Cloudwave QoreStor

Remediation & Configuration Report

Adrian Moir & Ratna Bolla – December 2024

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## QoreStor utilisation in Cloudwave with Bridgehead RAPiD

QoreStor is currently used by Cloudwave as a backup target data repository with the Bridgehead RAPiD backup solution. It provides data reduction via deduplication and compression, along with the facility to move backup data to cloud storage.

Backups are sent to and retained on QoreStor using a generational retention policy. For example, keeping backups for five generations, when the sixth backup is taken it overwrites the contents of the first generational backup. In this way Bridgehead RAPiD maintains the last 5 successful backups in case a recovery is required. Data being ingested into QoreStor is subject to global deduplication. Compression is applied after deduplication to provide further savings.

### Cloud Tiering

QoreStor moves backup data to the cloud deduplicated and compressed. Data movement is controlled by a policy set on each QoreStor instance. The policy has two elements, the time a data file must be idle before being copied to cloud and the amount of time the backup data remains on the local QoreStor instance. Here is a description of the two policy elements…

* Idle Time
  + The amount of time that data files need to have been stable and idle for before being considered as candidates to be copied to cloud storage.
* Retention
  + The amount of time that data is held on the local storage after being copied to cloud before it is ‘stubbed’ and unrequired data blocks are cleaned up.

An example of the cloud tiering policy…

* Idle time is set to 2 hours
* Retention is set to 48 hours

This policy will wait for backup files that have been stored to become stable and idle for at least two hours. Once this threshold is reached the data files are copied to cloud. After 48 hours, if the data has been successfully copied QoreStor will remove the unwanted data from the local instance and replace it with ‘stubs’. A ‘stub’ is a file that points to the actual data files located in the cloud storage.

Varying the policy can influence how soon data is copied to cloud and how much local disk space is used for retention. Reducing the retention time will cause data to be ‘stubbed’ sooner rather than later. While this may be desirable to hold less data locally it may impact the speed of recovery as there is less data locally to pull from. Increasing the retention time does the opposite, there will be more data locally to recover from, which could reduce time to recovery (RTO), but it will consume more local disk space.

Local disk space can also come under pressure if the ingest rate increases over time and the retention time is kept the same, this means more data will have to be held locally before it is copied and ‘stubbed’ by QoreStor. Maintaining a balance between data ingestion and retention without adding extra space needs to be monitored.

Quest recommends that email alerting is configured on each QoreStor instance so that low disk space warnings can be sent. Retention and Idle times can be changed without the need for restarting any QoreStor services.

## Customer Observations, Engineering Discovery and Remediation.

### QoreStor instances running out of storage space.

### QoreStor instances slow cleaning of unwanted data and running out of space.

### QoreStor instances with excessive cloud tier storage.

### QoreStor instances stopping / restarting.

### QoreStor instances not sending data from local to cloud storage.

## Support & Engineering discovery

### QoreStor instances running out of storage space.

Symptom.

QoreStor instance runs out of disk space locally and in the cloud but is still showing good data space reduction in local and cloud storage. Local storage is physically less than the applied licence, physical disk would fill before any license usage

This situation can occur when there is insufficient storage both locally and, in the cloud, to facilitate the amount of data and rate of ingestion. Data size and ingestion rates may have increased, the cloud tiering policies and local storage space have not been updated. QoreStor licences cloud tier storage at a rate of three time the local storage licence. For example, if the local storage licence is 60TiB, then the cloud storage limit will be 3 x 60TiB = 180TiB. QoreStor will stop functioning and become ‘read-only’ as it no longer has enough space to operate.

Remediation.

To resolve the full storage space issue, more local storage was added to the QoreStor instance and a temporary larger license added. This gave the QoreStor instance some space to work withing and increased the available space in the cloud storage. The cloud tier retention policy was also updated and temporarily set the retention to 1 hour.  
This immediately allowed QoreStor to ‘stub’ some local data and free up space.

### QoreStor instances slow cleaning of unwanted data.

Symptom.

It was noted that the general storage usage was high as cleaning out unwanted backup data was taking a long time and sometimes not completing but running continuously.   
Quest Engineering noted that the cleaner for both local storage and cloud storage were a serial set of processes. One waiting for the other to complete. This proved unworkable within the boundaries of data ingestion and the cloud tiering policy being utilised. Quest made a product change to allow the cleaning operations of local storage and cloud storage to work in parallel, thus removing the need for to complete before the other could begin.

Remediation.

This was released in version 7.4.0 and requests were made to upgrade QoreStor instances to version 7.4.0. Certain QoreStor instances were running short on available cleaner threads, with the adoption of version 7.4.1, a ‘soft’ increase of CPU counts can be made to allow more threads to run. Normally this is one thread per CPU, however having more threads to address a backlog of cleaning enabled a faster resolution.

Further observation.

Cleaning of local storage was improved freeing up more disk space, but it was noted that the cloud cleaner was still taking a long time. Further investigation was required around the size of the data stored in cloud as well as cleaning.

### QoreStor instances with excessive cloud tier storage.

Symptom

Data that had met the conditions as per the defined policy had been moved out to cloud storage (AWS). However, the amount of data was not reducing and cleaning did not appear to complete its ‘laundry phase’ where it would actively remove data.

Engineering discovery

With Quest engineers reviewing diagnostic files and remotely viewing the system with assistance from Cloudwave personnel, it was found that the ‘dictionary’ on certain QoreStor instances had filled up and older entries were being dropped for newer ones. This leaves blocks of data in the cloud ‘orphaned’. The observation of cleaning not taking place in cloud storage is a result of the default setting of not enabling ‘Cloud Compaction’.

Remediation

In QoreStor instances where dictionary issues were found, depending on the depth of the issue the ‘dictionary’ space was increased to account for the level of deduplication and data being held locally and in the cloud.

After this, QoreStor versions now all have a larger ‘dictionary’ size as default. This was implemented in Version 7.4.0, however any systems from previous versions may need to have their dictionary increased manually.

There were certain systems that were in a situation that required manual intervention by Quest engineering to resolve the issues and walk through a pre-defined set of steps to provide a good working solution. During this process the ‘refcount log files’ exceeded a file size that would normally be not seen during normal operations. An updated ‘ofsck’ binary was created to circumvent this manually generated issue. The updated binary will be included in the next release of QoreStor (7.5) to cater for this edge case. See Appendix A for the defined 10 steps.

Once the above pre-checks and ten step repair plan was used, to clear unwanted data from cloud the ‘Cloud Compact’ options were turned on.  
This will actively remove any defunct unwanted data left orphaned after the ten-step plan. This does impact cloud costs as I/O activities will be increased to remove the now defunct unwanted data.

Two Machines we observed where issues of orphaned data in the cloud tier had created an overall negative deduplication result. These machines had the cloud compact option enabled to remove the unwanted data. This process will take a significant amount of time to complete.

