Scalog: Seamless Reconfiguration and Total Order in a Scalable Shared Logs

NSDI'20

Cong Ding, David Chu, and Evan Zhao, Cornell University; Xiang Li, Alibaba Group;
Lorenzo Alvisi and **Robbert van Renesse**, Cornell University

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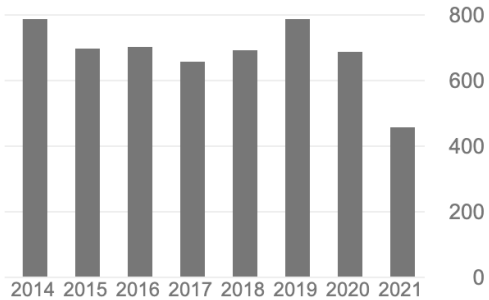

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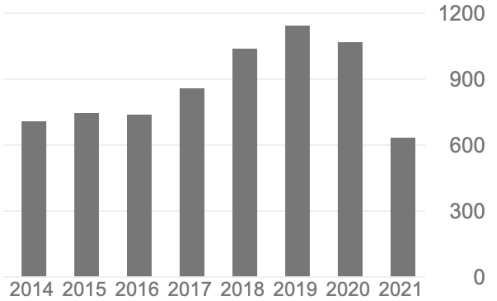

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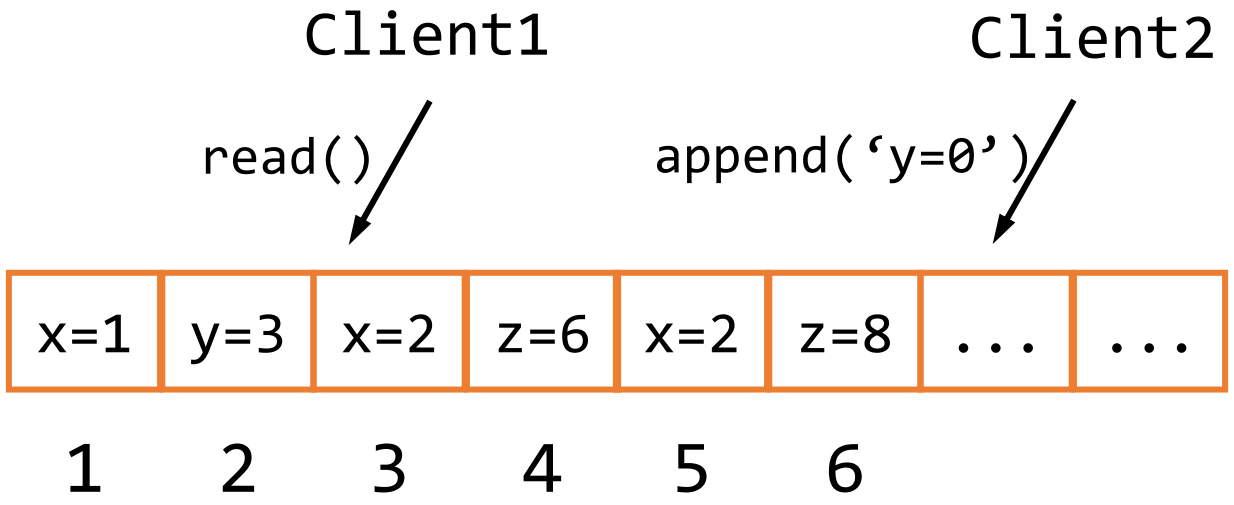
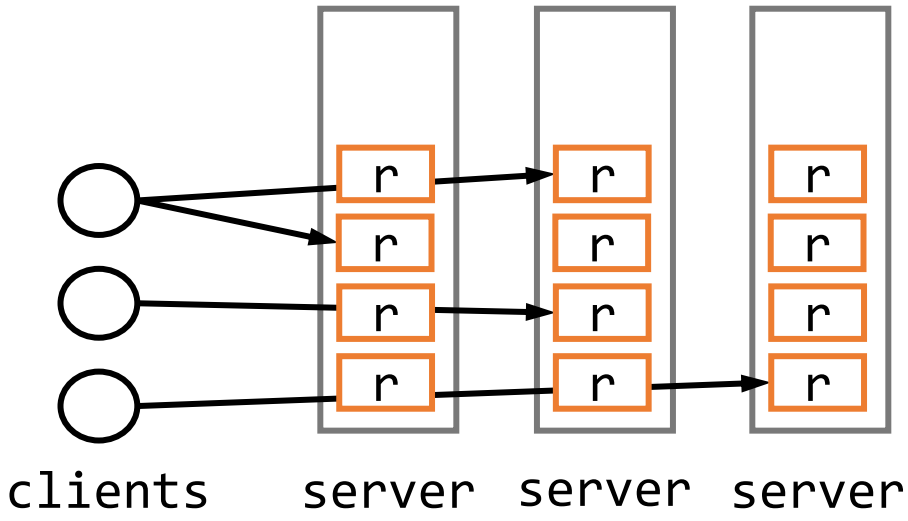
Background – Shared Log

- A set of ordered records
- Concurrently appended to and read by multiple clients



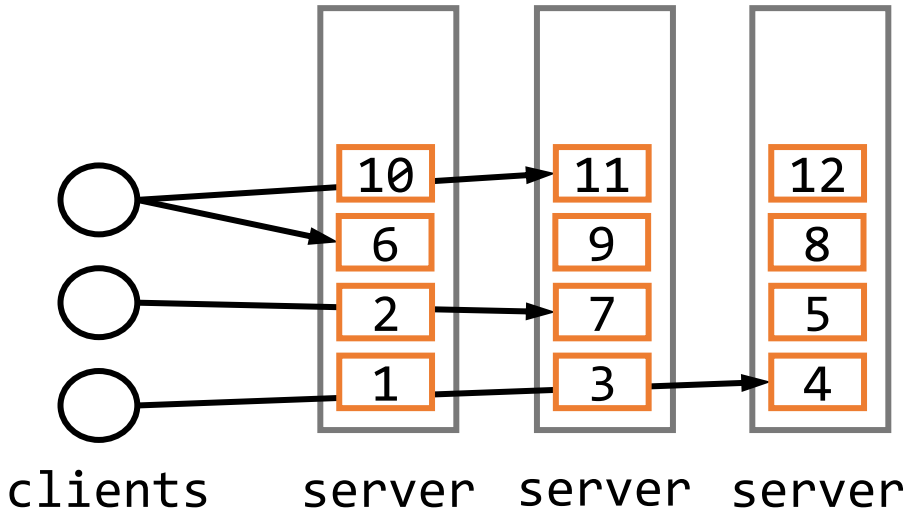
Background – Shared Log

- A set of ordered records
- Concurrently appended to and read by multiple clients
- Additional features:
  - Scalability



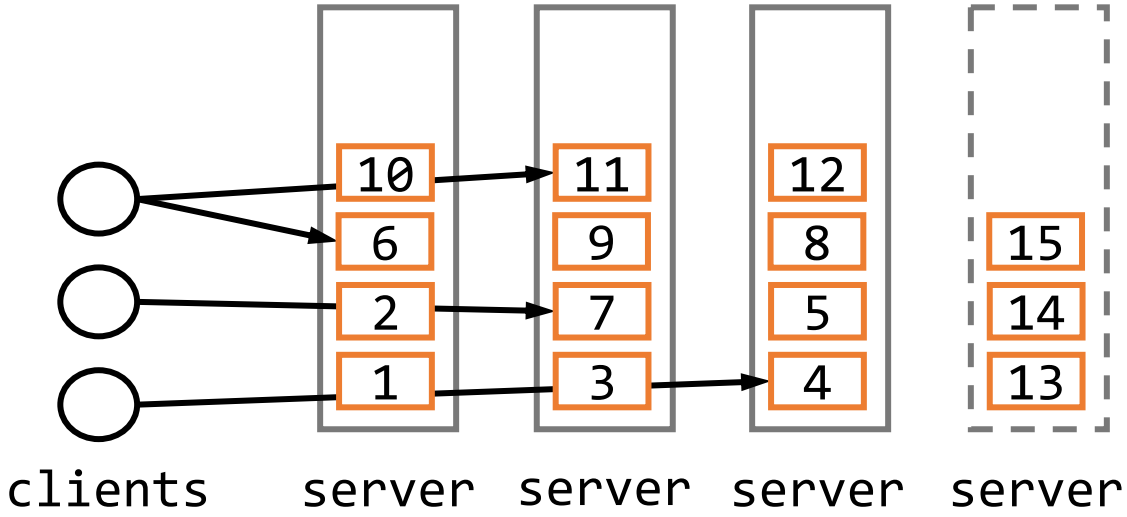
Background – Shared Log

- A set of ordered records
- Concurrently appended to and read by multiple clients
- Additional features:
  - Scalability
  - Total order



Background – Shared Log

- A set of ordered records
- Concurrently appended to and read by multiple clients
- Additional features:
  - Scalability
  - Total order
  - Seamless reconfiguration(add/remove instances)



Background – Existing Implementation

- 右边还有corfu、 fuzzylog、 kafka

Corfu[nsdi'12]

FuzzyLog[osdi'18]

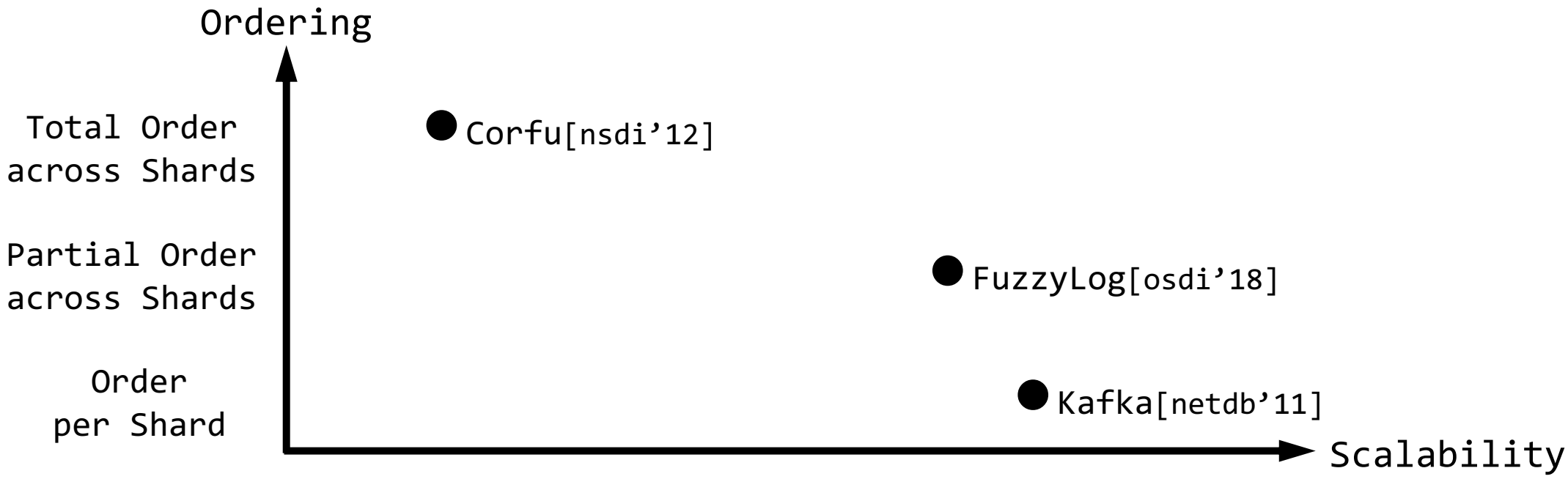
Kafka[netdb'11]

