

The dCache Book

for 3.1-series (FHS layout)



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Abstract

The dCache Book is the guide for administrators of dCache systems. The first part describes the installation of a simple single-host dCache instance. The second part describes the components of dCache and in what ways they can be configured. This is the place for finding information about the role and functionality of components in dCache as needed by an administrator. The third part contains solutions for several problems and tasks which might occur during operating of a dCache system. Finally, the last two parts contain a glossary and a parameter and command reference.

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Preface

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Welcome to the dCache. dCache is a distributed storage solution for storing huge amounts of data without a hard limit, used to provide storage in the petabyte range. Therefore it qualifies as the storage system supporting data intensive experiments.

dCache is a joined effort between the Deutsches Elektronen-Synchrotron (DESY) in Hamburg, Nordic Data Grid Facility (NDGF based in Copenhagen), the Fermi National Accelerator Laboratory near Chicago with significant distributions and support from the University of California, San Diego, INFN, Bari as well as Rutherford Appleton Laboratory, UK and CERN in Geneva.

dCache can use hierarchical storage management (e.g., hard disk and tape), provides mechanisms to automatically increase performance and balance loads, increase resilience and availability. It also supplies advanced control systems to manage data as well as data flows. Normal filesystem (btrfs, ext4, XFS, ZFS) is used to store data on storage nodes.

There are several ways of accessing data stored in dCache:

- NFS v4.1 (Chimera)
- HTTP and WebDAV
- GridFTP (GSI-FTP)
- xrootd
- SRM (versions 1.1 and 2.2)
- dCap and GSIdCap

dCache supports certificate based authentication through the Grid Security Infrastructure used in GSI-FTP, GSIdCap transfer protocols and the SRM management protocol. Certificate authentication is also available for HTTP and WebDAV.

dCache also supports fine-grain authorization with support for POSIX file permissions and NFS-style access control lists.

Other features of dCache are:

- Resilience and high availability can be implemented in different ways by having multiple replicas of the same files.

- Easy migration of data via the migration module.
- A powerful cost calculation system that allows to control the data flow (reading and writing from/to pools, between pools and also between pools and tape).
- Load balancing and performance tuning by hot pool replication (via cost calculation and replicas created by pool-to-pool-transfers).
- Space management and support for space tokens.
- Garbage collection of replicas, depending on their flags, age, et cetera.
- Detailed logging and debugging as well as accounting and statistics.
- XML information provider with detailed live information about the cluster.
- Scriptable administration interface with a terminal-based front-end.
- Web-interface with live information of the most important information.
- Ensuring data integrity through checksumming.

dCache / SRM can transparently manage data distributed among dozens of disk storage nodes (sometimes distributed over several countries). The system has shown to significantly improve the efficiency of connected tape storage systems, by caching, gather and flush and scheduled staging techniques. Furthermore, it optimizes the throughput to and from data clients by dynamically replicating datasets on the detection of load hot spots. The system is tolerant against failures of its data servers, which allows administrators to deploy commodity disk storage components.

Access to the data is provided by various standard protocols. Furthermore the software comes with an implementation of the Storage Resource Manager protocol (SRM), which is an open standard for grid middleware to communicate with site specific storage fabrics.

Who should read this book?

This book is primarily targeted at system administrators.

Minimum System Requirements?

For minimal test installation:

- Hardware: contemporary CPU , 1 GiB of RAM , 100 MiB free harddisk space
- Software: Oracle/Sun Java, Postgres SQL Server

For a high performance Grid scenario the hardware requirements highly differ, which makes it impossible to provide such parameters here. However, if you wish to setup a dCache-based storage system, just let us know and we will help you with your system specifications. Just contact us: <support@dcache.org>.

What is inside?

This book shall introduce you to dCache and provide you with the details of the installation. It describes configuration, customization of dCache as well as the usage of several protocols that dCache supports. Additionally, it provides cookbooks for standard tasks.

Here is an overview part by part:

Part 1, Getting started: This part introduces you to the cells and domain concept in dCache. It provides a detailed description of installing, the basic configuration, and upgrading dCache.

Part 2, Configuration of dCache: Within this part the configuration of several additional features of dCache is described. They are not necessary to run dCache but will be needed by some users depending on their requirements.

Part 3, Cookbook: This part comprises guides for specific tasks a system administrator might want to perform.

Looking for help?

This part gets you all the help that you might need:

- For acquiring resources:
 - The download page [<http://www.dcache.org/downloads>].
 - The YUM repositories [<http://trac.dcache.org/projects/dcache/wiki/manuals/Yum>].
- For getting help during installation:
 - Developers <support@dcache.org>
 - Additional Support:
 - German support:<german-support@dcache.org>
 - UK support:<GRIDPP-STORAGE@JISCMAIL.AC.UK>
 - USA support:<osg-storage@opensciencegrid.org>
 - User Forum: <user-forum@dcache.org>
- For features that you would like to see in dCache or bugs that should be fixed: Just write an e-mail to <support@dcache.org>
- If you like to stay up-to-date about new releases you can use the RSS feeds available from our downloads page [<http://www.dcache.org/downloads>].

Part I. Getting started

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This part is intended for people who are new to dCache. It gives an introduction to dCache, including how to configure a simple setup, and details some simple and routine administrative operations.

Chapter 1. Introduction

dCache is a distributed storage solution. It organises storage across computers so the combined storage can be used without the end-users being aware of where their data is stored. They simply see a large amount of storage.

Because end-users do not need to know on which computer their data is stored, it can be migrated from one computer to another without any interruption of service. As a consequence, (new) servers may be added to or taken away from the dCache storage cluster at any time.

dCache supports requesting data from a tertiary storage system. Such systems typically store data on magnetic tapes instead of disks, which must be loaded and unloaded using a tape robot. The main reason for using tertiary storage is the better cost-efficiency, archiving a very large amount of data on rather inexpensive hardware. In turn the access latency for archived data is significantly higher.

dCache also supports many transfer protocols (allowing users to read and write to data). These have a modular deployment, allowing dCache to support expanded capacity by providing additional front-end machines.

Another performance feature of dCache is hot-spot data migration. In this process, dCache will detect when files are requested very often. If this happens, dCache can generate duplicates of the popular files on other computers. This allows the load to be spread across multiple machines, so increasing throughput.

The flow of data within dCache can also be carefully controlled. This is especially important for large sites as chaotic movement of data may lead to suboptimal usage. Instead, incoming and outgoing data can be marshaled so they use designated resources guaranteeing better throughput and improving end-user experience.

dCache provides a comprehensive administrative interface for configuring the dCache instance. This is described in the later sections of this book.

Cells and Domains

dCache, as distributed storage software, can provide a coherent service using multiple computers or *nodes* (the two terms are used interchangeable). Although dCache can provide a complete storage solution on a single computer, one of its strengths is the ability to scale by spreading the work over multiple nodes.

A *cell* is dCache's most fundamental executable building block. Even a small dCache deployment will have many cells running. Each cell has a specific task to perform and most will interact with other cells to achieve it.

Cells can be grouped into common types; for example, pools, doors. Cells of the same type behave in a similar fashion and have higher-level behaviour (such as storing files, making files available). Later chapters will describe these different cell types and how they interact in more detail.

There are only a few cells where (at most) only a single instance is required. The majority of cells within a dCache instance can have multiple instances and dCache is designed to allow load-balancing over these cells.

A *domain* is a container for running cells. Each domain runs in its own Java Virtual Machine (JVM) instance, which it cannot share with any other domain. In essence, a domain *is* a JVM with the additional functionality

necessary to run cells (such as system administration and inter-cell communication). This also implies, that a node's resources, such as memory, available CPU and network bandwidth, are shared among several domains running on the same node.

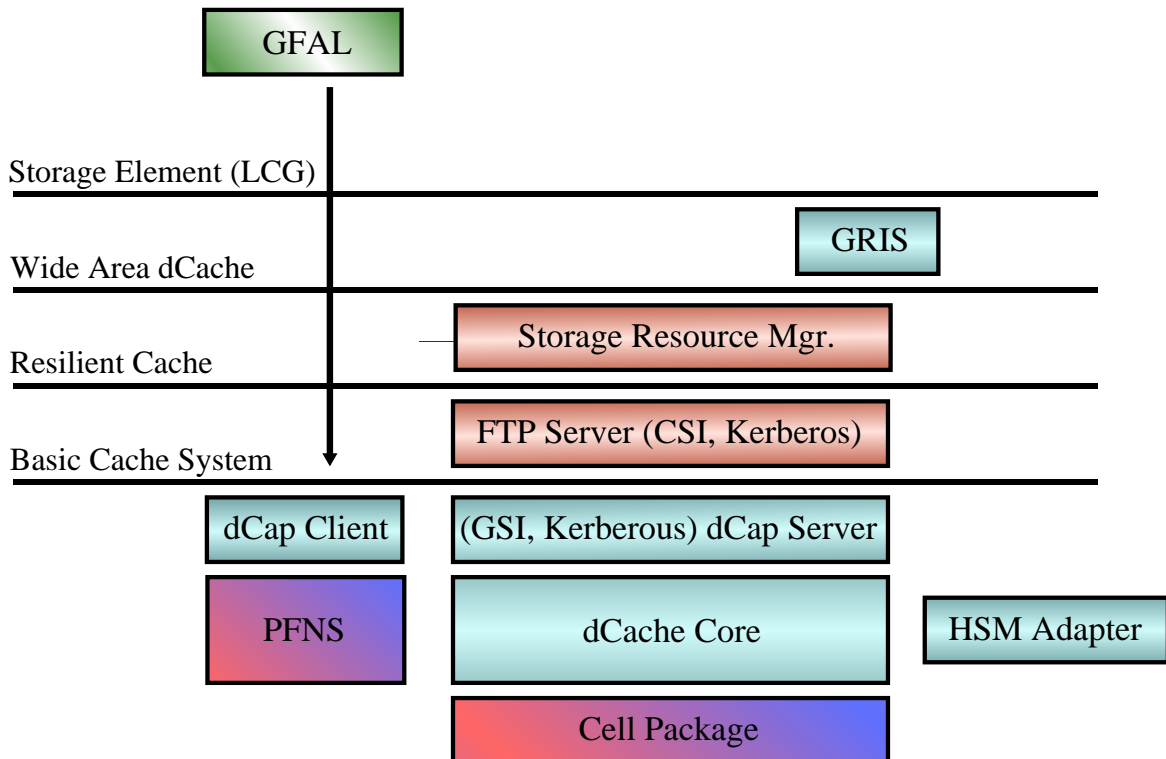
dCache comes with a set of domain definitions, each specifying a useful set of cells to run within that domain to achieve a certain goal. These goals include storing data, providing a front-end to the storage, recording file names, and so on. The list of cells to run within these domains are recommended deployments: the vast majority of dCache deployments do not need to alter these lists.

A node is free to run multiple domains, provided there's no conflicting requirement from the domains for exclusive access to hardware. A node may run a single domain; but, typically a node will run multiple domains. The choice of which domains to run on which nodes will depend on expected load of the dCache instance and on the available hardware. If this sounds daunting, don't worry: starting and stopping a domain is easy and migrating a domain from one node to another is often as easy as stopping the domain on one node and starting it on another.

dCache is scalable storage software. This means that (in most cases) the performance of dCache can be improved by introducing new hardware. Depending on the performance issue, the new hardware may be used by hosting a domain migrated from a overloaded node, or by running an additional instance of a domain to allow load-balancing.

Most cells communicate in such a way that they don't rely on in which domain they are running. This allows a site to move cells from one domain to another or to create new domain definitions with some subset of available cells. Although this is possible, it is rare that redefining domains or defining new domains is necessary. Starting or stopping domains is usually sufficient for managing load.

Figure 1.1. The dCache Layer Model



The layer model shown in Figure 1.1, “The dCache Layer Model” gives an overview of the architecture of the dCache system.

Protocols Supported by dCache

	dCap	FTP	xrootd	NFSv4.1	WebDAV	SRM
	+	+	+	+	+	-
kerberos	+	+	-	+	-	-
Client Certificate	+	+	+	-	+	+
username/ password	+	+	-	-	+	-
Control Connection Encrypted	+	+	+	+	+	+
Data Connection Encrypted	-	-	-	+	-	-
passiv	+	+	+	+	+	+
active	+	+	-	-	-	-

Chapter 2. Installing dCache

The first section describes the installation of a fresh dCache instance using RPM files downloaded from the dCache home-page [<http://www.dcache.org>]. It is followed by a guide to upgrading an existing installation. In both cases we assume standard requirements of a small to medium sized dCache instance without an attached *tertiary storage system*. The third section contains some pointers on extended features.

Installing a dCache instance

In the following the installation of a dCache instance will be described. The Chimera name space provider, some management components, and the SRM need a PostgreSQL server installed. We recommend running this PostgreSQL on the local node. The first section describes the configuration of a PostgreSQL server. After that the installation of Chimera and of the dCache components will follow. During the whole installation process root access is required.

Prerequisites

In order to install dCache the following requirements must be met:

- An RPM-based Linux distribution is required for the following procedure. For Debian derived systems we provide Debian packages and for Solaris the Solaris packages or the tarball.
- dCache requires Java 8 JRE. Please use the latest patch-level and check for upgrades frequently. It is recommended to use JDK as dCache scripts can make use of some extra features that JDK provides to gather more diagnostic information (heap-dump, etc). This helps when tracking down bugs.
- PostgreSQL must be installed and running. We recommend the use of PostgreSQL version 9.2 (at least PostgreSQL version 8.3 is required).

Important

For good performance it is necessary to maintain and tune your PostgreSQL server. There are several good books on this topic, one of which is *PostgreSQL 9.0 High Performance* [<http://www.2ndquadrant.com/books/postgresql-9-0-high-performance>].

Installation of the dCache Software

The RPM packages may be installed right away, for example using the command:

```
[root] # rpm -ivh dcache-3.1.0-1.noarch.rpm
```

The actual sources lie at <http://www.dcache.org/downloads/IAgree.shtml>. To install for example Version 3.1.0-1 you would use this:

```
[root] # rpm -ivh http://www.dcache.org/downloads/1.9/repo/3.1/dcache-3.1.0-1.noarch.rpm
```

The client can be found in the download-section of the above url, too.

Readying the PostgreSQL server for the use with dCache

Using a PostgreSQL server with dCache places a number of requirements on the database. You must configure PostgreSQL for use by dCache and create the necessary PostgreSQL user accounts and database structure. This section describes how to do this.

Starting PostgreSQL

Install the PostgreSQL server with the tools of the operating system.

Initialize the database directory (for PostgreSQL version 9.2 this is `/var/lib/pgsql/9.2/data/`), start the database server, and make sure that it is started at system start-up.

```
[root] # service postgresql-9.2 initdb
Initializing database: [ OK ]
[root] # service postgresql-9.2 start
Starting postgresql-9.2 service: [ OK ]
[root] # chkconfig postgresql-9.2 on
```

Enabling local trust

Perhaps the simplest configuration is to allow password-less access to the database and the following documentation assumes this is so.

To allow local users to access PostgreSQL without requiring a password, ensure the file `pg_hba.conf`, which (for PostgreSQL version 9.2) is located in `/var/lib/pgsql/9.2/data`, contains the following lines.

#	TYPE	DATABASE	USER	ADDRESS	METHOD
# "local" is for Unix domain socket connections only					
local	all		all		trust
# IPv4 local connections:					
host	all		all	127.0.0.1/32	trust
# IPv6 local connections:					
host	all		all	:::1/128	trust

Note

Please note it is also possible to run dCache with all PostgreSQL accounts requiring passwords. See the section called “Configuring Access to PostgreSQL” for more advice on the configuration of PostgreSQL.

Restarting PostgreSQL

If you have edited PostgreSQL configuration files, you *must* restart PostgreSQL for those changes to take effect. On many systems, this can be done with the following command:

```
[root] # service postgresql-9.2 restart
Stopping postgresql-9.2 service: [ OK ]
Starting postgresql-9.2 service: [ OK ]
```

Configuring Chimera

Chimera is a library providing a hierarchical name space with associated meta data. Where pools in dCache store the content of files, Chimera stores the names and meta data of those files. Chimera itself stores the data in a relational database. We will use PostgreSQL in this tutorial. The properties of Chimera are defined in `/usr/share/dcache/defaults/chimera.properties`. See Chapter 4, *Chimera* for more information.

Creating users and databases for dCache

Create the Chimera database and user.

```
[root] # createdb -U postgres chimera
CREATE DATABASE
[root] # createuser -U postgres --no-superuser --no-createrole --createdb --pwprompt chimera
Enter password for new role:
Enter it again:
You do not need to enter a password.
```

The dCache components will access the database server with the user `srmdcache`.

```
[root] # createuser -U postgres --no-superuser --no-createrole --createdb --pwprompt srmdcache
Enter password for new role:
Enter it again:
You do not need to enter a password.
```

Several management components running on the head node as well as the SRM will use the database `dcache` for storing their state information:

```
[root] # createdb -U srmdcache dcache
```

There might be several of these on several hosts. Each is used by the dCache components running on the respective host.

