Research Faculty Summit 2018

Systems | Fueling future disruptions

Microsoft

BlockchainDB—Towards a Shared Database on Blockchains

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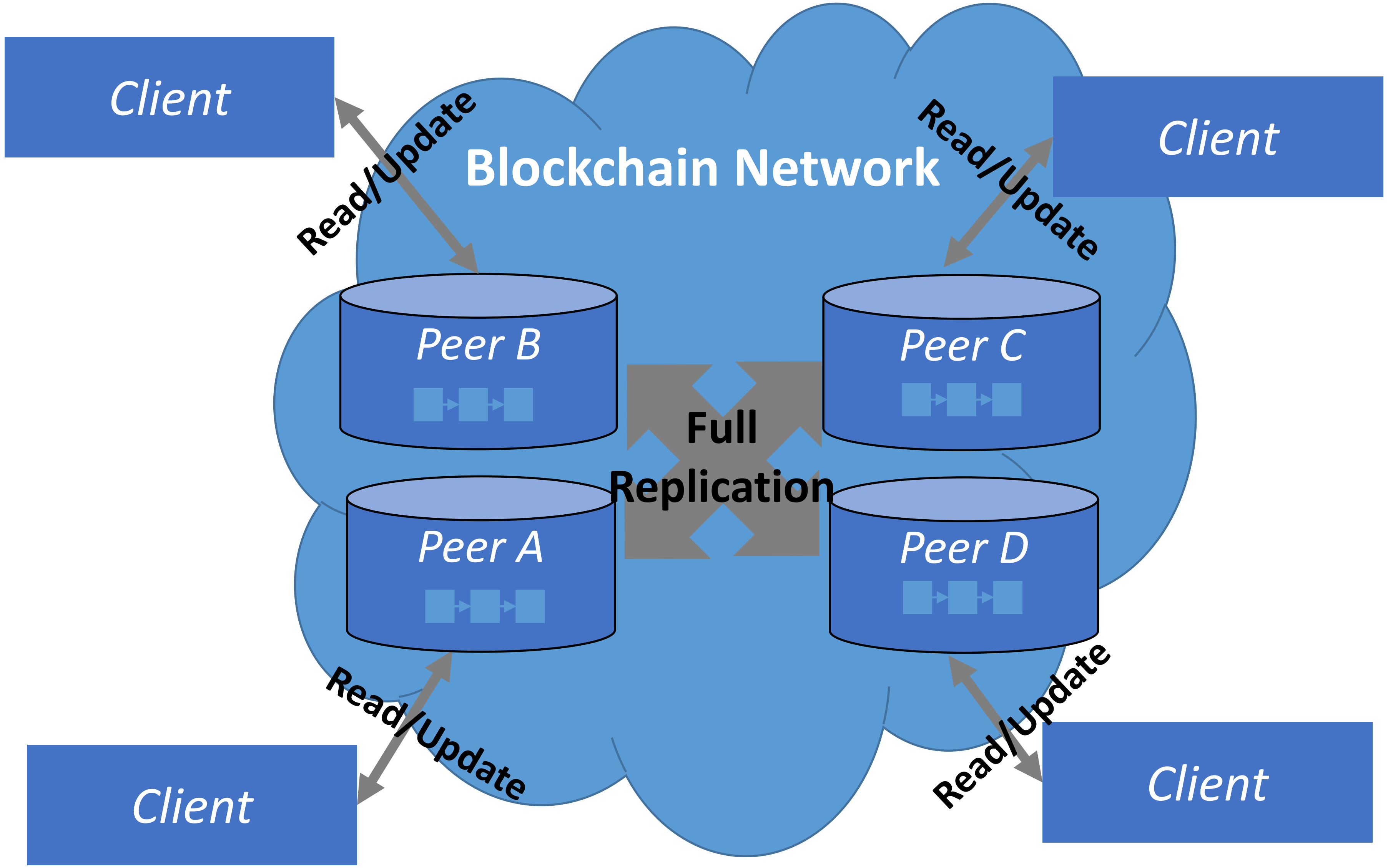
Blockchains: A Shared Database?



Blockchains are not only used for crypto-currencies today

More and more application to use Blockchains as shared database

Main reasons why Blockchains are being used for data sharing:

- Keeps history of all transactions (Even counts as evidence in court)
- No tampering after-the-fact (once data is written)
- Needs no trusted authority

Potential Use Cases

Sharing **Health Records** (https://medicalchain.com)

Tracing Goods in **Supply Chains**
(https://www.ibm.com/blockchain/industries/supply-chain)

Decentralized **Copyright Management** (e.g., https://binded.com/ for images)

Decentralized **Domain-Name-Service** (https://namecoin.org/)

…

Are existing **Blockchains good enough** to be used as a shared database?