Background – Why Shared Log

- Analytics
  - Record and analyze web accesses for recommendations, ad placement, intrusion detection, performance debugging, etc
- Failure recovery
  - Committed steps to replay
- Consensus engine with an order

Motivation – Scalability vs Ordering

- Trade-off



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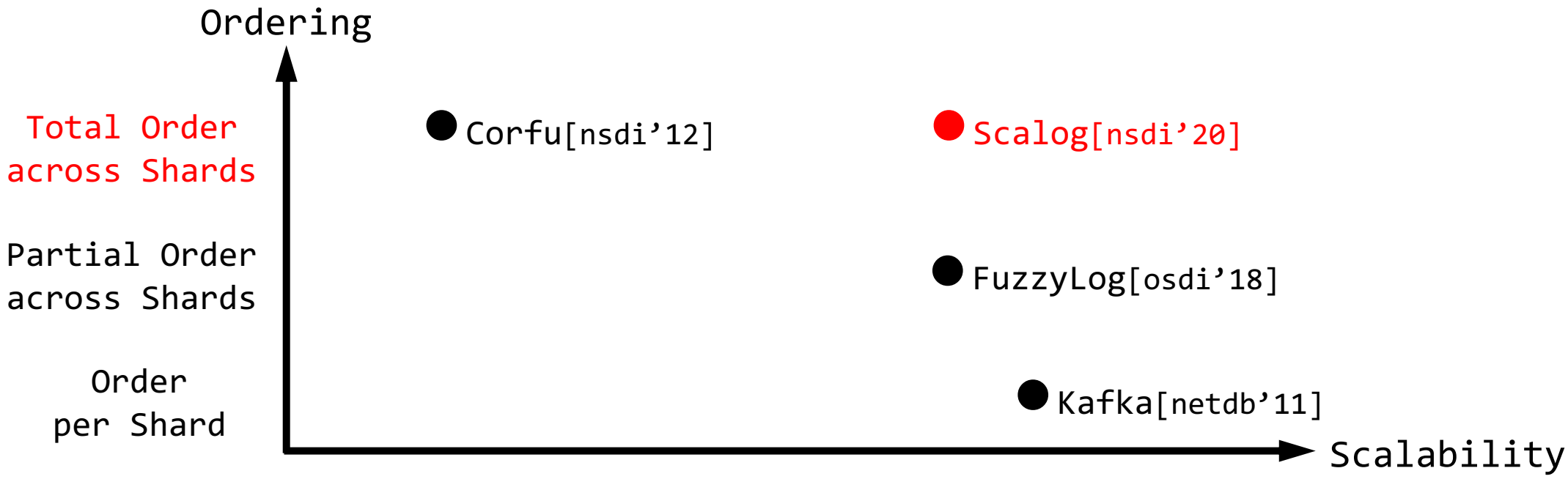
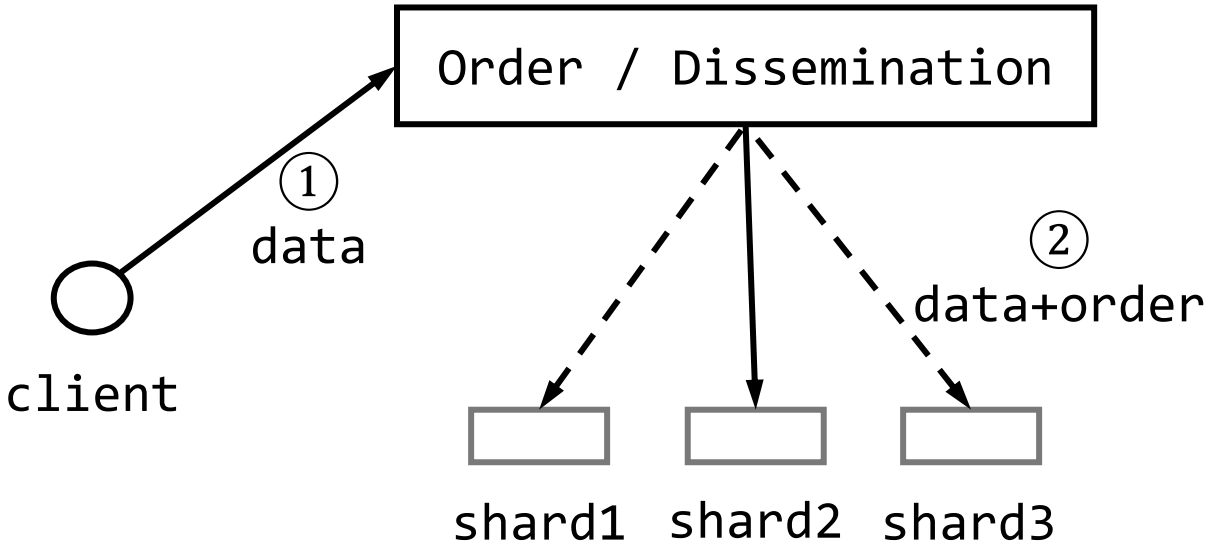


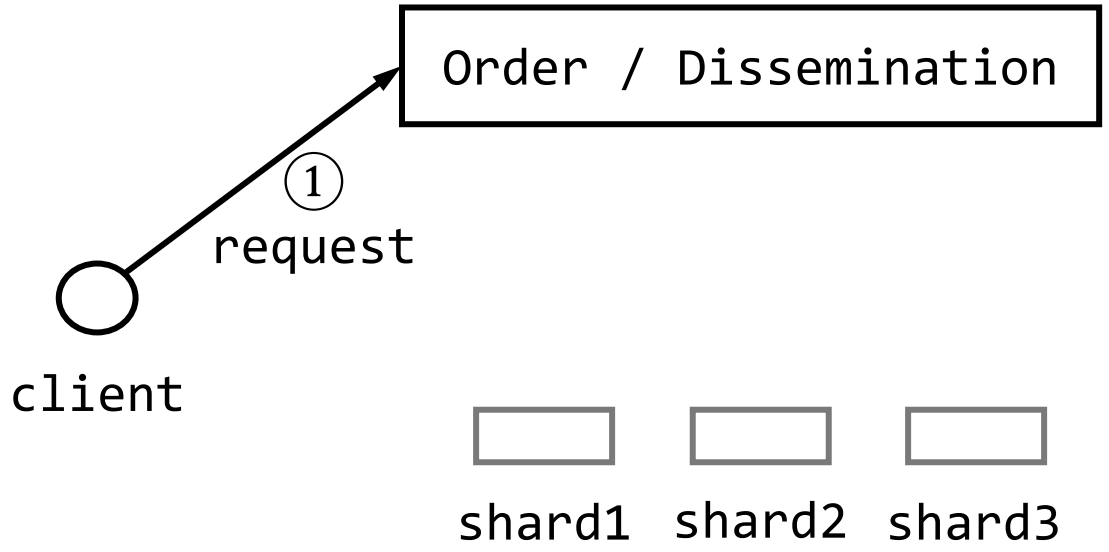
Motivation – Scalability vs Seamless Reconfiguration

- Shared log: LogDevice from Facebook
  - High throughput: ❌
    - bottleneck
  - Seamless reconfiguration: ✅
    - still available



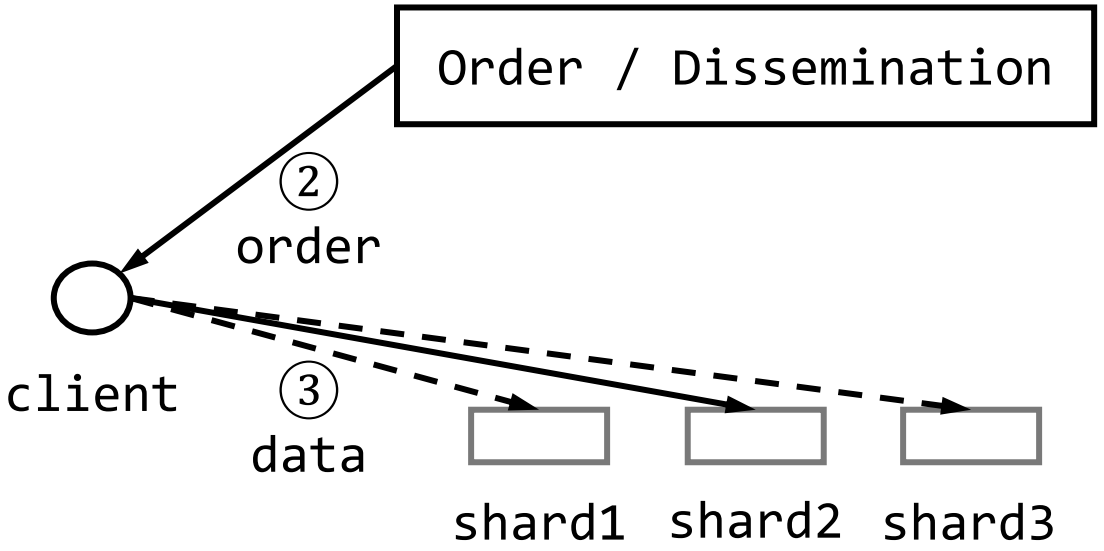
Motivation – Scalability vs Seamless Reconfiguration

