Nils Haustein | Senior Technical Staff Member | EMEA Storage Competence Center

IBM Spectrum Scale | Information Lifecycle Management

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Agenda

➔**Spectrum Scale ILM**

Hints & Tips

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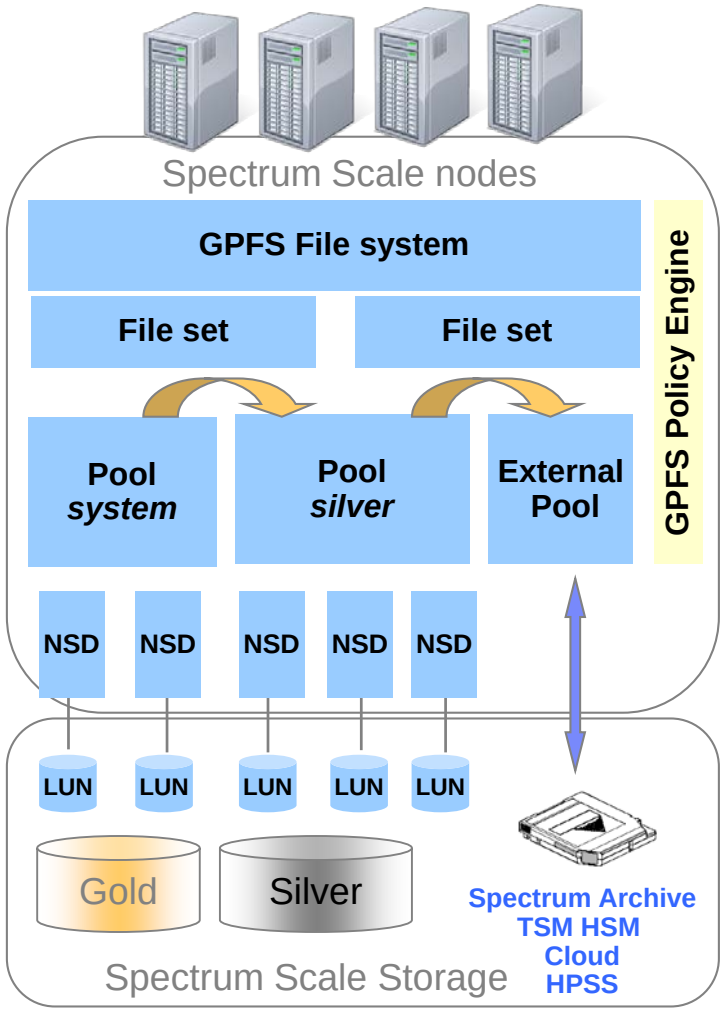
Spectrum Scale ILM tools

- Files stored in file system and underlying pools
  - Storage pool is a collection of disks of the same type
- **Placement policy** controls where files are placed
  - Files are placed in pools
  - Placement policy is applied during file creation
- **Migration policies** control transparent migration of files from one pool to another
  - Applied during life cycle
  - Migrated files can be transparently accessed
  - Files can also be migrated to tape
    - Transparent access through file system
- **Policy engine** applies and executes policies



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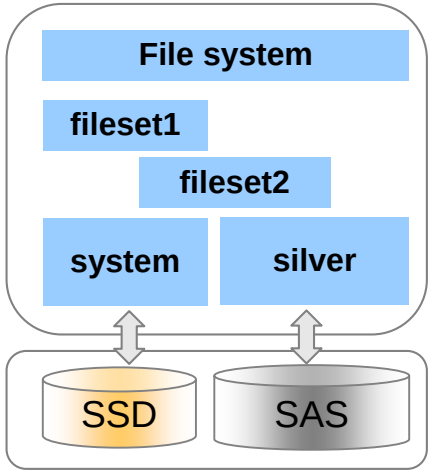
File system and filesets



