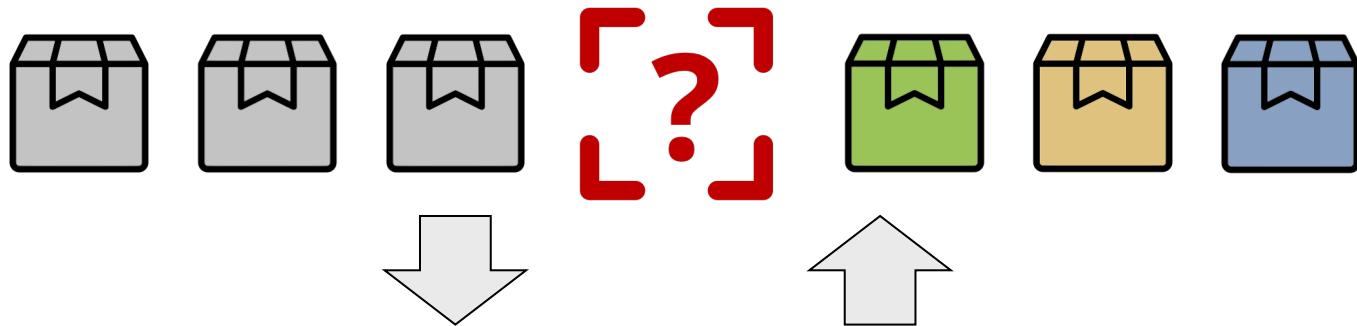
- Parser

- ▶ Extract fields of known length
 - Fixed length
 - Explicit length identifier
 - ▶ No match-action steps

- Match-Action Units

- ▶ Focus on operations with fixed latency
 - No multiplications, divisions
 - Limited stateful operations (single access rule)





- Traditional Way
 - ▶ Five Tuple

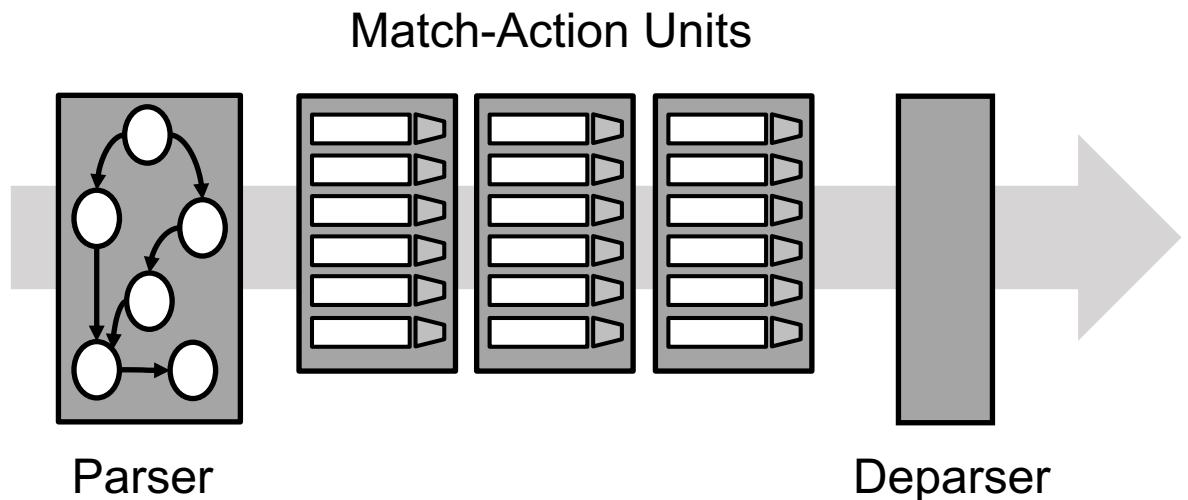
Src IP	Dst IP	Src Port	Dst Port	Proto	Flow
...	
...	
...	