* MEV-QSTOR - ~800TiB of logical data (not physical size) space to be removed
* MHC-QSTOR - ~300TiB of logical data (not physical size) space to be removed.

### QoreStor Instances Stopping/Restarting

Symptom

It was observed that certain QoreStor instances were restarting services on a regular basis. With no indication of the issue.

Engineering discovery

On systems where the QoreStor watcher, restarted services it was found that the system had run out of memory, core dumped and autonomously restarted the services as designed. However, this process continued as after a period the system would run out of memory again and restart again. It was observed that 3 core dump files existed, indicating three restarts due to a memory usage issue. The memory increase requirement is due to the need to expand the dictionary. The dictionary was expanded to it filling up. The dictionary was filling up due to the amount of data being held within the instance at a high level of deduplication

Engineering request for HGM-QSTOR

“On HGM, we are going out of memory, every four days.   32 GB was the recommended for ‘cloud optimized’ installs, and then we extended dictionary which is consuming 8GB extra.

  So can we please increase the memory to > 40GB. May be 42GB to be on safe side.”

### QoreStor instances not sending data from local to cloud storage.

Symptom

Running out of local disk space, QoreStor UI showing that license consumption does not match the physical used disk space on the QoreStor instance.

Engineering discovery

Upon receiving a diagnostic report, it was found that an error state had been triggered preventing the data to be moved to cloud. It appears that it manifests when a file has already been sent to cloud and has some form of renaming happening in the backup workflow. The Bridgehead product does overwrite its backup files based upon a generational retention plan. For example, with a retention plan ‘Five Generations’ the sixth backup would overwrite the first of the five. Thus, keeping the last five backups available to restore from. This operation is expected behaviour from the Bridgehead software.

What we found was in certain instances, with a rename it was not being acted upon correctly by QoreStor if that file was in cloud. Therefore, QoreStor was generating an error and not moving or updating the file to the cloud tier.

The following is the expected operational methodology in this occurrence.

When a file or directory is changed on the local QoreStor storage and that file also exists in cloud storage, QoreStor checks to see if the meta-data is local and if the meta-data is in the cloud storage as well. If the meta-data in the cloud storage doesn’t yet exist, then we copy it out to cloud storage along with the file data. If the meta-data for the local source file exists locally and, in the cloud, but they do not match QoreStor performs an update and relinks the new meta-data to the data due to be copied to cloud.

However, we found a regression bug in the code of the QoreStor file systems daemon binary relating to the ‘do not match’ condition above. It causes the file cloud copy selection to bail out with an error instead of running the operation to refresh the cloud-meta data with the newer local meta-data and copy the data to cloud. As a result all files that are in this particular state that are due to be copied to cloud, they fail with the error right away. This data is not moved to cloud as it should be and stays local. Thus, filling the local storage. A new binary was created with the regression bug fixed and deployed on this machine, it is now working through the data that is local and updating its associated cloud content.

A new binary has been added to a release of QoreStor (7.4.1.173) such that this condition, if met will not cause the error but will relink the meta-data and files in cloud correctly.







## Recommendations

For further monitoring of QoreStor systems, there are some recommendations that we advise to be taken up such that prior warnings can be provided to alert an administrator before the issue becomes critical.

There are several options for notification, given the number of instances the preferred method would be to have relevant users added to the Cloudwave organisations in QorePortal to centralise alerting across all QoreStor instances. This requires those users to have the *‘Owner’* role for the relevant organisation. Multiple users can have the *‘Owner’* role in an organisation.  
  
Local Alternative for email alerting

# /opt/qorestor/bin/email\_alerts --enable

Service enabled successfully.

# /opt/qorestor/bin/email\_alerts --status

Service is running.

# /opt/qorestor/bin/email\_alerts --configure

Please enter the SMTP Relay FQDN or IP address: <*Enter your email relay IP/FQDN>*

Please enter the sender's email address: no-reply@<*Hostname*>

Please enter the sender's name: <*Name you wish the sender to appear as e.g. Hostname* Admin>

Please enter the list of recipient email addresses: <*recipients email address>*

Please enter the list of email addresses to be CC'ed: <optional *recipients email address>*

Please enter the list of email addresses to be BCC'ed: <optional *recipients email address>*

Applied configuration:

SMTP Relay: 10.3.19.10

Sender Address: no-reply@<Hostname>

Sender Name: Hostname Admin

Recipient(s): <recipients email address>

### Configure daily e-mail reports

The daily email reports will show the status of the QoreStor instance and the delta storage changes from the previous day across all configured target containers.  
  
email\_stats --clear-config | --enable | --disable | --status | --configure | --test-email

--clear-config removes the stored stats email configuration

--enable enables the QoreStor Stats Email service

--disable disables the QoreStor Stats Email service

--status checks that QoreStor Stats Email service is running

--configure interactive prompts to configure email relay, sender name and email address, recipients, CC recipients, and BCC recipients

--test-email send a test email

Configure email stats report using option “--configure”.

#email\_stats --configure

Please enter the SMTP Relay FQDN or IP address: <enter relay host>  
Please enter the sender's email address: <enter email id>  
Please enter the sender's name: <can be QS Admin>  
Please enter the SMTP Password (if a password is not required, leave this field blank):  
Please enter the list of recipient email addresses: <email id>  
Please enter the list of email addresses to be CC'ed:  
Please enter the list of email addresses to be BCC'ed:  
Please enter the time when the report should be sent (in HH:MM format): <enter time>

Applied configuration:

SMTP Relay: <…>  
Sender Address: <…>  
Sender Name: <…>  
Recipient(s): <…>  
CC:  
BCC:  
Send Report at: <..>

To enable email reporting execute the following :

email\_stats --enable  
Service is already enabled.

Find status of email\_stats service:

email\_stats --status  
  
Service is running.

Test the configuration:

email\_stats --test-email  
SUCCESS; Test email sent.

Disable email\_stats service:

email\_stats --disable  
Service disabled successfully.

To remove stored email\_stats configuration:

email\_stats --clear-config

A screenshot of a data sheet

Description automatically generatedA typical daily report includes daily delta changes on the QoreStor system as well as changes within a backup target container.

### Checking Dictionary size and Cloud Tier Consumption if an alert is raised

To find the current consumption of the dictionary, the following command can be carried out:

/opt/qorestor/bin/ctrlrpc -p 9911 show.dedupe\_stats

The variable we need to check is the number of keys used uhd\_total\_nrecs.

This number indicates, the consumed number of keys in the dictionary.

If the number of keys is near or has reached the maximum allowed in the current dictionary, this is when we start to see issues. This can also be seen if the there is a high number shown by uhd\_pruned.  
For example, uhd\_pruned : 7250

Checking which dictionary size is running a simple list of the files in the meta-data dictionary location.

To determine the current size of the dictionary a list of the directory location will reveal the file names in use, the last two numbers on the file name indicate the shift size..

