Inside an Apache Ozone Upgrade

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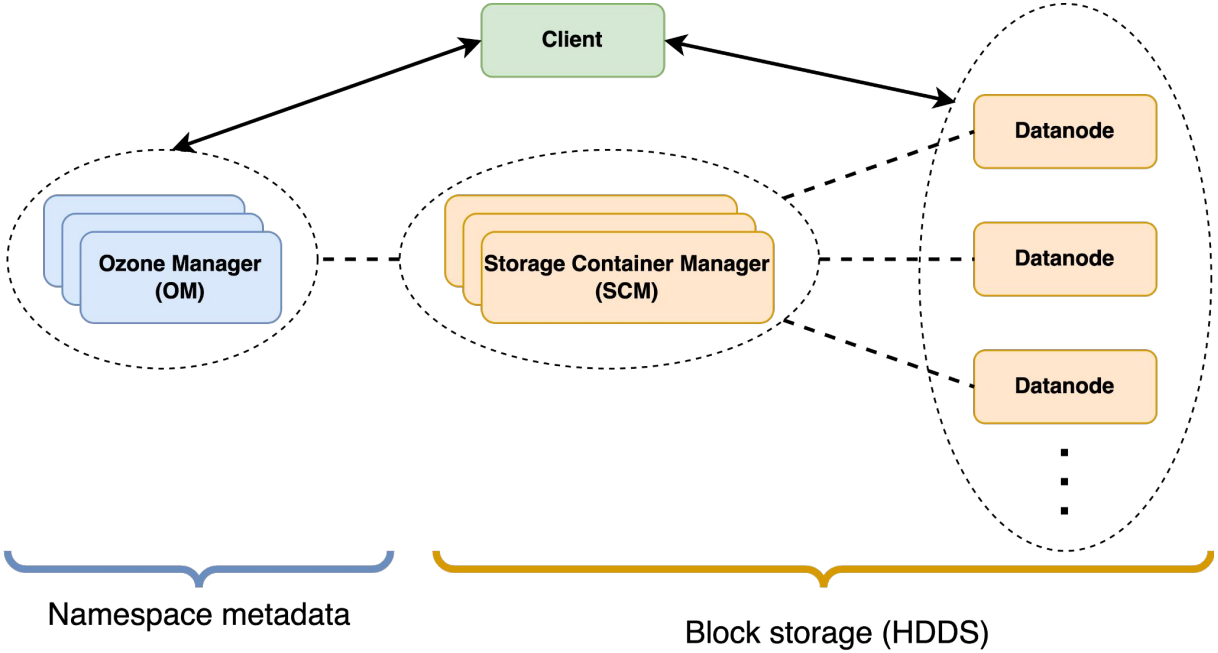
Agenda

- Introduction to Ozone
- How an Ozone upgrade works
- Ozone’s upgrade compatibility guarantees
- Managing disk compatibility
- Managing client compatibility

Introduction to Ozone

- Distributed storage system
- Strongly consistent
- Supports HDFS and S3 protocols
- Improvements from HDFS:
  - Metadata stored in RocksDB, only working set is kept in memory
    - Scales to billions of objects
  - Decoupled namespace and block space
    - Handles many small files

