

GHI Management Guide

*Spectrum Scale (GPFS) - HPSS Interface
Release 3.0*

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Who Should Read This Book. The GHI Management Guide is intended as a resource for GHI

administrators. For those performing the initial configuration for a new GHI system, Chapter 1 provides a configuration roadmap. For both new systems and those upgraded from a previous release, Chapter 1 provides a configuration, operational, and performance checklist which should be consulted before bringing the system into production. The remaining chapters contain the details for configuring, reconfiguring, monitoring, and managing a GHI system.

Conventions Used in This Book. Example commands that should be typed at a command line will be preceded by a percent sign ("%") and be presented in a Courier font:
% sample command

Any text preceded by a pound sign ("#") should be considered comment lines:
This is a comment

Angle brackets ("<>") denote a required argument for a command:
% sample command <argument>

Square brackets ("[]") denote an optional argument for a command:
% sample command [optional argument]

Vertical bars ("|") denote different choices within an argument:
% sample command <argument1 | argument2>

Commands written within the sentence will be bolded.
Sample sentence with a **command** in it.

A byte is an eight-bit data octet. A kilobyte, KB, is 1024 bytes (2^{10} bytes). A megabyte, MB, is 1,048,576 bytes (2^{20} bytes). A gigabyte, GB, is 1,073,741,824 bytes (2^{30} bytes), a terabyte, TB, is 1,099,511,627,776 bytes (2^{40} bytes), and a petabyte, PB, is 1,125,899,906,842,624 bytes (2^{50} bytes). An exabyte, EB, is 1,152,921,504,606,846,976 bytes (2^{60} bytes).

CHAPTER 1. GHI BASICS

1.1 Introduction

The Spectrum Scale/HPSS Interface feature of HPSS (GHI) is software to connect Spectrum Scale and HPSS together under the Spectrum Scale Information Lifecycle Management (ILM) policy framework. This integration of Spectrum Scale with HPSS creates a hierarchical Spectrum Scale file system having virtually unlimited storage capability and provides the option to use the hierarchical capabilities of Spectrum Scale and HPSS to provide disaster recovery protection for the Spectrum Scale file systems. GHI is an optional feature of HPSS and is offered under the HPSS license agreement. GHI users are expected to acquire or have acquired Spectrum Scale under a separate Spectrum Scale license agreement.

Both Spectrum Scale and HPSS scalability and performance are designed to meet the needs of data-intensive applications such as engineering design, digital media, data mining, financial analysis, seismic data processing and scientific research. Typically, users tend to have many files in a file system, and these may be any mixture of sizes from very small to very large. Both Spectrum Scale and HPSS are highly scalable and are capable of ingesting thousands of files per second at rates limited by the hardware – usually the storage hardware and the transfer media. GHI is a scalable extension of HPSS.

A primary goal of GHI is to offer an integrated Hierarchical Storage Management (HSM) and backup solution for Spectrum Scale. GHI uses and extends Spectrum Scale ILM capabilities, providing a cost-efficient integrated storage solution that is scalable to 100s of petabytes and billions of files. GHI enables Spectrum Scale file data transfers between Spectrum Scale high performance storage, usually high-speed disk and HPSS cost-efficient storage (high capacity disk and tape). This movement between Spectrum Scale and HPSS occurs automatically under control of Spectrum Scale ILM policy rules and the DMAPI (Data Management API) framework, thus providing a complete and scalable HSM and backup solution that exploits HPSS parallel file system capabilities.

Spectrum Scale and HPSS are both network-centered cluster solutions offering horizontal scalability by adding cluster components. The GHI feature extends this architecture. Thus, the archive is not a single processor as in conventional storage systems. GHI provides servers that can be distributed across a high-performance network to provide scalability and parallelism.

GHI uses the Parallel I/O (PIO) interface provided as part of the HPSS Client Application Program Interface (Client API) to support parallel access to storage devices for fast access to very large files stored in HPSS. The GHI I/O Manager (IOM) organizes and manages the data transfer. An IOM will spawn threads to accomplish the actual collection and transfer the data, one per stripe based on the HPSS stripe width of the COS configuration.

GHI uses ISHTAR (Independent Standalone HPSS TAR) to aggregate many small files into one large file before migrating them into HPSS. Temporary storage on Spectrum Scale file system is used to build the index files for the aggregate. The temporary files are removed once the

aggregate file is written to HPSS. ISHTAR uses a multi-threaded buffering scheme to write files directly into HPSS, thereby achieving a high rate of performance.

GHI is written in ANSI C. It uses Remote Procedure Calls (RPC), Kerberos or UNIX for server authentication, and DB2 as the basis for its portable, distributed architecture for maintaining Spectrum Scale backups. The DB2 Server for HPSS is used to store the backup tables for GHI. Several DB2 tables are configured in the GHI database for each GHI managed Spectrum Scale file system. These tables support GHI backups, GHI garbage collection and GHI mapping information. The GHI Session nodes are configured as DB2 clients to access the backup tables during GHI backup and restore operations.

1.2 GHI Configuration

This section defines the high-level steps necessary to configure, start, and verify correct operation of a new GHI system, whether that system is created from scratch or created by upgrade from any previous version of GHI. To create or modify the GHI configuration, we recommend that the administrator first be familiar with the information described in the GHI Installation Guide, Chapter 3: HPSS Basics and Chapter 4: HPSS Planning.

Before performing the procedures described below, be certain that the appropriate system preparation steps have been performed. See the GHI Installation Guide, Chapter 5: System Preparation for more information. For a system created from scratch, be certain that the GHI installation and infrastructure configuration have been completed. See the HPSS Installation Guide, Chapter 6: HPSS Installation and Infrastructure Configuration for more information. To upgrade from a previous system, see the release notes for the upgraded version for specifics on the upgrade procedures.

1.2.1 Starting GHI for the First Time

The GHI system is ready to be configured once the GHI software is installed on the node and the GHI infrastructure components are configured. To start GHI, you must first start all infrastructure components for HPSS and Spectrum Scale as follows:

1. Make sure HPSS, Spectrum Scale, and all GHI nodes are powered on and the networks connecting them are working.
2. On the HPSS Core server, as root, start DB2, the SSM, and the Startup Daemon with:

```
% /opt/hpss/bin/rc.hpss start
```

If there is a remote PVR in the HPSS cluster, start the Startup Daemon there also.

3. Log in to the HPSS graphic user interface (**hpssgui.pl**) or HPSS administrator tool (**hpssadm.pl**) and start the rest of the HPSS servers and movers.
4. On the Spectrum Scale Cluster Manager node, start GPFS on all the servers that GHI is installed on:

```
% /usr/lpp/mmfs/bin/mmstartup -N ghinode1,ghinode2,ghinode3, ...ghinodeN
```

5. On the Spectrum Scale Cluster Manager node, start the GHI cluster:

```
% /opt/hpss/bin/ghistartup -g
```

NOTE: During the initial GHI configuration, Spectrum Scale callbacks are established to automatically start when Spectrum Scale starts, so it may already be running when this command is run.

1.2.2 Configuring GHI for a New System Roadmap

The following steps summarize the configuration of a GHI file system and policies needed to get GHI running. This list assumes that GHI has been installed following the steps in the GHI Install Guide.

1. Configure the GHI File system. The settings to be changed can be listed with **ghilsfs** and changed with **ghichfs**. Each setting is defined in detail later in this document, but there are settings that need to be changed before the file system is used in production. First, the Classes of Service(COS) that will be used must be set. There are two for the file system: Backup and aggregate index. The backup COS is what the backup data is stored. The aggregate index COS stores the aggregate index files. The indexes should not be purged from HPSS disk so this will be a specific HPSS COS. Next, are the minimum and maximum files per aggregate. These settings will depend on the cutoff size of aggregate versus nonaggregate files. The final settings are for the monitor files. The SD and IOM monitor files need to be enabled. The frequency should be set to 60 seconds to start, and can be modified as needed. Once these settings are set, restart the ED, SD and IOM for them to take effect. These settings are described in more detail later in this document.
2. There are at least 3 policies that need to be modified for GHI to work: **migrate.policy**, **backup_migration.policy**, and **threshold.policy**. The **migrate.policy** and **backup_migration.policy** will define how data is moved from Spectrum Scale to HPSS and will have the same rules in them. The **backup_migration.policy** will have an additional argument to release some restrictions on aggregates to create more complete backups. The less rules in these policies the better performance the policy scan will have. The rules are written based on how the data is stored in the Spectrum Scale file system. In most cases, rules are written for each project stored in Spectrum Scale. The **threshold.policy** defines how the automatic purge of the Spectrum Scale file system takes place. There are three main rules in this policy: The path where the files are purged from, the thresholds and the file size. The path will be the file system mount point. There are two thresholds, high mark and low mark. The high mark is percentage of space filled in the file system where purge starts and the low mark is percentage of space filled in the file system where the purge stops. Finally, the file size is configured. The policy should be configured so that the largest files are purged first so that the most space can be free with the least amount data movement.

1.2.3 Stopping GHI

The following steps show how to stop GHI.

1. Disable any automated scripts that are using GHI. Normally this includes automated migration, backups or purges, but it could include more depending on the site.
2. Dismount the Spectrum Scale file system. You should always dismount the file system before stopping GHI. If you leave it mounted, then any DMAPAPI event that is triggered will be aborted by GHI.

```
% /usr/lpp/mmfs/bin/mmumount <file system> -a
```

3. Shutdown GHI. Spectrum Scale will still be running at this point. If you want to stop Spectrum Scale and GHI at the same time, you can use the -G instead of the -g.

```
% /opt/hpss/bin/ghishutdown -g
```

CHAPTER 2. GHI CONCEPTS

2.1 Terminology

Spectrum Scale and HPSS have different meanings for the same term. GHI uses the HPSS terminology, here are definitions of those terms.

- **Backup** - Backup refers to backing up a Spectrum Scale file system into HPSS. The information needed to restore a Spectrum Scale file system including the restoration of the Spectrum Scale cluster file system configuration will be backed up into HPSS as well.
- **Cluster** - A loosely-coupled collection of independent system nodes organized into a network for sharing resources and communicating with each other.
- **Garbage Collection** – A GHI and DB2 process for removing GHI files from HPSS that are no longer referenced by Spectrum Scale or a valid backup.
- **Migration** - Migration refers to the movement of file data from Spectrum Scale to HPSS while maintaining the file data in Spectrum Scale. There are two scenarios where migrations are performed. The first scenario is when the Spectrum Scale policy engine is run to transfer file copies from Spectrum Scale to HPSS. The second scenario is during a backup, which is when the most recent version of all files that have not been copied during a HSM migration, triggered by a policy, are copied to HPSS. The Spectrum Scale term is “pre-migration”.
- **Purge** – Purge refers to freeing up data segments in the Spectrum Scale file to free up Spectrum Scale resources. A Spectrum Scale policy is used to trigger a threshold request. The data blocks for the selected files are freed, leaving a stub in Spectrum Scale. The Spectrum Scale term is “punching a hole”.
- **Recall** - Recall refers to the movement of file data from HPSS to Spectrum Scale using **ghi_stage** or from an ILM policy. This is not a DMAPI event. Recall events can be synchronous or asynchronous. The Spectrum Scale term is “pre-stage”.
- **Restore** – Restore refers to the capability to restore either a Spectrum Scale file system or a Spectrum Scale cluster from a selected backup.
- **Stage** - Stage refers to the movement of file data from HPSS to Spectrum Scale. This process is invoked by accessing a file that is not dual-resident, and the data only resides in HPSS. This is a synchronous event. This process generates a DMAPI I/O event to stage the file back. This is sometimes referred to as “stage on-demand”.
- **Pin** – Pin or pinning refers to flagging a file so it cannot be purged from the Spectrum Scale file system.
- **GHI User Data** – The files written by the users. in Spectrum Scale.
- **Full-Access File System** - File systems will normally be full-access; a GHI backup may be taken and migrated files may be deleted from Spectrum Scale to cause GHI to do garbage collection within HPSS.
- **Read-only File System** - A read-only file system is one that is created and associated with a full-access file system and populated by restoring a GHI backup of the full-access file system. Restored files on a read-only file system may be recalled or staged from HPSS, purged from GHI, but they may not be modified or deleted. New files may be created, modified, or deleted but they may not be migrated into HPSS. In short, file-related actions on a read-only file system will not result in any addition of data to HPSS or

deletion of data from HPSS. Read-only file systems were implemented to allow the validation of GHI backups. They may also be used to retrieve files from a backup without affecting the full-access file system or the status of backups.

2.2 Hierarchical Storage Management

GHI supports the following ILM mechanisms to transfer data between Spectrum Scale and HPSS, as well as manage available space in the Spectrum Scale file system:

- Data migration
- Data recall
- File system limits
- Garbage collection

GHI also uses the Spectrum Scale DMAPI interface to stage data back from HPSS on-demand when a user attempts to access (e.g. open) a Spectrum Scale file.

2.2.1 Data Migration - Transferring Data into HPSS

Files are transferred (i.e. migrated) from Spectrum Scale into HPSS based on rules sent to the Spectrum Scale policy engine. A migration policy provides a set of rules to identify which Spectrum Scale files are candidates for transfer to HPSS. The policy engine can generate two lists of files to be migrated. One list contains the files to be aggregated together as they are transferred into HPSS. The other list contains non-aggregate files which are individually transferred to HPSS. After the candidate lists are generated, the policy engine invokes the GHI script **ghi_migrate**.

ghi_migrate: One or more instances of the script is invoked by the policy engine to coordinate with the GHI Scheduler to migrate the files to HPSS. For aggregation, files are placed in groups of an “aggregate bulk size” so that each **ghi_migrate** receives a request for a single aggregate. For non-aggregates, a single **ghi_migrate** instance receives a list of files to be processed based on the same “aggregate bulk size”, but in practice, the number of files is usually only a small fraction of “aggregate bulk size”. The policy engine calls **ghi_migrate**; do not run this manually. GHI provides the following migration template in the `/var/hpss/ghi/policy` directory as an example of how to generate a list of files to be migrated:

migrate.policy: Rules used to split files that are to be migrated into two categories: aggregates and non-aggregates. Non-aggregate are larger files that are migrated into HPSS as a single file. Aggregates are smaller files that are combined with other small files into a single large file and then migrated into HPSS. GHI IBM Standalone HTAR or GHI-ISHTAR is used to combine the files into larger aggregate files and migrated them into HPSS. When GHI-ISHTAR migrates files into HPSS, it creates two files in HPSS, the aggregate file and the index file. The aggregate file contains the data of all the files combined into. The index file is the list of the all the files in the corresponding aggregate and where they are in the aggregate. The location is call the ordinal. The index file is not required for migration or recall of the files from the aggregate, but it speeds things up when it is available.

Any attempt to migrate files from a GHI read-only file system will be rejected. The rejection code is -1 (Operation not permitted). This file should be modified by the GHI administrator to

migrate the data from Spectrum Scale to HPSS in a tape smart way. Here is an example of a Tape Smart Policy for non-aggregates:

```
RULE EXTERNAL POOL 'hsm_aggr' EXEC '/opt/hpss/bin/ghi_migrate' OPTS '-f ##'  
  
RULE 'toHsm_aggr' MIGRATE FROM POOL 'system'  
SIZE (FILE_SIZE)  
WEIGHT (DIRECTORY_HASH)  
TO POOL 'hsm_aggr' SHOW ('-s' FILE_SIZE)  
WHERE FILE_SIZE > ## AND PATH_NAME LIKE '%<project_path>%'
```

This policy does is tell Spectrum Scale to sort the files selected by the migration policy by their directory hash, instead of the default inode. Then, when GHI-ISHTAR migrates the files as aggregates, they are grouped with files in the similar path together. This helps when recalling data from HPSS tapes by minimizing the number of tape mounts needed to stage the data back. The more understanding of the data in the Spectrum Scale namespace, the more efficient the data can be migrated and recalled from HPSS tape. Please work with the GHI support representative for suggestion on how to configure this policy.

2.2.2 Data Recall - Transferring Data from HPSS

Files are transferred from HPSS to Spectrum Scale two ways, recall or stage. When a non-aggregate is transferred from HPSS to Spectrum scale, it is recalled as single file, just like in migration. However, when a single file that is part of an aggregate, GHI-ISHTAR will search the index to determine where the file is and transfer only that single file from the aggregate back to Spectrum Scale. The other files in the aggregate will remain in HPSS until they are requested.

Recall Operations: Recall files from HPSS occur as a background or a scheduled task. Either Spectrum Scale policy rules or a list of files/directories can be defined to retrieve the file data in advance of a user request to access those files. Policy rules in Spectrum Scale identify a list of candidate files that are eligible for recalling from HPSS. Next, the Spectrum Scale policy engine invokes the GHI script, **ghi_recall**.

ghi_recall: The script parses through the list and generates buckets of requests based on files belonging to the same aggregate and files residing on the same tape. This will optimize the retrieval of the data.

Files that reside on the same tape will be recalled together to minimize the number of tape mounts. Files that reside in the same aggregate will be recalled together using a single ISHTAR request. There is a recall template file, **recall.policy**, in the `/var/hpss/ghi/policy` directory that provides an example of how to generate a list of files to be recalled.

The **ghi_stage** command is the alternative to recalling files using a policy. The command accepts either a list of files with subdirectories or the fully qualified path name of the file or files that contain the actual files to recall. If the list contains files and directories, **ghi_stage** will recall the files and directories.

Stage Operations: Stage files back from HPSS synchronously when the files are accessed by a user or a program. When files reside in HPSS, regions are placed on the files. When a user accesses the file data, DMAPI events are generated. The stage operation for a Spectrum Scale file is performed differently depending on where the data resides. If a file resides in both Spectrum Scale and HPSS, a WRITE or TRUNCATE event is generated when the user updates the file. This does not cause the file to be staged because it still resides in both places. It does however cause GHI to clear out the DMAPI regions since the file contains new data and needs to be migrated again, and the original backup of the file in HPSS will become a candidate for garbage collection.

If a file only exists in HPSS, a READ event is generated when the user opens the file in Spectrum Scale. This causes the file to be staged from HPSS and become dual resident (i.e. resides in HPSS and Spectrum Scale). If the file is modified after the stage is complete, a WRITE or TRUNCATE event will be generated and processed as just stated above. The location of the file is transparent to the users, GHI handles all of this under the covers.

Staging can be turned on or off for each file system using **ghichfs** and passing in the `--sod` parameter. An error number can also be configured for each file system when staging is turned off. This is configured using **ghichfs** and passing in the `--dse` option.

2.2.3 Managing Available Space

There are high and low water marks that can be configured to indicate if a Spectrum Scale file system is out of space or is low on space. When the system triggers a high (NO_SPACE) or low (LOW_SPACE) event, the Spectrum Scale policy engine generates a list of files to be purged from the file system. Candidates to be purged are based upon file age, file size, etc. The Spectrum Scale ILM policy allows the candidates to be weighted so you can specify which files to be considered first. The list of files generated will be enough to free up resources until the low water mark is reached. There is a threshold template, **threshold.policy**, in the `/var/hpss/ghi/policy` directory that needs to be customized to list files to be purged.

To configure the system to react to these events, add the threshold policy and update the Spectrum Scale configuration to enable threshold processing. When activated and one of the DMAPI events is triggered, the **tsmigrate** process will run **mmstartpolicy**, which starts **mmapplypolicy** on one of the nodes in the cluster and the threshold policy will be used to determine what files to “punch holes” into.

2.2.4 Garbage Collection and File Deletion

When files are deleted from Spectrum Scale, a DMAPI event is triggered and GHI processes the event accordingly. GHI Garbage collection is the removal of unreferenced GHI files from HPSS. Unreferenced files are GHI files in HPSS that no longer exist in Spectrum Scale and are not referenced by a backup of the Spectrum Scale file system. Files are not referenced when:

- They have not been migrated to HPSS.
- They are not part of a valid backup (i.e. successful backup).

Spectrum Scale will notify GHI when a GHI-managed file is deleted or updated. GHI will place an entry for each notification into the DB2 garbage collection (GC) table. When the GHI backup manager is executed to delete a backup, entries will be pulled from the GC table and processed as follows:

- If the file is not part of a backup, the file will be deleted from HPSS.
- If the file is part of a backup that is invalidated due to a restore of an earlier backup, the file will be deleted from HPSS.
- If the file is part of another backup, GHI will retain the notification in the GC table until all referencing backups are deleted.

When a file is deleted from Spectrum Scale and the file is not part of a backup:

- For a non-aggregate, GHI will delete the file from HPSS.
- For an aggregate, GHI will mark the file as invalid in the aggregate. If all the files in the aggregate have been deleted, the aggregate file and the index file will be deleted.

The following diagrams demonstrates what happens to a file, still in Spectrum Scale namespace and HPSS namespace, that has been deleted after it was migrated to HPSS.

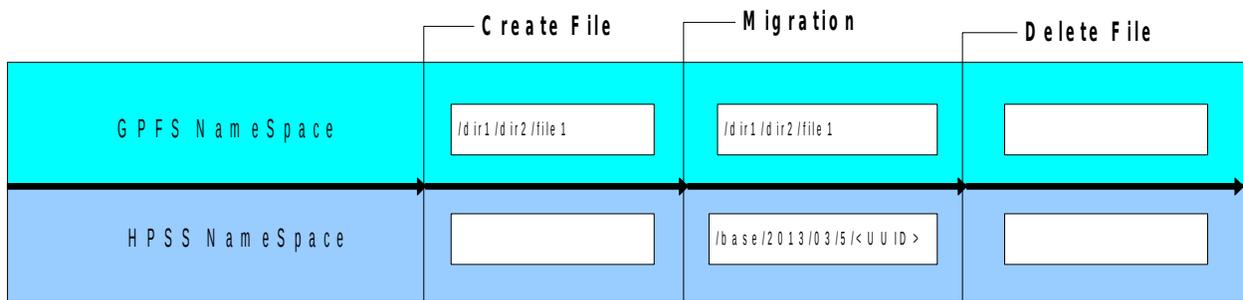


Figure 1 – Namespace Mapping Table

When a file is deleted from Spectrum Scale and the file is part of a backup:

- An entry will be added to the GHI garbage collection table.
- The file will not be deleted from HPSS until all the backups associated with the file are deleted.