Outline

Blockchain Background

Challenges of using Blockchains

BlockchainDB – A Shared Database on Blockchains

Summary and Next Steps

The Technology behind Blockchains

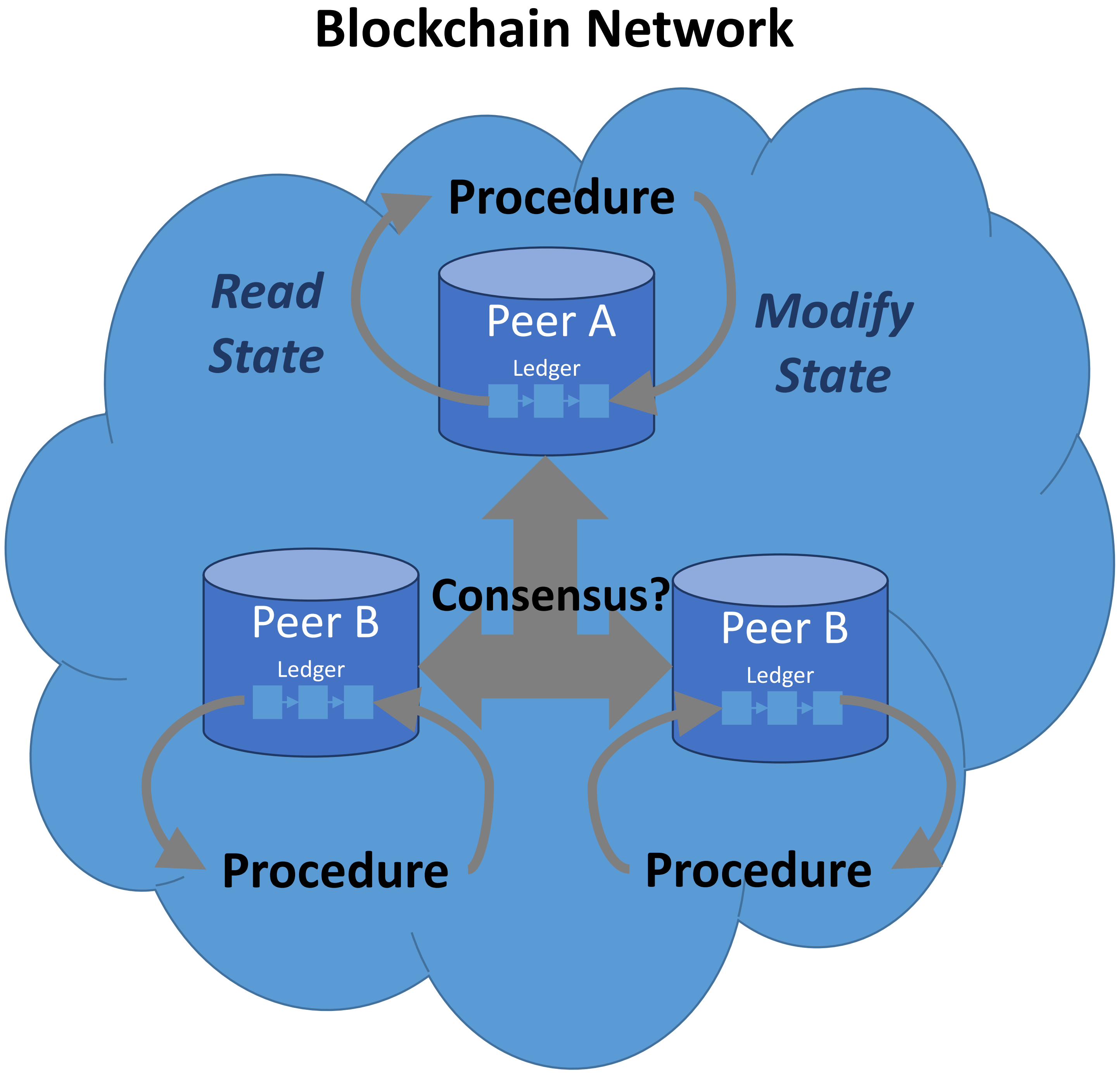
(from 10000 feet)

Blockchains peers use a **tamper-proof ledger** to store shared data

- Ledger is an append-only **list of all tx's** (e.g., tx = transfers between accounts)
- Tx's are **appended in blocks** to ledger
- Ledger is **fully-replicated** across peers

Consensus ensures that every peer **agrees on new tx's appended to ledger**

Smart contracts are "trusted" **procedures in the BC** triggered by tx's to modify data



Categories of Blockchain Networks

Public (aka permission-less)

- **Anyone** can participate in the BC network as a participant
- Uses expensive **computation-based consensus protocols** (e.g., proof of work)
- **Example:** Bitcoin, Ethereum (public)

Private (aka permissioned)

- Limited to a **small set of known participants**
- Uses less expensive **voting-based consensus protocols** (e.g., PBFT, …)
- **Example:** Hyperledger, Ethereum (private)

