StreamChain: Do Blockchains Need Blocks?

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StreamChain in a nutshell

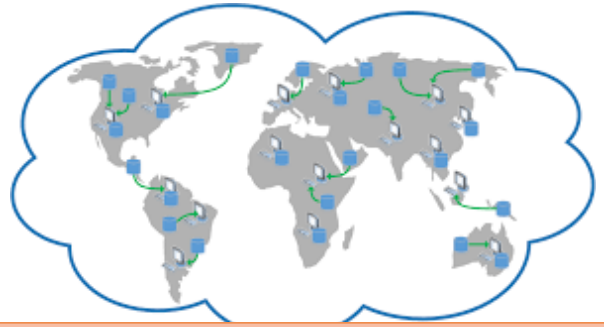
- **Goal**: Low latency *and* high throughput operation in permissioned ledgers for wider adoption (without changing security or reliability properties)

- **Idea**: Revisit core design decisions → turn block-based processing into streaming processing

- **Enables**: New opportunities for blockchains, ability to benefit from recent hardware trends

The lineage of permissioned ledgers

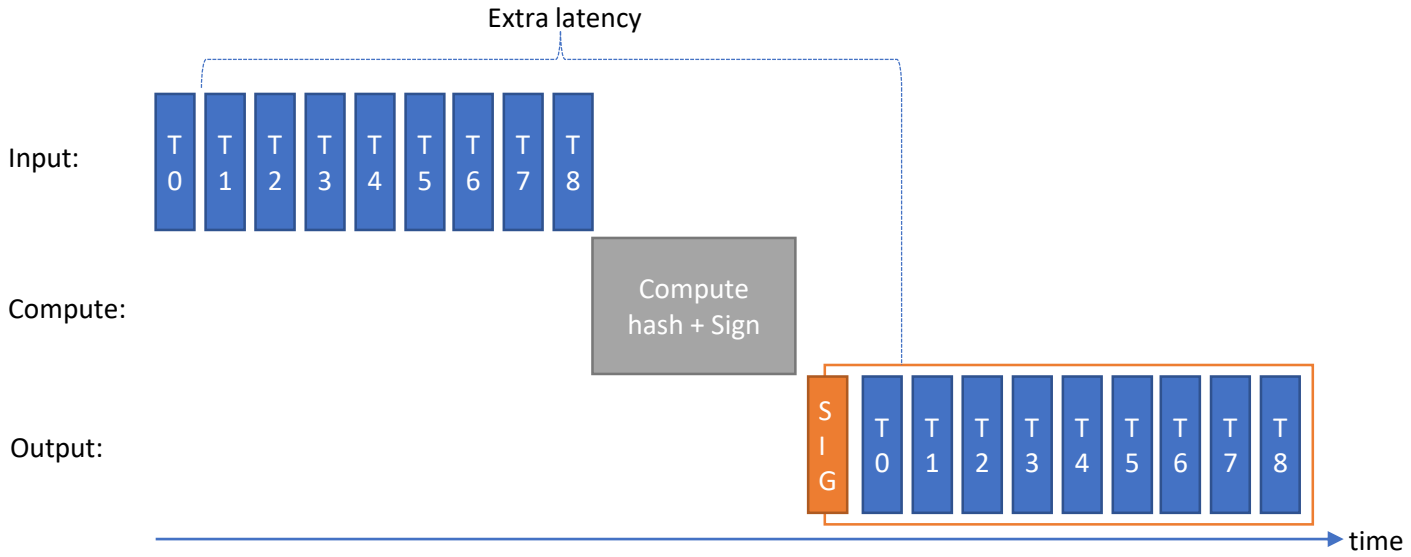
- Public ledgers (blockchains)
  - Geo-distribution → no way around communication latency, gossip to keep everyone up to date
  - Proof-of-work → amortize cost by packaging up many TXs in blocks