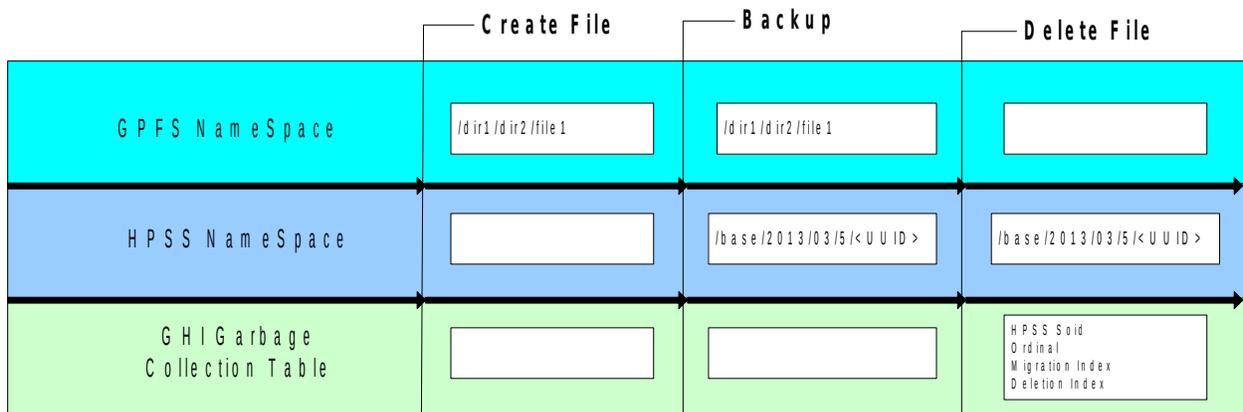


Figure 2 – Namespace Mapping Table

When a file is added to the garbage collection, it is added as the SOID, ordinal, migration index and deletion index. The SOID and ordinal identify which file in HPSS is to be deleted. The migration and delete index determine when the file is deleted. When a GHI backup is deleted, GHI compares the backup index of the backup being deleted. This is compared to the migration and delete index of the files in the garbage collection to determine if it is read to be deleted. For example, there are 5 backups with indices 1, 2, 3, 4 and 5. A file was written after backup 1, and deleted before backup 5, so backups 2, 3 and 4 have this file. The file will not be deleted from HPSS until backups 2, 3, 4 and 5 are deleted. Backup 5 is in this list because it is the next pending backup. When the file was deleted, that backup could have been in progress when the delete happened, so it is included as a safety check. Once all these backups are deleted, the file is removed from HPSS.

2.3 How Spectrum Scale Files are Stored in HPSS

The Spectrum Scale name space is not mirrored in HPSS, meaning the file name is different in HPSS than it is in Spectrum Scale. All files associated with a Spectrum Scale file system are in their own directory in HPSS. Each file that is transferred into HPSS is given a unique file name based on the UUIDs. Aggregate files have an additional file ending with `‘.idx’`.

With the Mapping tool, a user can locate or map a file using the Spectrum Scale file name, the HPSS file name, or the inode/igen that is assigned to the file in Spectrum Scale. Chapter 5 provides more details on mapping.

2.3.1 Extended Attributes

The Spectrum Scale extended attributes contain the following information that are used to map a Spectrum Scale file system object to an HPSS object:

HPSS Identifier – A unique identifier to locate where the Spectrum Scale file contents are archived in HPSS.

Hash – This is the bit file ID hash to the HPSS object. This is added to support HPSS 7.5.

Aggregate Flag – A flag to indicate whether the file is in an aggregate or not.

Ordinal – The index into the aggregate index file for the member. Applies to aggregates only.

Snapshot Identifier – This identifier associates the Spectrum Scale object with the backup in which the object was last backed up into HPSS.

Version Number – This is used to determine the format of the extended attributes. The format of the extended attributes could vary between HPSS releases, so the version number allows you to query a file to see what version was used when the file was last backed up into HPSS.

A separate DMAPI attribute contains the flag that indicates a file has been pinned.

2.3.2 Location of Spectrum Scale Files in HPSS

Migrated Files

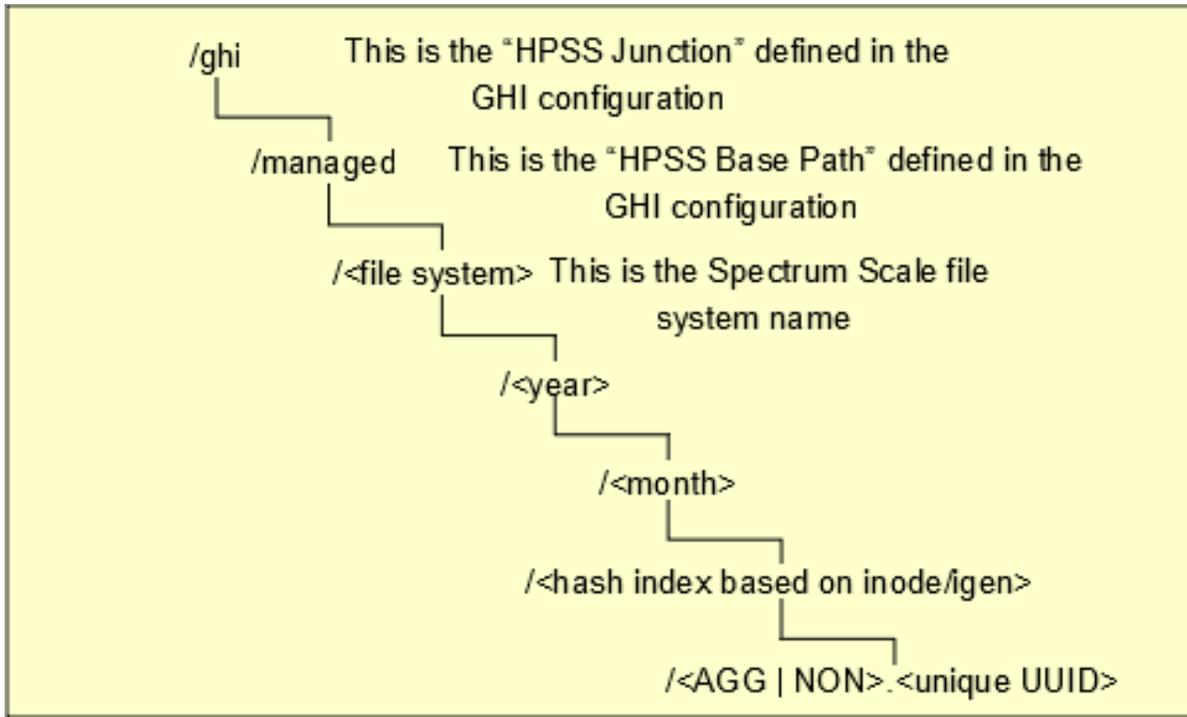


Figure 3 – Location of Spectrum Scale Files in HPSS

Hashing directories are created to store the Spectrum Scale files in HPSS. The directories are generated based on the following information:

- **/ghi** – default root directory in HPSS for storing the Spectrum Scale files. This value can be reconfigured by modifying the GHI configuration with **ghichfs** command. However, this value must not be changed unless the existing directory is empty.
- **file system** – Spectrum Scale file system name.
- **year** – The year the file was migrated into HPSS.
- **month** – The month the file was migrated into HPSS.
- **hash directory** – For non-aggregate files, the inode and igen are used to determine the directory. For aggregate files, the file's UUID is used to determine the directory. The index and data file for the aggregate are placed in the same directory.
- **unique UUID** – Unique ID for each file.

Files in a Non-Image (non-SOBAR) Backup

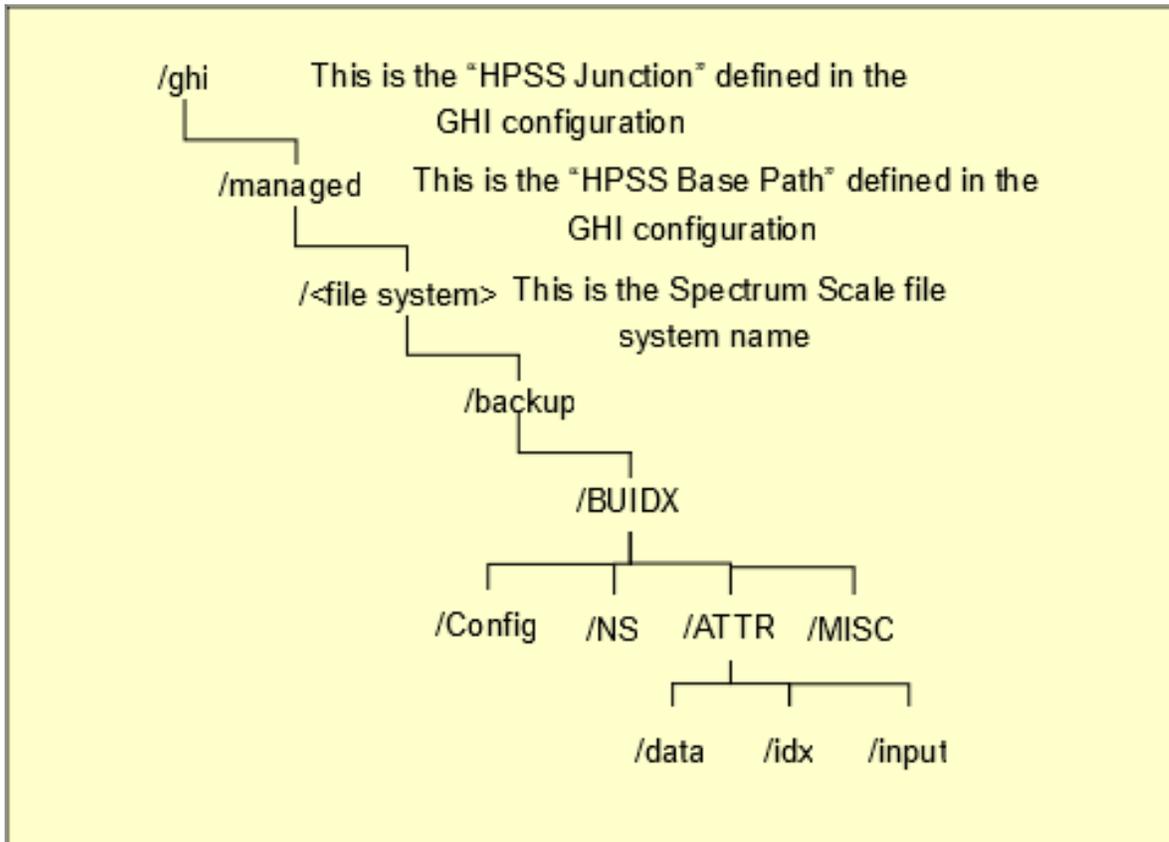


Figure 4 - Location of Backup Files in HPSS for non-image backups

Backups not taken with the Spectrum Scale image backup feature are stored in HPSS based on the snapshot ID at the time of the backup.

- **/ghi** – default root directory in HPSS for storing the Spectrum Scale backup files. This value can be reconfigured by running the **ghichfs** command. However, this value must not be changed unless the existing directory is empty.
- **File system** – Spectrum Scale file system name.
- **BU Index** – DB2 index associated with the backup.
- **Config, NS, ATTR and MISC directories** – Based on type of files.
 - **Config** – contains the Spectrum Scale cluster and file system configuration information.
 - **NS** – contains the Spectrum Scale namespace file attribute information.
 - **ATTR** – contains aggregate file information.
 - **MISC** – contains the Spectrum Scale quota files and the version file.

Files in an Image Backup via mmimgbackup

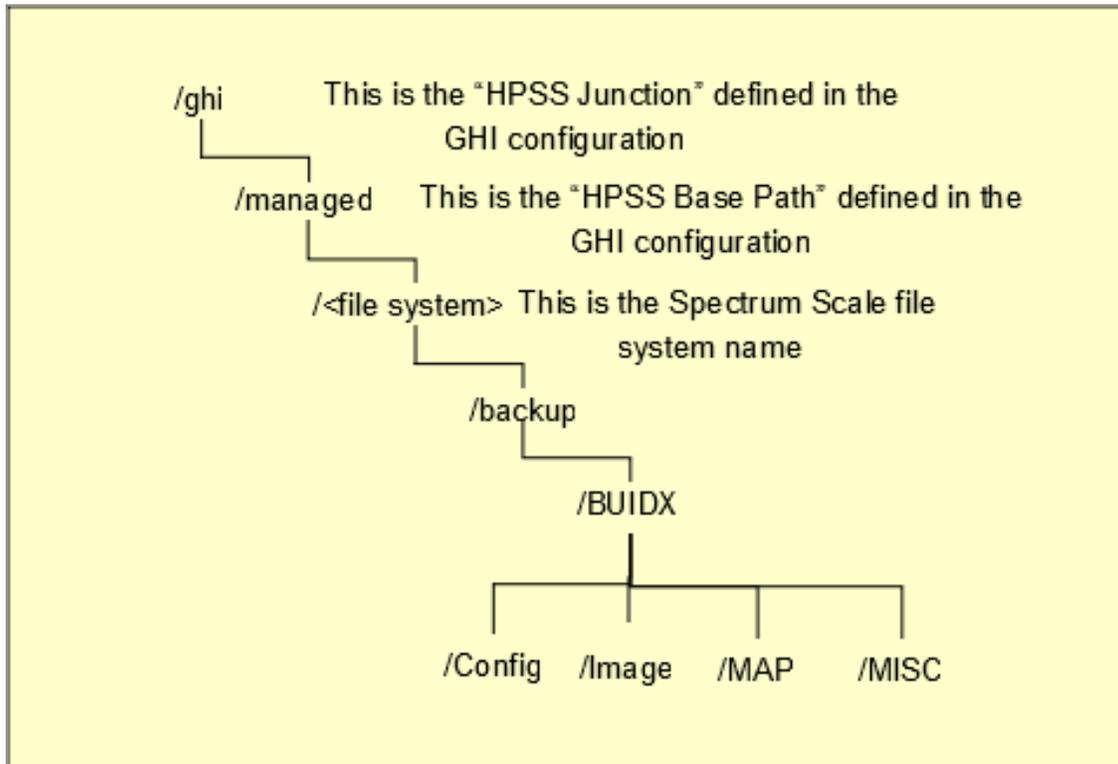


Figure 5 – Location of image backup files in HPSS

Image backup files are stored in HPSS based on the backup index of the backup.

- **/ghi** – default root directory in HPSS for storing the Spectrum Scale backup files. This value can be reconfigured by running **ghichfs**. However, this value must not be changed unless the existing directory is empty.
- **File system** – Spectrum Scale file system name.
- **BU Index** – DB2 index associated with the backup.
- **Config, Image and MISC directories** – Based on the type of files.
 - o **Config** – contains the Spectrum Scale cluster and file system configuration information.
 - o **Image** – contains the Spectrum Scale image backup files.
 - o **MAP** – contains the GHI mapping information for this backup.
 - o **MISC** – contains the Spectrum Scale quota files and the version file.

2.3.3 HPSS Characteristics

Classes of Service (COS)

Each file in HPSS is assigned a Class of Service (COS). The COS defines a set of parameters associated with operations and performance characteristics of a file. Refer to the HPSS Management Guide for information on COS. Each GHI file, which appears to HPSS as a user file, belongs to a COS which is selected when the file is created. The **Force Selection** flag can be

set in the COS definition in the HPSS GUI to prevent automatic selection. If the flag is set, that COS must be specified in the policy to be able to store files to it. There are three classes of GHI files written to HPSS:

- **Data files (aggregate and non-aggregate).** By default, a data file uses the Class of Service Maximum File Size Hints information passed to HPSS when the file is created. A policy can be defined to override the default COS by specifying a “*OPTS -c <COS>*” or “*OPTS -c <COS:auto>*.” in the policy for non-aggregates and aggregates respectively. For example, “*OPTS -c 5*” means that GHI will ignore the default COS and use COS 5 instead when migrating files.
- **Aggregate index files.** By default, these files are written to HPSS using the “Aggregate Index COS” in the GHI configuration. All aggregate index files for a file system will go to the same COS. The site can override the default COS by specifying “*OPTS -c <COS for data file>:<COS for index file>*” or “*OPTS -c auto:<COS for index file>*”. For example, “*OPTS -c auto:5*” means that GHI will migrate aggregate files using the default COS and the aggregate index files will be migrated using COS 5.
- **Backup Files.** These files are written to HPSS using the Backup COS in the GHI configuration. All backup files for a file system will go to the same COS.

The administrator can also specify a COS for individual rules in a policy run. This allows a site administrator to further configure policies to direct files to a specific Classes of Service.

HPSS File Families

HPSS files can be grouped into families. HPSS supports grouping files per file family for tape volumes only. All files in each family are stored on a set of tapes assigned to the family. When files are migrated from disk to tape, they are stored on a tape with other files in the same family. If no tape volume associated with the family is available, a newly imported blank tape is reassigned from the default family. The family affiliation is preserved when tapes are repacked.

Each GHI file belongs to a file family which is selected when either the file is created (tape-only COS) or when the file is migrated from disk to tape. File Families can be specified for each rule in a GHI policy. There are two types of GHI files that are associated with file families:

- **Data files (aggregate and non-aggregate).** By default, data files are not associated with a file family. However, a policy can be defined to specify the file family by adding an “*OPTS -f<file family>:auto*” or “*OPTS -f <file family>*” in the policy for aggregates and non-aggregates respectively.
- **Aggregate index files.** By default, these files are not associated with a file family. However, a policy can be defined to specify the file family by adding a “*OPTS -f auto:<file family>*” in the policy. The “auto” tells the system to not use a file family for the data file. However, the policy can be written as “*OPTS -f <file family>:<file family>*” to associate both the data and index files with the same or different file families.

There is currently no way to associate backup files with a file family.

HPSS Storage Subsystems

Storage Subsystems can be used to separate HPSS resources. Spectrum Scale files can be placed in their own resources based on the HPSS Storage Subsystem. GHI currently supports one subsystem per Spectrum Scale file system.

Please see the HPSS Management Guide for in-depth information on the three characteristics that GHI uses to determine where files should be stored in HPSS.

CHAPTER 3. GHI INTERNALS

3.1 Servers and Processes

A typical GHI system configuration consists of a single Primary Session Node, one or more designated Secondary Session Nodes for fail-over, multiple I/O Manager Nodes, and multiple Client nodes which do not run any GHI software. The Secondary Session Nodes can act as I/O Manager Nodes until they are told to take over as the Primary Session Node.

The Primary and Secondary Session Nodes MUST be designated on the Spectrum Scale nodes as quorum nodes. Spectrum Scale selects the Cluster Configuration Manager from one of the quorum nodes. GHI Session node processes run on the quorum node designated as the Cluster Configuration Manager. This section goes into detail on the responsibilities of the GHI servers and processes.

The figure below shows the basic architecture of an GHI system and the relationship to HPSS.

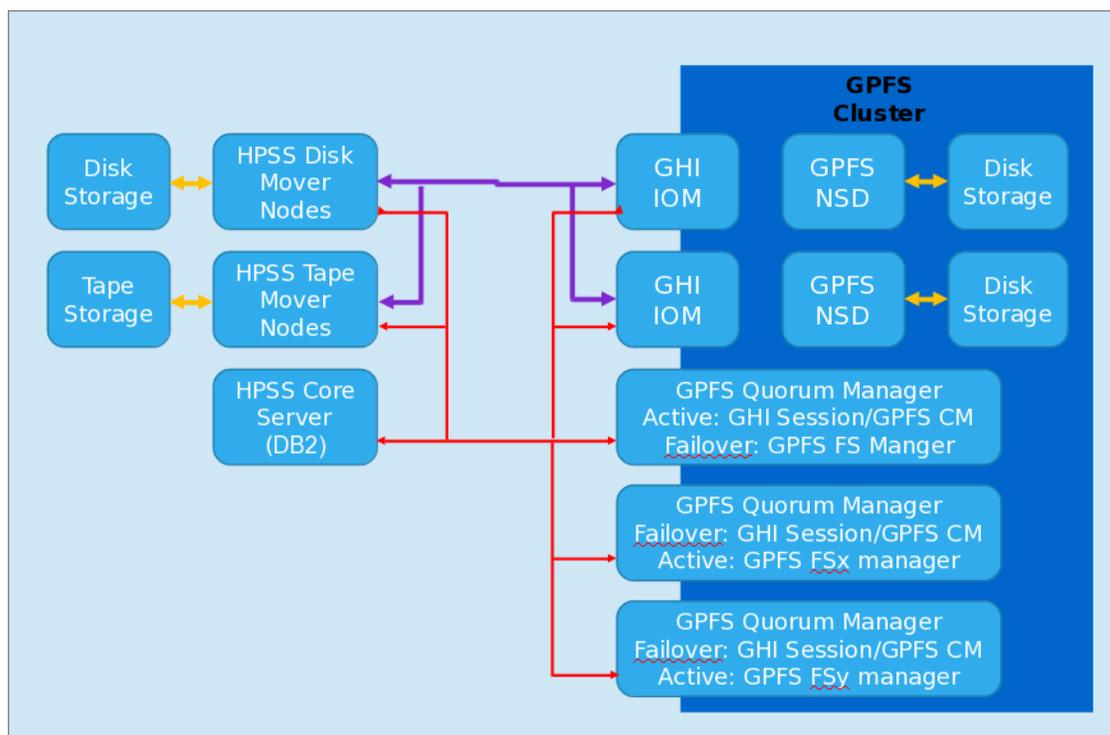


Figure 6 – HPSS and GHI

- **Process Manager (PM):** The Process Manager is responsible for the execution of the other Session Node processes. The PM is started by Spectrum Scale as part of its heartbeat mechanism. It is started with the Spectrum Scale Cluster Configuration Manager node start-up process by calling the GHI utility `hpssEventNotify`. When Spectrum Scale stop or loses quorum on the Session Node, the `hpssEventNotify` stops processes on the Session

Node. In the event of a failover, it starts the processes on another configured quorum node. The GHI Process Manager runs on the GHI Session Node. It is responsible for the following activities:

Starts and stops other GHI processes.

- a) On startup, the Process Manager starts the Mount Daemon and the GHI Configuration Manager as child processes.
 - b) The Process Manager, at the request of the Mount Daemon, starts/stops an Event Daemon and a Scheduler Daemon when the file system is mounted/unmounted on the Session node.
 - o Ensures the Mount Daemon, Configuration Manager, Event Daemon(s), and Scheduler Daemon(s) are running and that they can perform work, and minimizes system hangs from occurring.
 - o When one of the child processes dies, the Process Manager receives a SIGCHLD signal, this is an operating inter-process communication (IPC) signal. After receiving the signal, the Process Manager restarts that process.
- **Session Node:** A machine where a DMAPI session has been instantiated and the machine is registered to receive DMAPI events. The session node controls GHI activity. There can be only one session node active at a time. This node also functions as the Spectrum Scale Cluster Configuration Manager (CM) Node. If the CM moves, the Session Node will move with the CM. The session node processes are automatically started using Spectrum Scale Callbacks when the CM starts. The following GHI processes run on the Session Node:
 - o GHI Configuration Manager (one instance per cluster).
 - o Event Daemon (one instance per managed file system).
 - o Mount Daemon (one instance per cluster).
 - o Process Manager (one instance per cluster).
 - o Scheduler Daemon (one per managed file system).
 - o I/O Manager (if configured).
- **Configuration Manager (CM):** The CM is responsible for handling GHI configuration changes. GHI must be configured to run on every possible Spectrum Scale CM. GHI session node processes run on the CM.
- **Event Daemon (ED):** The Event Daemon runs on the Session node and is responsible for capturing DMAPI events for GHI managed files, including:
 - o Registers for DMAPI I/O (DESTROY, REMOVE, RENAME, READ, WRITE and TRUNCATE) events.
 - o Receives read, write, and truncate events for files from the DMAPI session queue and submits the requests to the GHI Scheduler Daemon. If running on a read-only file system, WRITE and TRUNCATE events are aborted (instead of passing the request to the GHI Scheduler Daemon).
 - o Receives DESTORY events for files from the DMAPI session queue and performs garbage collection logic on the file.
 - o Receives responses from the GHI Scheduler Daemon and responds to the user request.