- Shared log: Corfu[nsdi'12]



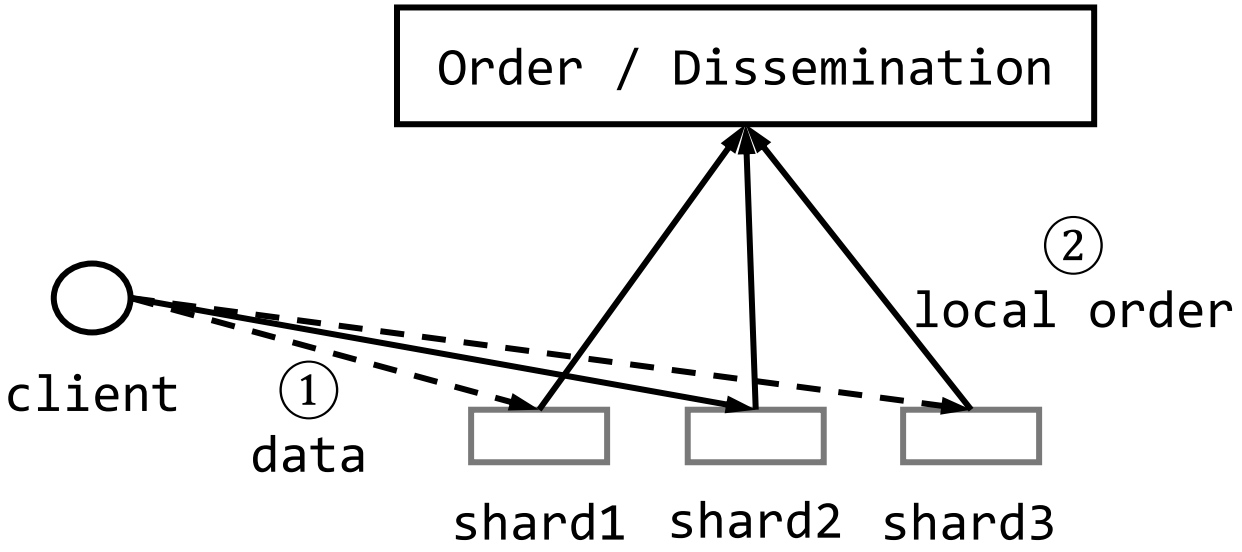
Motivation – Scalability vs Seamless Reconfiguration

- Shared log: Corfu[nsdi'12]
  - High throughput: ✅
    - data separated from ordering
  - Seamless reconfiguration: ❌
    - not available



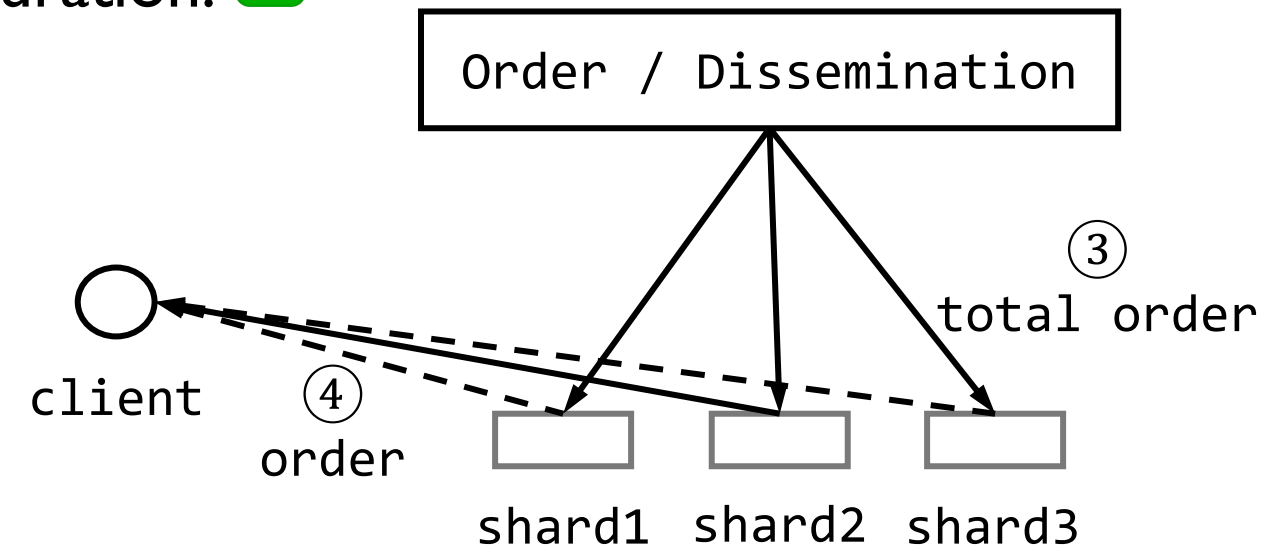
Motivation – Scalability vs Seamless Reconfiguration

- Shared log: Scalog[nsdi'20]