- User stores data in file system (global name space)
- **Fileset** is a partition of the file system
  - For the user it is a directory
  - For the admin it allows more granular operations such as quota, snapshots*, AFM caching*, immutability, backup and tiering
- Two kinds of filesets: independent and dependent
  - Independent file sets have own inode space and allow snapshot & AFM
- File system is comprised of storage **pools**
  - There is at least one storage pool per file system (system pool)
  - File system capacity is represented by all pools
  - Pools are used for placement and migration
  - Data in a file set can be aligned to a pool using placement policies

* Independent fileset only

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File system storage pools

- **Internal pool** – allows placement and migration
  - A collection of disks or arrays with similar properties that are managed together
  - Every file system has at least a “system” pool
    - GPFS file system metadata is only stored in “system” pool
    - Maximum of 8 storage pools are possible per file system
- **External pool** – allows migration
  - External pool is an interface (script) to an external application
  - Scripts supported for Spectrum Archive, TSM HSM, Cloud Object Storage or HPSS
  - External application is invoked by policy engine or by command
- Pools are designated by names
  - Pool name *system* is reserved for the standard pool

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Spectrum Scale policies and rules

- A **policy** is a set of rules that describes the life cycle of files
- Each **rule** defines selection criteria for files and operation to be applied
  - File selection based on file attributes (name, size, age, ...)
  - Selected files are processed according to rule type and definition
- Rule types are:
  - **File placement** OR
  - **File migration (threshold / scheduled)** OR
  - File deletion OR
  - File encryption etc.
- A policy can include a mix of different rules types

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Active and scheduled policies

- **One active policy** can be configured for a file system
  - Is automatically invoked based on rule type and definitions
  - Active ILM policy for one file system can include:
    - File placement rules
    - Threshold migration rules (space triggers)

- **One or more scheduled policies** can be run for a file system
  - Are invoked manually or via scheduler
  - Scheduled policies include migration rules
    - Based on file attribute (size, age)

- Active migration policies must be threshold based and simple
- Scheduled migration policies do not require threshold and can be more advanced

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Active migration policy (threshold based)

- Active migration policy triggers automated migration based on capacity threshold

```
RULE 'rule-name' MIGRATE FROM POOL 's-pool'
THRESHOLD(%high,%low) [WEIGHT(expression)] TO POOL 'd-pool'
[FOR FILESET ('fileset-name') WHERE (conditions)]
```

- Threshold statement defines threshold at which this rule is triggered
  - %high: Threshold triggers migration
  - %low: continue migration until this threshold is reached

- Activated for entire file system with command: `mmchpolicy`
  - When threshold is reached migration rules are applied automatically
  - Invokes GPFS callback (must be configured)
  - Callback invokes `mmapplypolicy` for this policy

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Migration Callback

- To invoke the policy engine when threshold is met a callback must be configured
  - For internal and external pool migrations
- Callback is invoked upon GPFS events
  - Relevant migration events are: `lowDiskSpace,noDiskSpace`
- Callback executes a customizable script with selective parameters
  - Parameters are typically: `'%eventName %fsName' (%storagePool)`
  - Default script is: `/usr/lpp/mmfs/bin/mmstartpolicy` - invokes `mmapplypolicy`
- Example for callback setup:

```
mmaddcallback MIGRATION --command /usr/lpp/mmfs/bin/mmstartpolicy
--event lowDiskSpace,noDiskSpace --parms '%eventName %fsName'
```


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Manual migration (scheduled)

- Manual migration is started on-demand

```
RULE 'rule-name' MIGRATE FROM POOL 's-pool'
[WEIGHT(expression)] TO POOL 'd-pool'
[FOR FILESET ('fileset-name')] WHERE (conditions)
```

- Conditions describe files to be selected for migration
  - Can be based on file attributes (names, size, age, owner)
  - Use of threshold is optional

- Start the policy engine for the entire file system:

```
mmapplypolicy <fsname> -P policyfile
[–s workdir -g workdir -I test|yes]
```


