Permissioned Blockchain Through the Looking Glass: Architectural and Implementation Lessons Learned


Suyash Gupta


Sajjad Rahnama


Mohammad Sadoghi

MokaBlox LLC

Exploratory Systems Lab

University of California, Davis

ExpoLab Creativity Unfolded

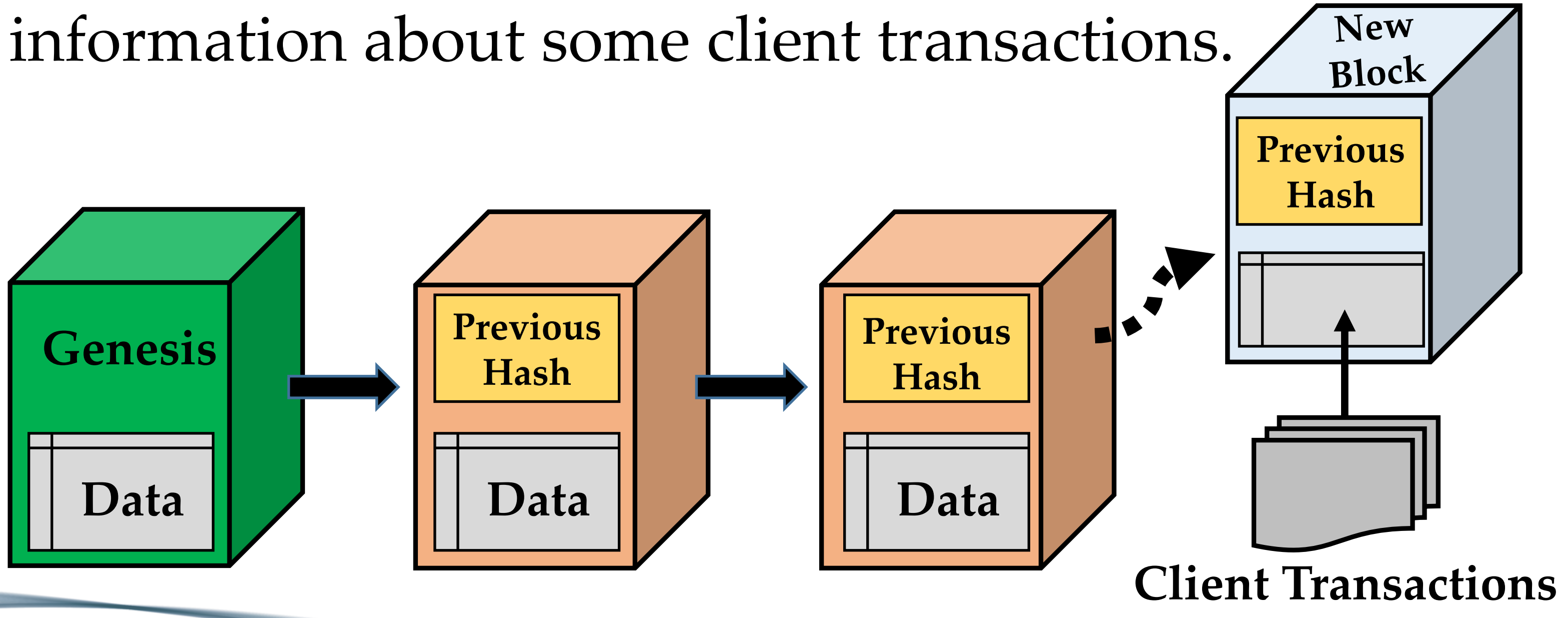
ResilientDB

UC DAVIS UNIVERSITY OF CALIFORNIA

*Proceedings of the 40th IEEE ICDCS 2020

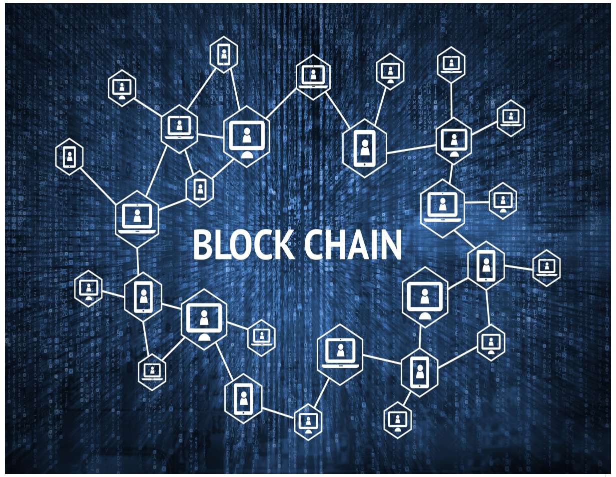
What is Blockchain?

- A linked list of blocks.
- Each block contains hash of the previous block.
- A block contains information about some client transactions.