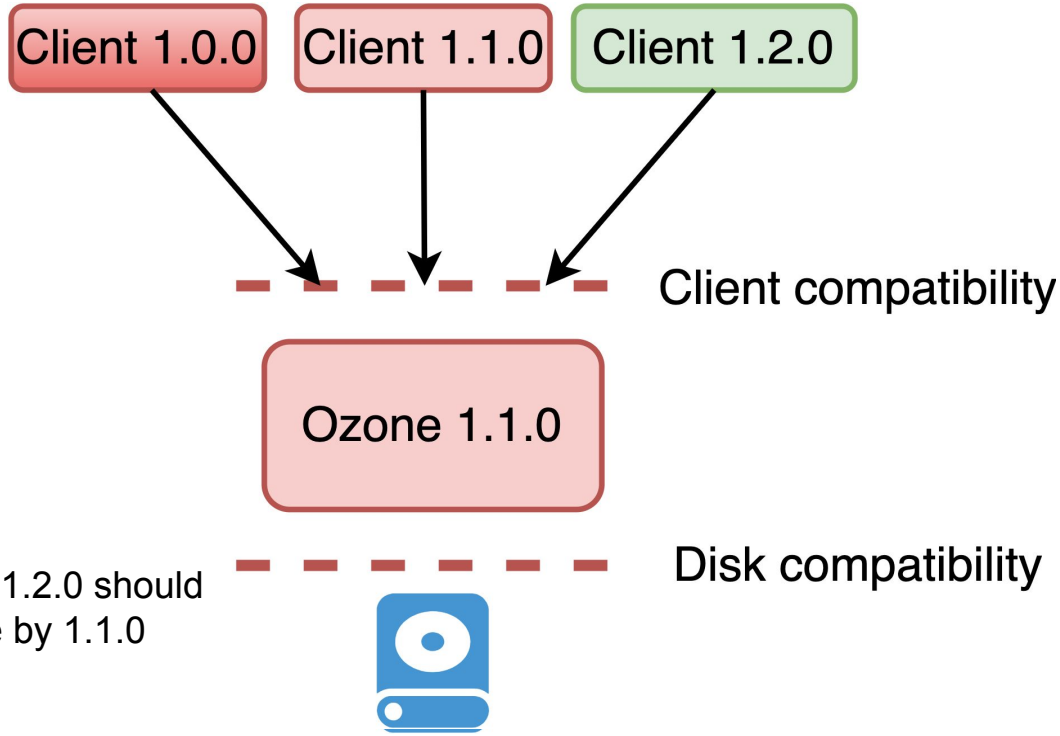
Ozone Architecture



Ozone's Upgrade Guarantees

- Non-rolling upgrades
  - All server side components are stopped in the old version, then started in the new version
- Downgrade support
  - Also non-rolling
  - Data written in newer version should still be readable
- Client cross compatibility
  - All clients released since Ozone 1.0.0 (GA) should work with all server versions released since Ozone 1.0.0
  - An Ozone server may see clients both older and newer than itself

Visualizing an Ozone Upgrade



What Affects Compatibility?

- New Ozone features in 2022:

Feature	Affects Disk Layout?	Affects Client Protocol?
1 RocksDB per Datanode Volume	✓	
S3 Gateway Persistent Connections		✓
S3 Multi-Tenancy	✓	
Bucket Layouts	✓	
Erasure Coding (EC)	✓	✓

Disk Compatibility

Managing upgrades and downgrades across features with incompatible disk changes

Managing Disk Compatibility

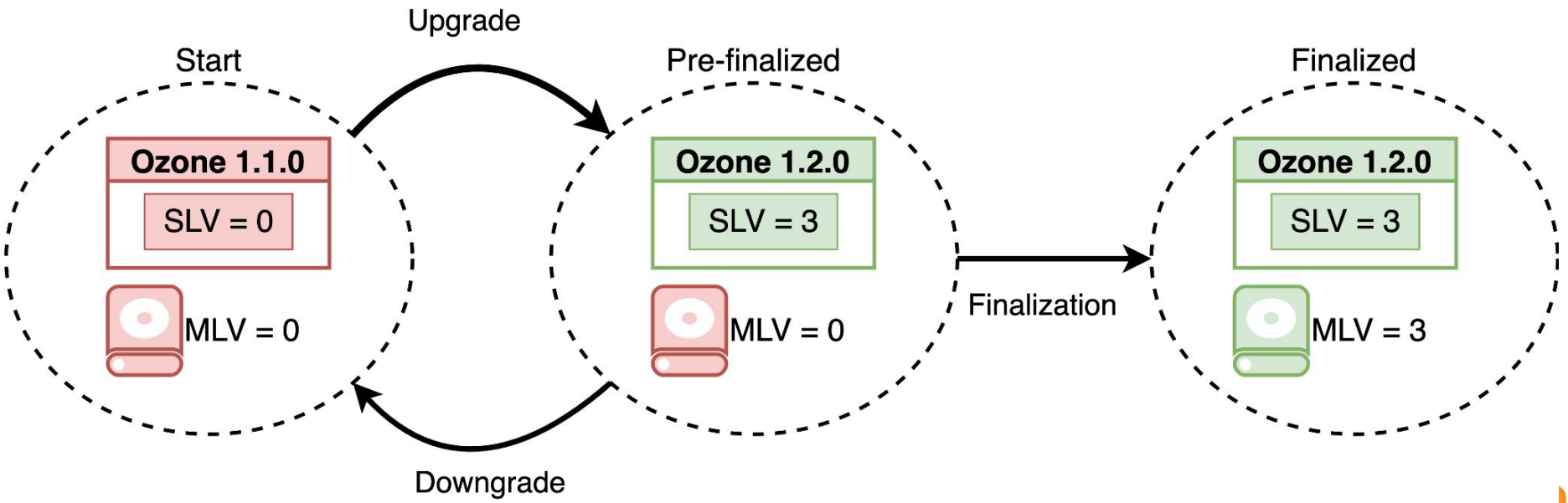
- Finalization
  - Concept borrowed from HDFS
- Pre-Finalized: New features cannot be used, but downgrade is allowed.
- Finalized: New features can be used, but downgrade is not allowed.