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Spectrum Scale policy engine

- Policy engine evaluates and applies policy rules by:
  - Selecting files based on criteria defined in rules
  - Initiating an action defined by the rules (placement, migration)

- Policy engine is invoked according to policy type
  - Active placement policy: when file is created (automatic)
  - Active migration policy: when threshold is reached (automatic)
  - Manual migration policy: when policy engine is invoked

- Policy engine runs in three phases on multiple Spectrum Scale nodes
  1. Metadata scan: reading directory file metadata from inodes
  2. Rule evaluation: matching file metadata against rules (top down) and selecting file
  3. File operation: performing the action (placement, migration, etc.)

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Starting the policy engine

- Active policy for a file system is configured with command: `mmchpolicy`
  - Starts policy engine automatically for **placement and threshold based migration**

```
mmchpolicy filesystem policyfile [–I yes|test]
```

  - When threshold is reached `mmapplypolicy` is invoked via callback

- Scheduled policy for a file system is invoked with command: `mmapplypolicy`
  - Starts policy engi**ne manually for migration**

```
mmapplypolicy filesystem –P policyfile [–I yes|test|defer|prepare]
```


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Migration to external pool

- External pool must be defined with an additional external pool rule

```
RULE EXTERNAL POOL 'ext-pool' EXEC 'program' OPTS option

RULE 'rule-name' MIGRATE FROM POOL 'int-pool' TO POOL 'ext-pool'
WHERE (conditions)
```

- Example for migration to Spectrum Archive EE:

```
RULE EXTERNAL POOL 'ltfs' EXEC '/opt/ibm/ltfsee/bin/ltfsee'
OPTS ‘-p Tapepool@Library'
RULE 'autoMigSilver' MIGRATE FROM POOL 'silver' THRESHOLD(90,70)
WEIGHT(KB_ALLOCATED) TO POOL 'ltfs’
```

  – To start the policy engine:

```
# mmapplypolicy <file-system> -P policyfile
-m 3 –B 1000 -N ltfsnodes -n 1 --single-instance [-I test|yes]
```


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Consideration for mmapplypolicy parameters for external pools

Option	Description	Consideration
-m	Number of threads dispatched for migration, each thread processes a bucket	Depend on number of nodes, bucket size and size of files
-B	Bucket size: number of files per bucket (per file list)	1000 – 10.000, depends on number and size of files
-n	Number of directory scan threads	1
-N	Node names to be involved in the policy execution	Nodes where Spectrum Archive is installed and running
--single-instance	Only one instance of mmapplypolicy can run for this file system	Should be used
-I	Run mode of policy (run, test or defer)	For testing
-s <directory>	Local work directory, default /tmp	Set to shared file system with sufficient capacity
-g <directory>	Global work directory, default sharedTmpDir	
-M	Allows to substitute strings in the policy file	Special use cases
-L <num>	Run in debug mode	For testing, shows the name of the selected files

- Parameters –m and –B can be used to control the max. numbers of files being migrated in parallel (m * B * N)

