Linearizable Quorum Reads in Paxos

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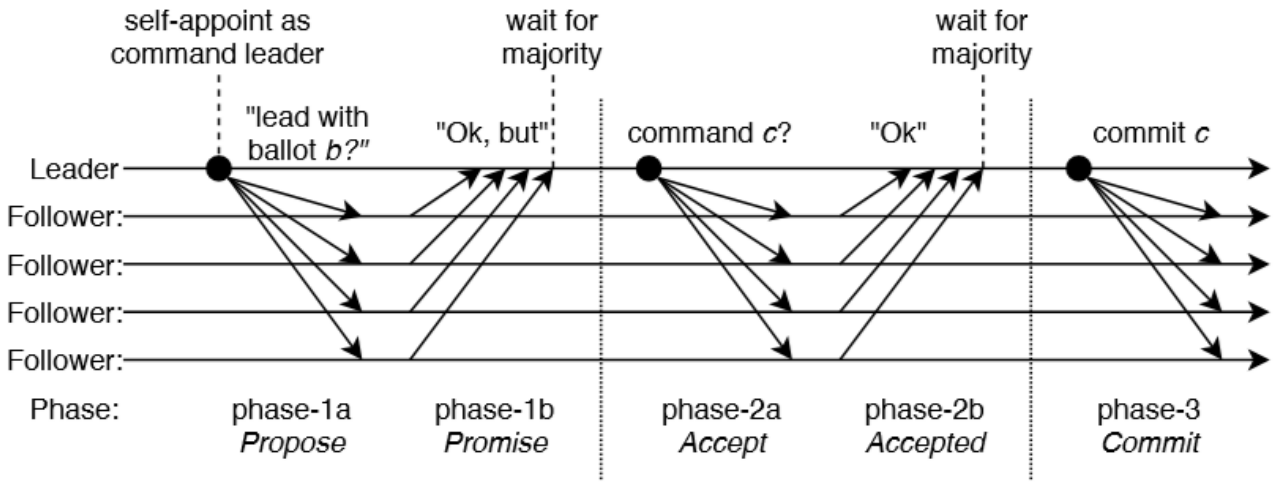
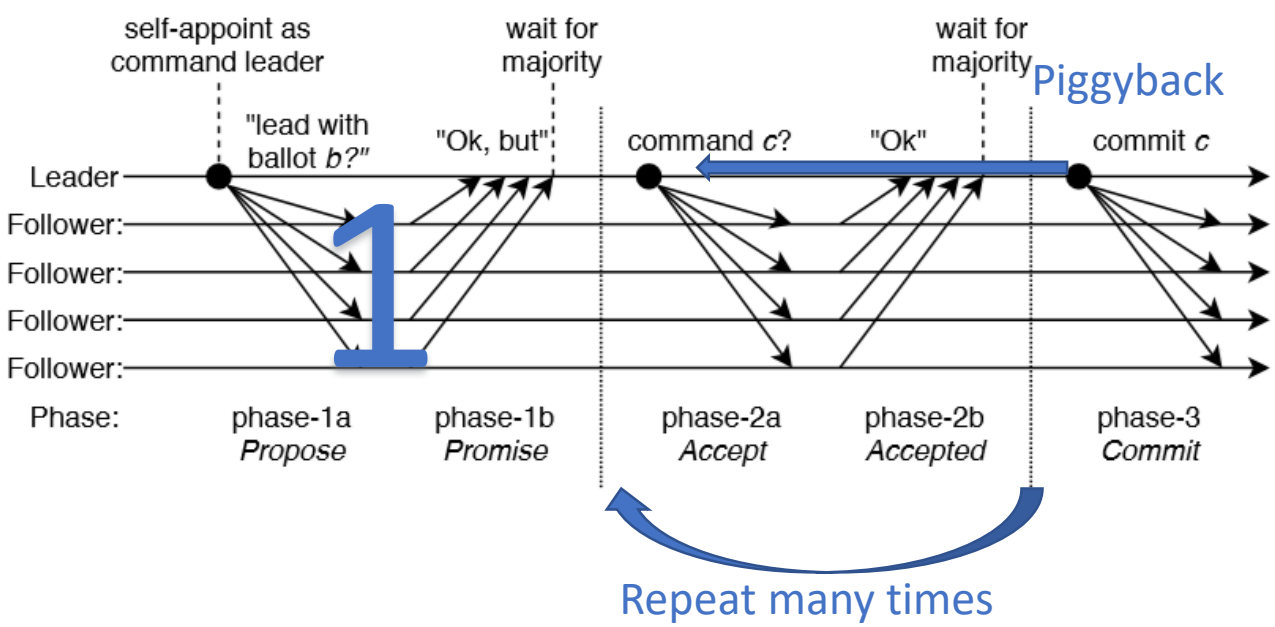
What is Paxos

