DAOS Feature Update

DAOS User Group – SC 2020

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Outline

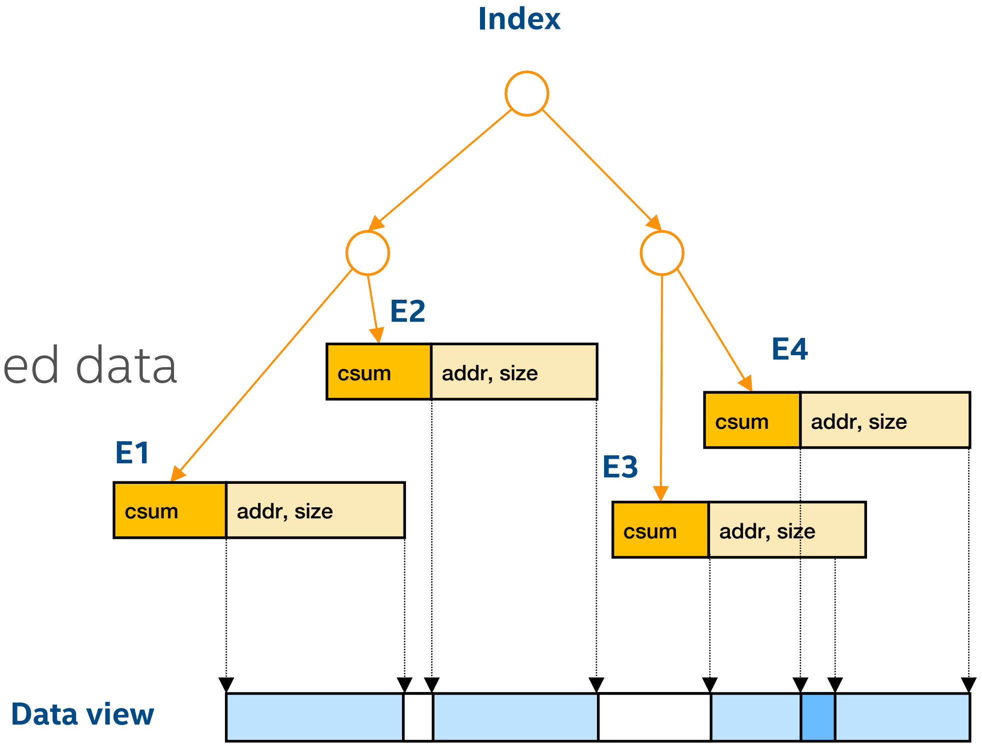
- Background: Data protection and Self-healing
- End-to-end data integrity
- Data reconstruction and Online Server Addition
- Erasure Coding
- Distributed Transaction

Background: Data protection and Self-healing

- Data protection
  - Replication
    - Simple, high capacity and bandwidth overhead
  - Erasure coding (EC)
    - Complex, high computation overhead, low capacity and bandwidth overhead
- Resilience for node failure or media corruption
  - Object shards are stored across multiple storage nodes
  - Degraded mode I/O
  - Background data recovery by self-healing system

End-to-end data integrity

- Calculated internally by the client library
  - Server-side verification is optional
- Stored persistently along with the data
- Detect silent data corruption on fetch
  - Server: verify and recompute checksum only for misaligned fetch
  - Client: verify checksum for data from server
  - Client: switch to degraded mode fetch for corrupted data
- Future works
  - Checksum scrubbing