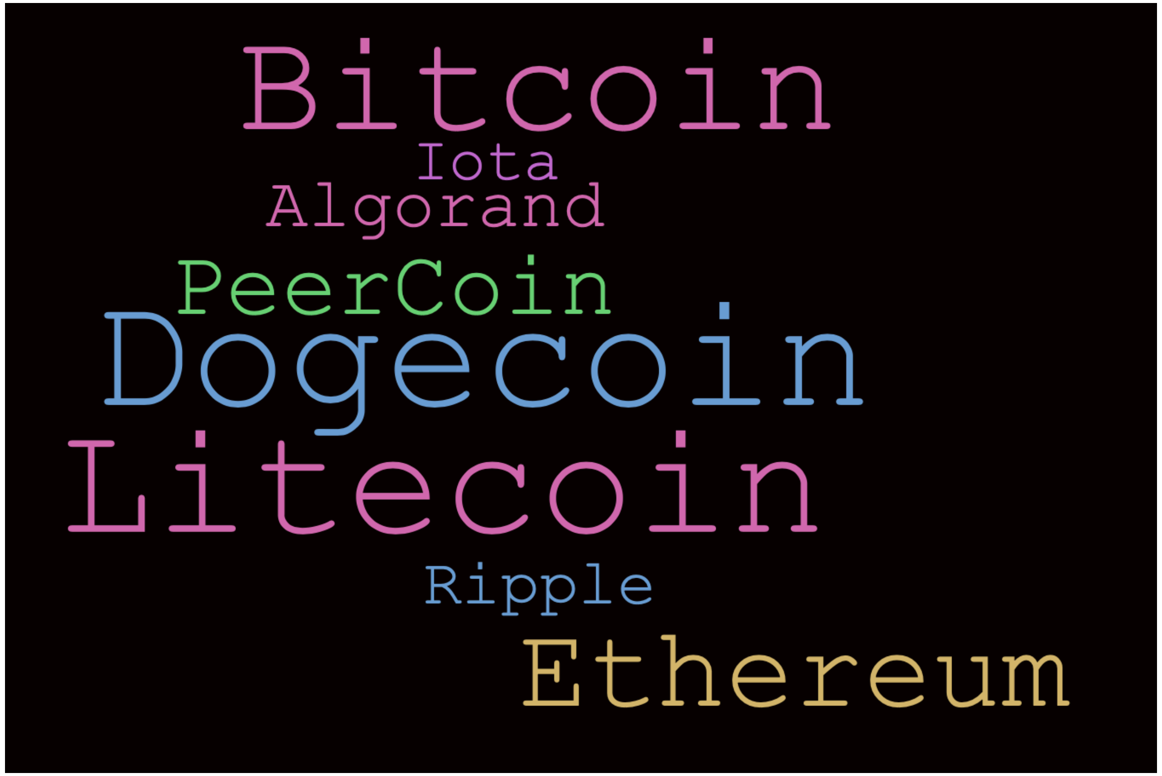
Components of a Blockchain System

- Replicas → Store all the data.
- Client → Sends transactions to process.
- Consensus Protocol → Helps ordering transactions.
- Cryptographic Constructs → Authenticate replicas and clients.
- Ledger → Records transactions.



ResilientDB ExpoLab Creativity Unfolded

Famous Blockchain Applications?



Why only Cryptocurrencies?

- Throughput of initial cryptocurrencies → < 10 txns/s.
- Throughput of existing distributed databases → 1 million txns/s.
- Low throughput acceptable in *permissionless* applications.
- **Aim:** 1) Cryptocurrency that is decentralized.

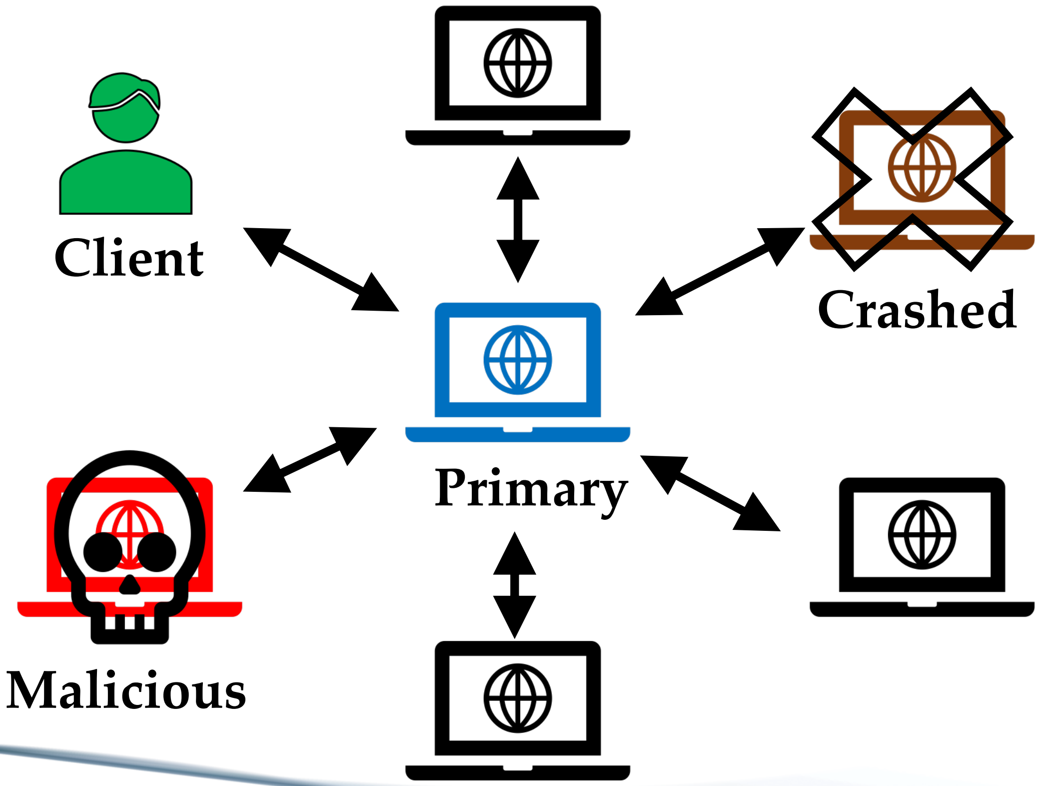
  2) Identities are hidden or unknown.
- **Result:** 1) Forks in the chain.

  2)Not acceptable to industries.

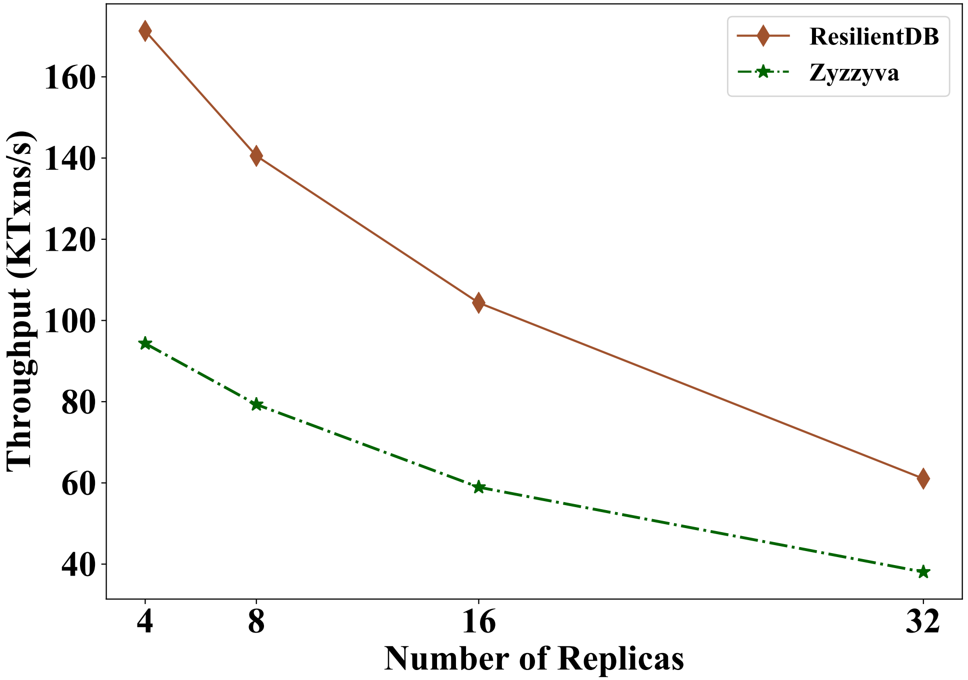
Rise of Permissioned Blockchains

- Only a selected group of replicas, although untrusted can participate.
- Identities of the replica known a priori.
- Prevent chain forks.
- Suitable for needs of an industry → JP Morgan, IBM, Oracle
- Open design of *Blockchain Databases.*
- Throughput? < 10K txns/s.
- Often cited reason → Traditional BFT consensus protocols are expensive!