#ls -al /QSmetadata/qs\_metadata/dict2

-rw-------. 1 root root  68723736576 Nov 18 11:47 dict19  
-rw-------. 1 root root 137447407616 Nov 18 11:47 dict20  
-rw-------. 1 root root 274894749696 Nov 18 11:48 dict21  
-rw-------. 1 root root 343631003648 Nov 18 11:49 dict22  
-rw-------. 1 root root 584182726656 Nov 18 11:49 dict23

Each Shift size has a maximum number of keys that can be used to reference the stored data chunks. With a 2KiB page size and an average 32KiB chunk size the number of referenceable chunk entries are shown below. If a dictionary needs to be expanded, extra disk space and RAM may need to be added as shown in the [table 1](#_Table_1._–) below.

### Table 1. – Dictionary Sizing Requirements

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Dictionary Shift number | Number of keys (Billion) | Disk Size Space  GiB | Cache Memory Required for Dictionary MB | Additional Memory Required  MB | Total memory required MB | Memory uplift  MB | Disk space uplift required GiB |
| Shift 19 | 3 | 64 | 2,048 | 128 | 2,176 | - | - |
| Shift 20 | 6 | 128 | 4,096 | 240 | 4,336 | 2,160 | 64 |
| Shift 21 | 11 | 256 | 8,192 | 512 | 8,704 | 4,368 | 128 |
| Shift 22 | 23 | 384 | 16,384 | 1,424 | 17,808 | 9,104 | 128 |
| Shift 23 | 48 | 650 | 32,768 | 2,576 | 35,344 | 17,536 | 266 |

### Checking cloud tier consumption and health *if an alert is raised*.

stats --cloud\_tier

#stats --cloud\_tier

Total Inodes : 9321

Read Throughput : 0.00 MiB/s

Write Throughput : 0.00 MiB/s

Current Files : 9136

**Current Bytes : 19859598233824**

**Post Dedupe Bytes : 2789951204098**

Post Compression Bytes : 1303787964127

Post Encryption Bytes : 1304559767680

Post Encryption Bytes in GiB : 1215.0 GiB

Bytes decrypted : 165032460416

**Cleaner Status : Done**

Compression Status : Done

Encryption Status : Done

**Dedupe Savings : 85.95 %**

Compression Savings : 53.27 %

Total Savings : 93.43 %

Current Recycle Bin Files : 0

Current Recycle Bin Logical Bytes: 0

Current Recycle Bin Physical Bytes (estimated): 0

Cloud read Throughput : 0.00 MiB/s

Cloud write Throughput : 0.00 MiB/s

Files in progress to cloud : 0

Total cloud bytes uploaded : 12045161385255

Total cloud bytes downloaded : 673258904582

Total cloud cache bytes read : 99680219555

Total cloud read bytes optimized: 52487912326

Total cloud files : 585091

Total cloud overwritten files : 509

Total cloud bytes : 1356098871664

Total cloud bytes processed : 0

Total cloud ds bytes reclaimed : 0

Total Fast Cache space used (physical): 0

Total cloud metadata bytes : 51539103984

Total space (rehydrated) : 19911137337808

If the "Dedupe Savings" are 0 % or less.  (i.e "**Current Bytes**" are far greater than "**Post Dedupe Bytes**") and if the cloud cleaner status is done.  Then enable cloud compaction with [10 step process](#_Ten_Step_procedure).

Expanding dictionary if required – NOTE: This has a memory and disk space usage impacts.  
Refer to [Table 1](#_Table_1._–). For the minimum disk and memory uplifts required.   
See [Appendix C](#_Appendix_C) for systems with known issues that have already had this change implemented.

By default, all new QoreStor installations now have an initial dictionary size of 256GiB, this is an improvement up from the normal ‘Cloud’ optimised and ‘Standard’ of 64GiB and 128GiB respectively. This is a Shift 21 sized dictionary with an 11 billion Keys available.

### Check relevant version is installed and up to date

Installation of version 7.4.1.173 – this includes the binary fixes covered in this document.

A full list of Cloudwave QoreStor instances can be exported from QorePortal in the ‘Cloudwave Organisation’ directly to an Excel spreadsheet. This provides a simple way to check the version of QoreStor across all QoreStor instances. The download button is shown below in red.

For a full list of machines, see [Appendix C](#_Appendix_C).

A screenshot of a computer

Description automatically generated

## Appendix A. Ten Step procedure pre-check to see if it is required.

1. Check dictionary usage

/opt/qorestor/bin/ctrlrpc -p 9911 show.dedupe\_stats.

Need to know uhd\_total\_nrecs number

2. If an alert has been raised and an email has been received with the following warning(s)…

* 2065:en:Cloud Tier Storage usage is approaching capacity. %s cleaner will be enabled outside of scheduled setting and performance impact may be observed.
* 2066:en:Cloud Tier Storage usage reached full capacity. %s switching to read-only mode for Cloud Tier containers.

Use the stats --cloud\_tier command to see if the cloud tier storage deduplication has been impacted.

Check the following.

If the "Dedupe Savings" are **0 % or less**.  (i.e "**Current Bytes**" are far greater than "**Post Dedupe Bytes**")

***And*** if the cloud cleaner status is “**Done**”.  Then enable cloud compaction with 10 step process.

3. If not then update memory setting ENV, Cleaner will take more memory - Need new diagnostic

4. If all is completed then needs 10 step procedure if dedupe savings on cloud tier are negative.

### Ten Step Procedure..

1. maintenance --filesystem --start\_scan --storage\_group DefaultCloudTier

2. Once it finishes cleaner and starts OFSCK, stop the scan.   
(monitor scan\_status).

*[These two steps make sure cleaner is done and active datastores are flushed to disk, before we remove refcounts.]*

3. mkdir /QSdata/refcnt\_backup

4. Add the following to /etc/oca/customer.env

export PLATFORM\_ENABLE\_CLOUD\_DS\_COMPACT=1

export PLATFORM\_ENABLE\_CLOUD\_DS\_COMPACT\_RDWR=1

5. mv /QSdata/ocaroot/3/.ocarina\_hidden/refcnt/   
/QSdata/refcnt\_backup/

6. mkdir /QSdata/ocaroot/3/.ocarina\_hidden/refcnt/

7. touch "/var/ocarina/skip\_logging”

*[To avoid logging in ofsck.log – this improves speed]*

8. kill -CONT $(pid of ocafsd); maintenance --filesystem --start\_scan --storage\_group DefaultCloudTier

*[single command, as we need to start scan immediately after* CONT*]*

9. Wait for ofsck to finish, it will ask for repair.

10. maintenance --filesystem --repair\_now

## Appendix B

List of QoreStor alerts that can be generated and sent via email. Items highlighted would be pertinent to issues in QoreStor instances that have manifested in systems at Cloudwave. Using the email notification capability is highly recommended such that if any issues arise a notification is sent directly to an administrator.

