DAOS & PMEM Usage

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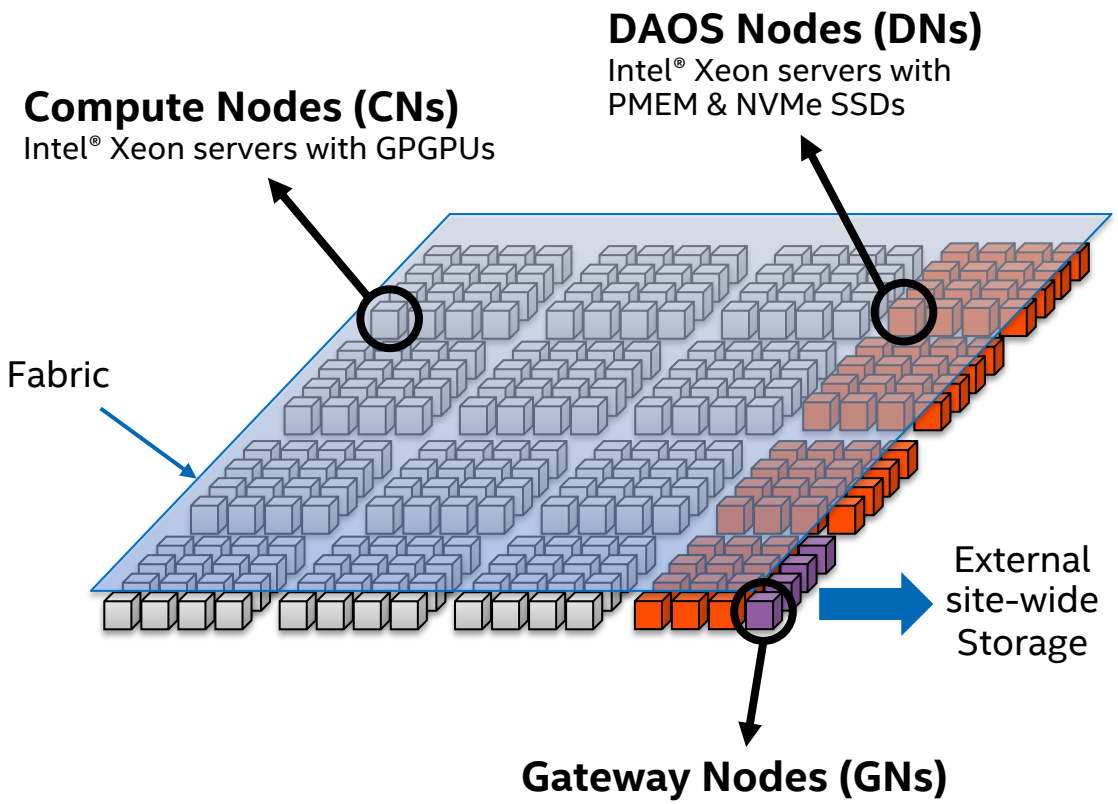
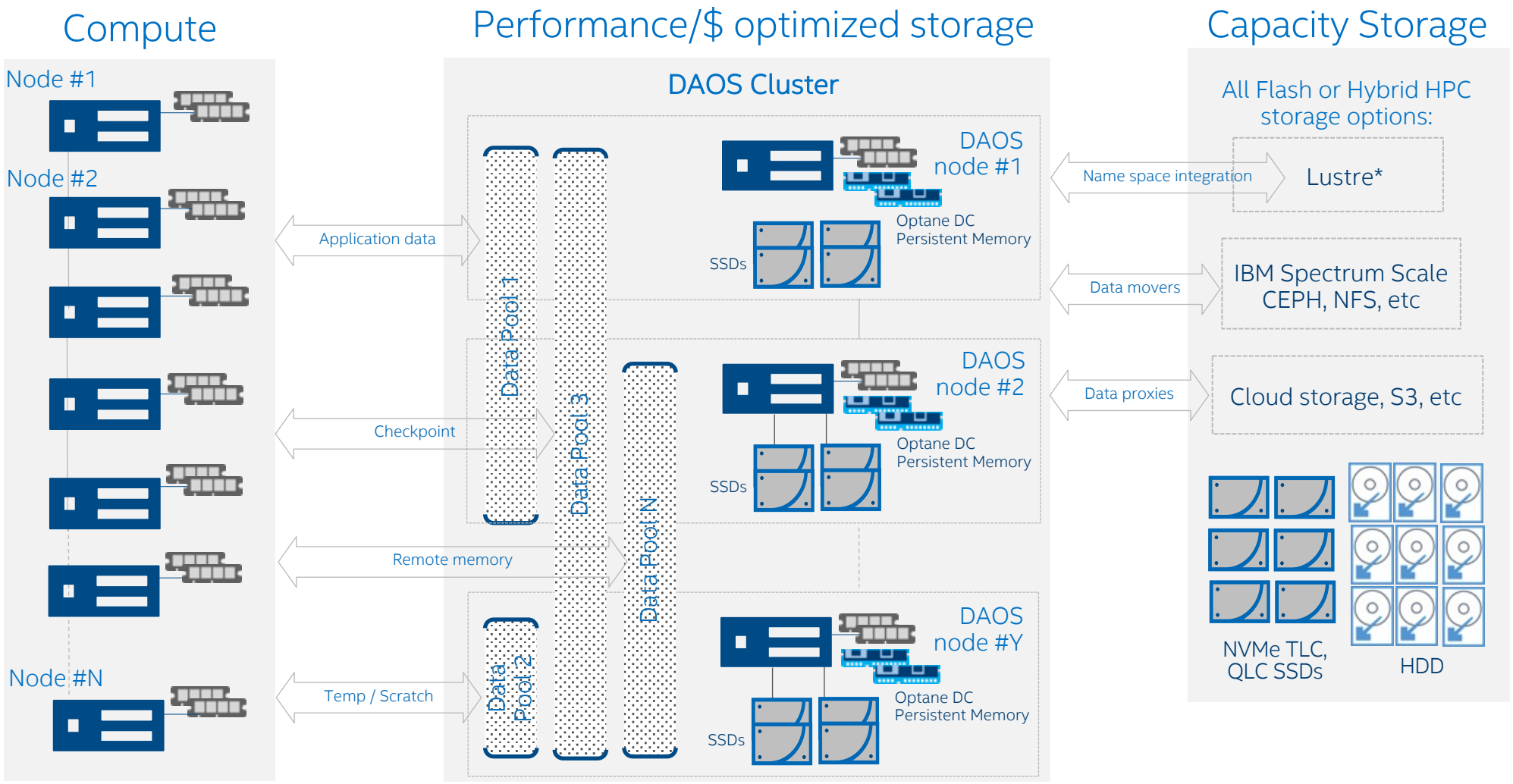
What is DAOS?

- A new, innovative distributed parallel file system based on Intel® Optane™ Persistent Memory and Intel® TLC and QLC NVMe SSDs
- Overcomes industry bottlenecks in block-based IO and POSIX
- Delivers exceptionally high bandwidth and IOPS on commodity servers, meeting the demands of HPC, AI, and high-performance data analytics
- Can be utilized either as a standalone file system, or as a performance tier integrated with existing storage systems