At the core of *any* Blockchain application is a Byzantine Fault-Tolerant (BFT) consensus protocol.



Can a well-crafted system based on a classical BFT protocol outperform a modern protocol?



ResilientDB employs three-phase (of which two require quadratic communication) PBFT protocol and scales better than protocol-centric permissioned blockchain system that uses single linear-phase Zyzzyva.

ResilientDB ExpoLab Creativity Unfolded

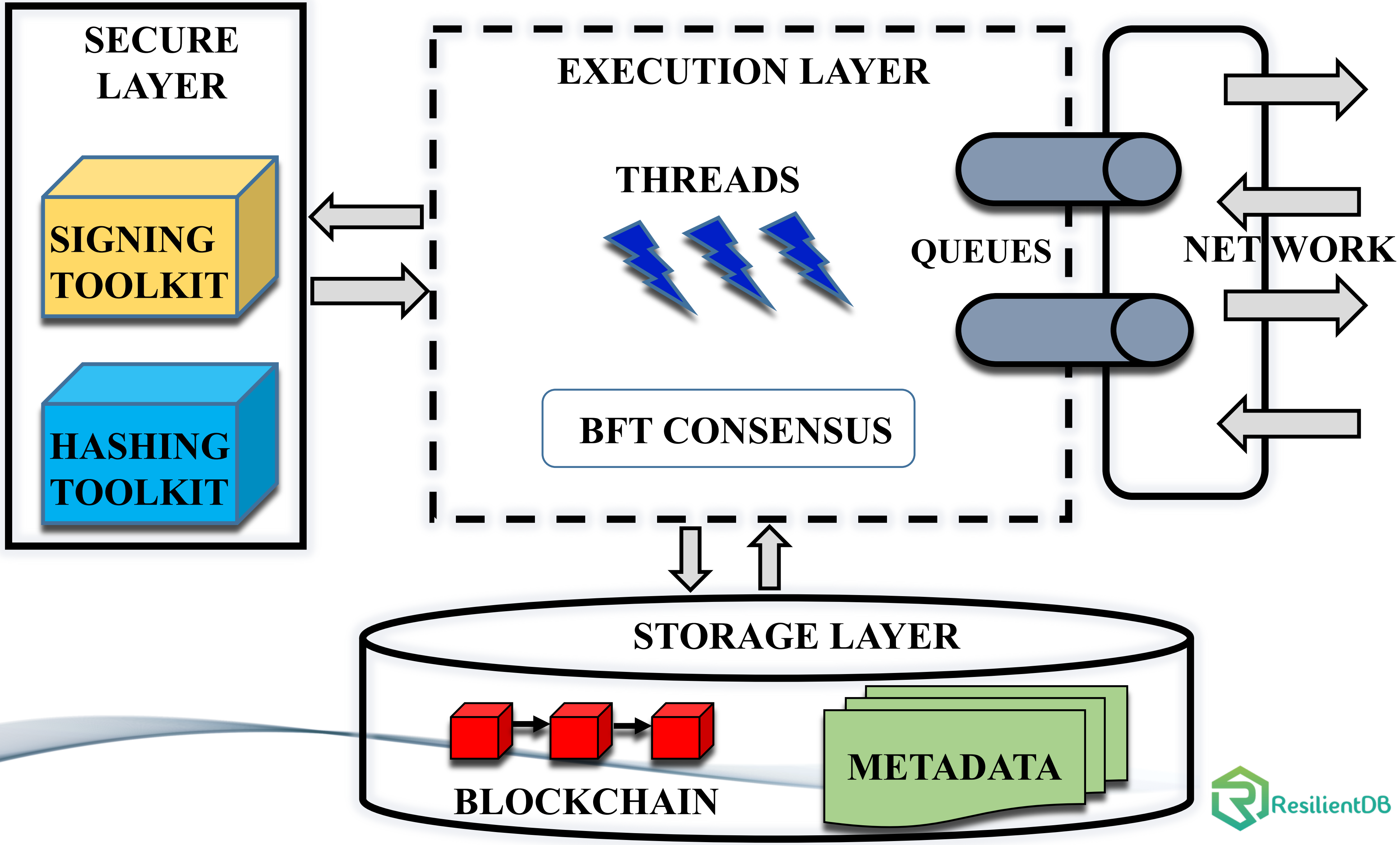
Existing Permissioned Blockchain systems overlook system design!

ResilientDB adopts *well-researched* database and system practices.

Dissecting existing Permissioned Blockchain

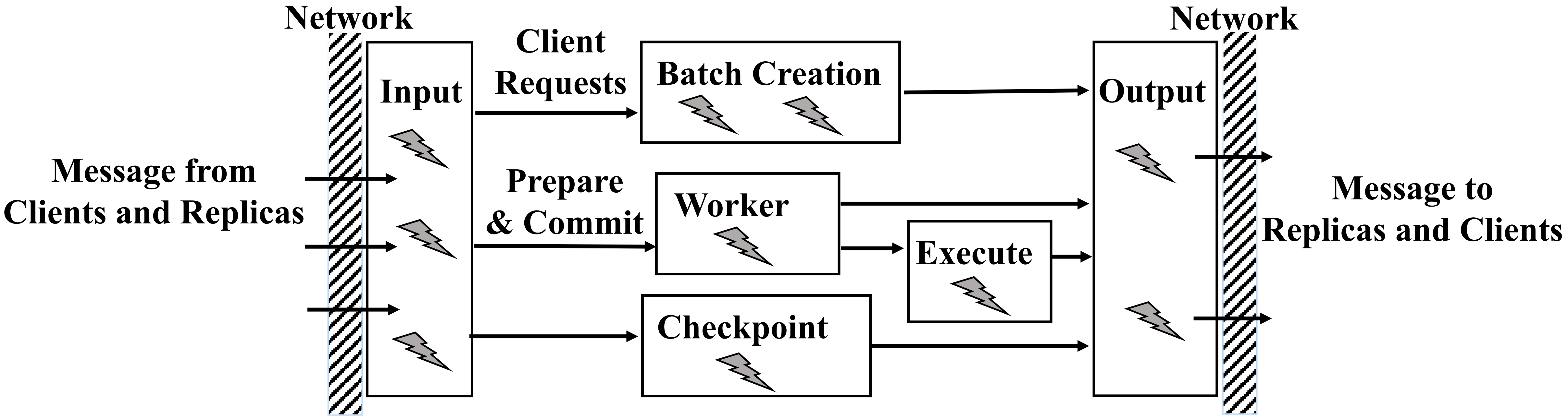
1) Single-threaded Monolithic Design
2) Successive Phases of Consensus
3) Integrated Ordering and Execution
4) Strict Ordering
5) Off-Chain Memory Management
6) Expensive Cryptographic Practices

