Efficient Middleware for Byzantine Fault Tolerant Database Replication

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1. Motivation

Databases are central in computing infrastructures

Byzantine faults occur in practice:

- Software bugs
- Hardware errors
- Intrusions

Goal:

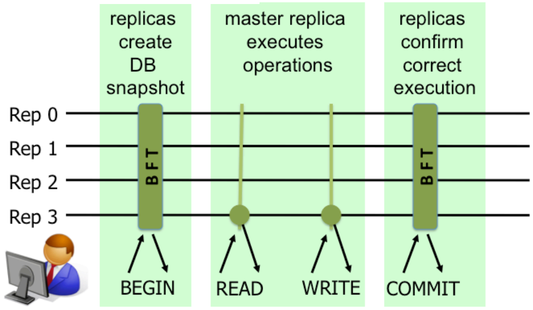
Efficient database BFT replication

Challenges:

Avoid serializing every operation through BFT

Exploit weaker consistency (snapshot isolation)

2. Basic solution


replicas create DB snapshot
master replica executes operations
replicas confirm correct execution
Rep 0
Rep 1
Rep 2
Rep 3
BFT
BFT
BEGIN
READ
WRITE
COMMIT

- Only run begin/commit as BFT operations
- Replicas must confirm tentative execution

3. Limitations

(1) Database systems use locks ⇒

Need to avoid deadlocks in the system

Two solutions

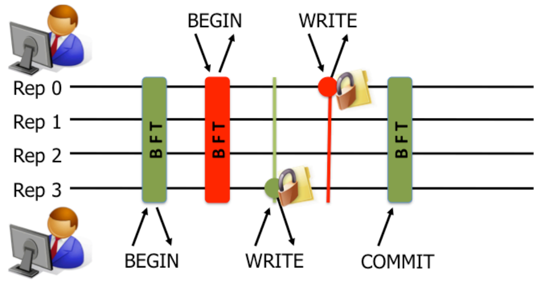
- Single master
- Multi-master

(2) Read-only transactions execute in all replicas

Execute read-only transaction in f+1 replicas

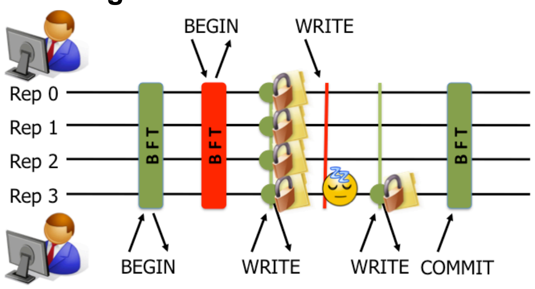
Striping transactions among different replicas

4. Multi-master



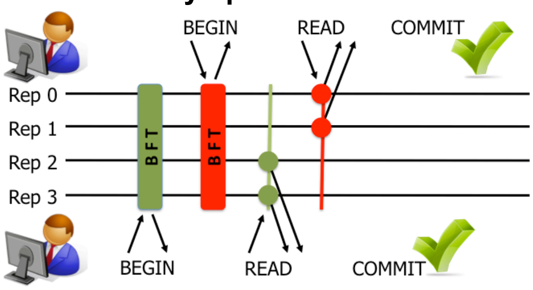
- At commit, execute all operations at non-masters
- Non-masters may have to undo local transactions

5. Single master



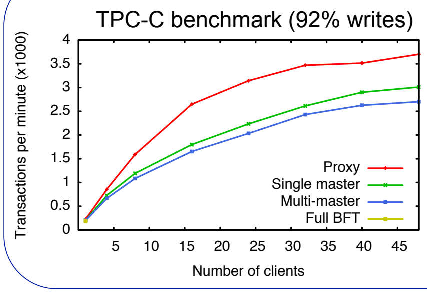
- Optimization: non-masters execute penultimate op
- At commit, only one operation left to execute

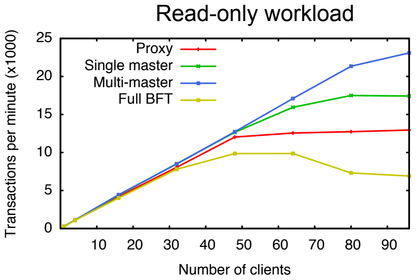
6. Read-only operations



- Read from f+1 ⇒ correct reply
- Commit confirmed locally if all reads ok

7. Evaluation and conclusions





First solution for efficient BFT DBMS without trusted central components

Good performance results

- Modest overhead for R-W
- Striping for improving read-only performance

Several new techniques can be reused

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