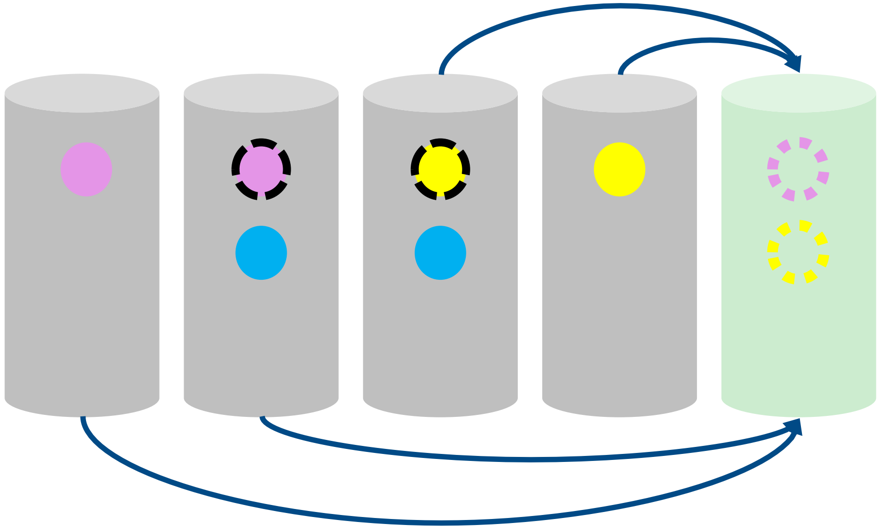


Data reconstruction and Online Server Addition

- Rebuild
  - Health monitoring, auto eviction and self-healing
- Drain
  - Manually evict storage target(s)
- Reintegration
  - Add evicted storage target(s) back
- Addition
  - Extend storage pool by adding more targets

Online Server Addition

- Data migration service
  - Input: object IDs (algorithmic object placement)
  - Action: data movement
- Generic service for data movement in the system
  - All data movement activities share the same protocol and service
    - Rebuild, reintegration, addition, drain
  - Scan objects
    - Call different placement APIs for different data movement activities
  - Pull and reconstruct
    - Data migration service



Erasure coding (EC)

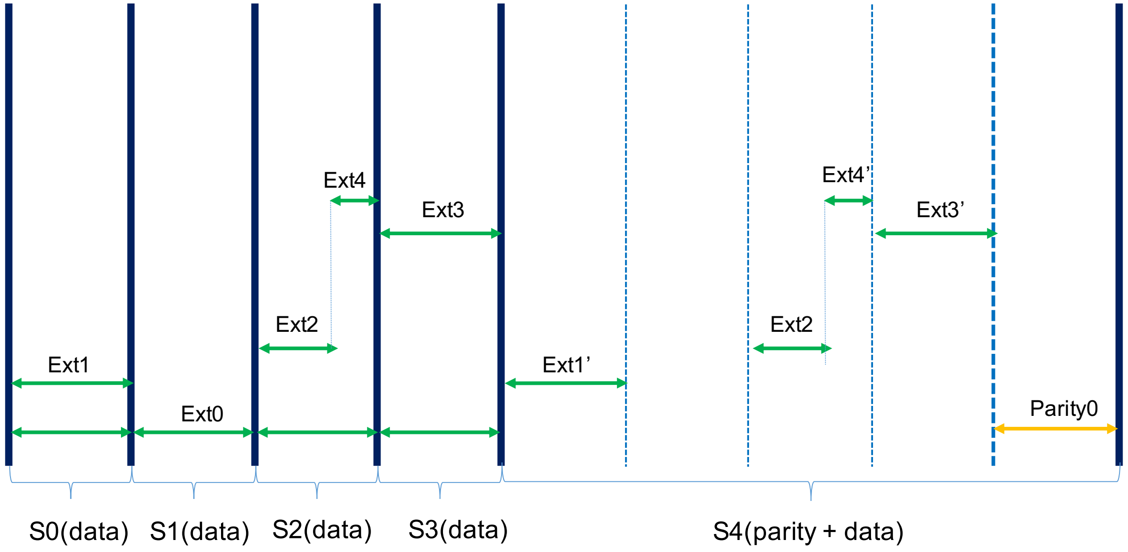
- Replication has high storage and bandwidth overhead
  - N-way replication
    - Overhead == (N – 1) * size
  - Efficient recovery
- Erasure coding is more space efficiency
  - EC(N + M)
    - overhead == M/N * size
  - Expensive recovery

- EC Functionalities
  - Reed-Solomon based EC
  - Data recovery
    - Degraded mode (client): inflight data reconstruction
    - Rebuild (server): background data recovery
  - Aggregation (server): background encoding and space reclaim