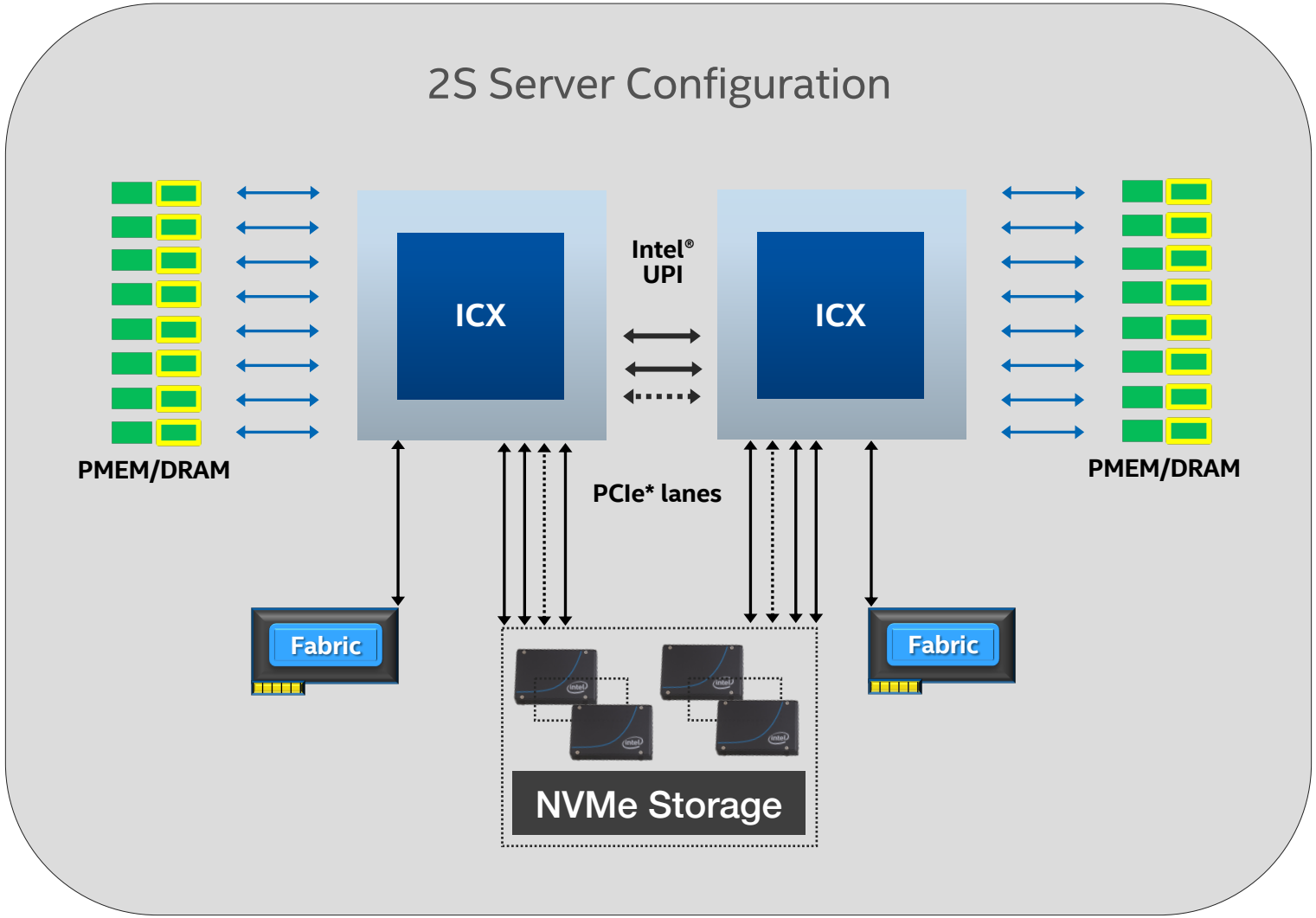


Generational leap forward in storage performance

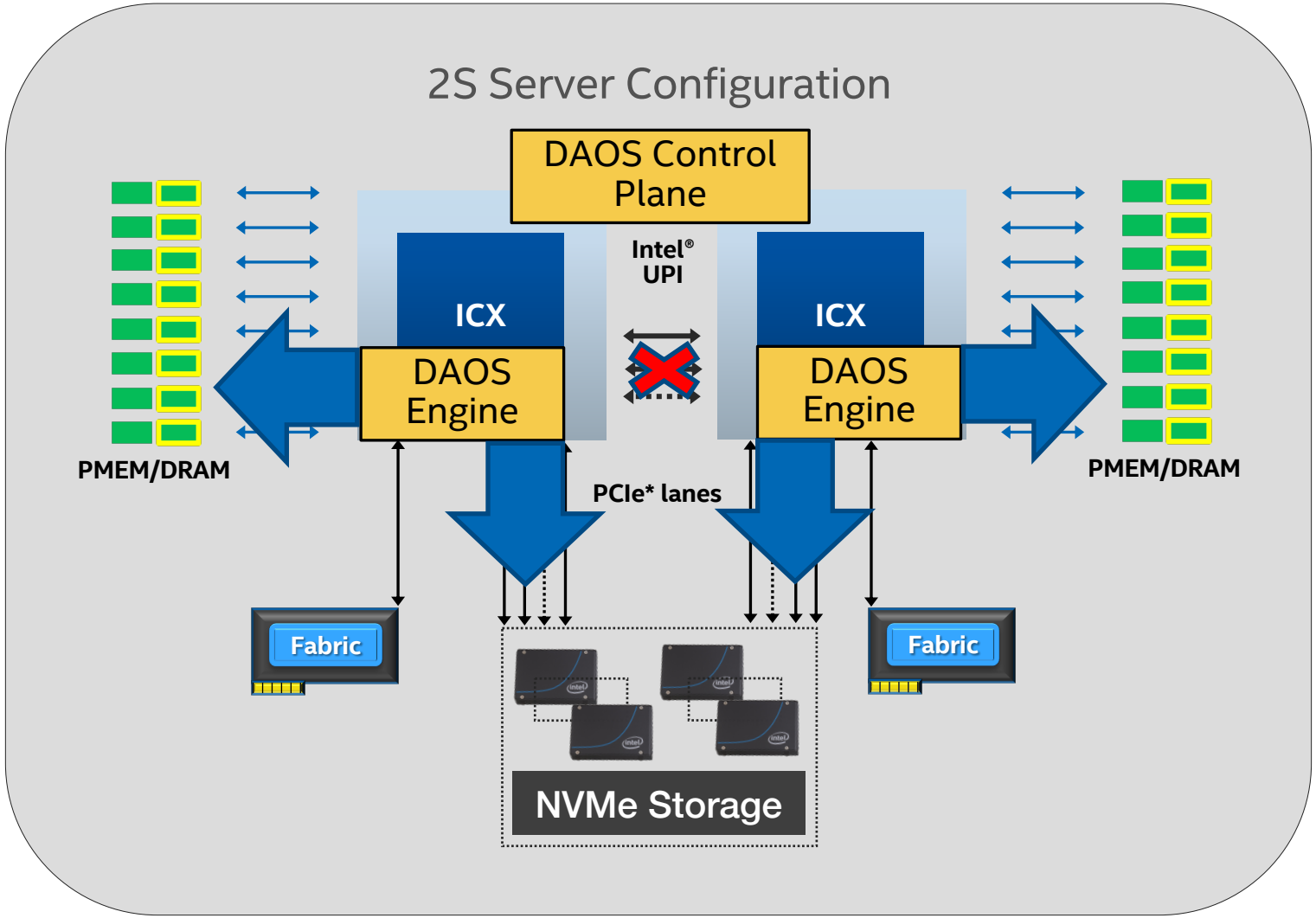
DAOS in the Overall Cluster Architecture



