Making Speculative BFT Resilient with Trusted Monotonic Counters

Lachlan J. Gunn, Jian Liu, Bruno Vavala, N. Asokan

Aalto University

- Current speculative BFT protocols have a performance-resilience trade-off
- Trusted hardware provides an efficient and secure ordering mechanism
- SACZyzzyva breaks the trade-off: full performance and full fault-tolerance simultaneously

Byzantine Fault Tolerance (BFT)

- Replication of deterministic state machines
- Replicated system looks like one state machine, despite compromised replicas

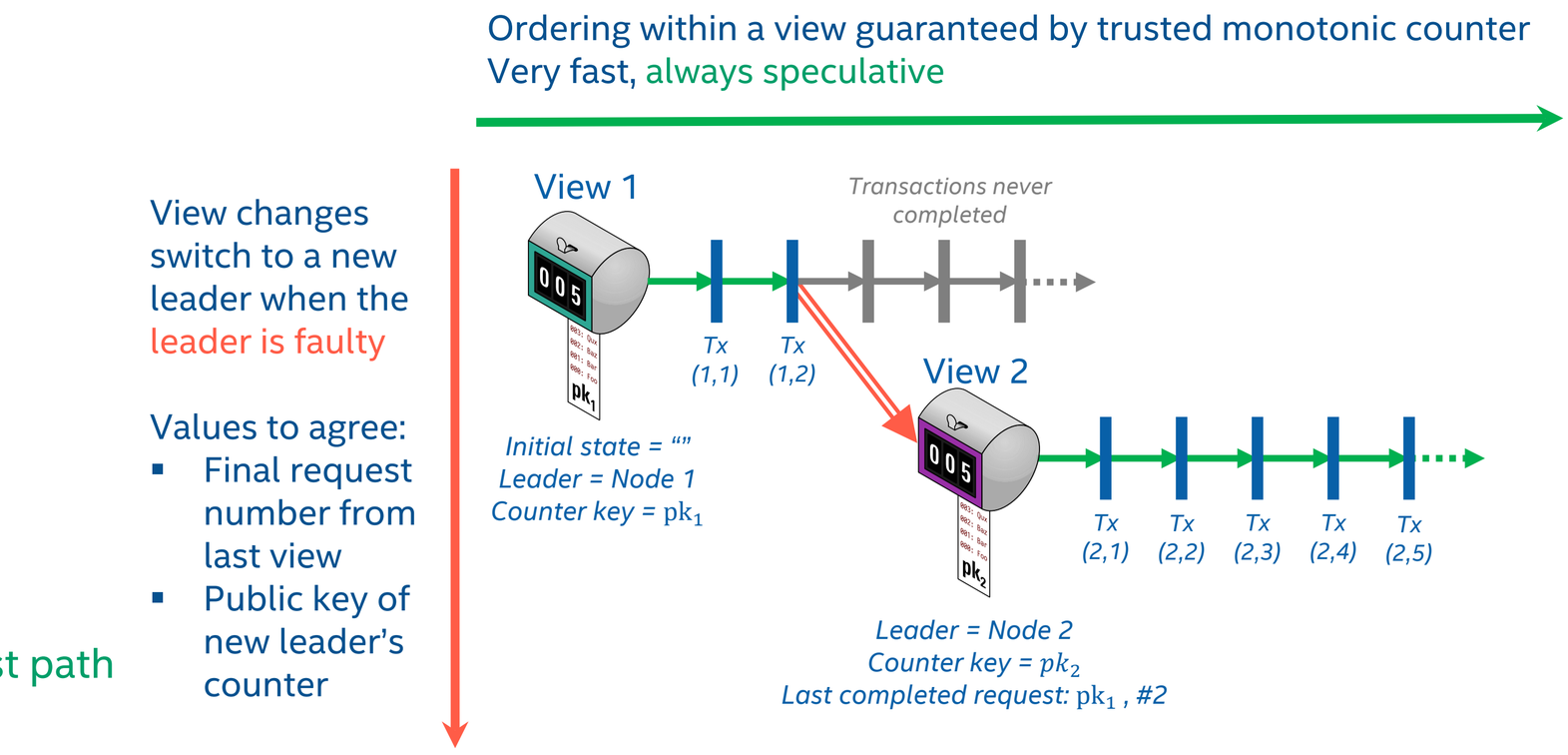
Zyzzyva

- Speculative BFT:
  - Very fast: no waiting for coordination
- Very simple protocol when no faults occur
  1. Leader sends requests to replicas
  2. Replicas respond immediately
- *Any fault* triggers non-speculative fallback
- Zyzzyva5 sacrifices robustness for speed

  To tolerate *f* faults:
  - Zyzzyva: 3*f*+1 replicas, slow after 1 fault
  - Zyzzyva5: 5*f*+1 replicas, never slow in fast path
- Goal: 3*f*+1 replicas, never slow in fast path

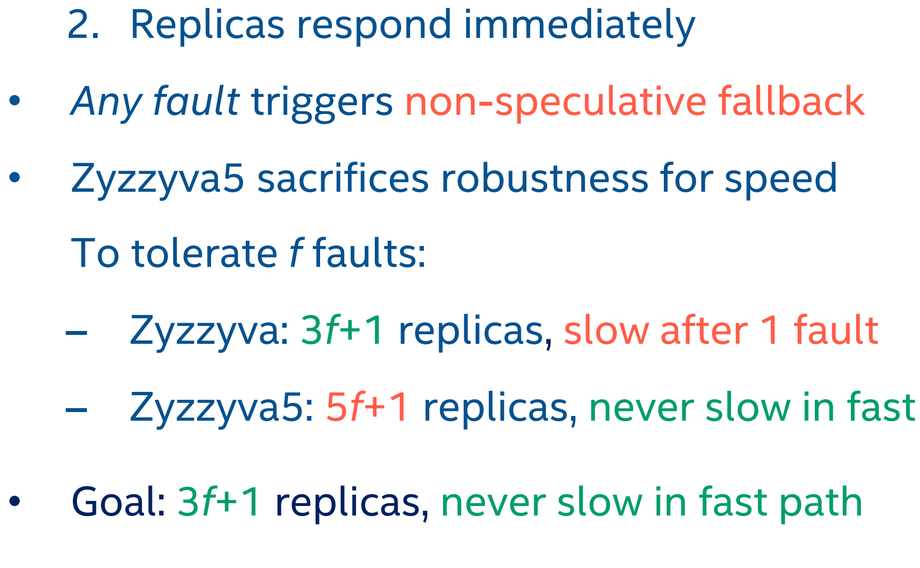
Single Active Counter Zyzzyva (SACZyzzyva)

- Leader orders requests and sends to replicas
- Ordering by trusted monotonic counter in the leader only
- Never slow in fast path: *only a faulty leader* can slow progress
- Same methodology applies to other protocols



Trusted hardware and BFT

- Trusted hardware can increase robustness
- Common primitive: monotonic counter
- *New result*: tolerating *f* faults *always* requires at least one of the following:
  - 2*f*+1 replicas with trusted hardware
  - 3*f*+1 replicas total



Theoretical limit of tolerable faults with partial availability of trusted hardware

Performance

- We outperform Zyzzyva5 at the same level of robustness
- C++ Implementation of fault-free path for Zyzzyva5 & SACZyzzyva
- Low- and high-latency experiments using Amazon EC2
- Marginal latency increase for additional replicas: <100µs/replica

Latency with all replicas in one EC2 region

Latency with replicas spread across Frankfurt, Ohio, and Sydney regions

Research Institute for Collaborative Autonomous and Resilient Systems