- On a read-only file system, receives RENAME and REMOVE events for files from the DMAPI session queue and determines whether the files are being managed by GHI (i.e., they originated from a GHI backup of the associated full-access file system). If the files are managed by GHI, Spectrum Scale is instructed to abort the rename or remove operation. Thus, Spectrum Scale will not generate the usual subsequent DESTROY event for that file.
- **Mount Daemon (MD):** The Mount Daemon runs on the Session Node. It is responsible for the following activities:
 - Captures MOUNT and UNMOUNT events GHI managed file systems and instructs the Process Manager to start/stop the associated Event Daemon and Scheduler.
 - Processes remote mounts for DMAPI enabled file systems.
- **Scheduler Daemon (SD):** The Scheduler daemon runs on the Session Node and starts when the file system mounts. It is responsible for distributing work to the IOMs, including:
 - Accepts data transfer requests from the ED and ILM clients and schedules them in the queue based on their priority. The priority is Recall, Migrate, Admin, DMAPI and Backup. Once an event is scheduled, then it will not be over taken by a higher priority event. For example, if there are DMAPI stages in the queue, on a read-only file system, it immediately rejects requests to transfer data to HPSS.
 - Communicates with the I/O Managers to transfer data.
 - Provides a mechanism to transfer results to the ED and ILM clients.
 - Provides file system's full-access or read-only status.
 - Provides load balancing of I/O to the IOMs.
 - Detects an IOM failure and redistribute the work to other IOM machines.
 - Processes purge requests for threshold processing.
 - Filters out duplicate file requests. For example, a recall policy could be running recalling files and someone then performs a **ghi_stage** on one or more of these same files. The SD will filter out the duplicate requests.
- **I/O Manager (IOM):** A daemon that is responsible for data movement between Spectrum Scale and HPSS. The IOM starts via the **systemd** and remains in standby mode until the Spectrum Scale file system is mounted. The IOM can run on any Spectrum Scale node, although it is not recommended to run IOMs on the Network Shared Disk (NSD) node because the IOM will add an extra load that may decrease performance of the NSDs. The number of concurrent data transfers is limited to the configured thread pool size. The IOM is responsible for the following activities:
 - Spawns GHI-ISHTAR to perform aggregate data transfers.
 - Coordinates with HPSS to perform non-aggregate data transfers.
 - Receives Spectrum Scale metadata and namespace information and transfers them to HPSS during a non-SOBAR backup.
 - Retrieves Spectrum Scale metadata and namespace information from HPSS and forward to Spectrum Scale to effect file system restoration when the backup type is a non-SOBAR GHI backup.

GHI Session Node

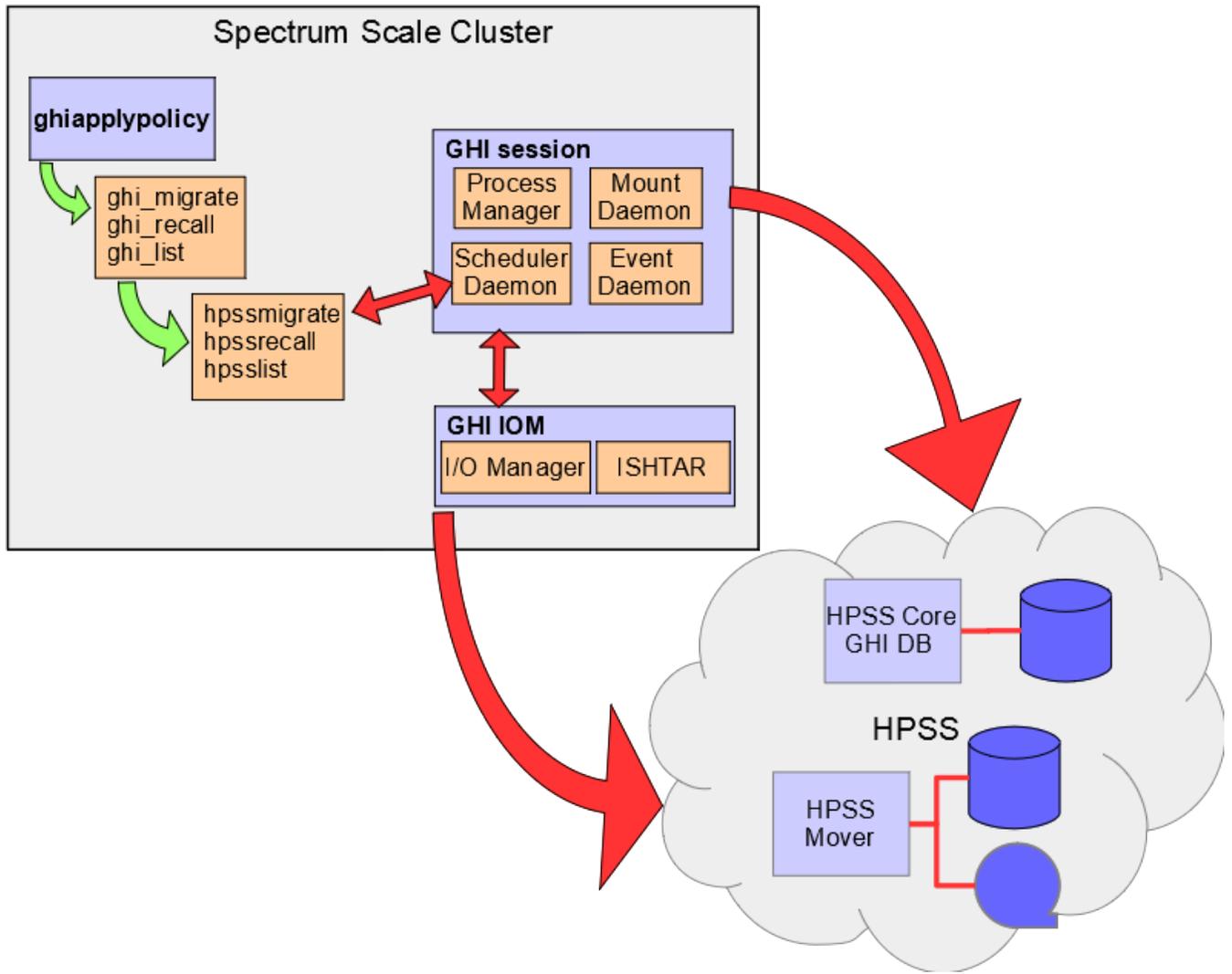


Figure 7 – GHI Session Node

GHI IOM

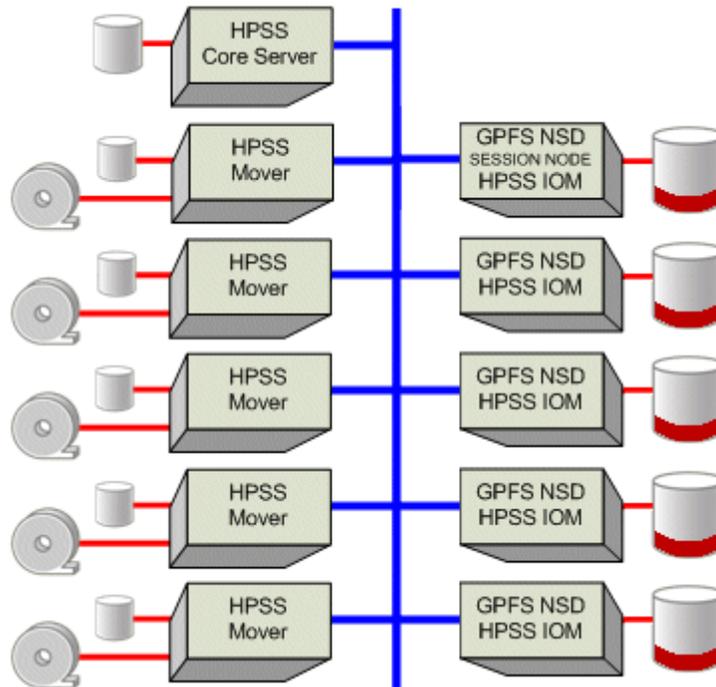


Figure 8 – GHI I/O Manager

- **ISHTAR:** Software that aggregate files before migrating them into HPSS. ISHTAR clients are installed on each I/O Manager node. The ISHTAR process is started via a script, **htar.ksh**, that resides in the `/var/hpss/hsi/bin/` directory. An ISHTAR process starts when an IOM requests processing of an aggregate. ISHTAR generates two files in HPSS, one file contains the data and the other file contains the index information. The GHI configuration setting “Max Aggregate Size” determines how many files are grouped into an aggregate. The Spectrum Scale ILM size option can also be used to construct aggregates. GHI aggregated data relies upon ISHTAR index files to always be available to the system. If an index is inaccessible (missing, damaged, or delayed for an extended period), retrieving user file contents are impacted, including to the point of failure by the end-user to access their files. Storage of the index files must be constructed to protect this data from media failures and/or catastrophic damage. Index files should be considered equivalent to HPSS metadata and require the use of mirrored disk copies as well as multiple tape copies to properly protect the data. This includes using remote or off-site backups of this vital information as one would do for HPSS DB2 metadata.

3.2 Infrastructure

The GHI infrastructure components common among servers are discussed in this section.

Remote Procedure Call (RPC). Most GHI servers communicate requests and status (control information) via RPCs. GHI does not use RPCs to transfer user data. RPCs provide a communication interface resembling simple, local procedure calls.

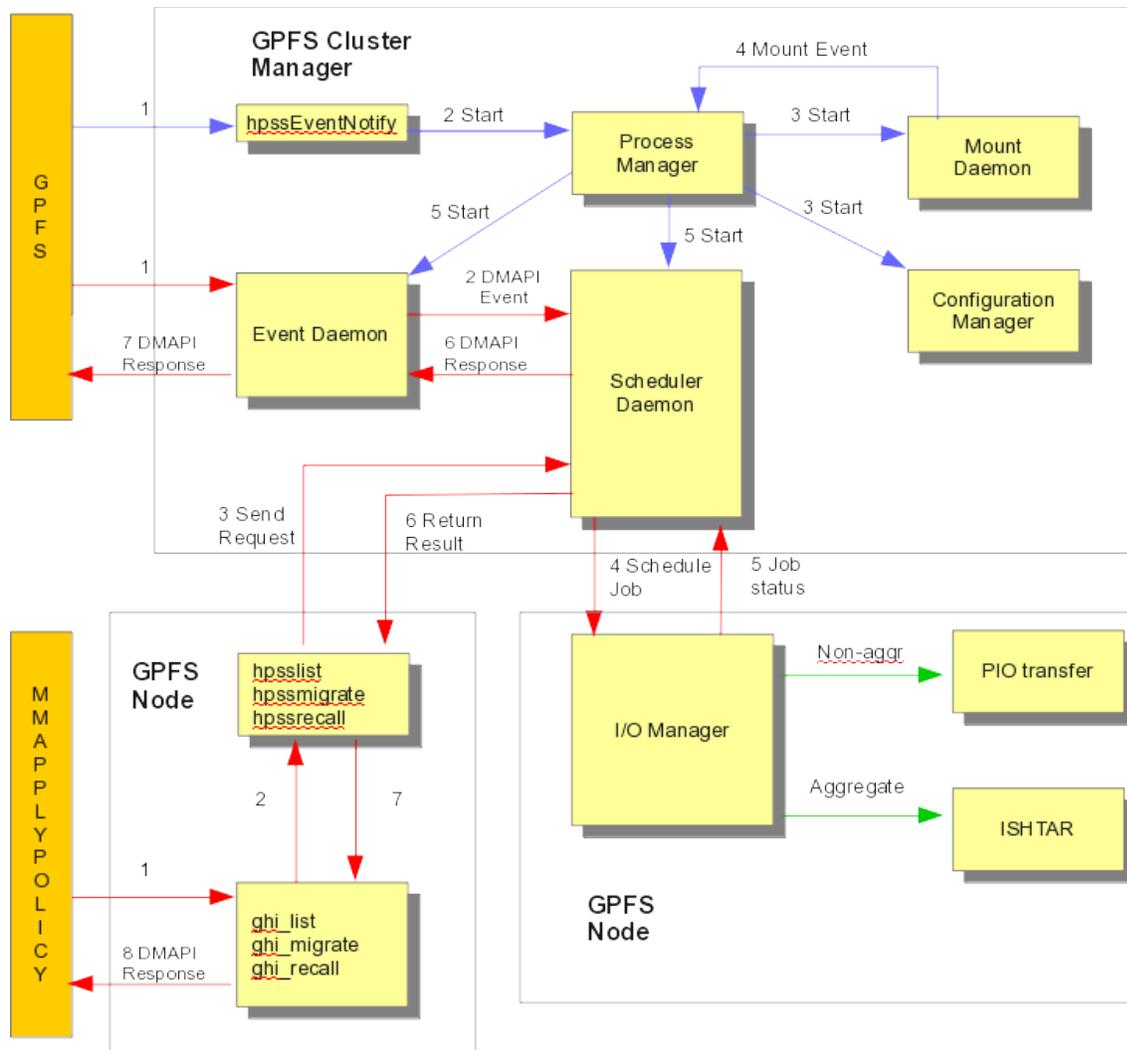


Figure 10 - Intra-Process Communication

Threads. GHI uses a threads package for multitasking. The threads package enables GHI to run two or more processes simultaneously.

Security. GHI uses the HPSS security software to authenticate, to authorize access to HPSS objects, to enforce access control on HPSS objects, and to issue log records for security-related events.

- **Authentication:** Responsible for guaranteeing that the GHI principal user, **hpssdmg**, is the entity that is claimed and that information received is from that entity.
- **Authorization:** Responsible for enabling an authenticated entity access to an allowed set of resources and objects. Authorization enables end user access to HPSS directories and files.
- **Enforcement:** Responsible for guaranteeing that operations are restricted to the authorized set of operations.

GHI components that communicate with each other maintain a joint security context. The security context for both sides of the communication contains identity and authorization information for the peer principals as well as an optional encryption key.

Logging. GHI uses **rsyslog** for logging. Changing the GHI logging levels will alter which log messages are sent to **rsyslog**. The logging levels can be changed per component and per file system. See the **rsyslog** man page for more information.

User Interfaces. GHI provides the user with a transfer interface, **ghiapplypolicy**. The interface is used to control the location where output files from the policy run are placed. It also controls the number of entries, i.e. bulk rates, of each of the output files.

3.3 Network

Because of its distributed nature and high-performance requirements, a GHI system is highly dependent on the infrastructure network to communicate between GHI, HPSS, and Spectrum Scale servers. For control communications (i.e., all communications except the actual transfer of data) among GHI servers, GHI requires TCP/IP services. Since control requests and replies are relatively small, a low-latency network is well suited to handle the control path.

The data path is logically separate from the control path but it may also be physically separate, although this is not required. For the data path, GHI supports the same TCP/IP networks as those supported for the control path. For large data transfers, the latency of the network may not impact the overall data throughput.

HPSS Core server must be able to connect to the network configured for Spectrum Scale.

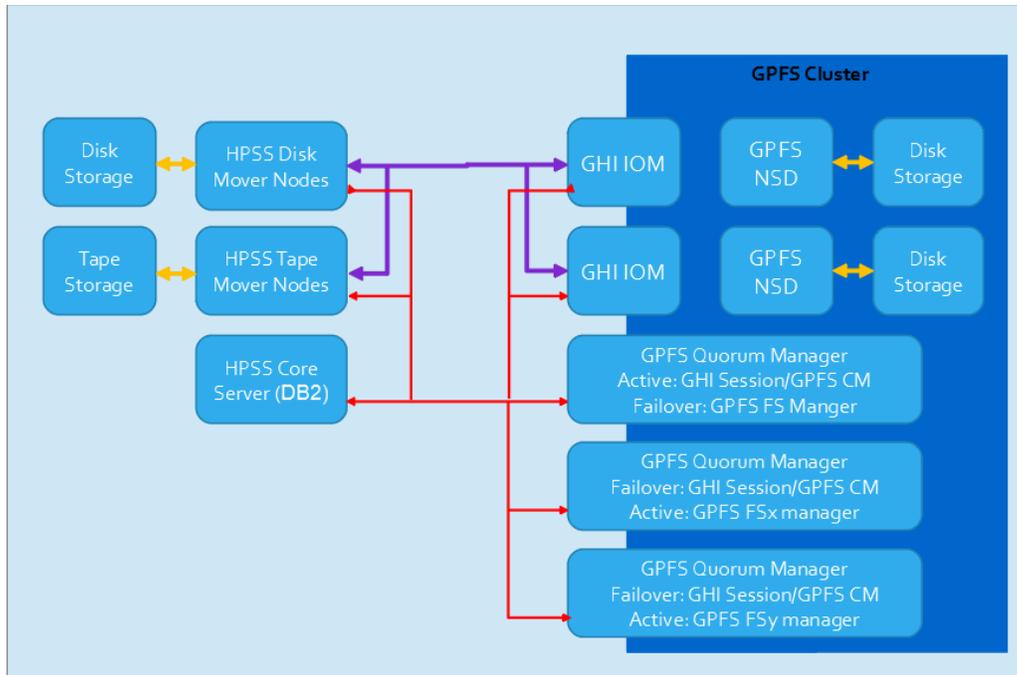


Figure 11 – HPSS/Spectrum Scale Network Map

Notice how the blue network only connects to the Spectrum Scale nodes and does not connect to the HPSS nodes, which means GHI cannot migrate data to HPSS. There is a connection from the Spectrum Scale nodes to the HPSS nodes, the red network. This is because GHI communicates over the same network that Spectrum Scale is configured for. To communicate to HPSS, there must be a network route to the HPSS Core Server or move the HPSS Core Server to the blue network. The data movement now can take place over the configured data network, the red network, because it is set up in the HPSS configuration using the `HPSS_API_HOSTNAME` in the `env.conf` file.

GHI supports using IPV6 addresses. The `HPSS_NET_FAMILY` can be set to `ipv4_only`, `ipv6`, or `ipv6_only`. This value must be set in `/var/hpss/etc/env.conf`, otherwise it will result in connection and data transfer errors.

3.4 ILM Policy

GHI uses Spectrum Scale ILM policies to select files for migrations, purges, recalls, and backups. The administrator decides when to run each policy. GHI has a special command, **ghiapplypolicy**, that runs the policies on Spectrum Scale nodes that are configured for GHI. **ghiapplypolicy** is a wrapper for the Spectrum Scale **mmapplypolicy** command.

When Spectrum Scale processes a policy, the policy's rules are processed in the order in which they appear in the policy. Files which are rejected by a rule will not be considered under subsequent rules. Files which are selected by a rule are passed on for processing under the next rule. To avoid delays in processing the policy, the policy should be constructed so that rules that select the least number of files or reject the greatest number of files are listed first in the policy file. For example, if it is only desired to migrate un-migrated files within `/ghi/users/joe/` and `/ghi/users/john/`, the policy could be written to first select all non-migrated files and

then those in the two directories. Or, it could be written to first select only files in the two directories and then only those [from the two directories] which are not migrated. The second option will result in a faster policy run assuming these two directories contain only a small fraction of the total files on the file system.

The Spectrum Scale ILM migration policy provides the capability for GHI to copy (migrate) files from Spectrum Scale to HPSS. The migration policy identifies files that are new or recently modified that need to be copied to the HPSS repository. GHI processes the lists of files that have been identified and copies them from Spectrum Scale to HPSS. Larger files are usually copied straight to HPSS, while the smaller files are usually aggregated via GHI-ISHTAR into larger HPSS objects.

The Spectrum Scale ILM purge policy provides the capability for GHI to space manage the Spectrum Scale file system. New and updated Spectrum Scale files are copied to HPSS on a periodic basis. When the Spectrum Scale file system reaches a pre-defined space threshold, the ILM purge policy is invoked to identify file candidates whose data can be removed from the file system. The ILM purge policy identifies the older, larger files as candidates. GHI “punches a hole” in the files that have been identified to free Spectrum Scale disk resources. The inode and metadata for these files are left in the Spectrum Scale file system, so from the user’s point of view, nothing about these files has changed.

The Spectrum Scale ILM recall policy provides the capability for GHI to stage files in bulk from HPSS back to Spectrum Scale. The site administrator needs to create an ILM policy rule to stage a given set of files back from HPSS. These requests are optimized because files located on the same tape are recalled together to minimize tape mounts.

The Spectrum Scale ILM backup policy provides the capability for GHI to make a point-in-time backup of the Spectrum Scale file system. The ILM backup policy generates lists of files that need to be migrated, the file system namespace information, and a list of the Spectrum Scale files to be used to gather file attributes.

Administrators need to customize the policies to meet their needs. If a site has a large amount of disk file write activity, the administrator may want to have more free space and therefore run the purge policy frequently. However, if a site has a large amount of file read activity, the administrator may want to leave files on disk longer which means they would run the purge policy less frequently.

The result of a policy execution generates multiple ***.exc** and a ***.ok** files. The exception files (*.exc) contains all the files that failed during the policy run. The okay (*.ok) files contain all the files that were successfully transferred. General options used by the policy files are:

- d**: The “-d” option keeps both the exception files and the okay files from being deleted when the policy run is complete.

- D**: The “dirty flag” option keeps the exception and okay files, and the generated policy files from being deleted.

If files are retained following the policy run, it is up to the administrator to clean those files out.

Note. It is important to monitor the ILM policies to ensure they complete without errors. Some, errors in the migration process may cause the file system to fill up, or backups may not complete, etc.

Migrate Policy – migrate.policy

The migrate policy defines how and which files are selected for migration into HPSS. GHI uses the directory /<file system>/scratch/.ghi to store temporary files during a migration, therefore this directory should be omitted from the migrate policy. Additionally, you should exclude files that are already in HPSS and Spectrum Scale (co-managed), or files that are zero length in size. The migrate policy template file supplied with GHI includes these three rules by default.

The “Max Aggregate Files” sets the maximum number of files in an aggregate for migration. For example, if the Max Aggregate Files is set to 100 and 500 files are candidates to be migrated, then five files each containing a file list of 100 files will be generated from the policy engine. If all 500 files are selected for aggregation, then five 100 file ISHTAR aggregated objects will be created in HPSS. If some number of these 500 files end up being migrated into HPSS as individual (non-aggregated) objects, then fewer than 5 aggregates would be created in HPSS.

This figure shows what occurs when **ghiapplypolicy** is called to start a migration.

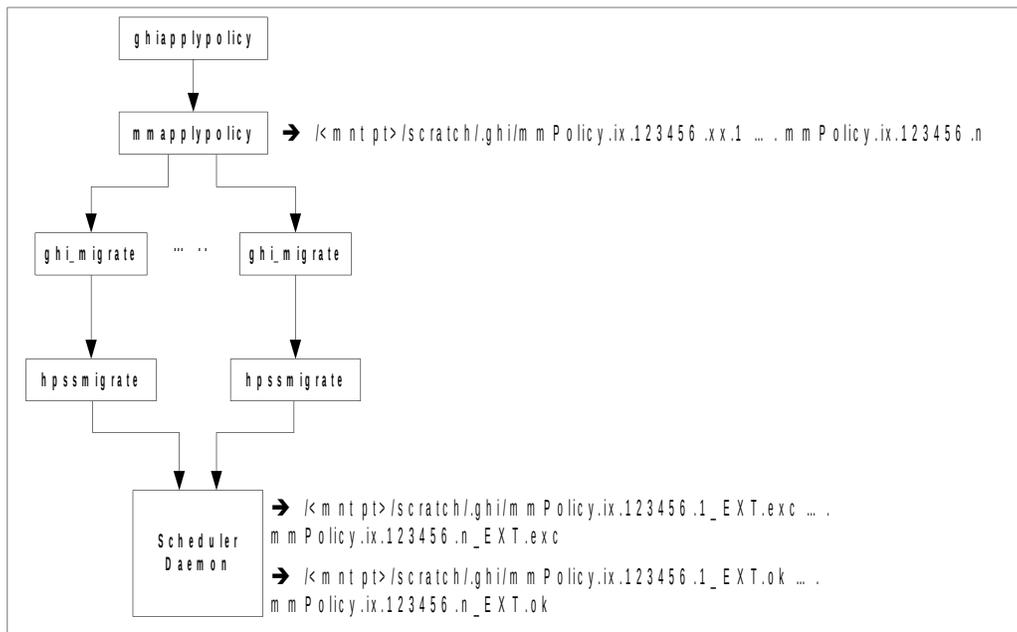


Figure 12 – ghi_migrate

Recall Policy – recall.policy

The recall policy defines which files are selected for recall from HPSS to Spectrum Scale. GHI uses the directory /<file system>/scratch/.ghi to store temporary files during a recall, therefore this directory should be omitted from the recall policy. Additionally, you should

exclude files that are not co-managed. The recall policy template supplied with GHI includes these two rules by default.