Create the database used for the billing plots.

```
[root] # createdb -O srmdcache -U postgres billing
```

And run the command `dcache database update`.

```
[root] # dcache database update
PnfsManager@dCacheDomain:
INFO - Successfully acquired change log lock
INFO - Creating database history table with name: databasechangelog
INFO - Reading from databasechangelog
many more like this...
```

Now the configuration of Chimera is done.

Before the first start of dCache replace the file `/etc/dcache/gplazma.conf` with an empty file.

```
[root] # mv /etc/dcache/gplazma.conf /etc/dcache/gplazma.conf.bak
[root] # touch /etc/dcache/gplazma.conf
```

dCache can be started now.

```
[root] # dcache start
Starting dCacheDomain done
```


So far, no configuration of dCache is done, so only the predefined domain is started.

Configuring dCache

Terminology

dCache consists of one or more *domains*. A domain in dCache is a Java Virtual Machine hosting one or more dCache *cells*. Each domain must have a name which is unique throughout the dCache instance and a cell must have a unique name within the domain hosting the cell.

A *service* is an abstraction used in the dCache configuration to describe atomic units to add to a domain. It is typically implemented through one or more cells. dCache keeps lists of the domains and the services that are to be run within these domains in the *layout files*. The layout file may contain domain- and service-specific configuration values. A *pool* is a cell providing physical data storage services.

Configuration files

In the setup of dCache, there are three main places for configuration files:

- `/usr/share/dcache/defaults`
- `/etc/dcache/dcache.conf`
- `/etc/dcache/layouts`

The folder `/usr/share/dcache/defaults` contains the default settings of the dCache. If one of the default configuration values needs to be changed, copy the default setting of this value from one of the files in `/usr/share/dcache/defaults` to the file `/etc/dcache/dcache.conf`, which initially is empty and update the value.

Note

In this first installation of dCache your dCache will not be connected to a tape system. Therefore please change the values for `pnfsmanager.default-retention-policy` and `pnfsmanager.default-access-latency` in the file `/etc/dcache/dcache.conf`.

```
pnfsmanager.default-retention-policy=REPLICA
pnfsmanager.default-access-latency=ONLINE
```

Layouts describe which domains to run on a host and which services to run in each domain. For the customized configuration of your dCache you will have to create a layout file in `/etc/dcache/layouts`. In this tutorial we will call it the `mylayout.conf` file.

Important

Do not update configuration values in the files in the `defaults` folder, since changes to these files will be overwritten by updates.

As the files in `/usr/share/dcache/defaults/` do serve as succinct documentation for all available configuration parameters and their default values it is quite useful to have a look at them.

Defining domains and services

Domains and services are defined in the layout files. Depending on your site, you may have requirements upon the doors that you want to configure and domains within which you want to organise them.

A domain must be defined if services are to run in that domain. Services will be started in the order in which they are defined.

Every domain is a Java Virtual Machine that can be started and stopped separately. You might want to define several domains for the different services depending on the necessity of restarting the services separately.

The layout files define which domains to start and which services to put in which domain. Configuration can be done per domain and per service.

A name in square brackets, *without* a forward-slash (/) defines a domain. A name in square brackets *with* a forward slash defines a service that is to run in a domain. Lines starting with a hash-symbol (#) are comments and will be ignored by dCache.

There may be several layout files in the layout directory, but only one of them is read by dCache when starting up. By default it is the `single.conf`. If the dCache should be started with another layout file you will have to make this configuration in `/etc/dcache/dcache.conf`.

Example:

```
dcache.layout=mylayout
```

This entry in `/etc/dcache/dcache.conf` will instruct dCache to read the layout file `/etc/dcache/layouts/mylayout.conf` when starting up.

Example:

These are the first lines of `/etc/dcache/layouts/single.conf`:

```
dcache.broker.scheme=none

[dCacheDomain]
[dCacheDomain/admin]
[dCacheDomain/poolmanager]
```

`[dCacheDomain]` defines a domain called `dCacheDomain`. In this example only one domain is defined. All the services are running in that domain. Therefore no messagebroker is needed, which is the meaning of the entry `messageBroker=none`.

`[dCacheDomain/admin]` declares that the `admin` service is to be run in the `dCacheDomain` domain.

Example:

This is an example for the `mylayout.conf` file of a single node dCache with several domains.

```
[dCacheDomain]
[dCacheDomain/topo]
[dCacheDomain/info]
```

```
[namespaceDomain]
[namespaceDomain/pnfsmanager]
[namespaceDomain/cleaner]
[namespaceDomain/dir]

[poolmanagerDomain]
[poolmanagerDomain/poolmanager]

[adminDoorDomain]
[adminDoorDomain/admin]

[httpdDomain]
[httpdDomain/httpd]
[httpdDomain/billing]

[gPlazmaDomain]
[gPlazmaDomain/gplazma]
```

Note

If you defined more than one domain, a messagebroker is needed, because the defined domains need to be able to communicate with each other. This means that if you use the file `single.conf` as a template for a dCache with more than one domain you need to delete the line `messageBroker=none`. Then the default value will be used which is `messageBroker=cells`, as defined in the defaults `/usr/share/dcache/defaults/dcache.properties`.

Creating and configuring pools

dCache will need to write the files it keeps in pools. These pools are defined as services within dCache. Hence, they are added to the layout file of your dCache instance, like all other services.

The best way to create a pool, is to use the `dcache` script and restart the domain the pool runs in. The pool will be added to your layout file.

```
[<domainname>/pool]
name=<poolname>
path=/path/to/pool
pool.wait-for-files=${path}/data
```

The property `pool.wait-for-files` instructs the pool not to start up until the specified file or directory is available. This prevents problems should the underlying storage be unavailable (e.g., if a RAID device is offline).

Note

Please restart dCache if your pool is created in a domain that did not exist before.

Example:

```
[root] # dcache pool create /srv/dcache/p1 pool1 poolDomain
Created a pool in /srv/dcache/p1. The pool was added to poolDomain in
file:/etc/dcache/layouts/mylayout.conf.
```

In this example we create a pool called `pool1` in the directory `/srv/dcache/p1`. The created pool will be running in the domain `poolDomain`.

Mind the Gap!

The default gap for pool sizes is 4GiB. This means you should make a bigger pool than 4GiB otherwise you would have to change this gap in the dCache admin tool. See the example below. See also the section called “The Admin Interface”.

```
(local) admin > cd <poolname>
(<poolname>) admin > set gap 2G
(<poolname>) admin > save
```

Adding a pool to a configuration does not modify the pool or the data in it and can thus safely be undone or repeated.

Starting dCache

Restart dCache to start the newly configured components `dcache restart` and check the status of dCache with `dcache status`.

Example:

```
[root] # dcache restart
Stopping dCacheDomain 0 1 done
Starting dCacheDomain done
Starting namespaceDomain done
Starting poolmanagerDomain done
Starting adminDoorDomain done
Starting httpdDomain done
Starting gPlazmaDomain done
Starting poolDomain done
[root] # dcache status
DOMAIN          STATUS  PID  USER
dCacheDomain    running 17466 dcache
namespaceDomain running 17522 dcache
poolmanagerDomain running 17575 dcache
adminDoorDomain running 17625 dcache
httpdDomain     running 17682 dcache
gPlazmaDomain   running 17744 dcache
poolDomain      running 17798 dcache
```

Now you can have a look at your dCache via The Web Interface, see the section called “The Web Interface for Monitoring dCache”: `http://<httpd.example.org>:2288/`, where `<httpd.example.org>` is the node on which your `httpd` service is running. For a single node dCache this is the machine on which your dCache is running.

Java heap size

By default the Java heap size and the maximum direct buffer size are defined as

```
dcache.java.memory.heap=512m
dcache.java.memory.direct=512m
```

Again, these values can be changed in `/etc/dcache/dcache.conf`.

For optimization of your dCache you can define the Java heap size in the layout file separately for every domain.

Example:

```
[dCacheDomain]
dcache.java.memory.heap=2048m
dcache.java.memory.direct=0m
...
[utilityDomain]
dcache.java.memory.heap=384m
dcache.java.memory.direct=16m
```

Note

dCache uses Java to parse the configuration files and will search for Java on the system path first; if it is found there, no further action is needed. If Java is not on the system path, the environment variable `JAVA_HOME` defines the location of the Java installation directory. Alternatively, the environment variable `JAVA` can be used to point to the Java executable directly.

If `JAVA_HOME` or `JAVA` cannot be defined as global environment variables in the operating system, then they can be defined in either `/etc/default/dcache` or `/etc/dcache.env`. These two files are sourced by the init script and allow `JAVA_HOME`, `JAVA` and `DCACHE_HOME` to be defined.

Installing dCache on several nodes

Installing dCache on several nodes is not much more complicated than installing it on a single node. Think about how dCache should be organised regarding services and domains. Then adapt the layout files, as described in the section called “Defining domains and services”, to the layout that you have in mind. The files `/etc/dcache/layouts/head.conf` and `/etc/dcache/layouts/pool.conf` contain examples for a dCache head-node and a dCache pool respectively.

Important

You must configure a domain called `dCacheDomain` but the other domain names can be chosen freely.

Please make sure that the domain names that you choose are unique. Having the same domain names in different layout files on different nodes may result in an error.

On any other nodes than the head node, the property `dcache.broker.host` has to be added to the file `/etc/dcache/dcache.conf`. This property should point to the host containing the special domain `dCacheDomain`, because that domain acts implicitly as a broker.

Tip

On dCache nodes running only pool services you do not need to install PostgreSQL. If your current node hosts only these services, the installation of PostgreSQL can be skipped.

Securiting your dCache installation

dCache uses the `LocationManager` to discover the network topology of the internal communication: to which domains this domain should connect. The domain contacts a specific host and queries the information using UDP port 11111. The response describes how the domain should react: whether it should allow incoming connections and whether it should contact any other domains.

Once the topology is understood, dCache domains connect to each other to build a network topology. Messages will flow over this topology, enabling the distributed system to function correctly. By default, these connections use TCP port 11111.

It is essential that both UDP and TCP port 11111 are firewalled and that only other nodes within the dCache cluster are allowed access to these ports. Failure to do so can result in remote users running arbitrary commands on any node within the dCache cluster.

Upgrading a dCache Instance

Important

Always read the release notes carefully before upgrading!

Upgrading to bugfix releases within one supported branch (e.g. from 3.1.0 to 3.1.1) may be done by upgrading the packages with

```
[root] # rpm -Uvh <packageName>
```

Now dCache needs to be started again.

Chapter 3. Getting in Touch with dCache

This section is a guide for exploring a newly installed dCache system. The confidence obtained by this exploration will prove very helpful when encountering problems in the running system. This forms the basis for the more detailed stuff in the later parts of this book. The starting point is a fresh installation according to the the section called “Installing a dCache instance”.

Checking the Functionality

Reading and writing data to and from a dCache instance can be done with a number of protocols. After a standard installation, these protocols are dCap, GSIdCap, and GridFTP. In addition dCache comes with an implementation of the SRM protocol which negotiates the actual data transfer protocol.

dCache without mounted namespace

Create the root of the Chimera namespace and a world-writable directory by

```
[root] # /usr/bin/chimera mkdir /data
[root] # /usr/bin/chimera mkdir /data/world-writable
[root] # /usr/bin/chimera chmod 777 /data/world-writable
```

WebDAV

To use WebDAV you need to define a WebDAV service in your layout file. You can define this service in an extra domain, e.g. [webdavDomain] or add it to another domain.

```
[webdavDomain]
[webdavDomain/webdav]
webdav.authz.anonymous-operations=FULL
```

to the file /etc/dcache/layouts/mylayout.conf.

Note

Depending on the client you might need to set `webdav.redirect.on-read=false` and/or `webdav.redirect.on-write=false`.

```
# ---- Whether to redirect GET requests to a pool
#
# If true, WebDAV doors will respond with a 302 redirect pointing to
# a pool holding the file. This requires that a pool can accept
# incoming TCP connections and that the client follows the
# redirect. If false, data is relayed through the door. The door
# will establish a TCP connection to the pool.
#
(one-of?true|false)webdav.redirect.on-read=true

# ---- Whether to redirect PUT requests to a pool
#
# If true, WebDAV doors will respond with a 307 redirect pointing to
# a pool to which to upload the file. This requires that a pool can
```

```
# accept incoming TCP connections and that the client follows the
# redirect. If false, data is relayed through the door. The door
# will establish a TCP connection to the pool. Only clients that send
# a Expect: 100-Continue header will be redirected - other requests
# will always be proxied through the door.
#
(one-of?true|false)webdav.redirect.on-write=true
```

Now you can start the WebDAV domain

```
[root] # dcache start webdavDomain
```

and access your files via `http://<webdav-door.example.org>:2880` with your browser.

You can connect the webdav server to your file manager and copy a file into your dCache.

To use `curl` to copy a file into your dCache you will need to set `webdav.redirect.on-write=false`.

Example:

Write the file `test.txt`

```
[root] # curl -T test.txt http://webdav-door.example.org:2880/data/world-writable/curl-
testfile.txt
```

and read it

```
[root] # curl http://webdav-door.example.org:2880/data/world-writable/curl-testfile.txt
```

dCap

To be able to use dCap you need to have the dCap door running in a domain.

Example:

```
[dCacheDomain]
[dCacheDomain/dcap]
```

For anonymous access you need to set the property `dcap.authz.anonymous-operations` to `FULL`.

Example:

```
[dCacheDomain]
[dCacheDomain/dcap]
  dcap.authz.anonymous-operations=FULL
```

For this tutorial install dCap on your worker node. This can be the machine where your dCache is running.

Get the gLite repository (which contains dCap) and install dCap using **yum**.

```
[root] # cd /etc/yum.repos.d/
[root] # wget http://grid-deployment.web.cern.ch/grid-deployment/glite/repos/3.2/glite-UI.repo
[root] # yum install dcap
```


Create the root of the Chimera namespace and a world-writable directory for dCap to write into as described above.

Copy the data (here `/bin/sh` is used as example data) using the `dccp` command and the dCap protocol describing the location of the file using a URL, where `<dcache.example.org>` is the host on which the dCache is running

```
[root] # dccp -H /bin/sh dcap://<dcache.example.org>/data/world-writable/my-test-file-1
[#####] 100% 718
kiB
735004 bytes (718 kiB) in 0 seconds
```

and copy the file back.

```
[root] # dccp -H dcap://<dcache.example.org>/data/world-writable/my-test-file-1 /tmp/mytestfile1
[#####] 100% 718
kiB
735004 bytes (718 kiB) in 0 seconds
```

To remove the file you will need to mount the namespace.

The Web Interface for Monitoring dCache

In the standard configuration the dCache web interface is started on the head node (meaning that the domain hosting the `httpd` service is running on the head node) and can be reached via port 2288. Point a web browser to `http://<head-node.example.org>:2288/` to get to the main menu of the dCache web interface. The contents of the web interface are self-explanatory and are the primary source for most monitoring and trouble-shooting tasks.

The “Cell Services” page displays the status of some important *cells* of the dCache instance.

The “Pool Usage” page gives a good overview of the current space usage of the whole dCache instance. In the graphs, free space is marked yellow, space occupied by *cached files* (which may be deleted when space is needed) is marked green, and space occupied by *precious files*, which cannot be deleted is marked red. Other states (e.g., files which are currently written) are marked purple.

The page “Pool Request Queues” (or “Pool Transfer Queues”) gives information about the number of current requests handled by each pool. “Actions Log” keeps track of all the transfers performed by the pools up to now.

The remaining pages are only relevant with more advanced configurations: The page “Pools” (or “Pool Attraction Configuration”) can be used to analyze the current configuration of the *pool selection unit* in the pool manager. The remaining pages are relevant only if a *tertiary storage system (HSM)* is connected to the dCache instance.

The Admin Interface

Just use commands that are documented here

Only commands described in this documentation should be used for the administration of a dCache system.

First steps

dCache has a powerful administration interface. It can be accessed with the `ssh1` or with the `ssh2` protocol. The server is part of the `adminDoor` domain.

It is useful to define the `admin` service in a separate domain. This allows to restart the `admin` service separately from other services. In the example in the section called “Installing a dCache instance” this domain was called `adminDoorDomain`.

Example:

```
[adminDoorDomain]
[adminDoorDomain/admin]
```

Note

The `admin` interface is using `ssh2`. It used to be available using `ssh1`, which is insecure and therefore discouraged. If you want to run the `admin` service with `ssh1` you need to define the `ssh1` service.

