STORAGE QUOTA MANAGEMENT AND PROVISIONING WITH DELL EMC POWERSCALE SMARTQUOTAS

Abstract

Most file systems are a thin layer of organization on top of a block device and cannot efficiently address data at large scale. This paper focuses on OneFS, a modern file system that meets the unique needs of big data. OneFS includes SmartQuotas, a native data management capability, which enables enterprises to reduce storage costs with a simple to use, highly scalable and flexible storage quota and provisioning application for scale-out storage environments.

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Executive Summary

Unstructured data continues to grow at an astonishing rate making the need for optimized file-based data storage and its simplified and automated management more crucial than ever.

To help enterprises maximize the long-term value of their critical business data and drive down storage management cost and complexity, Dell EMC PowerScale offers SmartQuotas: A simple, scalable and flexible quota management and provisioning software application that integrates seamlessly with the OneFS operating system.

Intended Audience

This paper presents best practices for deploying and managing storage quotas in a Dell EMC PowerScale cluster. It also offers configuration and tuning recommendations to help achieve optimal performance for different workloads. This paper does not intend to provide a comprehensive background to the OneFS architecture.

Please refer to the OneFS Technical Overview white paper for further details on the OneFS architecture.

The target audience for this white paper is anyone configuring and managing storage quotas in a OneFS powered clustered storage environment. It is assumed that the reader has an understanding and working knowledge of the OneFS components, architecture, commands and features.

More information on OneFS commands and feature configuration is available in the OneFS Administration Guide.

Overview

Dell EMC PowerScale SmartQuotas enables administrators to understand, predict, control and limit storage usage across their organization and provision a cluster to best meet their storage needs.

Figure 1: SmartQuotas User Quotas
SmartQuotas also facilitates ‘thin provisioning’, or the ability to present more storage capacity to applications and users than is physically present (over-provisioning). This allows customers to buy and provision storage as they grow rather than having to make large, speculative purchasing decisions ahead of time.

In this paper, we’ll explore how SmartQuotas can be configured by organizations to establish storage usage quotas and how these can be enforced. The document also illustrates the reporting and notification options available to simplify the management of scale-out NAS storage environments and data lakes.

**Architecture**

From the file system point of view, there are three main elements to SmartQuotas:

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>Define which files and directories belong to a quota.</td>
</tr>
<tr>
<td>Resource</td>
<td>The quantity being limited.</td>
</tr>
<tr>
<td>Enforcement</td>
<td>Specify the limits and what actions are taken when those thresholds are exceeded.</td>
</tr>
</tbody>
</table>

Each Quota Domain includes a set of usage levels, limits and configuration options. Most of this information is organized and managed by the file system and stored in the Quota Database. This database is represented in a B-tree structure, known as the Quota Tree, and provides both scalability and fast random access. Because of its importance, the Quota Database is protected at highest level for metadata in OneFS. The Quota Accounting Blocks (QABs) within individual records are protected at the same level as the associated directory.
A Quota Domain is made up of the following principle parts:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quota domain key</td>
<td>Where the unique identifier for the domain is stored.</td>
</tr>
<tr>
<td>Quota domain header (QDH)</td>
<td>Contains various state and configuration information that affects the domain as a whole.</td>
</tr>
<tr>
<td>Quota domain enforcements</td>
<td>Manages quota limits, including whether they have been hit or exceeded, notification information, and the quota grace period.</td>
</tr>
<tr>
<td>Quota domain account (QDA)</td>
<td>Handles tracking of usage levels for the domain. The QDA tracks physical, logical and file resource types for each domain.</td>
</tr>
</tbody>
</table>

**Quota Database**

The QDB is a data structure that stores Quota Domain Record (QDR). Resource allocation and governance changes are recorded in the quota operation associated with a transaction, totaled and applied persistently to the QDRs.

**Quota Domain Record**

The Quota Domain Record stores all configuration and state associated with a domain. The record can be broken down into three components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>Fields within quota config, such as whether the domain is a container. Despite the name, this includes some state fields like the Ready flag.</td>
</tr>
<tr>
<td>Enforcements</td>
<td>A list of quota enforcements, which include the limit, grace period, and notification state. Although the structure is flexible, only three enforcements are allowed and only for a single resource.</td>
</tr>
<tr>
<td>Account</td>
<td>The quota account for the domain.</td>
</tr>
</tbody>
</table>

The on-disk format of the QDR is shown in the following diagram. The structure is dynamic, based on the configured enforcements and state of the account, so the on-disk structures look much different than the in-memory structures. The main components are further described in subsequent sections.
Quota Domain Locks

Quota domain locks synchronize access to quota domain records in the QDB.

The main challenge for quota domain locks is that the need to lock quota domains exclusively is not known until the accounting is fully determined. In fact, it may not be until responses from transaction deltas are received before this is reported to the initiator. To address this, Quota Domain Locks use optimistic restarts.

Constituents and Quota Account Blocks

Quota Account Blocks (QABs) enable high-performance accounting using transaction deltas. Since when the quota usage info if viewed it is stale anyway, locking is simplified by using an exclusive domain lock for coherent reads of usage.

Quota accounts also have a mechanism to avoid hot spots on the nodes storing QABs. It is quite easy to imagine all nodes in a cluster producing accounting changes in the same domain, for example when an ALL domain is configured on a top-level directory. This problem is solved using Quota Account Constituents, which parallelize the accounting to include additional QABs. This is covered in more detail within the performance tuning section, towards the end of this paper.

Quota Types

SmartQuotas comprises two types of capacity quota:

- Accounting Quotas
- Enforcement Quotas

Accounting Quotas simply monitor and report on the amount of storage consumed, but do not take any limiting action or intervention. Instead, they are primarily used for auditing, planning, or billing purposes. For example, SmartQuotas accounting quotas can be used to:

- Generate reports to analyze and identify storage usage patterns and trends. These can then be used to define storage policies for the business, etc.
- Track the amount of disk space used by various users, groups, or departments to bill each entity for only the storage capacity they actually consume (charge-back).
- Intelligently plan for capacity expansions and future storage need.

Enforcement Quotas on the other hand include all of the functionality of the accounting option plus the ability to limit disk storage and send notifications. Using enforcement limits, you can logically partition a cluster to control or restrict how much storage that a user,
group, or directory can use. For example, you can set capacity limits to ensure that adequate space is always available for key projects and critical applications and to ensure that users of the cluster do not exceed their allotted storage capacity.