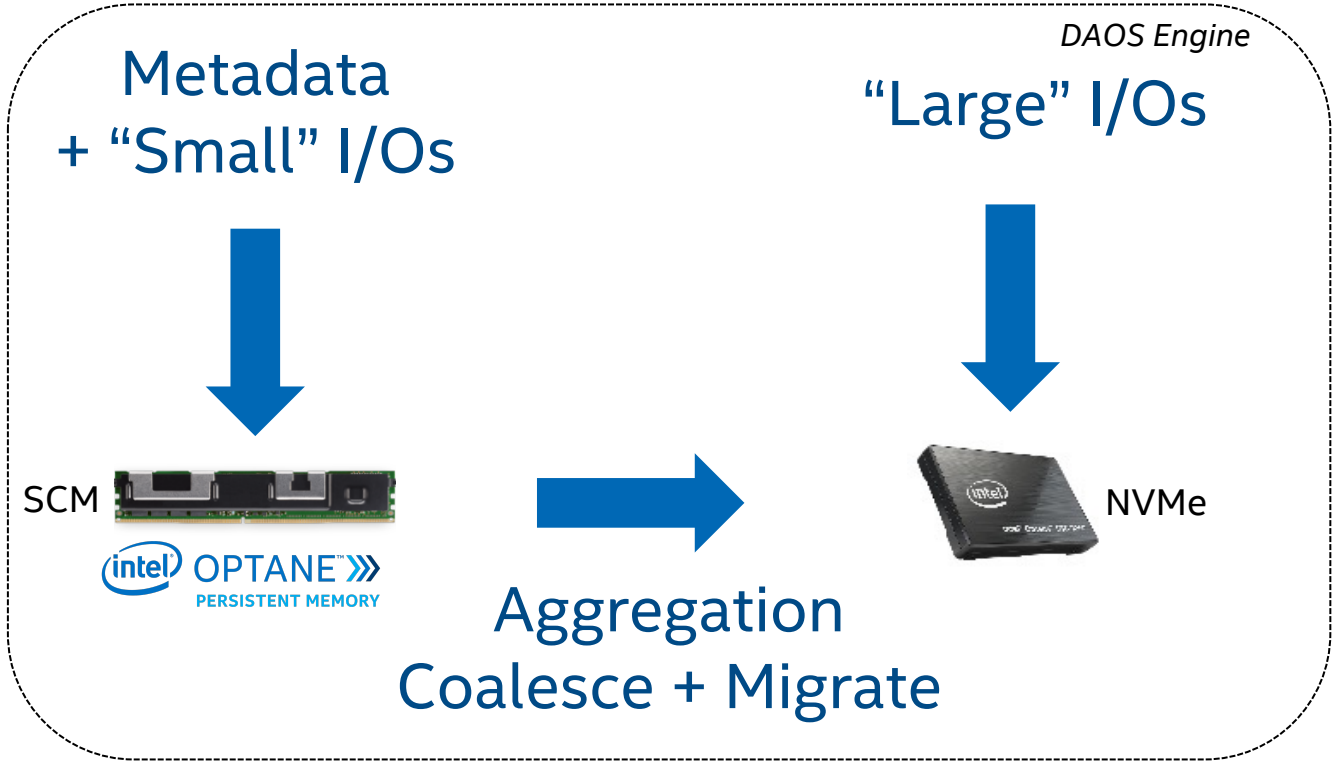
DAOS Node Design



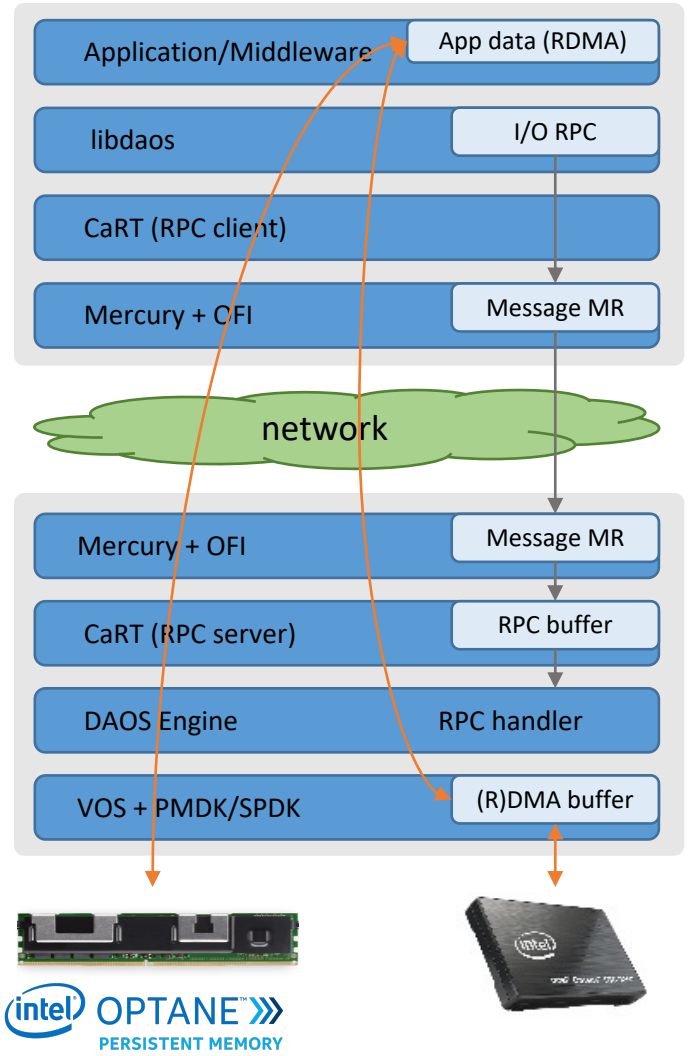
DAOS Node Design



Engine: Media Management



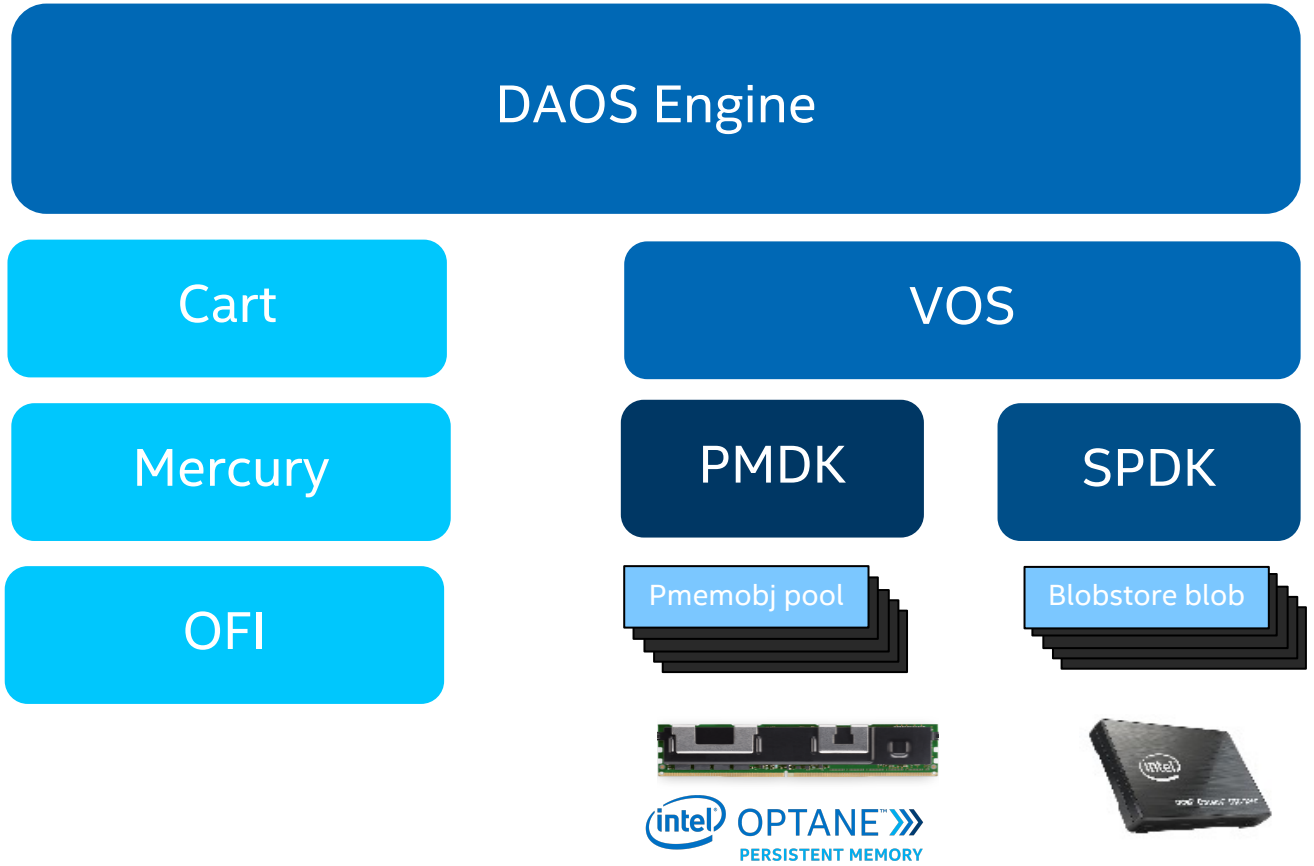
DAOS I/O Flow



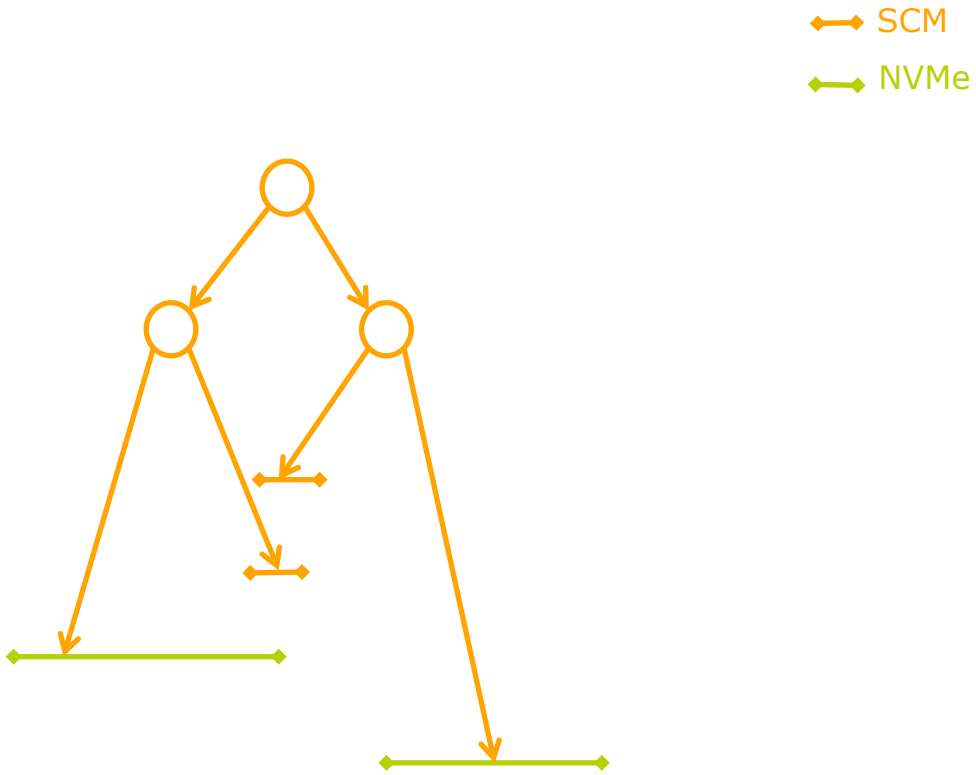
- No memory copy for RDMA capable network
- Client registers MR for each bulk I/O (MR register can be expensive on some providers)
- Server currently registers MR for each I/O, but it can be optimized by pre-registering all DMA buffers and persistent memory as RDMA buffers