The policy generates one list for recalls. The list is parsed into aggregate and non-aggregate files. Aggregates are sorted based on where aggregates are in HPSS. The results of the sort are sent to the Scheduler Daemon on a per-aggregate basis, which allows GHI to make a single request to ISHTAR to retrieve all files from that aggregate. Non-aggregate files are sorted by the tape that contains the files and the file position on the tape.

Backup Policies

There are two parts to the backup: the migration of data and the backup of namespace and attribute files. The migration of data uses the migration policy. Backing up the namespace and attribute files is performed via the Spectrum Scale **mmimgbackup** command. Any attempt to take a GHI backup of a Spectrum Scale read-only file system will fail.

Threshold Policy – threshold.policy

The threshold policy is configured directly with Spectrum Scale and will start automatically to purge or punch holes in the Spectrum Scale file system to free space. There are four components in the policy that need to be configured. The first two are the high and low watermarks. When the Spectrum Scale file system is filled to the high watermark, then the purge is started, and will continue until the file system reaches the low water mark and stops. The next component is the path in which the files will be purged. Finally, the file sizes that are going to be purged. Here is an example of a rule in the **threshold.policy**:

```
RULE 'toHsm1' MIGRATE FROM POOL 'system'  
      THRESHOLD(85,55)  
      WEIGHT(CURRENT_TIMESTAMP - ACCESS_TIME)  
      TO POOL 'hsm_punch'  
      WHERE path_name LIKE '/mount/point/%'  
      WHERE FILE_SIZE > 262144
```

The high watermark is 85% full, and the low is 55%. The path is defined by the path_name. Finally, any file greater than FILE_SIZE could become a candidate for purging. Any file smaller will not be purged.

CHAPTER 4. GHI CONFIGURATION DIRECTORIES

System memory and disk space requirements for nodes where the GHI processes run depend on the configuration of the servers, the nodes that each server will run on, and the amount of concurrent access they are configured to handle. At least 8 GB of memory is required for the Spectrum Scale cluster nodes running GHI processes. When Spectrum Scale is running an ILM policy scan, it consumes a considerable amount of memory. Paging space should be sized with the same amount of space as the memory.

4.1 Data

When GHI is installed on the Spectrum Scale cluster, several directories are installed, each requiring approximately 15MB of disk space. GHI uses space on the Spectrum Scale file system for temporary files, ILM policy output, and GHI-ISHTAR, in `/<mountpoint>/scratch/.ghi`.

/opt/hpss. Contains HPSS and GHI binaries, source code, include files, libraries, and utilities. The GHI software is installed in the `/opt/hpss/src/ghi` directory.

/var/hpss. The default location of HPSS and GHI configuration files and other files needed by the servers. It is required that this file system be at least 1 GB in size. Within `/var/hpss`, the following subdirectories are:

/var/hpss/cred. The default directory where credential files are placed. These files are typically very small.

/var/hpss/etc. The default directory where some additional HPSS configuration files are placed. These files are typically very small.

/var/hpss/ghi. The default directory where GHI files are located. There are five sub-directories: `config`, `etc`, `log`, `policy`, and `tmp`. The HPSS environment variable `$HPSS_GHI_ETC_PATH` contains the base path to the GHI `/var/hpss/ghi/etc/` directory.

/var/hpss/ghi/tmp. The default directory where the Process Manager creates a lock file for each GHI process it starts. GHI may also write diagnostic log files and performance files here. The lock files are very small; the log files may get into the MB range; the performance files can easily grow into GB or even larger. Performance monitoring, which results in creation of performance files, is normally disabled because of its large file size.

/var/hpss/adm/core. The default directory where GHI servers put core files when GHI processes terminate abnormally. Core files may be large so it is required there be at least 2 GB reserved for this purpose on the Session node and at least 1 GB on IOM nodes.

Note. The administrator needs to remove unwanted core files to prevent `/var/hpss` from filling up.

`/var/hpss/hpssdb`. The location where the GHI database instance is stored. The database is used to access the DB2 server on the HPSS Core Server. The minimum file system size required is 20-30 MB for the runtime DB2 client, but should be larger to accommodate DB2 logs.

4.2 Metadata

The GHI backup, garbage collection, and mapping metadata is stored in the HGHI DB2 database of the HPSS Core Server.

The backup table has one row, 48 bytes in length, generated each time a GHI backup is performed. Rows in the table are added each time a backup is initiated and are never deleted. Rows are modified when a backup is deleted and when files are restored. The columns for the backup table contain the backup index, time stamp of the backup, snapshot ID, and the backup status. The backup index is unique for each backup and is how the admin selects a backup. The snapshot ID is a unique ID created when the Spectrum Scale `mmcrsnapshot` command is ran as part of a GHI backup. The status of a backup can be in one of the following eight states:

- Pending – Next Backup index to be used.
- In progress – Backup is in progress.
- Failed – The Backup did not complete successfully and cannot be used for a restore.
- Complete – Completed successfully and can be used if a restore is needed.
- Deleted – Backup has been deleted.
- Deleting – The Backup is being deleted, or was in the process of being delete when it was interrupted and therefore needs to be restarted.
- Invalidated – A backup is not valid. This happens if you restore a backup that is not the latest. For example, BU5 is invalidated if BU4 is restored.
- Restore – A backup is being restored. Once restore completes, the backup will become Complete again.

The garbage collection table has one row, 76 bytes in length, generated for each deleted file in a backup. Rows are added each time a GHI-managed file is deleted from Spectrum Scale or altered. Rows are deleted when backups are deleted and the row meets the deletion criteria. When a row is deleted, the file it represents in HPSS is deleted. The columns in the garbage collection table contain the SOID (storage object identifier), ordinal, migration index, and delete index, ordinal, state, and count. The SOID is how the file in HPSS is represented in DB2. The ordinal is where the file is in the aggregate. The migration index is the index when file what migrate.

The mapping table has one row, 2176 bytes in length, per file in the Spectrum Scale file system for each backup loaded into the DB2 table. For example, a file is written and three backups are taken, then the file is deleted, and three more backups are taken, now there are six backups loaded into the mapping table. There are three rows for this file, one for each backup it is contained in. Rows are added and deleted by using the GHI mapping utilities.

The DB2 backup script that is packaged with the HPSS Core RPM does not include provisions to back up the GHI database. The administrator must modify the script to include HGHI in the daily DB2 backups.

CHAPTER 5. GHI FEATURES

GHI includes many features to help the administrator manage the system. A few of those features are highlighted in this chapter.

5.1 Mapping

The purpose of the GHI Mapping is to create maps of the GHI backups that will tell the administrator which Spectrum Scale files point to which HPSS files and to which inode and igen. The mapping can also be used to locate and restore a file from a previous backup. One key feature of this tool is once the map is loaded and DB2 is accessible, the map can be used with or without access to GHI or HPSS. With this map, the user can locate the file using the Spectrum Scale file name, the HPSS file name, or the inode/igen assigned to the file in Spectrum Scale. GHI backups from version 2.4.0.1 and prior version cannot have their backups mapped.

To create the mapping table:

1. Create the tablespace - see the *GHI 3.0 Installation Guide for instructions*.
2. Use **ghiCreateMapping** to make a base table for the file system. This is a one-time command to make the base table.
3. Use **ghiLoadMapping** to load all the backups that are GHI 2.5 and greater:

```
% /opt/hpss/bin/ghiLoadMapping <file system> <backup index>
```

Once all the backups are loaded, the administrator can search for files using the HPSS file name, Spectrum Scale file name, or Spectrum Scale inode using **ghiSearchMapping**:

```
% /opt/hpss/bin/ghiSearchMapping <file system> [-h|-g|-i] <value>
```

After a GHI backup is deleted, the administrator needs to unload the deleted backup from the mapping table with **ghiUnloadMapping**.

```
% /opt/hpss/bin/ghiUnloadMapping <file system> <buidx>
```

The GHI Mapping tables will take up space in the GHI database. Plan for the additional space. You can reduce the amount of space the mapping table uses by decreasing the number of valid GHI backups. Load the mapping information only when needed.

5.2 HTAR Repack

This feature allows the administrator to identify sparse aggregates and combines them into new aggregates to free up space. This works by resetting the attributes of files that have already been migrated to HPSS, and re-migrating them as more complete aggregates during the next migration or backup. This means a migration will need to be run after the **ghirepackfs** command is complete. After the **ghirepackfs** command finishes, the User Defined Attributes (UDA) will be updated on the old aggregate file in HPSS to be deleted when the backups that reference those files are deleted.

There are two ways to perform **ghirepackfs**. The first is based on a percentage of deleted files to active files in an aggregate to repack. When files in Spectrum Scale that are members of a GHI-HTAR aggregate are deleted and processed through the garbage collection table, the UDAs on the HPSS files are updated to reflect the number of deleted files in that aggregate:

```
scrub> udalist
//ghi/davis-1/2017/08/1306/AGG.d4b316cc-812a-11e7-b49b-00215ec467d4
```

Found 3 attributes:

KEY	VALUE
/hpss/ghi/Midx	7
/hpss/ghi/aggr/total	5000
/hpss/ghi/aggr/deleted	187

```
scrub>
```

The administrator can provide this percentage to the **ghirepackfs** command for GHI to repack these aggregates. To use this method, the administrator must first create a GHI mapping table, load all the current backups into it, and unload all the deleted backups from it. The old aggregate files are then cleaned up when the backups that reference them are deleted. To run the tool, select a starting point ratio and test it to see how many files are selected. In this example, the ratio is 50%

```
% /opt/hpss/bin/ghirepackfs <file system> -Tv -r 50
```

The second way is for the administrator to create a list of HPSS aggregate files to repack and pass that to the **ghirepackfs** command. This method does not require the mapping tables to be in place or up to date. Once the files are selected to be repacked by either method, GHI stages the data to be repacked back to Spectrum Scale and on the next migration or backup, the data is re-migrated into complete aggregates. The tool can also repack specific aggregates by using the force option:

```
% /opt/hpss/bin/ghirepackfs <file system> -v -f /tmp/filelist
```

Where /tmp/filelist is a list of the ISHTAR files names. This tool does not accept Spectrum Scale file names. The GHI backups do not have to be loaded into the mapping table for the -f option to work.

IBM recommends you use this utility on a quarterly basis, after a month's worth of GHI backups have been deleted, or if there is a directory that has several aggregates.

5.3 File System Verification

There is a tool to check the file system for three types of inconsistencies: Spectrum Scale metadata, orphan files, and UDA mismatch files. Spectrum Scale metadata inconsistencies are

Spectrum Scale files that do not have a corresponding HPSS file. Orphan files are HPSS files that do not have a corresponding Spectrum Scale file. UDA mismatch checks the aggregate file's metadata for incorrect counts of destroy/delete events. Before the administrator can run the orphan or UDA mismatch arguments, the administrator must first create a GHI Mapping table, load all the current backups into it and unload all the deleted backups from it. The Spectrum Scale metadata inconsistencies argument does not require the Mapping table.

To check for Spectrum Scale files with incorrect metadata, run the command after a completed migration:

```
% /opt/hpss/bin/ghiverifyfs -f
```

To check for orphan files in HPSS, first create a GHI Mapping table, load all current valid (i.e. successful) backups into it, unload all the deleted backups, and run:

```
% /opt/hpss/bin/ghiverifyfs -o
```

To check for UDA mismatch, first create a GHI Mapping table, load all current valid (i.e. successful) backups into the map, unload all deleted backups, and run:

```
% /opt/hpss/bin/ghiverifyfs -u
```

This tool does not need to be run very often. The Spectrum Scale metadata inconsistency check runs as part of a GHI backup. Use the orphan file flag to check the system about once a year or after a suspected discrepancy between Spectrum Scale and HPSS. Your GHI support representative will ask you to run the UDA verification if there is a problem, otherwise it does not need to be run. Performance of each command will vary from system to system, but the arguments that require the GHI mapping table to be searched will take longer to complete. The number of files in a file system will also impact the performance; the more files, the longer it will take.

5.4 File System Logging

GHI messages are sent to **rsyslog**, which is an open-source software utility that permits the logging of data in a central repository. **rsyslog** needs to be configured to print DEBUG log level messages. There are 17 levels of logging available for each GHI process. Processes do not have to be restarted if the logging level is changed. Configure logging in `/etc/rsyslog.conf` to filter specific log messages. The following changes to `/etc/rsyslog.conf` are recommended:

- Change System Log Rate Limit Interval to 0
`$SystemLogRateLimitInterval 0`
- Change the Format of log messages
`$template myFormat,"%timegenerated% %HOSTNAME% %syslogseverity-text%\n [%programname%]\n %msg%\n`
`$ActionFileDefaultTemplate myFormat`
- Turn off Repeated Log Messages
`$RepeatedMsgReduction on`
- Allow anything debug or higher to be routed to `/var/log/messages`
`*.debug;mail.none;authpriv.none;cron.none /var/log/messages`

Starting in GHI 3.0, the log facility number can be configured. To configure the log facility number, follow the steps below:

1. From your GHI source directory, copy the file `templates/syslog.conf.template` to `/var/hpss/ghi/etc/syslog.conf`.
2. Open the file and set the `FACILITY_CODE` to one of the following values and save the file.

```
# The following are valid facility codes
# LOG_USER - Messages generated by user processes. This is the default facility
# when none is specified.
# LOG_MAIL - Messages generated by the mail system
# LOG_DAEMON - Messages generated by system daemons.
# LOG_AUTH - Messages generated by the authorization system: login, su, and
# so
# on.
# LOG_AUTHPRIV - private security/authorization messages
# LOG_FTP - Messages generated by the ftp daemon
# LOG_LPR - Messages generated by the line printer spooling system.
# LOG_LOCAL0 - Reserved for local use.
# LOG_LOCAL1 - Reserved for local use.
# LOG_LOCAL2 - Reserved for local use.
# LOG_LOCAL3 - Reserved for local use.
# LOG_LOCAL4 - Reserved for local use.
# LOG_LOCAL5 - Reserved for local use.
# LOG_LOCAL6 - Reserved for local use.
# LOG_LOCAL7 - Reserved for local use.
# LOG_NEWS - Messages generated by USENET news subsystem
# LOG_UUCP - Messages generated by UUCP subsystem
```

3. If you need to redirect your log messages to somewhere other than `/var/log/messages`, modify the `/etc/rsyslog.conf` file to indicate where you want to redirect them to.
4. If you change the `rsyslog.conf` file, restart the **rsyslog** service using the command
`% systemctl restart rsyslog`

5.5 Stage on Demand

The purpose of this tool is to allow administrators to turn off DMAPi stages to prevent users from excessively issuing stages that lock up HPSS tape resources. If a file is being staged by the IOM when Stage on Demand is enabled, the file will continue to stage uninterrupted. Future stages will fail, and return an error number (configured by the administrator), until Stage on Demand is disabled.

5.6 ISHTAR

ISHTAR is a tool that GHI uses to aggregate small files from Spectrum Scale to HPSS. This is a change from GHI-HTAR because ISHTAR uses the HPSS Client API instead of an HSI Gateway. Other than implementation, ISHTAR behaves the same as GHI-HTAR. Please refer to the *GHI Install Guide* for information on how to install and configure ISHTAR.

5.7 Memcached

Memcached is an open-source, high-performance, distributed memory object caching system intended for use in improving the HPSS Name Server (NS) performance. Some GHI operations require looking up many NS objects, sometimes the same NS object repeatedly in the same operation. **Memcached** will increase the performance of GHI's NS operations while also decreasing the load on the NS itself. The GHI operations include full (non-image) backups, image backup verification steps, and **ghi_ls** on a large set of files. Please refer to the *GHI Install Guide* for information on how to install and configure **memcached**.

CHAPTER 6. PROCESS FAILURE AND RECOVERY

GHI provides a fault tolerant system to keep the file system online and available. Spectrum Scale supports a means for GHI to provide exit scripts to be notified when there are changes in the quorum. This mechanism will allow GHI to either move the processes to another node, or do what is needed to stay running on the existing node. There are currently eight (8) events that can be captured for this purpose: init, ready, up, down, node failure, file system recovery, pre-unmount, and quorum loss. The events will invoke either a single “user” defined script, a High Available/NFS defined script, or both. The scripts will be invoked on those nodes that have the exit script installed.

6.1 Node Failures

6.1.1 Session Node

The node defined as the Session node is selected by Spectrum Scale when the system is brought online. It is typically the node that is the Spectrum Scale Cluster Configuration Manager node. GHI utilizes the Spectrum Scale heartbeat mechanism to monitor the nodes in the cluster that are potential Session node candidates. During startup, Spectrum Scale executes the script, **hpssEventNotify**, to start all GHI processes and mount the file systems. Likewise, during failure, Spectrum Scale executes the script, **hpssEventNotify**, to unmount the file systems and stop all GHI processes. If the node fails and another node needs to take over, Spectrum Scale selects the new Session node.

6.1.2 Manager Node

The nodes running the I/O Managers start the processes using **systemd**. The I/O Managers, once started, remain idle until the file system is mounted on that node. If a file system is subsequently un-mounted, its associated IOM will go back to being idle. If an I/O Manager node fails, there are two scenarios that can follow:

1. The Scheduler loses the connection to the I/O Manager, cancels all requests to the failed I/O Manager, and sends them to a new I/O Manager that is active.
2. If a policy script was running on the node that failed, the policy manager will be notified that the request failed. In the case of a backup, the backup must be rerun. In the case of a migration/recall/purge, no user action will need to be taken because the process will resume from the time of the failure.

6.1.2 Client Node

There is no special failover logic for a client node. If the node fails, the I/O Manager detects a failure completing the data transfer. There is retry logic in the IOM to retry the data transfer, if the request is for a non-aggregate. For an ISHTAR request, the IOM does not spawn a new ISHTAR process if the return from ISHTAR indicates a failure.

6.2 Single Process Failures

6.2.1 ILM Client

The processes, **hpssmigrate**, **hpssrecall**, and **hpsslist**, are started from the corresponding **ghi_migrate**, **ghi_recall**, and **ghi_list** policy scripts to perform the requested action. They are used to bridge the communication between the scripts and the GHI Scheduler. If one of the GHI script detects that the HPSS process has terminated abnormally, the process will be restarted. The new process will start processing the policy file from the beginning.

6.2.1 Process Daemon

In the case of an error or termination of Spectrum Scale on the GHI Session node, the **hpssEventNotify** script will be executed. This script shuts down the GHI processes by notifying the Process Manager to shut the other processes down and then terminate itself.

6.2.1 Mount Daemon

If the Mount Daemon abnormally terminates, the Process Manager automatically restarts it. There is no special recovery logic for this process. File systems cannot be mounted if the Mount Daemon fails. The mount or unmount request hangs and the user will need to kill and retry the mount or unmount request. Mount and unmount requests can only be handled when the Mount Daemon is registered to receive those DMAPI events.

6.2.2 Configuration Manager Daemon

Failure of the GHI Configuration Manager Daemon will impact system operability by inhibiting the capability to make configuration changes and by loss of periodic cross-cluster consistency checks. If the *GHI Configuration Manager* Daemon abnormally terminates, the Process Manager automatically restarts it. There is no special recovery logic for the Mount daemon.

6.2.3 Event Daemon

The Event Daemon is started and monitored by the Process Manager via a request from the Mount Daemon when a file system is mounted, and terminated via a request from the Mount Daemon when a file system is un-mounted. Failure of the Event Daemon will have a severe effect on the file system since the process is tightly coupled to file system user activity. For example, if the Event Daemon stops responding to synchronous events, the user processes that generated the events will block indefinitely.

If the Event Daemon abnormally terminates, the Process Manager automatically restarts it. Upon restart, it will assume the current Session ID and check for outstanding DMAPI events. The ED will add the events to the internal queue and wait for responses from the Scheduler. It will then do normal processing and wait for new DMAPI events.

6.2.4 Scheduler Daemon

The Scheduler Daemon is started and monitored by the Process Manager via a request from the Mount Daemon when a file system is mounted, and terminated via a request from the Mount Daemon when a file system is un-mounted. If the Scheduler process abnormally terminates, the Process Manager will restart it. There is no special recover logic for this process. The outstanding scheduled tasks will be lost, as well as the tasks being worked by the IOMs. All

client requests that were being processed by the Scheduler at the time it terminated will result in failures to the client.

6.2.5 I/O Manager

I/O Managers are started using the **inittab** on the IOM host systems. If the I/O Manager abnormally terminates, it is automatically restarted by **inittab**. It will then wait for new requests from the Scheduler. If the Scheduler Daemon detects that an I/O Manager has abnormally terminated, it attempts to re-assign its workload to another IOM(s). There is no special recovery logic for this process.

6.3 Multiple Process Failures

6.3.1 ILM Client and Scheduler

If one or more ILM clients abnormally terminate and the Scheduler terminates as well, the original request must be resent when the client and Scheduler are restarted.

6.3.2 Scheduler and Event Daemon

If the Scheduler and Event Daemon abnormally terminates, the Process Manager will automatically restart both processes. Upon restart, the Event Daemon sends any outstanding DMAPI requests to be processed. Those requests are sent to one or more I/O Managers, and if the files have already been staged, the managed regions will be updated if needed and a successful response will be sent back to the application. Otherwise, the I/O Manager will stage the file.

6.3.3 Scheduler and I/O Manager

If the Scheduler and one or more I/O Managers abnormally terminates, the Process Manager will restart the Scheduler, and the I/O Manager(s) will be restarted by **inittab**. All requests at the time of the failure must be retried by the application. The Event Daemon will resend all DMAPI requests which may cause duplicate stages.

6.4 HPSS Unavailable

When HPSS is unavailable, most file system operations will continue to work. The operations that require data to be transferred between Spectrum Scale and HPSS will fail. The following operations will fail:

- User read events on co-managed files. Files where the data only reside in HPSS cannot be staged back to Spectrum Scale.
 - When a user requests the file through a DMAPI event, an abort will be sent to the application.
- All policy manager executions.
 - Files that are recalled using the ILM interface will return an error to **ghiapplypolicy**. Files that are to be migrated/pre-migrated using the ILM interface will return an error to **ghiapplypolicy**.
 - Backups will fail with an error.