- Solves Distributed Consensus
- Operates in 3 Phases
  1. Elect a Leader for a round
  2. Accept value
  3. Mark committed



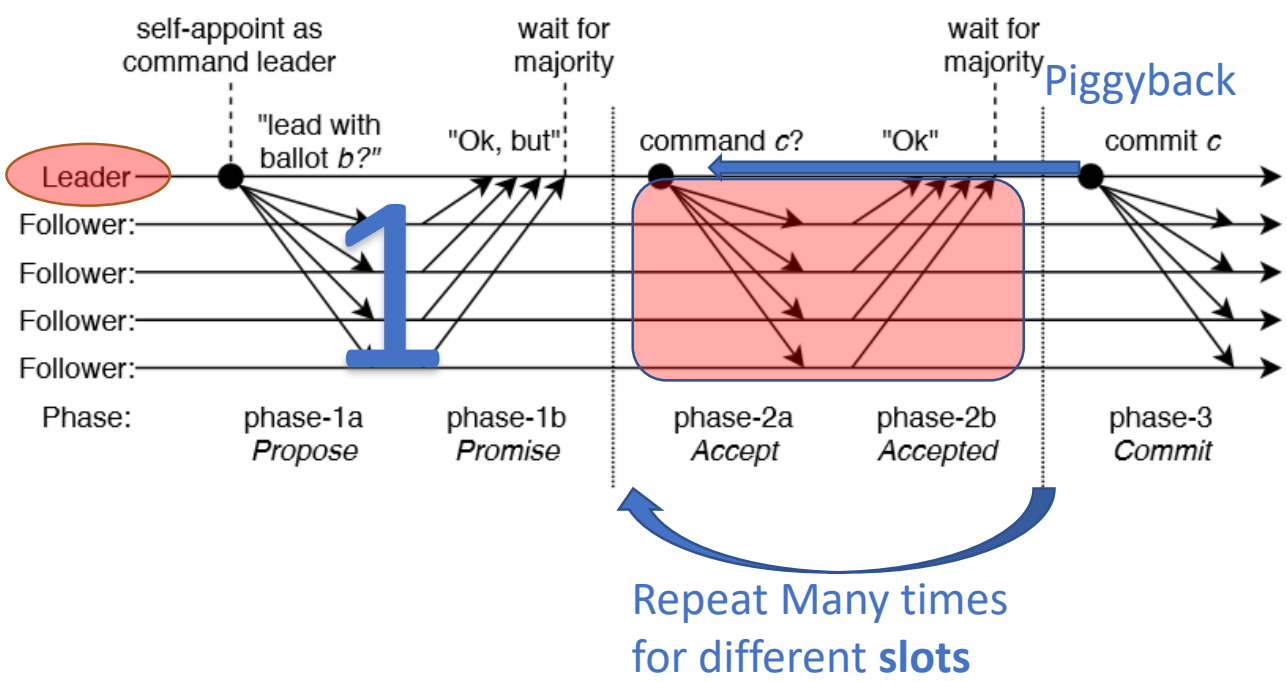
From Paxos to MultiPaxos

- Run Phase-1 once
- Keep stable leader
- Repeat phase-2 many times
- Piggyback phase-3 to some next phase-2



Problems with Paxos

- Single Leader Bottleneck
  - Lots of messages to send/receive



Paxos in Distributed Databases

- Data replication
  - Paxos and its derivatives are often used in strongly-consistent databases.
    - CockroachDB
    - Spanner/Cloud Spanner
    - YugaByte
    - PaxosStore

CockroachDB (Raft)

YugaByte (Raft)

Cloud Spanner (Paxos)