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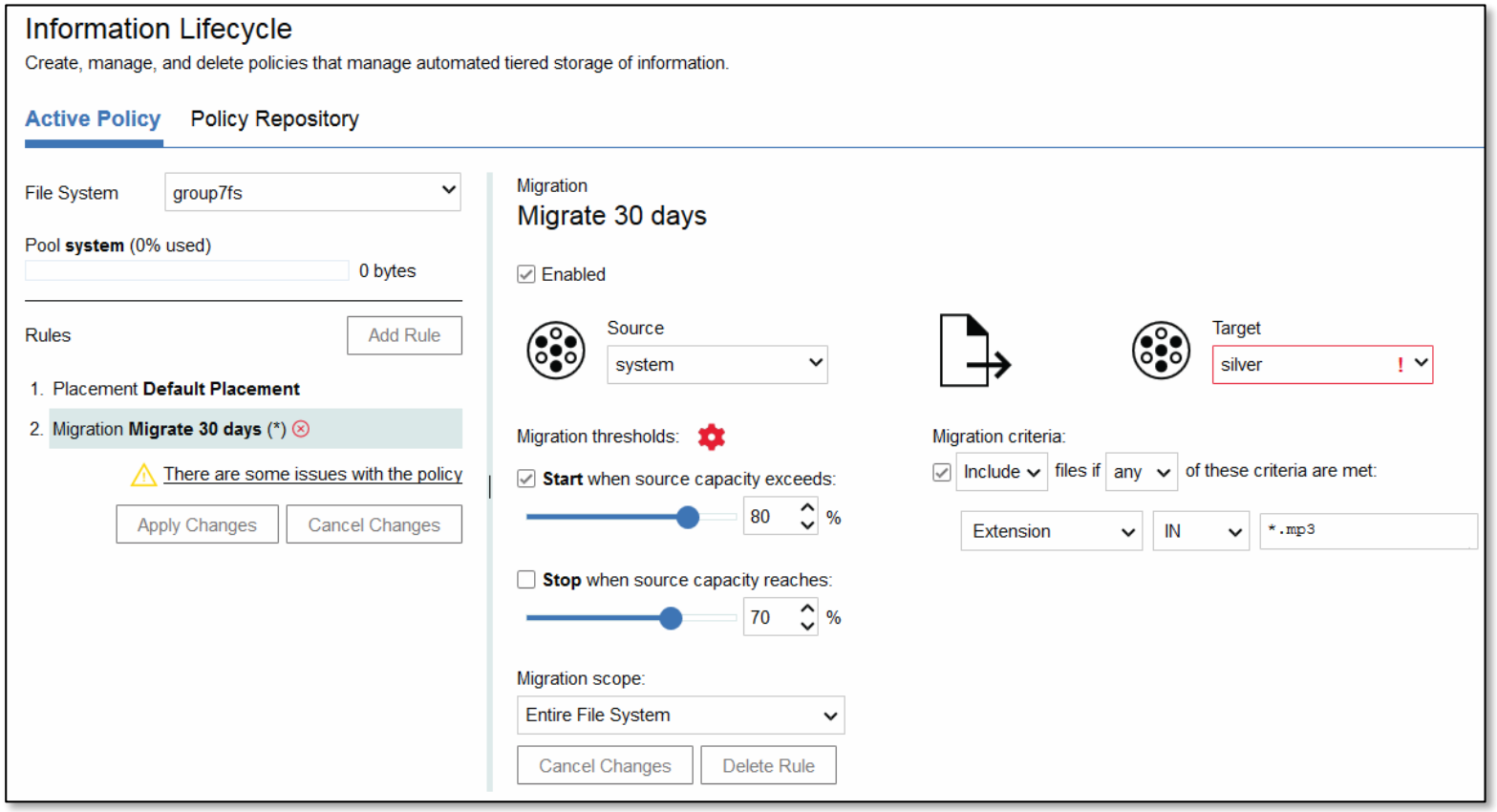
GUI integration of ILM

- GUI intuitively allows to manage placement and migration policies
  - Including syntax and prerequisite check, displays rules



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Agenda

Spectrum Scale ILM concept

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General guidance for Spectrum Scale ILM

- Use scheduled policies to control pool utilization
  - Use Threshold based migration as last line of defense
    - Kicks in unexpected and generates unexpected workloads
    - Triggers every two minutes
- Policies for Threshold based migration should be simple and effective
  - Scheduled policies can be more sophisticated
- Migration between pools causes additional I/O – plan for this
- Use `–single-instance` when migrating to external pools
- Use parameter `–s` and `–g` to set the directories for temporary files
  - Prior to Spectrum Scale 5.0 default location is /tmp
  - With Spectrum Scale version 5.0 default location is /fs/.mmSharedTmpDir
    - Can be set with global configuration parameter: `sharedTmpDir`
- Exclude certain directories when migrating to external pools
  - Such as .SpaceMan, .snapshot, mmSharedTmpDir, CES shared root and .ltfsee
  - Consider EXCLUDE rules