- QUIC
 - ▶ Variable-length Connection ID (CID)
 - ▶ Length negotiated during the handshake



- Short header packet

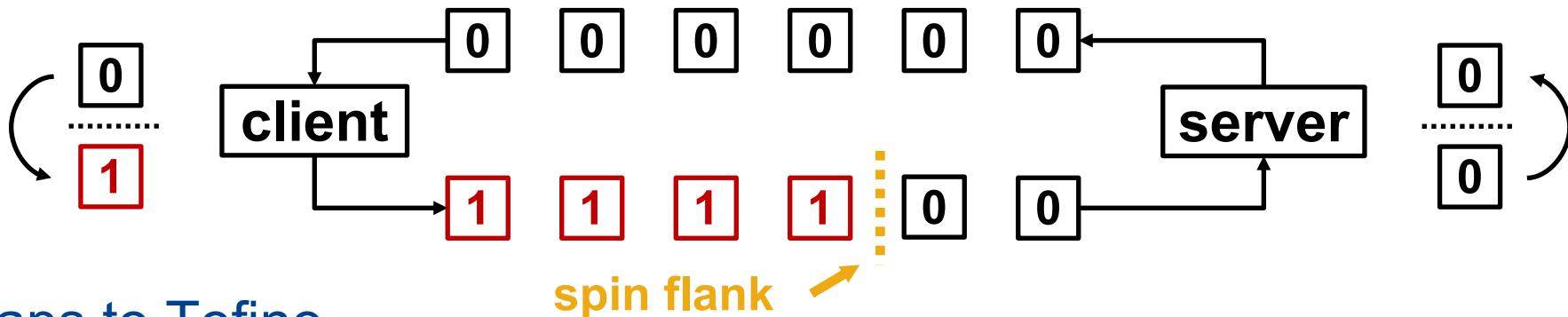
- ▶ No length field
- ▶ Solution
 - Parse all 20 Bytes
 - Extract in MAUs



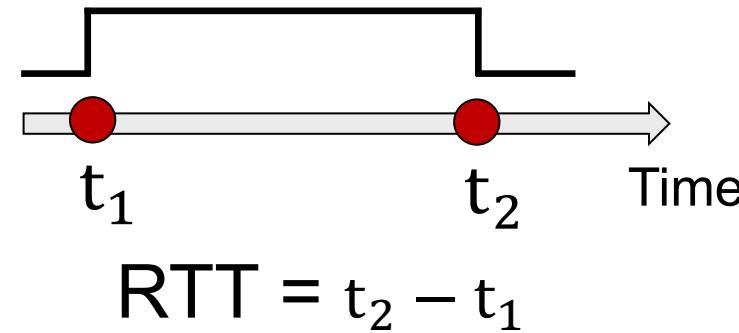
- Long header packet

- ▶ Variable length
- ▶ Explicit length given
- ▶ Challenge
 - Tofino limitations regarding variable length parsing
- ▶ Solution
 - One metadata field for each possible length

Spin Phase Detection & RTT Calculation



- Directly maps to Tofino
 - ▶ One spin state register
 - ▶ One timestamp register
 - ▶ One entry per flow
- Nanosecond timestamp
 - ▶ Scaled to millisecond resolution