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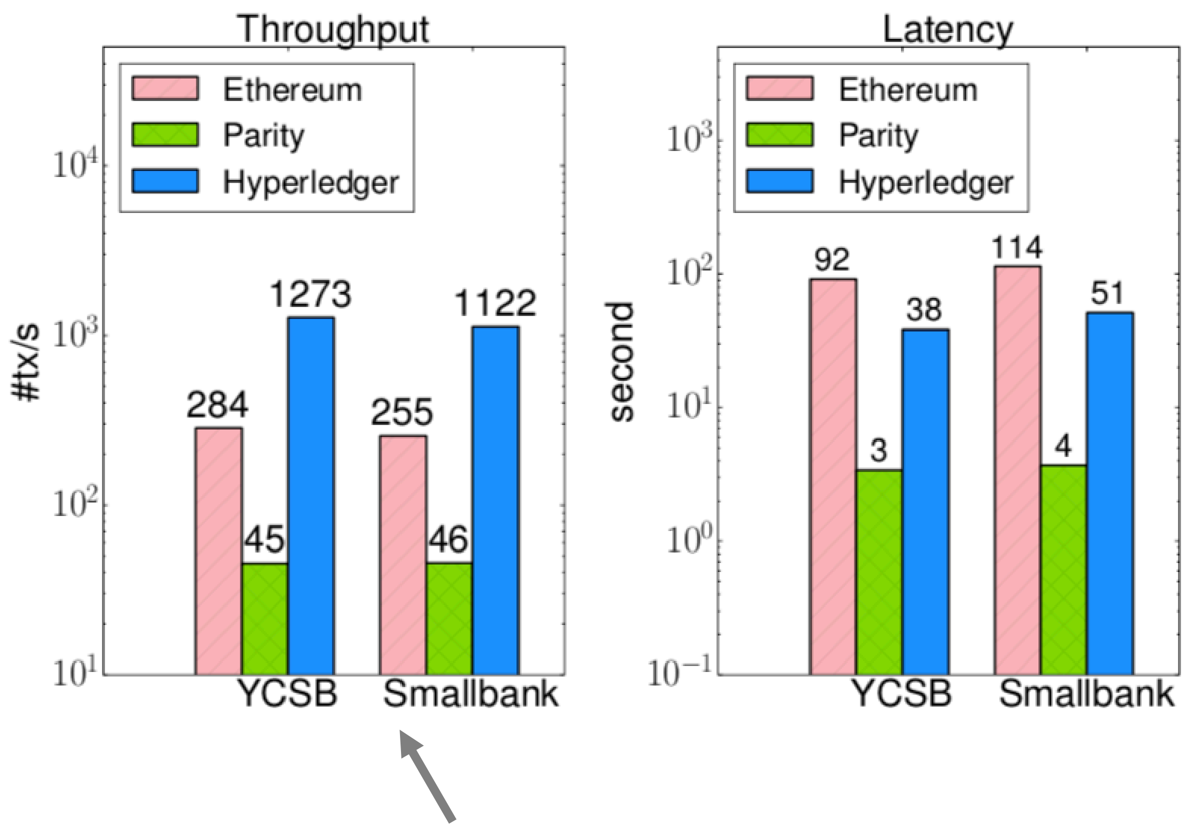
Challenge 1: Performance of Blockchains

Very limited performance even for **private blockchains**



Max. Throughput (Avg. much lower)!

Low throughput (<100's tx/s on average) and **high latency**

AND **bad scalability** with # of peers

Not sufficient for many use-cases (e.g., Visa processes on avg. 2000 tx/s)

From: BLOCKBENCH: A Framework for Analyzing Private Blockchains. SIGMOD Conference 2017: 1085-1100

Challenge 2: “Zoo” of Blockchains

	Application	Smart contract execution	Smart contract language	Data model	Consensus
Hyperledger	General	Dockers	Golang, Java	Key-value	PBFT

Many different **programming and execution models!**

Unclear which one is **best for your workload?**

Hard to predict **which platforms will “survive”!**

OpenChain [35]	*Digital assets*	-	-	*Transaction-based*	*Single validator*
IOTA [36]	*Digital assets*	-	-	*Account-based*	*IOTA's Tangle Consensus*

…

From: Untangling Blockchain: A Data Processing View of Blockchain Systems. IEEE Trans. Knowl. Data Eng. 30(7) 2018

Challenge 3: Missing Guarantees and Functions

Blockchains provide **only limited guarantees** for data access
(e.g., **no guarantees for reads** -> executed by only ONE peer!!!)

Guarantees desired for shared databases

- Verifiability of execution of DB transactions (sequence of reads & writes)
- Recovery to valid checkpoints (before violation was detected)

Many other desired functions for data sharing missing in BC's:
privacy (e.g., by encryption) of data, fine-grained authorization, ….

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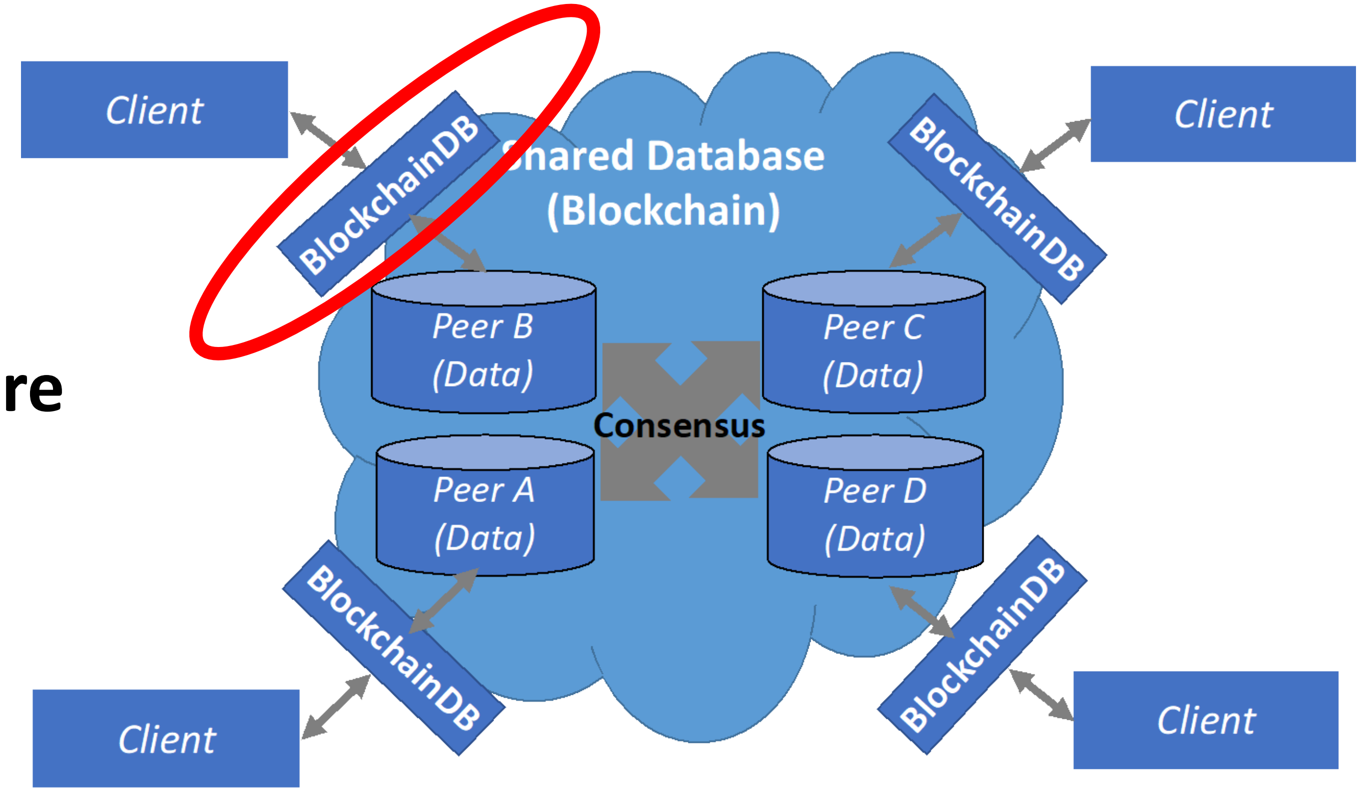
Vision of BlockchainDB