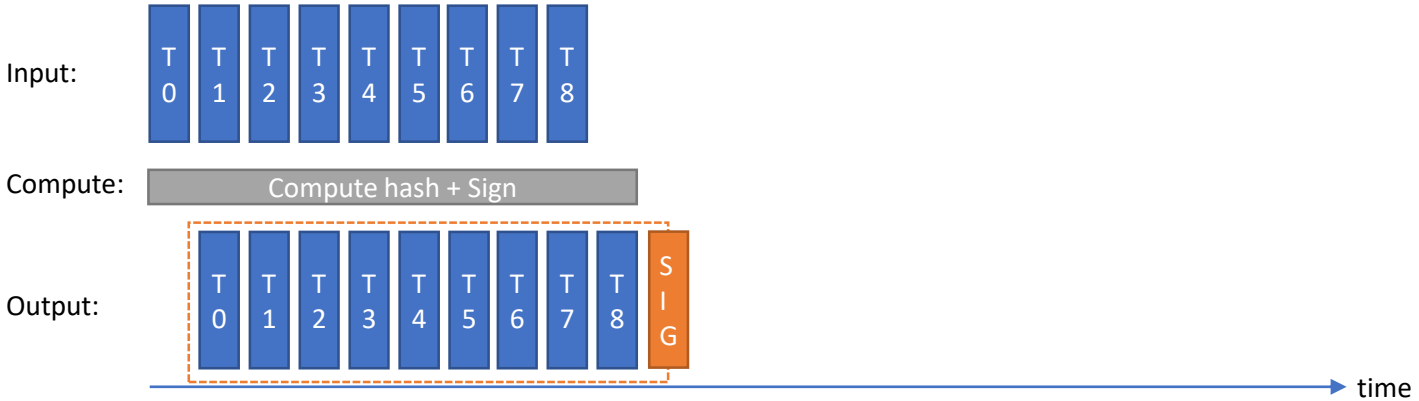
- Permissioned ledgers
  - Compelling non geo-distributed use-cases
    - Low latency, high bandwidth, gossip not necessary
  - No proof-of-work

Pain point: When executed inside the same datacenter, permissioned ledgers still take hundreds of milliseconds for transaction finality!