Example:

```
[adminDoorDomain]
[adminDoorDomain/ssh1]
```

Access with `ssh2`

There are two ways of authorizing administrators to access the dCache `ssh2` admin interface. The preferred method authorizes users through their public key. The second method employs `gPlazma2` and the `dcache.kpwd` file. Thereby authorization mechanisms can be added later by deploying another `gPlazma2` plugin. The configuration of both authorization mechanisms is described in the following.

Note

All configurable values of the `ssh2` admin interface can be found in the `/usr/share/dcache/defaults/admin.properties` file. Please do NOT change any value in this file. Instead enter the key value combination in the `/etc/dcache/dcache.conf`.

Public Key Authorization

To authorize administrators through their public key just insert it into the file `authorized_keys2` which should by default be in the directory `/etc/dcache/admin` as specified in the file `/usr/share/dcache/defaults/admin.properties` under `admin.paths.authorized-keys=`. Keys have to be in one line and should have a standard format, such as:

```
ssh-dss AAAAB3...GWvM= /Users/JohnDoe/.ssh/id_dsa
```

Important

Please make sure that the copied key is still in one line. Any line-break will prevent the key from being read.

Note

You may omit the part behind the equal sign as it is just a comment and not used by dCache.

Key-based authorization will always be the default. In case the user key can not be found in the file `authorized_keys2` or the file does not exist, `ssh2Admin` will fall back to authorizing the user via `gPlazma2` and the `dcache.kpwd` file.

Now you can login to the admin interface by

```
[user] $ ssh -l admin -p 22224 headnode.example.org
dCache Admin (VII) (user=admin)
(local) admin >
```

Access via gPlazma2 and the dcache.kpwd File

To use `gPlazma` make sure that you defined a `gPlazmaDomain` in your layout file.

Example: Part of the layout file in `/etc/dcache/layouts`:

```
[<gplazma- $\{host.name\}$ >Domain]
[<gplazma- $\{host.name\}$ >Domain/gplazma]
```

To use `gPlazma2` you need to specify it in the `/etc/dcache/dcache.conf` file:

```
# This is the main configuration file of dCache.
#
...
#
# use gPlazma2
gplazma.version=2
```

Moreover, you need to create the file `/etc/dcache/gplazma.conf` with the content

```
auth optional kpwd "kpwd=/etc/dcache/dcache.kpwd"
map optional kpwd "kpwd=/etc/dcache/dcache.kpwd"
session optional kpwd "kpwd=/etc/dcache/dcache.kpwd"
```

and add the user `admin` to the `/etc/dcache/dcache.kpwd` file using the `dcache` script.

Example:

```
[user] $ dcache kpwd dcuseradd admin -u 12345 -g 1000 -h / -r / -f / -w read-write -p password
writing to /etc/dcache/dcache.kpwd :

done writing to /etc/dcache/dcache.kpwd :

[user] $
```

adds this to the `/etc/dcache/dcache.kpwd` file:

```
# set pwd
passwd admin 4091aba7 read-write 12345 1000 / /
```

Edit the file `/etc/dcache/dcachesrm-gplazma.policy` to switch on the `kpwd-plugin`. For more information about `gPlazma` see Chapter 10, *Authorization in dCache*.

Now the user `admin` can login to the admin interface with his password `password` by:

```
[user] $ ssh -l admin -p 22224 headnode.example.org
admin@headnode.example.org's password:

    dCache Admin (VII) (user=admin)

(local) admin >
```

To allow other users access to the admin interface add them to the `/etc/dcache/dcache.kpwd` file as described above.

Just adding a user in the `dcache.kpwd` file is not sufficient. The generated user also needs access rights that can only be set within the admin interface itself.

See the section called “Create a new user” to learn how to create the user in the admin interface and set the rights.

Access with `ssh1`

Connect to the server using `ssh1` with:

```
[user] $ ssh -c blowfish -p 22223 -l admin headnode.example.org
```

The initial password is “`dickerelch`” (which is German for “fat elk”) and you will be greeted by the prompt

```
    dCache Admin (VII) (user=admin)

(local) admin >
```

The password can now be changed with

```
(local) admin > cd acm
(acm) admin > create user admin
(acm) admin > set passwd -user=admin <newPasswd> <newPasswd>
(acm) admin > ..
(local) admin > logoff
```

How to use the Admin Interface

The command `help` lists all commands the cell knows and their parameters. However, many of the commands are only used for debugging and development purposes.

Warning

Some commands are dangerous. Executing them without understanding what they do may lead to data loss.

Starting from the local prompt (`(local) admin >`) the command `cd` takes you to the specified *cell*. In general the address of a cell is a concatenation of cell name @ symbol and the domain name. `cd` to a cell by:

```
(local) admin > cd <cellName>@<domainName>
```

Note

If the cells are *well-known*, they can be accessed without adding the domain-scope. See Chapter 5, *The Cell Package* for more information.

The domains that are running on the dCache-instance, can be viewed in the layout-configuration (see Chapter 2, *Installing dCache*). Additionally, there is the `topo` cell, which keeps track of the instance's domain topology. If it is running, it can be used to obtain the list of domains the following way:

Note

The `topo` cell rescans every five minutes which domains are running, so it can take some time until `ls` displays the full domain list.

Example:

As the `topo` cell is a well-known cell you can `cd` to it directly by `cd topo`.

Use the command `ls` to see which domains are running.

```
(local) admin > cd topo
(topo) admin > ls
adminDoorDomain
gsidcapDomain
dcapDomain
utilityDomain
gPlazmaDomain
webdavDomain
gridftpDomain
srmDomain
dCacheDomain
httpdDomain
namespaceDomain
poolDomain
(topo) admin > ..
(local) admin >
```

The escape sequence `..` takes you back to the local prompt.

The command `logoff` exits the admin shell.

If you want to find out which cells are running on a certain domain, you can issue the command `ps` in the `System` cell of the domain.

Example:

For example, if you want to list the cells running on the `poolDomain`, `cd` to its `System` cell and issue the `ps` command.

```
(local) admin > cd System@poolDomain
(System@poolDomain) admin > ps
Cell List
-----
c-dCacheDomain-101-102
System
```

```
pool_2
c-dCacheDomain-101
pool_1
RoutingMgr
lm
```

The cells in the domain can be accessed using **cd** together with the cell-name scoped by the domain-name. So first, one has to get back to the local prompt, as the **cd** command will not work otherwise.

Note

Note that **cd** only works from the local prompt. If the cell you are trying to access does not exist, the **cd** command will complain.

Example:

```
(local) admin > cd nonsense
java.lang.IllegalArgumentException: Cannot cd to this cell as it doesn't exist
```

Type **..** to return to the `(local) admin >` prompt.

Login to the routing manager of the `dCacheDomain` to get a list of all well-known cells you can directly **cd** to without having to add the domain.

Example:

```
(System@poolDomain) admin > ..
(local) admin > cd RoutingMgr@dCacheDomain
(RoutingMgr@dCacheDoorDomain) admin > ls
Our routing knowledge :
Local : [PoolManager, topo, LoginBroker, info]
adminDoorDomain : [pam]
gsidcapDomain : [DCap-gsi-example.dcache.org]
dcapDomain : [DCap-example.dcache.org]
utilityDomain : [gsi-pam, PinManager]
gPlazmaDomain : [gPlazma]
webdavDomain : [WebDAV-example.dcache.org]
gridftpDomain : [GFTP-example.dcache.org]
srmDomain : [RemoteTransferManager, CopyManager, SrmSpaceManager, SRM-example.dcache.org]
httpdDomain : [billing, srm-LoginBroker, TransferObserver]
poolDomain : [pool_2, pool_1]
namespaceDomain : [PnfsManager, dirLookupPool, cleaner]
```

All cells know the commands **info** for general information about the cell and **show pinboard** for listing the last lines of the *pinboard* of the cell. The output of these commands contains useful information for solving problems.

It is a good idea to get acquainted with the normal output in the following cells: `PoolManager`, `PnfsManager`, and the pool cells (e.g., `<poolHostname>_1`).

The most useful command of the pool cells is **rep ls**. To execute this command **cd** into the pool. It lists the files which are stored in the pool by their `pnfs` IDs:

Example:

```
(RoutingMgr@dCacheDoorDomain) admin > ..
```

```
(pool_1) admin > rep ls
0001000000000000000000001120 <-P------(0)[0]> 485212 si={myStore:STRING}
0001000000000000000000001230 <C------(0)[0]> 1222287360 si={myStore:STRING}
```

Each file in a pool has one of the 4 primary states: “cached” (<C---), “precious” (<-P--), “from client” (<--C-), and “from store” (<---S).

See the section called “How to Store-/Restore files via the Admin Interface” for more information about **rep ls**.

The most important commands in the PoolManager are: **rc ls** and **cm ls -r**.

rc ls lists the requests currently handled by the PoolManager. A typical line of output for a read request with an error condition is (all in one line):

Example:

```
(pool_1) admin > ..
(local) admin > cd PoolManager
(PoolManager) admin > rc ls
0001000000000000000000001230@0.0.0.0/0.0.0.0 m=1 r=1 [<unknown>]
[Waiting 08.28 19:14:16]
{149,No pool candidates available or configured for 'staging'}
```

As the error message at the end of the line indicates, no pool was found containing the file and no pool could be used for staging the file from a tertiary storage system.

See the section called “Obtain information via the dCache Command Line Admin Interface” for more information about the command **rc ls**

Finally, **cm ls** with the option **-r** gives the information about the pools currently stored in the cost module of the pool manager. A typical output is:

Example:

```
(PoolManager) admin > cm ls -r
pool_1={R={a=0;m=2;q=0};S={a=0;m=2;q=0};M={a=0;m=100;q=0};PS={a=0;m=20;q=0};PC={a=0;m=20;q=0};
  (...continues...) SP={t=2147483648;f=924711076;p=1222772572;r=0;lru=0;{g=20000000;b=0.5}}
pool_1={Tag={hostname=example.org};size=0;SC=0.16221282938326134;CC=0.0;}
pool_2={R={a=0;m=2;q=0};S={a=0;m=2;q=0};M={a=0;m=100;q=0};PS={a=0;m=20;q=0};PC={a=0;m=20;q=0};
  (...continues...) SP={t=2147483648;f=2147483648;p=0;r=0;lru=0;{g=4294967296;b=250.0}}
pool_2={Tag={hostname=example.org};size=0;SC=2.7939677238464355E-4;CC=0.0;}
```

While the first line for each pool gives the information stored in the cache of the cost module, the second line gives the costs (SC: *space cost*, CC: *performance cost*) calculated for a (hypothetical) file of zero size. For details on how these are calculated and their meaning, see the section called “Classic Partitions”.

Create a new user

To create a new user, **<new-user>** and set a new password for the user **cd** from the local prompt ((local) admin >) to the acm, the access control manager, and run following command sequence:

```
(local) admin > cd acm
(acm) admin > create user <new-user>
```

```
(acm) admin > set passwd -user=<new-user> <newPasswd> <newPasswd>
```

For the new created users there will be an entry in the directory `/etc/dcache/admin/users/meta`.

Note

As the initial user `admin` has not been created with the above command you will not find him in the directory `/etc/dcache/admin/users/meta`.

Give the new user access to a particular cell:

```
(acm) admin > create acl cell.<cellName>.execute
(acm) admin > add access -allowed cell.<cellName>.execute <new-user>
```

Example:

Give the new user access to the `PnfsManager`.

```
(acm) admin > create acl cell.PnfsManager.execute
(acm) admin > add access -allowed cell.PnfsManager.execute <new-user>
```

Now you can check the permissions by:

```
(acm) admin > check cell.PnfsManager.execute <new-user>
Allowed
(acm) admin > show acl cell.PnfsManager.execute
<noinheritance>
<new-user> -> true
```

The following commands allow access to every cell for a user `<new-user>`:

```
(acm) admin > create acl cell.*.execute
(acm) admin > add access -allowed cell.*.execute <new-user>
```

The following command makes a user as powerful as `admin` (dCache's equivalent to the `root` user):

```
(acm) admin > create acl *.*.*
(acm) admin > add access -allowed *.*.* <new-user>
```

Use of the `ssh` Admin Interface by scripts

The `ssh` admin interface can be used non-interactively by scripts. For this the dCache-internal `ssh` server uses public/private key pairs.

The file `/etc/dcache/authorized_keys` contains one line per user. The file has the same format as `~/.ssh/authorized_keys` which is used by `sshd`. The keys in `/etc/dcache/authorized_keys` have to be of type `RSA1` as dCache only supports SSH protocol 1. Such a key is generated with

```
[user] $ ssh-keygen -t rsa1 -C 'SSH1 key of <user>'
Generating public/private rsa1 key pair.
Enter file in which to save the key (/home/<user>/.ssh/identity):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/<user>/.ssh/identity.
Your public key has been saved in /home/<user>/.ssh/identity.pub.
The key fingerprint is:
c1:95:03:6a:66:21:3c:f3:ee:1b:8d:cb:46:f4:29:6a SSH1 key of <user>
```


The passphrase is used to encrypt the private key (now stored in `/home/<user>/.ssh/identity`). If you do not want to enter the passphrase every time the private key is used, you can use `ssh-add` to add it to a running `ssh-agent`. If no agent is running start it with

```
[user] $ if [ -S $SSH_AUTH_SOCK ] ; then echo "Already running" ; else eval `ssh-agent` ; fi
```

and add the key to it with

```
[user] $ ssh-add
Enter passphrase for SSH1 key of <user>:
Identity added: /home/<user>/.ssh/identity (SSH1 key of <user>)
```

Now, insert the public key `~/.ssh/identity.pub` as a separate line into `/etc/dcache/authorized_keys`. The comment field in this line “SSH1 key of `<user>`” has to be changed to the dCache user name. An example file is:

```
1024 35 141939124(... many more numbers ...)15331 admin
```

Using `ssh-add -L >> /etc/dcache/authorized_keys` will not work, because the line added is not correct. The key manager within dCache will read this file every minute.

Now, the `ssh` program should not ask for a password anymore. This is still quite secure, since the unencrypted private key is only held in the memory of the `ssh-agent`. It can be removed from it with

```
[user] $ ssh-add -d
Identity removed: /home/<user>/.ssh/identity (RSA1 key of <user>)
```

In scripts, one can use a “Here Document” to list the commands, or supply them to `ssh` as standard-input (stdin). The following demonstrates using a Here Document:

```
#!/bin/sh
#
# Script to automate dCache administrative activity

outfile=/tmp/${basename $0}.$$out

ssh -c blowfish -p 22223 admin@<adminNode> > $outfile << EOF
cd PoolManager
cm ls -r
(more commands here)
logoff
EOF
```

or, the equivalent as stdin.

```
#!/bin/bash
#
# Script to automate dCache administrative activity.

echo -e 'cd <pool_1>\nrep ls\n(more commands here)\nlogoff' \
| ssh -c blowfish -p 22223 admin@<adminNode> \
| tr -d '\r' > rep_ls.out
```

Authentication and Authorization in dCache

In dCache digital certificates are used for authentication and authorisation. To be able to verify the chain of trust when using the non-commercial grid-certificates you should install the list of certificates of grid

Certification Authorities (CAs). In case you are using commercial certificates you will find the list of CAs in your browser.

```
[root] # wget http://grid-deployment.web.cern.ch/grid-deployment/glite/repos/3.2/lcg-CA.repo
--2011-02-10 10:26:10-- http://grid-deployment.web.cern.ch/grid-deployment/glite/repos/3.2/lcg-CA.repo
Resolving grid-deployment.web.cern.ch... 137.138.142.33, 137.138.139.19
Connecting to grid-deployment.web.cern.ch|137.138.142.33|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 449 [text/plain]
Saving to: `lcg-CA.repo'

100%[=====] 449      --.-K/s  in
0s

2011-02-10 10:26:10 (61.2 MB/s) - `lcg-CA.repo' saved [449/449]
[root] # mv lcg-CA.repo /etc/yum.repos.d/
[root] # yum install lcg-CA
Loaded plugins: allowdowngrade, changelog, kernel-module
CA                                     | 951 B
00:00
CA/primary                             | 15 kB
00:00
CA
...
```

You will need a server certificate for the host on which your dCache is running and a user certificate. The host certificate needs to be copied to the directory `/etc/grid-security/` on your server and converted to `hostcert.pem` and `hostkey.pem` as described in [Using X.509 Certificates](#). Your user certificate is usually located in `.globus`. If it is not there you should copy it from your browser to `.globus` and convert the `*.p12` file to `usercert.pem` and `userkey.pem`.