2008:en:Data volume not present. Check all drives are inserted and powered up. Contact Quest Support.

2009:en:%s Service failed to start after multiple attempts. Contact Quest Support.

2010:en:%s Service crashed multiple times. Entering Maintenance mode. Contact Quest Support.

2011:en:Insufficient disk space. %s switched to read-only mode.

2012:en:Unable to detect %s type on Data Volume. Contact Quest Support.

2013:en:Unable to detect %s type on Namespace Volume. Contact Quest Support.

2014:en:%s scan discovered inconsistencies. Please check report and take action.

2059:en:Available space at %s scan report path reached threshold. Please cleanup old diagnostics to proceed the scan.

2016:en:Storage usage approaching system capacity. %s cleaner will be enabled outside of scheduled setting and performance impact may be observed.

2017:en:Replication re-sync cannot proceed as namespace depth reached maximum.

2018:en:%s has reached the maximum allowable File(s) and Directories limit, new file and directory creation will be denied, please cleanup %s.

2019:en:%s is reaching the maximum allowable File(s) and Directories limit, new file and directory creation will be denied after the limit is reached, please cleanup %s.

2020:en:Replication encountered unexpected error. Contact Quest support

2021:en:Datacheck detected potential inconsistency. Run %s scan with data verification check as soon as possible. ("maintenance --filesystem --start\_scan verify\_data")

2028:en:Datacheck detected potential namespace inconsistency. Run %s scan as soon as possible. ("maintenance --filesystem --start\_scan")

2036:en:Datacheck detected inconsistency in lsu image. Run %s scan as soon as possible. ("maintenance --filesystem --start\_scan verify\_rda\_metadata")

2037:en:Datacheck detected potential corrupt lsu info. Run %s scan as soon as possible. ("maintenance --filesystem --start\_scan verify\_rda\_metadata")

2023:en:%s name space partition has reached maximum allowable limits, please delete old unused file(s) or disable replication(s).

2024:en:%s name space partition is reaching maximum allowable limits, new replication resynch(s) will be stopped.

2025:en:One or more software package is incompatible, please upgrade the appliance to rectify the issue.

2026:en:%s volume has become in-active. Please call Quest Support, to fix the issue.

2027:en:%s Service response time exceeded max threshold.

2030:en:An OST container quota is exceeded. Check the event for container details.

2034:en:System has a huge backlog of book keeping work. %s cleaner will be enabled outside of schedule setting and performance impact will be observed.

2035:en:System clock has drifted more than 24 hours, from the last %s start, please check your clock settings and reboot.

2038:en:Replication is disconnected on one or more containers. Please check event log or replication stats for details.

2039:en:One or more replication target systems are running low in space. Please check event log or replication stats for details.

2040:en:%s scan completed with no inconsistencies. Switching back to operational mode.

2041:en:Replication detected potential inconsistency. Run filesystem scan with data verification check as soon as possible. ("maintenance --filesystem --start\_scan verify\_data")

2042:en:Seeding device became full, add new device to continue.

2043:en:Seeding cannot contact the target device. Check to make sure that the target device is available and write-enabled. Then remove and re-add the target device.

2044:en:Seeding process complete.

2045:en:System has reached space full condition, seeding will be stopped.

2046:en:Seeding failed to create Zero log entries, switch to maintenance mode to correct the issue.

2047:en:Found corrupted stream on seeding device. This error will be rectified during replication resync done on this seed data.

2048:en:Seeding device metadata info file missing, unable to import.

2049:en:Seeding device mount not accessible.

2050:en:Seeding export paused as the device contains data from another seeding job. Cleanup the device and re-add to continue seeding.

2051:en:Seeding encountered error.

2052:en:Unable to decrypt the Seeding data, please check that the "password" and "encryption type" matches the Seeding export job.

2053:en:System diagnostics partition is running low on space. Please copy out the old diagnostics bundles and delete for future auto diagnostics collection.

2054:en:Appliance available storage level is below the set threshold, please schedule %s cleaner or expire older backups.

2056:en:Appliance available storage level reached VTL threshold, unload all drives, expire old backups and schedule %s cleaner. Run "vtl --set\_rw ..." to set the containers IO mode back to Read-Write.

2055:en:Primary Keystore corruption detected. Run %s scan with data verification check

2057:en:%s cleaner took longer time in processing the phases.

2058:en:%s cleaner was not run to complete all phases since long time.

2060:en:One of the Fiber Channel ports is not online. Please run "fc --show --target" to check the status of each FC port.

2061:en:One or more storage groups are close to exhausting their storage quota limit. Please check the events for more details.

2062:en:One or more storage groups have exceeded their storage quota limit. Please check the events for more details.

2063:en:Insufficient disk space in Performance Tier. %s switched to read-only mode for Performance Tier containers.

2064:en:Performance Tier Storage usage approaching system capacity. %s cleaner will be enabled outside of scheduled setting and performance impact may be observed.

2065:en:Cloud Tier Storage usage is approaching capacity. %s cleaner will be enabled outside of scheduled setting and performance impact may be observed.

2066:en:Cloud Tier Storage usage reached full capacity. %s switching to read-only mode for Cloud Tier containers.

2067:en:Unable to Bind to standard NFS ports. Check and stop nfs server.

2068:en:Unable to Bind to standard NFS ports. Check and stop nfs server.

2069:en:One or more Cloud Tier(s) are marked offline as cloud is not reachable. Check details of each Cloud Tier. There might be failures in reading data in Cloud Tier.

2070:en:%s Disaster recovery requested. Switching to Disaster recovery.

2071:en:Object Direct Storage usage is approaching capacity. %s cleaner will be enabled outside of scheduled setting and performance impact may be observed.

2072:en:Object Direct Storage usage reached full capacity. %s switching to read-only mode for Object Direct containers.

2073:en:Object Direct marked offline as Cloud is not reachable. There might be failures in reading data in Object Direct.

2170780:en:%s disaster recovery triggered.

2074:en:Cloud Archive Tier marked offline as Cloud is not reachable. There might be failures in reading from Cloud Archive Tier.

2075:en:Archive Tier Storage usage is approaching capacity. %s cleaner will be enabled outside of scheduled setting and performance impact may be observed.

2076:en:Cloud Archive Tier Storage usage reached full capacity. %s switching to read-only mode for Cloud Archive Tier containers.

2077:en:Writing data to object storage failed, because object storage space reached its full capacity.

2078:en:Cloud Tier for %s is marked offline as Cloud Storage Service is not reachable. There might be failures in reading data from Cloud Tier.

2079:en:Cloud Archive Tier for %s is marked offline as Cloud Storage Service is not reachable. There might be failures in reading data from Cloud Archive Tier.

2080:en:Physical storage space reaching near full capacity.

2081:en:One of the dictionaries is full, Please check events for more details.