The source of high latency



a) "Block" behavior



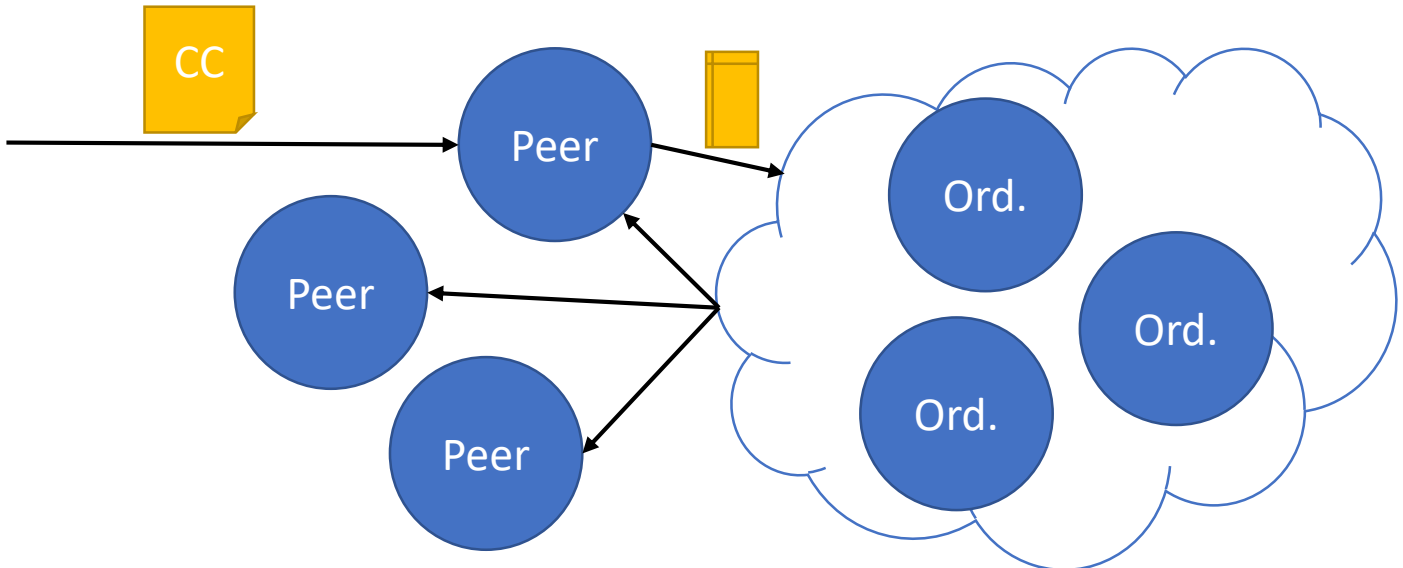
b) Streaming behavior

StreamChain – Design principles

- Process transactions system-wide as they arrive
  - Reduces latency without impacting throughput
- Use batching to hide the cost of high-latency operations (disk accesses)
  - Logical “blocking” of transactions and batching are decoupled
- Use multi-core parallelism to speed up cryptographic operations
  - Streaming doesn’t change the cost of these…

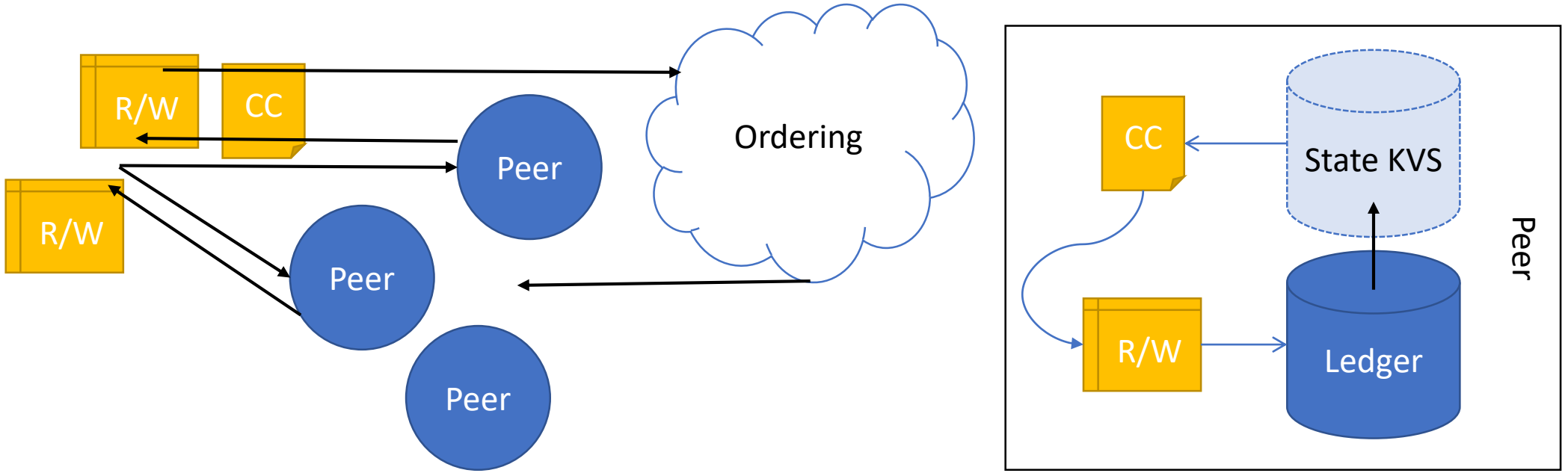
Hyperledger Fabric 101

- Open source platform for building applications on top of a permissioned ledger
  - Smart contracts as “chain code” written in various languages
  - Customizable behavior
  - Separates ordering of transactions into dedicated service – pluggable implementations for BFT