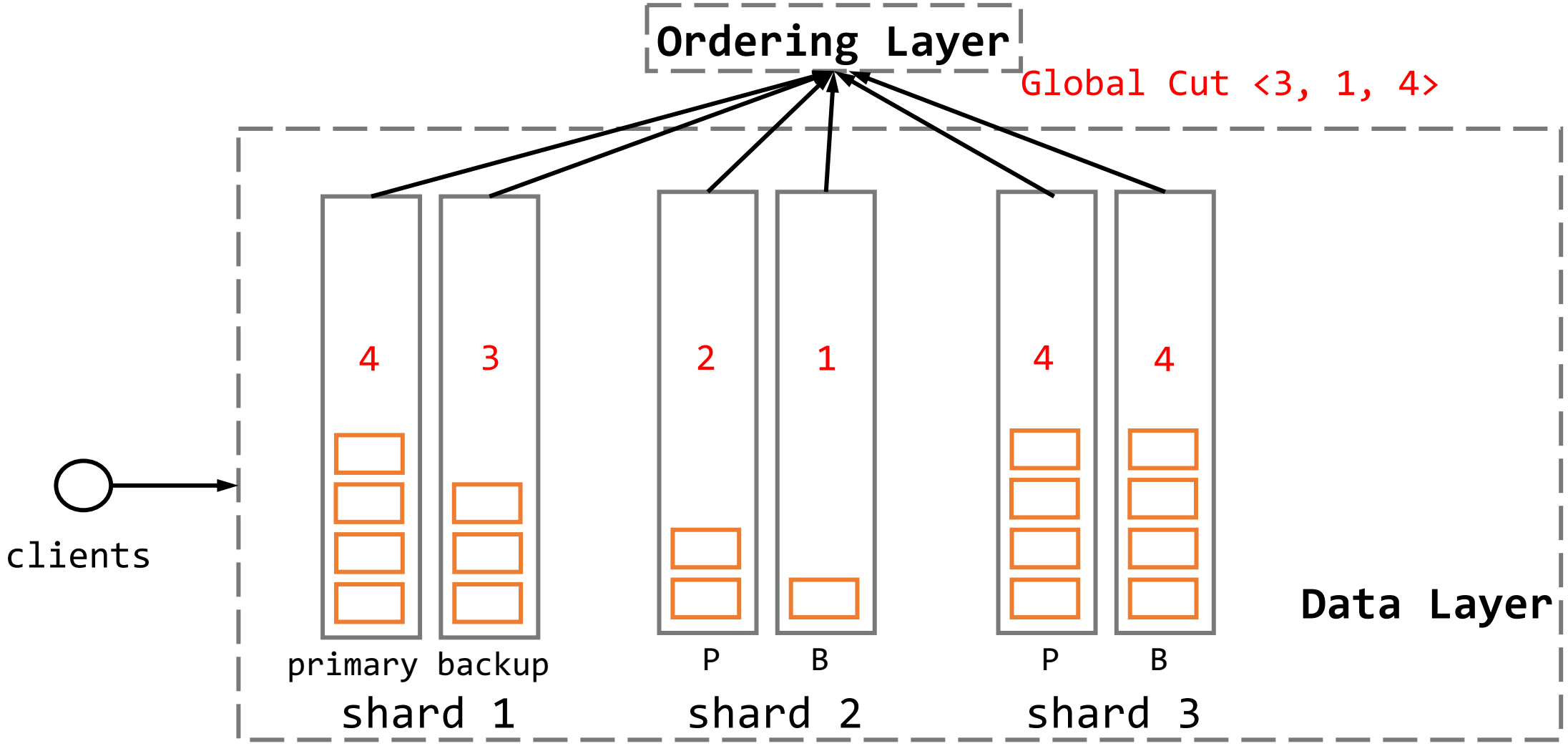


Motivation – Scalability vs Seamless Reconfiguration

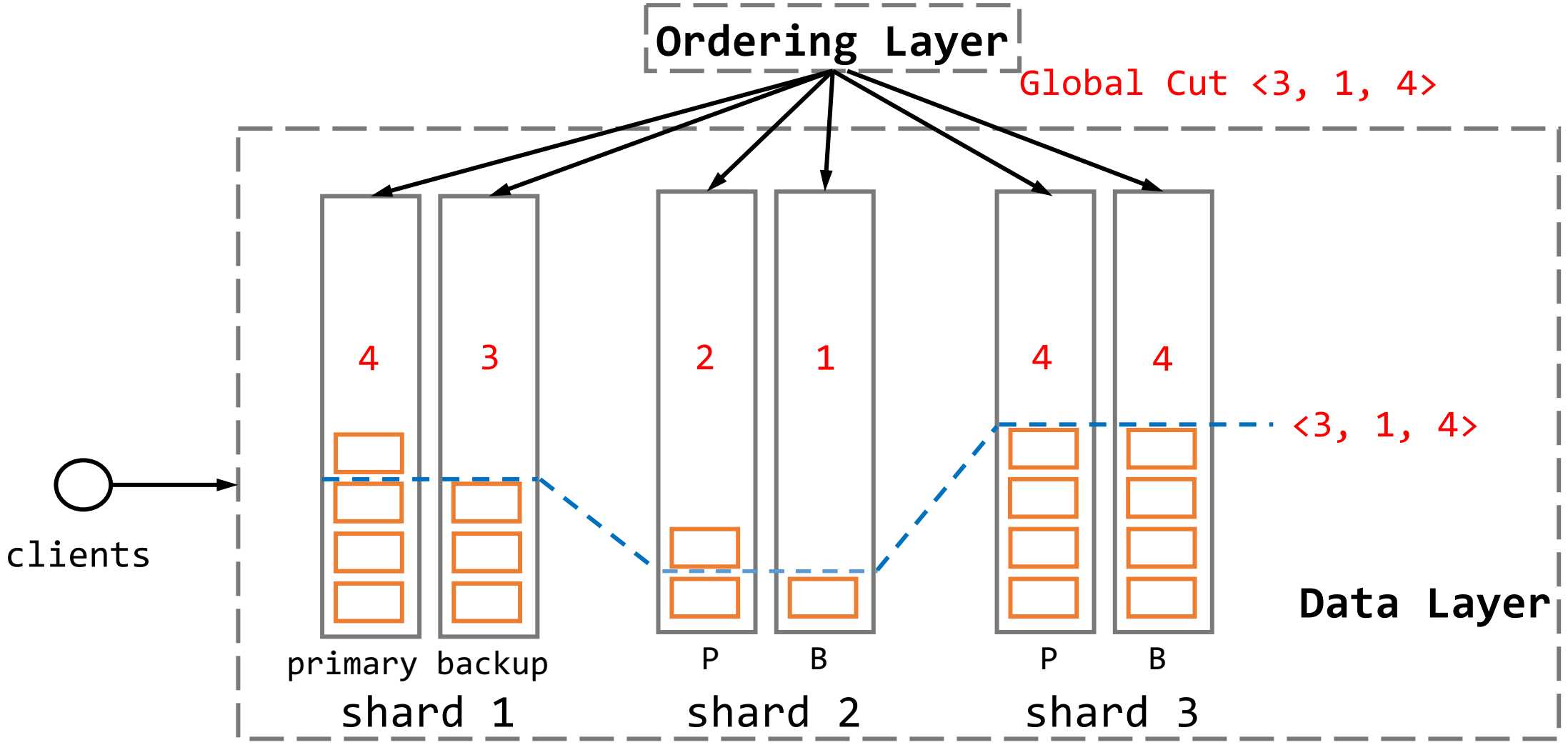
- Shared log: Scalog[nsdi'20]
  - High throughput: ✅ ✅
    - data separated from ordering
    - nearest server
  - Seamless reconfiguration: ✅
    - available!