Example:

If you have the clients installed on the machine on which your dCache is running you will need to add a user to that machine in order to be able to execute the `voms-proxy-init` command and execute `voms-proxy-init` as this user.

```
[root] # useradd johndoe
```

Change the password of the new user in order to be able to copy files to this account.

```
[root] # passwd johndoe
Changing password for user johndoe.
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully.
[root] # su johndoe
[user] $ cd
[user] $ mkdir .globus
```

Copy your key files from your local machine to the new user on the machine where the dCache is running.

```
[user] $ scp .globus/user*.pem johndoe@<dcache.example.org>:.globus
```

Install `glite-security-voms-clients` (contained in the `gLite-UI`).

```
[root] # yum install glite-security-voms-clients
```

Generate a proxy certificate using the command `voms-proxy-init`.

Example:

```
[user] $ voms-proxy-init
Enter GRID pass phrase:
Your identity: /C=DE/O=GermanGrid/OU=DESY/CN=John Doe

Creating proxy ..... Done
Your proxy is valid until Mon Mar  7 22:06:15 2011
```

With **voms-proxy-init -voms <yourVO>** you can add VOMS attributes to the proxy. A user's roles (Fully Qualified Attribute Names) are read from the certificate chain found within the proxy. These attributes are signed by the user's VOMS server when the proxy is created. For the **voms-proxy-init -voms** command you need to have the file `/etc/vomses` which contains entries about the VOMS servers like

Example:

```
"desy" "grid-voms.desy.de" "15104" "/C=DE/O=GermanGrid/OU=DESY/CN=host/grid-voms.desy.de" "desy"
"24"
"atlas" "voms.cern.ch" "15001" "/DC=ch/DC=cern/OU=computers/CN=voms.cern.ch" "atlas" "24"
"dteam" "lcg-voms.cern.ch" "15004" "/DC=ch/DC=cern/OU=computers/CN=lcg-voms.cern.ch" "dteam" "24"
"dteam" "voms.cern.ch" "15004" "/DC=ch/DC=cern/OU=computers/CN=voms.cern.ch" "dteam" "24"
```

Now you can generate your voms proxy containing your VO.

Example:

```
[user] $ voms-proxy-init -voms desy
Enter GRID pass phrase:
Your identity: /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
Creating temporary proxy ..... Done
Contacting grid-voms.desy.de:15104 [/C=DE/O=GermanGrid/OU=DESY/CN=host/grid-voms.desy.de] "desy"
Done
Creating proxy ..... Done
Your proxy is valid until Thu Mar 31 21:49:06 2011
```

Authentication and authorization in dCache is done by the `gplazma` service. Define this service in the layout file.

```
[gPlazmaDomain]
[gPlazmaDomain/gplazma]
```

In this tutorial we will use the `gplazmalite-vorole-mapping` plugin. To this end you need to edit the `/etc/grid-security/grid-vorolemap` and the `/etc/grid-security/storage-authzdb` as well as the `/etc/dcache/dcachesrm-gplazma.policy`.

Example:

The `/etc/grid-security/grid-vorolemap`:

```
"/C=DE/O=GermanGrid/OU=DESY/CN=John Doe" "/desy" doegroup
```

The `/etc/grid-security/storage-authzdb`:

```
version 2.1
authorize doegroup read-write 12345 1234 / / /
```

The `/etc/dcache/dcachesrm-gplazma.policy`:

```
# Switches
xacml-vo-mapping="OFF"
saml-vo-mapping="OFF"
kpwd="OFF"
grid-mapfile="OFF"
gplazmalite-vorole-mapping="ON"

# Priorities
xacml-vo-mapping-priority="5"
saml-vo-mapping-priority="2"
kpwd-priority="3"
grid-mapfile-priority="4"
gplazmalite-vorole-mapping-priority="1"
```

How to work with secured dCache

If you want to copy files into dCache with GSIdCap, SRM or WebDAV with certificates you need to follow the instructions in the section above.

GSIdCap

To use GSIdCap you must run a GSIdCap door. This is achieved by including the `gsidcap` service in your layout file on the machine you wish to host the door.

```
[gsidcapDomain]
[gsidcapDomain/dcap]
dcap.authn.protocol=gsi
```

In addition, you need to have `libdcap-tunnel-gsi` installed on your worker node, which is contained in the `gLite-UI`.

Note

As ScientificLinux 5 32bit is not supported by `gLite` there is no `libdcap-tunnel-gsi` for SL5 32bit.

```
[root] # yum install libdcap-tunnel-gsi
```

It is also available on the dCap downloads page [<http://www.dcache.org/downloads/dcap/>].

Example:

```
[root] # rpm -i http://www.dcache.org/repository/yum/s15/x86_64/RPMS.stable//libdcap-tunnel-gsi-2.47.5-0.x86_64.rpm
```

The machine running the GSIdCap door needs to have a host certificate and you need to have a valid user certificate. In addition, you should have created a voms proxy as mentioned above.

Now you can copy a file into your dCache using GSIdCap

```
[user] $ dccp /bin/sh gsidcap://<dcache.example.org>:22128/data/world-writable/my-test-file3
801512 bytes in 0 seconds
```

and copy it back

```
[user] $ dccp gsidcap://<dcache.example.org>:22128/data/world-writable/my-test-file3 /tmp/  
mytestfile3.tmp  
801512 bytes in 0 seconds
```

SRM

To use the SRM you need to define the `srm` service in your layout file.

```
[srmDomain]  
[srmDomain/srm]
```

In addition, the user needs to install an SRM client for example the `dcache-srmclient`, which is contained in the `gLite-UI`, on the worker node and set the `PATH` environment variable.

```
[root] # yum install dcache-srmclient
```

You can now copy a file into your dCache using the SRM,

```
[user] $ srmcp -2 file:///bin/sh srm://<dcache.example.org>:8443/data/world-writable/my-test-file4
```

copy it back

```
[user] $ srmcp -2 srm://<dcache.example.org>:8443/data/world-writable/my-test-file4 file:///tmp/  
mytestfile4.tmp
```

and delete it

```
[user] $ srmrm -2 srm://<dcache.example.org>:8443/data/world-writable/my-test-file4
```

If the grid functionality is not required the file can be deleted with the NFS mount of the Chimera namespace:

```
[user] $ rm /data/world-writable/my-test-file4
```

WebDAV with certificates

To use WebDAV with certificates you change the entry in `/etc/dcache/layouts/mylayout.conf` from

```
[webdavDomain]  
[webdavDomain/webdav]  
webdav.authz.anonymous-operations=FULL  
webdav.root=/data/world-writable
```

to

```
[webdavDomain]  
[webdavDomain/webdav]  
webdav.authz.anonymous-operations=NONE  
webdav.root=/data/world-writable  
webdav.authn.protocol=https
```

Then you will need to import the host certificate into the dCache keystore using the command

```
[root] # dcache import hostcert
```

and initialise your truststore by

```
[root] # dcache import cacerts
```

Now you need to restart the WebDAV domain

```
[root] # dcache restart webdavDomain
```

and access your files via `https://<dcache.example.org>:2880` with your browser.

Important

If the host certificate contains an extended key usage extension, it must include the extended usage for server authentication. Therefore you have to make sure that your host certificate is either unrestricted or it is explicitly allowed as a certificate for TLS Web Server Authentication.

Allowing authenticated and non-authenticated access with WebDAV

You can also choose to have secure and insecure access to your files at the same time. You might for example allow access without authentication for reading and access with authentication for reading and writing.

```
[webdavDomain]
[webdavDomain/webdav]
webdav.root=/data/world-writable
webdav.authz.anonymous-operations=READONLY
port=2880
webdav.authn.protocol=https
```

You can access your files via `https://<dcache.example.org>:2880` with your browser.

Files

In this section we will have a look at the configuration and log files of dCache.

The dCache software is installed in various directories according to the Filesystem Hierarchy Standard. All configuration files can be found in `/etc/dcache`.

Log files of domains are by default stored in `/var/log/dcache/<domainName>.log`.

More details about domains and cells can be found in Chapter 5, *The Cell Package*.

The most central component of a dCache instance is the `PoolManager` cell. It reads additional configuration information from the file `/var/lib/dcache/config/poolmanager.conf` at start-up. However, it is not necessary to restart the domain when changing the file. We will see an example of this below.

Part II. Configuration of dCache

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This part contains descriptions of the components of dCache, their role, functionality within the framework. In short, all information necessary for configuring them.

Chapter 4. Chimera

dCache is a distributed storage system, nevertheless it provides a single-rooted file system view. While dCache supports multiple namespace providers, Chimera is the recommended provider and is used by default.

The inner dCache components talk to the namespace via a module called `PnfsManager`, which in turn communicates with the Chimera database using a thin Java layer, which in turn communicates directly with the Chimera database. Chimera allows direct access to the namespace by providing an NFSv3 and NFSv4.1 server. Clients can NFS-mount the namespace locally. This offers the opportunity to use OS-level tools like `ls`, `mkdir`, `mv` for Chimera. Direct I/O-operations like `cp` and `cat` are possible with the NFSv4.1 door.

The properties of Chimera are defined in `/usr/share/dcache/defaults/chimera.properties`. For customisation the files `/etc/dcache/layouts/mylayout.conf` or `/etc/dcache/dcache.conf` should be modified (see the section called “Defining domains and services”).

Example:

This example shows an extract of the `/etc/dcache/layouts/mylayout.conf` file in order to run dCache with NFSv3.

```
[namespaceDomain]
[namespaceDomain/pnfsmanager]
[namespaceDomain/nfs]
nfs.version=3
```

Example:

If you want to run the NFSv4.1 server you need to add the corresponding `nfs` service to a domain in the `/etc/dcache/layouts/mylayout.conf` file and start this domain.

```
[namespaceDomain]
[namespaceDomain/pnfsmanager]
[namespaceDomain/nfs]
nfs.version = 4.1
```

If you wish dCache to access your Chimera with a PostgreSQL user other than `chimera` then you must specify the username and password in `/etc/dcache/dcache.conf`.

```
chimera.db.user=myuser
chimera.db.password=secret
```

Important

Do not update configuration values in `/usr/share/dcache/defaults/chimera.properties`, since changes to this file will be overwritten by updates.

Mounting Chimera through NFS

dCache does not need the Chimera filesystem to be mounted but a mounted file system is convenient for administrative access. This offers the opportunity to use OS-level tools like `ls` and `mkdir` for Chimera.

However, direct I/O-operations like `cp` are not possible, since the NFSv3 interface provides the namespace part only. This section describes how to start the Chimera NFSv3 server and mount the name space.

If you want to mount Chimera for easier administrative access, you need to edit the `/etc/exports` file as the Chimera NFS server uses it to manage exports. If this file doesn't exist it must be created. The typical `exports` file looks like this:

```
/ localhost(rw)
/data
# or
# /data *.my.domain(rw)
```

As any RPC service Chimera NFS requires `rpcbind` service to run on the host. Nevertheless `rpcbind` has to be configured to accept requests from Chimera NFS.

On RHEL6 based systems you need to add

```
RPCBIND_ARGS="-i"
```

into `/etc/sysconfig/rpcbind` and restart `rpcbind`. Check your OS manual for details.

```
[root] # service rpcbind restart
Stopping rpcbind: [ OK ]
Starting rpcbind: [ OK ]
```

If your OS does not provide `rpcbind` Chimera NFS can use an embedded `rpcbind`. This requires to disable the `portmap` service if it exists.

```
[root] # /etc/init.d/portmap stop
Stopping portmap: portmap
```

and restart the domain in which the NFS server is running.

Example:

```
[root] # dcache restart namespaceDomain
```

Now you can mount Chimera by

```
[root] # mount localhost:/ /mnt
```

and create the root of the Chimera namespace which you can call `data`:

```
[root] # mkdir -p /mnt/data
```

If you don't want to mount chimera you can create the root of the Chimera namespace by

```
[root] # /usr/bin/chimera mkdir /data
```

You can now add directory tags. For more information on tags see the section called "Directory Tags".

```
[root] # /usr/bin/chimera writetag /data sGroup "chimera"
[root] # /usr/bin/chimera writetag /data OSMTemplate "StoreName sql"
```

Using dCap with a mounted file system

If you plan to use dCap with a mounted file system instead of the URL-syntax (e.g. `dccp /data/file1 /tmp/file1`), you need to mount the root of Chimera locally (remote mounts are not allowed yet). This will allow us to establish wormhole files so dCap clients can discover the dCap doors.

```
[root] # mount localhost:/ /mnt
[root] # mkdir /mnt/admin/etc/config/dCache
[root] # touch /mnt/admin/etc/config/dCache/dcache.conf
[root] # touch /mnt/admin/etc/config/dCache/'.(fset)(dcache.conf)(io)(on)'
[root] # echo "<door host>:<port>" > /mnt/admin/etc/config/dCache/dcache.conf
```

The default values for ports can be found in Chapter 29, *dCache Default Port Values* (for dCap the default port is 22125) and in the file `/usr/share/dcache/defaults/dcache.properties`. They can be altered in `/etc/dcache/dcache.conf`

Create the directory in which the users are going to store their data and change to this directory.

```
[root] # mkdir -p /mnt/data
[root] # cd /mnt/data
```

Now you can copy a file into your dCache

```
[root] # dccp /bin/sh test-file
735004 bytes (718 kiB) in 0 seconds
```

and copy the data back using the `dccp` command.

```
[root] # dccp test-file /tmp/testfile
735004 bytes (718 kiB) in 0 seconds
```

The file has been transferred successfully.

Now remove the file from the dCache.

```
[root] # rm test-file
```

When the configuration is complete you can unmount Chimera:

```
[root] # umount /mnt
```

Note

Please note that whenever you need to change the configuration, you have to remount the root `localhost:/` to a temporary location like `/mnt`.

Communicating with Chimera

Many configuration parameters of Chimera and the application specific meta data is accessed by reading, writing, or creating files of the form `.(<command>) (<para>)`. For example, the following prints the ChimeraID of the file `/data/some/dir/file.dat`:

```
[user] $ cat /data/any/sub/directory/'.(id)(file.dat)'
000400000000000002320B8 [user] $
```

From the point of view of the NFS protocol, the file `.(id)(file.dat)` in the directory `/data/some/dir/` is read. However, Chimera interprets it as the command `id` with the parameter `file.dat` executed in the directory `/data/some/dir/`. The quotes are important, because the shell would otherwise try to interpret the parentheses.

Some of these command files have a second parameter in a third pair of parentheses. Note, that files of the form `.(<command>) (<para>)` are not really files. They are not shown when listing directories with `ls`. However, the command files are listed when they appear in the argument list of `ls` as in

```
[user] $ ls -l '.*(tag)(sGroup)'  
-rw-r--r-- 11 root root 7 Aug 6 2010 .(tag)(sGroup)
```

Only a subset of file operations are allowed on these special command files. Any other operation will result in an appropriate error. Beware, that files with names of this form might accidentally be created by typos. They will then be shown when listing the directory.

IDs

Each file in Chimera has a unique 18 byte long ID. It is referred to as ChimeraID or as pnfsID. This is comparable to the inode number in other filesystems. The ID used for a file will never be reused, even if the file is deleted. dCache uses the ID for all internal references to a file.

Example:

The ID of the file `example.org/data/examplefile` can be obtained by reading the command-file `.(id)(examplefile)` in the directory of the file.

```
[user] $ cat /example.org/data/'.(id)(examplefile)'  
0000917F4A82369F4BA98E38DBC5687A031D
```

A file in Chimera can be referred to by the ID for most operations.

Example:

The name of a file can be obtained from the ID with the command `nameof` as follows:

```
[user] $ cd /example.org/data/  
[user] $ cat '.(nameof)(0000917F4A82369F4BA98E38DBC5687A031D)'  
examplefile
```

And the ID of the directory it resides in is obtained by:

```
[user] $ cat '.(parent)(0000917F4A82369F4BA98E38DBC5687A031D)'  
0000595ABA40B31A469C87754CD79E0C08F2
```

This way, the complete path of a file may be obtained starting from the ID.

Directory Tags

In the Chimera namespace, each directory can have a number of tags. These directory tags may be used within dCache to control the file placement policy in the pools (see the section called “The Pool Selection Mechanism”). They might also be used by a tertiary storage system for similar purposes (e.g. controlling the set of tapes used for the files in the directory).

Note

Directory tags are not needed to control the behaviour of dCache. dCache works well without directory tags.