Implementing Finalization

- Layout Feature: Feature with disk compatibility concerns that is assigned a layout version
- Software Layout Version (**SLV**): Hard coded layout version
- Metadata Layout Version (**MLV**): Layout version written to disk

Layout Versions	State	New Layout Features Usable?	Downgrade Allowed?
MLV < SLV	Pre-finalized	✘	✓
MLV == SLV	Finalized	✓	✘
MLV > SLV	Error, startup fails	N/A	N/A

Ozone Upgrade/Downgrade Flow



Representing Layout Features

```
public enum OMLayoutFeature implements LayoutFeature {
  ////////////////////////////  ////////////////////////////
  INITIAL_VERSION(0, "Initial Layout Version"),

  ERASURE_CODED_STORAGE_SUPPORT(1, "Ozone version with built in support for"
      + " Erasure Coded block data storage."),

  BUCKET_LAYOUT_SUPPORT(2, "Ozone version supporting bucket " +
      "layouts and introducing the FILE_SYSTEM_OPTIMIZED and OBJECT_STORE " +
      "bucket layout types."),

  MULTITENANCY_SCHEMA(3, "Multi-Tenancy Schema");
  ////////////////////////////  ////////////////////////////
  ...
}
```

Developer Requirements

➔ Block incompatible requests while pre-finalized

Without a dedicated framework…

✘ No clear guidance for devs to handle upgrade concerns

✘ Every feature's upgrade concerns are mixed with unrelated code

✘ Difficult to locate code that handles upgrade concerns

✘ Higher chance of error if devs are not familiar with upgrade/downgrade process

➔ **Separation of Concerns**: Separate compatibility handling from other business logic

Blocking a New Request While Pre-Finalized

```
@DisallowedUntilLayoutVersion(MULTITENANCY_SCHEMA)
public OMRequest preExecute(OzoneManager ozoneManager) throws IOException {
  ...
}
```

- ✓ Easier for devs to use
- ✓ Upgrade logic separated from business logic

Blocking a New Variation of an Existing Request While Pre-Finalized

➔ Example: Only block bucket creation with EC replication type

```
@RequestFeatureValidator(
    conditions = ValidationCondition.CLUSTER_NEEDS_FINALIZATION,
    processingPhase = RequestProcessingPhase.PRE_PROCESS,
    requestType = Type.CreateBucket
)
public static OMRequest disallowCreateBucketWithECReplicationConfig(
    OMRequest req, ValidationContext ctx) throws OMException {
  ...
}
```

✓ Easier for devs to use

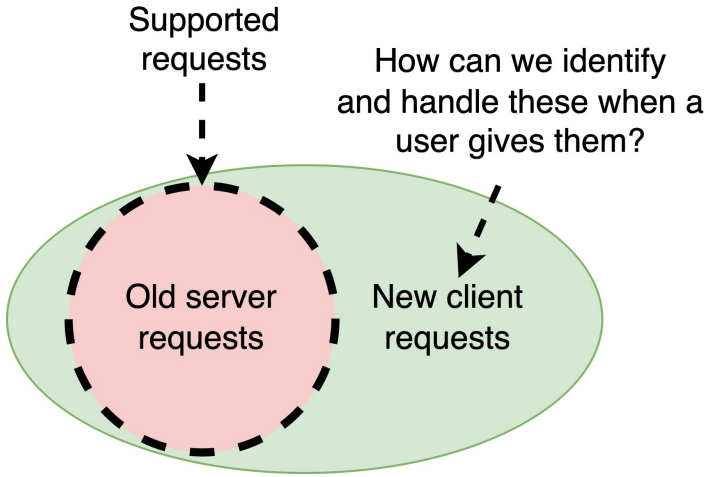
✓ Upgrade logic separated from business logic