Optionally, real-time email quota notifications can be sent to users, group managers, or administrators when they are approaching or have exceeded a quota limit.

A SmartQuota can have one of four enforcement types:

<table>
<thead>
<tr>
<th>Enforcement Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>A limit that cannot be exceeded. If an operation such as a file write causes a quota target to exceed a hard quota, the operation fails, an alert is logged to the cluster and a notification is sent to any specified recipients. Writes resume when the usage falls below the threshold.</td>
</tr>
<tr>
<td>Soft</td>
<td>A limit that can be exceeded until a grace period has expired. When a soft quota is exceeded, an alert is logged to the cluster and a notification is issued to any specified recipients. However, data writes are permitted during the grace period. If the soft threshold is still exceeded when the period expires, writes will be blocked, and a hard-limit notification issued to any specified recipients.</td>
</tr>
<tr>
<td>Advisory</td>
<td>An informal limit that can be exceeded. When an advisory quota threshold is exceeded, an alert is logged to the cluster and a notification is issued to any specified recipients. Reaching an advisory quota threshold does not prevent data writes.</td>
</tr>
<tr>
<td>None</td>
<td>No enforcement. Quota is accounting only.</td>
</tr>
</tbody>
</table>

All three quota types have both a limit, or threshold, and a grace period. In OneFS 8.2 and later, a soft quota and advisory quota threshold can be specified as a percentage, as well as a specific capacity. For example:

```
# isi quota quotas create /ifs/quota directory --percent-advisory-threshold=80 --percent-soft-threshold=90 --soft-grace=1d --hard-threshold=100G
```

A hard quota has a zero-time grace period, an advisory quota has an infinite grace period and a soft quota has a configurable grace period. When a quota limit and grace period have been exceeded, a client write operations to anywhere within that quota domain will fail with EDQUOT. Although enforcements are implemented generically in the quota data bases, only one resource may be limited per domain, either logical or physical space.

Even when a hard quota limit is reached, there are certain instances where operations are not blocked. These include administrative control via root (UID 0), system maintenance activities and the ability of a blocked user to free up space.

The table below describes the three SmartQuotas enforcement states:

<table>
<thead>
<tr>
<th>Enforcement State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under (U)</td>
<td>If the usage is less than the enforcement threshold, the enforcement is in state U.</td>
</tr>
<tr>
<td>Over (O)</td>
<td>If the usage is greater than the enforcement threshold, the enforcement is in state O.</td>
</tr>
<tr>
<td>Expired (E)</td>
<td>If the usage is greater than the soft threshold, and the usage has remained over the enforcement threshold past the grace period expiration, the soft threshold is in state E. If an administrator modifies the soft threshold but not the grace period and the usage still exceeds the threshold, the enforcement is in state E.</td>
</tr>
</tbody>
</table>

There are a few exceptions to enforcement of Quotas including the following scenarios:
• If a domain has an accounting only quota, enforcements for the domain are not applied.

• Any administrator action may push a domain over quota. Examples include changing protection, taking a snapshot, removing a snapshot, etc. The administrator may write into any domain without obeying enforcements.

• Any system action may push a domain over quota, including repair etc. OneFS maintenance processes are as powerful as the administrator.

Governance is the mechanism by which SmartQuotas determines which domains apply to a given file or directory. After a sequence of domain configuration changes, a persistent record is needed in order to know where a file had been accounted. As such, quotas use tagging and the governing domains are recorded in a dynamic attribute of the inode.

A Quota Domain Account tracks usages and limits of a particular domain. For scalability reasons, the QDA system dynamically breaks up the Quota Domain’s account of the quota into some number of Quota Domain Account Constituents (QAC), each of which tracks a part of the account. Modifications to the account are distributed at random among these constituents. Each Quota Domain Account Constituent is stored in a set of mirrored Quota Accounting Blocks (QAB). QABs track usage of a quota and comprise several level counters for different tracked resource types and level limits for advisory, soft, and hard quotas.

The Quota Domain Record stores all configuration and state associated with a domain. The record can be subdivided into three components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>Quota configuration.</td>
</tr>
<tr>
<td>Enforcement</td>
<td>This includes the grace period, limit, and notification state.</td>
</tr>
<tr>
<td>Account</td>
<td>The mechanism for space utilization accounting.</td>
</tr>
</tbody>
</table>

With SmartQuotas, there are three main ways of tracking, enforcing, and reporting resource usage:

<table>
<thead>
<tr>
<th>Tracking Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical size</td>
<td>This is simple to track, since it includes all the data and metadata resources used, including the data-protection overhead. The quota system is also able to track the difference before and after the operation.</td>
</tr>
<tr>
<td>File system logical size</td>
<td>This is slightly more complex to calculate and track but provides the user with a more comprehensible means of understanding their usage.</td>
</tr>
<tr>
<td>File accounting</td>
<td>This is the most straightforward, since whenever a file is added to a domain, the file count is incremented.</td>
</tr>
<tr>
<td>Application logical size</td>
<td>Reports total logical data store across different tiers, including CloudPools, to account for the exact file sizes. Allows users to view quotas and free space as an application would view it, in terms of how much capacity is available to store logical data, regardless of data reduction or tiering technology.</td>
</tr>
</tbody>
</table>
Prior to OneFS 8.2, SmartQuota size accounting metrics typically used a count of the number of 8KB blocks required to store file data on cluster. Accounting based on block count can result in challenges, such as small file over-reporting. For example, a 4KB file would be logically accounted for as 8KB. Similarly, block-based quota accounting only extends to on-premise capacity consumption. This means that a 100MB file stored within a CloudPools tier would only be account for as an 8KB SmartLink stub file, rather than its actual size.

To directly address this issue in OneFS 8.2 and later, application logical quotas provide a new quota accounting metric. Application logical size accounts for, reports and enforces on the actual space consumed and available for storage, independent of whether files are cloud-tiered, sparse, deduplicated, compressed, etc. Application logical quotas can be easily configured from the CLI with the following syntax:

```
# isi quota quotas create <dir> directory --thresholds-on=applogicalsize
```

Legacy quotas created on earlier OneFS versions can easily be converted to use application logical size after upgrading to OneFS 8.2.