Reading from Paxos-Based System

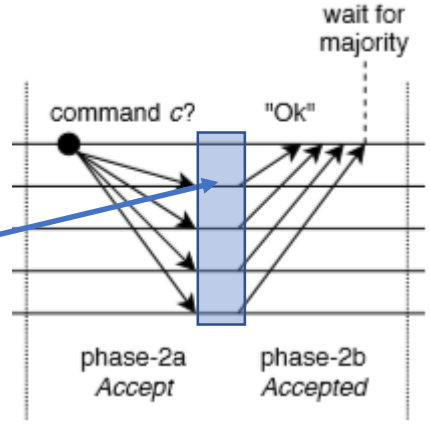
- Paxos has no notion of ‘Reads’.
  - Consensus on commands
  - Order of commands
  - ‘Read’ is a command.
  - Strong Consistency for any type of command

Reading from Paxos-Based System II

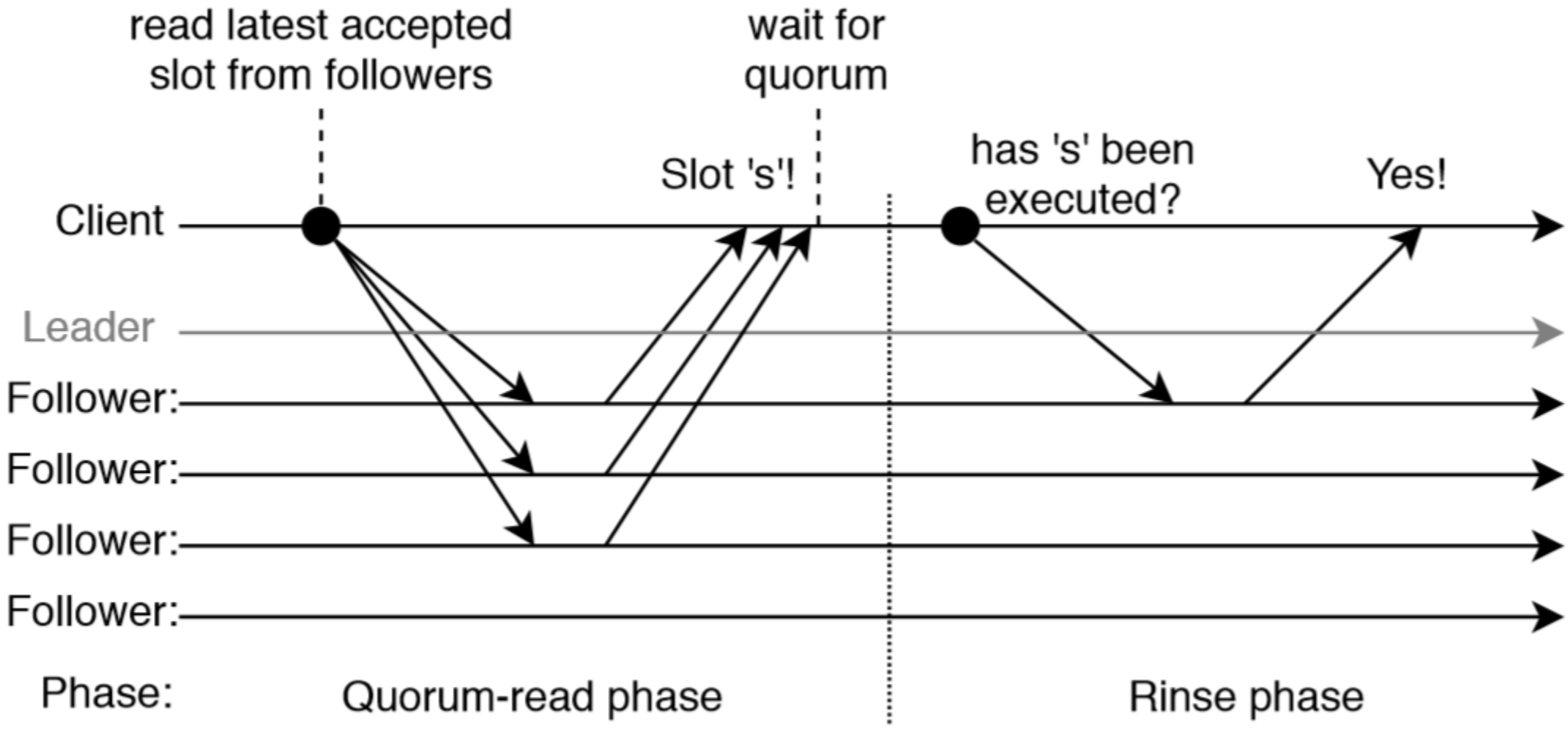
- Read from the leader
  - Need leases to protect the leader
- Read from any replica
  - Read stale data (ZooKeeper)
- Read from quorum of replicas
  - Leader may still be slightly ahead!

