BARNS: Backup and Recovery for NoSQL Databases

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Why Backup/Restore NoSQL DBs?

Customers are directly ingesting into NoSQL

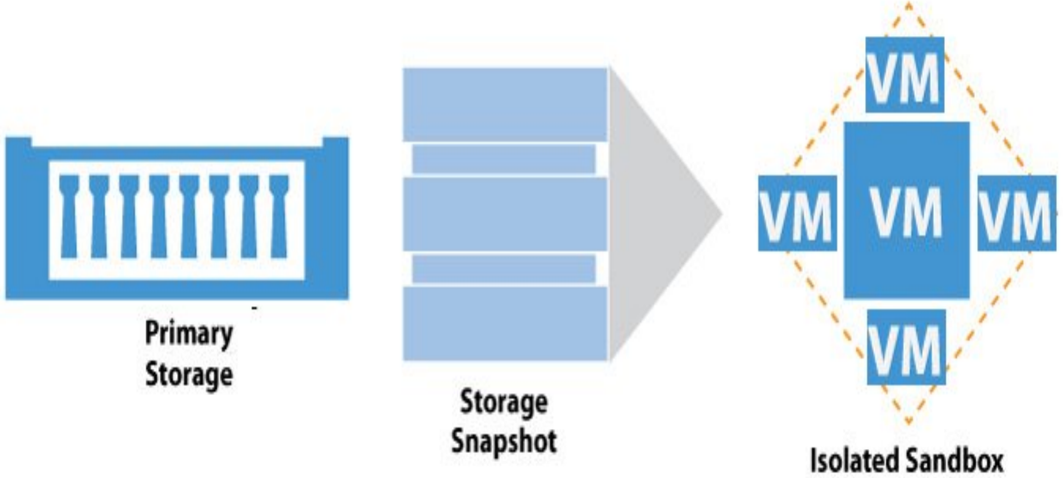
Security breach are on the rise e.g. **ransomware attacks** on MongoDB [1] and recent **WannaCrypt** exploits

“Fat-finger” errors eventually propagate to replicas

Ransomware

Sandbox deployments for **test/dev**

- Bring up shadow clusters of different cardinality (from production cluster snapshots)



Compliance and regulatory requirements

IDC, 2016 report [2] lists data-protection and retention as one of the top infrastructural requirements for NoSQL

[1] http://thehackernews.com/2017/01/secure-mongodb-database.html [2] Nadkarni A., Polyglot Persistence: Insights on NoSQL Adoption and the Resulting Impact on Infrastructure. IDC. 2016 Feb.

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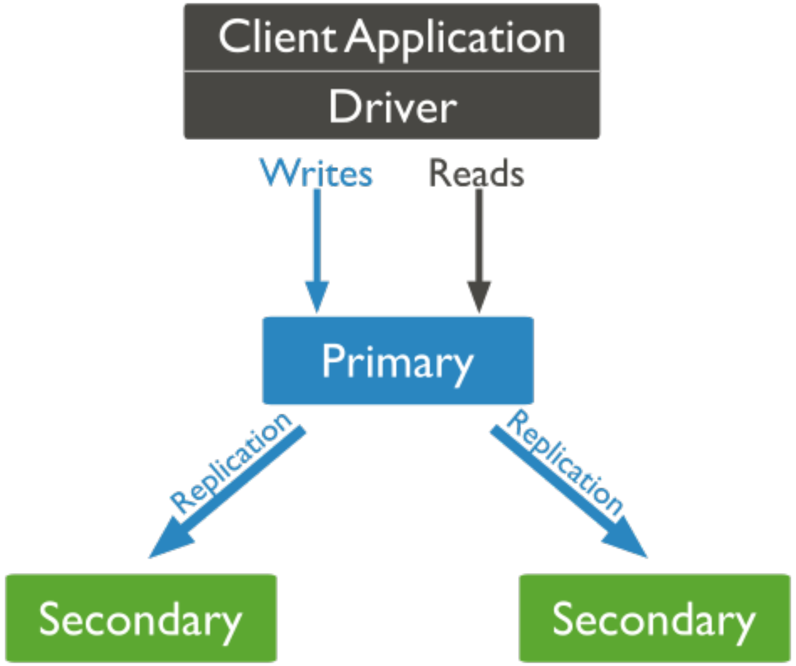
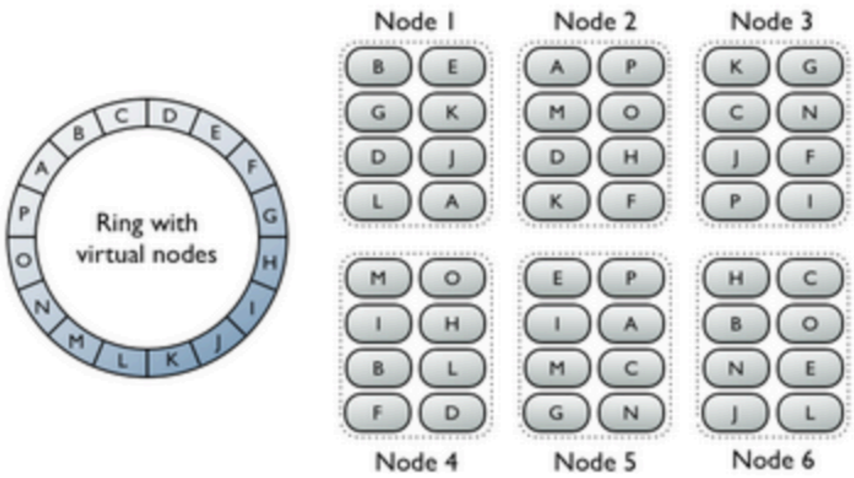
NoSQL Database Classes