ResilientDB Architecture



ResilientDB ExpoLab Creativity Unfolded

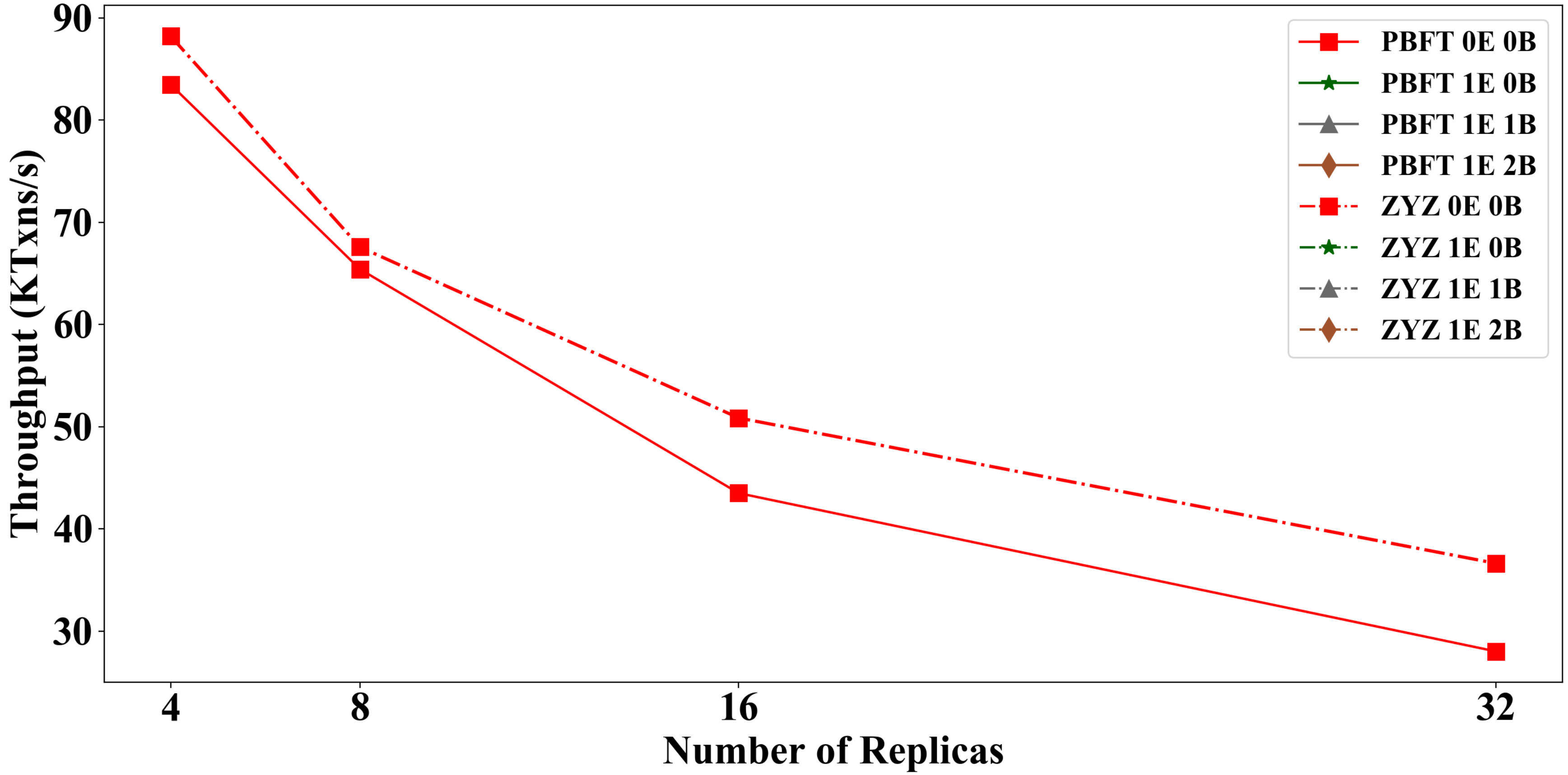
Multi-Threaded Deep Pipeline at Replicas