Client Compatibility

Managing client/server protocol changes while maintaining cross compatibility

Client Compatibility Requirements

- Cross compatibility between all clients and servers since Ozone 1.0.0 (GA)
- Client/server protocol should function at the level of the oldest component
- Incompatible requests fail cleanly

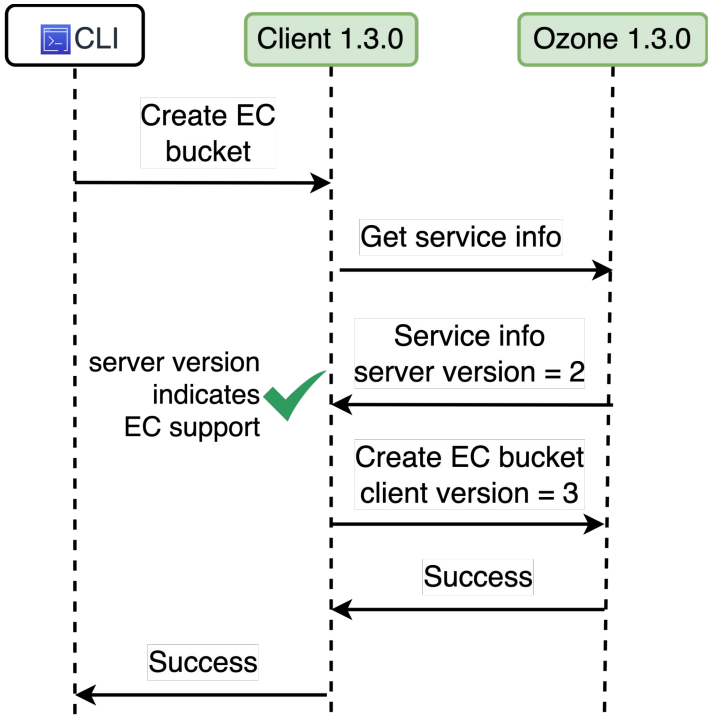


Client Compatibility Implementation

- Each component has:
  - Its own version
  - The latest versions of other components it knows about
- Components can choose actions based on the versions they receive.
- The newest component must handle compatibility concerns

Client and Server are the Same Version

```
$ ozone sh bucket create vol/ecbucket
--type EC --replication rs-3-2-1024k
```



Client is Newer Than Server

- **Client** compares the server's version with its known server versions
- **Client** should block user requests the server will not understand
- Prevents unnecessary requests resulting in messy protocol errors being returned to the user

New client's known server versions

```
public enum OzoneManagerVersion implements ComponentVersion {
  ////////////////////////////  //////////////////////////////
  DEFAULT_VERSION(0, "Initial version"),
  S3G_PERSISTENT_CONNECTIONS(1,
      "New S3G persistent connection support is present in OM."),
  ERASURE_CODED_STORAGE_SUPPORT(2, "OzoneManager version that supports"
      + "ECReplicationConfig"),

  FUTURE_VERSION(-1, "Used internally in the client when the server side is "
      + " newer and an unknown server version has arrived to the client.");
  ////////////////////////////  //////////////////////////////
  ...
}
```