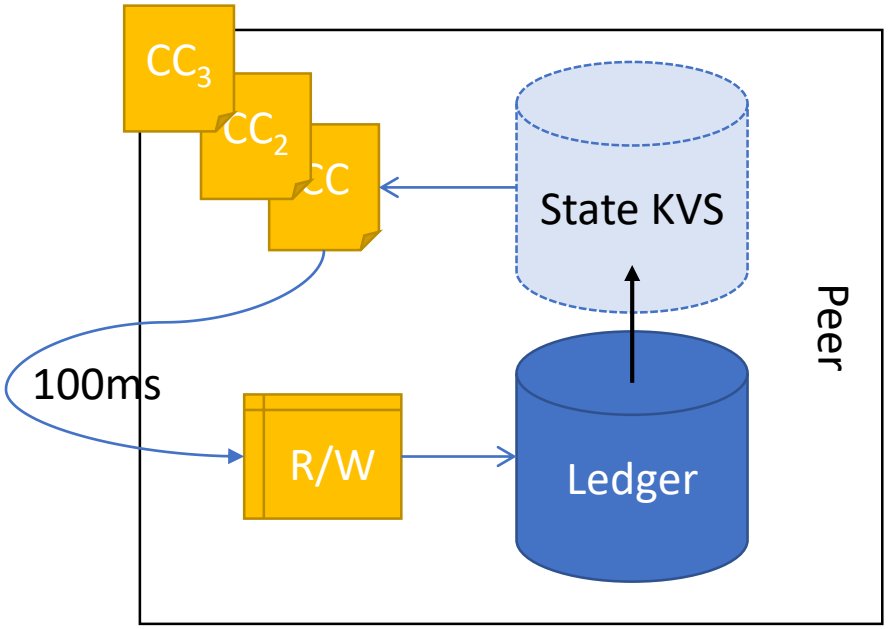
Executing transactions in Fabric

- Has an EOV model to save resources, provide confidentiality
  - **Execute**: Choice of endorsers depends on a user's endorsement policy and produce R/W set of the TX
  - **Order**: Orderer orders the transactions (R/W sets signed by endorsers), signs blocks
  - **Validate**: Nodes apply R/W set if endorsement is valid and compatible with state