Data flow

Engine Software Stack



I/O Operation Flow



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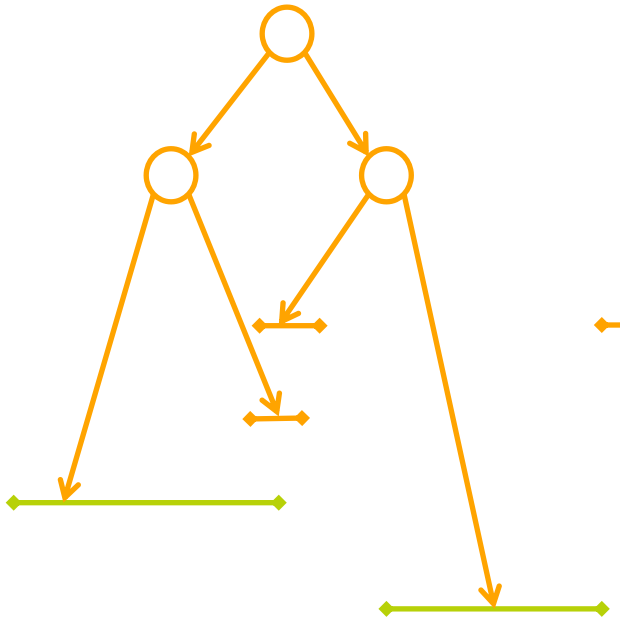


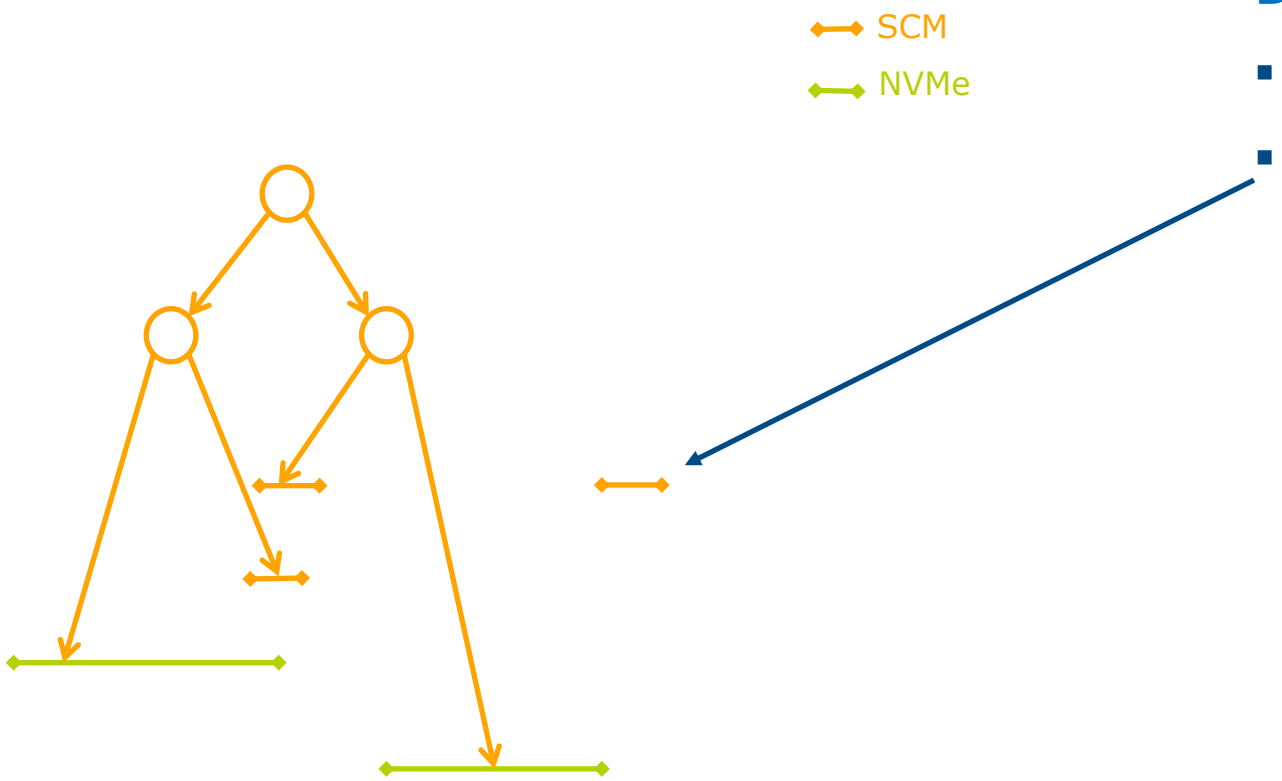
SCM

NVMe

DAOS XStream

- pmemobj_reserve() new buffer

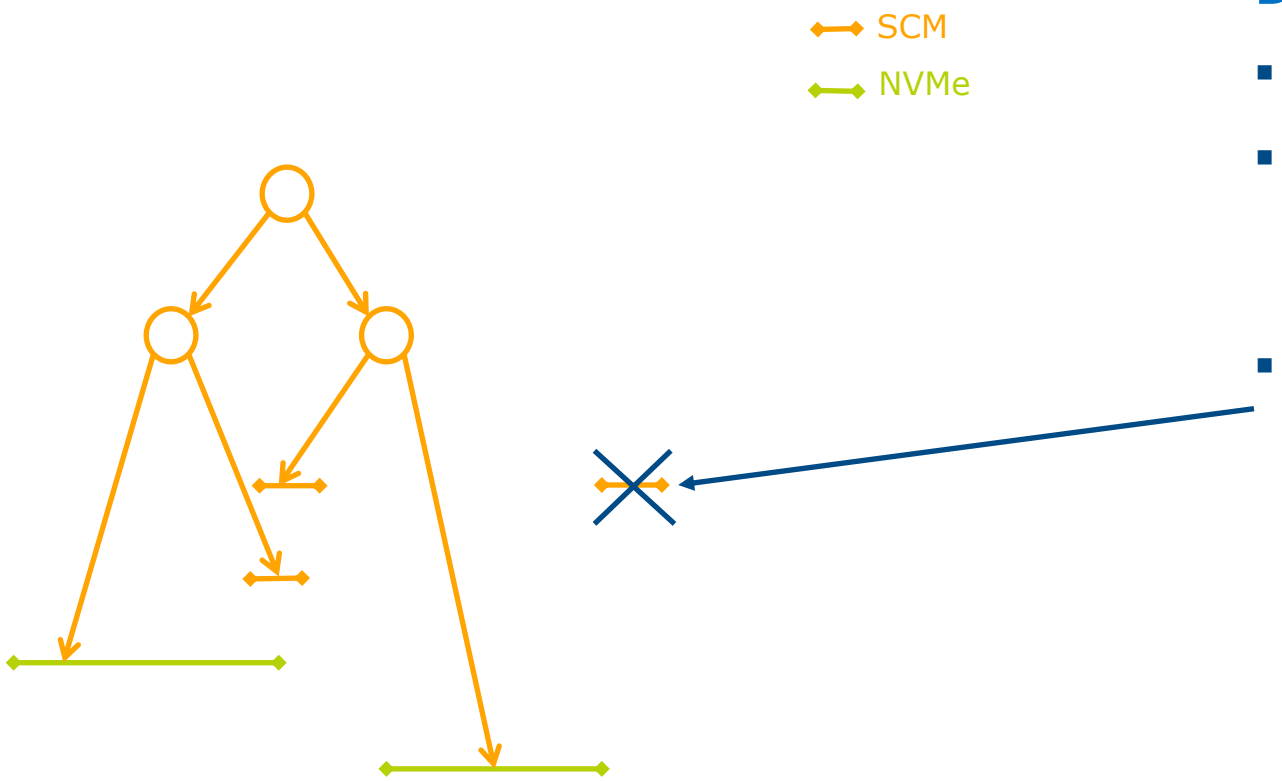
I/O Operation Flow



DAOS XStream

- pmemobj_reserve() new buffer
- Start RDMA transfer to newly allocated buffer
  - Switch to other ULT until completion is reported