For logical space accounting, some inode attributes such as ACLs and symbolic links are included in the resource count. This uses the same data that is displayed in the 'logical size' field by the `isi get -DD <file>` CLI command.

### QuotaScan Job

The QuotaScan job updates quota accounting for domains created on an existing directory path. Although it is typically run without any intervention, the administrator has the option of manually control if necessary or desirable. By default, QuotaScan runs with a 'low' impact policy and a low priority value of '6'.

If quotas are created on empty directories, governance will instantaneously propagate from parent to child incrementally. If the directory is not empty, the QuotaScan job is used to update the governance.

A domain created on a non-empty directory will not be marked as ready. This triggers a QuotaScan job to be started. QuotaScan is executed by the OneFS job engine and is subject to the general scheduling and prioritization of jobs. The QuotaScan performs a treewalk to traverse the directory tree under the domain root.

The QuotaScan job is the cluster maintenance process responsible for scanning the cluster to performing accounting activities to bring the desired governance to each inode. In essence, the job is a distributed tree walk that is performed based on the state of the domain.

Further information regarding the job engine is available in the OneFS Job Engine white paper.

### Quota Domains

Under the hood, SmartQuotas is based on the concept of domains - the linchpins of quota accounting. Since OneFS is a single file system, it relies on domains for defining the scope of a quota in place of the typical volume boundaries found in most storage systems. As such, a domain defines which files belong to a quota, accounts for each resource type in that set and defines the top-level directory configuration point.

For SmartQuotas, the three main resource types are:

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directory</td>
<td>A specific directory and all its subdirectories</td>
</tr>
<tr>
<td>User</td>
<td>A specific user</td>
</tr>
<tr>
<td>Group</td>
<td>All members of a specific group</td>
</tr>
</tbody>
</table>

A domain defined as “name@folder” would be the set of files under “folder”, owned by “name”, which could be either a user or a group. The files accounted include all files reachable from the given path, without traversing any soft links. The owner “name” can be ALL, and “/ifs”, the OneFS root directory, is also an effective ALL for “folder”.

With SmartQuotas it’s easy to create traditional domain types quickly by using “ALL”. The following are examples of domain types:
- All files belonging to user Jane: user:Jane@/ifs
- All files under /ifs/home, belonging to any user: ALL@/ifs/home.
- All files under /ifs/home that belong to user Jane: user:Jane@/ifs/home

Domains cannot be created on anything but directories. More specifically, domains are associated with the actual directories themselves, not directory paths. For example, if the domain is ALL@/ifs/home/data, but /ifs/home/data gets renamed to /ifs/home/files, the domain stays with the directory.

Domains can also be nested and may overlap. For example, say a hard quota is set on /ifs/data/marketing for 5TB. 1TB soft quotas are then placed on individual users in the marketing department. This ensures that the marketing directory as a whole never exceeds 5TB, while limiting the users in the marketing department to 1TB each.

**Default Quota Domains**

A default quota domain is one that does not account for any specific set of files but instead specifies a policy for new domains that match a specific trigger. In other words, default domains are configuration templates for actual domains. SmartQuotas use the identity notation ‘default-user’, ‘default-group’, and ‘default directory’ to describe domains with default policies. For example, the domain default-user@/ifs/home becomes specific-user@/ifs/home for each specific-user that is not otherwise defined. All enforcements on default-user are copied to specific-user when specific-user allocates within the domain and the new inherited domain quota is termed as a Linked Quota. There may be overlapping defaults (i.e. default-user@/ifs and default-user@/ifs/home may both be defined).

Default quota domains help drastically simplify quota management for large environments by providing a mechanism to define top level template configurations from which many actual quotas are cloned, or linked. When a default quota domain is configured on a directory, any subdirectories created directly underneath this will automatically inherit the quota limits specified in the parent domain. This streamlines the provisioning and management quotas for large enterprise environments. Furthermore, default directory quotas can co-exist with user and/or group quotas and legacy default quotas.

![Figure 5: Default Quota Domains](image)

**Default directory quotas are available in OneFS 8.2 and later, in addition to the default user and group quotas available in earlier releases.**

If the enforcements on a default domain change, SmartQuotas will automatically propagate the changes to the Linked Quota domains. If a default quota domain is deleted, SmartQuotas will delete all children marked as inherited. An administrator may also choose to delete the default without deleting the children, but this will break inheritance on all inherited children.

A domain may be in one of three accounting states as described in the following table:

<table>
<thead>
<tr>
<th>Quota Accounting States</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ready</td>
<td>A domain in the ready state is fully accounted. SmartQuotas displays “ready” domains in all interfaces and all enforcements apply to such domains.</td>
</tr>
<tr>
<td>Accounting</td>
<td>A domain is placed in the Accounting state when it’s waiting on accounting updates.</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Deleting</td>
<td>After a request to delete a domain, SmartQuotas will place the domain in the deleting state until tear-down is complete. Domain removal may be a lengthy process.</td>
</tr>
</tbody>
</table>

**Figure 6: Quota Accounting States**

SmartQuotas displays accounting domains in all interfaces including usage data but indicate they are in the process of being “Accounted”. SmartQuotas applies all enforcements to accounting domains, even when it might reject an allocation that would have proceeded if it had completed the QuotaScan.

Domains in the deleting state are hidden from all interfaces and the top-level directory of a domain may be deleted while the domain is still in the deleting state (assuming there are no domains in “Ready” or “Accounting” state defined on the directory). No enforcements are applied for domains in “Deleting” state.

A quota scan is performed when the domain is in an Accounting State. This can occur during quota creation to account the new domain if a quota has been set for the domain and quota deletion to un-account the domain. A QuotaScan is required when creating a quota on a non-empty directory. If quotas are created up-front on an empty directory, no QuotaScan is necessary.

In addition, a QuotaScan job may be started from the WebUI or command line interface using the “isi job” command. Any path specified on the command line is treated as the root of a tree that should be processed. This is provided primarily as a means to re-scan a directory or maintenance reasons.

**Quota Daemons**

There are main three processes or daemons associated with SmartQuotas:

- **isi_quota_notify_d**
- **isi_quota_sweeper_d**
- **isi_quota_report_d**

The job of the notification daemon, isi_quota_notify_d, is to listen for ‘limit exceeded’ and ‘link denied’ events and generate notifications for each. It also responds to configuration change events and instructs the QDB to generate ‘expired’ and ‘violated’ over-threshold notifications.