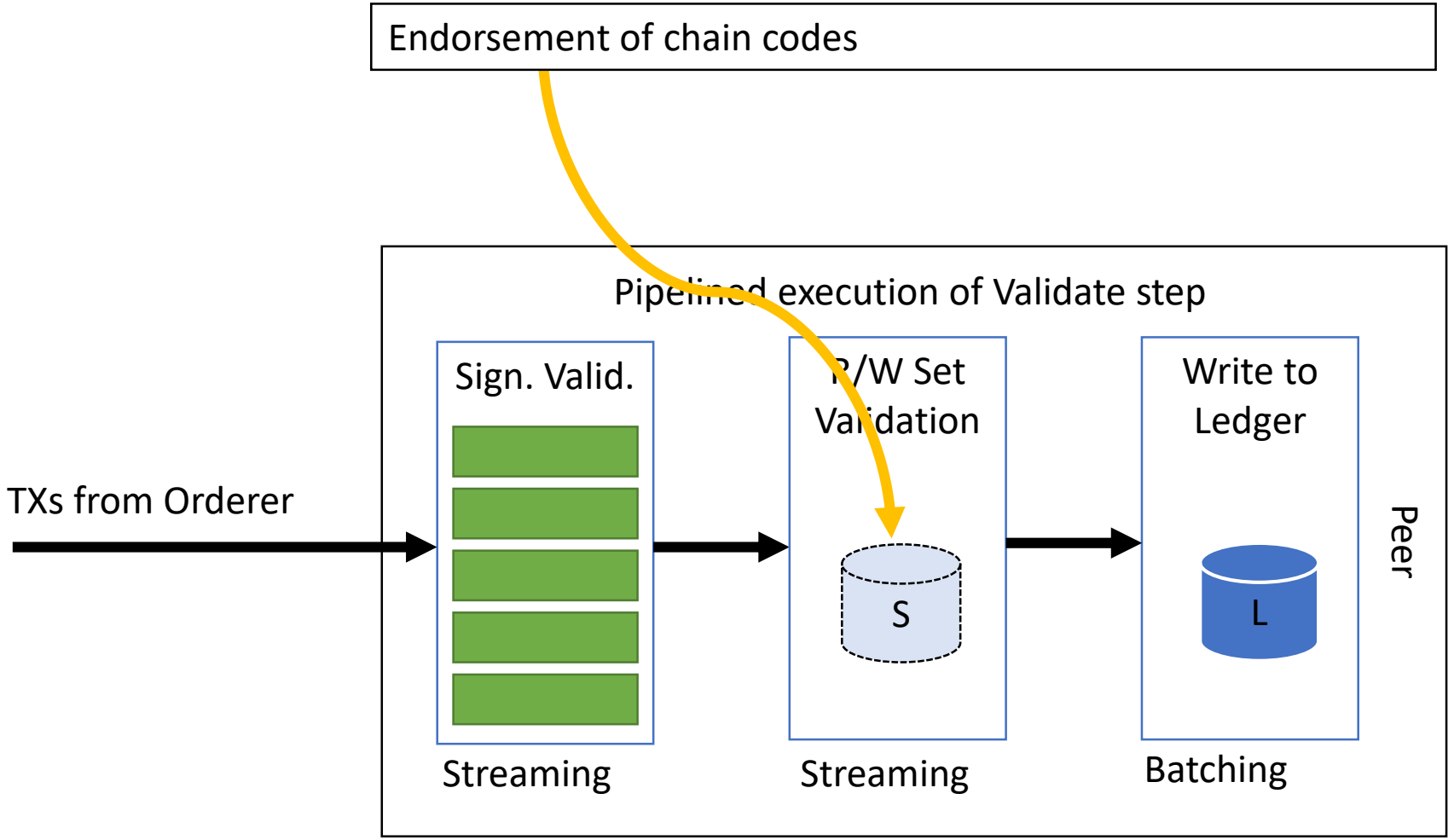


Life after Ordering in Fabric

- Fabric can have *failed* transactions due to R/W set conflicts
  - Client have to retry transaction
  - (Or use a suitable programming model)
- The less latency between execution and validation, the less chance of failing TX
  - StreamChain brings this additional benefit in Fabric



Sketch of StreamChain in Fabric



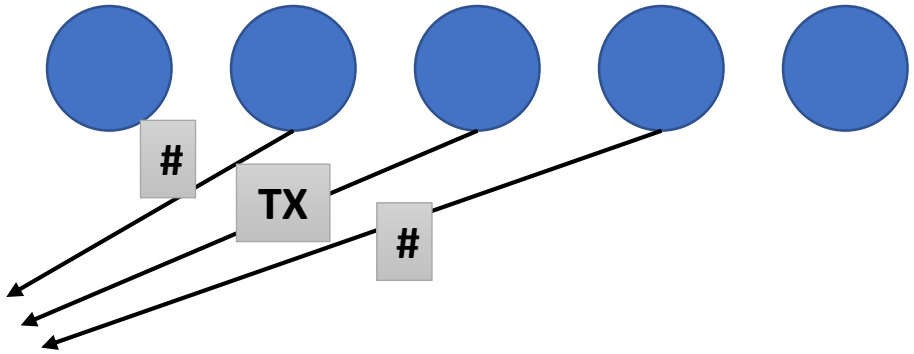
Our Proof of Concept

- Modifies Fabric v1.0 code to simulate behavior
- Streaming by making blocks with 1 TX and null signatures from CFT ordering service
  - Still relies on TLS connections
  - Cost of Orderer signature checking per block is negligible compared to TX signatures
- Implemented parallel signature checks on TXs in the peers
- Simulating amortized cost of disk access using RAMdisk

Does this work with ordering service failures?

- For CFT: Connections to ordering nodes set up via TLS
  - Can rely on single ordering node until crash

- For BFT: If each node connects to *t+1* ordering nodes: data can be streamed from one, hashes from the others
  - High bandwidth requirement, many connections



Does this work with a BFT ordering service?