2082:en:Scan requested on a Storage group. Switching storage group to read-only access. See events for details.

2083:en:Filesystem checker did not complete on a storage group. Please check events for details and contact Quest Support.

2084:en:OS-audit is not running or stopped or not logging events

2085:en:Filesystem checker did not start on a storage group. Storage group is in read only mode. Please check events for details and contact Quest Support.

2086:en:Filesystem checker did not complete on a storage group. Please check events for details and contact Quest Support.

2087:en:Anomaly Detection service stopped. Please check events for details and contact Quest Support.

2088:en:OS Authentication stats collection is not working for Anomaly Detection. Please check events for details and contact Quest Support.

2089:en:Stats collection is not working for Anomaly Detection. Please check events for details and contact Quest Support.

2090:en:DB Authentication issue for stats collection. Please check events for details and contact Quest Support.

2091:en:One or more metadata objects could not be locked, or the lock could not be extended. Please check the events for more details.

## Appendix C

QoreStor systems that have had their dictionary size upgraded and relevant changes made to support this increase.

### Table 2. Remediation Actions taken

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| QoreStor Server | Actions taken | # Records | Shift Size | Current state | Notes | Cloud Compact Enabled? | Next steps |
| txos-vm-qstor2 | Increased dictionary to 21 bit Shift | 11 Billion | 20 🡪 21 | Complete | Had to restart choam service to get alerts reset. | No | None |
| txos-vm-qstor1 | Increased dictionary to 21 bit Shift | 10 Billion | 20 🡪 21 | Complete |  | No | None |
| gvi-qorestor | Cloud compaction was enabled | 15 Billion | 21 🡪 22 | Waiting for cloud cleaner to complete, dictionary will be ok then. | Cleaner needs to be scheduled to run for all 24 hours. |  | Monitor |
| mhc-qstor | Increased CPU count to 16 via customer.env file. |  | 22 | Cloud compaction is still on going. Cleaner schedule is fine. Cleanup going at 67MB/sec  That amounts to 80 days more. | Running 22 shift dictionary, already extended. Once the cloud cleaner completes, we will have a normal dictionary. | Enabled | Need to restart services. Need to upgrade to 7.4.1.173 |
| sma-qstor | Increased dictionary from 19 bit to 20 bit shift.  Extended RAM to 30GB. |  | 19 🡪 20 | Monitor | We will have to watch out for overflow, as it is still running smaller dictionary, but is sufficient for this box as of now. | No | Monitor |
| pros-qstor-maasvn01 | Extended dictionary with small page size than it has with a 21 shift dictionary, so that memory requirements would stay the same.   Metadata partition is extended to 1TB  Dictionary is expanded to 22 shift size. | 11 Billion | 19 🡪 20 🡪 22 | Complete | Dictionary is full. Alert is genuine. Dedupe savings are ok at 50%. Cloud cleaner is not done, but there are only 2000 files in laundry to be cleaned up, in a total of 30000 files on the system. So would not get much space back from running cleaner to end.  So, no immediate need to enable cloud compaction. System has 32 G RAM.  RAM extension is not needed. Metadata partition is only 470G. 22 shift extended dictionary would need around 385GB itself. So we must extend metadata partition. (Dictionary was already extended from 19 shift to 21 shift on this box earlier. Now on to 22 shift.) | No |  |
| quv-qstor | metadata partition is being extended to 1TB. extending dictionary to 22 shift. | 11 Billion | 21 🡪 22 | Incomplete – See Next steps | Same as ‘pros-qstor-maasvn01’ It has more than 40G of RAM No need for cloud compaction, but we lost some dedupe savings looks like. Cleaner is pending, but not much to prevent larger dictionary.  Cloud capacity is approaching license limits. | No | Needs upgrade to 7.4.1.173.  Monitor cloud usage license – Close to cloud limit. |
| gej-qstor | Extending it to 21 shift dictionary. | 6-7 Billion | 19 🡪 21 | Incomplete – See Next steps | Running 19 shift very small dictionary Lost dedupe savings. No negative savings. 21 shift dictionary is needed Cleaner is almost done.  No need to do cloud compact as of now, as dedupe savings % is still positive. Post Dedupe Bytes divided by avg (32k) chunk size asks for 6-7 billion records on this box, which is 21 shift dictionary, which can hold up to 11 Billion records. So going with 21 shift dictionary for now. | No | **needs upgrade to 7.4.1.173** |
| **npa-qstor** | Extending dictionary to 21 shift on the system. Increased RAM size from 24 to 30G. Metadata partition is extended to 1TB. Cloud compaction enabled 14th November |  | 19 🡪 21 | Completed | Running overflowed dictionary since June/24.  It is on very small 19 shift dictionary. Negative savings on cloud tier. Cleaner is completely done. [Negative dedupe savings + Cleaner is done] -> indicates the need for cloud compaction procedure on cloud tier.   Cloud compaction to be done later once all the dictionary extensions are done. | No | It has recovered from negative dedupe savings state to a cloud tier savings of about 11 %.  So we decided to let it continue and not enable expensive cloud compaction. |
| bnc-qstor | Extending RAM to 28 GB only - We went to 30 GB just to be uniform across. Metadata partition extended to 750GB. Extending it to only 20 shift dictionary, which is sufficient for now. |  | 19🡪20 | Completed | No cloud compaction is needed Using small 19 shift dictionary Dictionary is full Loss in dedupe savings. No negative savings. Cleaner is done 20 shift dictionary is sufficient for now. Have to watch out for dictionary alerts. This may require another extension to 21 or 22 shift dictionary soon. Extending it to only 20 shift dictionary, which is sufficient for now. |  | Monitor alerts for dictionary. |
| spm-qstor | extended dictionary from 19 shift to 21 shift which is enough for now, which can hold up to 6 billion records, to support 100+TB, post dedupe bytes. |  | 19 🡪 21 | Completed |  |  |  |
| ups-qstor | cleaner to run full time. |  |  | Completed | dictionary is full at present. But it will recover when cleaner is done.   Right now, we have negative savings on cloud tier. Once the cloud cleaner is done, we will re-evaluate if cloud compaction is needed. |  | Monitor for cloud savings |
| whg-qstor | extended dictionary from 19 shift to 21 shift which is enough for now, which can hold up to 6 billion records, to support 100+TB, post dedupe bytes. |  | 19 🡪 21 | Completed | dictionary is full at present. But it will recover when cleaner is done.   Right now, we have negative savings on cloud tier. Once the cloud cleaner is done, we will re-evaluate if cloud compaction is needed. |  | Monitor |