Erasure coding – Read and write protocols

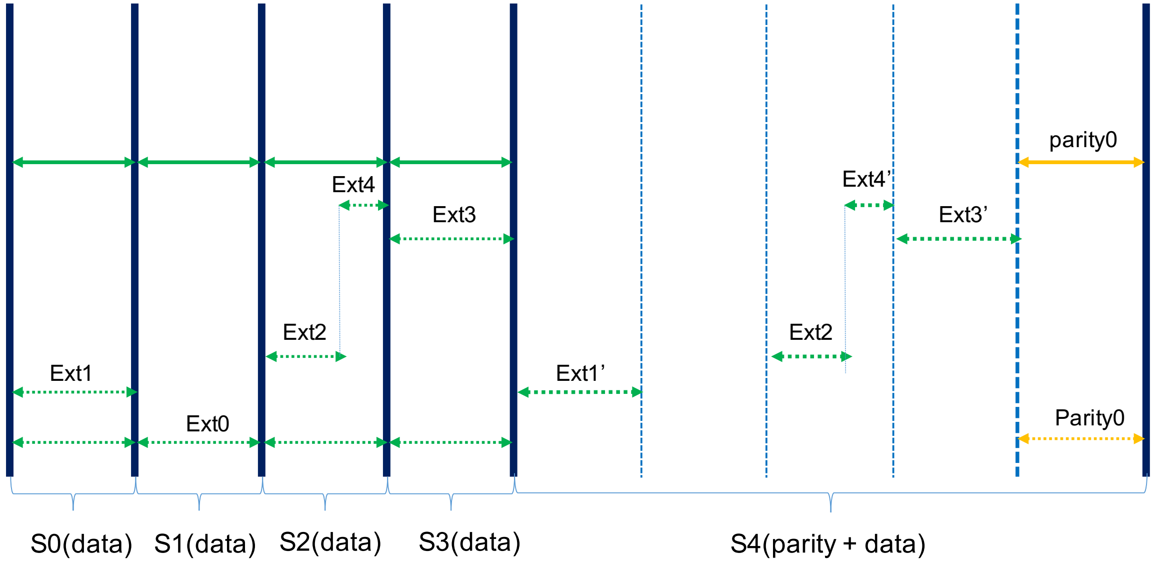
- Full stripe write
  - Client-side encoding
  - Client sends RPC to parity target (store parity)
  - Parity target forwards RPC to all the data targets (store data)
- Read
  - Client sends RPC to data targets
  - Transaction status should be considered

- Partial write
  - No encoding
  - Client sends RPC to parity target (store data)
  - Parity target forwards it to corresponding data targets (store data)



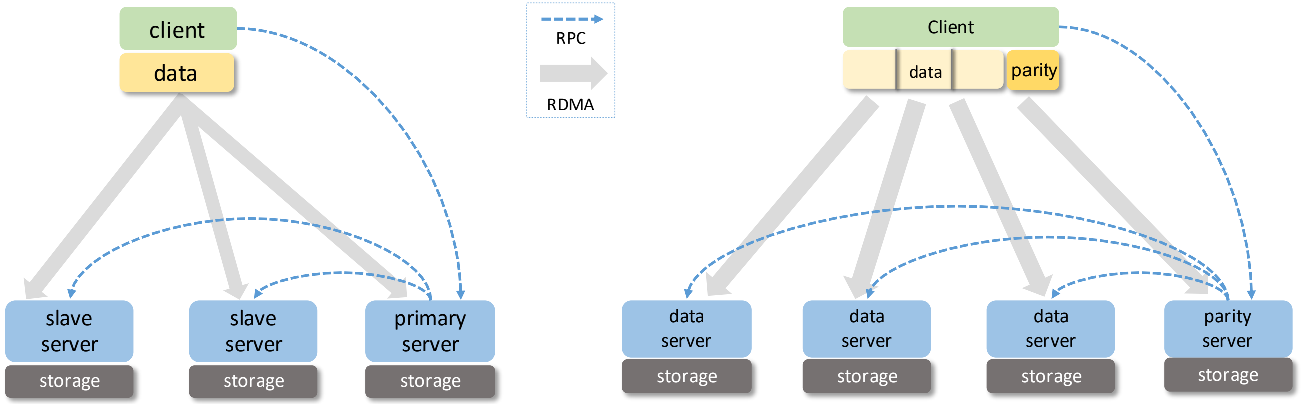
Erasure coding – Data recovery and space reclaim

- Degraded mode
  - Client: reconstruct data inflight (read extra data/parity)
- Rebuild
  - Server: reconstruct data in the background
- Aggregation
  - Server: merge overwrites and compute parity for merged data