CHAPTER 7. BACKUP AND RECOVERY

7.1 Taking a GHI Backup

A GHI Backup will backup Spectrum Scale namespace, file system configuration, including file sets, and file system metadata. There are three types of GHI backups: full, image and incremental. A full backup is the legacy backup that uses special backup policies. An image backup uses the Spectrum Scale image backup functionality or officially known as Scale Out Backup and Restore (SOBAR) via the **mmimgbackup** command. SOBAR is available with IBM Spectrum Scale Standard Edition or higher. An incremental backup does not take a complete backup of the file system, but only a of the changes in the file system since the last full backup and the time the incremental is taken.

Each GHI backup works in 2 phases. The first phase is to run a backup migration. GHI needs to backup to be as complete as possible, so it starts with a migration.

This migration is the same migration that is normally run, except there is an extra argument in the policy file, -b. This argument tells GHI to be as complete as possible, and if needed, ignore things like the minimum files per aggregate. The second phase is the metadata migration phase. Each of the backup type does this phase differently. The full backup calls the **ghiapplypolicy** script, which executes the **mmapplypolicy** command with the **backup_metadata.policy** file. Based on this policy file the metadata for each file is individually backed up to HPSS. The image backup calls the **mmimgbackup** Spectrum Scale command, which instead of processing each file individually, backs up the metadata as an “image” to an image file that is then backed up to HPSS

GHI backups use the Spectrum Scale snapshot feature to take a point-in-time image of the file system. When running a backup, a snapshot of the Spectrum Scale namespace is saved after the backup migration policy and any other running migration policies complete, and the state of each of the files is saved. When migrating metadata, GHI uses the snapshot, instead of the active file system. If a file is modified after the snapshot has been taken, neither the updated file contents nor the metadata will appear in the snapshot or the resulting backup. If the modified file still exists at the next backup, the update(s) will appear in the snapshot and in the GHI backup.

To start a GHI backup, use the **ghi_backup** command. The **ghi_backup** calls the Spectrum Scale commands depending on what type of GHI backup is called. For example, when a full back up or incremental is started policy scans are used for metadata and configuration. For an image backup, the **mmimgbackup**. The Spectrum Scale commands will call the ILM policy management engine. Each file system to be backed up uses its own copy of each of the following backup policy files that reside in the `/var/hpss/ghi/policy` directory. Customize the templates in the directory to suit your needs.

- **backup_migration.policy**. The backup migration policy contains the migration rules for the Spectrum Scale file system to be backed up. The rules can migrate files as aggregate

or non-aggregates. The rules should select all the files to be backed up. This policy should match the **migrate.policy** with the addition of the -b argument.

- **backup_metadata.policy.** The backup metadata policy contains the rules that older GHI releases need to capture the file system’s metadata. The SOBAR (i.e. image) backup feature does not require a metadata policy run for the second phase of a backup (metadata backup) because the metadata is included in the image generated by Spectrum Scale as part of the backup process. This policy must not be modified by the administrator.
- **backup_error.policy.** The backup error policy contains the rules that are used to validate the capture of the file system’s metadata. This policy must not be modified by the administrator.

To run a **ghi_backup**, execute:

```
% /opt/hpss/bin/ghi_backup <file system> <full | image | incr>
```

Each backup has advantages and disadvantages. The advantage to taking a full backup is... The disadvantage is that it is slower as the file system scales out because it is based on policy scans. The advantage to using an image backup is it is faster and more efficient than a full backup if the file system is large because it uses the SOBAR technology. The disadvantage is a second Spectrum Scale file system is needed for temporary space to perform an image restore. A full backup does not have this limitation.

Create a script or cron job to start the backups automatically. Run a GHI backup at a time when the Spectrum Scale system is the least busy to minimize impact to user operations. Work with your IBM GHI Support Representative to determine how often GHI backups should be taken; most sites run a GHI backup at least once a day.

Once the GHI backup completes, it is critical to view the backup logs and output to ensure there are no errors. One of the important errors that you should be looking for is “Administrator action”. Files with “Administrator action” are not included in the backup and must be investigated.

7.2 Restoring Files from GHI

Every quarter or at a minimum twice a year, test the backup by restoring to a read-only file system. This gives the administrator the ability to verify the backup was good. Also, you can restore certain files from a backup to a read-only file system without needing to restore the entire file system. Restored files can be copied back to the full-access file system. To perform a read-only restore of a Spectrum Scale file system, execute:

```
% /opt/hpss/bin/ghi_restore <read-only file system> [-g temp GPFS file space] <file system>
```

The read-only file system does not need to match the name of the full access file system. The **ghilsfs** settings “--junct”, “--basep” and “--bupath” must be the same as the full access file system. The read-only file system will need its own IOMs to recall data from HPSS.

Note. Any attempt to take a GHI backup of a GHI read-only file system will be rejected. A read-only restore of an image backup requires three Spectrum Scale file systems, the primary file system, the read-only file system, and the temporary file system.

The **ghi_restore** utility displays the full backups stored in HPSS and if available for the selected backup, each of the incremental backups associated with a full backup. Incremental backups are only applicable to backups taken on pre-GHI 2.4 releases.

To restore to a full-access file system:

1. Restore the Spectrum Scale configuration using **mmrestoreconfig**.
2. Restore the namespace (directories, filenames, hard links, and symbolic links) and associated attributes (owner, permissions, etc) using the Spectrum Scale **mmimgrestore** command.
3. Mark future backups as invalid and mark files associated only with those backups as orphans which may be garbage-collected.
4. Recall file data resident on the file system when the backup was taken. The administrator can run **ghi_recall** or **ghi_stage** commands to recall file data or files will be recalled on-demand when users attempt to access a file.

Refer to the *GHI Backup & Recovery* document for additional details.

CHAPTER 8. GHI CONFIGURATION SETTINGS

The GHI Configuration tools allows the administrator to configure GHI via a command line interface. The GHI Configuration Manager daemon (the **ghi_cm** [CM] server process runs on the GHI session node) does an integrity check once a day of the configuration across the cluster. It checks for things like the file format, are variables defined, etc. If there is a problem with a file, the CM will override it with the last working copy of that file. The CM also checks that the configuration files on all GHI nodes are the same as on the Session Node. If there's any difference, the CM will push the file(s) from the Session Node to the appropriate node(s). The update is quick, a few seconds to complete, and may also be executed on-demand by sending a SIGHUP to the CM process. This is an operating system signal that requires executing the **kill -SIGHUP <process id>** to the **ghi_cm** process.

The configuration files are:

```
/var/hpss/ghi/etc/ghi.conf  
/var/hpss/ghi/etc/ghinode.conf  
/var/hpss/ghi/etc/ghi_<file system>.conf  
/var/hpss/ghi/etc/memcached.conf
```

These files should never be edited unless directed by IBM support personnel. GHI configuration can be broadly divided into three areas: cluster-wide, file system specific, and IOM specific. See Chapter 9 for details on each command.

Cluster wide commands are:

- ghicrcluster** – create the GHI cluster the first time.
- ghiupdate** – after a GHI version update, this pushed the configuration to all GHI nodes
- ghilscluster** – list GHI cluster.
- ghichcluster** – deprecated starting with GHI 2.5.
- ghilsnodes** – list GHI nodes within the cluster.
- ghiaddnode** – add a GHI node within the cluster.
- ghidelnode** – delete a GHI node within the cluster.
- ghilsfsdefaults** – lists the GHI file system configuration default settings.
- ghichfsdefaults** – change the default configuration when you first add a file system

File system specific commands are used to manage the Event Daemon and Schedule Daemon, provide general configurations of the IOMs, and define how the file system's data are stored in HPSS. Configuration changes made with these commands generally do not adversely affect GHI beyond the file system to which they are applied. File system commands are:

- ghilsfs** – lists the GHI file system configuration settings.
- ghiaddfs** – adds a Spectrum Scale file system to GHI.
- ghichfs** – changes the GHI file system configuration.
- ghidelfs** – deletes a file system from the GHI configuration.

And finally, the IOM specific commands manage individual IOMs:

- ghilsiom** – lists the IOMs configured for a GHI file system.

- ghiaddiom** – adds an IOM to a GHI file system.
- ghichiom** – changes the IOM configuration for a GHI file system.
- ghideliom** – deletes and IOM from a GHI file system.

All the *GHI Configuration Utility* commands may be executed from any Spectrum Scale node in the cluster. A command begins by retrieving the underlying configuration files from the current GHI session node and copying them to temporary files on the node on which the command is running. All processing is done to these temporary files. GHI configuration commands require both Spectrum Scale and GHI to be running. When one command is running, no other *GHI Configuration Utility* command can run. This is done by a locking mechanism built into the **ghi_cm**.

The **ghils*** commands do nothing more than pull data from the temporary files and print it for display. The other commands apply the requested updates to the temporary files and push the updated files to all GHI nodes to replace their configuration files. As a command executes, it maintains a record of steps executed since startup. If an error should occur, it uses this list to undo all changes made prior to the error. The **ghils*** takes the **'-v' for verbose output**. This adds output from the call to the **ghi_cm** server process on the GHI session node.

Commands that modify the GHI configuration, i.e., commands other than **ghils***, can be executed with the **'-v'** option to enable verbose output. Although this can result in a substantial amount of output and should be used in case an error occurs and the automated error-recovery fails and must be corrected manually.

Each GHI configuration item consists of three parameters: Key, Description and Value.

Key - is in the form **'--xxx'**, where **'xxx'** is a short alphanumeric string and identifies the configuration setting.

Description - a longer string, which may contain spaces and special characters. The description provides more information about the configuration setting.

Value - may include a comment the format of Value depends on what data is being conveyed, and may be a string, number, Boolean, member of a list, etc. If Value contains a **'#'** preceded by at least one space, then anything following the **'#'** is considered a comment, and anything preceding is the Value.

Each **ghich*** command take **"<key_value>"** parameters. A **<key_value>** can be specified via the Key or Description, which can be mixed when specifying multiple **<key_value>** parameters into a single command. The first way of supplying a **<key_value>** to a command uses the configuration item's Key followed by the desired value/comment and results in two command-line parameters:

```
--Key "value [ # comment]"
```

The value need not be enclosed in quotes if it does not contain spaces or special characters, and a comment is not included. Note that single or double quotes are necessary with a comment.

The second way of supplying a **<key_value>** is through the configuration item's Description and requires the entire **<key_value>** to be enclosed within single or double quotes, and results in a single command-line parameter:

```
"Description = value [ # comment]"
```

Since the Description contains spaces, the '=' is required to separate it from the value/comment. Regardless of which method is used to specify a <key_value>, the '[', and ']' are not specified when including a comment but are shown here merely to indicate that specification of a comment is optional.

To reduce typing when entering commands at the terminal, the Key form is used to specify a <key_value>. The Description form is used for better readability from within a script. For example, to change the network speed of an IOM because a new network was added to the node:

```
# ghichiom davis-1 davis.clearlake.ibm.com:8012 --etr "10GB # New Network added"
Distributing updated GHI FS config to all GHI nodes...
Done.
```

Key	Description	Value (# comment)

IOM Node:Port		davis.clearlake.ibm.com:8012
--asn	Active Session Node	TRUE
--etr	Estimated Transfer Rate	10GB (# New Network added)

When a command that modifies the GHI configuration completes normally, it displays "Done." as shown above. Otherwise, it will display an error and attempt to back out the changes. Example of an error message follows:

```
# ghichiom davis.clearlake.ibm.com:8012 --etr "10GB # New Network added"
There was a command execution error:

<IOM> must be specified as '<node>:<port>'
*** Command terminating with error
*** No changes have been made
```

If an error occurs prior to any permanent changes made, there is nothing to be backed out and "*** No changes have been made" is displayed. If an error occurs after permanent changes have been made anywhere in the cluster, the message "!!! ABORTING -- UNDOING CHANGES !!!" is displayed and it attempts to back-out the changes. You would see this message in the "ghiupdate" command.

A few configuration items are not displayed with a Key from the **ghils*** command, which signifies they cannot be modified or their entry doesn't follow as described above. For example, configuration item "GHI Version" (displayed via **ghilscluster**) cannot be changed without upgrading GHI, therefore the following command would fail:

```
% ghichcluster "GHI Version = 12345"
Invalid key - "GHI Version"
*** No changes have been made ***
```

An IOM's node or port cannot be changed with **ghichiom**. The IOM must be deleted and re-added via **ghideliom** and **ghiaddiom**.

Each of the **ghich*** commands keep a date-stamped history of successfully applied changes. There is currently not a *GHI Configuration Utility* command to extract this history. If this history

is needed, it can be obtained from the files located in “\$HPSS_GHI_PATH”. History records appear under the configuration item to which they apply, most recent first and are formatted as follows:

```
# <date> = <old_value> <old_comment>
```

where:

<date> - when the change was made.

<old_value> - the value before the change.

<old_comment> - the comment before the change.

If a history of applied changes is not required, issue the **ghich*** command with the option ‘-H’.

A list of items that can be configured, grouped by their associated *GHI Configuration Utility* commands are described in the subsections below.

8.1 GHI Logging Configuration

GHI logging has been enhanced to use **rsyslog**. The administrator can configure **rsyslog** so that all GHI logs across all GHI nodes point to a single central log file, making troubleshooting much simpler. The administrator can also configure the format of each log message to suite any log monitoring tools they have implemented. There are some recommended **rsyslog** settings that produce more useful logging:

- Change System Log Rate Limit Interval to 0
`$SystemLogRateLimitInterval 0`
- Change the format of log messages in syslog
`$template myFormat, "%timegenerated% %HOSTNAME% %syslogseverity-text%\n [%programname%]\n %msg%\n"`
`$ActionFileDefaultTemplate myFormat`
- Turn off repeatedRepeated messages
`$RepeatedMsgReduction on`
- Allow anything debug or higher to be routed to /var/log/messages
`*.debug;mail.none; authpriv.none;cron.none`

Increasing the log level on a process will increase the number of messages recorded for that specific process. Processes do not have to be restarted after logging is changed. GHI has separated as many individual processes to give the administrator the most granular control over logging. The processes that can have their individual level increase are:

- -p Process Manager
- -m Mount Daemon
- -c Configuration Manager
- -t Tools
- -s Scheduler (requires name of the file system)
- -e Event Daemon (requires name of the file system)
- -q Policy (requires name of the file system)
- -I IOM (requires name of the file system)

There are 17 levels of logging available for each GHI process and they can be expressed in any order. The default levels are info, notice, error, critical, and alert.

DEBUG: Log events and data used to debug error conditions. These log messages are written only to the process log. Normally meaningful only to GHI support personnel. Operator intervention is not required unless instructed by support personnel.

THREAD: Debug log events related to adding work items to the work list. Each item in the work list is handled on its own separate thread.

QUEUE: Debug log events related to adding work items to the SD queue and log events related to the IOM processing those work items on the queue within GHI.

RPC: Debug log events related to the Remote Procedure Calls (RPC), such as the success or failure of an RPC connection or registration within GHI.

CONFIG: Debug log events related to opening configuration files, locating configuration settings, and modifying configuration settings (e.g. log level) within GHI.

DB2: Debug log events related to DB2 operations performed by GHI, such as garbage collection updates or SQL queries performed.

GPFS: Debug log events related to Spectrum Scale DMAPi operations performed by GHI., such as setting or retrieving file attributes.

HPSS: Debug log events related to HPSS client interface calls performed by GHI, such as connecting to HPSS and reading or writing a file to HPSS.

TRACE: Log events that provide additional information which allows development or support personnel to trace what is happening in the code at a particular time (e.g. The starting or stopping of a process). Normally meaningful only to GHI support personnel. Operator intervention is not required unless otherwise instructed by support personnel.

POLICY: This is information from a policy run. Operator interaction is not required.

BACKUP: These log events can be anything related to GHI backups. Depending on the message displayed, the operator may have action.

INFO: These are informational messages, such as “Sending stripe group info to clients”. These are not error messages. Operator intervention should not be required.

NOTICE: Log events for when a process starts or stops. These are not error messages. Operator interaction is not required.

WARN: Log events for minor errors such as “Failed to create a directory”. These warning messages are more like an inconvenience, but they may lead to additional problems. Operator intervention is probably not immediately required.

ERROR: Log events for major errors such as “Failed to open file”. These kinds of errors signify that some substantial GHI processing or capabilities are lost or malfunctioning. Operator intervention will be required.

CRITICAL: Log events for critical errors such as “Failed to start Event Daemon”. These errors signify loss of multiple capabilities and GHI will require immediate operator intervention.

ALERT: Log events that require operator investigation into messages in /var/log/messages.

8.2 GHI Cluster Configuration

The **ghicluster** tool is deprecated starting with GHI 2.5. It is included in this document for completeness.

8.3 GHI File System Configuration

The GHI file system configuration settings define how GHI works within the given file system and how data is handled during migrations, purges, stage and backups. In addition, the GHI File system configuration settings define how to monitor the system and the access control of the file system. These settings can be listed with **ghilsfs** and changed with **ghichfs**. Here is a list and a brief description of each GHI file system configuration setting:

Minimum Number of Files in an Aggregate (ghichfs --minagg)

This value, together with “Max Files Per Aggr” (see next section) determines whether all files selected for aggregation are migrated. Selected files are migrated into an aggregate file containing “Max Files Per Aggr” until the number remaining to be migrated is under minagg value. If there are less remaining files than the minagg value, they will not migrate until a subsequent migration policy is executed and the number of files are greater than minagg value. During backups, this minimum value does not have any effect because all selected files get migrated.

Maximum Number of Files in an Aggregate (ghichfs --maxagg)

The maximum number of files to be placed in an aggregate.

Aggregate Index COS (ghichfs --aggcos)

The HPSS class of service used to store GHI-ISHTAR index files. This COS should not purge the index files off HPSS disk to maintain GHI-ISHTAR listing performance. Acceptable values are integers greater than or equal to zero that correspond to a COS configured in HPSS.

Aggregate Thread Pool Size (ghichfs --aggtps)

The maximum number of threads to use for copying Spectrum Scale files to the GHI-ISHTAR file in HPSS. Refer to the `-T` option in GHI-ISHTAR. Acceptable values are integers greater than or equal to zero.

Bulk Count Backup (ghichfs --bbc)

This is the file grouping count used by a full backup. If you divide the total number of files being backed up by this number you get the number of backup files generated.

Backup COS (ghichfs --bucos)

The HPSS class of service used to store namespace and attribute files (metadata files) created as part of a backup. Acceptable values are integers greater than or equal to zero that correspond to COS configured in HPSS.

HPSS Junction (ghichfs --junct)

The HPSS Junction name used to link to the fileset of a subsystem in the HPSS namespace. It must not be blank, use a forward slash if a directory is not specified.

HPSS Base Path (ghichfs --basep)

The high-level directory to store migrated files into HPSS. This will be placed directly under “HPSS Junction”.

Performance Logging (ghichfs --perf)

Types of file-transfer performance logging. To set the type of performance logging, create a space or comma separated concatenation of the following values, which can be expressed in any order:

- **ED:** Log performance of the ED’s handling of DMAPI events.
- **ILM:** Log performance of policies executed via the **ghiapplypolicy** script.
- **SD:** Log performance of the SD’s handling of data transfer requests.
- **IOM:** Log performance of the IOM’s handling of data transfer requests.
- **ISHTAR:** Log performance of the ISHTAR’s handling of data transfers into/out of aggregates.
- **PIO:** Log performance of the PIO portion of non-aggregate data transfers.

Two additional values are allowed, which are mutually-exclusive with each other and with all the above-listed values:

All: Produce all possible types of performance logging.

None: Produce no performance logging.

The default setting is “None”. Performance logging can result in exceedingly large data files because unlike the GHI error logs, which are capped at 10MB each, the performance log has no upper limit. For this reason, performance logging is normally enabled only to gather supporting data if performance issues are suspected.

Purge Only if on Tape (ghichfs --poiote)

This setting determines whether GHI checks that Spectrum Scale file that has already been migrated to HPSS disk before it executes a GHI purge on that file. The possible values are “true” and “false”. A setting of “true” means checking with HPSS that every to-be-purged file has been migrated to HPSS Tape. If the file is not on HPSS tape, GHI will not purge it from Spectrum Scale. This is more resource intensive, but will increase the integrity of the data by making sure it is on tape. A setting of “false” means that all files selected for purging will be purged if they have been migrated to HPSS disk regardless of whether the files have been migrated to HPSS tape.

Purge File Size (ghichfs --pblock)

The amount of file data, in bytes, to remain resident in the Spectrum Scale file system after a file is purged. Acceptable values are integers greater than or equal to zero. The actual amount of data which remains in a file after purging is dependent upon Spectrum Scale.

ED Max Connections (ghichfs --edmaxc)

The number of concurrent open connections the Event Daemon will allow. Acceptable values are integers greater than or equal to zero.

ED Thread Pool Size (ghichfs --edtps)

When the ED captures DMAPI events from Spectrum Scale it sends them to this thread pool. The thread pool sends them to the SD. On most production systems, the default setting is more than sufficient. Acceptable values are integers greater than or equal to zero.

ED Request Queue Size (ghichfs --edrqs)

The number of slots in the wait list of DMAPI Events. The wait list is used to keep the overflow requests when the ED Thread Pool is filled with DMAPI events. Acceptable values are integers greater than or equal to zero.

ED Port Number (ghichfs --edport)

The port used by the Scheduler Daemon to communicate with the Event Daemon. Valid values are integers from 0 to 65535.

IOM Max Connections (ghichfs --iommaxc)

The maximum number of concurrent open connections the IOM will allow. This should be the number of connections to the Scheduler Daemon and any administrative utility. Acceptable values are integers greater than or equal to zero.

IOM Thread Pool Size (ghichfs --iomtps)

The number of requests each IOM will process at a time. The value should be based on the number of required concurrent transfers. MA Acceptable values are integers greater than or equal to zero. Do not alter without GHI support input.

IOM Request Queue Size (ghichfs --iomrqs)

The number of slots in the wait list. The wait list is used to keep the overflow requests when the thread pool fills up. Acceptable values are integers greater than or equal to zero.

IOM Monitor Flag (ghichfs --iomon)

This flag indicates that the Scheduler Daemon should perform IOM activity monitoring (value = “on”) or should not be performed (value = “off”).

IOM Monitor Frequency (ghichfs --iomonf)

This is the frequency in seconds (integer greater than zero) at which information will be logged to <IOM Monitor Output Path>.

IOM Monitor Output Path (ghichfs --iomonp)

This is the path used to store the monitor output log. There is no size limit imposed. With each <IOM Monitor Frequency> iteration, approximately 70 bytes plus 100 bytes for each idle IOM and 200 bytes for each IOM actively transferring a file will be written to the monitor output log. Thus, if the frequency is every 10 seconds and there are 50 IOMs, the log could grow by as much as $(70 + 200 \times 50) \times 6 =$ approximately 60K bytes per minute. This monitor file will display information about the IOM in the form of columns. Here is an example of what the IOM monitor prints out:

```
***** Thu Sep 28 13:38:11 2017 *****
Active , TC:    4, F:   0, R:   0, WL:   0 , RP:* 164MB, Node:
davis.clearlake.ibm.com:8012
***** Thu Sep 28 13:38:41 2017 *****
```

Active , TC: 4, F: 0, R: 0, WL: 0 , RP:* 164MB, Node:
davis.clearlake.ibm.com:8012

Each abbreviation means:

Active – This is the operational state of the IOM. It can be in 1 of 3 states:

Active: ready to transfer data

Econn: Disconnected. The IOM is not able to connect to GHI in this state and needs troubleshooting.