Scalog – Workflow: Append



Scalog – Workflow: Append



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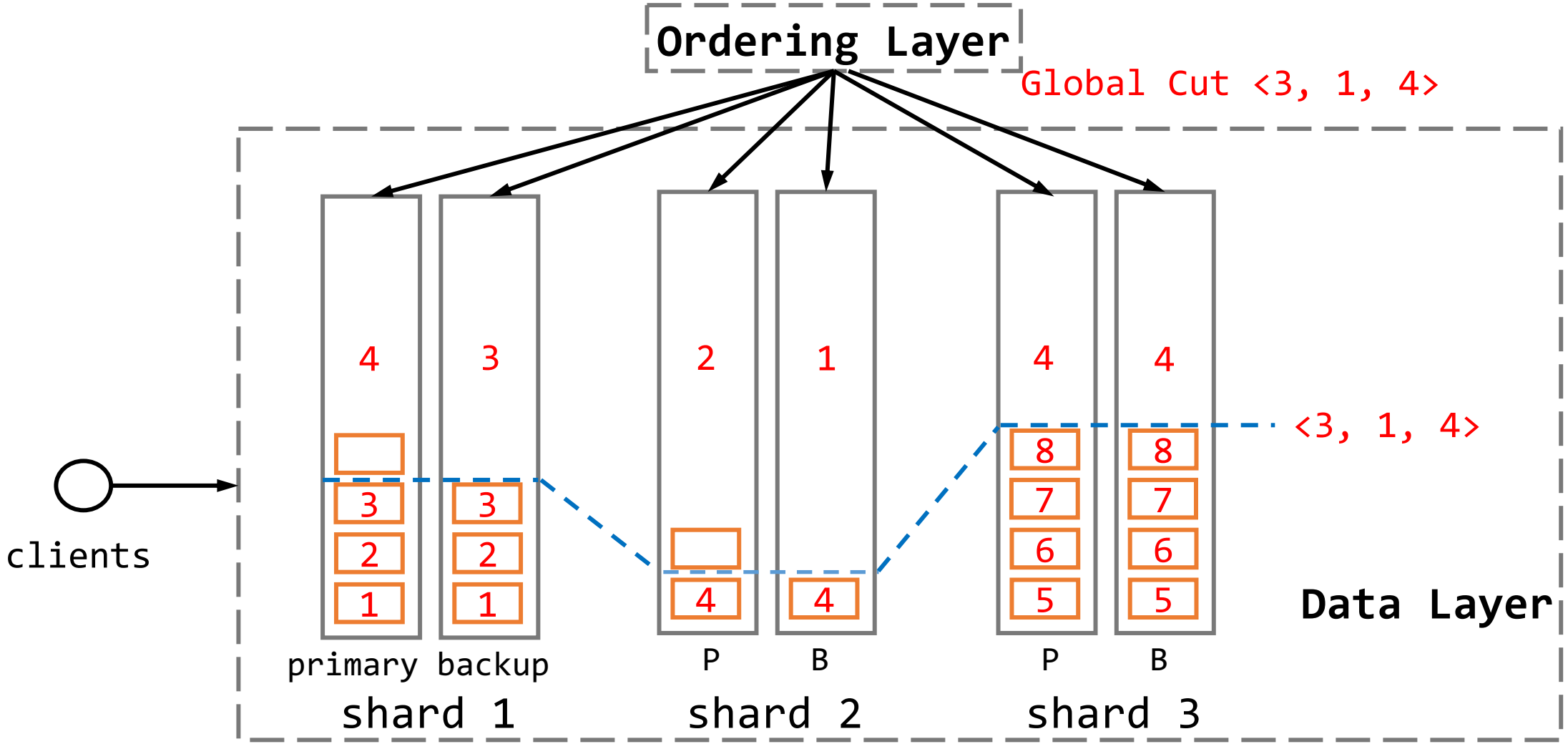

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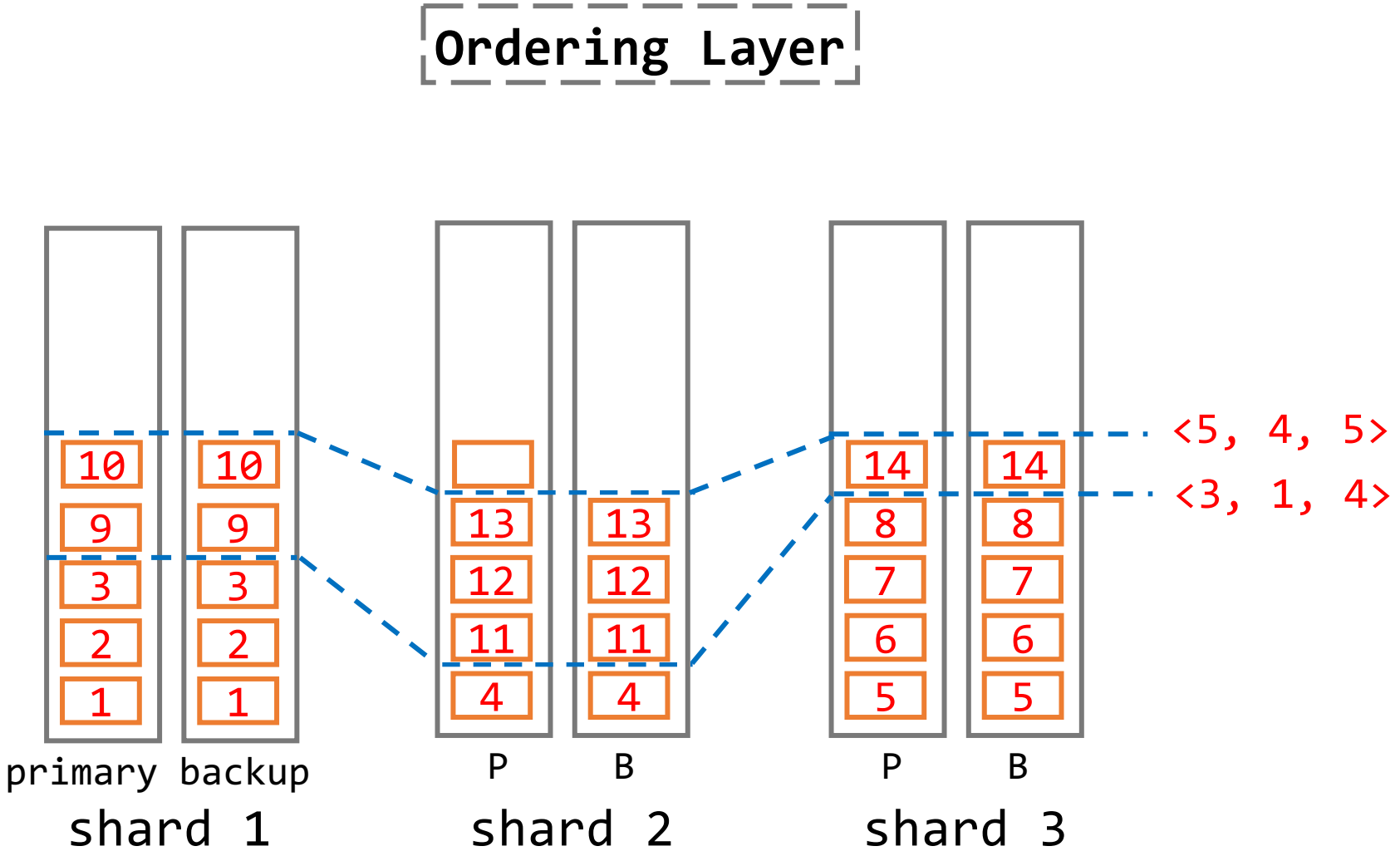
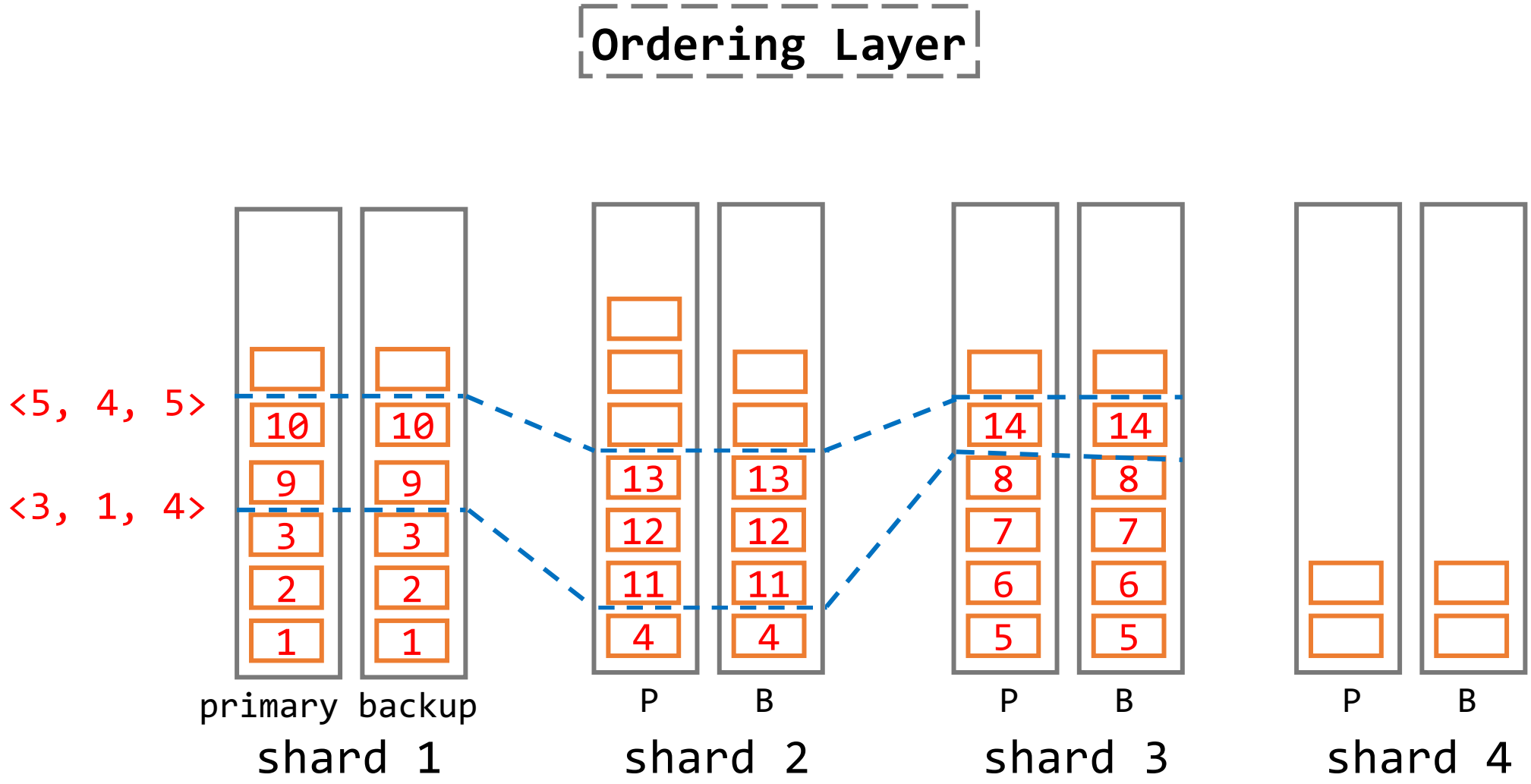