From Backup/Restore Service Perspective

- Master-slave
  - Authoritative copy of each partition is contained in the master node that we can backup.
  - Loss of primary node leads to shard/partition-*unavailability* until new leader is elected.
  - Example: MongoDB, Redis, Oracle NoSQL, MarkLogic



- Master-less
  - Data is scattered across nodes using consistent hashing techniques, no single node has all data for a given partition
  - *Eventual consistency*: Unavailability of a destination node does not lead to write-failure, data is eventually replicated
  - Example: Cassandra, Couchbase



https://www.slideshare.net/mongodb/sharding-v-final, https://blog.imaginea.com/consistent-hashing-in-cassandra/

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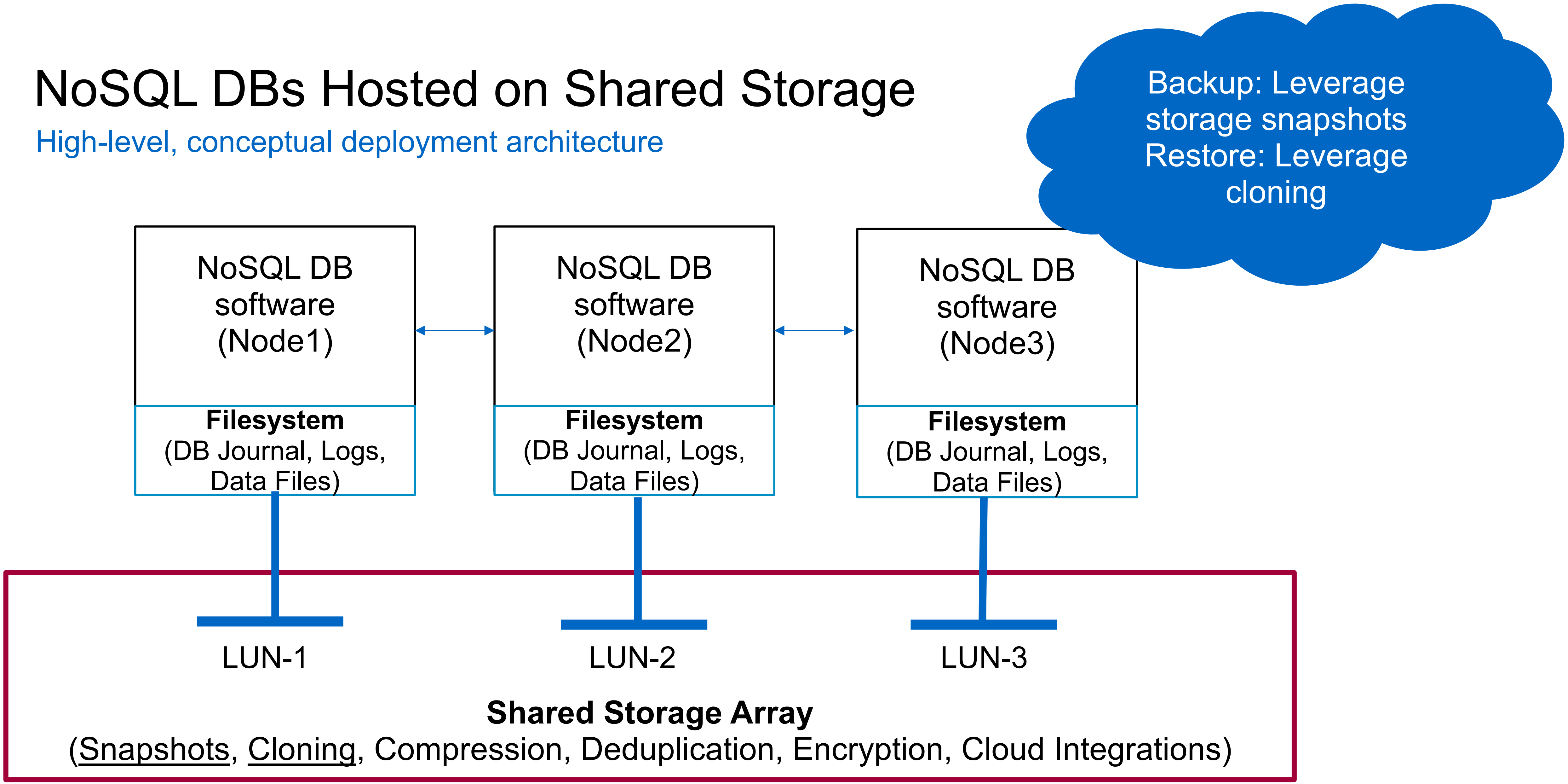
NoSQL DBs Hosted on Shared Storage