BlockchainDB = Middleware on top of Blockchains

1. **Unified API & Pluggable Backends**
(i.e., be the MySQL for Blockchains)

2. **Apply typical DB optimizations in Middleware**
(e.g., sharding, batching, …)

3. **Support for verifiable DB transactions**
(i.e., sequences of reads/writes to BC)

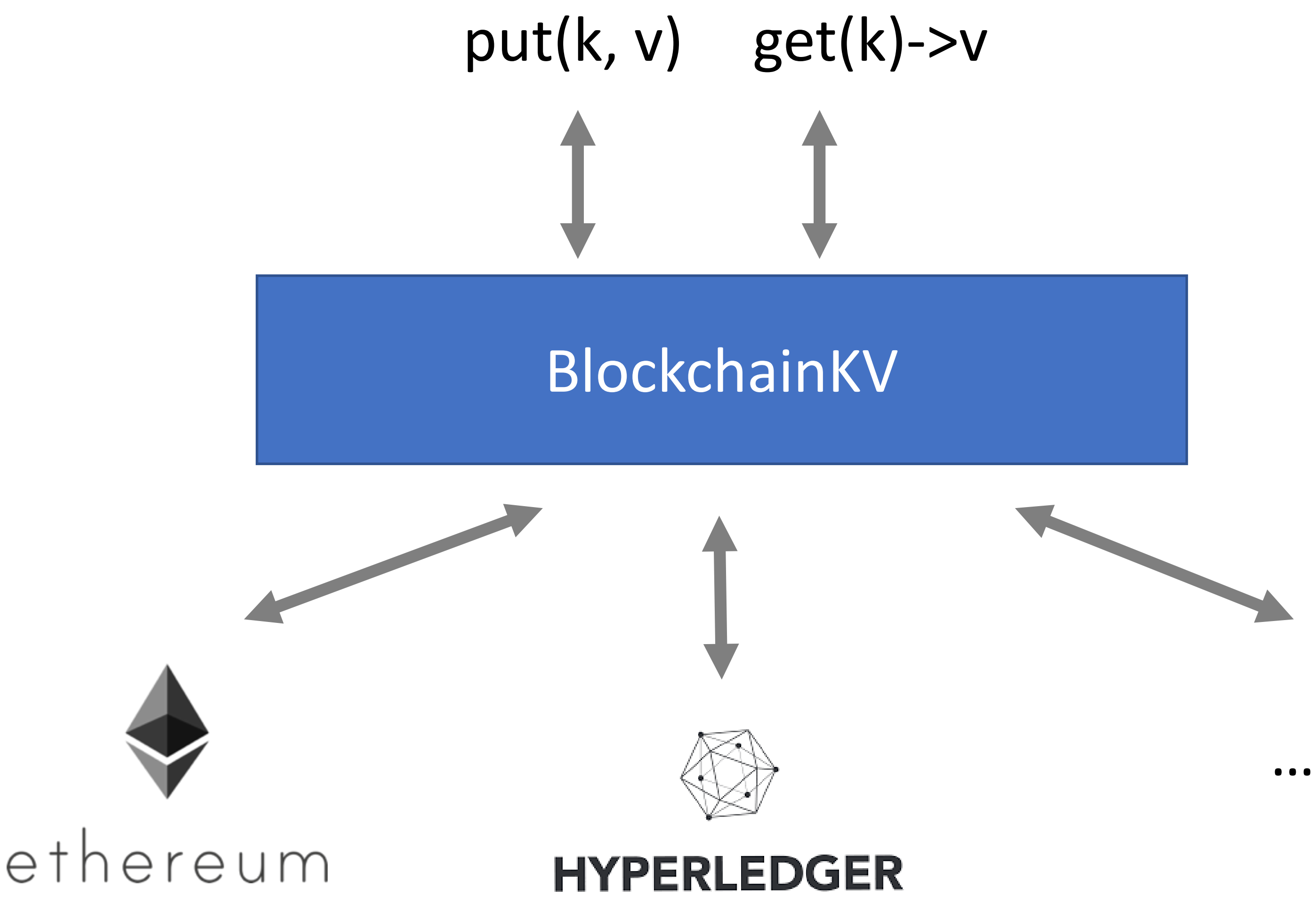


First Step: BlockchainKV (Goal 1)