A quota sweeper daemon, isi_quota_sweeper_d, is responsible for a number of quota housekeeping tasks such as propagating default changes, domain and notification rule garbage collection and kicking off QuotaScan jobs when necessary.

Finally, the reporting daemon, isi_quota_report_d, is responsible for generating quota reports. Since the QDB only produces real-time resource usage, reports are necessary for providing point-in-time vies of a quota domain’s usage. These historical reports are useful for trend analysis of quota resource usage.

OneFS 8.2 and later also include the rpc.quotad service to facilitate client-side quota reporting on UNIX and Linux clients via native ‘quota’ tools. The service which runs on tcp/udp port 762 is enabled by default, and control is under NFS global settings.

Additionally, in OneFS 8.2 and later, users can view their available user capacity set by soft and/or hard user and group quotas rather than the entire cluster capacity or parent directory-quotas. This avoids the ‘illusion’ of seeing available space that may not be associated with their quotas.

**SmartQuotas Licensing**

SmartQuotas is included as a core component of OneFS but requires a valid product license key in order to activate. This license key can be purchased through your Dell EMC account team. An unlicensed cluster will show a SmartQuotas warning until a valid product license has been purchased and applied to the cluster.

License keys can be easily added via the ‘Activate License’ section of the OneFS WebUI, accessed by navigating via Cluster Management > Licensing.
Quota Notifications

A crucial part of the quota system is to provide user notifications regarding enforcement violations, both when a violation event occurs and while violation state persists on a scheduled basis. An enforcement quota may have several notification rules associated with it. Each notification rule specifies a condition and an action to be executed when the condition is met. Notification rules are considered part of enforcements. Clearing an enforcement also clears any notification rules associated with it.

Enforcement quotas support the notification settings, with the following types being available:

<table>
<thead>
<tr>
<th>Quota Notification Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global default</td>
<td>Uses the global default notification for the specified type of quota.</td>
</tr>
<tr>
<td>Custom – basic</td>
<td>Enables creation of basic custom notifications that apply to a specific quota. Can be configured for any or all of the threshold types (hard, soft, or advisory) for the specified quota.</td>
</tr>
<tr>
<td>Custom - advanced</td>
<td>Enables creation of advanced, custom notifications that apply to a specific quota. Can be configured for any or all of the threshold types (hard, soft, or advisory) for the specified quota.</td>
</tr>
<tr>
<td>None</td>
<td>Disables all notifications for the quota.</td>
</tr>
</tbody>
</table>

Prior to OneFS 8.2, a quota can only have a single notification setting.

A quota notification condition is an event which may trigger an action defined by a notification rule. These notification rules may specify a schedule (e.g. "every day at 5:00 AM") for executing an action or immediate notification of a certain condition. Examples of notification conditions include:

- Turn Off Notifications for this Quota: Disable all notifications for this quota.
- Use Default Notification Rules: Use the default notification rules for the specified limit type. Default notifications can be configured from the Settings tab.
- Use Custom Notification Rules: Use custom notifications that apply to only this quota.

Figure 7: Quota Notification Setting

![Quota Notification Setting](image)
• Notify when a threshold is exceeded; at most, once every 5 minutes
• Notify when allocation is denied; at most, once an hour
• Notify while over threshold, daily at 2 AM
• Notify while grace period expired weekly, on Sundays at 2 AM

Notifications are triggered for events grouped by the following two categories:

• **Instant notifications**: Includes the write-denied notification triggered when a hard threshold denies a write and the threshold-exceeded notification, triggered at the moment a hard, soft, or advisory threshold is exceeded. These are one-time notifications because they represent a discrete event in time.

• **Ongoing notifications**: Generated on a scheduled basis to indicate a persisting condition, such as a hard, soft, or advisory threshold being over a limit or a soft threshold's grace period being expired for a prolonged period.

### Notification Actions

Each notification rule can execute either one or none of the following notification actions.

<table>
<thead>
<tr>
<th>Quota Notification Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert</td>
<td>Sends an alert for one of the quota actions, detailed below.</td>
</tr>
<tr>
<td>Email Manual Address</td>
<td>Sends email to a specific address, or multiple addresses (OneFS 8.2 and later).</td>
</tr>
<tr>
<td>Email Owner</td>
<td>Emails an owner mapping based on its identity source.</td>
</tr>
</tbody>
</table>

**Figure 8: Quota Notification Action**

The email owner mapping is as follows:

• **Active Directory**: Lookup is performed against the domain controller (DC). If the user does not have an email setting, a configurable transformation from user name and DC fully qualified domain name is performed to generate an email address.

• **LDAP**: LDAP user email resolution is similar to AD users. In this case, only the email attribute looked up in the LDAP server is configurable by an administrator based on the LDAP schema for the user account information.

• **NIS**: Only the configured email transformation for the NIS fully qualified domain name is used.

• **Local users**: Only the configured email transformation is used.

The actual quota notification is handled by a daemon, isi_quota_notify_d, which performs the following functions:

• Processes kernel notification events that get sent out. They are matched to notification rules to generate instant notifications (or other actions as specified in the notification rule)

• Processes notification schedules – The daemon will check notification rules on a scheduled basis. These rules specify what violation condition should trigger a notification on a regular scheduled basis.

• Executes notifications based on rule configuration to generate emails or alert notifications.

• Manages persistent notification states so that pending events are processed in the event of a restart.

• Handles rescan requests when quotas are created or modified
Notification Email Templates

SmartQuotas provides email templates for advisory, grace, and regular notification configuration, which can be found under /etc/ifs. The advisory limit email template (/etc/ifs/quota_email_advisory_template.txt) for example, displays:

Subject: Disk quota exceeded

The <ISI_QUOTA_DOMAIN_TYPE> quota on path <ISI_QUOTA_PATH> owned by <ISI_QUOTA_OWNER> has exceeded the <ISI_QUOTA_TYPE> limit.

The quota limit is <ISI_QUOTA_THRESHOLD>, and <ISI_QUOTA_USAGE> is currently in use.

<ISI_QUOTA_HARD_LIMIT> Contact your system administrator for details.