Distributed transaction – Distributed I/O

- Both replication and EC updates are distributed I/O
  - Atomicity of distributed I/O
  - 2-phase commit protocol
- Consistency of conditional operations
  - Update
  - Insert
  - Punch



(a) Replicated write

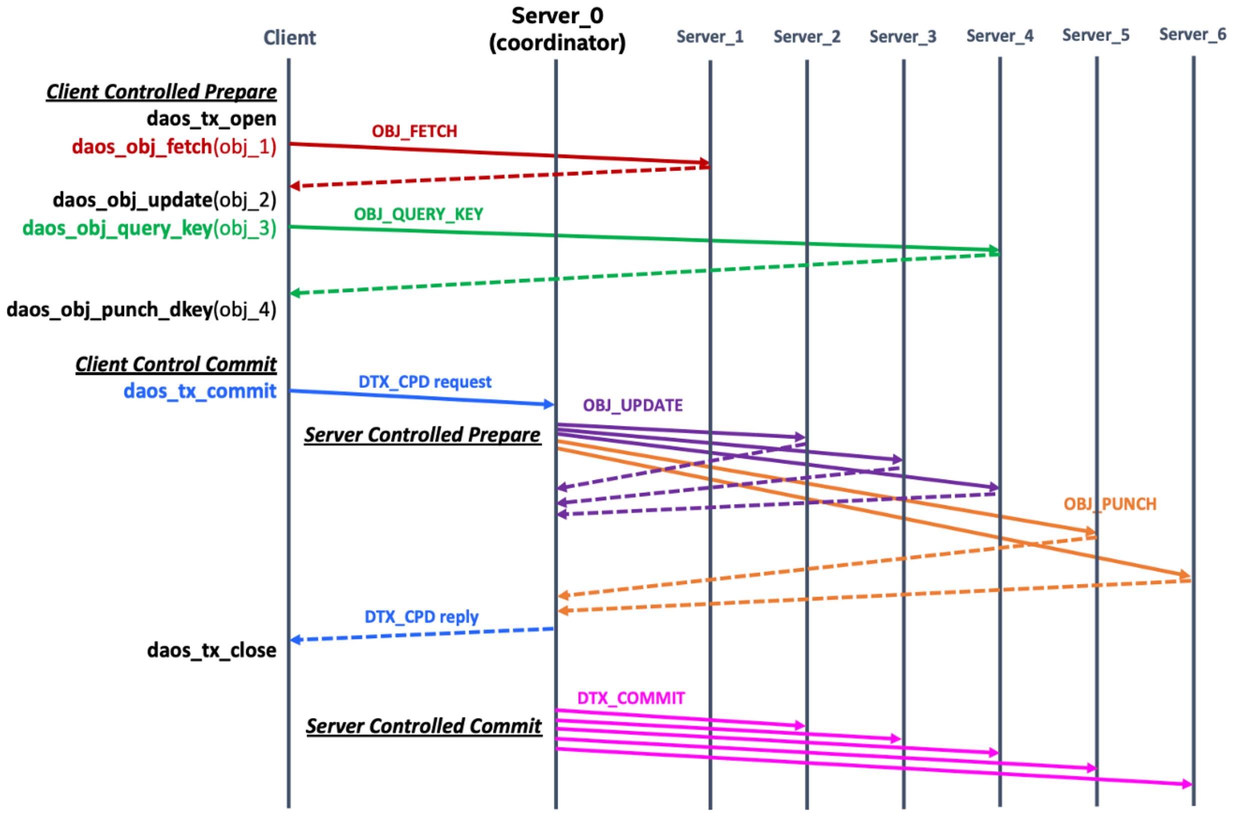
(b) Erasure coding write

Distributed transaction – Transactional API

- Transactional operations
  - Atomicity of multiple operations (e.g. rename)
  - Exported by API

- Client cached transaction
  - Client: submit reads within transaction
  - Client: cache update/punch (no RPC to server)
  - Client: send compound RPC to “commit” update/punch
  - Server: unpack the compound RPC and run

    2-PC protocol for operations of compound RPC



- Multi-version concurrency control (MVCC)
  - Ensure that transactions execute as if they are serialized in time order
  - Transaction involving both reads and writes must follow all rules
  - When a transaction is rejected, it restarts with the same transaction ID but a higher timestamp