High-level, conceptual deployment architecture



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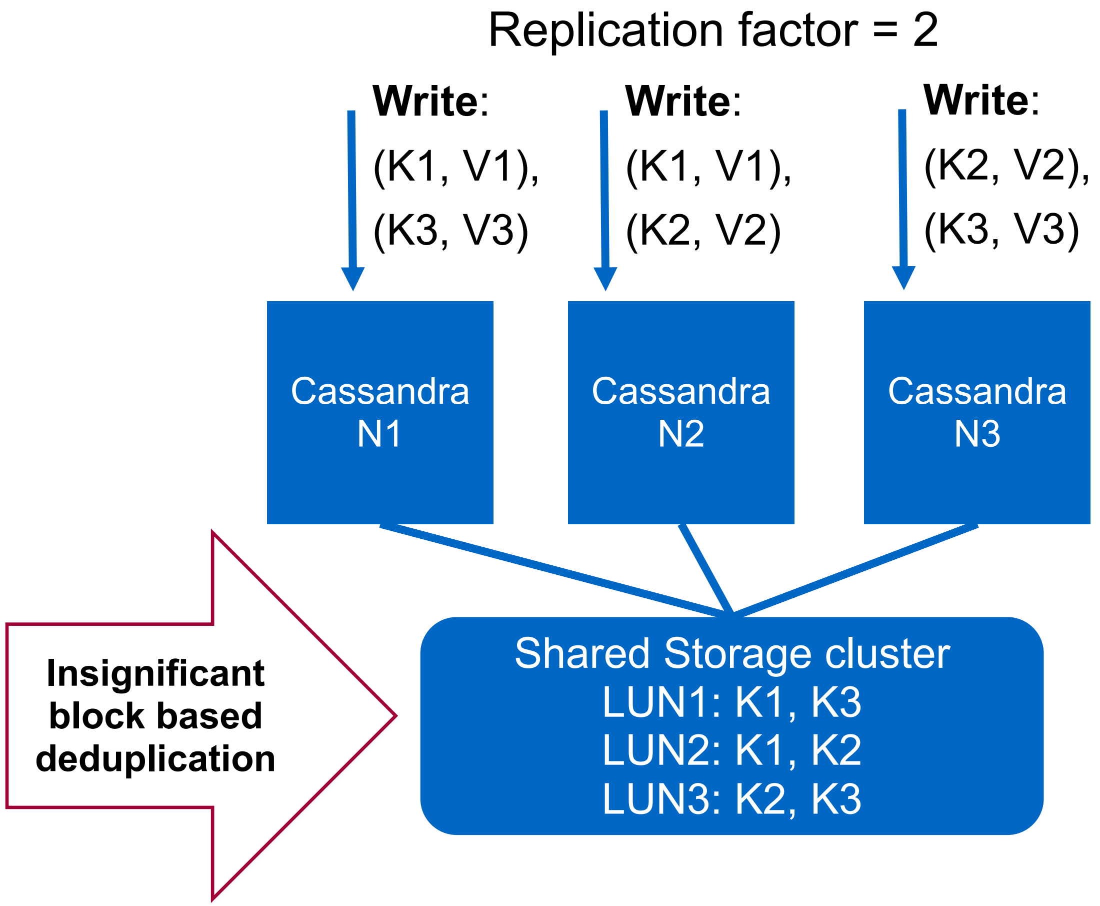
Backup/Restore Challenges

- **Cluster-consistency at scale**
  - Cluster/App quiesce – significantly hampers application performance. Cross node consistency not guaranteed
    - Take crash consistent snapshots
    - Post process crash consistent snapshots (in a sand-box) using NoSQL DB stack to reach an cluster-consistent state
- **Space Efficiency**
  - Replica set data copies do not de-duplicate – small row sizes, scattered across nodes (Cassandra) and unique ids added by storage engines (MongoDB)
  - DB performs compression and encryption
  - Remove replicas logically (application aware backup)
- **Topology Changes**
  - Commodity nodes, at scale of 10-100s of nodes. E.g., Primary node might be unreachable while taking backup in case of MongoDB
  - Storage snapshots do not have context about cluster topology
  - Use cases may require restore to a test/dev cluster of different cardinality
  - Save Cluster topology and storage mapping as part of backup



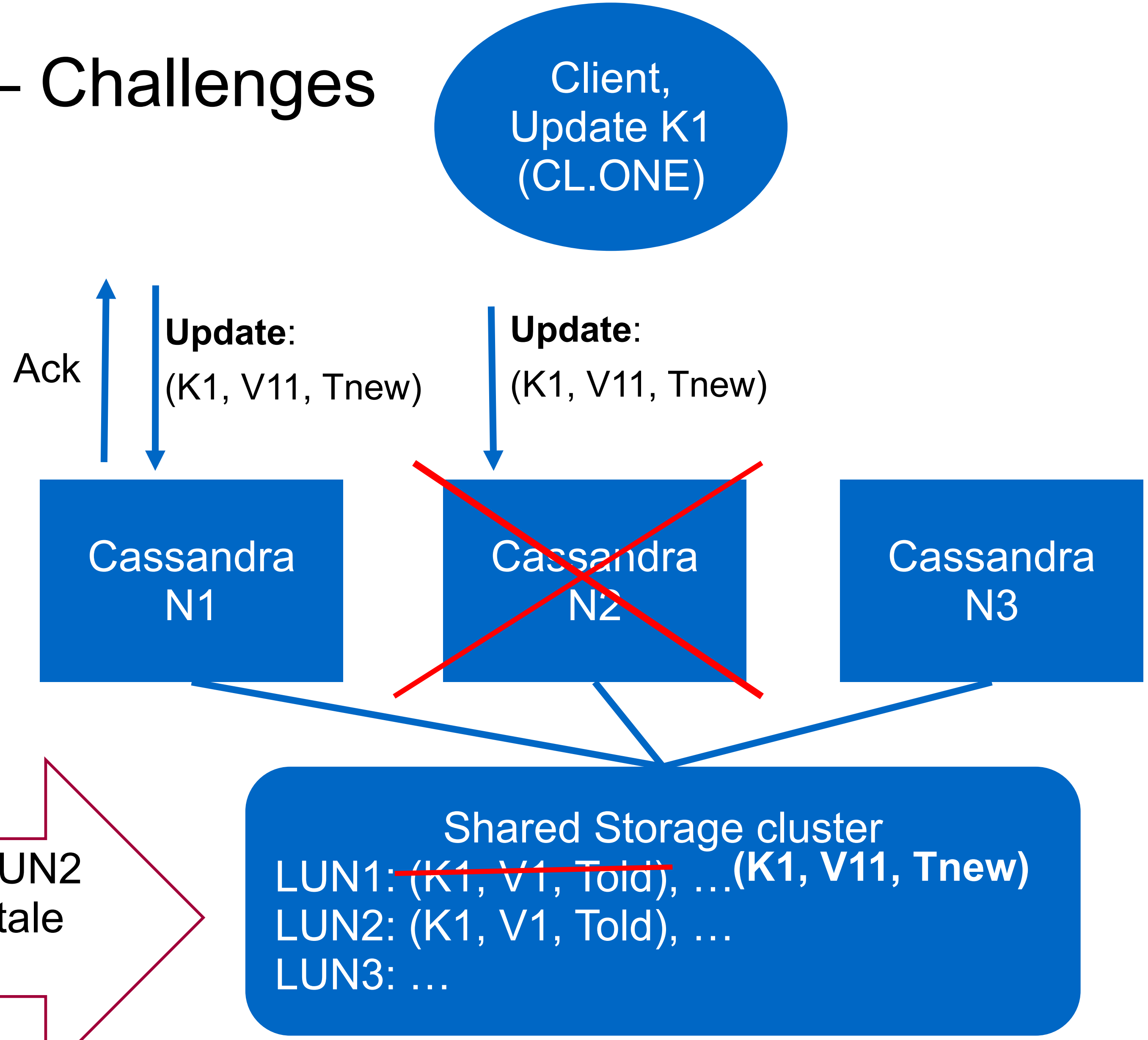
Existing open source utilities like Mongodump and Cassandra snapshots suffer from above challenges.