System Alerts

Various system alerts are sent out to the standard cluster Alerting system when specific events occur. These include:

<table>
<thead>
<tr>
<th>Alert Type</th>
<th>Level</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NotifyFailed</td>
<td>Warning</td>
<td>An attempt to process a notification rule failed externally, such as an undelivered email.</td>
</tr>
<tr>
<td>NotifyConfig</td>
<td>Warning</td>
<td>A notification rule failed due to a configuration issue, such as a non-existent user or missing email address.</td>
</tr>
<tr>
<td>NotifyExceed</td>
<td>Warning</td>
<td>A child quota's advisory/soft/hard limit is greater than any of parent quota's hard limit.</td>
</tr>
<tr>
<td>ThresholdViolation</td>
<td>Info</td>
<td>A quota threshold was exceeded. The conditions under which this alert is triggered are defined by notification rules.</td>
</tr>
<tr>
<td>DomainError</td>
<td>Error</td>
<td>An invariant was violated that resulted in a forced domain rescan.</td>
</tr>
</tbody>
</table>

Figure 9: System Alert Type

Quota Accounting

SmartQuotas has four main resources used in quota accounting:

<table>
<thead>
<tr>
<th>Accounting Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Size</td>
<td>This includes all the on-disk storage associated with files and directories, with the exception of some metadata objects including the LIN tree, snapshot tracking files (STFs). For deduplicated data and file clones, each file's 8KB reference to a shadow store is included in the physical space calculation.</td>
</tr>
<tr>
<td>File system logical size</td>
<td>File system logical size calculation approximates disk usage on 'typical' storage arrays by ignoring the erasure code, or FEC, protection overhead that OneFS employs. For regular files, the logical data space is the amount of storage required to house a particular file if it was 1x mirrored. Logical space also incorporates a file’s metadata resources.</td>
</tr>
<tr>
<td>Application Logical Size</td>
<td>Reports total logical data store across different tiers, including CloudPools. This allows users to view quotas and free space as an application would view it, in terms of how much capacity is available to store logical data regardless of data reduction or tiering technology.</td>
</tr>
</tbody>
</table>
Inodes | SmartQuotas counts the number of logical inodes, which allows accounting for files without any ambiguity from hard links or protection.

When configuring a quota, these are accounting options available as enforcement limits. For example, from the OneFS WebUI:

![SmartQuotas WebUI screenshot]

Figure 10: Quota Configuration Accounting Options

- Application logical size quotas are available in OneFS 8.2 and later. Existing quotas can easily be configured to use application logical size upon upgrading from an earlier OneFS version. The benefits of application logical size quotas include:
  - Snapshots, protection overhead, dedupe, compression, and location of files all have no effect on quota consumption
  - Removes previous limitation where SmartQuotas only reported on-cluster storage, ignoring cloud consumption
  - Presents view that aligns with Windows storage accounting
  - Enables accounting and enforcing quota on actual file sizes
  - Precisely accounts for small files
  - Enables enforcing quotas on a path irrespective of the physical location of file.

The following table describes how SmartQuotas accounts for a 1KB file with the various data types:
### Data Type

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Accounting</th>
</tr>
</thead>
<tbody>
<tr>
<td>File: physical size</td>
<td>Every non-sparse 8KB disk block a file consumes including protection</td>
</tr>
<tr>
<td>File: file system logical size</td>
<td>Every non-sparse 8KB disk block a file consumes excluding protection</td>
</tr>
<tr>
<td>File: application logical size</td>
<td>Actual size of file (rather than total of 8KB disk blocks consumed)</td>
</tr>
<tr>
<td>CloudPools file: file system logical size</td>
<td>Size of CloudPools SmartLink stub file (8KB)</td>
</tr>
<tr>
<td>CloudPools file: application logical size</td>
<td>Actual size of file on cloud storage (rather than local stub file)</td>
</tr>
<tr>
<td>Directories</td>
<td>Sum of all directory entries</td>
</tr>
<tr>
<td>Symlinks</td>
<td>Data size</td>
</tr>
<tr>
<td>ACL and similar</td>
<td>Data size</td>
</tr>
<tr>
<td>Alternate data stream</td>
<td>Each ADS is charged as a file and a container as a directory</td>
</tr>
</tbody>
</table>

#### Figure 11: Quota Accounting Data Type

The example below shows each method of accounting for a 1KB file.

![Logical quota reports physical size without overhead – 8KB](Image)

- **Logical size accounting** is sum of physical sizes of all files/directories without overhead
- **Physical size accounting** is sum of physical sizes of all files/dirs with protection overhead
- **Application Logical size accounting** is sum of actual sizes of all files/directories

![Physical quota includes protection overhead – 24KB](Image)

![Application logical reports actual file size – 1KB](Image)

#### Figure 12: Quota Accounting Data Type

Logical size reports 8KB, or one block, physical size reports 24KB (file with 3x mirroring protection), and application logical shows its actual size of 1KB.

Other resources encountered during quota accounting include:

- **Hard Links** - Each logical inode is accounted exactly once in every domain to which it belongs. If an inode is present in multiple domains, it is accounted in multiple domains. Alternatives such as shared accounting were considered. However, if inodes are not accounted once in every domain, it is possible for the deletion of a hard link in one domain to put another domain over quota.

- **Alternate Data Streams (ADS)** - A file with an alternate data stream or resource fork is accounted as the sum of the resource usage of the individual file, the usage for the container directory and the usage for each ADS. SmartQuotas handles the rename of a file with ADS synchronously, despite the fact that the ADS container is just a directory. SmartQuotas will store an accounting summary on the ADS container to handle renames.

- **Directory Rename** – A directory rename presents a unique challenge to a per-directory quota system. Renames of directories within a domain are trivial - if both the source and target directories have the same domain membership, no accounting changes. However, non-empty directories are not permitted to be moved when the SmartQuotas configuration is different on the source and the target parent directories. If a user trusts the client operating systems to copy files and preserve all the necessary attributes, then the user...
may set dir_rename_errno to EXDEV, which causes most Unix and Windows clients to do a copy and delete of the directory tree to affect the move.

**Snapshot Accounting** – If desired, a quota domain can also include snapshot usage in its accounting. SmartQuotas will only support snapshots created after the quota domain was created. This is because determining quota governance (including QuotaScan job) for existing snapshots is a very time and resource consuming operation. As most administrators cycle their snapshots through timed expirations, SmartQuotas will eventually accrue enough accounting information to include the entire set of relevant snapshots on the system.