Create, List and Read Directory Tags if the Namespace is not Mounted

You can create tags with

```
[user] $ /usr/bin/chimera writetag <directory> <tagName> "<content>"
```

list tags with

```
[user] $ /usr/bin/chimera lstag <directory>
```

and read tags with

```
[user] $ /usr/bin/chimera readtag <directory> <tagName>
```

Example:

Create tags for the directory data with

```
[user] $ /usr/bin/chimera writetag /data sGroup "myGroup"
[user] $ /usr/bin/chimera writetag /data OSMTemplate "StoreName myStore"
```

list the existing tags with

```
[user] $ /usr/bin/chimera lstag /data
Total: 2
OSMTemplate
sGroup
```

and their content with

```
[user] $ /usr/bin/chimera readtag /data OSMTemplate
StoreName myStore
[user] $ /usr/bin/chimera readtag /data sGroup
myGroup
```

Create, List and Read Directory Tags if the Namespace is Mounted

If the namespace is mounted, change to the directory for which the tag should be set and create a tag with

```
[user] $ cd <directory>
[user] $ echo '<content1>' > '.(tag)(<tagName1>)'
[user] $ echo '<content2>' > '.(tag)(<tagName2>)'
```

Then the existing tags may be listed with

```
[user] $ cat '.(tags)()'
.(tag)(<tagName1>)
.(tag)(<tagName2>)
```

and the content of a tag can be read with

```
[user] $ cat '.(tag)(<tagName1>)'
<content1>
[user] $ cat '.(tag)(<tagName2>)'
```

<content2>

Example:

Create tags for the directory data with

```
[user] $ cd data
[user] $ echo 'StoreName myStore' > '.(tag)(OSMTemplate)'
[user] $ echo 'myGroup' > '.(tag)(sGroup)'
```

list the existing tags with

```
[user] $ cat '.(tags)()'
.(tag)(OSMTemplate)
.(tag)(sGroup)
```

and their content with

```
[user] $ cat '.(tag)(OSMTemplate)'
StoreName myStore
[user] $ cat '.(tag)(sGroup)'
myGroup
```

A nice trick to list all tags with their contents is

```
[user] $ grep "" $(cat ".(tags)()")
.(tag)(OSMTemplate):StoreName myStore
.(tag)(sGroup):myGroup
```

Directory Tags and Command Files

When creating or changing directory tags by writing to the command file as in

```
[user] $ echo '<content>' > '.(tag)(<tagName>)'
```

one has to take care not to treat the command files in the same way as regular files, because tags are different from files in the following aspects:

1. The `<tagName>` is limited to 62 characters and the `<content>` to 512 bytes. Writing more to the command file, will be silently ignored.
2. If a tag which does not exist in a directory is created by writing to it, it is called a *primary* tag.
3. Tags are *inherited* from the parent directory by a newly created directory. Changing a primary tag in one directory will change the tags inherited from it in the same way. Creating a new primary tag in a directory will not create an inherited tag in its subdirectories.

Moving a directory within the Chimera namespace will not change the inheritance. Therefore, a directory does not necessarily inherit tags from its parent directory. Removing an inherited tag does not have any effect.

4. Empty tags are ignored.

Directory Tags for dCache

The following directory tags appear in the dCache context:

OSMTemplate

Must contain a line of the form “StoreName <storeName>” and specifies the name of the store that is used by dCache to construct the storage class if the *HSM Type* is *osm*.

HSMType

The *HSMType* tag is normally determined from the other existing tags. E.g., if the tag *OSMTemplate* exists, *HSMTYPE=osm* is assumed. With this tag it can be set explicitly. A class implementing that HSM type has to exist. Currently the only implementations are *osm* and *enstore*.

sGroup

The storage group is also used to construct the storage class if the *HSMTYPE* is *osm*.

cacheClass

The cache class is only used to control on which pools the files in a directory may be stored, while the storage class (constructed from the two above tags) might also be used by the HSM. The cache class is only needed if the above two tags are already fixed by HSM usage and more flexibility is needed.

hsmInstance

If not set, the *hsmInstance* tag will be the same as the *HSMTYPE* tag. Setting this tag will only change the name as used in the storage class and in the pool commands.

WriteToken

Assign a *WriteToken* tag to a directory in order to be able to write to a space token without using the SRM.

Storage Class and Directory Tags

The storage class is a string of the form <StoreName>:<StorageGroup>@<hsm-type>, where <StoreName> is given by the *OSMTemplate* tag, <StorageGroup> by the *sGroup* tag and <hsm-type> by the *HSMTYPE* tag. As mentioned above the *HSMTYPE* tag is assumed to be *osm* if the tag *OSMTemplate* exists.

In the examples above two tags have been created.

Example:

```
[user] $ /usr/bin/chimera lstag /data
Total: 2
OSMTemplate
sGroup
```

As the tag *OSMTemplate* was created the tag *HSMTYPE* is assumed to be *osm*.

The storage class of the files which are copied into the directory */data* after the tags have been set will be *myStore:myGroup@osm*.

If directory tags are used to control the behaviour of dCache and/or a tertiary storage system, it is a good idea to plan the directory structure in advance, thereby considering the necessary tags and how they should be set up. Moving directories should be done with great care or even not at all. Inherited tags can only be created by creating a new directory.

Example:

Assume that data of two experiments, `experiment-a` and `experiment-b` is written into a namespace tree with subdirectories `/data/experiment-a` and `/data/experiment-b`. As some pools of the dCache are financed by `experiment-a` and others by `experiment-b` they probably do not like it if they are also used by the other group. To avoid this the directories of `experiment-a` and `experiment-b` can be tagged.

```
[user] $ /usr/bin/chimera writetag /data/experiment-a OSMTemplate "StoreName exp-a"
[user] $ /usr/bin/chimera writetag /data/experiment-b OSMTemplate "StoreName exp-b"
```

Data from `experiment-a` taken in 2010 shall be written into the directory `/data/experiment-a/2010` and data from `experiment-a` taken in 2011 shall be written into `/data/experiment-a/2011`. Data from `experiment-b` shall be written into `/data/experiment-b`. Tag the directories correspondingly.

```
[user] $ /usr/bin/chimera writetag /data/experiment-a/2010 sGroup "run2010"
[user] $ /usr/bin/chimera writetag /data/experiment-a/2011 sGroup "run2011"
[user] $ /usr/bin/chimera writetag /data/experiment-b sGroup "alldata"
```

List the content of the tags by

```
[user] $ /usr/bin/chimera readtag /data/experiment-a/2010 OSMTemplate
StoreName exp-a
[user] $ /usr/bin/chimera readtag /data/experiment-a/2010 sGroup
run2010
[user] $ /usr/bin/chimera readtag /data/experiment-a/2011 OSMTemplate
StoreName exp-a
[user] $ /usr/bin/chimera readtag /data/experiment-a/2011 sGroup
run2011
[user] $ /usr/bin/chimera readtag /data/experiment-b/2011 OSMTemplate
StoreName exp-b
[user] $ /usr/bin/chimera readtag /data/experiment-b/2011 sGroup
alldata
```

As the tag `OSMTemplate` was created the `HSMType` is assumed to be `osm`.

The storage classes of the files which are copied into these directories after the tags have been set will be

- `exp-a:run2010@osm` for the files in `/data/experiment-a/2010`
- `exp-a:run2011@osm` for the files in `/data/experiment-a/2011`
- `exp-b:alldata@osm` for the files in `/data/experiment-b`

To see how storage classes are used for pool selection have a look at the example 'Reserving Pools for Storage and Cache Classes' in the `PoolManager` chapter.

There are more tags used by dCache if the `HSMType` is `enstore`.

Chapter 5. The Cell Package

All of dCache makes use of the cell package. It is a framework for a distributed and scalable server system in Java. The dCache system is divided into cells which communicate with each other via messages. Several cells run simultaneously in one domain.

Each domain runs in a separate Java virtual machine and each cell is run as a separate thread therein. Domain names have to be unique. The domains communicate with each other via TCP using connections that are established at start-up. The topology is controlled by the location manager service. In the standard configuration, all domains connect with the `dCacheDomain`, which routes all messages to the appropriate domains. This forms a star topology.

Only for message communication

The TCP communication controlled by the location manager service is for the short control messages sent between cells. Any transfer of the data stored within dCache does not use these connections; instead, dedicated TCP connections are established as needed.

A single node provides the location-manager service. For a single-host dCache instance, this is `localhost`; for multi-host dCache instances, the hostname of the node providing this service must be configured using the `serviceLocatorHost` property.

The domain that hosts the location manager service is also configurable. By default, the service runs within the `dCacheDomain` domain; however, this may be changed by setting the `dcache.broker.domain` property. The port that the location manager listens on is also configurable, using the `dcache.broker.port` property; however, most sites may leave this property unaltered and use the default value.

Within this framework, cells send messages to other cells addressing them in the form `<cellName>@<domainName>`. This way, cells can communicate without knowledge about the host they run on. Some cells are *well known*, i.e. they can be addressed just by their name without `@<domainName>`. Evidently, this can only work properly if the name of the cell is unique throughout the whole system. If two well known cells with the same name are present, the system will behave in an undefined way. Therefore it is wise to take care when starting, naming, or renaming the well known cells. In particular this is true for pools, which are well known cells.

A domain is started with a shell script `bin/dcache start <domainName>`. The routing manager and location manager cells are started in each domain and are part of the underlying cell package structure. Each domain will contain at least one cell in addition to them.

Chapter 6. The replica Service (Replica Manager)

The replica service (which is also referred to as Replica Manager) controls the number of replicas of a file on the pools. If no *tertiary storage system* is connected to a dCache instance (i.e., it is configured as a *large file store*), there might be only one copy of each file on disk. (At least the *precious replica*.) If a higher security and/or availability is required, the resilience feature of dCache can be used: If running in the default configuration, the replica service will make sure that the number of *replicas* of a file will be at least 2 and not more than 3. If only one replica is present it will be copied to another pool by a *pool to pool transfer*. If four or more replicas exist, some of them will be deleted.

The Basic Setup

The standard configuration assumes that the database server is installed on the same machine as the replica service — usually the admin node of the dCache instance. If this is not the case you need to set the property `replica.db.host`.

To create and configure the database *replica* used by the replica service in the database server do:

```
[root] # createdb -U dcache replica
[root] # psql -U dcache -d replica -f /usr/share/dcache/replica/psql_install_replicas.sql
```

To activate the replica service you need to

1. Enable the replica service in a layout file.

```
[<someDomain>]
...
[<someDomain>/replica]
```

2. Configure the service in the `/etc/dcache/dcache.conf` file on the node with the `dCacheDomain` and on the node on which the `pnfsmanager` is running.

```
dcache.enable.replica=true
```

Note

It will not work properly if you defined the replica service in one of the layout files and set this property to `no` on the node with the `dCacheDomain` or on the node on which the `pnfsmanager` is running.

3. Define a pool group for the resilient pools if necessary.
4. Start the replica service.

In the default configuration, all pools of the dCache instance which have been created with the command `dcache pool create` will be managed. These pools are in the pool group named `default` which does exist by default. The replica service will keep the number of replicas between 2 and 3 (including). At each restart of the replica service the pool configuration in the database will be recreated.

Example:

This is a simple example to get started with. All your pools are assumed to be in the pool group default.

1. In your layout file in the directory `/etc/dcache/layouts` define the `replica` service.

```
[dCacheDomain]
...

[replicaDomain]
[replicaDomain/replica]
```

2. In the file `/etc/dcache/dcache.conf` set the value for the property `replicaManager` to `true` and the `replica.poolgroup` to `default`.

```
dcache.enable.replica=true
replica.poolgroup=default
```

3. The pool group `default` exists by default and does not need to be defined.
4. To start the `replica` service restart `dCache`.

```
[root] # dcache restart
```

Define a poolgroup for resilient pools

For more complex installations of `dCache` you might want to define a pool group for the resilient pools.

Define the resilient pool group in the `/var/lib/dcache/config/poolmanager.conf` file on the host running the `poolmanager` service. Only pools defined in the resilient pool group will be managed by the `replica` service.

Example:

Login to the admin interface and `cd` to the `PoolManager`. Define a poolgroup for resilient pools and add pools to that poolgroup.

```
(local) admin > cd PoolManager
(PoolManager) admin > psu create pgroup ResilientPools
(PoolManager) admin > psu create pool pool3
(PoolManager) admin > psu create pool pool4
(PoolManager) admin > psu addto pgroup ResilientPools pool3
(PoolManager) admin > psu addto pgroup ResilientPools pool4
(PoolManager) admin > save
```

By default the pool group named `ResilientPools` is used for replication.

To use another pool group defined in `/var/lib/dcache/config/poolmanager.conf` for replication, please specify the group name in the `etc/dcache.conf` file.

```
replica.poolgroup=<NameOfResilientPoolGroup>.
```

Operation

When a file is transferred into dCache its replica is copied into one of the pools. Since this is the only replica and normally the required range is higher (e.g., by default at least 2 and at most 3), this file will be replicated to other pools.

When some pools go down, the replica count for the files in these pools may fall below the valid range and these files will be replicated. Replicas of the file with replica count below the valid range and which need replication are called *deficient replicas*.

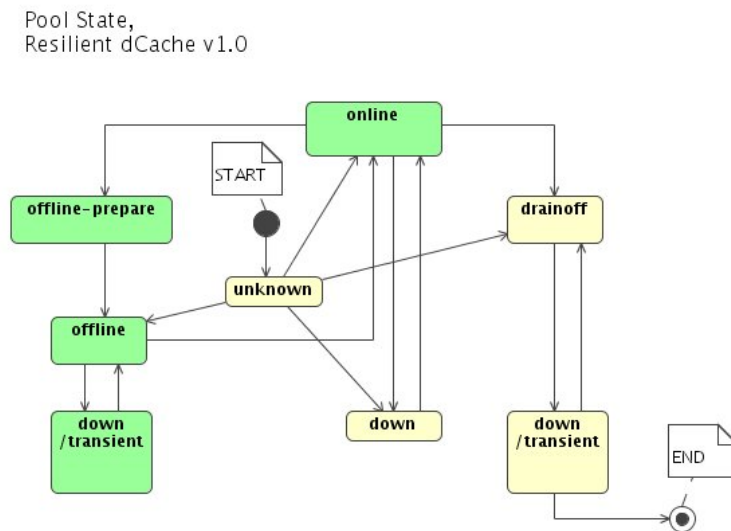
Later on some of the failed pools can come up and bring online more valid replicas. If there are too many replicas for some file these extra replicas are called *redundant replicas* and they will be “reduced”. Extra replicas will be deleted from pools.

The replica service counts the number of replicas for each file in the pools which can be used online (see Pool States below) and keeps the number of replicas within the valid range (`replica.limits.replicas.min`, `replica.limits.replicas.max`).

Pool States

The possible states of a pool are `online`, `down`, `offline`, `offline-prepare` and `drainoff`. They can be set by the admin through the admin interface. (See the section called “Commands for the admin interface”.)

Figure 6.1. Pool State Diagram



`online`

Normal operation.

Replicas in this state are readable and can be counted. Files can be written (copied) to this pool.

`down`

A pool can be down because

- the admin stopped the domain in which the pool was running.
- the admin set the state value via the admin interface.
- the pool crashed

To confirm that it is safe to turn pool down there is the command **ls unique** in the admin interface to check number of files which can be locked in this pool. (See the section called “Commands for the admin interface”.)

Replicas in pools which are down are not counted, so when a pool crashes the number of online replicas for some files is reduced. The crash of a pool (pool departure) may trigger replication of multiple files.

On startup, the pool comes briefly to the online state, and then it goes down to do pool “Inventory” to cleanup files which broke when the pool crashed during transfer. When the pool comes online again, the replica service will update the list of replicas in the pool and store it in the database.

Pool recovery (arrival) may trigger massive deletion of file replicas, not necessarily in this pool.

offline

The admin can set the pool state to be `offline`. This state was introduced to avoid unnecessary massive replication if the operator wants to bring the pool down briefly without triggering massive replication.

Replicas in this pool are counted, therefore it does not matter for replication purpose if an `offline` pool goes down or up.

When a pool comes online from an `offline` state replicas in the pool will be inventoried to make sure we know the real list of replicas in the pool.

offline-prepare

This is a transient state between `online` and `offline`.

The admin will set the pool state to be `offline-prepare` if he wants to change the pool state and does not want to trigger massive replication.

Unique files will be evacuated — at least one replica for each unique file will be copied out. It is unlikely that a file will be locked out when a single pool goes down as normally a few replicas are online. But when several pools go down or set `drainoff` or `offline` file lockout might happen.

Now the admin can set the pool state `offline` and then `down` and no file replication will be triggered.

drainoff

This is a transient state between `online` and `down`.

The admin will set the pool state to be `drainoff` if he needs to set a pool or a set of pools permanently out of operation and wants to make sure that there are no replicas “locked out”.

Unique files will be evacuated — at least one replica for each unique file will be copied out. It is unlikely that a file will be locked out when a single pool goes down as normally a few replicas are online. But when several pools go down or set `drainoff` or `offline` file lockout might happen.

Now the admin can set the pool state down. Files from other pools might be replicated now, depending on the values of `replica.limits.replicas.min` and `replica.limits.replicas.max`.

Startup

When the `replica` service starts it cleans up the database. Then it waits for some time to give a chance to most of the pools in the system to connect. Otherwise unnecessary massive replication would start. Currently this is implemented by some delay to start adjustments to give the pools a chance to connect.