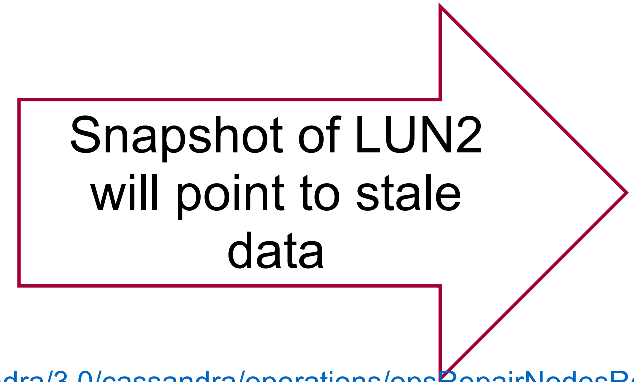
NoSQL Data Protection – Challenges

Master-Less Databases

Challenges:

- Fault tolerance
  - Backup may capture stale data due to *eventual consistency*
  - **Higher restore times**, since Cassandra will perform **repairs during restore**



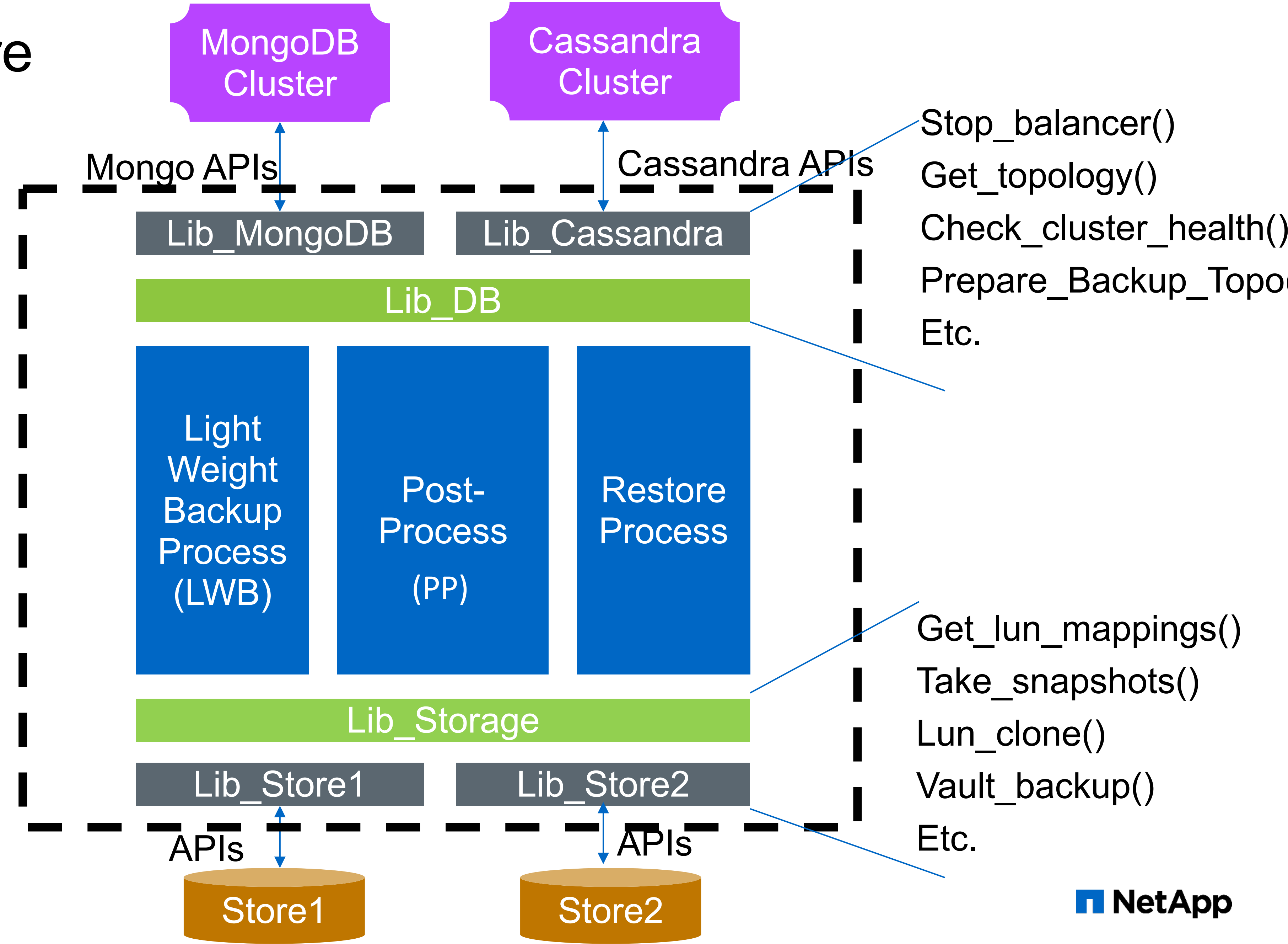


http://docs.datastax.com/en/cassandra/3.0/cassandra/operations/opsRepairNodesReadRepair.html, https://wiki.apache.org/cassandra/HintedHandoff

BARNS Architecture