**Storage Quotas & Usage Info**

SmartQuotas software supports flexible reporting options that enable administrators to more effectively manage cluster resources and analyze usage statistics. The goal of Quota Reporting is to provide a summarized view of the past or present state of the Quota Domains. There are three methods of data collection and reporting that are supported:

- Scheduled reports are generated and saved on a regular interval.
- Ad-hoc reports are generated and saved per request of the user.
- Live reports are generated for immediate and temporary viewing.

A summary of general quota usage info can be viewed from the WebUI, by navigating to File System > SmartQuotas > Quotas and Usage.

![Figure 13: General Quota Usage Summary](image)

For each quota profile, additional information and context is available by clicking on the ‘View / Edit’ button:
Client-Side Quota Views

Client-side quota reporting in OneFS 8.2 and later includes:

- Support for rpc.quotad, which allows NFS clients to view quota consumption for both hard and soft quotas using the native Linux and UNIX `quota` CLI utilities.

- The ability to view available user capacity set by soft and/or hard user or group quotas, rather than the entire cluster capacity or parent directory-quotas.

Quota Reports

Quota reports and summaries are typically stored in the `/ifs/.isilon/smartquotas/reports` directory, but this location is configurable.

Each generated report includes the quota domain definition, state, usage, and global configuration settings. By default, ten reports and ten summaries are kept at a time, and older versions are purged. This can be configured from the WebUI, by navigating to `File System > SmartQuotas > Settings:`
Ad hoc reports can also be created at any time to view the current state of the storage quotas system. These live reports can be saved manually.

Reports and summaries are prefixed by either ‘ad hoc’ or ‘scheduled’ to aid with identification.

The OneFS CLI export functionality makes use of the same data generation and storage format as quota reporting but should not require any extra requirements beyond the three types of reports. After the collection of the raw reporting data, data summaries can be produced given a set of filtering parameters and sorting type.

Reports can be viewed from historical sampled data or a live system. In either case, the reports are views of usage data at a given time. SmartQuotas does not provide reports on aggregated data over time (i.e. trending reports). However, the raw data can be used by a Quota Administrator to answer trending questions.

Quota Report Format

A quota report is a time-stamped XML file that starts off with global configuration settings and global notification rules:

```
# cat scheduled_quota_report_1465786800.xml
<global-config>
  <quota-global-config>
    <reports>
      <schedule-pattern>1100000000|every sunday at 11pm</schedule-pattern>
      <schedule-dir>/ifs/.isilon/smar
      <schedule-dir>/ifs/.isilon/smartquotas/reports</schedule-dir>
      <schedule-copies>10</schedule-copies>
      <adhoc-dir>/ifs/.isilon/smartquotas/reports</adhoc-dir>
      <adhoc-copies>10</adhoc-copies>
```
<reports>
</quota-global-config>
<global-config>
<global-notify>
</global-notify>
<domains>
    <domain type="default-group" snaps="0" lin="0x0000000100020006">
        <path>/ifs/home</path>
        <inactive/>
        <enforcements default-resource="logical"/>
        <notifications use="global"/>
    </domain>
    <domain type="group" snaps="0" lin="0x0000000100020006" id="0">
        <inherit/>
        <id-name>wheel</id-name>
        <usage resource="physical">109568</usage>
        <usage resource="logical">32929</usage>
        <usage resource="inodes">6</usage>
        <path>/ifs/home</path>
        <inactive/>
        <enforcements default-resource="logical"/>
        <notifications use="default"/>
    </domain>
    <domain type="group" snaps="0" lin="0x0000000100020006" id="10">
        <inherit/>
        <id-name>admin</id-name>
        <usage resource="physical">28160</usage>
        <usage resource="logical">8208</usage>
        <usage resource="inodes">2</usage>
        <path>/ifs/home</path>
        <inactive/>
        <enforcements default-resource="logical"/>
        <notifications use="default"/>
    </domain>
    <domain type="group" snaps="0" lin="0x0000000100020006" id="1800">
        <inherit/>
        <id-name>Isilon Users</id-name>
        <usage resource="physical">1811456</usage>
        <usage resource="logical">705620</usage>
        <usage resource="inodes">42</usage>
        <path>/ifs/home</path>
        <inactive/>
        <enforcements default-resource="logical"/>
        <notifications use="default"/>
    </domain>
    <domain type="user" snaps="0" lin="0x0000000100020006" id="2002">
        <id-name>nick</id-name>
        <usage resource="physical">1001984</usage>
        <usage resource="logical">483743</usage>
        <usage resource="inodes">12</usage>
        <path>/ifs/home/nick</path>
        <enforcements default-resource="logical"/>
        <enforcement type="soft" resource="logical">
            ...
        </enforcement>
    </domain>
</domains>
<limit>10485760</limit>  
<grace>7776000</grace>  
</enforcement>  
<enforcement type="advisory" resource="logical">  
<limit>5242880</limit>  
</enforcement>  
</enforcements>  
</notifications>  
</domain>  
</domains>  
</quota-report>

Figure 16: XML Quota Report

When listing domains, both inode & path as well as name & ID are stored with each domain. Quota Notification Rules are read and inserted into a domain entry only if the domain is not inherited to avoid any performance impact of reading the Quota Notification Rules with each domain.

**Quota Report Management**

SmartQuotas can be configured to produce scheduled reports to help monitor, track and analyze storage use on a OneFS powered cluster.

Quota reports are managed by configuring settings that provide control over when reports are scheduled, how they are generated, where and how many are stored and how they are viewed. The maximum number of scheduled reports that are available for viewing in the web-administration interface can be configured for each report type. When the maximum number of reports is stored, the system automatically deletes the oldest reports to make space for new reports as they are generated.

**Creating a Quota Report Schedule**

SmartQuotas can be easily configured to generate quota report settings to generate the quota report on a specified schedule. These settings determine whether and when scheduled reports are generated, and where and how the reports are stored. Even if scheduled reports are disabled, you can still run unscheduled reports at any time.

The method to do this is:

1. From the OneFS WebUI, navigate to File System Management > SmartQuotas > Settings.
2. (Optional) On the Quota settings page, for Scheduled Reporting, click On. The Report Frequency option appears.
3. Click Change schedule and select the report frequency that you want to set from the list.
4. Select the reporting schedule options that you want.
5. Click Save.