Evaluation and Analysis

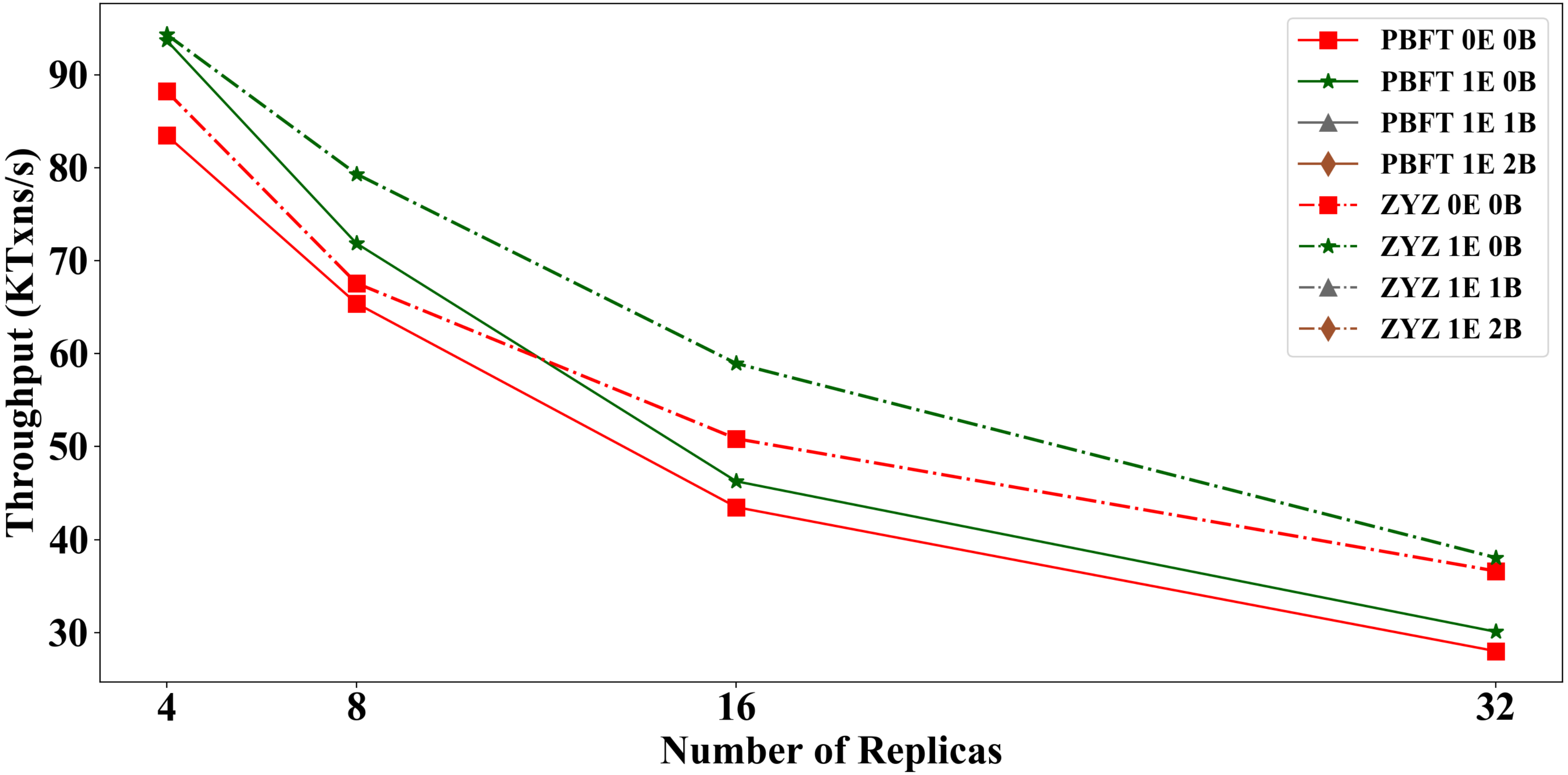
- We ask eleven distinct questions that affect performance of a Permissioned Blockchain.
- Workload provided by Yahoo Cloud Serving Benchmark (YCSB).
- PBFT to achieve BFT consensus among replicas.
- General Setup (unless stated otherwise):
  - 8-core Intel Xeon Cascade Lake CPU.
  - Requests sent by 80K clients deployed on 4 machines.
  - Employed batching → Batch size set at 100.
  - At each replica → one worker-thread, one execute-thread and two batch-threads

Insight 1: Multi-Threaded pipeline Gains



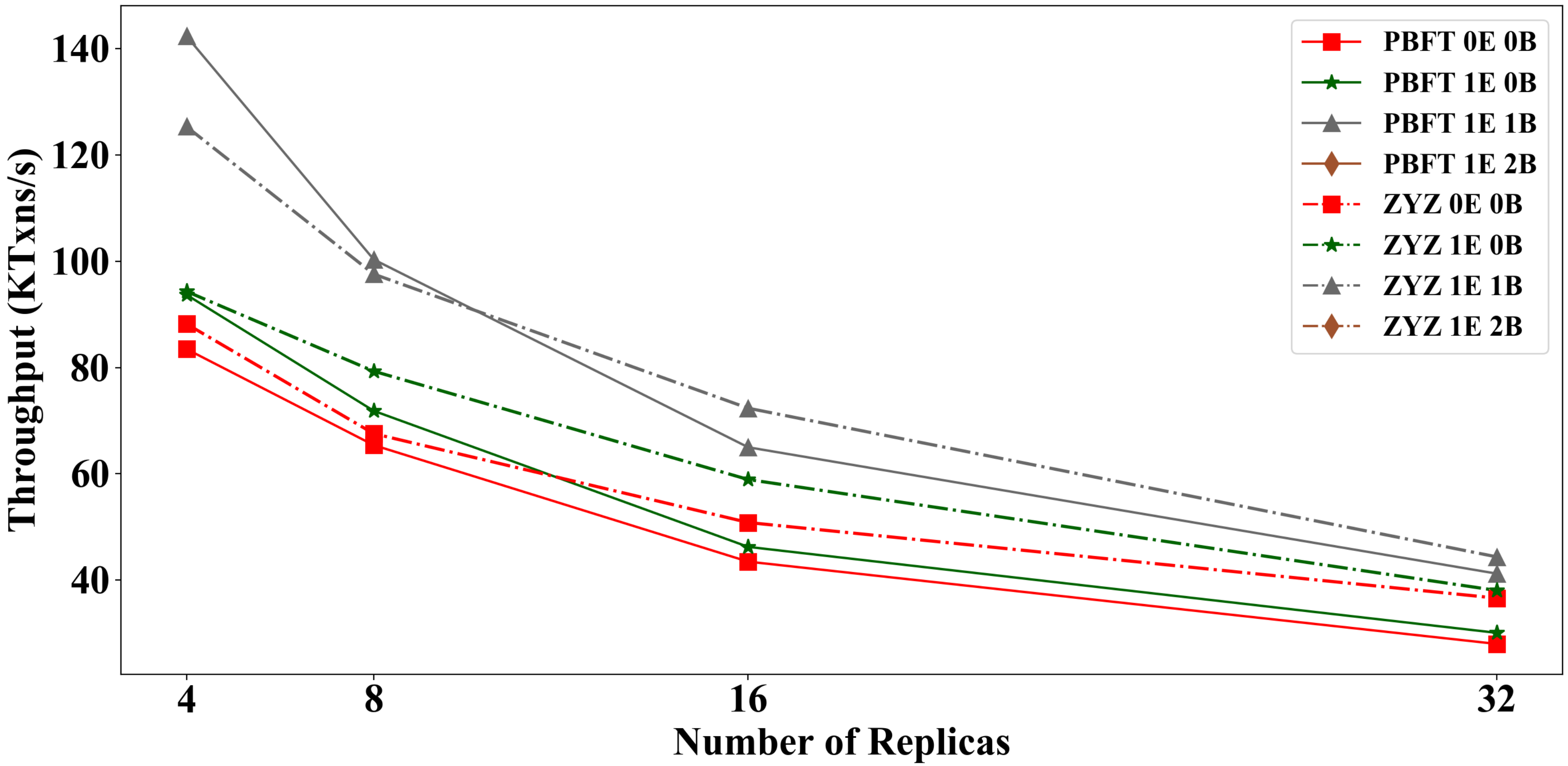
Parallelizing and Pipelining tasks across worker, execution (E) and batch-threads (B).