BlockchainKV: Middleware which provides a **unified put/get interface for different BC backends** (later: full transaction support on top)

Unified API

Pluggable Backends



BlockchainKV: Performance Optimizations (Goal 2

Performance Optimizations in BlockchainKV

- **Sharding** of data in BC
- **Reduced # of Replicas** per shard
- **Lower Consistency Levels** -> higher performance
- **Batching of put's** to lower the BC overhead per put
- **Caching data for get's** but still enabling verification
- …

BlockchainKV: Consistency

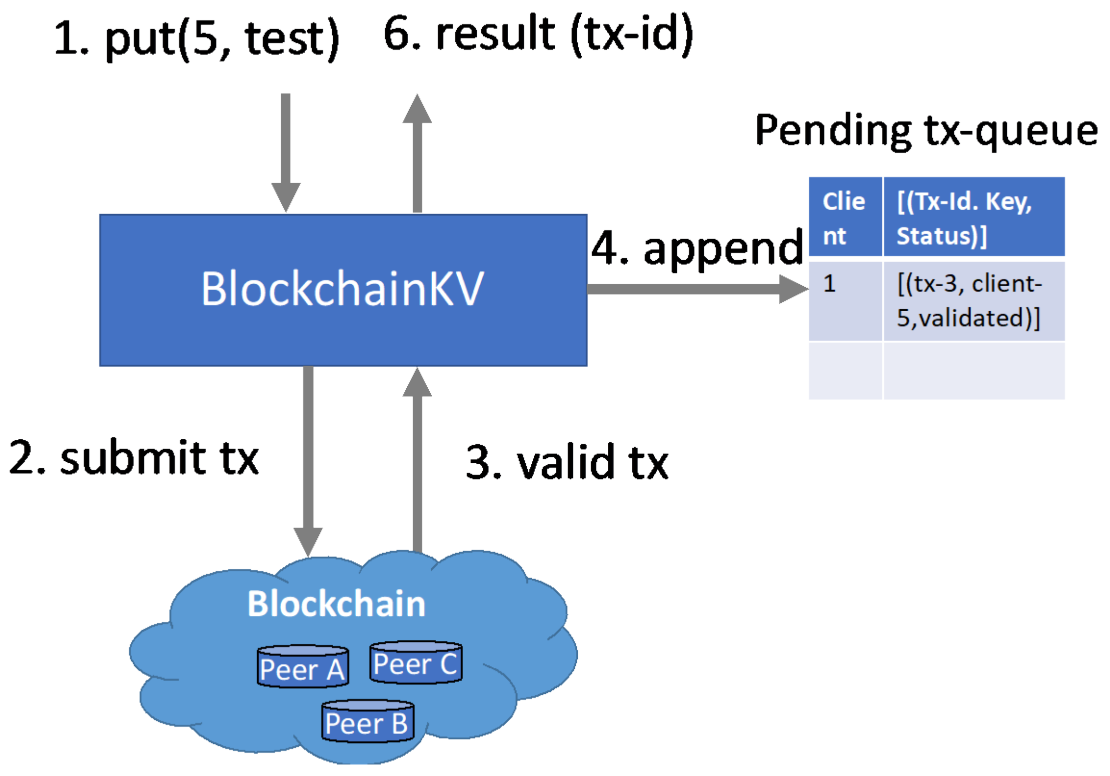
Provide different client-side consistency levels: lower cons. -> higher perf.

Read-Your-Writes:

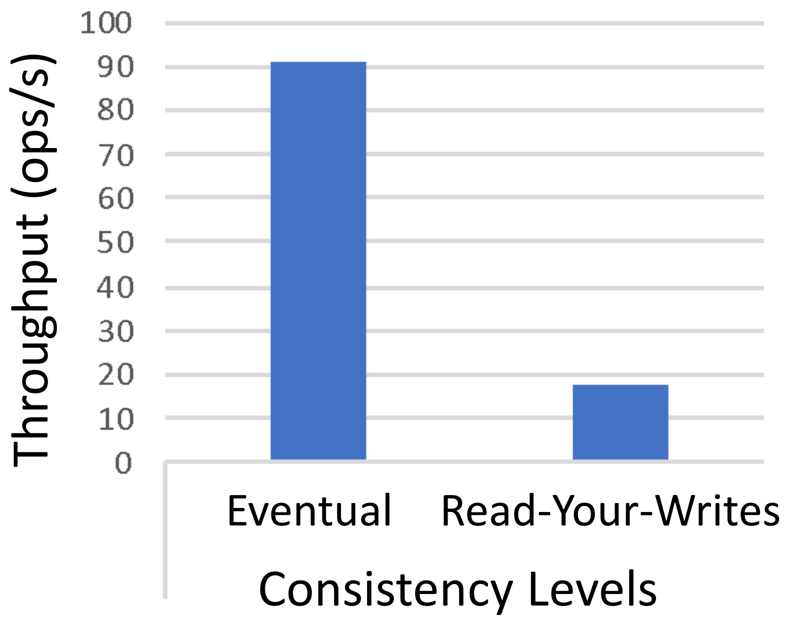
- **Put:** submit tx to BC and add it into pending tx-queue in middleware (if tx is valid)
- **Get:** wait for pending put tx's

Eventual consistency:

- **Put:** same as before
- **Get:** can be executed without waiting for pending put's!