## Appendix D

### Connected QoreStor instances as of 4th November 2024.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ID** | **Host Name** | **System IP Addresses** | **QoreStor Version** | **Agent Status** | **Total Licensed capacity (TiB)** | **Used Licensed Capacity (TiB)** | **Physical Capacity (TiB)** | **Host OS** | **Kernel Version** |
| 6b5ff4fb-c2ce-4361-9f08-50085aa01541 | pros-qstor-maasvn01 | |10.253.32.22 | 7.3.0.165 | Connected | 200 | 16.46 | 25 | Oracle Linux Server release 8.7 | 4.18.0-425.19.2.el8\_7.x86\_64 |
| 843182b1-0c72-4342-aa81-34072681655c | prod-stor-maas01 | |10.253.32.21 | 7.3.0.165 | Connected | 20 | 4.56 | 6 | Oracle Linux Server release 8.7 | 4.18.0-425.19.2.el8\_7.x86\_64 |
| a8c5ffb0-1420-4aa6-9e84-f1d015a30db6 | bnc-qstor | |172.24.14.196|10.150.147.20 | 7.4.0.222 | Connected | 50 | 0.96 | 5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| c285a695-8d30-45da-b89f-fc6863bc37f7 | cgi-qstor | |172.24.14.197|10.150.145.20 | 7.4.0.222 | Connected | 20 | 0 | 1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| c292453b-2528-4cb1-a270-881098356ab4 | gva-qstor | |172.25.14.197|10.160.132.20 | 7.4.0.222 | Connected | 20 | 4.46 | 12 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 62781536-1dbc-411e-ae21-28c83b42e9da | mex-qstor | |172.24.14.198|10.150.144.20 | 7.4.0.222 | Connected | 20 | 0.26 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 2ec6113c-de44-41d6-8fe4-7ca859051b3d | hmh-qstore | |172.24.14.192|10.150.115.20 | 7.4.0.222 | Connected | 10 | 1.51 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5812a0f0-e415-4869-8f8b-8daa0d02f196 | sti-qstor | |172.24.14.188|10.150.129.20 | 7.4.0.222 | Connected | 20 | 0.11 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 243e0867-ec16-43fe-b7cc-8936d15bc871 | btc-qstor | |172.24.14.187|10.150.149.20 | 7.4.0.222 | Connected | 20 | 1.12 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 0b6efe25-cbac-43e4-831c-e22e8e318ab8 | hud-qstor | |172.25.14.195|10.160.135.20 | 7.4.0.222 | Connected | 20 | 0.93 | 3 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5276bea8-d00f-424b-ae46-fd0e30bff762 | dho-qstor | |172.25.14.194|10.160.134.20 | 7.4.0.222 | Connected | 10 | 1.73 | 4.6 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 81cb5fc1-b0c7-4a68-b519-643a6eb0a2f2 | whg-qstor | |172.25.14.193|10.160.136.20 | 7.4.0.222 | Connected | 20 | 1.89 | 6 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| f9d36b3c-04af-4579-aead-f230ba375cbc | OHOS-BIHMT-QSTOR | |10.150.148.30|172.24.32.223 | 7.1.3.144 | Connected | 300 | 155.12 | 300 |  |  |
| c6c551b0-b042-457f-8a4d-44aee7122fb6 | wch-v-app | |10.10.1.212 | 7.1.3.144 | Connected | 10 | 2.26 | 5 |  |  |
| caa75625-32a4-4e78-a5ae-5a046e11e370 | dae-qstor | |10.253.32.199 | 7.4.0.222 | Connected | 100 | 13.12 | 19.5 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| afc31555-e6d6-4e60-9033-223566d2d5ca | cfr-qstor | |172.25.14.192|10.160.137.20 | 7.4.0.222 | Connected | 100 | 3.14 | 5.97 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 252f9529-6abc-4cba-bdf5-ab765b09ee84 | mev-qstor | |172.24.32.92|10.150.121.20 | 7.4.1.169 | Connected | 150 | 8.44 | 16.5 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| e4d61c67-465d-45c4-9f72-d3186174b553 | ins-qstor | |172.25.14.191|10.160.113.20 | 7.4.0.222 | Connected | 100 | 0.08 | 6 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 4f02db07-f546-4c7c-b05c-1e680137d4ac | gvi-qstor | |172.24.14.181|10.150.101.20 | 7.4.1.169 | Connected | 100 | 7.29 | 11.8 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| 29c78528-06c9-456d-aa11-8c96697cce16 | oe-tay-qstor01 | |10.173.0.150 | 7.4.0.222 | Connected | 50 | 7.42 | 24 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| 5db7777b-83f1-4208-bb9e-1f041cab782e | ccp-qstor | |10.253.32.197 | 7.4.0.222 | Connected | 50 | 0.5 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| d61a5a2b-8291-4309-8603-d55ac564ec83 | deb-qstor | |172.24.14.141|10.150.105.20 | 7.4.0.222 | Connected | 50 | 3.45 | 7 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| aacccc62-d427-40e9-915e-197425dbbe57 | dcn-qstor | |172.25.14.130|10.160.105.20 | 7.4.0.222 | Connected | 50 | 2.84 | 5.5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 85858100-c360-45c9-bb04-03b2a4bdc180 | drm-qstor | |172.25.14.132|10.160.107.20 | 7.4.0.222 | Connected | 50 | 2.74 | 6.3 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 19ecd2ca-cb39-44f4-bf2a-e8b0cd57dde1 | dem-qstor | |172.25.14.131|10.160.106.20 | 7.4.0.222 | Connected | 50 | 0.43 | 3 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5543ce20-dca1-4af0-9722-c8902ab499ca | gej-qstor | |172.25.14.133|10.160.108.20 | 7.4.0.222 | Connected | 50 | 2.86 | 6 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 594826e6-24ca-46d4-9e71-8bc605c8e0a1 | glm-qstor | |172.25.14.134|10.160.110.20 | 7.4.0.222 | Connected | 50 | 0.1 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5ce3850d-6b9f-4cf4-bfda-7d7a58b09d27 | hpe-qstor | |172.25.14.135|10.160.111.20 | 7.4.0.222 | Connected | 50 | 2.24 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5ff39bc3-635f-440a-8670-b9e66f89b9a7 | hzh-qstor | |172.25.14.136|10.160.112.20 | 7.4.0.222 | Connected | 50 | 0.97 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5ceb5e8a-9b79-404e-8073-27cec16c7b8a | lan-qstor | |172.25.14.138|10.160.115.20 | 7.4.0.222 | Connected | 50 | 2.43 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| c7dfc5f6-f162-48ee-9130-1c0e41c9a3a4 | asem-qstor | |10.253.32.200 | 7.4.0.222 | Connected | 50 | 2.4 | 8 | Oracle Linux Server release 8.9 | 4.18.0-513.11.0.1.el8\_9.x86\_64 |
| 2bcc18d2-8464-4e33-9e29-4280969b2f51 | bih-qstor | |172.24.14.99|10.150.148.29 | 7.3.0.165 | Connected | 350 | 0.00002 | 24 | Oracle Linux Server release 8.7 | 4.18.0-425.19.2.el8\_7.x86\_64 |
| fae9ae78-82f7-4e4f-b02d-a9abfee07323 | mhjv-qstor | |172.25.14.139|10.160.116.20 | 7.4.0.222 | Connected | 50 | 0.81 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| a50c00b4-1621-4e15-9661-23d0ad4878e9 | kib-qstor | |172.25.14.137|10.160.114.20 | 7.4.0.222 | Connected | 50 | 2.39 | 5.5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 618bf3ce-aa36-45d2-8212-2f37fc3d03b7 | mrx-qstor | |172.25.14.140|10.160.129.20 | 7.4.0.222 | Connected | 50 | 0.06 | 1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| b9ddd3b9-948d-420e-baf7-bd3abcb02962 | mti-qstor | |172.25.14.142|10.160.118.20 | 7.4.0.222 | Connected | 50 | 0.41 | 3 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 47e9e162-f776-49da-856c-d80b3bb1d0f1 | nop-qstor | |172.25.14.144|10.160.119.20 | 7.4.0.222 | Connected | 50 | 2.66 | 5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 3e97a8bd-bcae-4be5-92d2-ab4d55af8eed | nox-qstor | |172.25.14.146|10.160.120.20 | 7.4.0.222 | Connected | 50 | 0.72 | 5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| af70ab79-bee9-4918-a208-b1a9706684e2 | npa-qstor | |172.25.14.149|10.160.121.20 | 7.4.0.222 | Connected | 50 | 1.35 | 5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| c876a08d-326f-411f-9e78-00305a0c9b0c | ucl-qstor | |172.25.14.152|10.160.128.20 | 7.4.0.222 | Connected | 50 | 0.09 | 1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 2fff33bc-61c2-41fb-95f5-ebf0bb4ac74d | cpm-qstor | |172.24.14.124|10.150.104.20 | 7.4.0.222 | Connected | 50 | 0.96 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 