Insight 1: Multi-Threaded pipeline Gains



Parallelizing and Pipelining tasks across worker, execution (E) and batch-threads (B).

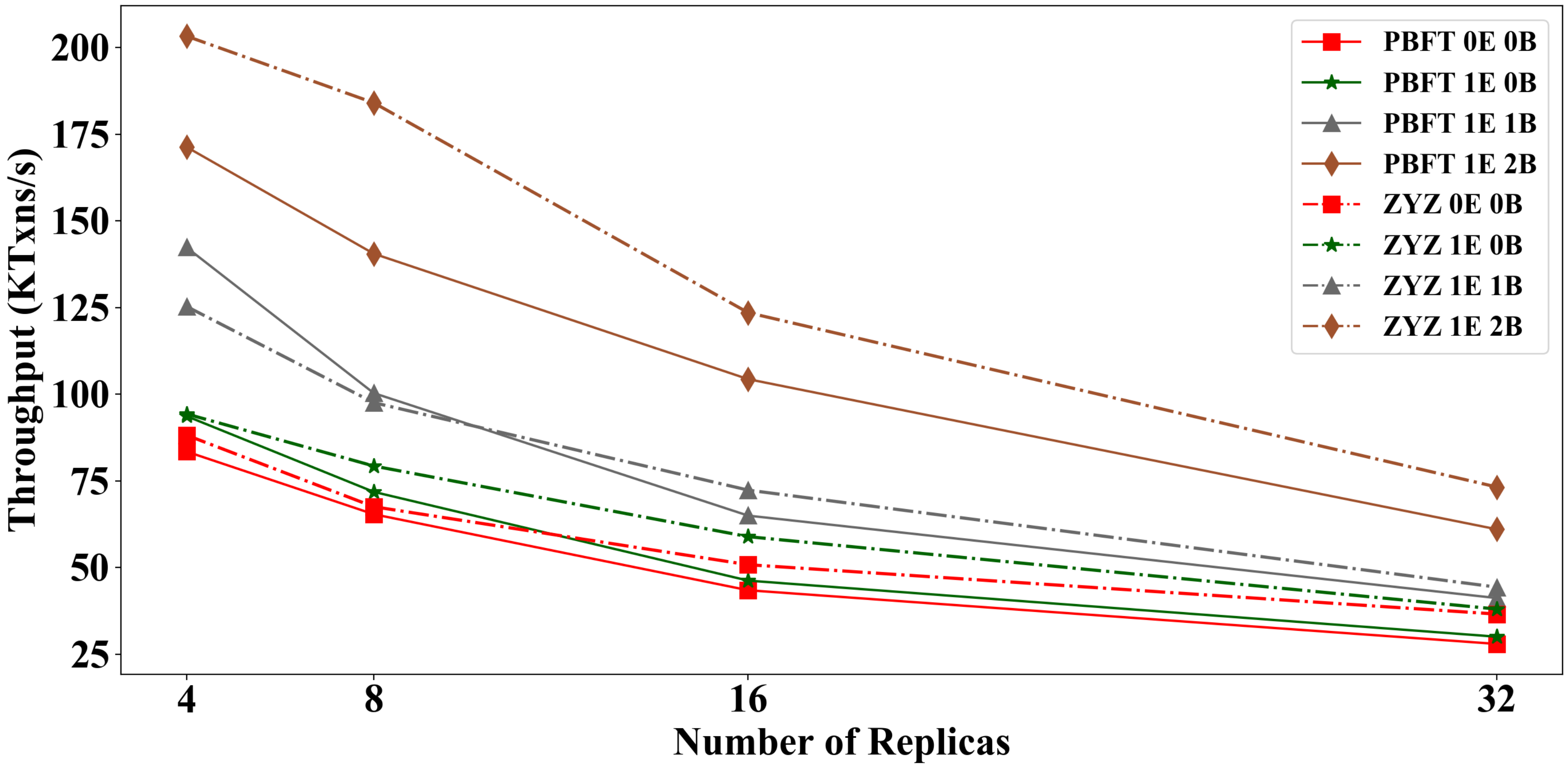
Insight 1: Multi-Threaded pipeline Gains



Parallelizing and Pipelining tasks across worker, execution (E) and batch-threads (B).