Workload: 50% reads / 50% writes (Ethereum as backend)



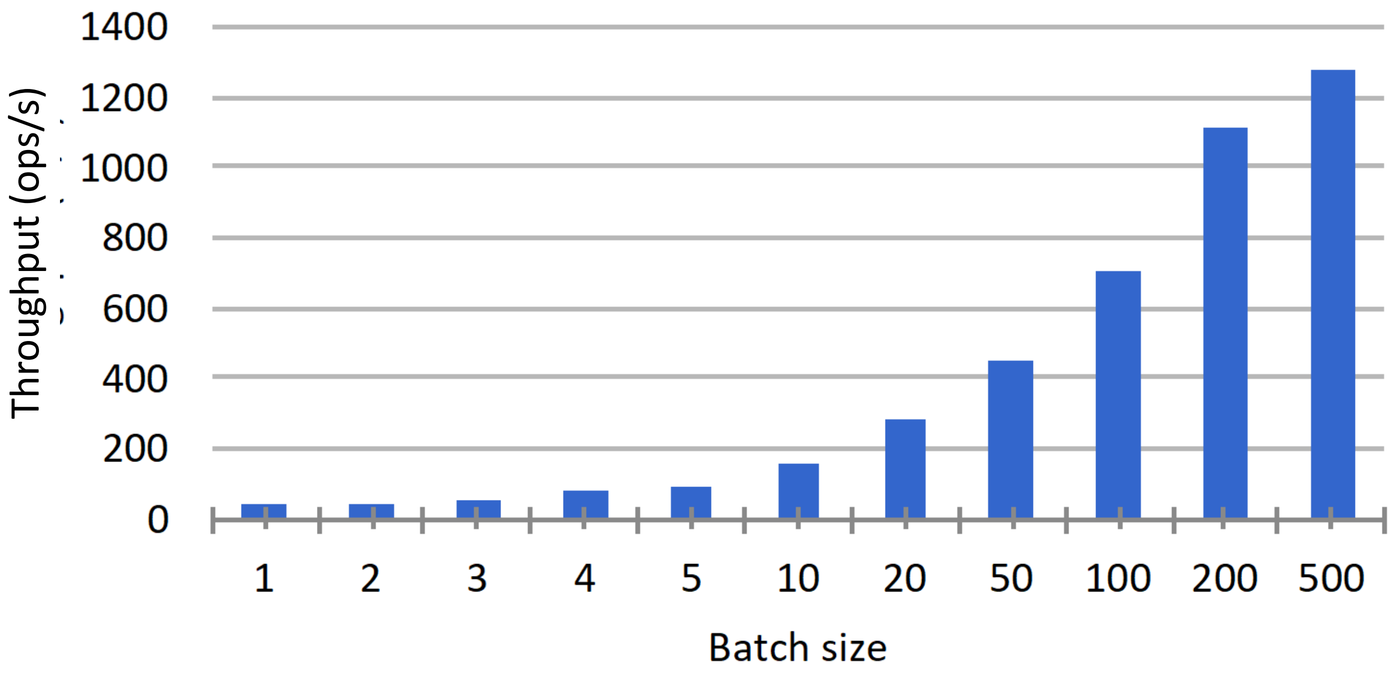
BlockchainKV: Batching

Blockchain has a **high per-tx overhead** (e.g., validation of tx)

Batching in BlockchainKV **merges multiple put’s into on BC tx**

Trivial for Eventual Consistency but more complex for **Sequential Consistency**

Workload: 100% writes
(Ethereum as backend)



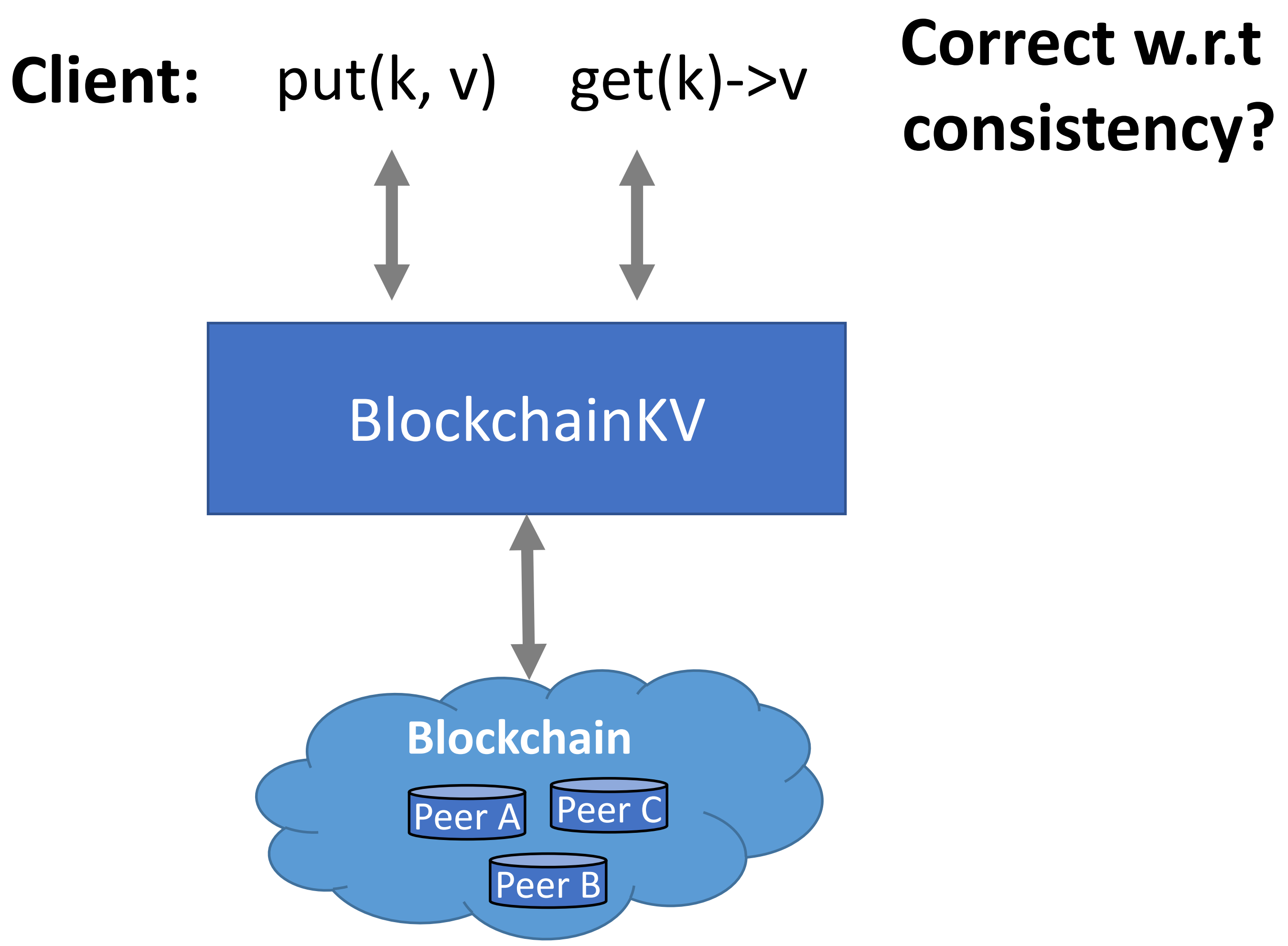
BlockchainKV: Verifiable Consistency (Goal 3)