Addresses challenges of:

1. Taking cluster-consistent backup at scale
2. Taking storage efficient backups (through replica removal)
3. Enables recovery/cloning to different cluster topologies



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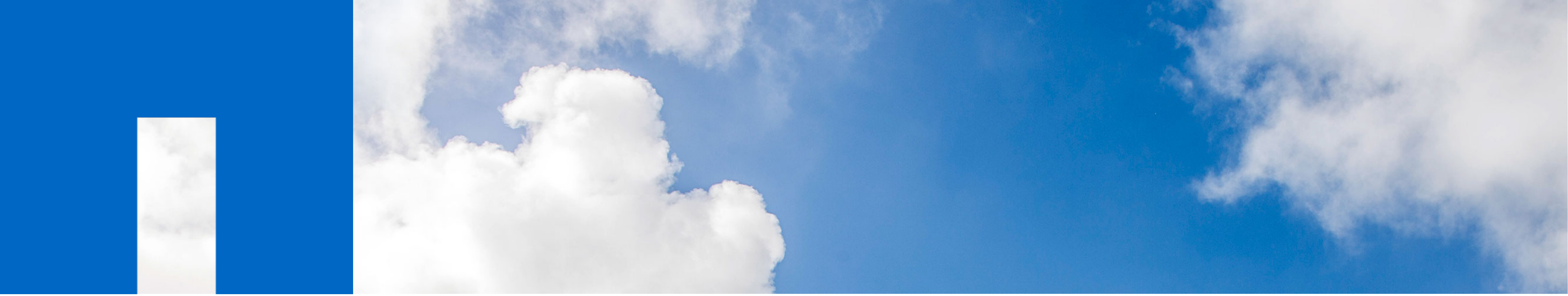

BARNS Solution: Cassandra

Master-less Distributed Database

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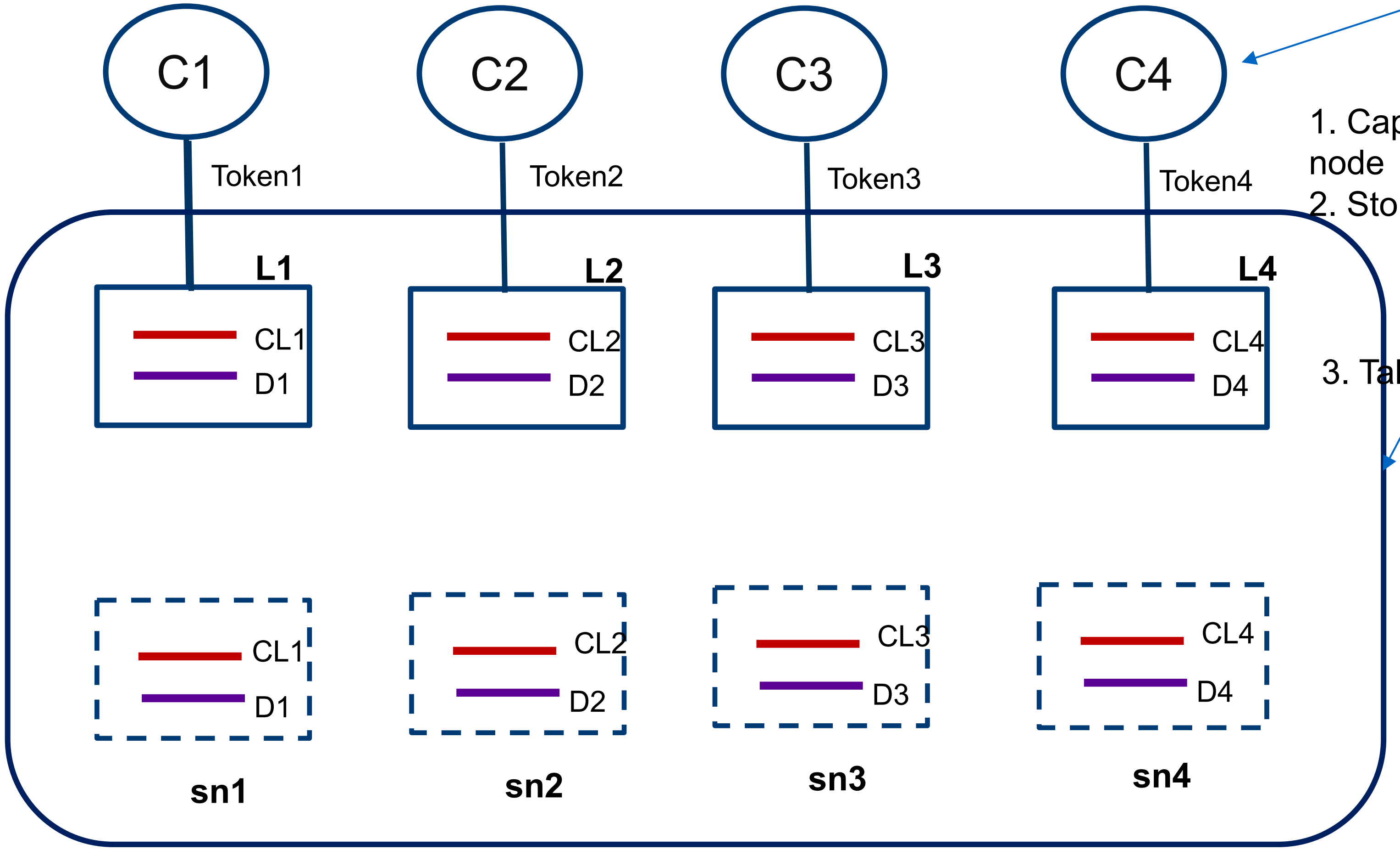
Phase 1: Light-weight Backup Phase