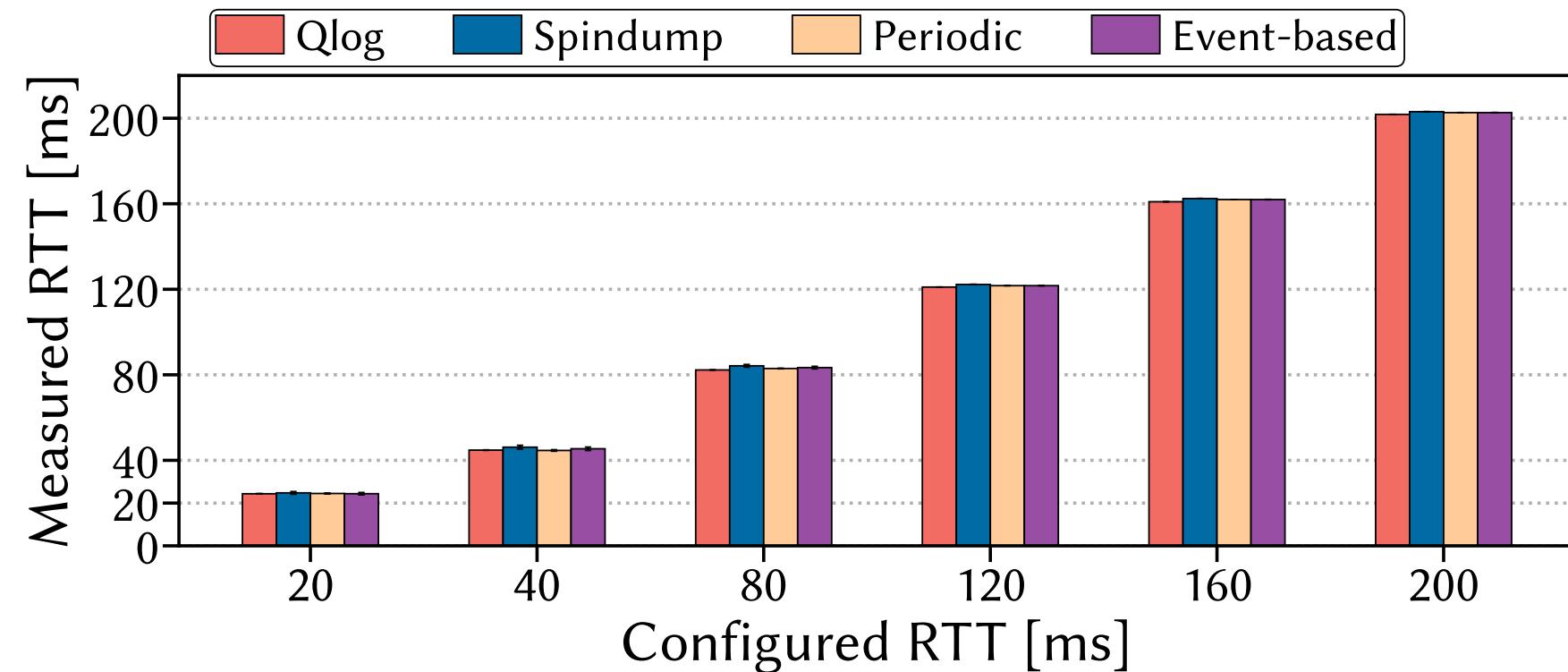
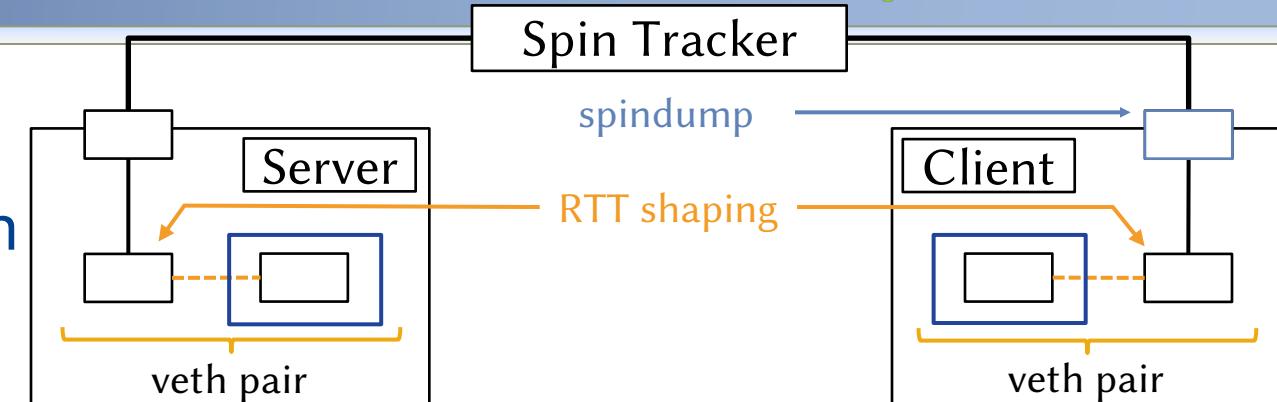