Scalog – Workflow: Adding a Shard



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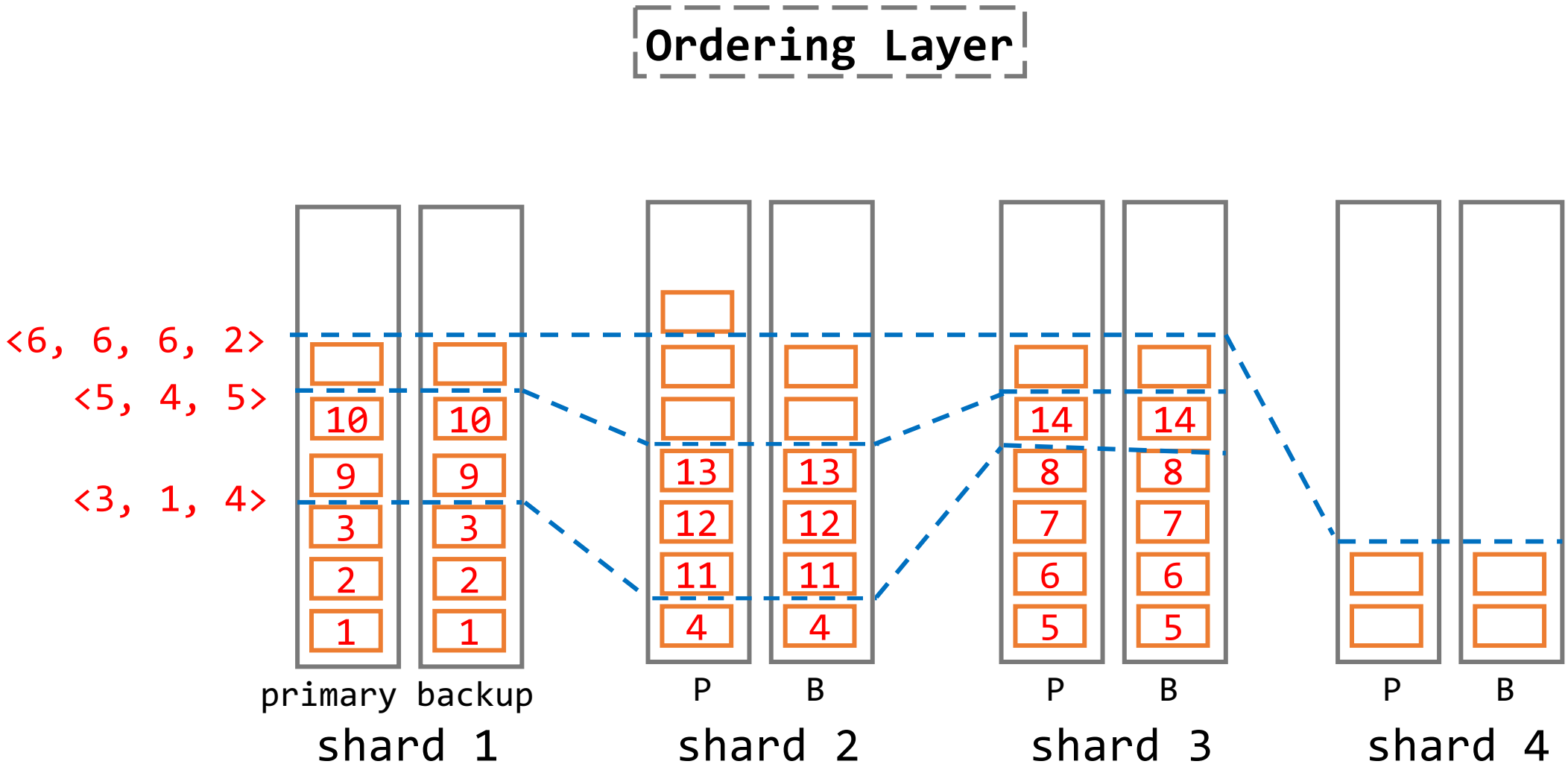
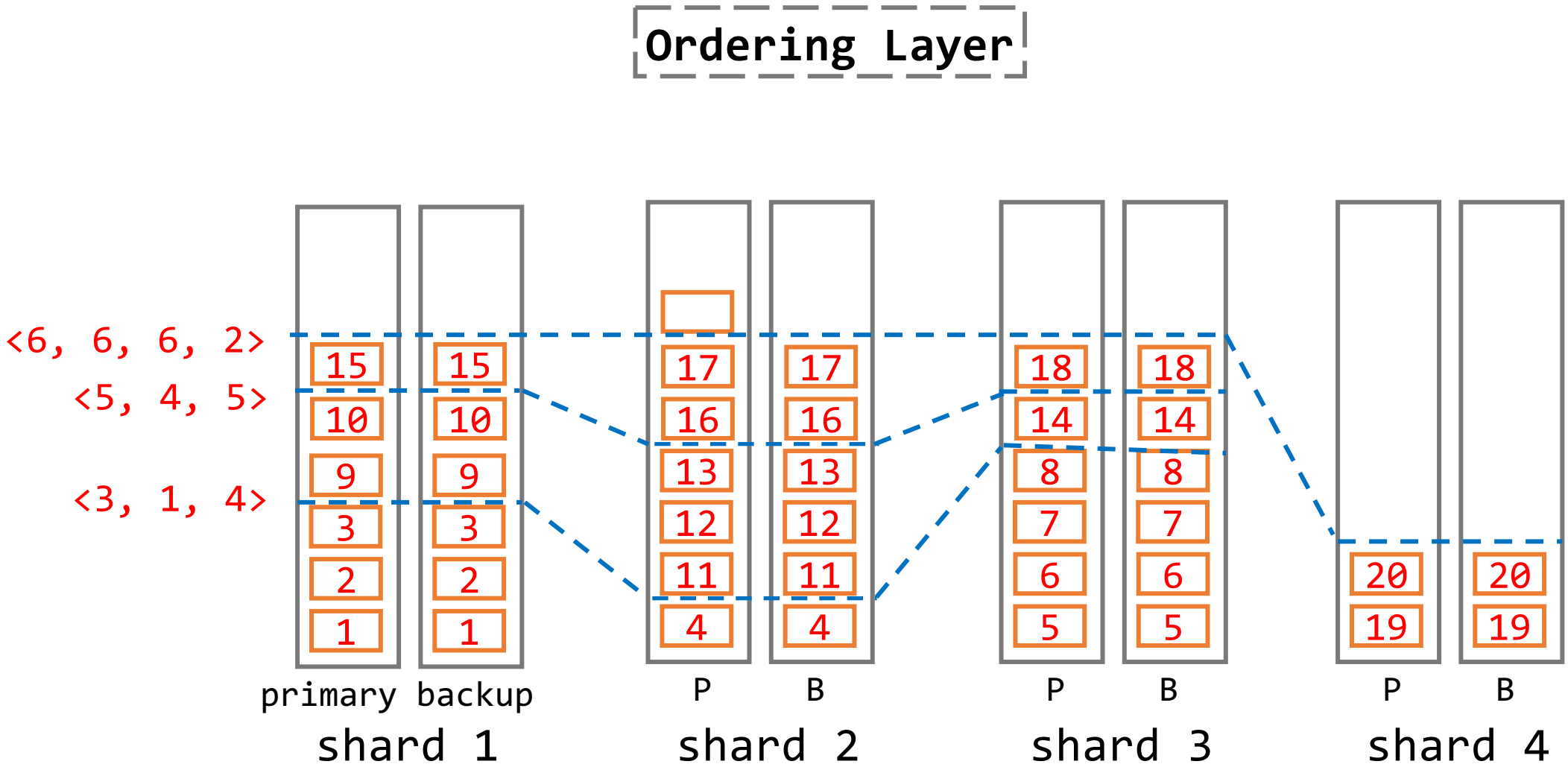
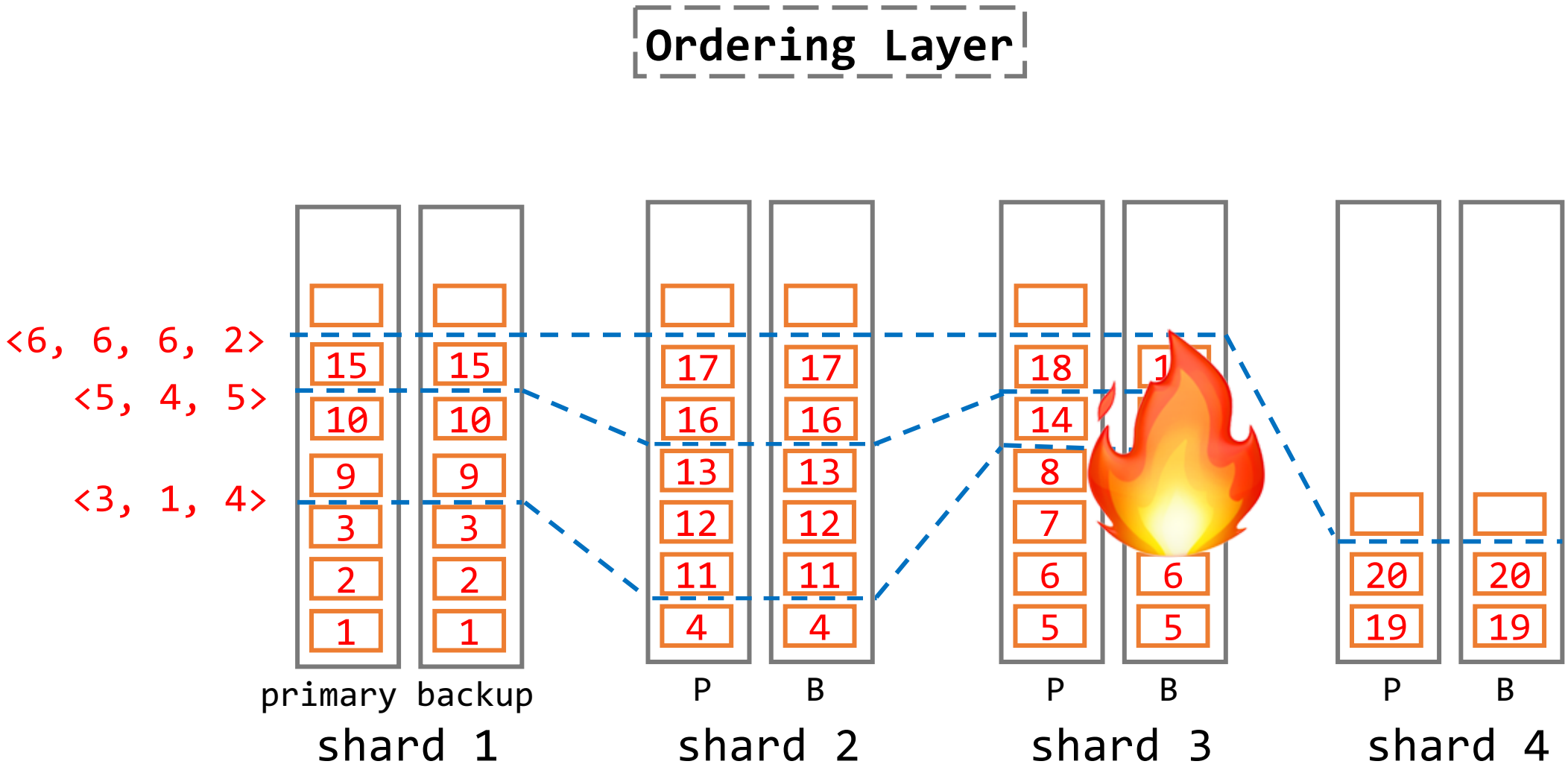