Production Cluster



BARNS: LWB

1. Capture token assignment of each node
2. Store mapping of LUNs → Tokens
3. Take snapshots of L1 to L4

Backup Metadata example


```
{"backup_name": 1488869633.586644,
 "cluster_name": "barns",
 "members": [
   {"lun": "/vol/cass1/lun_cass1",
    "snap-name": "17-03-02_01:02:18",
    "stateStr": "Healthy",
    "tokens": "<list of tokens> " }
   {"lun": "/vol/cass2/lun_cass2",
    "snap-name": "",
    "stateStr": "UnHealthy",
    "tokens": "<list of tokens> " }]}
```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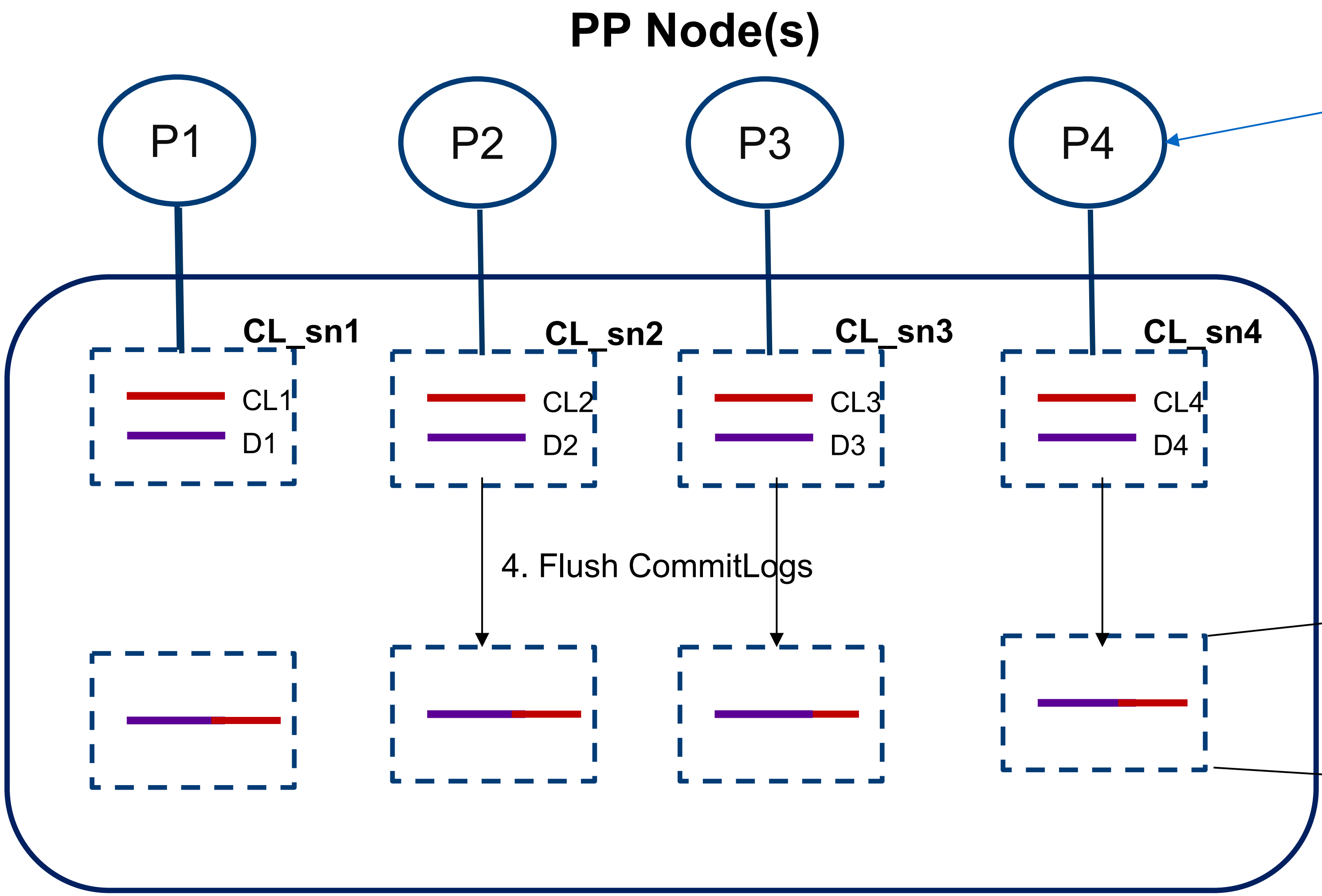
Phase2: Post Process Phase