Main Idea:

- Clients can verify correctness of all KV operations (put's and get's)
- **I.e., verify that puts' and get's adhere to selected consistency level**

Example: Eventual Consistency

- Read-set (RS) ⊆ write-set (WS) of all clients (i.e., **no "fake" reads**)
- Liveliness (i.e., **no dropped writes**)

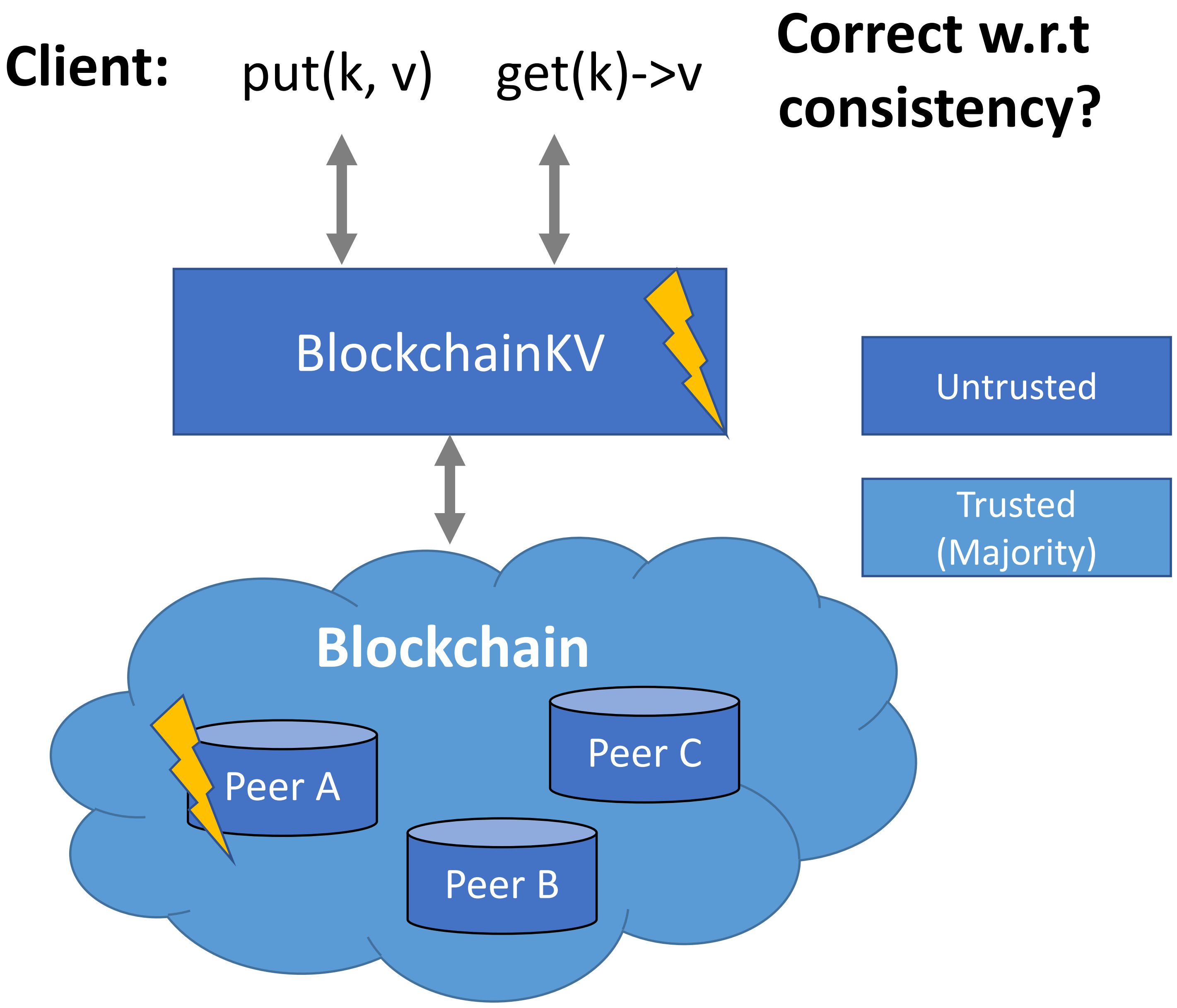


BlockchainKV: Violation of Consistency?