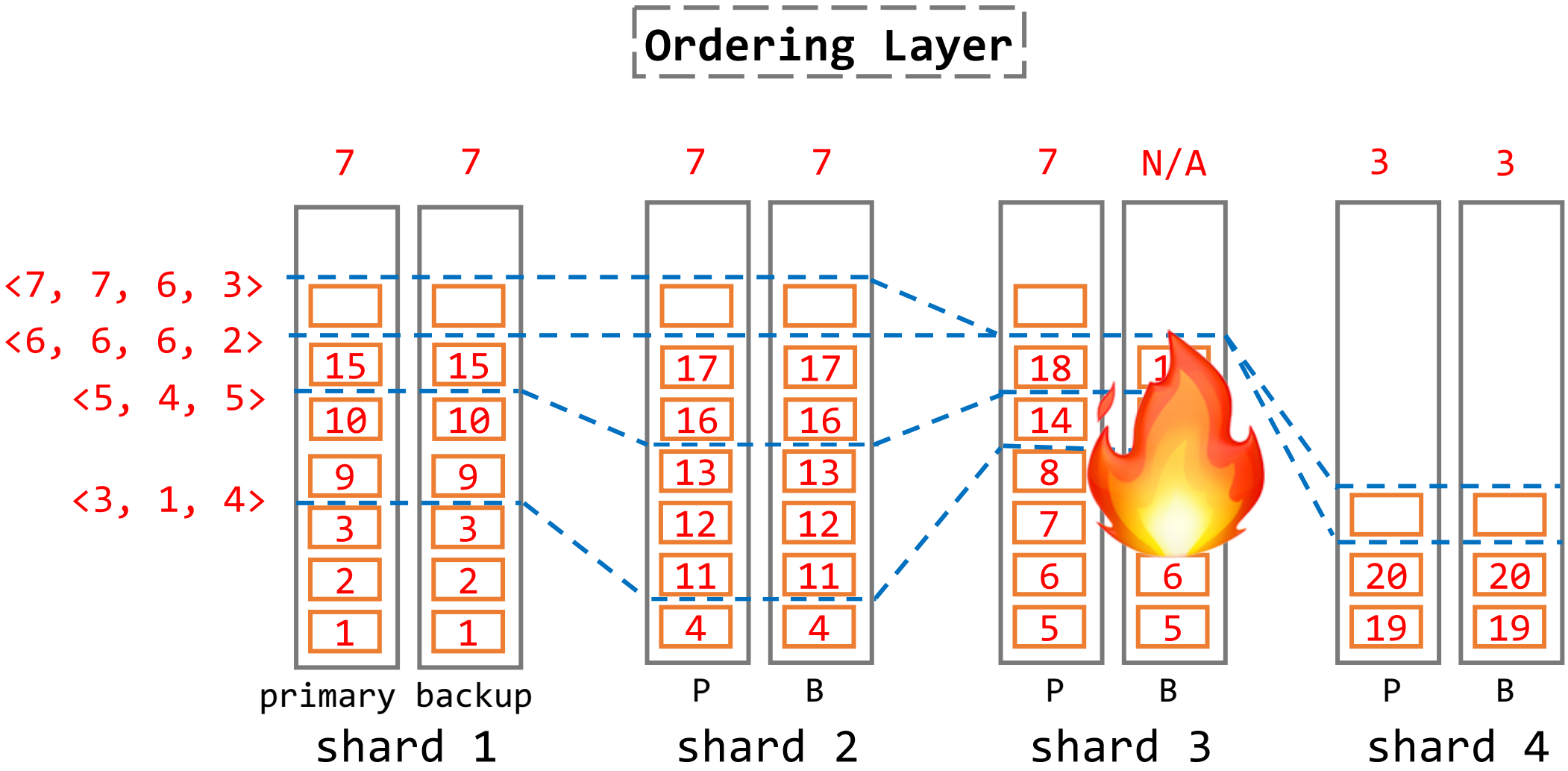
Scalog – Workflow: Adding a Shard



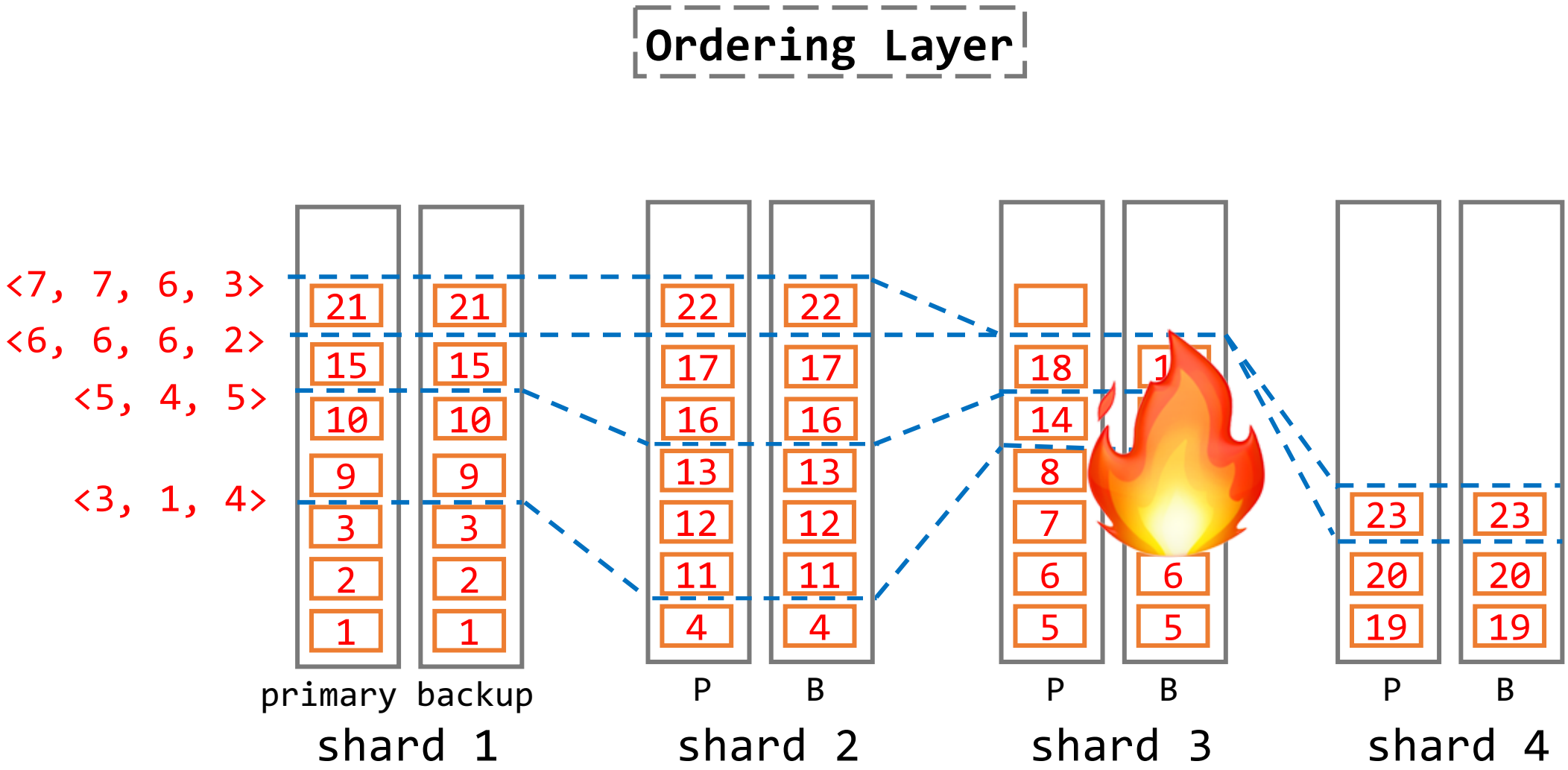
Scalog – Workflow: Handling Failures



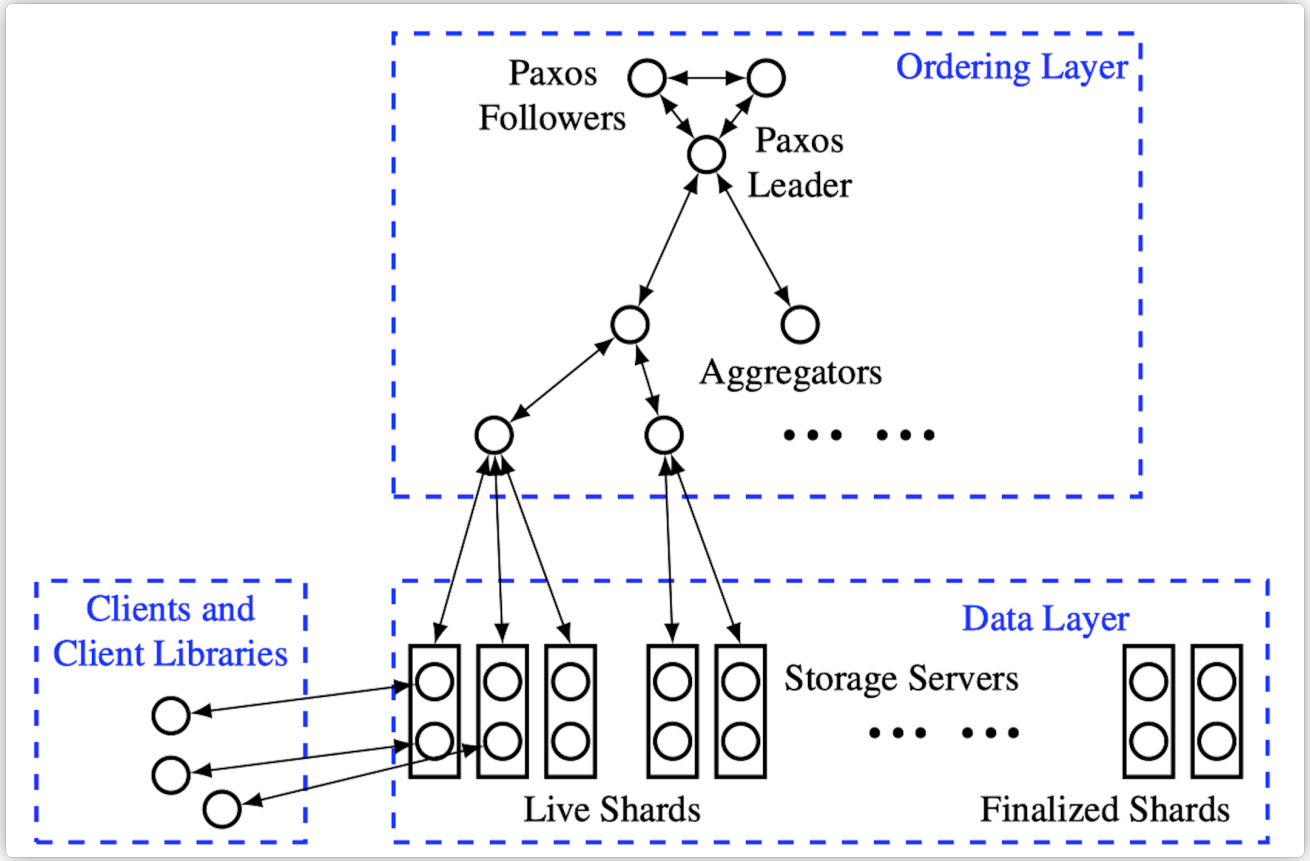
Scalog – Workflow: Handling Failures



Scalog – Workflow: Handling Failures



Scalog - Architecture



Scalog - API

`append`(r)	Append record r, and return the global sequence number.
`trim`(l)	Delete records before global sequence number l.
`subscribe`(l)	Subscribe to records starting from global sequence number l.
`setShardPolicy`(p)	Set the policy for which records get placed at which storage servers in which shards.
`appendToShard`(r)	Append record r, and return the global sequence number and shard identifier.
`readRecord`(l, s)	Request the record with sequence number l from shard s.

Table 1: Scalog API

Evaluation – Setup

- Scalog:
  - implemented in Golang
- Baseline: Corfu
  - re-implemented and optimized in Golang
  - achieves **higher** throughput and latency than open-source implementation. **lower**
  - write throughput: 530k/s ≤ 570k/s
    - reported in Tango([nsdi'13]) with FPGA+SSD

Evaluation – Setup

- Hardware:
  - 40 c220g1 servers in **CloudLab** and each has
    - 2 Intel E52630 v3 8-core CPUs at 2.40GHz,
    - 128GB ECC memory
    - a 480GB SSD
    - a 10Gbps intra-datacenter network connection.
- For higher throughput, evaluate by simulation
- Configuration:
  - Record size: 4KB
  - Aggregating interval: 0.1ms

Evaluation – Reconfiguration

- 6 shards (2 servers per shard)
- clients are notified before finalizing
- clients write with throughput as 50% peak of Corfu