4dcf2b18-bca9-4c93-a9ed-6b3dd256667e | fcm-qstor | |172.24.14.142|10.150.106.20 | 7.4.0.222 | Connected | 50 | 2.29 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| af7db36a-bac5-401d-8942-2793c77bc634 | ccb-qstor | |172.24.14.123|10.150.113.20 | 7.4.0.222 | Connected | 50 | 0.78 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 38bd5ab2-62ef-4ee6-b9ee-dad8819ef509 | cbr-qstor | |172.24.14.122|10.150.137.21 | 7.4.0.222 | Connected | 50 | 0.43 | 5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 3545b3fc-be58-4d7a-89cd-065b5ef035dd | clv-qstor | |172.24.14.121|10.150.103.20 | 7.4.0.222 | Connected | 100 | 0.84 | 3 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 65057e67-00dc-4c69-afa0-3ba328bef79f | ghs-qstor | |172.24.14.143|10.150.107.20 | 7.4.0.222 | Connected | 50 | 4.38 | 7.6 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 35e87322-cab6-418d-9466-113299b8fc84 | gri-qstor | |172.24.14.145|10.150.109.20 | 7.4.0.222 | Connected | 50 | 3.38 | 7 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5857761c-e0c7-4f3a-bd8f-acd50f49baa2 | han-qstor | |172.24.14.147|10.150.141.20 | 7.4.0.222 | Connected | 100 | 6.93 | 17.8 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 997e4e1b-a92f-427d-a314-3ec59bef377f | hou-qstor | |172.24.14.148|10.150.116.20 | 7.4.0.222 | Connected | 50 | 0.27 | 1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| a79e91e7-e103-41c1-a760-2ddc756b75a1 | lep-qstor | |172.24.14.202|10.150.134.20 | 7.4.0.222 | Connected | 50 | 4.24 | 7 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 8853ed0b-57f1-449a-841f-cb23022f2390 | jcb-qstor | |172.24.14.149|10.150.117.20 | 7.4.0.222 | Connected | 50 | 0.67 | 1.2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 3115c84a-3535-405f-8f3f-1c43672e26bc | mhc-qstor | |172.24.14.206|10.150.122.20 | 7.4.1.169 | Connected | 100 | 4.35 | 12.5 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| 49b0c470-a6b2-47ef-b023-96722d2c0a52 | maj-qstor | |172.24.14.204|10.150.136.20 | 7.4.1.169 | Connected | 50 | 7.33 | 10.5 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| 3073debe-15b8-454e-879e-f177c172c952 | me-qstor | |172.24.14.205|10.150.138.20 | 7.4.0.222 | Connected | 50 | 0.04 | 1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 3d9d358d-792f-4e3b-ad8b-13f024de9628 | vph-qstor | |172.25.14.92|10.160.126.20 | 7.4.0.222 | Connected | 50 | 3.09 | 6.5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| e2cb977c-9485-4888-b59f-5afdaa7a602c | ggh-qstor | |172.25.14.129|10.160.133.20 | 7.4.0.222 | Connected | 50 | 0.84 | 3 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 8c50be7a-d9a4-4663-aac7-caf9b37a37a4 | sge-qstor | |172.25.14.126|10.160.125.20 | 7.4.0.222 | Connected | 50 | 1.11 | 4 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| bf1c8750-8a42-4bd2-80b3-42882add61a5 | arv-qstor | |172.25.14.128|10.160.101.20 | 7.4.0.222 | Connected | 50 | 0.55 | 2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 5525cab3-f942-46c5-9327-6817f9e99821 | ax-qstor | |172.25.14.127|172.25.32.159 | 7.4.0.222 | Connected | 50 | 0.13 | 1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| cdb6c5e8-8726-479b-83fe-e37d5e31203e | m003-qstor | |10.2.10.28 | 7.4.0.222 | Connected | 100 | 14.75 | 19.2 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| a3d7ba2a-0a5c-4cdd-8f50-4c0c0728ca79 | ups-qstor | |172.24.14.218|10.150.131.20 | 7.4.0.222 | Connected | 100 | 3.15 | 6.5 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 2ceb8a32-8681-4423-8f5f-c73bf0174a85 | oe-riu-qstor | |10.173.4.242 | 7.4.1.169 | Connected | 50 | 6.39 | 7.42 | Oracle Linux Server release 8.9 | 4.18.0-513.18.0.2.el8\_9.x86\_64 |
| 3eda17f9-f619-44a2-b9d9-7ff55e49c7fa | txos-vm-qstor01 | |172.25.32.178 | 7.4.0.222 | Connected | 50 | 6.89 | 20.1 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| c6d0ae34-e48e-4db8-aee5-554655207878 | txos-vm-qstor02 | |172.25.32.179 | 7.4.0.222 | Connected | 50 | 11.73 | 19.79 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| fad9ab8e-4d20-4724-918f-40dbe1b8ec6f | m001-qstor | |172.24.14.119|10.150.155.20 | 7.4.0.222 | Connected | 100 | 9.82 | 12 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 0b046892-a94f-4a6e-8158-987a089e4bab | OHOS-PROD6-QSTOR | |172.24.33.23|10.150.250.15 | 7.4.0.222 | Connected | 100 | 5.53 | 8.1 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 789f4e67-aefa-432b-aaa5-d3bb08346e94 | OHOS-PROD4-QSTOR | |172.24.33.24|10.150.250.16 | 7.4.0.222 | Connected | 100 | 0.16 | 9.6 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| d524e3c6-1400-4d34-87bf-18b70af16b1f | OHOS-UCS02P2-QSTOR | |172.24.33.25|10.150.250.17 | 7.4.0.222 | Connected | 100 | 3.11 | 9 | Oracle Linux Server release 8.10 | 4.18.0-553.5.1.el8\_10.x86\_64 |
| 244be35c-caa5-4098-8a54-49d359b08e9d | OHOS-UCS02P3-QSTOR | |172.24.33.26|10.150.250.18 | 7.4.0.222 | Connected | 100 | 7.27 | 10.2 | Oracle Linux Server release 8.10 | 4.18.0-553.el8\_10.x86\_64 |
| ec5384da-8c82-4c5a-82b4-0c76350e38bb | OE-NTM-QSTOR01 | |10.173.14.24 | 7.4.0.222 | Connected | 50 | 3.04 | 5 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |
| a3866a90-7708-425c-becb-39fc1729e962 | clf-qstor | |172.24.14.118|10.150.156.20 | 7.4.0.222 | Connected | 50 | 0.04 | 1 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 213620d1-4170-4bdb-a494-0dae5b67ef74 | OHOS-ESXI-QSTOR02 | |172.24.33.61 | 7.4.1.169 | Connected | 100 | 2.36 | 9.9 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 1690cea5-33cb-452d-bdb8-9796b8438fd9 | oe-edec-qstor01 | |10.173.9.21 | 7.4.0.222 | Connected | 50 | 0 | 1.8 | Oracle Linux Server release 9.3 | 5.14.0-362.24.1.el9\_3.x86\_64 |
| e9b3ba91-0c85-4eed-b450-8b2dd1d2cb3a | OHOS-ESXIM3C2-QSTOR02 | |172.24.33.63 | 7.4.1.169 | Connected | 50 | 7.25 | 12.3 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 9927ff2a-4bc3-4654-ada5-6397fbb0fbcc | OHOS-ESXiM3-QSTOR02 | |172.24.33.62 | 7.4.0.222 | Connected | 50 | 0.49 | 11.1 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 21c74ef2-ef1f-4226-966b-930e1001f905 | OHOS-PROD5-QSTOR02 | |172.24.33.65 | 7.4.0.222 | Connected | 100 | 2.34 | 5.1 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 53b8dd24-875c-4b03-98ed-7a7a4bb4d8e2 | OHOS-UCS02P1-QSTOR02 | |172.24.33.67 | 7.4.0.222 | Connected | 50 | 2.95 | 9.9 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| cb1e3528-79c4-48b7-a50d-12ce2fd8dbc1 | HOB-QSTOR01 | |10.253.32.45 | 7.4.0.222 | Connected | 200 | 3.98 | 6.2 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 8ba80792-5a5f-43e6-b117-6fda459761ed | PROS-VM-QSTOR01 | |10.253.32.24 | 7.4.0.222 | Connected | 100 | 3.66 | 8.1 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 0105320c-a110-4460-bd06-da2585b3b325 | txos-vm-qstor03 | |172.25.32.180 | 7.4.0.222 | Connected | 100 | 5.9 | 9 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 49a4fc56-c5c2-45de-8f7b-d4658e7b81b1 | oe-ruc-qstor01 | |10.173.18.22 | 7.4.0.222 | Connected | 50 | 1.4 | 4 | Oracle Linux Server release 9.2 | 5.14.0-284.30.1.el9\_2.x86\_64 |
| 29f6b1b5-536a-4e1b-8092-bcb2b3d28444 | mwp-qstor | |172.24.14.112|10.150.162.20 | 7.4.1.169 | Connected | 50 | 1.72 | 2 | Oracle Linux Server release 9.4 | 5.14.0-427.18.1.el9\_4.x86\_64 |
| fdf6266c-482d-4f90-9ef8-add0c7d97e7b | wik-stor | |172.25.14.97|10.160.127.20 | 7.4.1.169 | Connected | 100 | 7.8 | 15.5 | Oracle Linux Server release 8.9 | 4.18.0-513.24.1.el8\_9.x86\_64 |