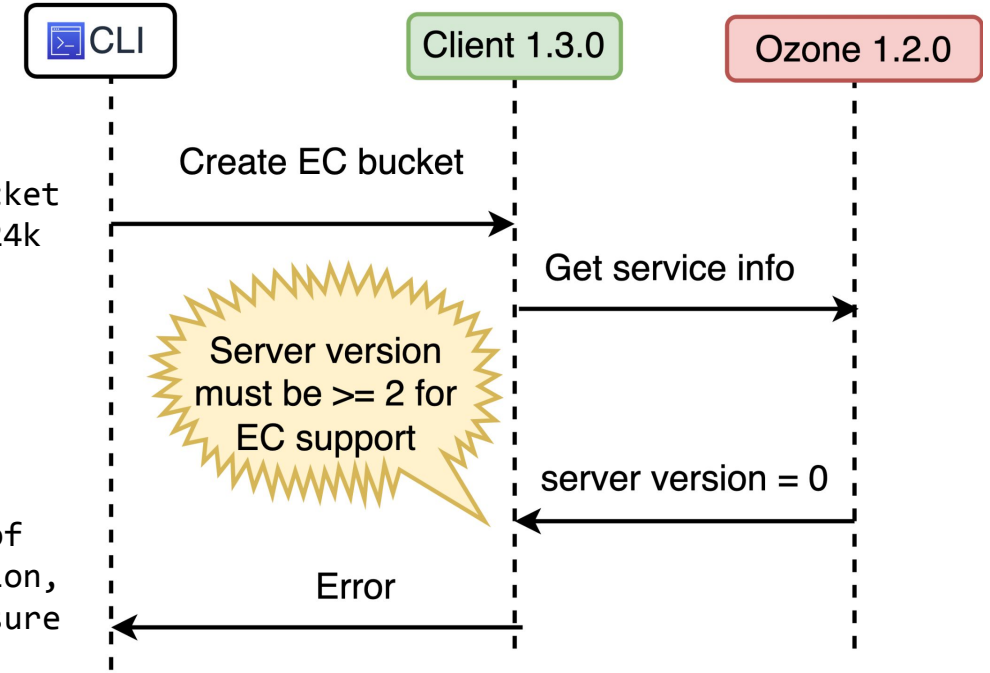
Old server's version

```
public enum OzoneManagerVersion implements ComponentVersion {
  ////////////////////////////  //////////////////////////////
  DEFAULT_VERSION(0, "Initial version"),

  FUTURE_VERSION(-1, "Used internally in the client when the server side is "
      + " newer and an unknown server version has arrived to the client.");
  ////////////////////////////  //////////////////////////////
  ...
}
```

Client is Newer Than Server

```
$ ozone sh bucket create vol/ecbucket
--type EC --replication rs-3-2-1024k
```



Can not set the default replication of the bucket to Erasure Coded replication, as OzoneManager does not support Erasure Coded replication.

Server is Newer than Client

- **Server** compares the client's version with its known client versions
- **Server** should block the client from reading data it cannot understand
    - This could happen if the data was written by a new client using a new format like erasure coding
- Prevents unnecessary requests resulting in messy protocol errors being returned to the user

New server's known client versions

```
public enum ClientVersion implements ComponentVersion {
  ////////////////////////////  ////////////////////////////
  DEFAULT_VERSION(0, "Initial version"),
  VERSION_HANDLES_UNKNOWN_DN_PORTS(1,
      "Client version that handles the REPLICATION port in DatanodeDetails."),
  ERASURE_CODING_SUPPORT(2, "This client version has support for Erasure Coding."),
  BUCKET_LAYOUT_SUPPORT(3, "This client version has support for Object Store and File " +
      "System Optimized Bucket Layouts."),

  FUTURE_VERSION(-1, "Used internally when the server side is older and an"
      + " unknown client version has arrived from the client.");
  ////////////////////////////  ////////////////////////////
  ...
}
```