Cold Start

Normally (during Cold Start) all information in the database is cleaned up and recreated again by polling pools which are `online` shortly after some minimum delay after the `replica` service starts. The `replica` service starts to track the pools' state (pool up/down messages and polling list of online pools) and updates the list of replicas in the pools which came online. This process lasts for about 10-15 minutes to make sure all pools came up online and/or got connected. Pools which once get connected to the `replica` service are in `online` or `down` state.

It can be annoying to wait for some large period of time until all known “good” pools get connected. There is a “Hot Restart” option to accelerate the restart of the system after the crash of the head node.

Hot Restart

On Hot Restart the `replica` service retrieves information about the pools' states before the crash from the database and saves the pools' states to some internal structure. When a pool gets connected the `replica` service checks the old pool state and registers the old pool's state in the database again if the state was `offline`, `offline-prepare` or `drainoff` state. The `replica` service also checks if the pool was `online` before the crash. When all pools which were `online` get connected once, the `replica` service supposes it recovered its old configuration and the `replica` service starts adjustments. If some pools went down during the connection process they were already accounted and adjustment would take care of it.

Example:

Suppose we have ten pools in the system, where eight pools were `online` and two were `offline` before a crash. The `replica` service does not care about the two `offline` pools to get connected to start adjustments. For the other eight pools which were `online`, suppose one pool gets connected and then it goes down while the other pools try to connect. The `replica` service considers this pool in known state, and when the other seven pools get connected it can start adjustments and does not wait any more.

If the system was in equilibrium state before the crash, the `replica` service may find some deficient replicas because of the crashed pool and start replication right away.

Avoid replicas on the same host

For security reasons you might want to spread your replicas such that they are not on the same host, or in the same building or even in the same town. To configure this you need to set the

`tag.hostname` label for your pools and check the properties `replica.enable.check-pool-host` and `replica.enable.same-host-replica`.

Example:

We assume that some pools of your dCache are in Hamburg and some are in Berlin. In the layout files where the respective pools are defined you can set

```
[poolDomain]
[poolDomain/pool1]
name=pool1
path=/srv/dcache/p1
pool.size=500G
pool.wait-for-files=${path}/data
tag.hostname=Hamburg
```

and

```
[poolDomain]
[poolDomain/pool2]
name=pool2
path=/srv/dcache/p2
pool.size=500G
pool.wait-for-files=${path}/data
tag.hostname=Berlin
```

By default the property `replica.enable.check-pool-host` is `true` and `replica.enable.same-host-replica` is `false`. This means that the `tag.hostname` will be checked and the replication to a pool with the same `tag.hostname` is not allowed.

Hybrid dCache

A *hybrid dCache* operates on a combination of pools (maybe connected to tape) which are not in a resilient pool group and the set of resilient pools. The `replica` service takes care only of the subset of pools configured in the pool group for resilient pools and ignores all other pools.

Note

If a file in a resilient pool is marked precious and the pool were connected to a tape system, then it would be flushed to tape. Therefore, the pools in the resilient pool group are not allowed to be connected to tape.

Commands for the admin interface

If you are an advanced user, have proper privileges and you know how to issue a command to the admin interface you may connect to the `ReplicaManager` cell and issue the following commands. You may find more commands in online help which are for debug only — do not use them as they can stop `replica` service operating properly.

set pool `<pool><state>`
set pool state

show pool `<pool>`
show pool state

ls unique <pool>

Reports number of unique replicas in this pool.

exclude <pnfsId>

exclude <pnfsId> from adjustments

release <pnfsId>

removes transaction/BAD status for <pnfsId>

debug true | false

enable/disable DEBUG messages in the log file

Properties of the replica service

replica.cell.name

Default: `dcache.enable.replica`

Cell name of the replica service

dcache.enable.replica

Default: `false`

Set this value to `true` if you want to use the replica service.

replica.poolgroup

Default: `ResilientPools`

If you want to use another pool group for the resilient pools set this value to the name of the resilient pool group.

replica.db.host

Default: `localhost`

Set this value to the name of host of the replica service database.

replica.db.name

Default: `replica`

Name of the replica database table.

replica.db.user

Default: `dcache`

Change if the replicas database was created with a user other than `dcache`.

replica.db.password.file

Default: `no password`

replica.db.driver

Default: `org.postgresql.Driver`

replica service was tested with PostgreSQL only.

replica.limits.pool-watchdog-period

Default: 600 (10 min)

Pools Watch Dog poll period. Poll the pools with this period to find if some pool went south without sending a notice (messages). Can not be too short because a pool can have a high load and not send pings for some time. Can not be less than pool ping period.

replica.limits.excluded-files-expiration-timeout

Default: 43200 (12 hours)

replica.limits.delay-db-start-timeout

Default: 1200 (20 min)

On first start it might take some time for the pools to get connected. If replication started right away, it would lead to massive replications when not all pools were connected yet. Therefore the database init thread sleeps some time to give a chance to the pools to get connected.

replica.limits.adjust-start-timeout

Default: 1200 (20 min)

Normally Adjuster waits for database init thread to finish. If by some abnormal reason it cannot find a database thread then it will sleep for this delay.

replica.limits.wait-replicate-timeout

Default: 43200 (12 hours)

Timeout for pool-to-pool replica copy transfer.

replica.limits.wait-reduce-timeout

Default: 43200 (12 hours)

Timeout to delete replica from the pool.

replica.limits.workers

Default: 6

Number of worker threads to do the replication. The same number of worker threads is used for reduction. Must be more for larger systems but avoid situation when requests get queued in the pool.

replica.limits.replicas.min

Default: 2

Minimum number of replicas in pools which are online or offline.

replica.limits.replicas.max

Default: 3

Maximum number of replicas in pools which are online or offline.

replica.enable.check-pool-host

Default: true

Checks tag.hostname which can be specified in the layout file for each pool.

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Set this property to `false` if you do not want to perform this check.

`replica.enable.same-host-replica`

Default: `false`

If set to `true` you allow files to be copied to a pool, which has the same `tag.hostname` as the source pool.

Note

The property `replica.enable.check-pool-host` needs to be set to `true` if `replica.enable.same-host-replica` is set to `false`.

Chapter 7. The `poolmanager` Service

The heart of a dCache system is the `poolmanager`. When a user performs an action on a file - reading or writing - a *transfer request* is sent to the dCache system. The `poolmanager` then decides how to handle this request.

If a file the user wishes to read resides on one of the storage-pools within the dCache system, it will be transferred from that pool to the user. If it resides on several pools, the file will be retrieved from one of the pools determined by a configurable load balancing policy. If all pools the file is stored on are busy, a new copy of the file on an idle pool will be created and this pool will answer the request.

A new copy can either be created by a *pool to pool transfer* (p2p) or by fetching it from a connected *tertiary storage system* (sometimes called HSM - hierarchical storage manager). Fetching a file from a tertiary storage system is called *staging*. It is also performed if the file is not present on any of the pools in the dCache system. The pool manager has to decide on which pool the new copy will be created, i.e. staged or p2p-copied.

The behaviour of the `poolmanager` service is highly configurable. In order to exploit the full potential of the software it is essential to understand the mechanisms used and how they are configured. The `poolmanager` service creates the `PoolManager` cell, which is a unique cell in dCache and consists of several sub-modules: The important ones are the *pool selection unit* (PSU) and the load balancing policy as defined by the *partition manager* (PM).

The `poolmanager` can be configured by either directly editing the file `/var/lib/dcache/config/poolmanager.conf` or via the Admin Interface. Changes made via the Admin Interface will be saved in the file `/var/lib/dcache/config/poolmanager.conf` by the **save** command. This file will be parsed, whenever the dCache starts up. It is a simple text file containing the corresponding Admin Interface commands. It can therefore also be edited before the system is started. It can also be loaded into a running system with the **reload** command. In this chapter we will describe the commands allowed in this file.

The Pool Selection Mechanism

The PSU is responsible for finding the set of pools which can be used for a specific transfer-request. By telling the PSU which pools are permitted for which type of transfer-request, the administrator of the dCache system can adjust the system to any kind of scenario: Separate organizations served by separate pools, special pools for writing the data to a tertiary storage system, pools in a DMZ which serves only a certain kind of data (e.g., for the grid). This section explains the mechanism employed by the PSU and shows how to configure it with several examples.

The PSU generates a list of allowed storage-pools for each incoming transfer-request. The PSU configuration described below tells the PSU which combinations of transfer-request and storage-pool are allowed. Imagine a two-dimensional table with a row for each possible transfer-request and a column for each pool - each field in the table containing either “yes” or “no”. For an incoming transfer-request the PSU will return a list of all pools with “yes” in the corresponding row.

Instead of “yes” and “no” the table really contains a *preference* - a non-negative integer. However, the PSU configuration is easier to understand if this is ignored.

Actually maintaining such a table in memory (and as user in a configuration file) would be quite inefficient, because there are many possibilities for the transfer-requests. Instead, the PSU consults a set of rules in

order to generate the list of allowed pools. Each such rule is called a *link* because it links a set of transfer-requests to a group of pools.

Links

A link consists of a set of unit groups and a list of pools. If all the unit groups are matched, the pools belonging to the link are added to the list of allowable pools.

A link is defined in the file `/var/lib/dcache/config/poolmanager.conf` by

```
psu create link <link> <unitgroup> psu set link <link> -readpref=<rpref> -  
writepref=<wpref> -cachepref=<cpref> -p2ppref=<ppref> psu add link <link>  
<poolgroup>
```

For the preference values see the section called “Preference Values for Type of Transfer”.

The main task is to understand how the unit groups in a link are defined. After we have dealt with that, the preference values will be discussed and a few examples will follow.

The four properties of a transfer request, which are relevant for the PSU, are the following:

Location of the File

The location of the file in the file system is not used directly. Each file has the following two properties which can be set per directory:

- **Storage Class.** The storage class is a string. It is used by a tertiary storage system to decide where to store the file (i.e. on which set of tapes) and dCache can use the storage class for a similar purpose (i.e. on which pools the file can be stored.). A detailed description of the syntax and how to set the storage class of a directory in the namespace is given in the section called “Storage Classes”.
- **Cache Class.** The cache class is a string with essentially the same functionality as the storage class, except that it is not used by a tertiary storage system. It is used in cases, where the storage class does not provide enough flexibility. It should only be used, if an existing configuration using storage classes does not provide sufficient flexibility.

IP Address

The IP address of the requesting host.

Protocol / Type of Door

The protocol respectively the type of door used by the transfer.

Type of Transfer

The type of transfer is either `read`, `write`, `p2p` request or `cache`.

A request for reading a file which is not on a read pool will trigger a `p2p` request and a subsequent `read` request. These will be treated as two separate requests.

A request for reading a file which is not stored on disk, but has to be staged from a connected tertiary storage system will trigger a `cache` request to fetch the file from the tertiary storage system and a subsequent `read` request. These will be treated as two separate requests.

Each link contains one or more *unit groups*, all of which have to be matched by the transfer request. Each unit group in turn contains several *units*. The unit group is matched if at least one of the units is matched.

Types of Units

There are four types of units: network (`-net`), protocol (`-protocol`), storage class (`-store`) and cache class (`-dcache`) units. Each type imposes a condition on the IP address, the protocol, the storage class and the cache class respectively.

For each transfer at most one of each of the four unit types will match. If more than one unit of the same type could match the request then the most restrictive unit matches.

The unit that matches is selected from all units defined in dCache, not just those for a particular unit group. This means that, if a unit group has a unit that could match a request but this request also matches a more restrictive unit defined elsewhere then the less restrictive unit will not match.

Network Unit

A *network unit* consists of an IP address and a net mask written as `<IP-address>/<net mask>`, say `111.111.111.0/255.255.255.0`. It is satisfied, if the request is coming from a host with IP address within the subnet given by the address/netmask pair.

```
psu create ugroup <name-of-unitgroup>
psu create unit -net <IP-address>/<net mask>
psu addto ugroup <name-of-unitgroup> <IP-address>/<net mask>
```

Protocol Unit

A *protocol unit* consists of the name of the protocol and the version number written as `<protocol-name>/<version-number>`, e.g., `xrootd/3`.

```
psu create ugroup <name-of-unitgroup>
psu create unit -protocol <protocol-name>/<version-number>
psu addto ugroup <name-of-unitgroup> <protocol-name>/<version-number>
```

Storage Class Unit

A *storage class unit* is given by a storage class. It is satisfied if the requested file has this storage class. Simple wild cards are allowed: for this it is important to know that a storage class must always contain exactly one `@`-symbol as will be explained in the section called “Storage Classes”. In a storage class unit, either the part before the `@`-symbol or both parts may be replaced by a `*`-symbol; for example, `*@osm` and `*@*` are both valid storage class units whereas `something@*` is invalid. The `*`-symbol represents a limited wildcard: any string that doesn’t contain an `@`-symbol will match.

```
psu create ugroup <name-of-unitgroup>
psu create unit -store <StoreName>:<StorageGroup>@<type-of-storage-system>
psu addto ugroup <name-of-unitgroup> <StoreName>:<StorageGroup>@<type-of-storage-system>
```

Cache Class Unit

A *cache class unit* is given by a cache class. It is satisfied, if the cache class of the requested file agrees with it.

```
psu create ugroup <name-of-unitgroup>
psu create unit -dcache <name-of-cache-class>
psu addto ugroup <name-of-unitgroup> <name-of-cache-class>
```

Preference Values for Type of Transfer

The conditions for the *type of transfer* are not specified with units. Instead, each link contains four attributes `-readpref`, `-writepref`, `-p2ppref` and `-cachepref`, which specify a preference value for the respective types of transfer. If all the unit groups in the link are matched, the corresponding preference is

assigned to each pool the link points to. Since we are ignoring different preference values at the moment, a preference of 0 stands for `no` and a non-zero preference stands for `yes`. A negative value for `-p2ppref` means, that the value for `-p2ppref` should equal the one for the `-readpref`.

Multiple non-zero Preference Values

Note

This explanation of the preference values can be skipped at first reading. It will not be relevant, if all non-zero preference values are the same. If you want to try configuring the pool manager right now without bothering about the preferences, you should only use 0 (for `no`) and, say, 10 (for `yes`) as preferences. You can choose `-p2ppref=-1` if it should match the value for `-readpref`. The first examples below are of this type.

If several different non-zero preference values are used, the PSU will not generate a single list but a set of lists, each containing pools with the same preference. The Pool Manager will use the list of pools with highest preference and select a pool according to the load balancing policy for the transfer. Only if all pools with the highest preference are offline, the next list will be considered by the Pool Manager. This can be used to configure a set of fall-back pools which are used if none of the other pools are available.

Pool Groups

Pools can be grouped together to pool groups.

```
psu create pgroup <name-of-poolgroup>
psu create pool <name-of-pool>
psu addto pgroup <name-of-poolgroup> <name-of-pool>
```

Example:

Consider a host `pool1` with two pools, `pool1_1` and `pool1_2`, and a host `pool2` with one pool `pool2_1`. If you want to treat them in the same way, you would create a pool group and put all of them in it:

```
psu create pgroup normal-pools
psu create pool pool1_1
psu addto pgroup normal-pools pool1_1
psu create pool pool1_2
psu addto pgroup normal-pools pool1_2
psu create pool pool2_1
psu addto pgroup normal-pools pool2_1
```

If you later want to treat `pool1_2` differently from the others, you would remove it from this pool group and add it to a new one:

```
psu removefrom pgroup normal-pools pool1_2
psu create pgroup special-pools
psu addto pgroup special-pools pool1_2
```

In the following, we will assume that the necessary pool groups already exist. All names ending with `-pools` will denote pool groups.

Note that a pool-node will register itself with the PoolManager: The pool will be created within the PSU and added to the pool group `default`, if that exists. This is why the dCache system will automatically

use any new pool-nodes in the standard configuration: All pools are in default and can therefore handle any request.

Storage Classes

The storage class is a string of the form `<StoreName>:<StorageGroup>@<type-of-storage-system>`, where `<type-of-storage-system>` denotes the type of storage system in use, and `<StoreName>:<StorageGroup>` is a string describing the storage class in a syntax which depends on the storage system. In general use `<type-of-storage-system>=osm`.

Consider for example the following setup:

Example:

```
[root] # /usr/bin/chimera lstag /data/experiment-a
Total: 2
OSMTemplate
sGroup
[root] # /usr/bin/chimera readtag /data/experiment-a OSMTemplate
StoreName myStore
[root] # /usr/bin/chimera readtag /data/experiment-a sGroup
STRING
```

This is the setup after a fresh installation and it will lead to the storage class `myStore:STRING@osm`. An adjustment to more sensible values will look like

```
[root] # /usr/bin/chimera writetag /data/experiment-a OSMTemplate "StoreName exp-a"
[root] # /usr/bin/chimera writetag /data/experiment-a sGroup "run2010"
```

and will result in the storage class `exp-a:run2010@osm` for any data stored in the `/data/experiment-a` directory.