Standby: Connected to the SD, but the IOM is unable to process jobs and needs time to become Active or if it is in Standby for longer than 30 mins, troubleshoot why it is still Standby.

TC - The number of transactions this IOM has processed

F - Number of failures this IOM has processed.

R - Number of Requests left to be processes

WL - Amount of Work Left for the current job in MB

RP - Rate Processed

Node - Hostname of the IOM

LJ - Longest Job IOM has been working on. there are many jobs possible in this field:

migrate - Migrating data from Spectrum Scale to GHI.

purge - punching holes, or purging data from Spectrum Scale.

stage - Synchronous recall of data from HPSS.

recall - Asynchronous recall of data from HPSS.

reset - resetting attributes from a Spectrum Scale file so that it no longer points to and HPSS file.

backup - Backing up the metadata from Spectrum Scale to HPSS.

restore - Restoring the metadata from a GHI backup to Spectrum Scale

sort_TS - used by **ghi_stage**, sorting the files into tape set list.

order_TS - used by **ghi_stage**, ordering the tape set lists to minimize tape mounts.

TS_recall – used by **ghi_stage** to recall sorted the data from HPSS.

SD IOM Max Connections (ghichfs --sinmaxc)

The number of connections the Scheduler can have. The value should be the number of connections to the IOMs and any administrative utility. The connections to the IOMs are short-lived connections, so the value can be slightly smaller. Value will be an integer greater than zero.

SD IOM Thread Pool Size (ghichfs --sitps)

The number of threads used to work off DMAPI events. Acceptable values are integers greater than or equal to zero.

SD IOM Request Queue Size (ghichfs --sirqs)

This is the overflow queue for IOM transfer responses. If it is exceeded then it will fail the transfers. If enough of these failures occur the system will deadlock. The value should be larger than the number of IOMs * number of worker threads. It should only be changed with feedback from HPSS Support. Acceptable values are integers greater than or equal to zero.

SD Client Max Connections (ghichfs --scmaxc)

This is the connection between ILM client workers and the SD. The SD requires 1 connection per client. It should be set to the lower of either the number of files in the filesystem / Backup Bulk Count or the GPFS limit of ILM scripts * number of clients allowed to run GHI policies. That will set it to the number of clients expected to run. The default value should be fine unless the file system exceeds 1 billion files. Acceptable values are integers greater than or equal to zero.

SD Client Thread Pool Size (ghichfs --sctps)

The number of threads used to work off DMAPI events. Acceptable values are integers greater than or equal to zero.

SD Client Request Queue Size (ghichfs --scrqs)

This is the overflow queue for SD ILM requests. If it is exceeded then it will fail the transfers. Acceptable values are integers greater than or equal to zero. It should only be changed with feedback from HPSS Support. Acceptable values are integers greater than or equal to zero.

SD Port Number (ghichfs --sdport)

The port used by the Scheduler Daemon to communicate with the I/O Managers. Valid values are integers from 0 to 65535.

SD Monitor Flag (ghichfs --sdmon)

This flag indicates that the Scheduler Daemon should perform monitoring (value = "on") or should not be performed (value = "off").

SD Monitor Frequency (ghichfs --sdmonf)

This is the frequency in seconds (integer greater than zero) at which information will be logged to <SD Monitor Output Path>.

SD Monitor Output Path (ghichfs --sdmonp)

This is the path used to store the monitor output log. There is no size limit imposed. With each <SD Monitor Frequency> iteration, approximately 250 bytes (i.e. 1/4K byte) will be written to the monitor output log. Typically, archiving this file once per year is sufficient. This monitor file will display information about what is happening in the SD in the form of columns. Here is an example of what the SD monitor prints out:

```
***** Thu Sep 28 12:50:12 2017 *****
Active Q:   0 W:   0 M:   0/0   R:   2 S:   0 P:   0 D:   0 B:  10 I:  1/1
            F:   0 F:   0/0   F:   0 F:   0 F:   0 F:   0 F:   0
***** Thu Sep 28 12:50:42 2017 *****
Active Q:   0 W:   0 M:   0/0   R:   2 S:   0 P:   0 D:   0 B:  10 I:  1/1
            F:   0 F:   0/0   F:   0 F:   0 F:   0 F:   0 F:   0
```

Each abbreviation means:

Active Q - The number of events

W - The number of items GHI IOMs are currently processing combined

M - The number of migrated files to HPSS (Aggregates/Non-aggregates)

R - The number of staged files from HPSS

- S - The number of recalled files from HPSS
- P - The number of purged Spectrum Scale files
- D - The number of processes destroy events.
- B - Latest Valid Backup Index
- I - The number of IOMs (Active/Total)
- F - Under each column there is an F for Failure. This is the number of failures for the respective operation.

These statistics will increment as GHI completes jobs, but if the SD is restarted, these stats will be reset to zero, except for the backup and IOM columns. There is not a way to reset these stats without restarting the SD.

Stage on Demand (**ghichfs --sod**)

By default, Stage on Demand is turned on and GHI allows files that are purged from the Spectrum Scale file system to automatically be staged when a user accesses the files. Stage on Demand allows the user to turn DMAPi stages On or Off. If DMAPi stages are turned off, GHI will report an error when a file is purged from the Spectrum Scale file system and an end user tries to access it.

DMAPi Stage Errno (**ghichfs --dse**)

This is the error number that is reported by GHI when Stage on Demand is turned off. The default number is 7500 but is configurable to any positive number.

8.4 GHI IOM Configuration

IOM_node:port (**ghideliom <IOM_node>:<port>**)

IOMs are specified using a pseudo Key or Description. They are specified as `--Node:Port` for the 'Key' (e.g. `--node3:8023`) or if the '--' is omitted, it becomes a 'Description'. For example,

```
% ghilsiom gpfs3fs
Key          Description          Value (# comment)
-----
IOM Node:Port
miami.clearlake.ibm.com:8032
--asn       Active Session Node    TRUE
--etr       Estimated Transfer Rate 1000
```

An IOM's node or port cannot be changed with **ghichiom**. If these settings need to be changed, the entire IOM must be deleted and re-created via **ghideliom** and **ghiaddiom**.

Active Session Node (**ghichiom --asn**)

A value of "true" indicates the IOM should be allowed to run whenever the node the IOM is configured on is the GHI Session Node. A value of "false" means the IOM process will not run when the node is also the GHI Session Node.

Estimated Transfer Rate (**ghichiom --etr**)

This is the estimated transfer rate available for the node, in bytes per second, and is used as the initial value for load-balancing the IOMs. The value is adjusted in real-time once the actual

transfer rate is determined. Acceptable values are an integer greater than zero optionally followed by a unit indicator: KB, MB, GB. If this argument is omitted, the default is GB.

CHAPTER 9. GHI CONFIGURATION COMMANDS

This chapter provides details of each GHI Configuration Utility commands.

ghilscluster. Lists the GHI cluster-wide configuration.

Usage: ghilscluster [-Hv]

Where:

-H – history of the key changes and the dates they were changed.

-v – Verbose.

Example:

```
# ghilscluster
```

Key	Description	Value (# comment)

--	GHI Version	3.0.0.0
--aix	AIX Source	N/A
--x86_64	Linux x86_64 Source	ticD
--ppc_64	Linux ppc64 Source	N/A
--ldmaxc	LD Max Connections	<missing value>
--ldtps	LD Thread Pool Size	<missing value>
--ldrqs	LD Request Queue Size	<missing value>
--ldbase	LD HPSS Base Path	<missing value>

ghichcluster Modifies the cluster-wide configuration. Restart GHI or run **ghi_admin** to reinitialize for the changes to take effect. This command is deprecated starting with GHI 2.5. There should not be any reason to change the compile node for a GHI cluster.

ghilsnodes. Lists all GHI nodes. Node[name] and Type are returned by the Spectrum Scale **mmlscluster** command.

Usage: ghilsnodes [-v] [-c <node>]

Where:

-v – Verbose.

-c – Display the detailed configuration for the node(s) given by "***<node>***", i.e., for all nodes whose node nodename contains <node>.

Example:

```
# ghilsnodes -c davis
```

Node	GPFS Type	System Type

davis.clearlake.ibm.com	quorum-manager	Linux/inittab x86_64

```
ghilscluster --x86_64
IOM for FS davis-1
```

ghiaddnode. Add a node to the GHI configuration. The node to be added must already be configured in Spectrum Scale. If you add a node to the Spectrum Scale after the GHI cluster has been created and you want to use that node as a Session or IOM node, it must first be added to the GHI cluster with **ghiaddnode**.

Usage: ghiaddnode [-Tv] <node>

Where:

-T – Test only, shows -- all processing steps but will not alter any files or restart any processes.
-v – Verbose.

ghidelnode. Delete a node from the GHI configuration. A confirmation of the delete request will be presented unless the -f option is specified, in which case the deletion will proceed without further user intervention. defers-pushes the node to be deleted must not be configured as an IOM for any file system. Use **ghideliom** to remove configuration of any configured IOMs. The current GHI session node cannot be deleted.

Usage: ghidelnode [-fTv] <node>

Where:

-f – Force; do not output the "Are you sure?" prompt for confirmation.
-T – Test only, show -- do all processing steps but do not alter any files or restart any processes
-v – Verbose.

The following example shows an attempt to delete a node that is still being used by an IOM:

```
% ghidelnode -v fresno
Are you sure you wish to delete this node? (y/n) y
GPFS cluster manager is node1.clearlake.ibm.com
Retrieving from GHI session node -- /var/hpss/ghi/etc/ghi.conf
  scp node1.clearlake.ibm.com:/var/hpss/ghi/etc/ghi.conf /tmp/ghi.conf
Retrieving from GHI session node -- /var/hpss/ghi/etc/ghi_gpfs3fs.conf
  scp node1.clearlake.ibm.com:/var/hpss/ghi/etc/ghi_gpfs3fs.conf
/tmp/ghi_gpfs3fs.conf
node2.clearlake.ibm.com is still referenced within configuration for gpfs3fs!
!!! ABORTING -- UNDOING CHANGES !!!
  TMP_FILE: -- /tmp/ghi_gpfs3fs.conf
  TMP_FILE: -- /tmp/ghi.conf
```

ghilfsdefaults. Displays the default configuration for GHI file system. Once a file system is added to GHI, **ghichfs** can be used to modify the file system configuration. Any of these default configurations can contain a “?xxx” to signify that it serves as a template to be set by **ghiaddfs**.

As **ghiaddfs** reads values from the default configuration, it searches the fetched text and replaces every occurrence of ‘?xxx’ with the run-time replacement. ‘?xxx’ is one of:

- ?FS_Name – the ghiaddfs command-line parameter <FS_name>
- ?Mount_Point – the ghiaddfs command-line parameter <mount_point>
- ?ED_Port – the port number assigned to the SD
- ?SD_Port – the port number assigned to the ED

For example, given a value of “/logs/SD_?FS_Name.log” for configuration item “SD Monitor Output Path”, and <FS_name> supplied to **ghiaddfs** as gpfs3fs, the configured “SD Monitor Output Path” for the FS would be /logs/SD_ gpfs3fs.log.

ghichfsdefaults. Changes the default settings used by GHI when a file system is added to GHI. You can change any of these default configuration items that contain a “?xxx” but the “?xxx” must still be there since it will be populated by the **ghiaddfs** when defaults are used.

Usage: ghichfsdefaults [-Tv] [-c "# <comment>"] [--junct <HPSS_junction>] [--basep <HPSS_path>] [--bupath <HPSS_path>] [--maxagg <number>] [--minagg <number>] [--aggcos <number>][--aggtps <number>] [--bbc <number>] [--bucos <number>] [--pblock <number>] [--perf <perf_logging>] [--poiote TRUE|FALSE] [--sod ON|OFF] [--dse <number>] [--edmaxc <number>] [--edtps <number>] [--edrqs <number>] [--edport <number>] [--iomaxc <IOM Max Connections>] [--iotps <number>] [--iorqs <number>] [--iomon ON|OFF] [--iomonf <number>] [--iomonp <GPFS_path>] [--simaxc <number>] [--sitps <number>] [--sirqs <number>] [--scmaxc <number>] [--sctps <number>] [--scrqs <number>] [--sdport <number>] [--sdmon ON|OFF] [--sdmonf <number>] [--sdmonp <GPFS_path>]

Where:

- c – a comment to be associated with the file system
- junct – the HPSS junction under which all system and user data reside
- basep – the path in HPSS under which all user data reside
- bupath – the path in HPSS under which all system data reside
- maxagg – the maximum number of Spectrum Scale files which GHI will place into a single aggregated HPSS file
- minagg – the minimum number of Spectrum Scale files which GHI will place into a single aggregated HPSS file
- aggcos – the HPSS Class of Service into which the associated index file for aggregated files will be placed
- aggtps – the Aggr Thread Pool Size
- bbc – the maximum number of Spectrum Scale files which GHI will place into a single GHI backup file
- bucos – HPSS Class of Of-Service into which the files used to store GHI backups will be placed
- pblock – Number of GPFS data blocks to be left GPFS-resident when a file is purged
- perf – Performance logging is one or more of the following: ED ILM SD IOM HTAR PIO
- poiote – Purge Only If On Tape
- sod – Stage On Demand

--dse – DMAPI Stage Error number
--edmaxc – ED Max Connections
--edtps – ED Thread Pool Size
--edrqs – ED Request Queue Size
--edport – Port used by the ED for communicating with its associated SD
--iomaxc – IOM Max Connections
--iotps – the IOM Thread Pool Size
--iorqs – the IOM Request Queue Size
--iomon – enable/disable output to the IOM monitor file
--iomonf – the interval, in seconds, at which the SD writes to the IOM monitor file
--iomonp – the pathname of the IOM monitor file
--simaxc – the SD IOM Max Connections
--sitps – the SD IOM Thread Pool Size
--sirqs – the SD IOM Request Queue Size
--scmaxc – the SD Client Max Connections
--sctps – the SD Client Thread Pool Size
--scrqs – the SD Client Request Queue Size
--sdport – the port used in communicating with the SD to request and monitor file transfers
--sdmon – Enable/disable output to the SD monitor file
--sdmonf – the interval, in seconds, at which the SD writes to the SD monitor file
--sdmonp – the pathname of the SD monitor file For example, given a value of “/logs/SD_?FS_Name.log” for configuration item “SD Monitor Output Path” and <FS_name> supplied to ghiaddfs as “gpfs3fs”, the configured “SD Monitor Output Path” for the FS would be “/logs/SD_gpfs3fs.log”. The “# <comment>” is comment text which will be applied to the “?FS_Name” whenever the ghiaddfs command is executed.

ghilsfs. Displays the configuration for a specific file systemspecific. If **ghilsfs** is run with no arguments, then it will return a complete list of GHI managed file systems. If a key value is given, **ghilsfs** will only list the single key.

Usage: *ghilsfs [-Hv] [<file_system> ...] [<key> ...]*

Where:

-H – the history of the key changes and the dates they were changed
-v – verbose
<file_system> – *The name of a file system -- only the specified FS(s) will be displayed.*
<key> – *A key from the above list -- only the specified key(s) will be displayed.*

Example:

```
# ghilsfs davis-1
```

Key	Description	Value (# comment)
--		
	File System Name	davis-1

```

--mp          Mount Point          /davis-1
--uid        Unique Identifier      1
--junct      HPSS Junction          /
--basep      HPSS Base Path         /ghi
--bupath     HPSS Backup Path       /ghi
--maxagg     Max Files Per Aggr     * 5000
--minagg     Min Files To Make Aggr * 200
--aggcos     Aggr Index COS         1
--aggtps     Aggr Thread Pool Size  40
--bbc        Backup Bulk Count      * 10000
--bucos      Backup COS             1
--pblock     Purged File Size       0
--perf       Performance logging    NONE
--pmiot      Purge Only If On Tape  * FALSE
--sod        Stage On Demand        ON
--dse        DMAPI Stage Errno      7500
--edmaxc     ED Max Connections     5
--edtpps     ED Thread Pool Size    50
--edrqs      ED Request Queue Size  10
--edport     ED Port Number         8011
--iomaxc     IOM Max Connections    5
--iotpps     IOM Thread Pool Size   * 15
--iorqs      IOM Request Queue Size 10
--iomon      IOM Monitor Flag       * ON
--iomonf     IOM Monitor Frequency  * 30
--iomonp     IOM Monitor Output Path /davis-1/scratch/mon/mon_iom.out
--simaxc     SD IOM Max Connections 20
--sitpps     SD IOM Thread Pool Size 5
--sirqs      SD IOM Request Queue Size 100
--scmaxc     SD Client Max Connections 500
--sctpps     SD Client Thread Pool Size 100
--scrqs      SD Client Request Queue Size 400
--sdport     SD Port Number         8010
--sdmon      SD Monitor Flag        * ON
--sdmonf     SD Monitor Frequency   * 30
--sdmonp     SD Monitor Output Path /davis-1/scratch/mon/mon_sd.out
--fstype     FS Type                full-access
--bustat     Backup Status           last good backup 10
--afs        Associated FS           none

```

ghiaddfs. Adds a file system to the GHI configuration. The file system name and mount point must be unique among all GHI clusters connected to the HPSS system. The default SD and ED ports are 80x0 for the SD and 80x1 for the ED, where 'x' is the order in which file systems were configured. For example, 8010 and 8011 are for the first configured file system, 8020 and 8021 for the second configured file system, etc. The actual configured port numbers will be the first available ports starting with the default. The file system to be added must be known to Spectrum Scale and not mounted. GHI assumes the file system is DMAPI enabled. Without the -r, the file system will be full-access. To configure a read-only file system, include the -r argument. The read_only_target must have already been configured and may reside on the same or a different GHI cluster.

```

ghiaddfs [-k|K|Tv] <file_system> [-c "# <comment>"] [-r
<read_only_target>] <mount_Point> [<SD_port> <ED_port>]

```

Where:

- k** - If GHI backup-related DB2 tables already exist for the new file system, use them as-is
- K** - If GHI backup-related DB2 tables already exist for the new file system, re-create them

-**T** - Test only, do all steps required but do not alter any files

or DB2 tables, or restart any processes

-**c** - comment

-**v** - Verbose

-**r** - Create the file system as a read-only version of the full-access file system, which must already be configured and not itself be a read-only FS. The read-only file system may reside on the same or a separate cluster as full-access file system .

<file_system> - The name of the Spectrum Scale file system to add to the GHI configuration. This **must** match the Spectrum Scale configuration and be unique among all GHI clusters which connect to the same HPSS

<mount_point> - The mount point for the Spectrum Scale file system. This must **Must** match the Spectrum Scale configuration and be unique among all GHI clusters which connect to the same HPSS

<SD_port> - the port the **ghi_sd** should use for the file system. GHI will assign a port if one is not specified.

<ED_port> - the port the **ghi_ed** should use for the file system. GHI will assign a port if one is not specified.

Example:

```
# ghiaddfs -k davis-1 /davis-1
Updating DB2 table GHI_FS_LIST...
Using existing DB2 BU/GC tables as-is...
Distributing updated GHI config to all GHI nodes...
Distributing updated GHI config to all GHI nodes...
Creating FS policy files on all GHI nodes...
Alerting the GHI PM and MD to the new FS...
Done.
```

Key	Description	Value (# comment)
-----	-------------	-------------------

--	File System Name	davis-1
----	------------------	---------

ghichfs. Changes the configuration of a file system. Neither the file system's name nor its mount point can be modified. To change the file system name or mount point, the file system name must be deleted and re-created via **ghidelfs** and **ghiaddfs**. All other configuration items can be modified.

```
ghichfs [-Tv] <file_system> [-c "# <comment>"] [--junct
<HPSS_junction>] [--basep <HPSS_path>] [--bupath <HPSS_path>]
[--maxagg <number>] [--minagg <number>] [--aggcos <number>]
[--aggtps <number>] [--bbc <number>] [--bucos <number>] [--pblock
<number>] [--perf <perf_logging>] [--poirot TRUE|FALSE] [--sod
ON/OFF] [--dse <number>] [--edmaxc <number>] [--edtps <number>]
```

```

[--edrqs <number>] [--edport <number>] [--iomaxc <IOM Max
Connections>] [--iotps <number>] [--iorqs <number>]
[--iomon ON/OFF] [--iomonf <number>] [--iomonp <GPFS_path>]
[--simaxc <number>] [--sitps <number>] [--sirqs <number>]
[--scmaxc <number>] [--sctps <number>] [--scrqs <number>]
[--sdport <number>] [--sdmon ON/OFF] [--sdmonf <number>]
[--sdmonp <GPFS_path>]

```

Where:

- T** - Test only, do all processing steps required but do not alter any files, or restart any processes
- v** - **Verbose mode**
- c** - a user comment
- junct** - the HPSS junction name under which all system and user data will reside
- basep** - the path in HPSS under which all user data will reside
- bupath** - the path in HPSS under which all system data will reside
- maxagg** - the maximum number of Spectrum Scale files which GHI will place into a single aggregated HPSS file
- minagg** - the minimum number of Spectrum Scale files which GHI will place into a single aggregated HPSS file
- aggcos** - the HPSS class of service into which the associated index file for aggregated files will be placed
- aggtps** - the Aggregate Thread Pool Size
- bbc** - the maximum number of Spectrum Scale files which GHI will place into a single GHI backup file
- bucos** - the HPSS class of service into which the files used to store GHI backups will be placed
- pblock** - the number of Spectrum Scale data blocks to be left GPFS-resident when a file is purged
- perf** - Performance logging is one or more of the following: ED, ILM, SD, IOM, HTAR, or PIO
- poiots** - **Purge** Only If on Tape
- sod** - Stage on Demand
- dse** - the DMAPI Stage Error number
- edmaxc** - the ED Max Connections
- edtpps** - the ED Thread Pool Size
- edrqs** - the ED Request Queue Size
- edport** - the **port** used by the ED for communicating with its associated SD
- iomaxc** - the IOM Max Connections
- iotpps** - the IOM Thread Pool Size
- iorqs** - the IOM Request Queue Size
- iomon** - enable/disable output to the IOM monitor file
- iomonf** - the **interval**, in seconds, at which the SD **writes** to the IOM monitor file
- iomonp** - the pathname of the IOM monitor file
- simaxc** - the SD IOM Max Connections

--sitps - the SD IOM Thread Pool Size
--sirqs - the SD IOM Request Queue Size
--scmaxc - the SD Client Max Connections
--sctps - the SD Client Thread Pool Size
--scrqs - the SD Client Request Queue Size
--sdport - the port used in communicating with the SD to request and monitor file transfers
--sdmon - enable/disable output to the SD monitor file
--sdmonf - the interval, in seconds, at which the SD writes to the SD monitor file
--sdmonp - *the path name of the SD monitor file*

Example:

```

# ghichfs davis-1 --sdmonf 60
  Key           Description                               Value (# comment)
  -----
  --sdmonf     SD Monitor Frequency                   60
  Distributing updated GHI config to all GHI nodes...
Done.

```

ghidelfs. Deletes a file system from the GHI configuration. A confirmation of the delete request is presented unless the '-f' option is specified, in which case the deletion will proceed without further user intervention. The file system to be deleted must be unmounted and not have any IOMs configured for it. Use **ghideliom** to remove the configuration of any configured IOMs for the file system.