I/O Operation Flow



DAOS XStream

- pmemobj_reserve() new buffer
- Start RDMA transfer to newly allocated buffer
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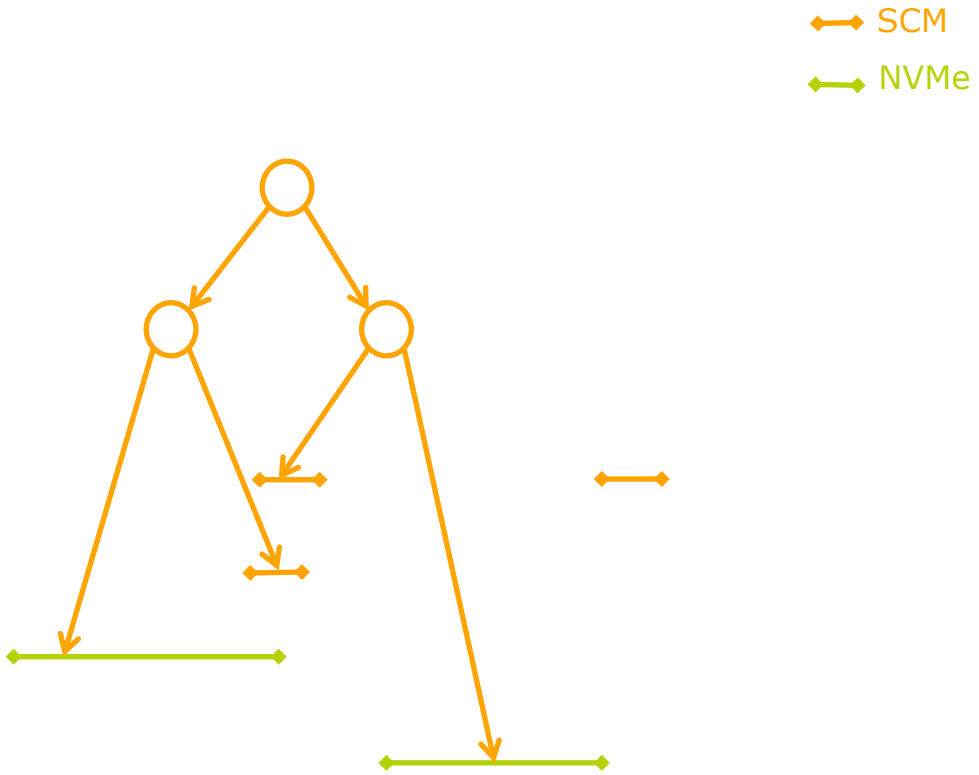
- If RDMA transfer failed, free buffer with pmemobj_cancel()

I/O Operation Flow



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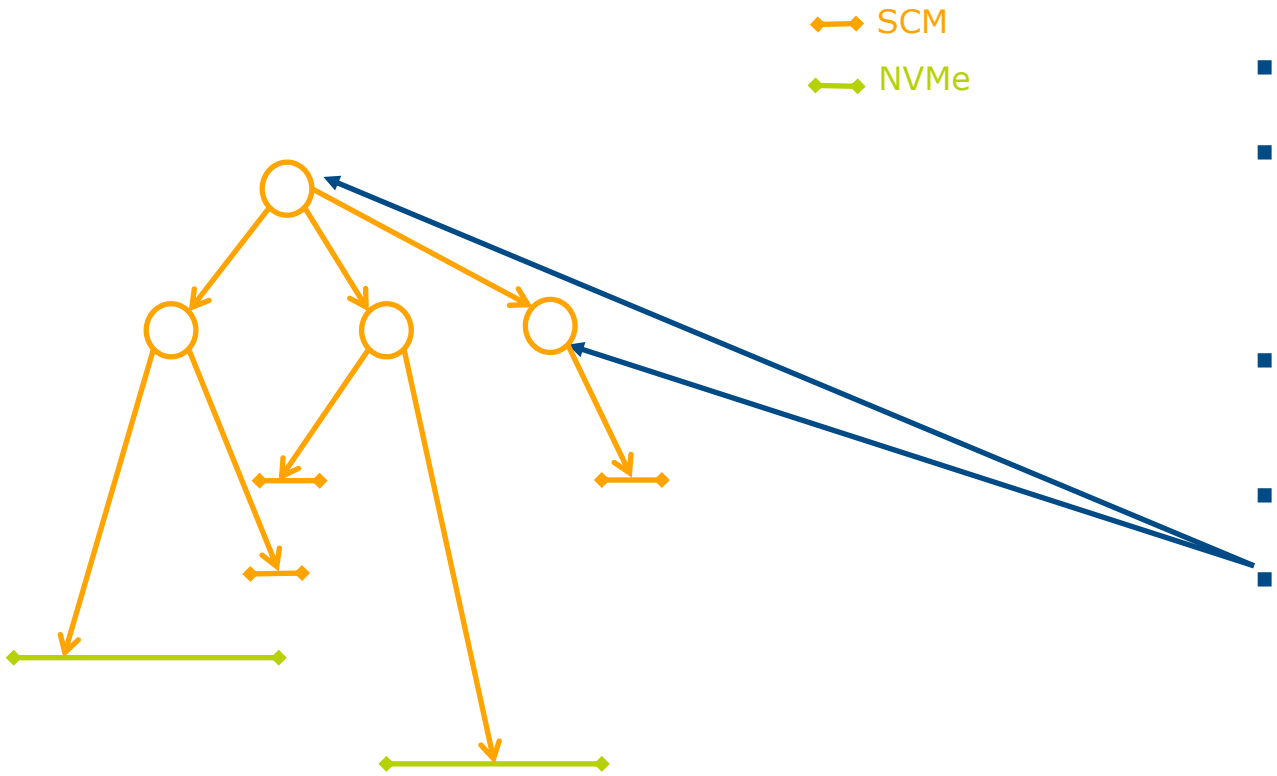
- Otherwise, start pmemobj transaction