To summarize: The storage class depends on the directory the data is stored in and is configurable.

Cache Class

Storage classes might already be in use for the configuration of a tertiary storage system. In most cases they should be flexible enough to configure the PSU. However, in rare cases the existing configuration and convention for storage classes might not be flexible enough.

Consider for example a situation, where data produced by an experiment always has the same storage class `exp-a:alldata@osm`. This is good for the tertiary storage system, since all data is supposed to go to the same tape set sequentially. However, the data also contains a relatively small amount of meta-data, which is accessed much more often by analysis jobs than the rest of the data. You would like to keep the meta-data on a dedicated set of dCache pools. However, the storage class does not provide means to accomplish that.

The cache class of a directory is set by the tag `cacheClass` as follows:

Example:

```
[root] # /usr/bin/chimera writetag /data/experiment-a cacheClass "metaData"
```

In this example the meta-data is stored in directories which are tagged in this way.

Check the existing tags of a directory and their content by:

```
[root] # /usr/bin/chimera lstag /path/to/directory
Total: numberOfTags
tag1
tag2
...
[root] # /usr/bin/chimera readtag /path/to/directory tag1
contentOfTag1
```

Note

A new directory will inherit the tags from the parent directory. But updating a tag will *not* update the tags of any child directories.

Define a link

Now we have everything we need to define a link.

```
psu create ugroup <name-of-unitgroup>
psu create unit - <type> <unit>
psu addto ugroup <name-of-unitgroup> <unit>

psu create pgroup <poolgroup>
psu create pool <pool>
psu addto pgroup <poolgroup> <pool>

psu create link <link> <name-of-unitgroup>
psu set link <link> -readpref=<10> -writepref=<0> -cachepref=<10>-p2ppref=<-1>
psu add link <link> <poolgroup>
```

Examples

Find some examples for the configuration of the PSU below.

Separate Write and Read Pools

The dCache we are going to configure receives data from a running experiment, stores the data onto a tertiary storage system, and serves as a read cache for users who want to analyze the data. While the new data from the experiment should be stored on highly reliable and therefore expensive systems, the cache functionality may be provided by inexpensive hardware. It is therefore desirable to have a set of pools dedicated for writing the new data and a separate set for reading.

Example:

The simplest configuration for such a setup would consist of two links “write-link” and “read-link”. The configuration is as follows:

```
psu create pgroup read-pools
psu create pool pool1
psu addto pgroup read-pools pool1
psu create pgroup write-pools
psu create pool pool2
psu addto pgroup write-pools pool2

psu create unit -net 0.0.0.0/0.0.0.0
psu create ugroup allnet-cond
psu addto ugroup allnet-cond 0.0.0.0/0.0.0.0

psu create link read-link allnet-cond
psu set link read-link -readpref=10 -writepref=0 -cachepref=10
```



```
psu add link read-link read-pools

psu create link write-link allnet-cond
psu set link write-link -readpref=0 -writepref=10 -cachepref=0
psu add link write-link write-pools
```

Why is the unit group `allnet-cond` necessary? It is used as a condition which is always true in both links. This is needed, because each link must contain at least one unit group.

Restricted Access by IP Address

You might not want to give access to the pools for the whole network, as in the previous example (the section called “Separate Write and Read Pools”), though.

Example:

Assume, the experiment data is copied into the cache from the hosts with IP `111.111.111.201`, `111.111.111.202`, and `111.111.111.203`. As you might guess, the subnet of the site is `111.111.111.0/255.255.255.0`. Access from outside should be denied. Then you would modify the above configuration as follows:

```
psu create pgroup read-pools
psu create pool pool1
psu addto pgroup read-pools pool1
psu create pgroup write-pools
psu create pool pool2
psu addto pgroup write-pools pool2

psu create unit -store *@*

psu create unit -net 111.111.111.0/255.255.255.0
psu create unit -net 111.111.111.201/255.255.255.255
psu create unit -net 111.111.111.202/255.255.255.255
psu create unit -net 111.111.111.203/255.255.255.255

psu create ugroup write-cond
psu addto ugroup write-cond 111.111.111.201/255.255.255.255
psu addto ugroup write-cond 111.111.111.202/255.255.255.255
psu addto ugroup write-cond 111.111.111.203/255.255.255.255

psu create ugroup read-cond
psu addto ugroup read-cond 111.111.111.0/255.255.255.0
psu addto ugroup read-cond 111.111.111.201/255.255.255.255
psu addto ugroup read-cond 111.111.111.202/255.255.255.255
psu addto ugroup read-cond 111.111.111.203/255.255.255.255

psu create link read-link read-cond
psu set link read-link -readpref=10 -writepref=0 -cachepref=10
psu add link read-link read-pools

psu create link write-link write-cond
psu set link write-link -readpref=0 -writepref=10 -cachepref=0
psu add link write-link write-pools
```

Important

For a given transfer exactly zero or one storage class unit, cache class unit, net unit and protocol unit will match. As always the most restrictive one will match, the IP `111.111.111.201` will match the `111.111.111.201/255.255.255.255` unit and not the `111.111.111.0/255.255.255.0` unit. Therefore if you only add `111.111.111.0/255.255.255.0` to the unit group “read-cond”, the transfer request

coming from the IP 111.111.111.201 will only be allowed to write and not to read. The same is true for transfer requests from 111.111.111.202 and 111.111.111.203.

Reserving Pools for Storage and Cache Classes

If pools are financed by one experimental group, they probably do not like it if they are also used by another group. The best way to restrict data belonging to one experiment to a set of pools is with the help of storage class conditions. If more flexibility is needed, cache class conditions can be used for the same purpose.

Example:

Assume, data of experiment A obtained in 2010 is written into subdirectories in the namespace tree which are tagged with the storage class `exp-a:run2010@osm`, and similarly for the other years. (How this is done is described in the section called “Storage Classes”.) Experiment B uses the storage class `exp-b:alldata@osm` for all its data. Especially important data is tagged with the cache class `important`. (This is described in the section called “Cache Class”.) A suitable setup would be

```
psu create pgroup exp-a-pools
psu create pool pool1
psu addto pgroup exp-a-pools pool1

psu create pgroup exp-b-pools
psu create pool pool2
psu addto pgroup exp-b-pools pool2

psu create pgroup exp-b-imp-pools
psu create pool pool3
psu addto pgroup exp-b-imp-pools pool3

psu create unit -net 111.111.111.0/255.255.255.0
psu create ugroup allnet-cond
psu addto ugroup allnet-cond 111.111.111.0/255.255.255.0

psu create ugroup exp-a-cond
psu create unit -store exp-a:run2011@osm
psu addto ugroup exp-a-cond exp-a:run2011@osm
psu create unit -store exp-a:run2010@osm
psu addto ugroup exp-a-cond exp-a:run2010@osm

psu create link exp-a-link allnet-cond exp-a-cond
psu set link exp-a-link -readpref=10 -writepref=10 -cachepref=10
psu add link exp-a-link exp-a-pools

psu create ugroup exp-b-cond
psu create unit -store exp-b:alldata@osm
psu addto ugroup exp-b-cond exp-b:alldata@osm

psu create ugroup imp-cond
psu create unit -dcache important
psu addto ugroup imp-cond important

psu create link exp-b-link allnet-cond exp-b-cond
psu set link exp-b-link -readpref=10 -writepref=10 -cachepref=10
psu add link exp-b-link exp-b-pools

psu create link exp-b-imp-link allnet-cond exp-b-cond imp-cond
psu set link exp-b-imp-link -readpref=20 -writepref=20 -cachepref=20
psu add link exp-b-imp-link exp-b-imp-pools
```

Data tagged with cache class “important” will always be written and read from pools in the pool group `exp-b-imp-pools`, except when all pools in this group cannot be reached. Then the pools in `exp-a-pools` will be used.

Note again that these will never be used otherwise. Not even, if all pools in `exp-b-imp-pools` are very busy and some pools in `exp-a-pools` have nothing to do and lots of free space.

The central IT department might also want to set up a few pools, which are used as fall-back, if none of the pools of the experiments are functioning. These will also be used for internal testing. The following would have to be added to the previous setup:

Example:

```
psu create pgroup it-pools
psu create pool pool_it
psu addto pgroup it-pools pool_it

psu create link fallback-link allnet-cond
psu set link fallback-link -readpref=5 -writepref=5 -cachepref=5
psu add link fallback-link it-pools
```

Note again that these will only be used, if none of the experiments pools can be reached, or if the storage class is not of the form `exp-a:run2009@osm`, `exp-a:run2010@osm`, or `exp-b:alldata@osm`. If the administrator fails to create the unit `exp-a:run2005@osm` and add it to the unit group `exp-a-cond`, the fall-back pools will be used eventually.

The Partition Manager

The partition manager defines one or more load balancing policies. Whereas the PSU produces a prioritized set of candidate pools using a collection of rules defined by the administrator, the load balancing policy determines the specific pool to use. It is also the load balancing policy that determines when to fall back to lesser priority links, or when to trigger creation of additional copies of a file.

Since the load balancing policy and parameters are defined per partition, understanding the partition manager is essential to tuning load balancing. This does not imply that one has to partition the dCache instance. It is perfectly valid to use a single partition for the complete instance.

This section documents the use of the partition manager, how to create partitions, set parameters and how to associate links with partitions. In the following sections the available partition types and their configuration parameters are described.

Overview

There are various parameters that affect the load balancing policy. Some of them are generic and apply to any load balancing policy, but many are specific to a particular policy. To avoid limiting the complete dCache instance to a single configuration, the choice of load balancing policy and the various parameters apply to *partitions* of the instance. The load balancing algorithm and the available parameters is determined by the *partition type*.

Each PSU link can be associated with a different partition and the policy and parameters of that partition will be used to choose a pool from the set of candidate pools. The only partition that exists without being explicitly created is the partition called `default`. This partition is used by all links that do not explicitly identify a partition. Other partitions can be created or modified as needed.

The default partition has a hard-coded partition type called `classic`. This type implements the one load balancing policy that was available in dCache before version 2.0. The `classic` partition type is described later. Other partitions have one of a number of available types. The system is pluggable, meaning that third party plugins can be loaded at runtime and add additional partition types, thus providing the ultimate control over load balancing in dCache. Documentation on how to develop plugins is beyond the scope of this chapter.

To ease the management of partition parameters, a common set of shared parameters can be defined outside all partitions. Any parameter not explicitly set on a partition inherits the value from the common set. If not defined in the common set, a default value determined by the partition type is used. Currently, the common set of parameters happens to be the same as the parameters of the default partition, however this is only due to compatibility constraints and may change in future versions.

Managing Partitions

For each partition you can choose the load balancing policy. You do this by choosing the type of the partition.

Currently four different partition types are supported:

`classic`:

This is the pool selection algorithm used in the versions of dCache prior to version 2.0. See the section called “Classic Partitions” for a detailed description.

`random`:

This pool selection algorithm selects a pool randomly from the set of available pools.

`lru`:

This pool selection algorithm selects the pool that has not been used the longest.

`wass`:

This pool selection algorithm selects pools randomly weighted by available space, while incorporating age and amount of garbage collectible files and information about load.

This is the partition type of the default partition. See How to Pick a Pool [<http://www.dcache.org/articles/wass.html>] for more details.

Commands related to dCache partitioning:

- `pm types`
Lists available partition types. New partition types can be added through plugins.
- `pm create [-type=<partitionType>] <partitionName>`
Creates a new partition. If no partition type is specified, then a `wass` partition is created.
- `pm set [<partitionName>] -<parameterName> =<value>|off`
Sets a parameter `<parameterName>` to a new value.

If `<partitionName>` is omitted, the common shared set of parameters is updated. The value is used by any partition for which the parameter is not explicitly set.

If a parameter is set to `off` then this parameter is no longer defined and is inherited from the common shared set of parameters, or a partition type specific default value is used if the parameter is not defined in the common set.

- `pm ls [-l] [<partitionName>]`
Lists a single or all partitions, including the type of each partition. If a partition name or the `-l` option are used, then the partition parameters are shown too. Inherited and default values are identified as such.
- `pm destroy <partitionName>`
Removes a partition from dCache. Any links configured to use this partition will fall back to the default partition.

Using Partitions

A partition, so far, is just a set of parameters which may or may not differ from the default set. To let a partition relate to a part of the dCache, links are used. Each link may be assigned to exactly one partition. If not set, or the assigned partition doesn't exist, the link defaults to the default partition.

```
psu set link [<linkName>] -section=<partitionName> [<other-options>...]
```

Whenever this link is chosen for pool selection, the associated parameters of the assigned partition will become active for further processing.

Warning

Depending on the way links are setup it may very well happen that more than just one link is triggered for a particular dCache request. This is not illegal but leads to an ambiguity in selecting an appropriate dCache partition. If only one of the selected links has a partition assigned, this partition is chosen. Otherwise, if different links point to different partitions, the result is indeterminate. This issue is not yet solved and we recommend to clean up the poolmanager configuration to eliminate links with the same preferences for the same type of requests.

In the Web Interface you can find a web page listing partitions and more information. You will find a page summarizing the partition status of the system. This is essentially the output of the command `pm ls -l`.

Example:

For your dCache on `dcache.example.org` the address is

```
http://dcache.example.org:2288/poolInfo/parameterHandler/set/matrix/  
*
```

Examples

For the subsequent examples we assume a basic poolmanager setup :

Example:

```
#  
# define the units  
#  
psu create unit -protocol */*  
psu create unit -protocol xrootd/*  
psu create unit -net 0.0.0.0/0.0.0.0  
psu create unit -net 131.169.0.0/255.255.0.0  
psu create unit -store *@*  
#  
# define unit groups
```

```
#
psu create ugroup any-protocol
psu create ugroup any-store
psu create ugroup world-net
psu create ugroup xrootd
#
psu addto ugroup any-protocol */*
psu addto ugroup any-store *@*
psu addto ugroup world-net 0.0.0.0/0.0.0.0
psu addto ugroup desy-net 131.169.0.0/255.255.0.0
psu addto ugroup xrootd xrootd/*
#
# define the pools
#
psu create pool pool1
psu create pool pool2
psu create pool pool3
psu create pool pool4

#
# define the pool groups
#
psu create pgroup default-pools
psu create pgroup special-pools
#
psu addto pgroup default-pools pool1
psu addto pgroup default-pools pool2
#
psu addto pgroup special-pools pool3
psu addto pgroup special-pools pool4
#
```

Disallowing pool to pool transfers for special pool groups based on the access protocol

For a special set of pools, where we only allow the xrootd protocol, we don't want the datasets to be replicated on high load while for the rest of the pools we allow replication on hot spot detection.

Example:

```
#
pm create xrootd-section
#
pm set default -p2p=0.4
pm set xrootd-section -p2p=0.0
#
psu create link default-link any-protocol any-store world-net
psu add link default-link default-pools
psu set link default-link -readpref=10 -cachepref=10 -writepref=0
#
psu create link xrootd-link xrootd any-store world-net
psu add link xrootd-link special-pools
psu set link xrootd-link -readpref=10 -cachepref=10 -writepref=0
psu set link xrootd-link -section=xrootd-section
#
```

Choosing pools randomly for incoming traffic only

For a set of pools we select pools following the default setting of cpu and space related cost factors. For incoming traffic from outside, though, we select the same pools, but in a randomly distributed fashion. Please note that this is not really a physical partitioning of the dCache system, but rather a virtual one, applied to the same set of pools.

Example:

```
#
pm create incoming-section
#
pm set default          -cpucostfactor=0.2 -spacecostfactor=1.0
pm set incoming-section -cpucostfactor=0.0 -spacecostfactor=0.0
#
psu create link default-link any-protocol any-store desy-net
psu add   link default-link default-pools
psu set   link default-link -readpref=10 -cachepref=10 -writepref=10
#
psu create link default-link any-protocol any-store world-net
psu add   link default-link default-pools
psu set   link default-link -readpref=10 -cachepref=10 -writepref=0
#
psu create link incoming-link any-protocol any-store world-net
psu add   link incoming-link default-pools
psu set   link incoming-link -readpref=10 -cachepref=10 -writepref=10
psu set   link incoming-link -section=incoming-section
#
```

Classic Partitions

The classic partition type implements the load balancing policy known from dCache releases before version 2.0. This partition type is still the default. This section describes this load balancing policy and the available configuration parameters.

Example:

To create a classic partition use the command: **pm create -type=classic <partitionName>**

Load Balancing Policy

From the allowable pools as determined by the *pool selection unit*, the pool manager determines the pool used for storing or reading a file by calculating a *cost* value for each pool. The pool with the lowest cost is used.

If a client requests to read a file which is stored on more than one allowable pool, the *performance costs* are calculated for these pools. In short, this cost value describes how much the pool is currently occupied with transfers.