Measurement Accuracy

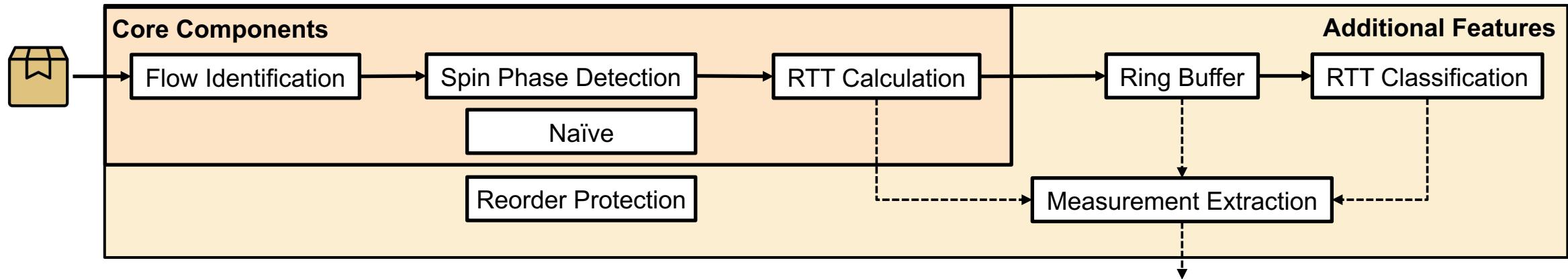
P4

- 2 MB download, 30 runs, mean RTT
- Spindump provides spin bit comparison
- Qlog provides groundtruth



Our contribution

- Spin Bit Tracker implementation in P4 for Tofino



- Goals

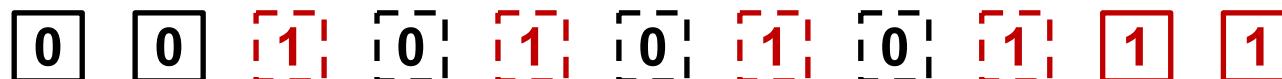
- ▶ Evaluate QUIC-specific challenges for monitoring
- ▶ Propose additional post-processing steps

Reorder Protection

- Reordering is a known weakness [1]



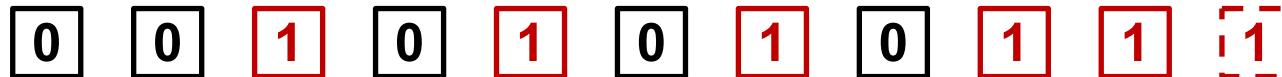
- No protection



- Protection v1 [2]:



- Protection v2:

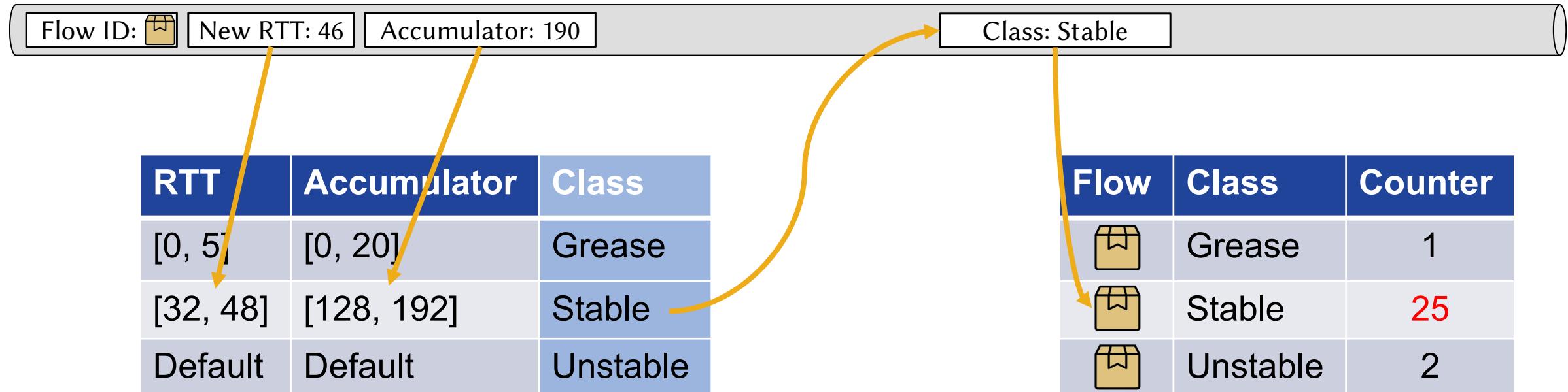


[1] De Vaere et al.: Three Bits Suffice: Explicit Support for Passive Measurement of Internet Latency in QUIC and TCP;
<https://doi.org/10.1145/3278532.3278535>

[2] Cocciglio et al.: Explicit Flow Measurements Techniques;
<https://datatracker.ietf.org/doc/draft-ietf-ippm-explicit-flow-measurements/>