Untrusted components can be compromised (i.e., “misbehave”)

Example: Violation of Eventual Consistency

- BlockchainKV (or even a BC Peer) can “misbehave” if compromised:
  - **Get’s** returns “fake”-values for a key OR
  - **Put’s** are dropped



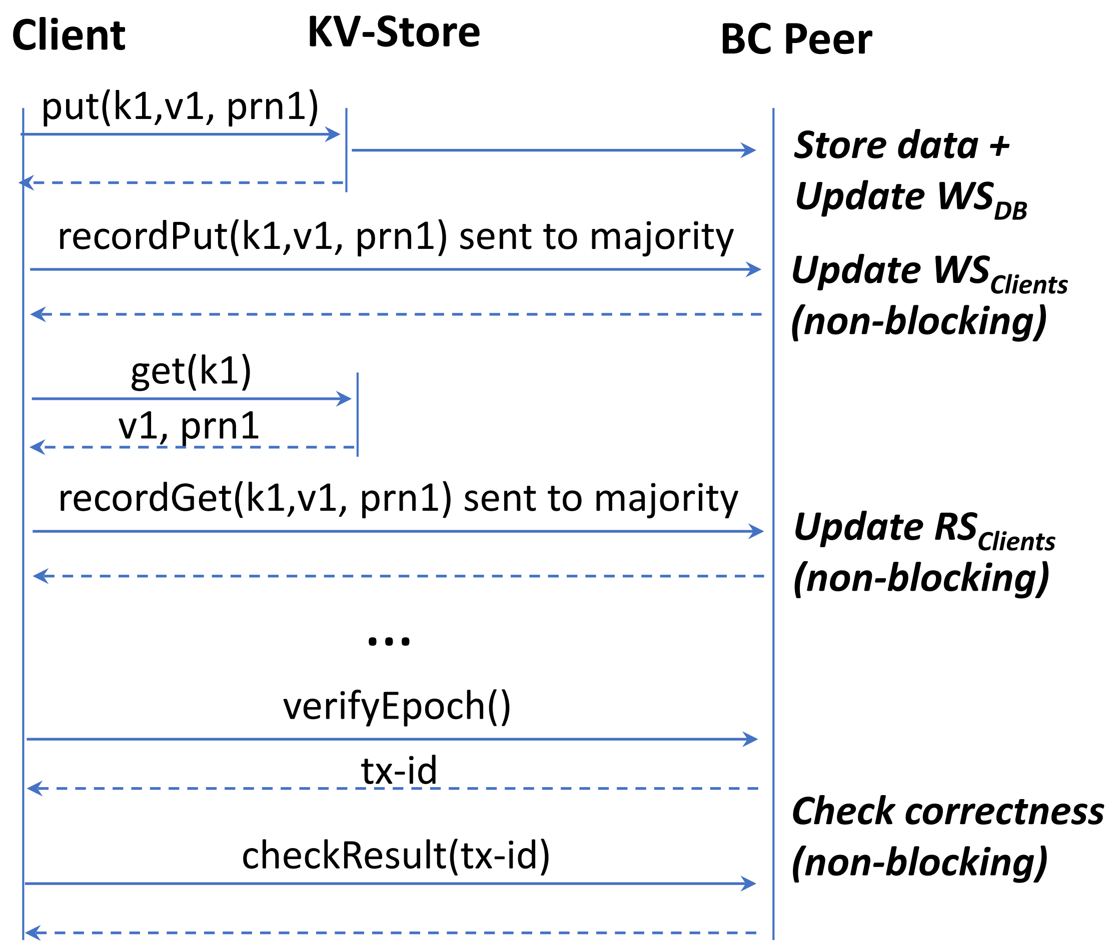
BlockchainKV: Verification Procedure

BlockchainKV uses deferred verification to detect violations of consistency guarantees

Idea: Epoch-based verification for Eventual Consistency (simplified)

- Blockchain keeps updated WS_{KV} of BlockchainKV (ALL put's)
- Clients logs $RS/WS_{Clients}$ of current epoch (bypasses BlockchainKV!)
- Check at end of epoch (non-blocking)
  - $WS_{Clients} \subseteq WS_{KV}$ (no dropped writes)
  - $RS_{Clients} \subseteq WS_{KV}$ (no "fake" reads)

Deferred Verification:



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What’s next?

BlockchainKV only a **first step towards a Shared Database System** on Blockchains

Next Steps:

- Add further **optimizations (e.g., caching)** to middleware
- Add support for **verifiable DB Transactions** on top
- **Hardware supported** verifiable DB Transactions

Long term: Integration into existing DBMSs (e.g., as a “shared” column/table)?

Collaborators

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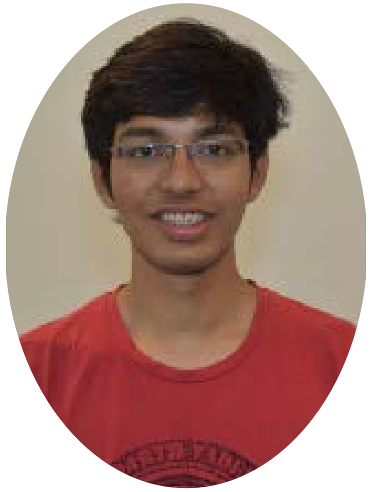

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See also https://distributedledger.center/

Thank you!

Microsoft