Part1: Flush Commitlogs



BARNS: PP-Phase

1. Clone the LWB Snapshot LUNs
2. Mount on different PP processes or different nodes
3. Start Cassandra processes P1 to P4

E.g. Data
K1, V1, T1
K2, V2, T1
K1,V11, T2

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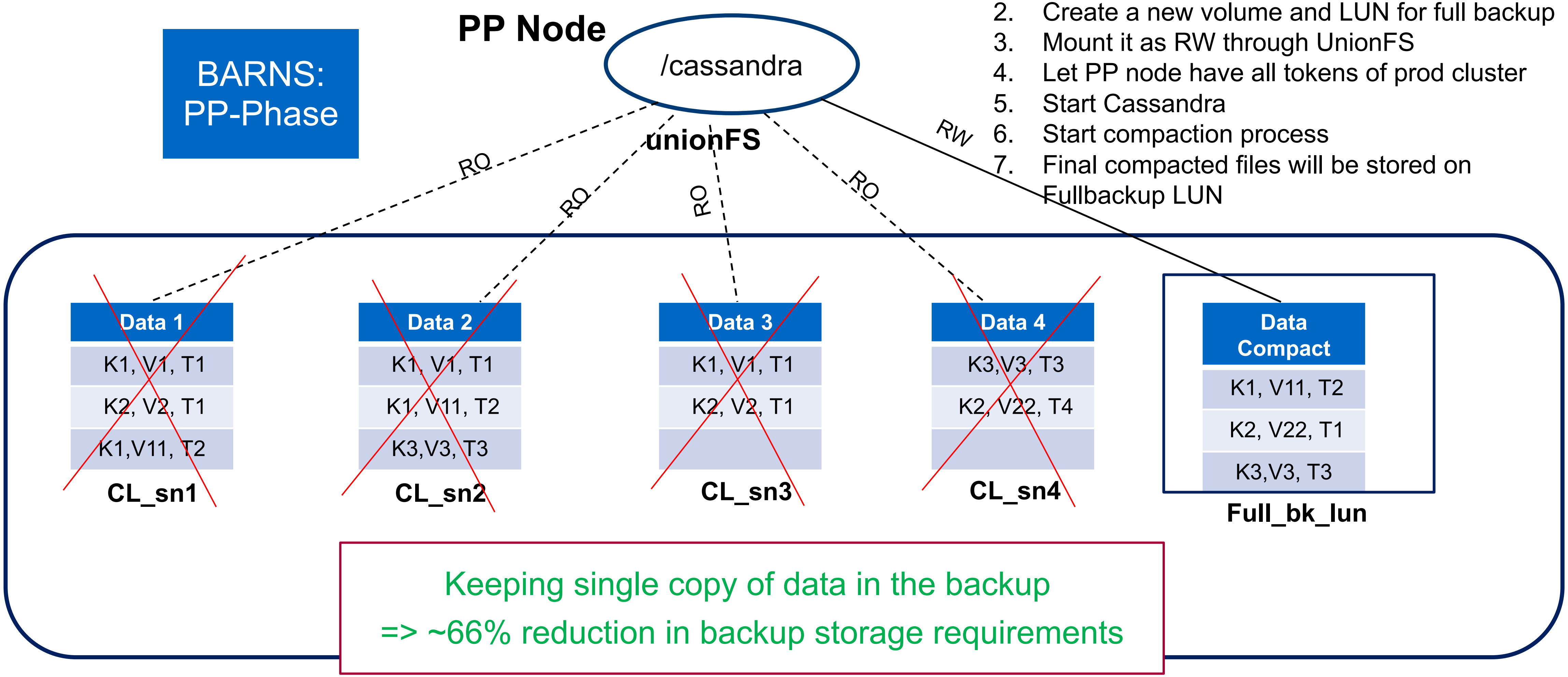
Phase2: Post Process Phase