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Macros

- Macros allow pre-defining certain conditions to make rules less complex to read

```
define( macro-name, (conditions & expressions) )
```

- Example: Migrate files older than 30 days

```
define( access_age,(DAYS(CURRENT_TIMESTAMP) - DAYS(ACCESS_TIME)) )
.
RULE 'MigToTape' MIGRATE FROM POOL ‘system' TO POOL 'ltfs'
WHERE (access_age > 30)
```

- More examples: define *migrated* state:
  `define( is_migrated,(MISC_ATTRIBUTES LIKE '%V%') )`

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Exclude rules

- Allow to exclude files and directories from migration (not for placement)

```
RULE ['RuleName'] EXCLUDE [DIRECTORIES_PLUS]
[FOR FILESET ('FilesetName'[,'FilesetName']...)]
[WHERE SqlExpression]
```

- Exclude rules are evaluated during inode scan phase
  - Files are excluded prior to matching the subsequent migration rules
  - Exclude rules are more efficient and faster than exclusion in WHERE clause

- To exclude directories from migration:

```
RULE 'exclude' EXCLUDE DIRECTORIES_PLUS WHERE
(PATH_NAME LIKE '%/.SpaceMan/%' OR
PATH_NAME LIKE  '%/.snapshots/%' OR
PATH_NAME LIKE  ‘%/.mmSharedTmpDir/%' OR
PATH_NAME LIKE  '%/.mmbackup/%')
```


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Weight statement

- Weight statement can be used in action rule to sort the files provided in file lists
  - Default weight is `KB_ALLOCATED` (largest files first)
- For age based migration access age my be used as weight
  - `(DAYS(CURRENT_TIMESTAMP) - DAYS(ACCESS_TIME)`
- Example: to prefer certain directories for migration:

```
define(dir_weight,
  (CASE
      /*=== dir1 has high priority ===*/
    WHEN PATH_NAME like '%/dir1/%'  THEN 4
      /*=== dir2 has medium priority ===*/
    WHEN PATH_NAME like '%/dir2/%'  THEN 3
  END)
)

RULE 'MigToTape' MIGRATE FROM POOL ‘system’ WEIGHT(dir_weight)
TO POOL 'ltfs' WHERE …
```


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Premigration

- Premigration copies files to the other pool, files are dual resident
  - Used with external pools
- Premigration can be configured with threshold rules

```
RULE 'rule-name' MIGRATE FROM POOL 's-pool'
THRESHOLD(%high,%low,%premig) [WEIGHT(expression)]
TO POOL 'd-pool' [FOR FILESET ('fileset-name') WHERE (conditions)]
```

- Thresholds control premigration and migration
  - %high: Threshold triggers migration rule
  - %low: Threshold stops pre-migration
  - %premig: Threshold triggers premigration. Must be between 0 and the %low value.
- If occupancy is above %low then files will be migrated until %low is met
  - Capacity between %low and %premig is premigrated

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Premigration example (schedule policies only)

- Always premigrate:

```
RULE ‘premig' MIGRATE FROM POOL ‘system’ THRESHOLD(0,100,0)
TO POOL ‘ltfs’ WHERE KB_ALLOCATED > 0
```

  - %high = 0: premigration rule is always started
  - %low = 100: always premigrate
  - %premig = 0: premigrate everything between 0 – 100%
  - Invoke this rule only as scheduled policy because %high is 0 !!!