Usage: *ghidelfs [-fTv] <file_system>*

Where:

- f - Force, do not ask "Are you sure?" prompt for confirmation
- T - est only, do all processing steps required but do not alter any files or restart any processes
- v - Verbose mode.

Example:

```

# ghidelfs davis-1
Are you sure you wish to delete this FS? (y/n) y
Updating DB2 tables...
Distributing updated GHI config to all GHI nodes...
Distributing updated GHI config to all GHI nodes...
Deleting associated GHI FS config data from all GHI nodes...
Alerting the GHI PM and MD to the deleted FS...
Done.

```

Looking for FS davis-1 in GHI configuration...

FS davis-1 not found in GHI configuration

ghilsiom. Lists the complete configuration of an individual IOM or all IOMs for a file system.

Usage: *ghilsiom [-Htv] <file_system> [<IOM> ...]*

Where:

- H – display the history of the key changes and the dates they were changed
- t – Alternate format
- v – Verbose mode

Example:

```
# ghilsiom davis-1
```

Key	Description	Value (# comment)

	IOM Node:Port	davis.clearlake.ibm.com:8012
--asn	Active Session Node	TRUE
--etr	Estimated Transfer Rate	10GB
[root@davis ~]#		

ghiaddiom. Adds an IOM to the GHI configuration. The Scheduler Daemon will also be re-started to make use of the updated IOM configuration.

Usage: `ghiaddiom [-RTv] <file_system> [-c "# <comment>"] <IOM_Node>[:<Port>] <Active_On_Session_Node> <Est_XFER_Rate>`

Where:

- R - **push** configuration changes to all GHI nodes and restart the GHI SD. If this is omitted, changes are only posted to the GHI session manager and the IOM node, and the SD is not restarted. The new IOM will not be used until the SD is restarted
- T - Test only, do all processing steps required but do not alter any files, or restart any processes
- v - **Verbose**
- c "# comment" - a user comment
- <IOM_Node>[:<Port>] - the GHI node on which the IOM will execute. If the port is not specified, GHI will select one.
- <Active_On_Session_node> - if the node becomes the GHI session node...should the IOM stay active?
- <Est_XFER_Rate> - the estimated transfer rate (per second) GHI should use when calculating load balancing before actual transfer rates can be determined. May append 'KB', 'MB', or 'GB'

Example:

```
# ghiaddiom davis-1 davis:8012 True 1GB
No IOMs currently configured for this FS.
Configuring IOM system services for davis.clearlake.ibm.com:8012
Distributing updated GHI FS config to all GHI nodes...
Distributing updated GHI config to all GHI nodes...
Not restarting the SD.
The new IOM will not be used until the SD gets restarted.
Done.
```

Key	Description	Value (# comment)
	IOM Node:Port	davis.clearlake.ibm.com:8012
--asn	Active Session Node	TRUE
--etr	Estimated Transfer Rate	1GB

ghichiom. Updates the configuration for an IOM. To change the IOM's node or port, the IOM must be deleted and recreated via **ghideliom** and **ghiaddiom**. All other configuration items can be modified.

Usage: *ghichiom [-Tv] <file_system> <IOM_node>:<port> [-c "# <comment>"] [--asn {TRUE|FALSE}] [--etr <rate>] [--sort]*

Where:

-T – Test only, do all processing steps required but do not alter any files, or restart any processes.

-v – Verbose

<file_system> – the GHI managed file system name

<IOM_node>:<port> – the IOM to be updated

-c "# <comment>" – a comment to be associated with the IOM

--asn {TRUE|FALSE} – Should the IOM remain active if the node becomes the GHI session node?

--etr <rate> – the estimated transfer rate (per second) GHI should use when calculating load balancing before actual transfer rates can be determined. Append 'KB', 'MB', or 'GB' as a unit's multiplier.

--sort – sort the list of IOMs alphabetically for the file system

Example:

```
# ghichiom davis-1 davis:8012 --asn FALSE
Distributing updated GHI FS config to all GHI nodes...
Done.
```

Key	Description	Value (# comment)
	IOM Node:Port	davis.clearlake.ibm.com:8012
--asn	Active Session Node	FALSE
--etr	Estimated Transfer Rate	10GB

ghideliom. Deletes an IOM from the GHI configuration. A confirmation of the delete request will be presented unless the '-f' option is specified, in which case the deletion will proceed without further user intervention. The Scheduler Daemon will need to be re-started to make use of the updated IOM configuration unless the -R option is used.

Usage: *ghideliom [-RfTv] <file_system> <IOM_node>:<port>*

Where:

-R - push configuration changes to all GHI nodes and restart the GHI SD. If this option is omitted, changes are only posted to the GHI session manager and the IOM node; the SD is not restarted. The SD will continue to try to use the deleted IOM until the SD is restarted

-f - force, do not output "Are you sure?" prompt for confirmation

-T - Test only, do all processing steps required but do not alter any files, or restart any processes-**-v** - verbose mode Verbose

<file_system> - the file system associated with the IOM to be deleted

<IOM_node> : <port> - the IOM to be deleted

Example:

```
# ghideliom davis-1 davis:8012
```

```
Are you sure you wish to delete this IOM? (y/n) y
```

```
De-configuring IOM system services for davis.clearlake.ibm.com:8012
```

```
Deleting associated GHI FS config data from all GHI nodes...
```

```
Distributing updated GHI config to all GHI nodes...
```

```
Not restarting the SD.
```

```
The SD will attempt to use the IOM until the SD gets restarted.
```

```
Done.
```

```
Looking for IOM davis.clearlake.ibm.com:8012 in FS configuration...
```

```
No IOMs are configured for this FS.
```

CHAPTER 10. SYSTEM MONITORING

GHI provides a utility, **ghi_mon**, to monitor the Scheduler Daemon and the progress of IOM activities. Monitoring can be scheduled to start when the SD and/or IOMs are online. This is done by configuring it via the *GHI Configuration Utility* or the user can call **ghi_mon <task>** to start the task.

10.1 Scheduler

The figure depicts the internals of the Scheduler.

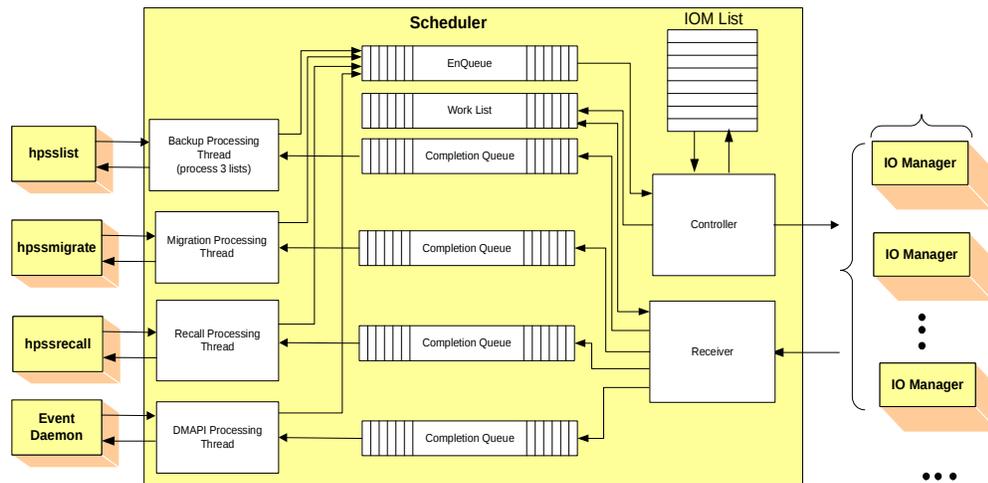


Figure 13 – Scheduler Internals

The Scheduler contains four different Schedule Queues:

- Namespace Backup requests
- Migration requests
- Recall requests
- DMAPI requests

As requests come in, the Scheduler places the items on the appropriate queue. As they are worked off, they are placed on the Work List. When monitoring the Scheduler, a single line item is printed containing the following information:

- **Mode:** The mode of the SD.
 - Active: The SD is running in active mode.
 - Backup: The SD is running a backup.
- **Queued:** Current number of requests on the Scheduler queue.
- **Working:** Current number of entries being worked off.
- **Migrations(A/N):** Total number of aggregates/non-aggregates that have been processed since the Scheduler was started. Aggregates are counted as one per aggregate and not the total number of requests within an aggregate.

- **Recalls:** Total number of files that have been recalled since the Scheduler was started. This can be misleading if there were multiple recalls in a single aggregate. The aggregate is only counted as a single increment.
- **Stages:** Total number of stage request.
- **Purged:** Total number of files that have been purged.
- **Failed:** Total number of migrations, recalls, stages, or purges that have failed.
- **IOM(A/T):** Total number of IOMs that are active or total number of IOMs configured.

10.2 I/O Manager

The figure depicts the internals of the I/O Manager.

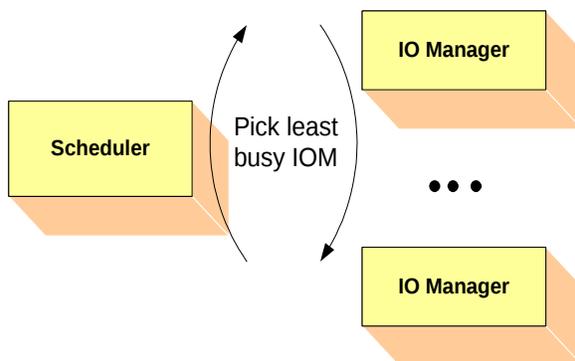


Figure 14 – I/O Manager Internals

The Scheduler sends requests to the configured/active IOMs in a round-robin fashion. The IOMs spawn off requests as they are received from the Scheduler. The IOM can be in four different states:

- **Active:** The IOM has the file system mounted and all the connections are valid.
- **Inactive:** The IOM is running on the session node and it is configured to be in an inactive state.
- **Standby:** Either the file system is not mounted on the node or the connection from the IOM to the Schedule is not valid.
- **Econn:** The scheduler has lost connection to the IOM.

When monitoring the IOMs, one or more lines are printed for each configured IOM. The first line contains the following information:

- **State:** The current state of the IOM (see node definitions above).
- **Requests:** Number of completed requests
- **Errors:** Number of errors, total and by request type, encountered since the IOM was started.
- **Processing Rate:** How busy the I/O Manager is. An ‘*’ indicates that I/O Manager will be selected next for work.
- **Node:** Hostname/Port where the IOM is running.

If the IOM is currently transferring a file, a second line is displayed that shows information on the longest running active transfer.

10.3 File Transfer Performance

Monitor the performance of a file transfer at various stages in the process to determine possible bottlenecks. Statistics are written to `/var/hpss/ghi/tmp/ghi_perf.log`. This file can grow to unlimited size therefore, performance monitoring is usually disabled. File transfer requests can enter the system in three ways: via the ED from a DMAPI event, via an ILM policy scan, or via the SD from the **ghi_stage** utility.

File transfers can be monitored for the following process and is configured via the GHI Configuration Utility (see Performance Logging (**ghichfs --perf**):

- **ED** - Transfers can be monitored starting with the ED's receipt of a DMAPI event from Spectrum Scale until it returns the response back to Spectrum Scale. The reported elapsed time includes all processing needed to generate the response from the SD, IOM, and PIO or ISHTAR.
- **ILM** - The complete lifetime of an ILM process as it handles its share of policy output resulting from execution of the **ghiapplypolicy** script. The reported elapsed time (the process' lifetime) includes all processing by the SD, IOM, and PIO or ISHTAR. Execution of **ghiapplypolicy** may result in launching of multiple ILM processes, each with its own reporting trail.
- **SD** - Transfers can be monitored starting with the SD's receipt of a file transfer request from either the ED, **ghi_stage**, or an ILM process until it returns a response back to the ED, **ghi_stage**, or ILM process. The reported elapsed time includes processing by the IOM and PIO OR ISHTAR.
- **IOM** - Extends from the IOM's receipt of a file transfer request from the SD until it returns the response back to the SD. The reported elapsed time includes the PIO or ISHTAR processing.
- **ISHTAR** - For aggregate file transfers, extends from IOM's launching of the ISHTAR process until it detects that the process has terminated. ISHTAR does all the DMAPI processing so this is not reported under the IOM.
- **PIO** - For non-aggregate file transfers, extends just around the actual PIO processing to affect the data transfer. PIO does no DMAPI processing so this is reported under the IOM.

10.3.1 Tracking File Transfer Requests

There are times when it is necessary to gather the records generated by a given file transfer request from the ILM policy. To do this, run with the '-d' or '-D' in the policy's OPTS field so that the generated filelists remain available after the process is completed. As a file transfer request gets processed, one or more records for each of the above types (ED, ILM, SD, IOM, ISHTAR, and PIO) may get written to the performance log file. For example, an ILM policy run (**ghiapplypolicy**) on non-aggregated files will result in 1) one ILM and one SD record for each ILM process that gets spawned, and 2) one IOM and one PIO record for each file selected by the policy run. Records will most likely get written to performance log files on multiple nodes. The

ED and SD records are always written on the GHI session node, while ILM, IOM, PIO, and ISHTAR records are written on the node on which the process runs. When multiple ILM processes get spawned from **ghiapplypolicy**, the processes may be on multiple nodes. The SD parcels out work to the IOMs independent of the requested source.

And lastly, the order of records within a file may not correspond to actual processing order. For instance, the ILM record may precede an IOM record, or an IOM record may precede an ISHTAR record even though one would expect the IOM to complete its work and write its record prior to reporting its status to the SD. The SD reports status to the ILM, which would then write its record (likewise with the IOM and ISHTAR). Underlying timing uncertainties with parallel processing account for this effect-before-cause behavior. Keeping all the above in mind, multiple queries may need to be made because the transfer identifier may be different as the transfer proceeds through the system. It is either the inode, igen, and snapID for non-aggregate transfers, or the filelist's pathname for aggregate transfers or in the ILM portion of processing before the SD extracts individual non-aggregate requests from the policy output. Once a file (or filelist) of interest has been identified, all records of the associated performance log files need to be queried for records containing the associated identifier(s). For example, assuming the inode and igen are available for the file of interest and it was included in the policy output as shown below, run the following on all nodes in the cluster to pull the associated records from the performance log file(s):

```
% PL="/var/hpss/ghi/tmp/ghi_perf.log
% GO="/common_disk/grep_output"
% grep "/ghi3/scratch/.ghi/mmPolicy.ix.25190.C3F04B6B.1" $PL >>$GO
% grep "Inode: 0.194799, Igen: 65555" $PL >>$GO
```

Note use of '>>' to append to the previous run's output to "grep_output". Once all the records of interest are collected, they can (based upon the discussions of each record type presented above) be sorted into the proper order to produce the processing trail. It is not sufficient to merely sort on the timestamps because on the nodes may not be in sync with each other.

10.3.2 Performance Log Record Formats

This section describes the format for each of the record type which may be written to the performance log file, i.e., ED, ILM, SD, IOM, PIO, and ISHTAR. Additionally, at GHI startup, daemon restart, or refresh via SIGHUP, each daemon that will be writing performance data to the log outputs has a timestamp record like this:

```
---- 2010-02-25-14:09:15 2486231360 ED /ghi4
```

The '----' in the example above is where measurement data would normally be shown. In this example, the '----' is displayed because this line in the log output is indicating the daemon-startup for the ED, so no measurement data needs to be displayed for this line. Following the timestamp is the daemon's PID, the daemon type (ED, SD, or IOM), and the final field is the associated mount point. As with GHI daemon logs, each IOM writes to its own local performance log file

- **ED Transfer Record** - An ED transfer record is created (but not yet written to the performance log file) as soon as the ED has queried enough information from Spectrum Scale to determine that the file is not already resident in Spectrum Scale and to make the recall request to HPSS. The newly-created record will contain the file data and current

(wall-clock) time for the start time. The request will be forwarded to the SD and the ED will wait on a response. When the response arrives, the response data from the SD will be added to the record with the current time for the end time and the completed record written to the performance log file. The ED record format is:

```
ED timestamp PID recall status size elapsed_time file_data
```

Where:

Timestamp - Date/time record was written to file.

PID - Process ID of the ED which created the record.

status - either 'SUCCESS' or 'FAILURE'.

size - size of the file (bytes).

elapsed_time - end time minus start time (seconds).

file_data - RqstID: 0 Inode: Inode, Igen: Igen, SnapID: 0.0.

Example of an ED transfer record:

```
ED 2011-01-12-13:47:31 1074145600 recall SUCCESS 512000 0.000389099  
RqstID: 0 Inode: 0.141457, Igen: 65542, SnapID: 0.0
```

The record format will be identical for both aggregates and non-aggregates because DMAPI requests are do not differ between the two file types.

- **ILM Transfer Record** - An ILM transfer record is created (but not yet written to the performance log file) as soon as the ILM process gets far enough in its processing to create a record. The newly-created record will contain the pathname of the associated filelist and the current (wall-clock) time for the start time. The request will be forwarded to the SD and the ILM process will wait on a response. When the response arrives, the response data from the SD will be added to the record with the current time for the end time, and the completed record written to the performance log file. The ILM record format is:

```
ILM timestamp PID operation status 0 elapsed_time filelist
```

Where are:

timestamp - Date/time record was written to file.

PID - Process ID of the ILM process which created the record.

operation - either 'migrate', 'purge', 'recall', or 'list'.

status - either 'SUCCESS' or 'FAILURE'.

elapsed_time - end time minus start time (seconds).

filelist - pathname of the associated filelist.

Example of an ILM transfer record:

```
ILM 2011-01-12-19:54:51 3970355248 purge SUCCESS 0 16.7519  
/gpfs3/scratch/.ghi/mmPolicy.ix.17350.45C7188E.1
```

- **SD Transfer Record** - An SD transfer record is created (but not yet written to the performance log file) as soon as the SD gets far enough in its processing to create a record. For aggregate requests, this is as soon as the SD receives the request. For non-aggregates, a

record is created for each file in the associated filelist as soon as it is read from the filelist. The newly created record will contain either the pathname of the aggregate filelist or the inode and igen of the non-aggregate file, and the current (wall-clock) time for the start time. When the transferring IOM indicates transfer is complete, the response data from the IOM will be added to the record with the current time for the end time, and the completed record written to the performance log file. The SD record format is:

```
SD timestamp PID operation status size elapsed_time file_data
```

Where:

timestamp - Date/time record was written to file.

PID - Process ID of the SD which created the record.

operation - either 'migrate', 'purge', or 'recall'.

status - either 'SUCCESS' or 'FAILURE'.

size - size of the file or aggregate (bytes).

elapsed_time - end time minus start time (seconds).

file_data - depends upon request for an individual file or a filelist.

If a file: RqstID: RqstID Inode: Inode, Igen: Igen, SnapID: SnapID.

If a filelist: RqstID: RqstID Filename: pathname, Size: size

Example of an SD transfer record:

```
SD 2011-01-12-13:53:33 1076185408 migrate SUCCESS 1048576000 133.899
RqstID: 1520863553 Inode: 0.26117, Igen: 65544, SnapID: 0.0
```

- **IOM Transfer Record** - An IOM transfer record is created (but not yet written to the performance log file) as soon as the IOM determines that PIO needs to be called to complete the transfer. The newly created record will contain the inode and igen of the non-aggregate file and the current (wall-clock) time for the start time. When the transfer is complete, the transfer data will be added to the record with the current time for the end time, and the completed record written to the [IOM's local] performance log file.

The IOM transfer record format is:

```
IOM timestamp PID operation status size elapsed_time file_data
```

Where:

Timestamp - Date/time record was written to file.

PID - Process ID of the IOM which created the record.

operation - either 'migrate', 'recall', or 'backup'.

status - either 'SUCCESS', 'XFER_FAILED', 'GETATTR_FAILED', 'SETATTR_FAILED', or 'REGIONS_FAILED'.

size - size of the file or aggregate (bytes).

elapsed_time - end time minus start time (seconds).

file_data - Depends upon request is for an individual file or a filelist.

If file: RqstID: RqstID Inode: Inode, Igen: Igen, SnapID: SnapID

If filelist: RqstID: RqstID Filename: pathname, Size: size

Example of an IOM record:

```
IOM 2011-03-23-15:56:32 1090451776 backup SUCCESS 3717 0.278038
RqstID: 1315662170 Filename:
/gpfs3/scratch/.ghi/backup_file_mtime/mmPolicy.ix.5900.09AFFAB9.2/mmPol
icy.ix.5900.09AFFAB9.2_0.data, Size: 0.0
```

- **PIO Transfer Record** - A PIO transfer record is created (but not yet written to the performance log file) just prior to the IOM initiating the PIO process with HPSS. The newly created record will contain the inode and igen of the non-aggregate file and the current (wall-clock) time for the start time. As soon as PIO processing is completed, the transfer data will be added to the record with the current time for the end time, and the completed record written to the [IOM's local] performance log file. The PIO record format is:

```
PIO timestamp PID operation status size elapsed_time throughput
file_data
```

Where:

Timestamp - Date/time record was written to file.

PID - Process ID of the IOM which created the record.

operation - either 'migrate', 'recall', or 'backup'.

status - either 'SUCCESS' or 'XFER_FAILED'.

size - size of the file (bytes).

elapsed_time - end time minus start time (seconds).

throughput - size / elapsed_time / 1000.

file_data - Depends upon request is for an individual file (migrate, recall) or a filelist.

If file: RqstID: RqstID Inode: Inode, Igen: Igen, SnapID: SnapID

If filelist: RqstID: RqstID Filename: pathname, Size: size

Example of a PIO record:

```
PIO 2011-03-31-11:24:06 1121962304 migrate SUCCESS 524288 9.48336
55.2851 RqstID: 1321016045 Inode: 0.136201, Igen: 65538, SnapID: 0.0
```

- **ISHTAR Transfer Record** - An ISHTAR transfer record is created (but not yet written to the performance log file) as soon as the IOM determines that ISHTAR needs to be called to complete the transfer. The newly created record will contain the pathname of the aggregate filelist and the current (wall-clock) time for the start time. When the transfer is completed, the transfer data will be added to the record with the current time for the end time, and the completed record written to the [IOM's local] performance log file. The ISHTAR record format is:

```
ISHTAR timestamp PID operation status size elapsed_time throughput
file_data
```

Where:

timestamp - Date/time record was written to file.

PID - Process ID of the IOM which created the record.

operation - either 'migrate' or 'recall'.

status - either 'SUCCESS' or 'FAILURE'.
size - size of the aggregate (bytes).
elapsed_time - end time minus start time (seconds).
throughput - size / elapsed_time / 1000.
file_data - RqstID: RqstID Filename: pathname, Size: size.

Example of an ISHTAR record:

```
ISHTAR 2011-03-31-13:50:41 1120872768 migrate SUCCESS 204856 6.2463  
32.7964 RqstID: 1310898517 Filename:  
/gpfs3/scratch/.ghi/mmPolicy.ix.19415.F41F1DF9.1, Size: 0.204600
```

CHAPTER 11. PROBLEM DIAGNOSIS AND RESOLUTION

It is important to monitor the GHI system daily and address problems early before they become severe. System administrators need to take these actions daily:

- **Policy runs:** Save and review the output from each of the policy runs. The policy runs can take several hours; therefore, we recommend saving the output for each of the runs in a specific location so they can be reviewed. The policy runs generate *.ok and *.exc files. Use the “-b” option in the policy to tell GHI to save the files instead of automatically cleaning them up. It is up to the site administrator to delete these files.
- **Backup:** Take a backup and review the output. The output indicates success or failure and details of each failure for investigation.
- **SD and IOM:** Monitor the SD and IOM output from the **ghi_mon** utility. If configured in the GHI file system configuration, the output is activated automatically. Refer to the ghi.conf configuration file.