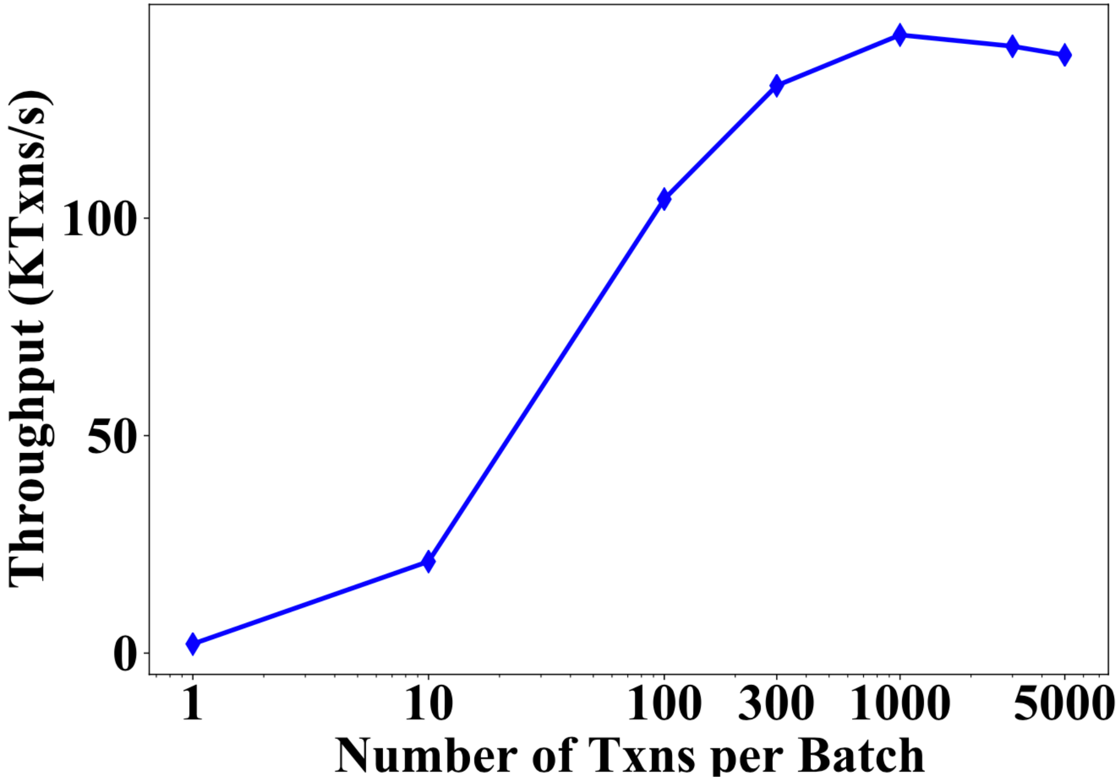
ResilientDB ExpoLab Creativity Unfolded

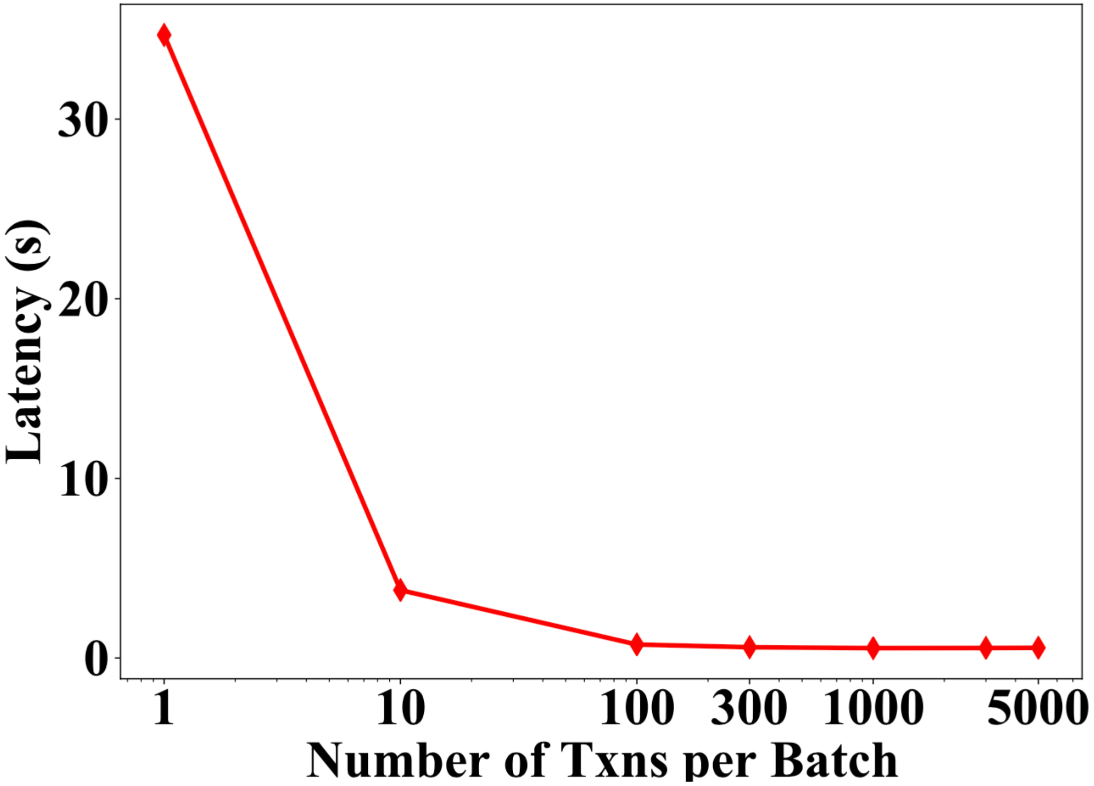
Insight 1: Multi-Threaded pipeline Gains



Parallelizing and Pipelining tasks across worker, execution (E) and batch-threads (B).