- Premigrate if pool is below 70 %, otherwise migrate

```
RULE ‘premig' MIGRATE FROM POOL ‘system’ THRESHOLD(0,70,0)
TO POOL ‘ltfs’ WHERE KB_ALLOCATED > 0
```

  - Below 70% will premigrate, above 70% will migrate until 70% is reached and than premigrate all files that are resident
  - Invoke this rule only as scheduled policy because %high is 0.

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Premigration example with active policy

- Challenge is that active policy is triggered with %high
  - %high should have a non-zero value, otherwise the policy will be constantly triggered

- Premigrate between 10 – 70 %, migrated above 70%

```
RULE ‘premig' MIGRATE FROM POOL ‘system’ THRESHOLD(80,70,10)
TO POOL ‘ltfs’ WHERE KB_ALLOCATED > 0
```

  - This active policy kicks in if pool has reached 80%
  - Note, the active policy will kick in un-controlled.

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List policies

- List policies allow identifying files based on file attributes using the policy engine

```
RULE EXTERNAL LIST 'list-name' EXEC 'program' OPTS option
RULE 'rule-name' LIST 'list-name' WHERE (conditions)
```

- Example of policy to list migrated files:

```
RULE EXTERNAL LIST 'migrated' EXEC ''
RULE 'm_files' LIST 'migrated' WHERE (MISC_ATTRIBUTES LIKE '%V%')
```

  – Use mmapplypolicy to run list policy and create file list:

```
# mmapplypolicy /filesystem -P policyfile -f ./fileprefix -I defer
```

  – Output file is stored in file **./fileprefix.list.migrated**

  – Format of the output (inodenumber, inodegeneration, snapid – path and filename)

```
27648 1566354680 0  -- /mnt/user1/test/file.doc
```


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List policy example

- Create a list of non-resident files including the tape ID (Spectrum Archive)

```
/* macro defining resident state */
define( is_resident,(MISC_ATTRIBUTES NOT LIKE '%M%') )

/* External list rule showing the tape ID */
RULE EXTERNAL LIST 'tape-id' EXEC ''
RULE 'tape-id' LIST 'tape-id' SHOW(xattr('dmapi.IBMTPS'))
where NOT (is_resident)
```

  - Run the policy

```
#  mmapplypolicy fsname -P policyfile -f /tmp/mia -I defer
```

  - Output file /tmp/mia.list.tape-id

```
27648 1566354680 0  1 SLE033L6@33490ef5-be30-4f23-b328-
527b5e3109a4@0000013100730409 -- /mnt/user1/test/file.doc
```


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List policy with external scripts

- List policies can invoke an external script for processing the identified files
  - Policy engine identifies files according to certain criteria
  - Policy engine passes lists of files to the external script
  - External script processes the file according to the needs

- Advantages:
  - Leverage speed of policy engine for file identification
  - Leverage parallelism of policy engine for processing the file lists

- EXTERNAL LIST rule allows to specify the name of an external script

```
RULE EXTERNAL LIST 'list-name' EXEC ‘external script' OPTS option
RULE 'rule-name' LIST 'list-name' WHERE (conditions)
```


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List Policy - External script

- External script is invoked by the policy engine with the following parameters:
  1. Parameter: string describing the operation (TEST and LIST)
     - TEST is invoked first and allows the script to perform some checking
     - LIST will pass the file lists in the second parameter
  2. Parameter: depends on 1. Parameter.
     - If the first parameter is LIST then the second parameter is the name of the file list
     - If the first parameter is TEST then the second parameter is the name of the file system.
  3. Parameter (optional): OPTS encoded in the EXTERNAL LIST rule

- Each file lists includes (-B bucket size) entries in the following format

```
27648 1566354680 0  -- /mnt/user1/test/file.doc
```

- External script has to process the parameters and perform its tasks:

```
case $1 in
  (TEST)     check if file system in $2 is mounted & exit;;
  (LIST)     convert and process file list;;
esac
```


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List policy with external script - implementation