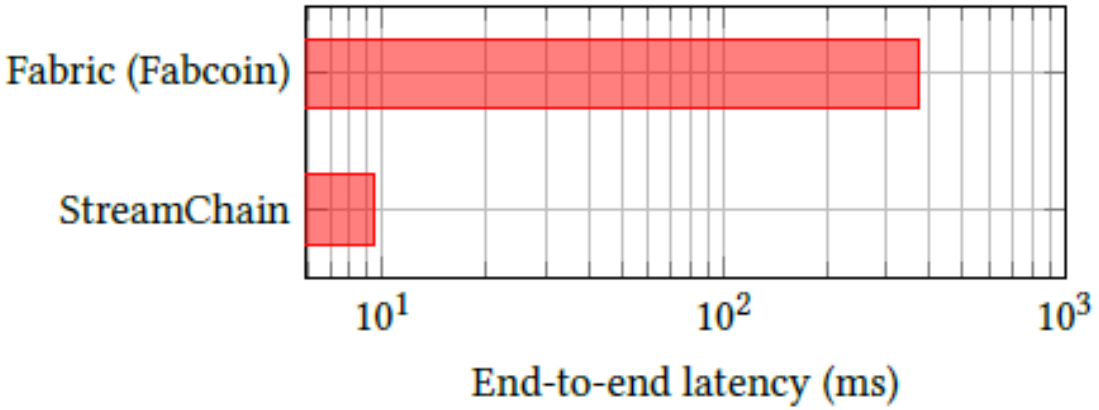
- If connecting to only one ordering node, transactions cannot be recorded to ledger as they arrive
  - Multi-signature required periodically
- Can speculate on state in the meantime – explained in the paper
  - Make transaction outcome immediately visible to execution logic
  - If signature is wrong, remove temporary state
- May waste work but no data corruption possible on ledger

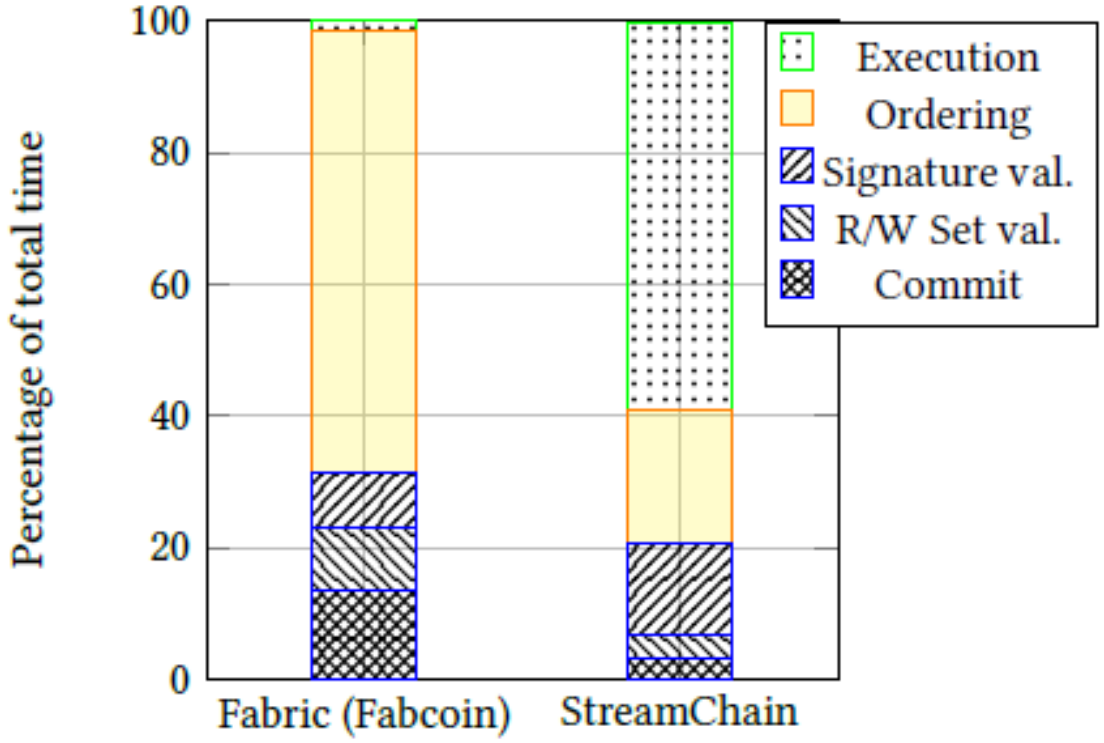
Evaluation

- Ran **StreamChain** in the IBM Cloud (9 machines)
  - Intel Xeon E5-2683 @ 2GHz
  - SSD storage
  - 1Gbps network