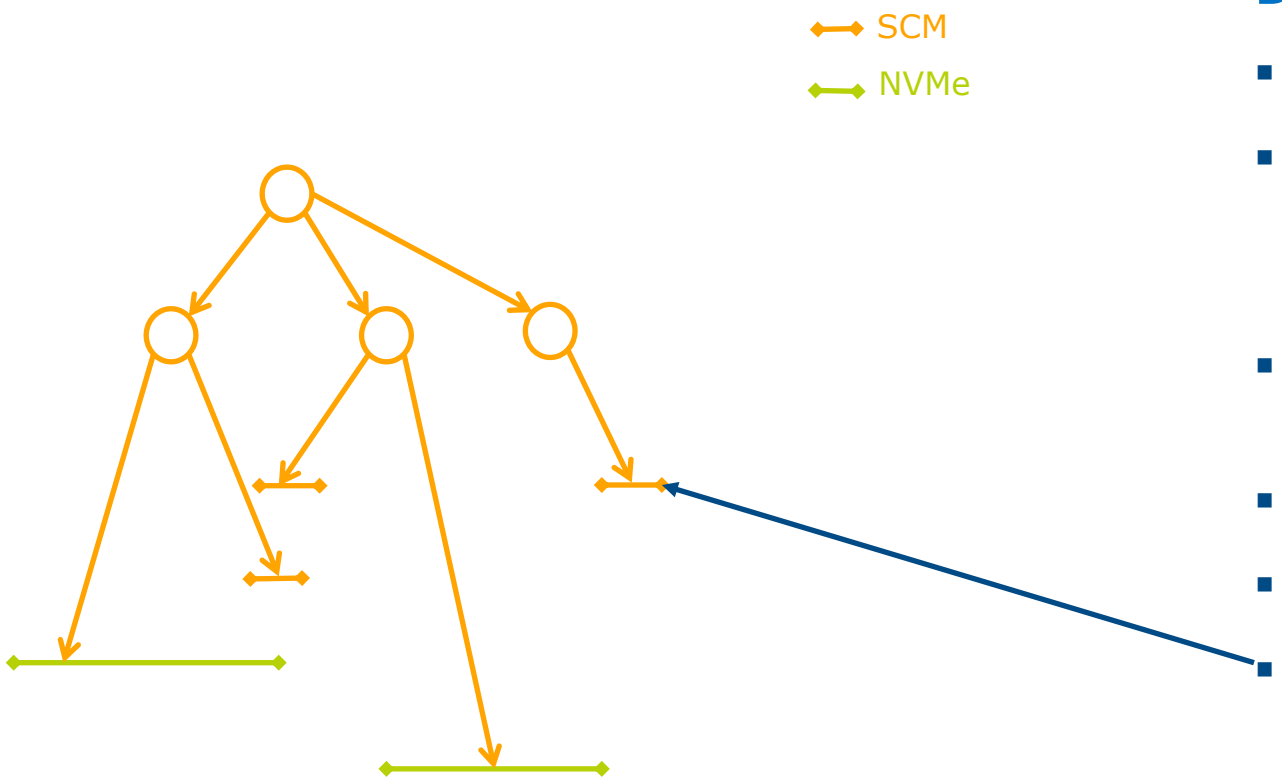
I/O Operation Flow



DAOS XStream

- pmemobj_reserve() new buffer
- Start RDMA transfer to newly allocated buffer
  - Switch to other ULT until completion is reported
- If RDMA transfer failed, free buffer with pmemobj_cancel()
- Otherwise, start pmemobj transaction
- Modify index to insert new extent

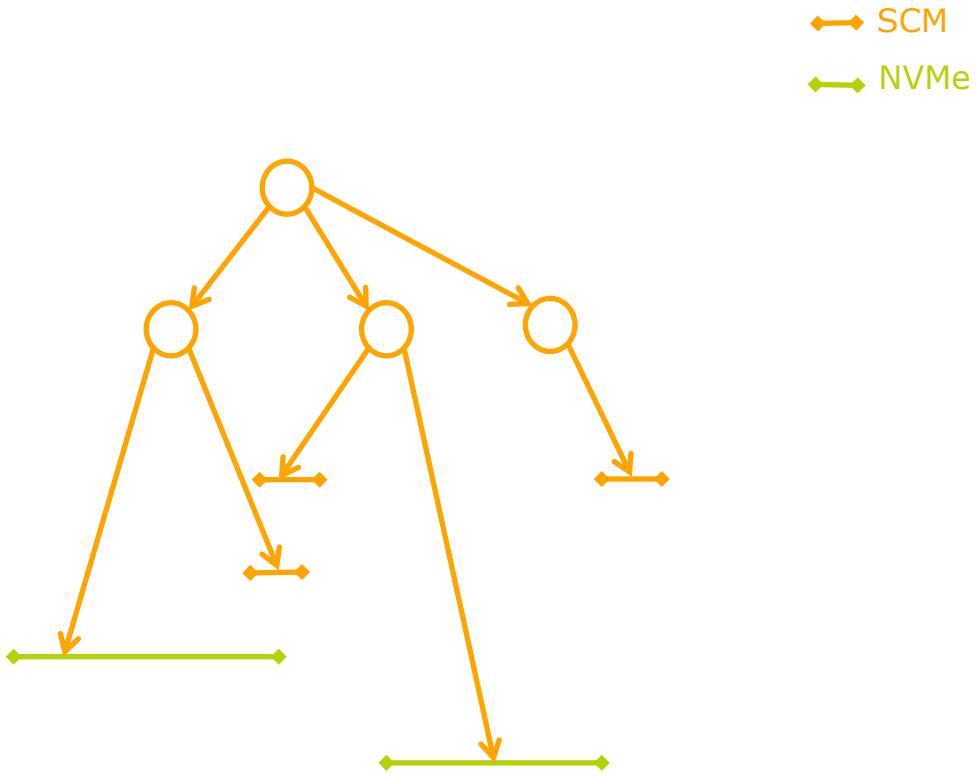
I/O Operation Flow



DAOS Xstream

- pmemobj_reserve() new buffer
- Start RDMA transfer to newly allocated buffer
  - Switch to other ULT until completion is reported
- If RDMA transfer failed, free buffer with pmemobj_cancel()
- Otherwise, start pmemobj transaction
- Modify index to insert new extent
- pmemobj_tx_publish()

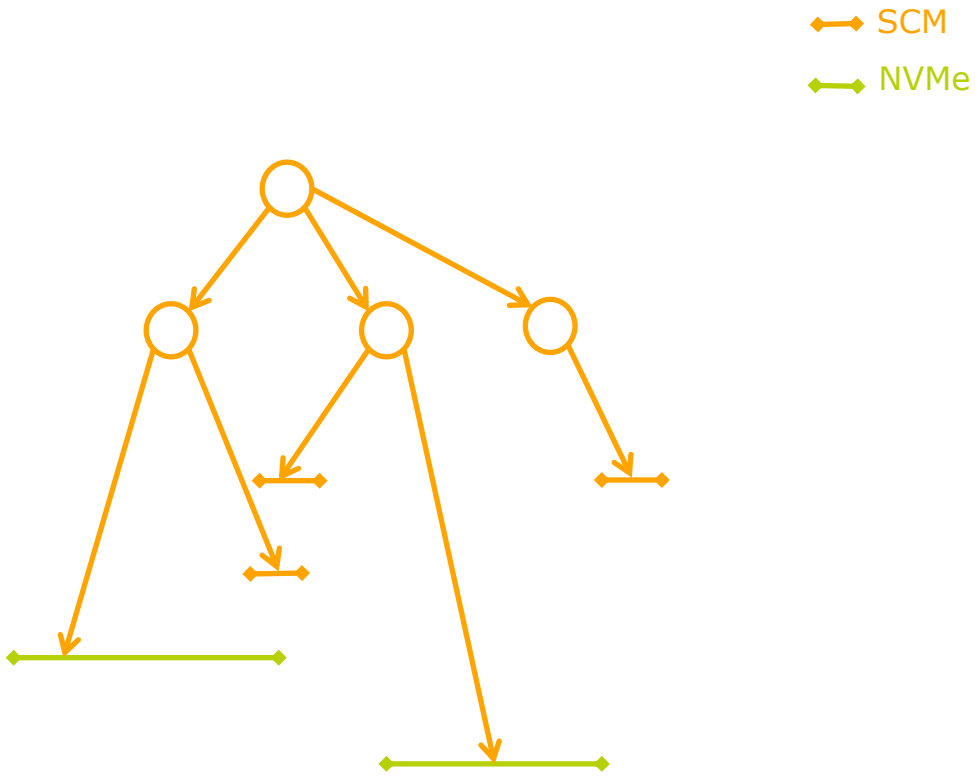
I/O Operation Flow



DAOS Xstream

- pmemobj_reserve() new buffer
- Start RDMA transfer to newly allocated buffer
  - Switch to other ULT until completion is reported
- If RDMA transfer failed, free buffer with pmemobj_cancel()
- Otherwise, start pmemobj transaction
- Modify index to insert new extent
- pmemobj_tx_publish()
- Commit pmemobj transaction