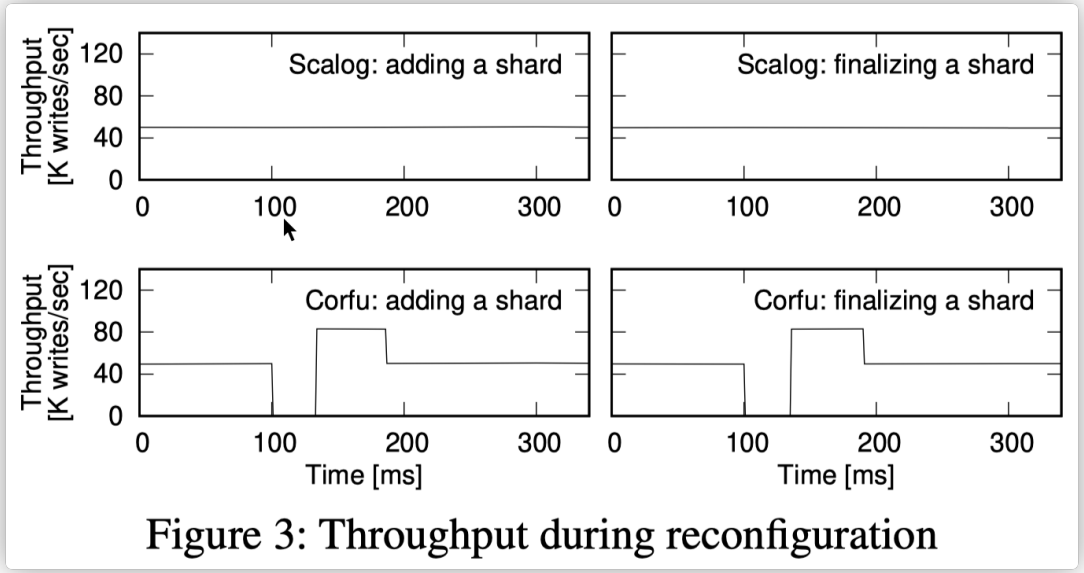


Figure 3: Throughput during reconfiguration

Evaluation – Reconfiguration

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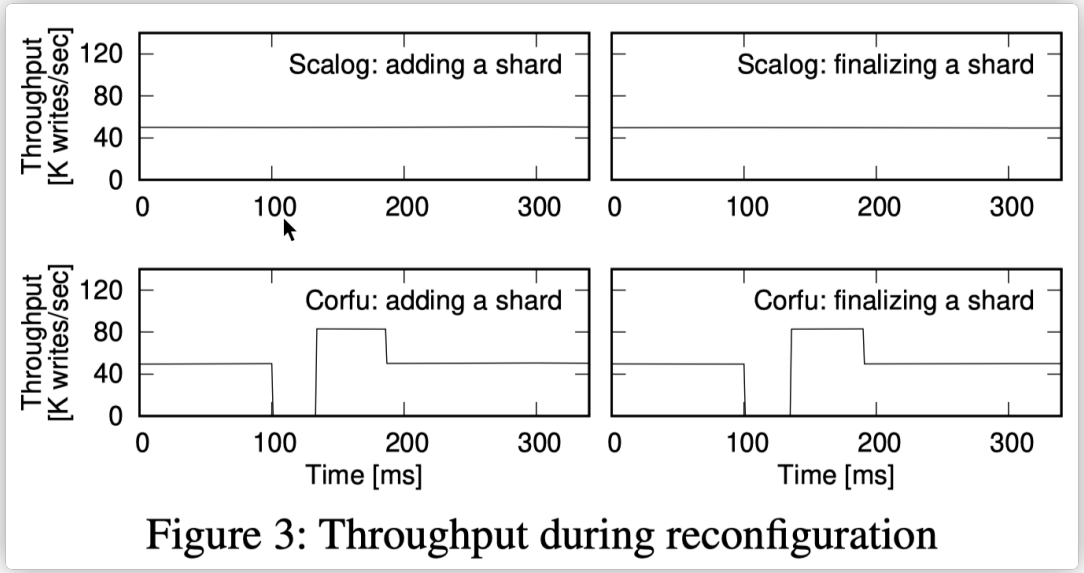
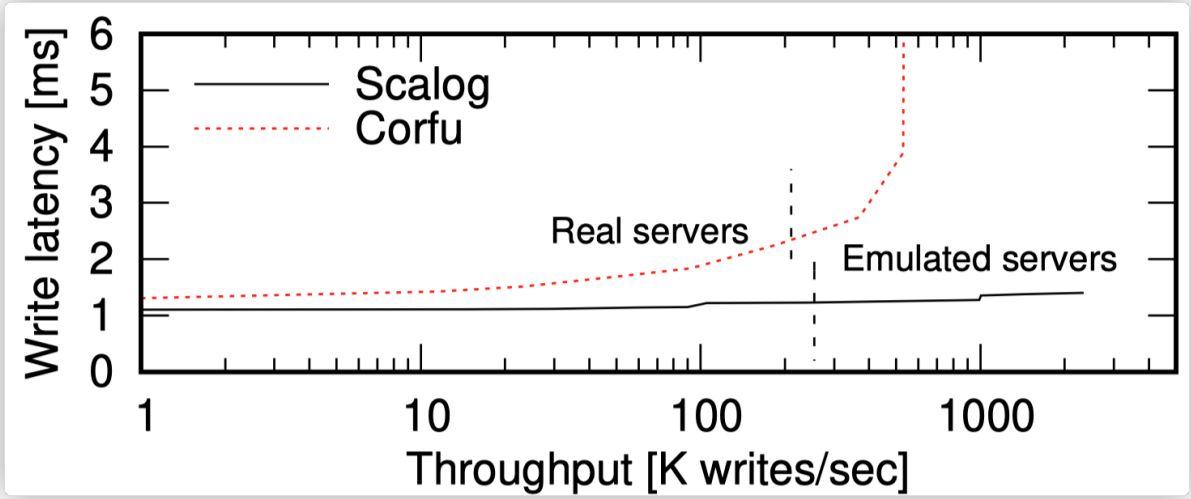


Figure 3: Throughput during reconfiguration

- Corfu is **unavailable** for ~30ms while Scalog isn't

Evaluation – Write Performance

- Less than 40 servers
  - Scalog: 2.34M writes/s vs Corfu: 530k writes/s
- Simulation for more than 40 servers
  - Paxos leader and aggregators are not simulated
  - Scalog's ordering layer can handle 3,500 shards with
    - 52M writes/p at 1.6ms latency



Evaluation – Read Performance

- Scalog and Corfu
  - Both reads from one server directly
  - Similar throughput and latency

Additional

- 3 applications are built on Scalog
  - Scalog-Store: vs Corfu-Store[from corfu paper]
    - key-value store based
    - mapping each key to a pair(***order_id***, ***shard_id***)
      - which specifies the latest value of that key
  - vScalog: vs vCorfu[nsdi'17]
    - object store based
    - higher robustness and read throughput
  - Online Marketplace
    - user activity analytics application

Additional

- Failure handling

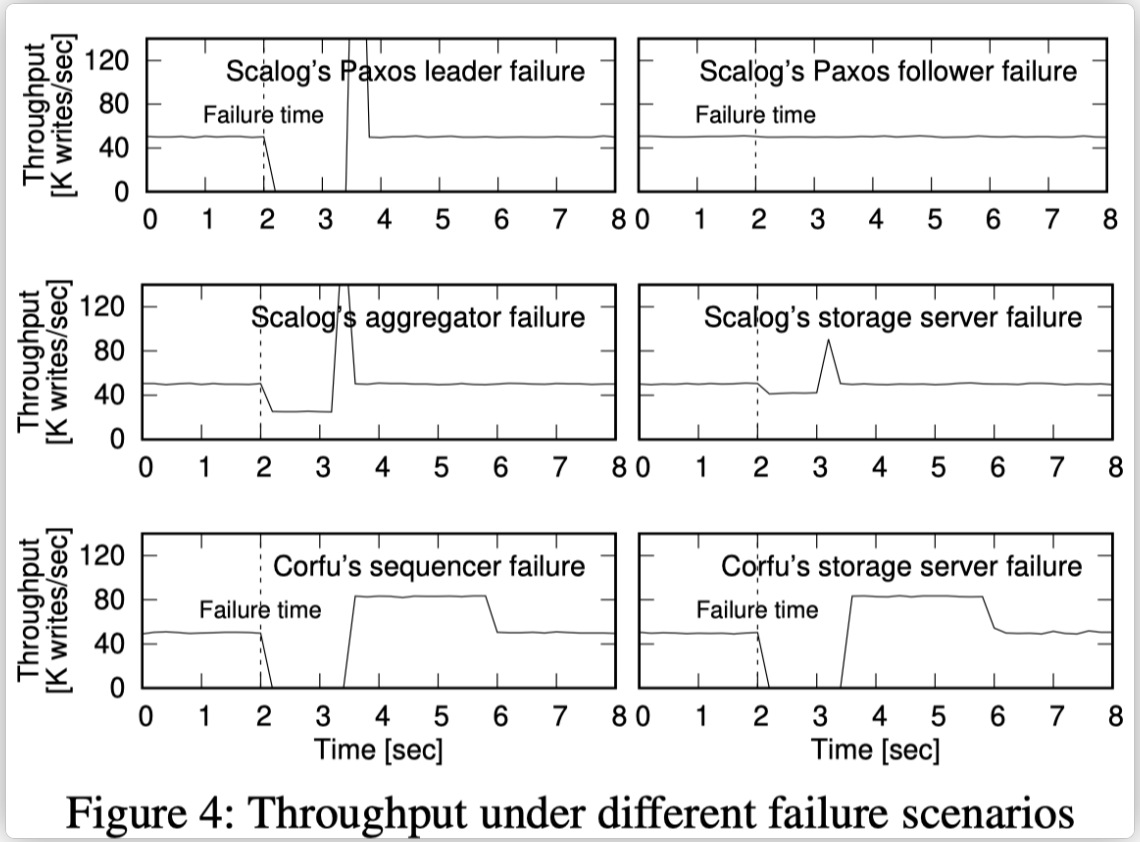
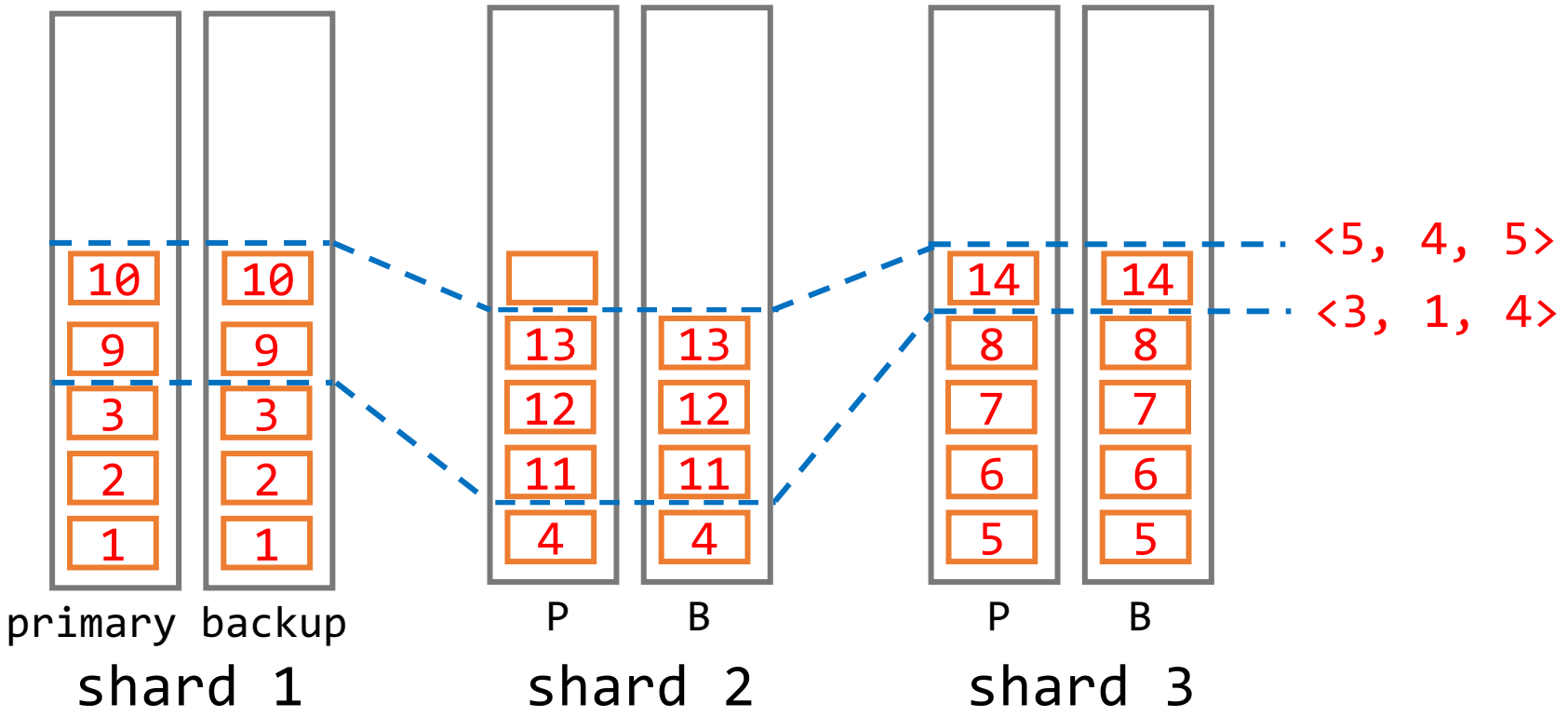


Figure 4: Throughput under different failure scenarios

Discussion

- Batching?
  - in Tango[nsdi'13]:
    - Corfu with 4 record batching attain 2M records/s



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