RTT Classification

packet and meta data





Reorder Protection & RTT Classification

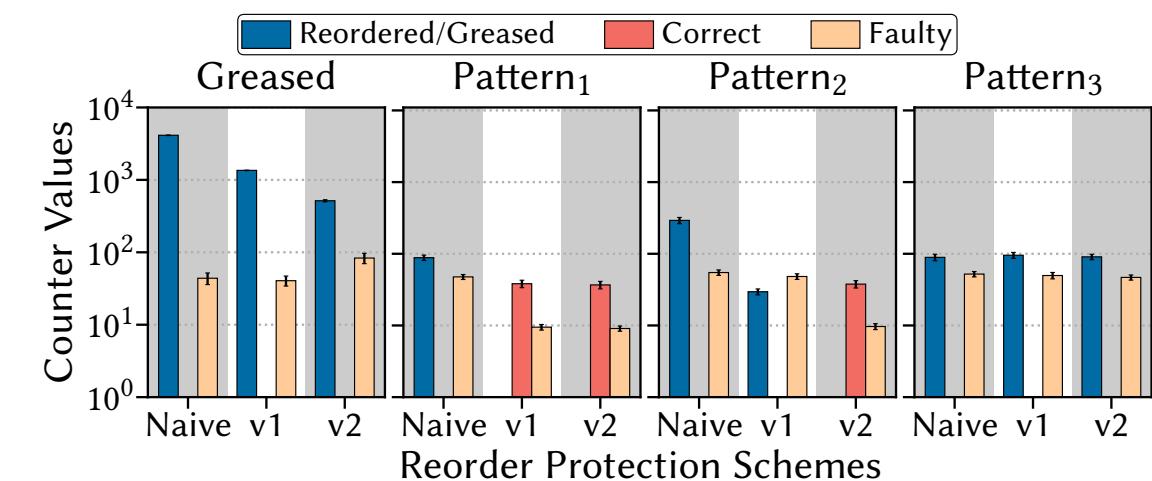
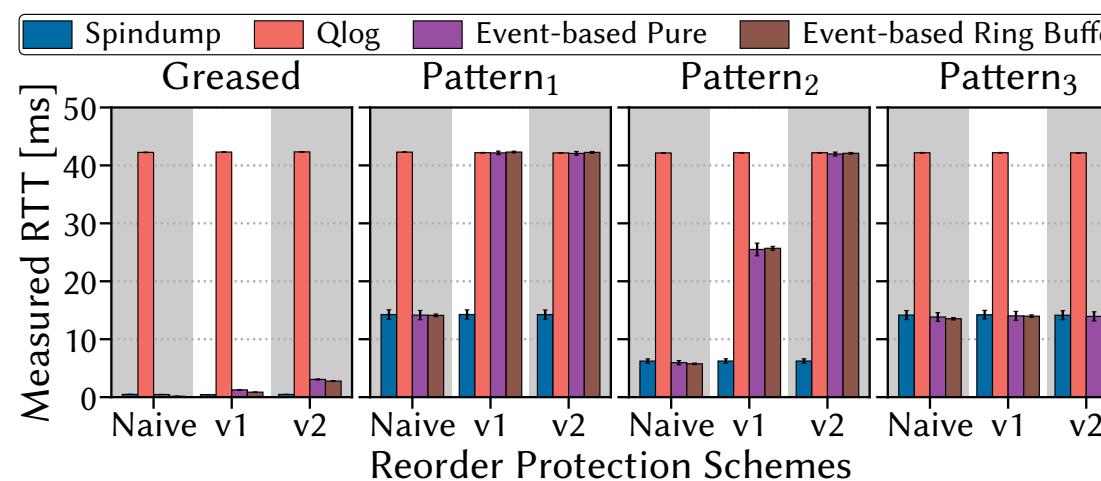
- Four patterns

- ▶ Greased: arbitrary value

- ▶ Pattern₁:

- ▶ Pattern₂:

- ▶ Pattern₃:



- Spin Bit Tracker implementation in P4 for Tofino



- Features

- ▶ Flow identification (using CIDs)
- ▶ Reorder protection
- ▶ RTT classification

- Future Work

- ▶ More detailed evaluation
- ▶ How to leverage the measurements?