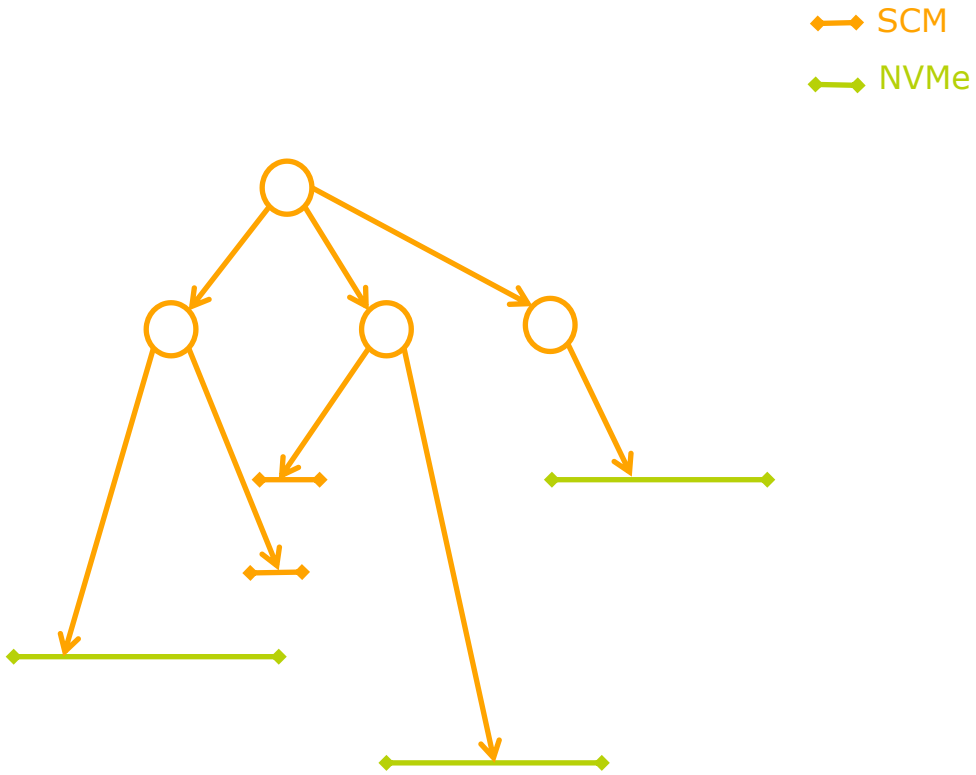
I/O Operation Flow



DAOS Xstream

- pmemobj_reserve() new buffer
- Start RDMA transfer to newly allocated buffer
  - Switch to other ULT until completion is reported
- If RDMA transfer failed, free buffer with pmemobj_cancel()
- Otherwise, start pmemobj transaction
- Modify index to insert new extent
- pmemobj_tx_publish()
- Commit pmemobj transaction
- Reply to the client

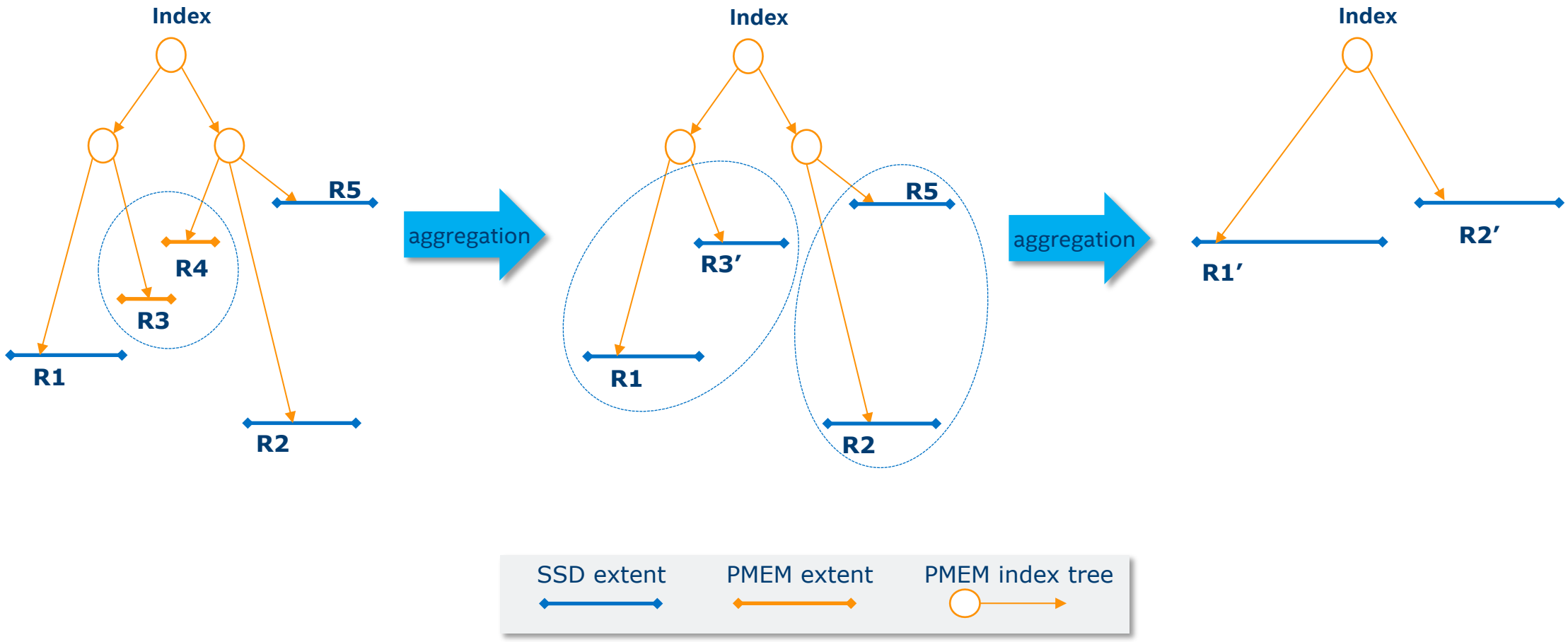
I/O Operation Flow



Extent in NVMe

- Track NVMe allocated/free space in data structures maintained in pmemobj pool
- Same processing flow

Data Aggregation

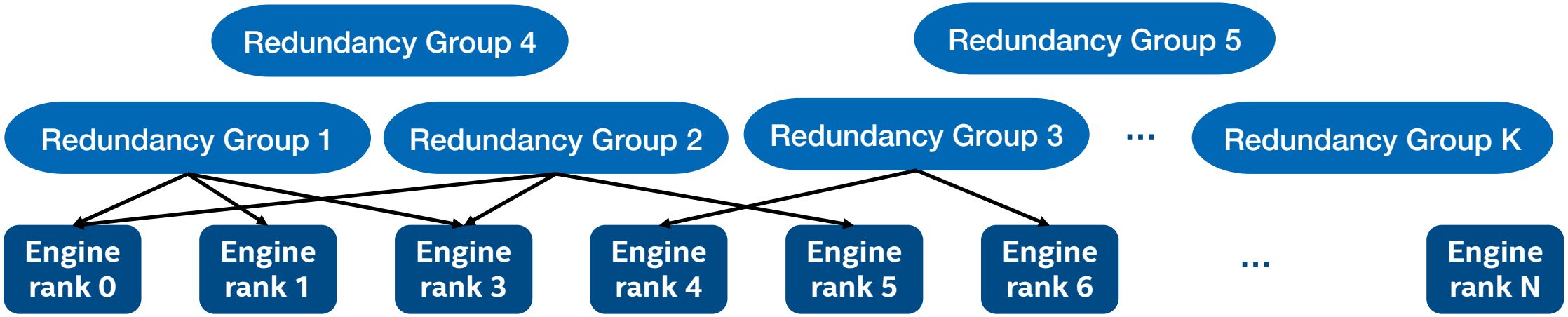


ACID Semantic of DAOS Operations

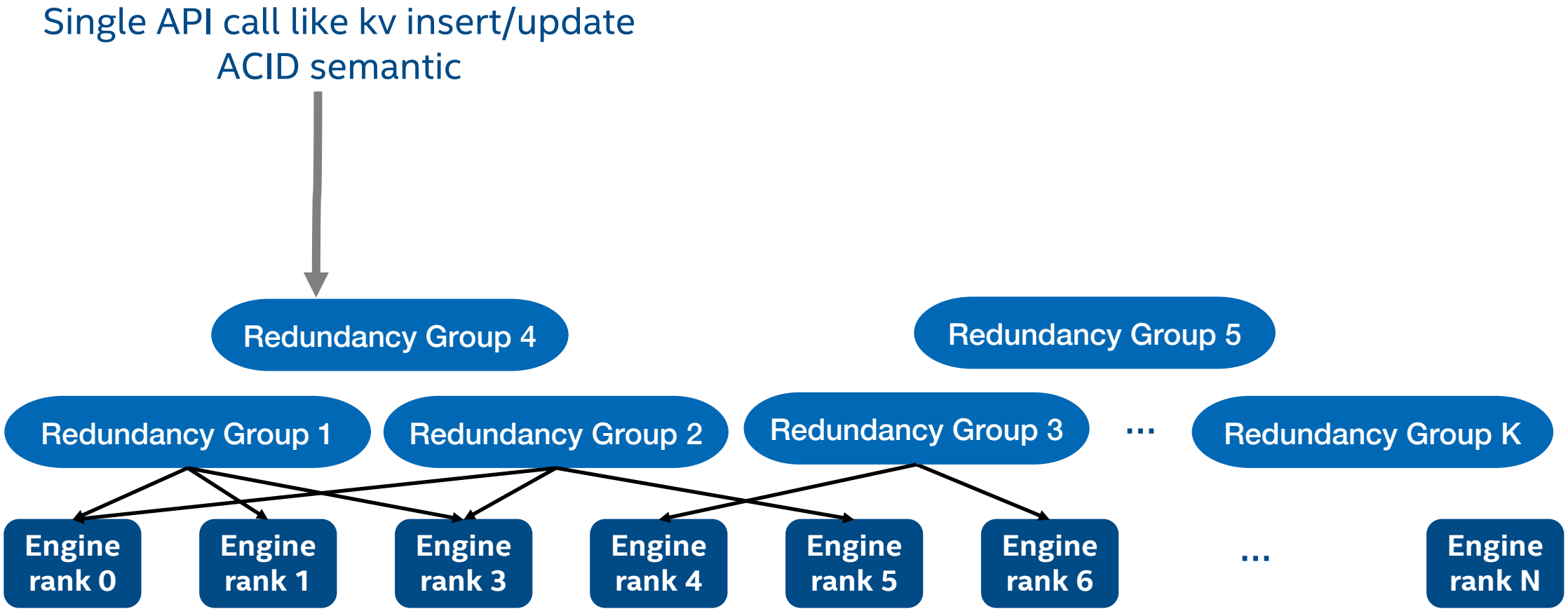
Single API call like kv insert/update
ACID semantic