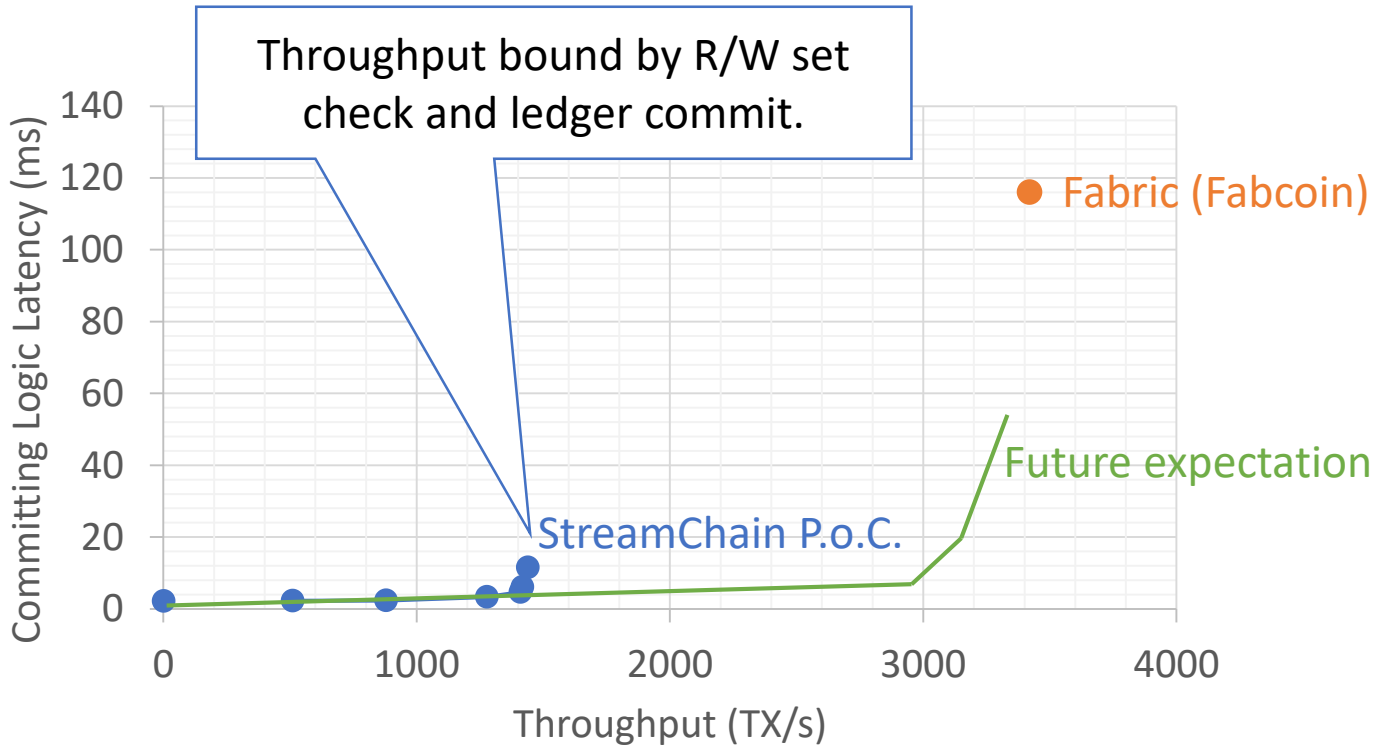
- Compared to **Fabric (Fabcoin)** [Eurosys18]
  - UTXO application
  - ~4000TX/s, ~350ms end-to-end latency
  - (Related work has similar orders of magnitude)

Latency


Fabric (Fabcoin)
StreamChain
10^1
10^2
10^3
End-to-end latency (ms)


Percentage of total time
100
80
60
40
20
0
Execution
Ordering
Signature val.
R/W Set val.
Commit
Fabric (Fabcoin)
StreamChain

Throughput vs Latency



Thoughts on the future

- Permissioned ledger adoption could hinge on performance
  - Revisit assumptions: streaming processing is a realistic option
  - Proof-of-concept using Hyperledger Fabric

- StreamChain exposes new bottlenecks → New research challenges
  - Ordering service optimizations
  - Smart contract execution

Birds of a Feather Session tomorrow:
Consensus and coordination using modern hardware