Reports are generated according to your criteria and can be viewed in the Generated Reports Archive.

**Generating a Quota Report**

In addition to scheduled quota reports, you can generate a report to capture usage statistics at a point in time. Before you can generate a quota report, quotas must exist and no QuotaScan jobs can be running.

The following procedure will achieve this:

1. Click File System Management > SmartQuotas > Generated Reports Archive.
2. In the Generated Quota Reports Archive area, click Generate a quota report.
Locating a Quota Report

You can locate quota reports, which are stored as XML files, and use your own tools and transforms to view them. This task can only be performed from the OneFS command-line interface.

Procedure

1. Open a secure shell (SSH) connection to any node in the cluster and log in.
2. Navigate to the directory where quota reports are stored. The following path is the default quota report location:
   
   /ifs/.isilon/smartquotas/reports

   ▶ If quota reports are not in the default directory, you can run the isi quota settings command to find the directory where they are stored.
3. At the command prompt, run the ls command.

To view a list of all quota reports in the directory, run the following command:

   # ls -a *.xml

To view a specific quota report in the directory, run the following command:

   # ls <filename>.xml

Quota Performance Tuning

Within OneFS, quota data is maintained in Quota Accounting Blocks (QABs). Each QAB contains a large number of Quota Accounting records, which need to be updated whenever a particular user adds or removes data from an area of the filesystem on which quotas are enabled (quota domain). If a large quantity of clients are simultaneously accessing the quota domain, these blocks can become highly contended and a potential bottleneck. Similarly, if a single client (or small number of clients) consistently makes a large number of small writes to files within a single quota, write performance could again be impacted.

To address this, quota accounts have a mechanism to help avoid hot spots on the nodes storing QABs. Quota Account Constituents (QACs) help parallelize the quota accounting by including additional QAB mirrors distributed across other nodes in the cluster.

Configuration is via a sysctl, efs.quota.reorganize.qac_ratio, which increases the number of quota accounting constituents. This provides better scalability and reduces latencies on heavy create/delete activities when quotas are used.

Using this parameter, the internally calculated QAC count for each quota is multiplied by the specified value. If a workflow experiences write performance issues, and it has many writes to files or directories governed by a single quota, then increasing the QAC ratio may significantly improve write performance.

The sysctl efs.quota.reorganize.qac_ratio can be reconfigured to its maximum value of 8 from its default value of 1 via the following CLI command:

   # isi_sysctl_cluster efs.quota.reorganize.qac_ratio=8

To verify the persistent change, run:

   # cat /etc/mcp/override/sysctl.conf | grep qac_ratio

   efs.quota.reorganize.qac_ratio=8 #added by script

   ▶ Although increasing the QAC count via this sysctl can improve performance on write heavy quota domains, some amount of experimentation may be required until the ideal QAC ratio value is found. Adjusting the parameter can adversely affect write
performance if you apply a value that is too high, or if you apply the parameter in an environment that does not have diminished write performance due to quota contention.

Additionally, OneFS provides a CLI command, which can restripe the QABs to improve their performance.

```
# isi_restripe_qabs retune
```

This utility can be run either ad-hoc or periodically to randomly redistribute QABs for all existing quotas. It does this by ignoring the default ‘rebalance’ layout and running a ‘retune’ layout strategy instead, thereby alleviating the performance impact from an imbalanced QAB layout.

More information on OneFS commands and feature configuration is available in the OneFS Administration Guide.

## Quota Best Practices

SmartQuotas best practices include:

- Avoid creating quotas on the root directory of the default OneFS share (/ifs). A root-level quota may result in performance degradation.
- The best practice is a maximum number of quotas per cluster of 500,000 in OneFS 8.2 and later and 20,000 in prior releases.
- SmartQuotas schedule notification rules are limited to 20,000.
- Governing a single directory with overlapping quotas can also degrade performance.
- Directory quotas can also be used to alert of and constrain runaway jobs, preventing them from consuming massive amounts of storage space.
- Enforcement quotas are not recommended for snapshot-tracking quota domains.
- Before using quota data for analysis or other purposes, verify that no QuotaScan jobs are running.
- Rather than editing the quota email notification templates directly, copy them from /etc/ifs to another directory to edit and deploy them.
- If quota reports are not in the default directory, you can run the `isi quota settings reports view` command to find the directory where they are stored.
- Use the `isi quota quotas notifications disable` command to disable all notifications for a quota.
- Default directory quotas (in addition to default user and group quotas), available in OneFS 8.2 and later, can be configured from the CLI with the following syntax:
  
  ```
  # isi quota quotas create --path=/ifs/parent-dir --type=default-directory --hard-threshold=<limit>.
  ```

- The TreeDelete job can be used to delete directories with quotas as in OneFS 8.2 and later, using the following syntax:
  
  ```
  # isi job start TreeDelete --paths=/ifs/quota_dir
  ```

## Quota Considerations

- Prior to OneFS 8.2, SmartQuotas only reports the true quota container size for directory quotas (user & group quotas report the entire filesystem size). OneFS 8.2 and later extends this functionality to user & group quotas.
• OneFS 8.2 and later includes NFS quota support, allowing customers to view quota soft & hard limits using UNIX and Linux-based quota tools (rpc.quotad protocol).

• With CloudPools data, the quota is calculated based on the size of the data local to the cluster. For example, for a 100MB file tiered to a cloud provider, SmartQuotas would calculate just the size of the local stub file (8K).

• SmartQuotas reports the logical capacity of the files, whether they are deduplicated or not.

• The QuotaScan job runs after the creation of a quota, but not after a change. However, it does run on a schedule and incorporates any changes then.

• If two quotas are created on the same directory – for example an accounting quota without Snapshots and a hard quota with Snapshots - the quota without Snapshot data overrules the limit from the quota with Snapshot data.

• SmartQuotas also provide a low impact way to provide directory file count reports.

• Configuration changes for linked quotas must be made on the parent quota that the linked quota is inheriting from. Changes to the parent quota are propagated to all children. To override configuration from the parent quota, you must unlink the quota first.

• If a quota type uses the accounting-only option, enforcement limits cannot be used for that quota.

• Cloned and deduplicated files are treated as ordinary files by quotas. If the quota includes data protection overhead, the data protection overhead for shared data is not included in the usage calculation.

• Moving quota directories across quota domains is not supported.