Paxos Quorum Read (PQR)

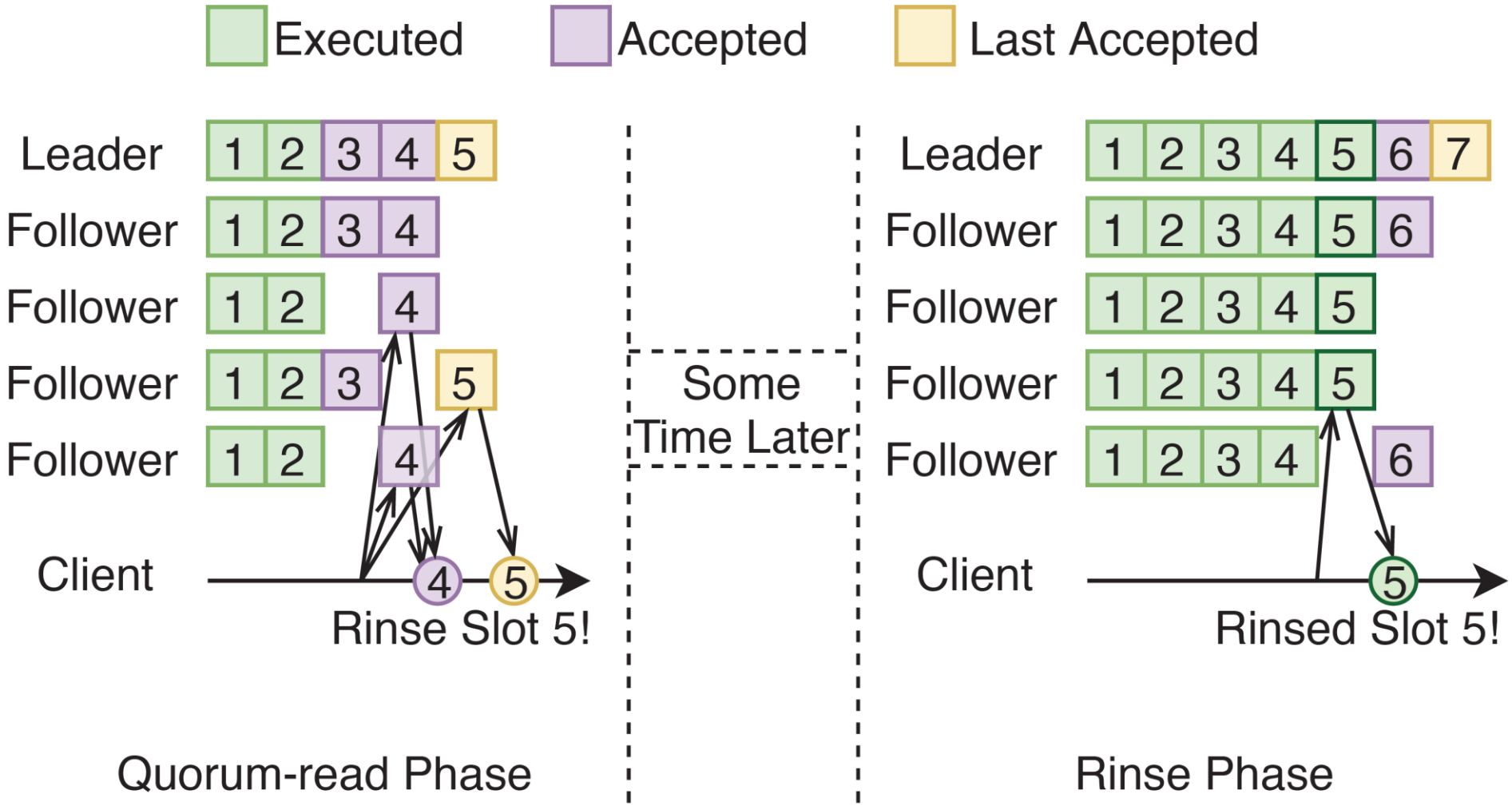
- Two-phases to make sure we read the latest value.
  - Quorum-read Phase
    - Read from quorum for latest accepted(!) value. Remember the max slot #
  - Rinse Phase
    - Read one(!) node for executed.
    - Executed slot is known to have been globally committed with no gaps.
    - Return value if executed slot # >= accepted slot # from Quorum-read phase.