Insight 2: Optimal Batching Gains

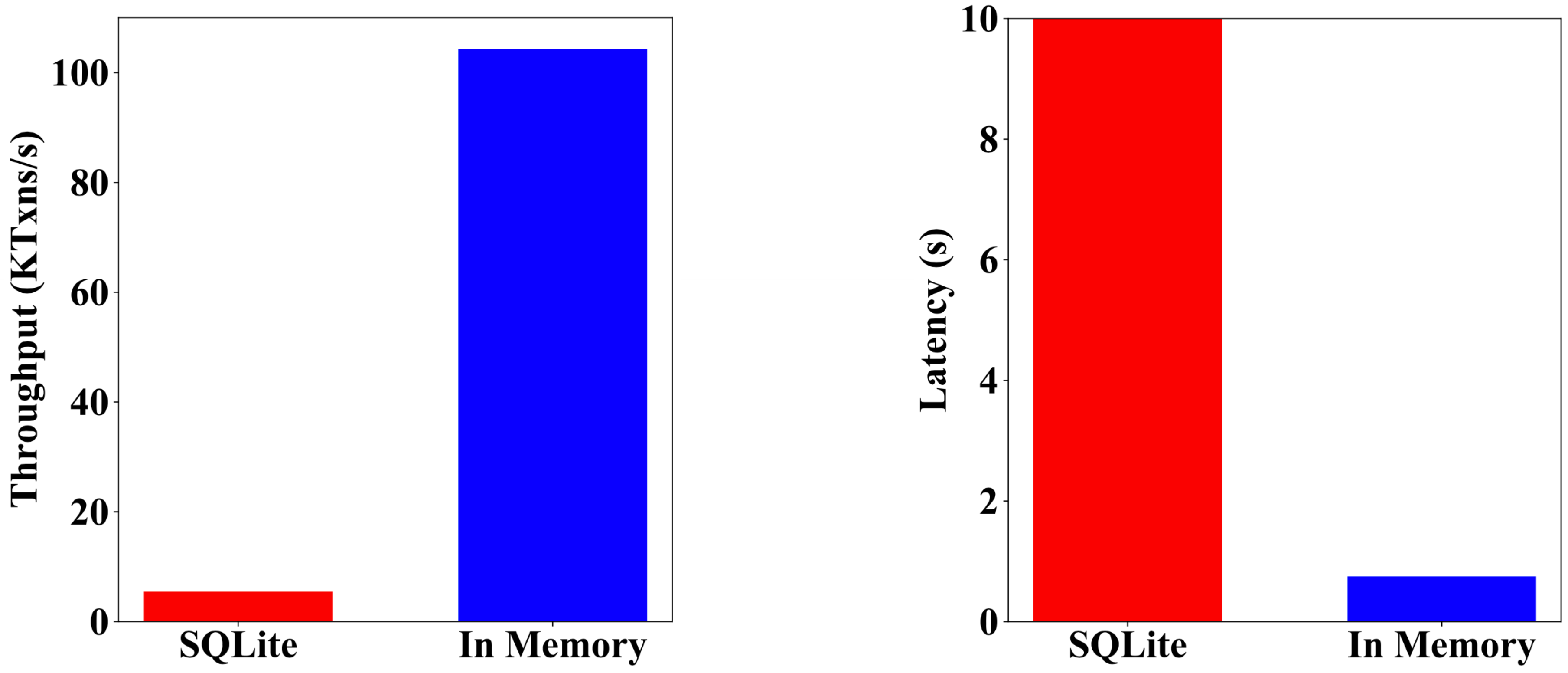




More transactions batched together → increase in throughput

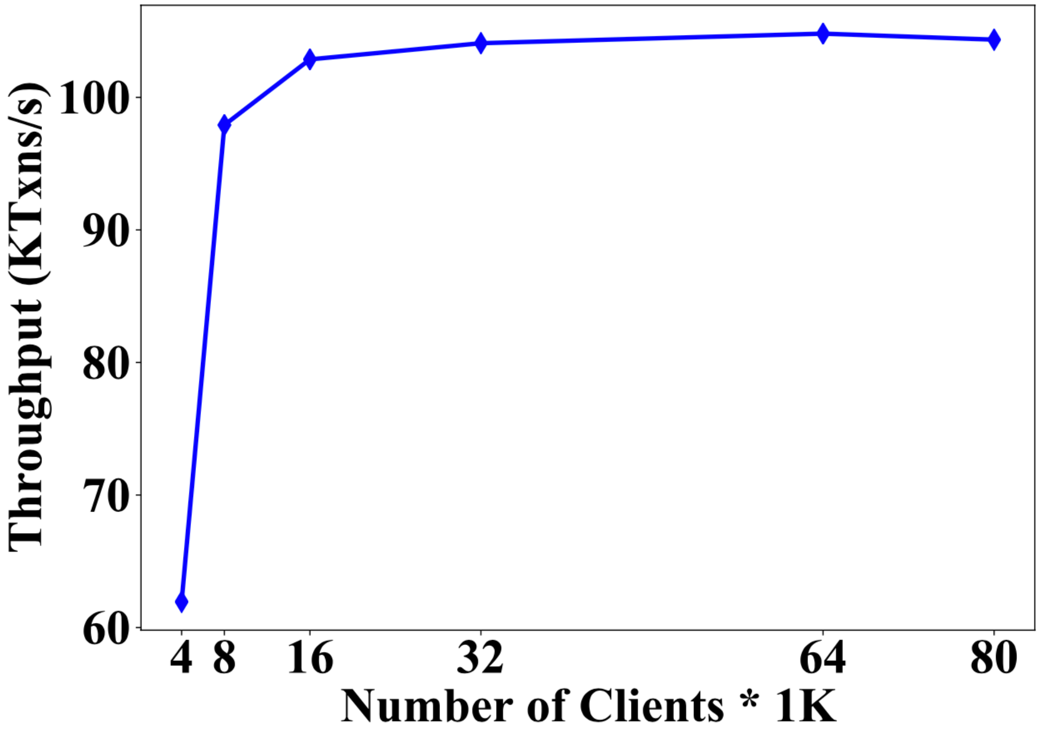
→reduced phases of consensus.

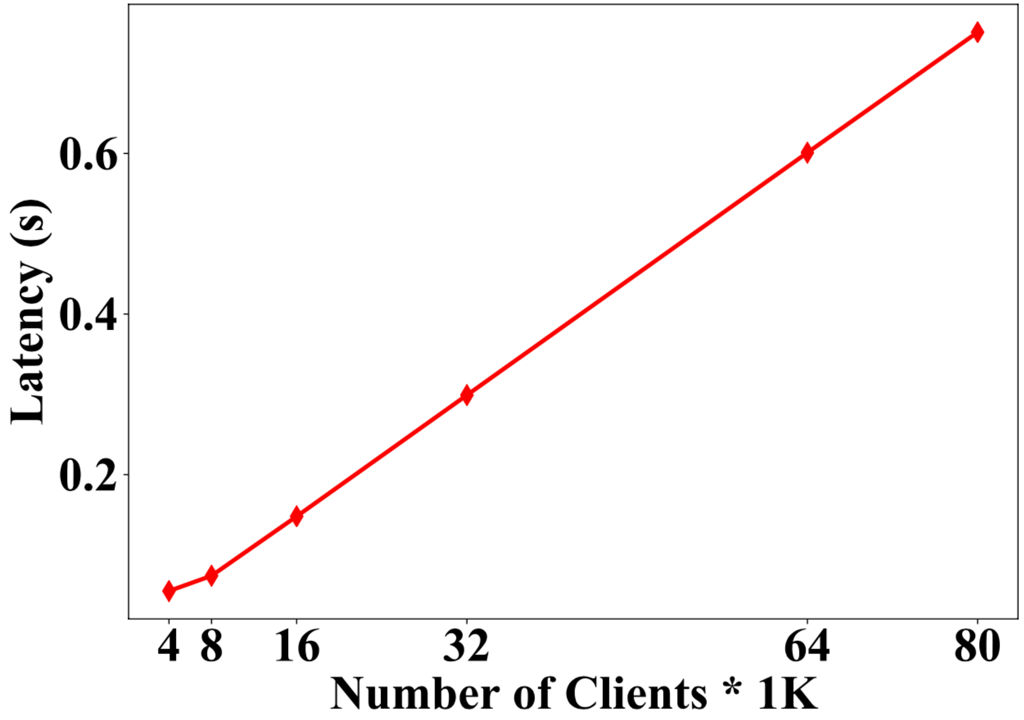
Insight 3: Memory Storage Gains



In-memory blockchain storage → reduces access cost.

Insight 4: Number of Clients





Too many clients → increases average latency.

Conclusions and Final Remarks

- There are several factors that affect throughput of a blockchain system.
- Fast consensus does not always implies an efficient blockchain system.
- We show that a well-crafted system-centric permissioned blockchain system can outperform a protocol-centric blockchain system.
- System designers need to dissect their application to find performance bottlenecks.

Thank You