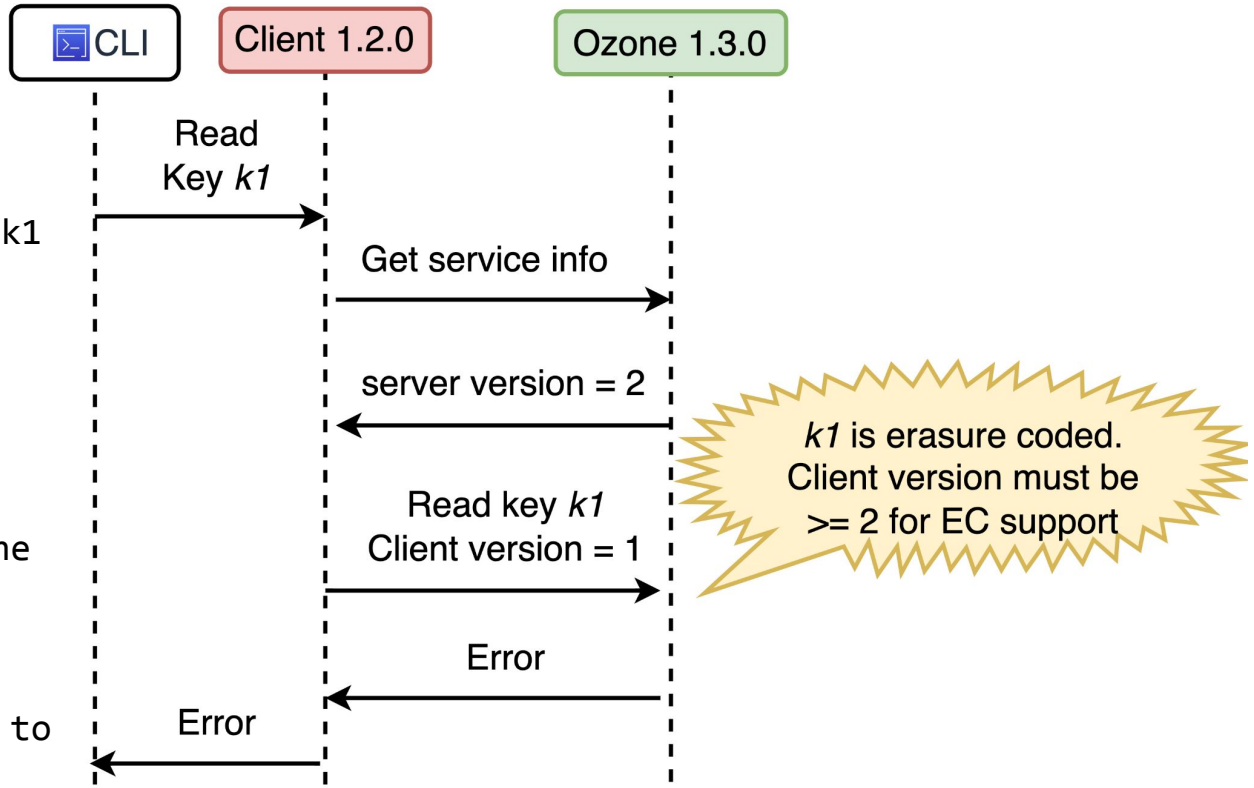
Old client's version

```
public enum ClientVersion implements ComponentVersion {
  ////////////////////////////  ////////////////////////////
  DEFAULT_VERSION(0, "Initial version"),
  VERSION_HANDLES_UNKNOWN_DN_PORTS(1,
      "Client version that handles the REPLICATION port in DatanodeDetails."),

  FUTURE_VERSION(-1, "Used internally when the server side is older and an"
      + " unknown client version has arrived from the client.");
  ////////////////////////////  ////////////////////////////
  ...
}
```

Server is Newer than Client

```
$ ozone sh key get
vol/ecbucket/k1 /tmp/k1
```




```
Key is a key with
Erasure Coded
replication, which the
client can not
understand.
Please upgrade the
client before trying to
read the key:
vol/ecbucket/k1
```

Where should the server block a read request?

1. Server receives the request to read a key
2. Server retrieves the metadata
3. Server uses the metadata to determine client compatibility

∴ Server must block the read after processing the request

```
@RequestFeatureValidator(
    conditions = ValidationCondition.OLDER_CLIENT_REQUESTS,
    processingPhase = RequestProcessingPhase.POST_PROCESS,
    requestType = Type.LookupKey
)
public static OMResponse disallowLookupKeyResponseWithECReplicationConfig(
    OMRequest req, OMResponse resp, ValidationContext ctx)
    throws ServiceException {...}
```

Summary

- Ozone supports non-rolling upgrades and downgrades. This requires:
  - Disk compatibility for downgrades
  - Client/server cross compatibility
- Downgrade disk compatibility is supported using finalization
- Client/server cross compatibility is supported as much as possible, but some specific requests must be blocked
- Ozone uses a developer friendly framework to handle compatibility of new features
  - Feature devs can easily plug in to the upgrade and request flows as needed
  - Separation of concerns and standardized implementations improve readability

Future Work

- Extend client compatibility annotations to other components
  - Currently only implemented on OM
  - Refactor client, SCM, datanode to use annotations as well
- More robust request annotations
  - Handle client/server and layout version checking in the annotations
- Monitor how the framework meets Ozone's evolving needs

Special Thanks

Special thanks to Aravindan Vijayan, Istvan Fajth, and everyone else involved in Ozone’s upgrade compatibility efforts in the last two years.

Thanks for Attending

Q&A

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