• You can edit or delete a quota report only when the quota is not linked to a default quota.

• A quota can only be unlinked when it’s linked to a default quota. Configuration changes for linked quotas must be made on the parent (default) quota that the linked quota is inheriting from. Changes to the parent quota are propagated to all children. If you want to override configuration from the parent quota, you must first unlink the quota.

• Disabling all quota notifications also disables all system notification behavior. Use the ‘—clear’ options to remove specific quota notification rules and fall back to the system default.

• In OneFS 8.2 and later, which supports multiple email recipients for notifications and alerts, the maximum size of the email address list (comma separated) supported is 1024 characters. Multi-email notifications can be configured with the following CLI syntax:

  ```
  # isi quota notifications create </ifs/quota> directory advisory exceeded --action-email-address=user1@mail.com,user2@mail.com,user3@mail.com --holdoff=0
  ```

• Quota containers compartmentalize /ifs, so that a directory with a container will appear as its own separate ‘file system slice’. To configure a directory quota with a 4TB container on /ifs/data/container1, you could use the following CLI command:

  ```
  # isi quota quotas create /ifs/data/container1 directory --hard-threshold 4T --container true
  ```

• Only soft or advisory limits can be defined as a percentage of a hard limit. Defining the same type of limit with both percent-based and absolute is not permitted in single request.

• While OneFS 8.2 and later supports an overall quota limit of up to 500,000, support for schedule notification rules is still limited to 20,000.
SmartQuotas and OneFS Feature Integration

Snapshots and SmartQuotas

In addition to data-protection overhead, the option is provided on whether to include snapshot data when calculating a quota’s usage limits.

Figure 17: Quota Snapshot Reporting

SmartQuotas will only report on snapshots created after the quota domain was created. This is because determining quota governance (including QuotaScan job) for existing snapshots is a very time and resource consuming operation. However, as snapshots age out, SmartQuotas will gradually accrue accounting information for the entire set of relevant snapshots.

Further information is available in the OneFS SnapshotIQ white paper.

Deduplication and SmartQuotas

Deduplicated files appear no differently than regular files to standard quota policies. However, if the quota is configured to include data-protection overhead, the additional space used by the shadow store will not be accounted for by the quota.

Further information regarding deduplication is available in the OneFS SmartDedupe white paper.

In-line Compression and SmartQuotas

SmartQuotas reports efficiency as a ratio across the desired data set as specified in the quota path field. The compression efficiency ratio is for the full quota directory and its contents, including any overhead, and reflects the net efficiency of compression.

Further information regarding compression is available in the OneFS In-line Compression white paper.

SyncIQ and SmartQuotas

Quotas are matched one-to-one across the replication set. Multiple quotas are supported within a source directory or domain structure, and the target directory is now included in a quota domain.

During replication SyncIQ ignores quota limits. However, if a quota is over limit, quotas still prevent users from adding additional data. SyncIQ will never automatically delete an existing target quota. Instead, a SyncIQ will fail, as opposed to deleting an existing quota. This may occur during an initial sync where the target directory has an existing quota under it, or if a source directory is deleted that has a quota on it on the target. The quotas still remains and requires administrative removal if desired.

Further information is available in the OneFS SyncIQ white paper.
CloudPools and SmartQuotas

Application logical quotas, available in OneFS 8.2 and later, provide a quota accounting metric, which accounts for, reports and enforces on the actual space consumed and available for storage, independent of whether files are on-premise or cloud-tiered.

SmartQuotas Use Cases

Scenario 1: Quota Management

A university wants to give their students and groups a fixed amount of storage to control and keep storage growth in check. The storage administrator wants to know how much each student is consuming and limit them. To accomplish this, the storage admin:

- Sets default user hard or soft quotas
- Configures email alerts to students to encourage self-cleanup of file usage

Scenario 2: Thin Provisioning and Scale-Out

A company in the Media and Entertainment industry wants to overprovision storage and only add capacity when needed. The company buys two 200TB of capacity for their cluster and allocates 1000 users 500GB each - effectively thin provisioning 500TB’s. To enable this, the storage administrator:

- Sets directory quotas for each user with hard quota of 500GB each
- Sets up a system alert to notify the storage admin to add capacity (nodes) when the 200TB is 75% full
- Scale-out effectively by adding additional capacity only when needed.

Scenario 3: HPC Compute Farm Constraining

A semiconductor company uses a large HPC compute cluster for parts of their EDA workflow, and wants to guard against runaway jobs for consuming massive amounts of storage. The company runs heavy computations jobs from a large compute farm against a ‘scratch space’ directory, housed on an S-node tier on their cluster, and garbage collection is run at midnight.

Throughout the workday, it’s hard for the storage admins to keep track of storage utilization. Occasionally, jobs from the compute farm run amok, tying up large swathes of fast, expensive storage resources and capacity. To help prevent this, the storage administrator:

- Sets an advisory directory quota on the scratch space at 80% utilization for advanced warning of an issue.
- Configures a hard directory quota to prevent writes at 90% utilization.

Conclusion

Traditional systems with volume quotas are limited to a single storage device—and to a single volume. Volume-level solutions are limited in management flexibility once they are initially set up. For example, typical implementations require the management of quotas across different volumes, multiple storage systems and multiple file systems. This approach creates challenges when making changes to resources, tracking specific users and groups, moving directory structures or moving data between file systems and volumes. As more storage silos are added, the complexity only increases.

OneFS SmartQuotas helps to eliminate these management challenges. By the virtue of being fully cluster-aware and spanning all nodes, regardless of the cluster size, IT managers can administer SmartQuotas from a single point of view, provisioning storage exactly how they want, and changing quota policy options on demand.

Storage administrators can define named quotas for specific individual users or groups or create default quotas that control disk usage for anyone accessing the cluster.

Administrators can manage storage across their enterprise so that specific users and groups are only allowed to “see” the storage they have been provisioned. Hard, soft and advisory limits can be set across the organization for specific users and groups, and across the various directory structures. Storage admins can also configure alerts and send e-mail notifications to end-users letting them know that quota limits are approaching, enforcing hard stops on writes or providing a grace period of several days before enforcing thresholds.
When new users need to be added or directory structures need to be changed, SmartQuotas allows IT managers to change their quota policies on the fly—easily meeting the changing storage demands of the enterprise.

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