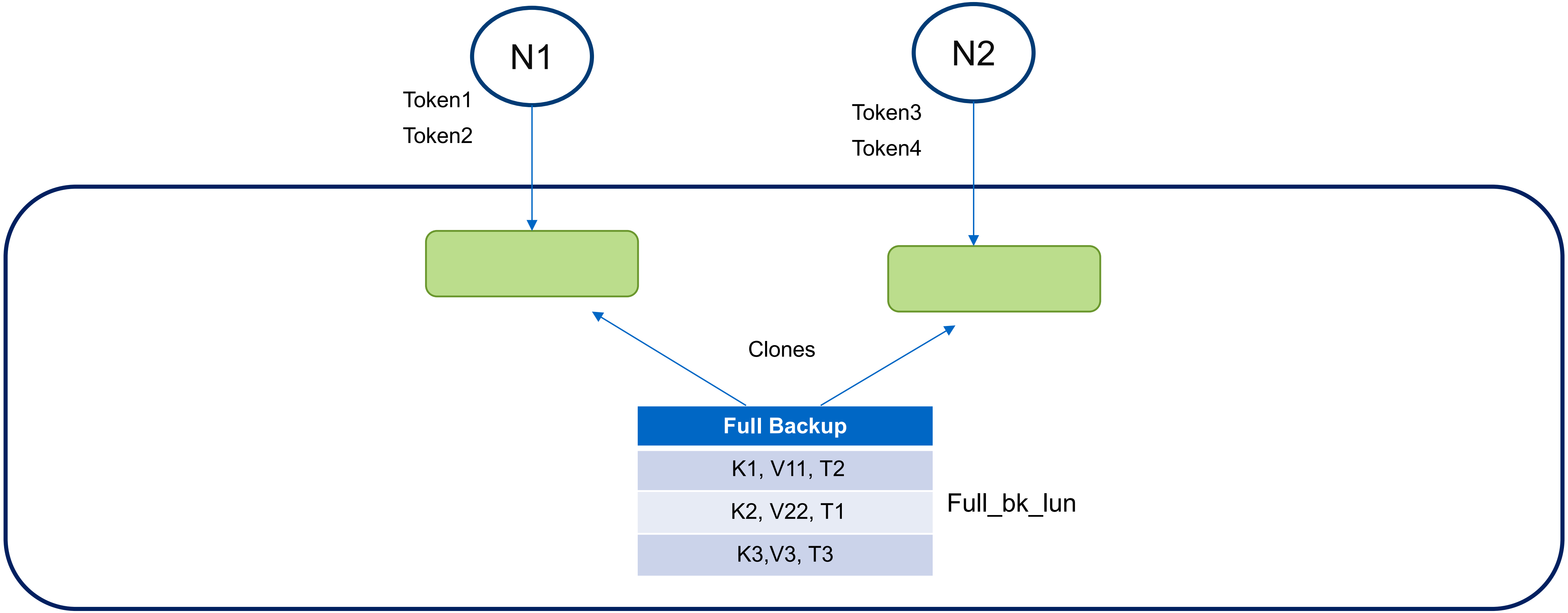
Part2: Compaction



1. Using UnionFS mount all snapshot clones as read-only
2. Create a new volume and LUN for full backup
3. Mount it as RW through UnionFS
4. Let PP node have all tokens of prod cluster
5. Start Cassandra
6. Start compaction process
7. Final compacted files will be stored on Fullbackup LUN

Cassandra Restore

The post-process step enables cloning to **different restore/clone topologies**



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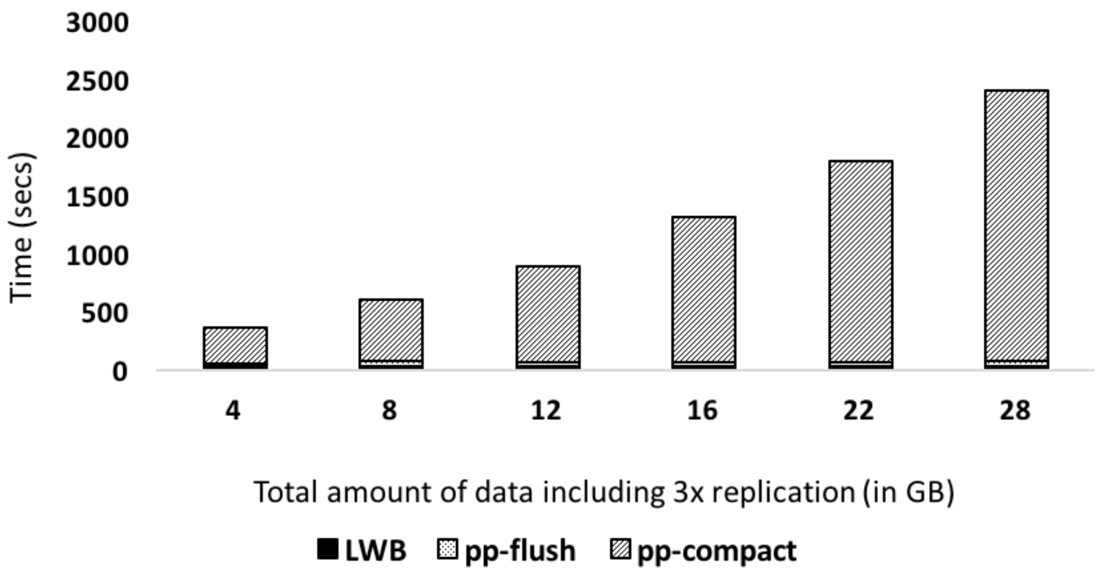
Evaluation - Cassandra Backup and Restore

Full Backup



- Production cluster
  - 4 nodes
  - 4 iSCSI LUNs
  - Commitlog and SSTables for a node on same LUN
  - Cassandra 4.0
- Post Process Node
  - 2 CPUs
  - 8GB RAM
- YCSB to ingest data

- LWB – <10 secs
- pp-flush - ~40 secs
- pp-compact – time increases by 35-40% → incremental backup
- Restore time – less than ~2 mins (irrespective of cluster size and data set size)

BARNS Solution: MongoDB

Master-Slave Distributed Database

- ➢ **Check the paper or just attend the poster session ☺**

Summary

- Tracking replicas and cluster topologies is important for taking backups and performing flexible topology restores

- Existing open-source solutions have several inefficiencies like need for repairs after restore, lack of storage efficiency in backup and poor integrations with shared storage

- Opportunity to provide efficient backup and restore through light-weight snapshots and clones

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Thank You.

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