Paxos Quorum Read (PQR)

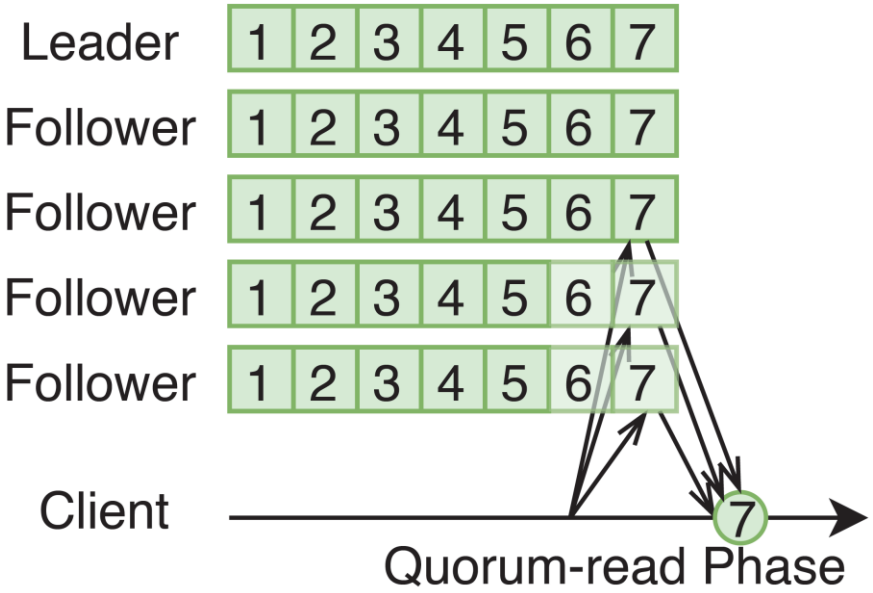


PQR Example

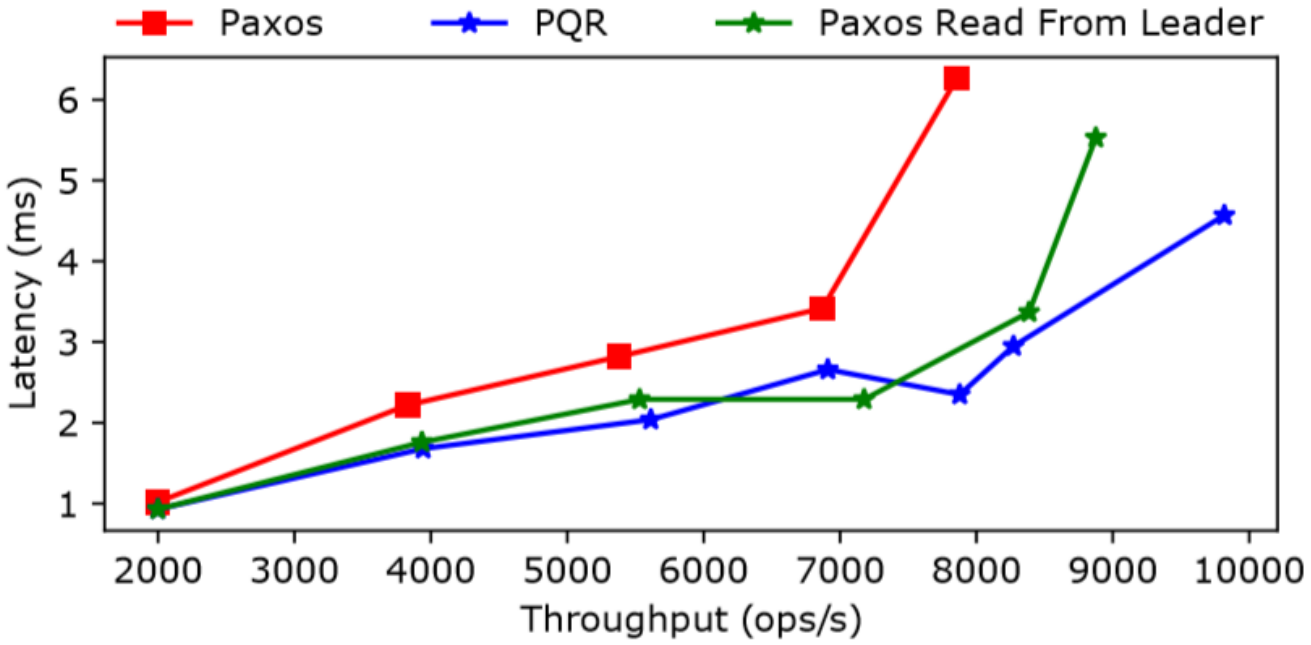

Executed
Accepted
Last Accepted
Leader
Follower
Follower
Follower
Follower
Client
Rinse Slot 5!
Some
Time Later
Leader
Follower
Follower
Follower
Follower
Client
Rinsed Slot 5!
Quorum-read Phase
Rinse Phase

Doing PQR in one RTT

- PQR takes 2 RTTs
- Possible to eliminate Rinse Phase in absence of new commands (no progress):
  - last accepted slot # = last executed slot #
  - Means that Rinse phase condition is already met!
- Can track progress per object or shard in similar way



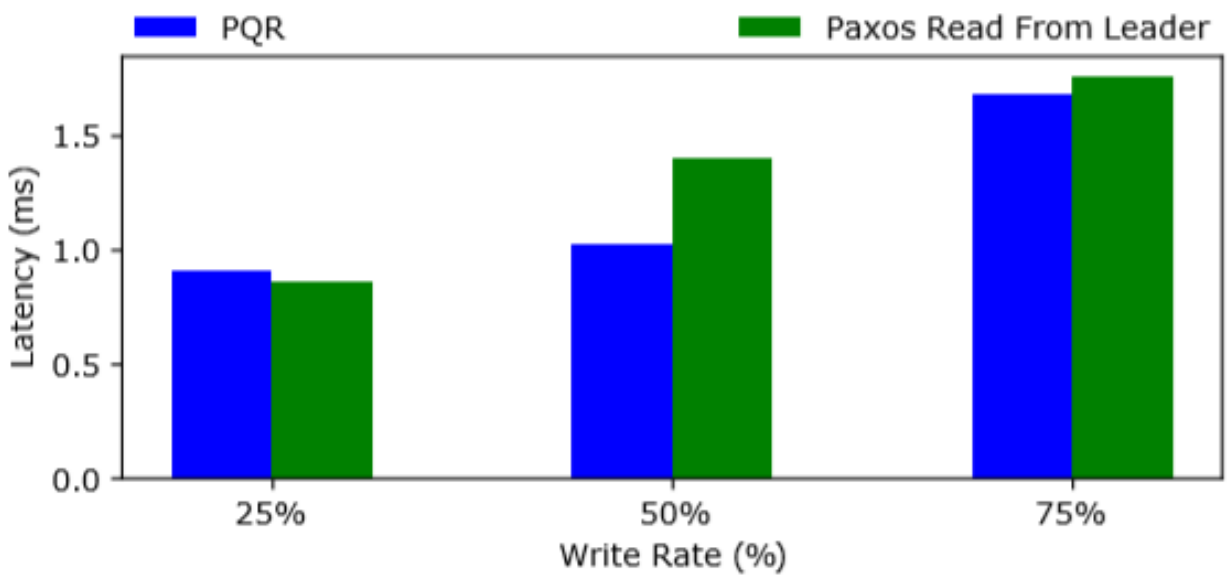
PQR Evaluation



Throughput and latency

- Paxos runs full round for read
- Paxos Read From Leader reads from dedicated leader node
- 75% writes
- Similar results at 50% and 25% writes, however, PQRs advantage starts to diminish.

PQR Evaluation: Latency



Latency

- Fixed throughput @ 4k req/sec
- Suggests a sweet spot for best PQR performance
- PQR works best when leader is close to being saturated, and reads go to followers.

Conclusion

- PQR helps balance load between Paxos leader and follower nodes
- Offloading leader form serving reads allows it to serve more writes
- Reads use underutilized follower nodes
- PQR Improves throughput, especially in write-heavy workloads.