This chapter provides some common problems seen in GHI and how to resolve them. A problem may have more than one diagnosis and resolution.

11.1 Common Infrastructure (Communication) Problems

Some commonly seen RPC and security-related problems with GHI are below:

- **A GHI server cannot communicate with another.**

Diagnosis 1: The target server may not have registered its RPC endpoint.

Resolution: Verify proper registration of the server with RPC. If shutting down the target server and restarting it does not fix the problem, you may have to manually delete the server’s RPC entry. using the **rpcinfo -d <program number> <version>** command. Once you’ve deleted the registration you can try restarting GHI to re-register the service

Diagnosis 2: A network communication failure may exist or security may be blocking the communication.

Resolution: First verify the network is up and the server is running. A less obvious cause for the problem may be that the server is not accepting calls from the client because of security reasons. To fix this problem, make sure that the client and server are using consistent security policies and that they have authenticated properly.

Diagnosis 3: The /var/hpss file system may be full.

Resolution: Determine what is causing the file system to fill up. Common problems are /var/hpss is too small or log files are not being archived out of this directory to free up space. Sometimes, a debug log turned on for problem resolution was not turned off and filled the file system.

Diagnosis 4: A server may be too busy to respond.

Resolution: If a server is very busy, other servers will not be able to communicate with it. To solve the problem, decrease the load on the server. For example, try increasing the

server's thread pool size and/or maximum connection count, or moving the server to a different machine, or adjusting one of the server-specific configuration parameters.

Diagnosis 5: A node does not have a network route to an interface used by a server on a different host.

Resolution: Verify that all nodes (Session node and IOM nodes) have network routes to the network interfaces required.

Diagnosis 6: The server may not have enough RPC connections configured that are necessary for communication.

Resolution: Increase the number of Maximum Connections for the appropriate server configuration.

Diagnosis 7: The server may have other configuration issues.

Resolution: Verify the appropriate server configuration, such as ulimits, xinetd settings, firewalls, hostnames, etc.

Diagnosis 8: The Domain Name Service (DNS) is not reachable.

Resolution: Add all necessary entries to the /etc/hosts file. Terminate all GHI servers, DB2, and Kerberos. Restart the system without DNS, then fix the DNS.

- **A server cannot register its RPC info.**

Diagnosis 1: Stale RPC information may exist for the server in the RPC table.

Resolution: Issue the **rpcinfo -p** command to see if the RPC program number for the server interface is already registered. If the interface is registered it can be removed using the **rpcinfo -d <program number> <version>** command. Once you've deleted the registration you can try restarting GHI to re-register the service.

- **A server cannot obtain its credentials.**

Diagnosis 1: There may be a problem with the keytab table.

Resolution: Make sure the keytab table (usually in /var/hpss/etc/) is readable by the UNIX username under which the server is running. Make sure the key contained in the keytab table is the correct one. Look for extra versions of the server's key, which can interfere with the authentication process.

- **The connection table may have overflowed.**

Diagnosis 1: The server may be so heavily loaded that it is unable to free up connections quick enough.

Resolution: Reduce the load on the server. The problem may also indicate that a server is configured incorrectly or there is a software problem in handling connections properly. One solution is to increase the Maximum Connections parameter in the configuration for the specific server.

11.2 Server Problems

- **The Process Manager dies after a mount request (PPC only).**

Diagnosis 1: The PM core dumps with a stack dump.

Resolution: Set the HPSS_PTHREAD_STACK to 262144 in /var/hpss/etc/env.conf.

- **The Mount Daemon fails to get events.**

Diagnosis 1: Failed to retrieve DMAPI events.

Resolution: Verify the file still exists. Verify the Session ID is valid for that node and is not owned by another node.

- **The Mount Daemon fails to respond to an event.**

Diagnosis 1: Failed to respond to a file system mount/unmount request.

Resolution: Verify the file still exists.

- **The Mount Daemon fails to mount a file system.**

Diagnosis 1: Failed to mount the file system.

Resolution: Verify the file system still exists and it is not a GHI read-only file system.

- **The Mount Daemon fails to dismount a file system.**

Diagnosis 1: Failed to dismount the file system.

Resolution: Verify there are no open files in the file system or there are no one in the file system. Use 'lsof' to determine what is using the file system.

- **The Event Daemon fails to get events.**

Diagnosis 1: Failed to retrieve DMAPI events.

Resolution: Verify the file still exists. Verify the Session ID is valid for that node and is not owned by another node.

- **The Event Daemon fails to respond to events.**

Diagnosis 1: Failed to respond to a request to access a file.

Resolution: Verify the process had not been restarted.

- **The Event Daemon fails to get attributes of a file.**

Diagnosis 1: When trying to get the attributes of a file, the call failed.

Resolution: Verify the file still exists. Verify the Session ID is valid for that node and is not owned by another node.

- **The Scheduler Daemon is stuck in “QUIESCING_FS” mode.**

Diagnosis 1: All file transfer requests terminate with error code -19 (ENODEV) and the monitor output is showing the SD's state to be “QUIESCING_FS”. This occurs when either an unmount command has been given or a GHI shutdown has been requested but not [yet] completed.

Resolution: It may be that the SD has begun to make the file system inactive but the file system could not be un-mounted. There may be ongoing file transfers to/from an HSM which needs to complete before the SD can terminate and GHI to shut down completely. If a command to unmount the file system failed, try to remove the condition which is blocking its completion and re-try it, or try a forced unmount (first see the Spectrum Scale documentation on the mmunmount command). If a GHI shutdown command has failed, retry the command until it succeeds or use the '-f' (force) option. If it is desired to

place the SD back into its normal operating mode, send a SIGHUP signal to the SD process id on the GHI session node. View the SD monitor output to verify the SD's state returns to active. The area below the "Active Q" text in the monitor output should be blank and not showing any error messages. This should not be done after a GHI shutdown because the status of other GHI system processes is uncertain. This may be done after a failed unmount of a file system if the file system still shows as mounted, and you wish to continue normal operations without attempting another unmount.

- **Out of Completion Queues.**

Diagnosis 1: There are too many requests for the Scheduler.

Resolution: The additional requests will not be lost, they will wait until some existing connections are complete and then the request will get scheduled.

- **Failed to set regions (punching a hole).**

Diagnosis 1: Unable to punch a hole in a file using **dm_punch_hole**.

Resolution: Verify the file exists.

- **Recovery started for an IOM.**

Diagnosis 1: An IOM abnormally terminated. The requests that it was working on are being redirected to another IOM.

Resolution: There is no action to be taken.

- **Failed to get a DMAPI handle for a file.**

Diagnosis 1: A failure occurred when attempting to read the DMAPI handle for a file before performing the data transfer.

Resolution: Verify the file has not been deleted. Verify the Session ID is still valid for that IOM.

- **The IOM is in ECONN mode.**

Diagnosis 1: The IOM shows ECONN during initializing.

Resolution: The IOM is initializing, wait until it finishes the connection logic.

Diagnosis 2: The IOM is configured incorrectly in `/etc/inittab`.

Resolution: Fix the entry and recycle **inittab (kill -1 <inittab pid>)**. The entry is added automatically by GHI, so this is unlikely the cause unless an admin or configuration manager (puppet, etc) changed it.

Diagnosis 3: The authentication configuration is incorrect in `/var/hpss/etc`.

Resolution: Copy the `/var/hpss/etc/` directory from the HPSS Core Server location.

Diagnosis 4: There is a time difference between the IOM node and the Session node that is greater than 5 minutes.

Resolution: Run an NTP daemon on all the nodes or verify NTP is working, or sync-up the date/time with the "date" command.

- **IOM is in STANDBY mode.**

Diagnosis 1: IOM loses connection to the SD.

Resolution: Verify the Scheduler Daemon is running or recycle the IOM.

- **IOM failed to get a handle for a file.**

Diagnosis 1: Unable to get a handle for a file.

Resolution: A handle is an integer value assigned by the operating system to access a file. When the IOM is unable to get this handle, you will want to verify first that the file still exists. Second, verify the Session ID is still valid for that IOM.

- **ISHTAR fails to run.**

Diagnosis 1: The ndapi.log reports that ISHTAR failed with “ndad_keytab_check : failed (code=22) for principal hpssdmg”.

Resolution: Issue a new hpss.htar.keytab and distribute the keytab file to all of the GHI nodes. Verify the /var/hpss/etc/unix.master.key does not contain all zeros.

Diagnosis 2: ISHTAR failed with 18431 (unable to open file).

Resolution: Verify the file still exists.

Diagnosis 3: ISHTAR failed with 18432.

Resolution: The htar.ksh file contains the incorrect value for HPSS_HOSTNAME. Fix the htar.ksh file and run a quick command line test the fix is good:

```
/var/hpss/ishtar/bin/htar.ksh -cvf /ghi/testfile /etc/motd
```

Diagnosis 4: ISHTAR fails with “-52 htar_ghiClose, Error setting managed regions”.

Resolution: Verify the SessionID is correct.

Diagnosis 5: ISHTAR fails to open the file in Spectrum Scale.

Resolution: Verify the file still exists.

- **ISHTAR appears to be hung or locked up.**

Diagnosis 1: The location for the ISHTAR temporary files is full: “WARNING: OUT OF SPACE writing HPSS archive - delaying/retrying”.

Resolution: Verify the file system is not full. Kill the htar.ksh process. Clean up the file system or allocate more space. Rerun the policy.

- **A “-1 makeXHandle” error was encountered from a migration policy run.**

Diagnosis 1: Failed with a call to makeXHandle because the /var/hpss/ghi/etc directory is inconsistent with the rest of the nodes in the cluster.

Resolution: Issue a **kill-SIGHUP <pid>** command to the GHI Configuration Manager (ghi_cm) on the GHI session node to have it execute a cluster-wide configuration scan to validate and correct anything wrong. Recycle the IOM.

- **A “Failed to migrate files, RPCError = 0, rc = -1” error from a migration policy run.**

Diagnosis 1: The output from a migration policy reported a failure because the file system is GHI read-only.

Resolution: No resolution is possible. Allowing files to be migrated into HPSS from a GHI read-only file system could result in corruption of the HPSS data for the associated GHI full-access file system. If a file must be migrated into HPSS, it will need to be copied to the full-access file system and migrated from there.

- **A “-5 PIOXferMgr” error from a migration policy run.**

Diagnosis 1: The HPSS Movers are having issues (they are not in green state as shown in the HPSS GUI), there are errors in the Alarms & Events, or the local.log file.

Resolution: See Chapter 1: HPSS Problem Diagnosis and Resolution in the HPSS Error Manual.

- **A “-19 sd_quiesce_FS” error from a migration policy run.**

Diagnosis 1: The file system was unmounted or a shutdown of GHI was requested after the migration had been requested, but before the actual file transfer request was sent to an IOM.

Resolution: Re-run the migration after mounting the file system or after GHI is restarted.

- **A “-28 PIOXferMgr” error from a migration policy run.**

Diagnosis 1: The HPSS Movers are having issues (they are not green), or there are errors in the Alarms & Events or the local.log file.

Resolution: See Chapter 1: See the HPSS Problem Diagnosis and Resolution in the HPSS Error Manual.

- **A “-78 PIOXfer” error from a migration policy run.**

Diagnosis 1: The inetd was configured incorrectly.

Resolution: See the IOM problems above.

Diagnosis 2: There is a problem with the HPSS Mover(s).

Resolution: Verify the Mover(s) are green. Look at the HPSS local.log file for error messages.

- **A “-19 sd_quiesce_FS” error from a recall policy run.**

Diagnosis 1: The file system was unmounted or a shutdown of GHI was requested after the recall had been requested, but before the actual file transfer request was sent to an IOM.

Resolution: Re-run the recall after mounting the file system or after GHI is restarted.

- **A “-78 PIOXfer” error from a recall policy run.**

Diagnosis 1: The xinetd was configured incorrectly.

Resolution: See the IOM problems above.

- **Problems with mounting file systems.**

Diagnosis 1: The **mount** command returned an error for “Stale NFS Handle”.

Resolution: There is potentially a disk problem with the file system, run **ghi_state**. Also, verify the file system is configured with the **ghilsfs** command.

Diagnosis 2: The **mount** command returned an error saying there was no handle for the mount event.

Resolution: Verify the PM and MD are running.

Diagnosis 3: The Mount Daemon is not running.

Resolution: Verify the Session node did not failover. Verify the Mount Daemon is running on the Session node and could take over the Session ID.

Diagnosis 4: The **mount** command returned an error for “can't read superblock”.

Resolution: Try to mount the file system on the Spectrum Scale cluster manager node first, then mount on the other nodes.

Resolution: There is potentially a disk problem with the file system, run **ghi_state**. Also, verify the file system is configured by executing the **ghilsfs** command.

Resolution: The file system is read-only and no backup has yet been restored to it. To check, issue the following command:

```
% ghilsfs <FS> --bustat
```

The following result will confirm if a backup needs to be restored:

```
Key Description Value (# comment)
-----
File System Name <FS>
--bustat Backup Status needs restore
```

- **Error indicating file is not managed by HPSS.**

Diagnosis 1: The purge policy that was configured is not excluding files that are already co-managed.

Resolution: Verify the policy has an entry to exclude files that are not managed by HPSS:

```
Rule "exclude_rule" EXCLUDE FROM POOL "system" WHERE MISC_ATTRIBUTES NOT LIKE '%M%'
```

- **A file fails to purge data blocks from Spectrum Scale.**

Diagnosis 1: Verify the file was not deleted after it was selected as a purge candidate.

Resolution: There is nothing to be done here.

Diagnosis 2: Verify the file meets the purge policy criteria

Resolution: Review the policy and the location of the file (via **ghi_ls**).

Diagnosis 3: Verify the file is larger than 1 data block.

Resolution: Files that are less than or equal to 1 data block will not be selected as purge candidates.

- **Failed to read/write a file in the system.**

Diagnosis 1: The request returns an Input/Output error.

Resolution: Verify neither the Event Daemon nor the Scheduler has been recycled recently. Verify the HPSS Mover(s) are green. Also, look at the HPSS *local.log* to see if there are any error messages.

- **Reading/Writing a file appears to hang.**

Diagnosis 1: The read or write request times out.

Resolution: Find out where the file resides in HPSS. If it is on tape, verify there is not an outstanding tape mount request and there is a free tape drive.

- **General problems with a utility/tool.**

Diagnosis 1: Problems with a utility.

Resolution: Check the syntax. Most utilities will print a usage summary if they are invoked with the *-?* option. Some utilities require several parameters to be specified that may not be obvious. Make sure the default arguments are being overridden when necessary. Many utilities use default values for several parameters. If the parameter is not overridden with a specific value, unexpected behavior may result.

- **The ghi_mon SD error count increases.**

Diagnosis 1: Numerous errors are encountered during migrations, recalls, stages, and/or purges.

Resolution: Review the actions performed and determine increase rates to determine which action is generating the errors. Review the **ghi_mon** output for the IOM as well to determine which IOM is encountering the problem.

- **The ghi_mon IOM error count increases.**

Diagnosis 1: The errors displayed from **ghi_mon** indicate the IOM was failing when performing data transfers.

Resolution: Review the exception files ending with the *exc* extension located in *<mount point>/scratch/* for that IOM (if running with the *-d* or *-D* option). Otherwise, run a migration and review the output from the policy run to determine what are the issues. Also, review the *local.log* file to see what errors are occurring from the HPSS Movers.

- **The ghi_mon shows the SD restarted.**

Diagnosis 1: The Session node failed over.

Resolution: View the system log to determine why the Scheduler was recycled. If the Scheduler Daemon terminates again, turn on additional logging so that the next time the Scheduler is recycled, additional error information can be viewed.

- **The ghi_mon shows the SD to be “QUIESCING_FS”.**

Diagnosis 1: The file system has been unmounted and/or GHI is shutting down.

Resolution: See Error: Reference source not found

- **Failed to connect to the SD.**

Diagnosis 1: The SD is not running because the file system is unmounted.

Resolution: Mount the file system and verify the SD is started.

- **GHI backup cannot communicate with DB2.**

Diagnosis 1: DB2 is not running.

Resolution: Verify DB2 is running and restart if necessary. Authenticate as the DB2 instance owner and start DB2 with the **db2start** command. There is no harm in executing this if the DB2 instance is already running.

- **Failed to back up a file from a snapshot.**

Diagnosis 1: The output from a backup shows that GHI failed to back up a file's data from a snapshot.

Resolution: Check the migration problems above to determine why the file failed to migrate.

- **Too many open files from image backup.**

Diagnosis 1: Too many open files from an image backup.

Resolution: The **ulimit** setting need to be set on GHI nodes for image backups. Refer to GHI Install Guide on how to set up the **ulimit** setting.

- **Failed to backup namespace information.**

Diagnosis 1: The output from a backup shows that GHI failed to back up a namespace file. One possible reason is there was a failure transferring the file to HPSS.

Resolution: Refer to IOM problems above.

GLOSSARY OF TERMS AND ACRONYMS

ACL	Access Control List.
AIX	Advanced Interactive Executive. An operating system provided on many IBM machines.
Alarm	A log record message type used to log high-level error conditions.
ANSI	American National Standards Institute.
API	Application Program Interface.
Archive	One or more interconnected storage systems of the same architecture.
Attribute	When referring to a managed object, an attribute is one discrete piece of information, or set of related information, within that object.
Class of Service	A set of storage system characteristics used to group files with similar logical characteristics and performance requirements together. A Class of Service is supported by an underlying hierarchy of storage classes.
co-managed	File data resides in both Spectrum Scale and HPSS.
Configuration	The process of initializing or modifying various parameters affecting the behavior of an GHI server or infrastructure service.
COS	Class of Service.
Core Server	An HPSS server which manages the namespace and storage for an HPSS system. The Core Server manages the Name Space in which files are defined, the attributes of the files, and the storage media on which the files are stored. The Core Server is the central server of an HPSS system. Each storage sub-system uses exactly one Core Server.
Daemon	A UNIX program that runs continuously in the background.
DB2	A relational database system, a product of IBM Corporation, used by HPSS and GHI to store and manage HPSS and GHI metadata.

Debug	A log record message type used to log lower-level error conditions.
Directory	An HPSS object that can contain files, symbolic links, hard links, and other directories.
Dismount	An operation in which a cartridge is either physically or logically removed from a device, rendering it unreadable and non-writable. In the case of tape cartridges, a dismount operation is a physical operation. In the case of a fixed disk unit, a dismount is a logical operation.
DMAPI	Data Management Application Programming Interface.
DNS	Domain Name Service.
DOE	Department of Energy.
Drive	A physical piece of hardware capable of reading and/or writing mounted cartridges. The terms device and drive are often used interchangeably.
DRP ED	Disaster/Recovery Plan Event Daemon.
Event	A log record message type used to log informational messages (e.g. subsystem starting, subsystem terminating).
File	An object than can be written to, read from, or both, with attributes including access permissions and type, as defined by POSIX (P1003.1-1990). HPSS supports only regular files.
file family	An attribute of an HPSS file that is used to group a set of files on a common set of tape virtual volumes.
fileset	A collection of related files that are organized into a single easily managed unit. A fileset is a disjoint directory tree that can be mounted in some other directory tree to make it accessible to users.
fileset ID	A 64-bit number that uniquely identifies a fileset.
fileset name	A name that uniquely identifies a fileset.
file system ID	A 32-bit number that uniquely identifies an aggregate.
FSID	File system unique identifier

GB	Gigabyte (2^{30}).
GHI	Spectrum Scale/HPSS Interface.
ISHTAR	Specially modified GHI-specific version of the HTAR program.
Hierarchy	See Storage Hierarchy.
HPSS	High Performance Storage System.
HSI	Hierarchical Storage Interface.
ISHTAR	HPSS tar program – a utility to aggregate a set of files directly into HPSS without first writing to local storage, and to randomly retrieve individual member files via creation of a separate index file.
IBM	International Business Machines Corporation.
ID	Identifier.
I/O	Input/Output.
IOM	I/O Manager.
IP	Internet Protocol.
junction	A mount point for an HPSS fileset.
KB	Kilobyte (2^{10}).
LAN	Local Area Network.
LANL	Los Alamos National Laboratory.
LLNL	Lawrence Livermore National Laboratory.
MB	Megabyte.
MD	Mount Daemon.
metadata	Control information about the data stored under HPSS, such as location, access times, permissions, and storage policies. Most HPSS metafile contents are stored in a DB2 relational database.

migrate	To copy file data from a level in the file's hierarchy onto the next lower level in the hierarchy.
mount	An operation in which a cartridge is either physically or logically made readable and/or writable on a drive. In the case of tape cartridges, a mount operation is a physical operation. In the case of a fixed disk unit, a mount is a logical operation.
mount point	A place where a fileset is mounted in the XFS and/or HPSS namespaces.
Mover	An HPSS server that provides control of storage devices and data transfers within HPSS.
Name Service	The portion of the Core Server that provides a mapping between names and machine oriented identifiers. In addition, the Name Service performs access verification and provides the Portable Operating System Interface (POSIX).
name space	The set of name-object pairs managed by the HPSS Core Server.
NLS	National Language Support.
NSL	National Storage Laboratory.
Object	See Managed Object.
OSF	Open Software Foundation.
PB	Petabyte (2^{50}).
PM	Process Manager.
POSIX	Portable Operating System Interface (for computer environments).
RPC	Remote Procedure Call.
SCSI	Small Computer Systems Interface.
SNL	Sandia National Laboratories.
Spectrum Scale	New name of General Parallel File System (GPFS)
SSA	Serial Storage Architecture.

storage class	An HPSS object used to group storage media together to provide storage for HPSS data with specific characteristics. The characteristics are both physical and logical.
storage hierarchy	An ordered collection of storage classes. The hierarchy consists of a fixed number of storage levels numbered from level 1 to the number of levels in the hierarchy, with the maximum level being limited to 5 by HPSS. Each level is associated with a specific storage class. Migration and stage commands result in data being copied between different storage levels in the hierarchy. Each Class of Service has an associated hierarchy.
storage subsystem	A portion of the HPSS namespace that is managed by an independent Core Server and (optionally) Migration/Purge Server.
TB	Terabyte (2^{40}).
TCP/IP	Transmission Control Protocol/Internet Protocol.
Transaction	<p>A programming construct that enables multiple data operations to possess the following properties:</p> <p>All operations commit or abort/roll-back together such that they form a single unit of work.</p> <p>All data modified as part of the same transaction are guaranteed to maintain a consistent state whether the transaction is aborted or committed.</p> <p>Data modified from one transaction are isolated from other transactions until the transaction is either committed or aborted.</p> <p>Once the transaction commits, all changes to data are guaranteed to be permanent.</p>

REFERENCES

- HPSS Installation Guide, Release 7.4.3.
- HPSS Management Guide Release 7.4.3.
- HPSS User's Guide Release 7.4.3.
- Spectrum Scale Data Management API Guide
- Spectrum Scale Administration and Programming Reference
- Spectrum Scale Advanced Administration
- ISHTAR, version 5.1.1.x
- POSIX 1003.1-1990 Tar Standard