- Create a EXTERNAL LIST policy that identifies files not immutable files

```
RULE EXTERNAL LIST ‘setWorm' EXEC ‘/usr/local/bin/setWorm.sh’
RULE ‘notimm' LIST ‘setWorm' WHERE NOT (MISC_ATTRIBUTES LIKE '%X%’)
```

- Create an interface script that sets files to immutable:
  - Obtains file list ($2) with file names identified by policy engine
  - Extracts file names
  - Set retention time (mmchattr –E) and immutability flag (mmchattr –i yes)

- Run the policy using

```
# mmapplypolicy fsname -P policyfile –N nodes –m 1 –B 1000
```

  - N specifies nodes running the external scripts – create a node class for this
  - m specifies the number of concurrent processes per node
  - B specifies the number of file names in one file list

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List policy with external script – using OPTS

- EXTERNAL LIST rule allows pass options to the external script:
  - Set different retention times for different file types:

```
define( immutable, MISC_ATTRIBUTES LIKE '%X%')

RULE EXTERNAL LIST 'mp3' EXEC ‘/…/setWorm.sh' OPTS ‘365'
RULE 'mp3' LIST 'mp3' WHERE NOT (immutable) and (NAME LIKE '%.mp3')

RULE EXTERNAL LIST 'pdf' EXEC ‘/…/setWorm.sh' OPTS ‘730'
RULE 'pdf' LIST 'pdf' WHERE NOT (immutable) and (NAME LIKE '%.pdf’)
```

- External script obtains the OPTS parameter together with the file list

```
filelist=$2; retime=$3
for each line in $filelist
  extract filename
  set WORM (mmchattr –E $(current + $retime) –i yes filename)
done
```


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Extracting the file names from the file lists

- Format of the file lists (inodenumber, inodegeneration, snapid – path and filename)

```
27648 1566354680 0  -- /mnt/user1/test/file_9.doc
```

  - Extracting path and file names can be challenging if they include spaces

- Use shift to isolate the file name from file list ($fileList):

```
cat $fileList | while read line
do
  set $line; shift 4
  fName="$*“
  … process file name …
done
```

- Use awk:

```
awk -F '[ ]' '{ for(i=7; i<=NF; i++) \
printf "%s",$i (i==NF?ORS:OFS) }’ $fileList
```


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String substitution in policies

- Policy engine (mmapplypolicy) allows to substitute strings in policy rules
  - Policy rule allowing to substitute the fileset name

```
RULE 'MigToTape' MIGRATE FROM POOL ‘system’ TO POOL 'ltfs’
FOR FILESET ('FILESETNAME’) WHERE (access_age > 30)
```

  - Substitute the string (fileset name = test) when running the policy

```
# mmapplypolicy fsname -P policyfile -M "FILESETNAME=test“ …
```

- Substitute fileset name and access age:

```
RULE 'MigToTape' MIGRATE FROM POOL ‘system’ TO POOL 'ltfs’
FOR FILESET ('FILESETNAME’) WHERE (access_age > ‘AGE’)

# mmapplypolicy fsname -P policyfile
  -M "FILESETNAME=test“ -M “AGE=30” …
```


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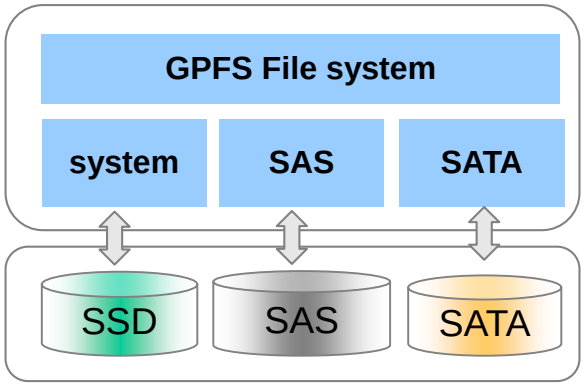
Using *Group Pools*