Engine rank 0 | Engine rank 1 | Engine rank 3 | Engine rank 4 | Engine rank 5 | Engine rank 6 | ... | Engine rank N

Placement & Declustering

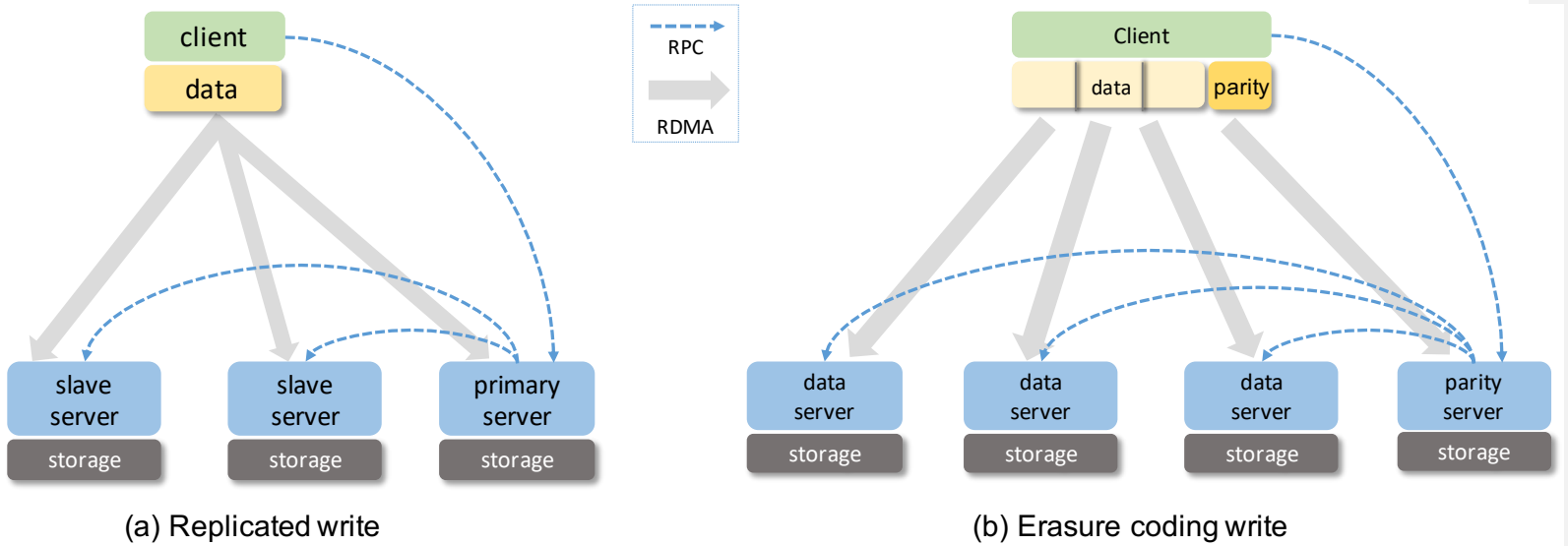


ACID Semantic of DAOS Operations (EC/RP)



Replication & Erasure Code Protocol

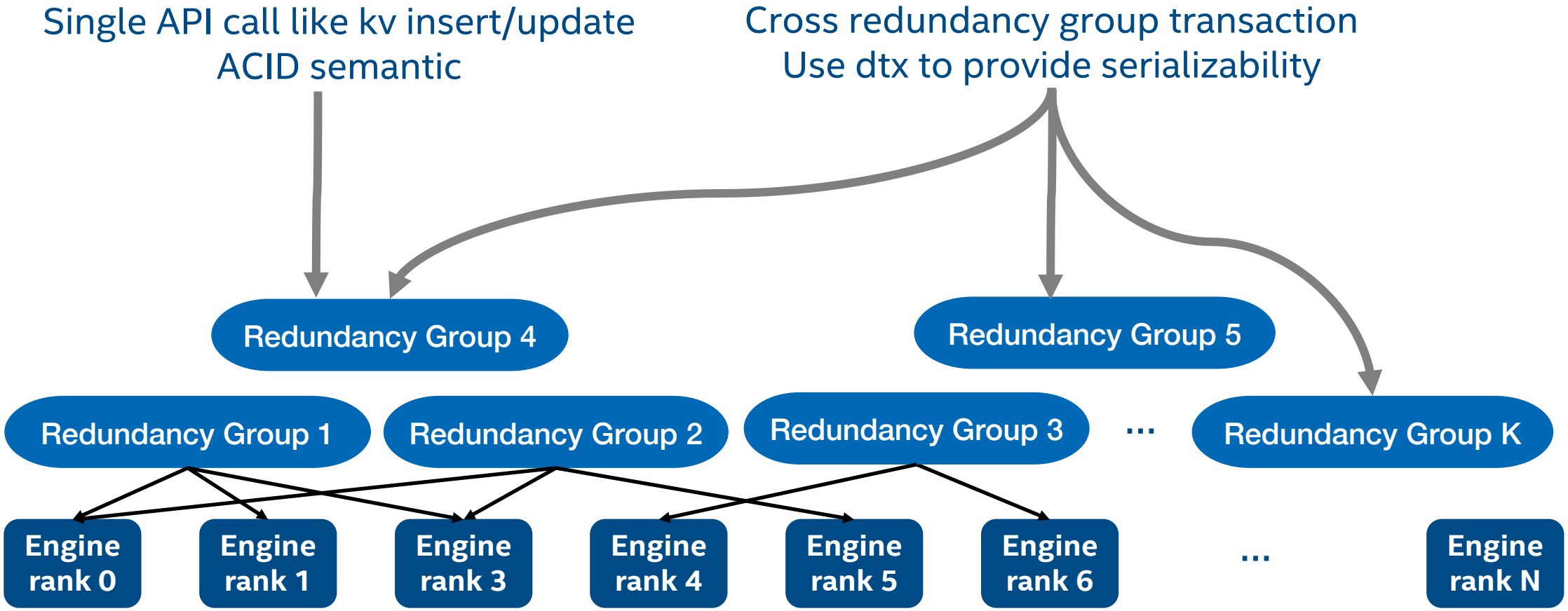
- Atomicity of distributed I/O
  - Replication, Erasure coding
- Two-phase commit based protocol
  - Prepare + commit
  - VOS is a write log
    - Indexed writes
    - Transaction status



(a) Replicated write

(b) Erasure coding write

Concurrency Control



Distributed Transaction

- DAOS distributed transactions (dtx):
  - No locking
  - Based on MVCC
  - Serializable
  - Similarity with Spanner & CockroachDB

```
        daos_tx_open(coh, &th, ...);
restart:
        daos_obj_fetch(..., th, ...);
        daos_obj_update(..., th, ...);
        daos_obj_fetch(..., th, ...);
        daos_obj_update(..., th, ...);
        daos_obj_dkey_punch(..., th, ...);
        rc = daos_tx_commit(th, ...);
        if (rc == -DER_RESTART) {
                daos_tx_restart(th, ...);
                goto restart;
        }
        daos_tx_close(th, ...);
```

Summary

- DAOS Overview
- Details of
  - how DAOS uses PMDK internally to guarantee internal consistency when processing a client request
  - erasure and replication protocol
- Introduction of distributed transactions crossing multiple redundancy groups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