## Glossary:

* OFSCK – Ocarina File System Check. This scans and checks the validity of the deduplication file system.
* Storage Group – logical space where target data containers are created to hold data.
* Refcounts – the number of references held against a chunk of data that is used across multiple deduplicated data sets.
* ocafsd – Ocarina file system daemon

#### Shift [number] (19,20,21,22)

* + To store **15 billion records** using a **21-bit shift approach**, you'll need to understand how data can be efficiently distributed and organized using bit-shifting for indexing. Here's how it could work:
    - **1. 21-bit Addressing Overview**
      * A **21-bit index** can uniquely address 221=2,097,152 different slots or buckets.
      * To handle **15 billion records**, you need a strategy to distribute these records across multiple buckets, partitions, or slots.
    - **2. Approach to Storage using 21-bit Shifts**
      * **Partitioning the Data**:
      * Divide your **15 billion records** into **multiple groups (or partitions)**, each of which can be addressed using the 21-bit index space.
      * For example, if you have 15 billion records and a 21-bit index can address around **2 million slots**, you'll need **approximately 7,200 partitions** since 15,000,000,000/2,097,152≈7200
      * **Indexing within Partitions**:
      * Use a **21-bit shift** for indexing **within each partition**. This means each partition can have up to 221 records.
      * A record is then uniquely addressed by its partition number and its index within that partition.
    - **3. Practical Storage Strategy**
      * **Hashing Technique**:
      * Use a **hashing function** that maps each record to a specific partition and assigns it an index within that partition using 21 bits. The combination of the partition number and the 21-bit index forms the complete address of a record.
      * Example: For a record R, you could compute partition\_number = hash(R) % 7200 and index = hash(R) >> log2(7200), using the lower bits for partitioning and higher bits for the index.
    - **Efficient Data Structures**:
      * Consider using data structures such as **hash tables, B-trees, or distributed storage systems** like **distributed hash tables (DHTs)** to implement this large-scale storage.
      * Systems like **NoSQL databases** or **distributed databases (e.g., Apache Cassandra, DynamoDB)** can efficiently handle such large-scale, partitioned data using similar approaches.
  + **Summary**
    - The key to storing 15 billion records using a 21-bit shift is to **divide and distribute** the data across **multiple partitions**, each of which is indexed using 21 bits. This approach leverages **partitioning, hashing, and indexing** to efficiently manage and access such a massive number of records.