- Group pool combine the content of multiple pools into one virtual pool
  - Allows for redistribute files across the pools in the group
  - Example for redistribution based on file heat:

```
RULE 'HeatTiering' GROUP POOL 'TIERS' IS
     'system' LIMIT(80)
     THEN 'sas' LIMIT(90)
     THEN 'sata'
RULE 'Rebalance' MIGRATE FROM POOL 'TIERS' TO POOL 'TIERS' WEIGHT(FILE_HEAT)
```

  - Puts hottest files in pool “system” up to the utilization limit (80%)
  - Processes the other pools in the order they are listed in the GROUP POOL rule

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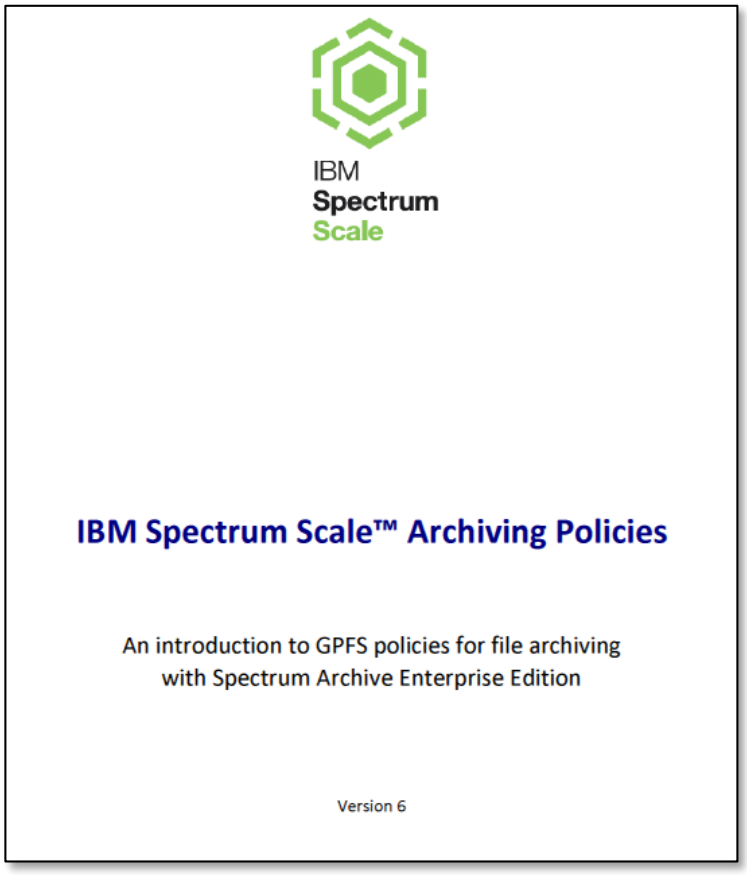
Recommended reading



Spectrum Scale ILM Policy Guide

Automation of ILM policies

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Links

- GPFS ILM Policy Guide:
  http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP102518
- Whitepaper: Introduction to Elastic Storage:
  http://public.dhe.ibm.com/common/ssi/ecm/en/dcw03057usen/DCW03057USEN.PDF
- Whitepaper: Elastic Storage Archiving with IBM LTFS Enterprise Edition
  http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP102504
- Whitepaper: Spectrum Protect HSM with Spectrum Scale AFM:
  https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/Tivoli%20Storage%20Manager/page/Configuring%20IBM%20Spectrum%20Scale%20Active%20File%20Management
- GPFS Home Page
  http://www.ibm.com/systems/gpfs
- GPFS Information Center:
  http://www-01.ibm.com/support/knowledgecenter/SSFKCN/gpfs_welcome.html
- GPFS Wiki
  http://www.ibm.com/developerworks/wikis/display/hpccentral/General+Parallel+File+System+(GPFS)
- GPFS FAQ
  http://publib.boulder.ibm.com/infocenter/clresctr/vxrx/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfsclustersfaq.pdf

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