If a pool has to be selected for storing a file, which is either written by a client or *restored* from a *tape backend*, this performance cost is combined with a *space cost* value to a *total cost* value for the decision. The space cost describes how much it “hurts” to free space on the pool for the file.

The *cost module* is responsible for calculating the cost values for all pools. The pools regularly send all necessary information about space usage and request queue lengths to the cost module. It can be regarded as a cache for all this information. This way it is not necessary to send “get cost” requests to the pools for each client request. The cost module interpolates the expected costs until a new precise information package is coming from the pools. This mechanism prevents clumping of requests.

Calculating the cost for a data transfer is done in two steps. First, the cost module merges all information about space and transfer queues of the pools to calculate the performance and space costs separately. Second, in the case of a write or stage request, these two numbers are merged to build the total cost for each pool. The first step is isolated within a separate loadable class. The second step is done by the partition.

The Performance Cost

The load of a pool is determined by comparing the current number of active and waiting *transfers* to the maximum number of concurrent transfers allowed. This is done separately for each of the transfer types (*store*, *restore*, pool-to-pool client, pool-to-pool server, and client request) with the following equation:

$$\text{perfCost(per Type)} = (\text{activeTransfers} + \text{waitingTransfers}) / \text{maxAllowed} .$$

The maximum number of concurrent transfers (*maxAllowed*) can be configured with the commands **st set max active** (*store*), **rh set max active** (*restore*), **mover set max active** (*client request*), **mover set max active -queue=p2p** (*pool-to-pool server*), and **pp set max active** (*pool-to-pool client*).

Then the average is taken for each mover type where *maxAllowed* is not zero. For a pool where *store*, *restore* and *client* transfers are allowed, e.g.,

$$\text{perfCost(total)} = (\text{perfCost(store)} + \text{perfCost(restore)} + \text{perfCost(client)}) / 3 ,$$

and for a read only pool:

$$\text{perfCost(total)} = (\text{perfCost(restore)} + \text{perfCost(client)}) / 2 .$$

For a well balanced system, the performance cost should not exceed 1.0.

The Space Cost

In this section only the new scheme for calculating the space cost will be described. Be aware, that the old scheme will be used if the *breakeven parameter* of a pool is larger or equal 1.0.

The cost value used for determining a pool for storing a file depends either on the free space on the pool or on the age of the *least recently used (LRU) file*, which would have to be deleted.

The space cost is calculated as follows:

If <i>freeSpace</i> > <i>gapPara</i>		then <i>spaceCost</i> = 3 * <i>newFileSize</i> / <i>freeSpace</i>
If <i>freeSpace</i> <= <i>gapPara</i>	and <i>lruAge</i> < 60	then <i>spaceCost</i> = 1 + <i>costForMinute</i>
If <i>freeSpace</i> <= <i>gapPara</i>	and <i>lruAge</i> >= 60	then <i>spaceCost</i> = 1 + <i>costForMinute</i> * 60 / <i>lruAge</i>

where the variable names have the following meanings:

freeSpace

The free space left on the pool

newFileSize

The size of the file to be written to one of the pools, and at least 50MB.

lruAge

The age of the *least recently used file* on the pool.

gapPara

The gap parameter. Default is 4 GiB. The size of free space below which it will be assumed that the pool is full and consequently the least recently used file has to be removed. If, on the other hand, the free space is greater than *gapPara*, it will be expensive to store a file on the pool which exceeds the free space.

It can be set per pool with the **set gap** command. This has to be done in the pool cell and not in the pool manager cell. Nevertheless it only influences the cost calculation scheme within the pool manager and not the behaviour of the pool itself.

costForMinute

A parameter which fixes the space cost of a one-minute-old LRU file to $(1 + costForMinute)$. It can be set with the **set breakeven**, where

$$costForMinute = breakeven * 7 * 24 * 60.$$

I.e. the the space cost of a one-week-old LRU file will be $(1 + breakeven)$. Note again, that all this only applies if $breakeven < 1.0$

The prescription above can be stated a little differently as follows:

If	$freeSpace > gapPara$	then	$spaceCost = 3 * newFileSize / freeSpace$
If	$freeSpace \leq gapPara$	then	$spaceCost = 1 + breakeven * 7 * 24 * 60 * 60 / lruAge ,$

where `newFileSize` is at least 50MB and `lruAge` at least one minute.

Rationale

As the last version of the formula suggests, a pool can be in two states: Either $freeSpace > gapPara$ or $freeSpace \leq gapPara$ - either there is free space left to store files without deleting cached files or there isn't.

Therefore, `gapPara` should be around the size of the smallest files which frequently might be written to the pool. If files smaller than `gapPara` appear very seldom or never, the pool might get stuck in the first of the two cases with a high cost.

If the LRU file is smaller than the new file, other files might have to be deleted. If these are much younger than the LRU file, this space cost calculation scheme might not lead to a selection of the optimal pool. However, in pratice this happens very seldomly and this scheme turns out to be very efficient.

The Total Cost

The total cost is a linear combination of the *performance* and *space cost*. I.e. $totalCost = ccf * perfCost + scf * spaceCost$, where `ccf` and `scf` are configurable with the command **set pool decision**. E.g.,

```
(PoolManager) admin > set pool decision -spacecostfactor=3 -cpucostfactor=1
```

will give the *space cost* three times the weight of the *performance cost*.

Parameters of Classic Partitions

Classic partitions have a large number of tunable parameters. These parameters are set using the **pm set** command.

Example:

To set the space cost factor on the default partition to 0.3, use the following command:

```
pm set default spacecostfactor=0.3
```

The poolmanager Service

```
pm set default -spacecostfactor=0.3
```

Command	Meaning	Type
pm set [<partitionName>] - spacecostfactor=<scf>	Sets the space cost factor for the partition. The default value is 1 . 0.	float
pm set [<partitionName>] - cpucostfactor=<ccf>	Sets the cpu cost factor for the partition. The default value is 1 . 0.	float
pm set [<partitionName>] - idle=<idle-value>	The concept of the <i>idle value</i> will be turned on if <idle-value> > 0 . 0. A pool is idle if its performance cost is smaller than the <idle-value>. Otherwise it is not idle. If one or more pools that satisfy the read request are idle then only one of them is chosen for a particular file irrespective of total cost. I.e. if the same file is requested more than once it will always be taken from the same pool. This allows the copies on the other pools to age and be garbage collected. The default value is 0 . 0, which disables this feature.	float
pm set [<partitionName>] - p2p=<p2p-value>	Sets the static replication threshold for the partition. If the performance cost on the best pool exceeds <p2p-value> and the value for <slope> = 0 . 0 then this pool is called <i>hot</i> and a pool to pool replication may be triggered. The default value is 0 . 0, which disables this feature.	float
pm set [<partitionName>] - alert=<value>	Sets the <i>alert value</i> for the partition. If the best pool's performance cost exceeds the p2p value and the alert value then no pool to pool copy is triggered and a message will be logged stating that no pool to pool copy will be made. The default value is 0 . 0, which disables this feature.	float
pm set [<partitionName>] - panic=<value>	Sets the <i>panic cost cut level</i> for the partition. If the performance cost of the best pool exceeds the panic cost cut level the request will fail. The default value is 0 . 0, which disables this feature.	float
pm set [<partitionName>] - fallback=<value>	Sets the fallback cost cut level for the partition. If the best pool's performance cost exceeds the fallback cost cut level then a pool of the next <i>level</i> will be chosen.	float

Command	Meaning	Type
	<p>This means for example that instead of choosing a pool with <code>readpref = 20</code> a pool with <code>readpref < 20</code> will be chosen.</p> <p>The default value is <code>0.0</code>, which disables this feature.</p>	
<pre>pm set [<partitionName>] - slope=<slope></pre>	<p>Sets the dynamic replication threshold value for the partition.</p> <p>If <code><slope>> 0.01</code> then the product of best pool's performance cost and <code><slope></code> is used as threshold for pool to pool replication.</p> <p>If the performance cost on the best pool exceeds this threshold then this pool is called hot.</p> <p>The default value is <code>0.0</code>, which disables this feature.</p>	float
<pre>pm set [<partitionName>] -p2p- allowed=<value></pre>	<p>This value can be specified if an HSM is attached to the dCache.</p> <p>If a partition has no HSM connected, then this option is overridden. This means that no matter which value is set for <code>p2p-allowed</code> the pool to pool replication will always be allowed.</p> <p>By setting <code><value> = off</code> the values for <code>p2p-allowed</code>, <code>p2p-oncost</code> and <code>p2p-fortransfer</code> will take over the value of the default partition.</p> <p>If <code><value> = yes</code> then pool to pool replication is allowed.</p> <p>As a side effect of setting <code><value> = no</code> the values for <code>p2p-oncost</code> and <code>p2p-fortransfer</code> will also be set to <code>no</code>.</p> <p>The default value is <code>yes</code>.</p>	boolean
<pre>pm set [<partitionName>] -p2p- oncost=<value></pre>	<p>Determines whether pool to pool replication is allowed if the best pool for a read request is hot.</p> <p>The default value is <code>no</code>.</p>	boolean
<pre>pm set [<partitionName>] -p2p- fortransfer=<value></pre>	<p>If the best pool is hot and the requested file will be copied either from the hot pool or from tape to another pool, then the requested file will be read from the pool where it just had been copied to if <code><value> = yes</code>. If <code><value> = no</code> then the requested file will be read from the hot pool.</p> <p>The default value is <code>no</code>.</p>	boolean
<pre>pm set [<partitionName>] - stage-allowed=<value></pre>	<p>Set the <i>stage allowed value</i> to <code>yes</code> if a tape system is connected and to <code>no</code> otherwise.</p> <p>As a side effect, setting the value for <code>stage-allowed</code> to <code>no</code> changes the value for <code>stage-oncost</code> to <code>no</code>.</p>	boolean

Command	Meaning	Type
	The default value is no.	
pm set [<partitionName>] - stage-oncost=<value>	If the best pool is hot, p2p-oncost is disabled and an HSM is connected to a pool then this parameter determines whether to stage the requested file to a different pool. The default value is no.	boolean
pm set [<partitionName>] -max- copies=<copies>	Sets the maximal number of replicas of one file. If the maximum is reached no more replicas will be created. The default value is 500.	integer

Link Groups

The PoolManager supports a type of objects called *link groups*. These link groups are used by the SRM SpaceManager to make reservations against space. Each link group corresponds to a number of dCache pools in the following way: A link group is a collection of links and each link points to a set of pools. Each link group knows about the size of its available space, which is the sum of all sizes of available space in all the pools included in this link group.

To create a new link group login to the Admin Interface and **cd** to the PoolManager.

```
(local) admin > cd PoolManager
(PoolManager) admin > psu create linkGroup <linkgroup>
(PoolManager) admin > psu addto linkGroup <linkgroup> <link>
(PoolManager) admin > save
```

With **save** the changes will be saved to the file `/var/lib/dcache/config/poolmanager.conf`.

Note

You can also edit the file `/var/lib/dcache/config/poolmanager.conf` to create a new link group. Please make sure that it already exists. Otherwise you will have to create it first via the Admin Interface by

```
(PoolManager) admin > save
```

Edit the file `/var/lib/dcache/config/poolmanager.conf`

```
psu create linkGroup <linkgroup>
psu addto linkGroup <linkgroup> <link>
```

After editing this file you will have to restart the domain which contains the PoolManager cell to apply the changes.

Note

Administrators will have to take care, that no pool is present in more than one link group.

Access latency and retention policy. A space reservation has a *retention policy* and an *access latency*, where retention policy describes the quality of the storage service that will be provided for files in the space

reservation and access latency describes the availability of the files. See the section called “Properties of Space Reservation” for further details.

A link group has five boolean properties called `replicaAllowed`, `outputAllowed`, `custodialAllowed`, `onlineAllowed` and `nearlineAllowed`, which determine the access latencies and retention policies allowed in the link group. The values of these properties (`true` or `false`) can be configured via the Admin Interface or directly in the file `/var/lib/dcache/config/poolmanager.conf`.

For a space reservation to be allowed in a link group, the the retention policy and access latency of the space reservation must be allowed in the link group.

```
(PoolManager) admin > psu set linkGroup custodialAllowed <linkgroup> <true|false>
(PoolManager) admin > psu set linkGroup outputAllowed <linkgroup> <true|false>
(PoolManager) admin > psu set linkGroup replicaAllowed <linkgroup> <true|false>
(PoolManager) admin > psu set linkGroup onlineAllowed <linkgroup> <true|false>
(PoolManager) admin > psu set linkGroup nearlineAllowed <linkgroup> <true|false>
```

Important

It is up to the administrator to ensure that the link groups’ properties are specified correctly.

For example dCache will not complain if a link group that does not support a tape backend will be declared as one that supports `custodial` files.

It is essential that space in a link group is homogeneous with respect to access latencies, retention policies and storage groups accepted. Otherwise space reservations cannot be guaranteed. For instance, if only a subset of pools accessible through a link group support `custodial` files, there is no guarantee that a `custodial` space reservation created within the link group will fit on those pools.

Chapter 8. The dCache Tertiary Storage System Interface

Introduction

One of the features dCache provides is the ability to migrate files from its disk repository to one or more connected Tertiary Storage Systems (TSS) and to move them back to disk when necessary. Although the interface between dCache and the TSS is kept simple, dCache assumes to interact with an intelligent TSS. dCache does not drive tape robots or tape drives by itself. More detailed requirements to the storage system are described in one of the subsequent paragraphs.

Scope of this chapter

This document describes how to enable a standard dCache installation to interact with a Tertiary Storage System. In this description we assume that

- every dCache disk pool is connected to only one TSS instance.
- all dCache disk pools are connected to the same TSS instance.
- the dCache instance has not yet been populated with data, or only with a negligible amount of files.

In general, not all pools need to be configured to interact with the same Tertiary Storage System or with a storage system at all. Furthermore pools can be configured to have more than one Tertiary Storage System attached, but all those cases are not in the scope of the document.

Requirements for a Tertiary Storage System

dCache can only drive intelligent Tertiary Storage Systems. This essentially means that tape robot and tape drive operations must be done by the TSS itself and that there is some simple way to abstract the file PUT, GET and REMOVE operation.

Migrating Tertiary Storage Systems with a file system interface.

Most migrating storage systems provide a regular POSIX file system interface. Based on rules, data is migrated from primary to tertiary storage (mostly tape systems). Examples for migrating storage systems are:

- HPSS [<http://www.hpss-collaboration.org/>] (High Performance Storage System)
- DMF [<http://www.sgi.com/products/storage/software/dmf.html>] (Data Migration Facility)

Tertiary Storage Systems with a minimalistic PUT, GET and REMOVE interface

Some tape systems provide a simple PUT, GET, REMOVE interface. Typically, a copy-like application writes a disk file into the TSS and returns an identifier which uniquely identifies the written file within the Tertiary Storage System. The identifier is sufficient to get the file back to disk or to remove the file from the TSS. Examples are:

- OSM [<http://www.qstar.com/qstar-products/qstar-object-storage-manager>] (Object Storage Manager)
- Enstore [<http://www-ccf.fnal.gov/enstore/>] (FERMILab)

How dCache interacts with a Tertiary Storage System

Whenever dCache decides to copy a file from disk to tertiary storage a user-provided `executable` which can be either a script or a binary is automatically started on the pool where the file is located. That `executable` is expected to write the file into the Backend Storage System and to return a URI, uniquely identifying the file within that storage system. The format of the URI as well as the arguments to the `executable`, are described later in this document. The unique part of the URI can either be provided by the storage element, in return of the `STORE FILE` operation, or can be taken from dCache. A non-error return code from the `executable` lets dCache assume that the file has been successfully stored and, depending on the properties of the file, dCache can decide to remove the disk copy if space is running short on that pool. On a non-zero return from the `executable`, the file doesn't change its state and the operation is retried or an error flag is set on the file, depending on the error return code from the `executable`.

If dCache needs to restore a file to disk the same `executable` is launched with a different set of arguments, including the URI, provided when the file was written to tape. It is in the responsibility of the `executable` to fetch the file back from tape based on the provided URI and to return 0 if the `FETCH FILE` operation was successful or non-zero otherwise. In case of a failure the pool retries the operation or dCache decides to fetch the file from tape using a different pool.

Details on the TSS-support executable

Summary of command line options

This part explains the syntax of calling the `executable` that supports `STORE FILE`, `FETCH FILE` and `REMOVE FILE` operations.

```
put <pnfsID> <filename> -si=<storage-information> [<other-options>...]
```

```
get <pnfsID> <filename> -si=<storage-information> -uri=<storage-uri> [<other-options>...]
```

```
remove -uri=<storage-uri> [<other-options>...]
```

- **put / get / remove**: these keywords indicate the operation to be performed.

- **put**: copy file from disk to TSS.
- **get**: copy file back from TSS to disk.
- **remove**: remove the file from TSS.
- `<pnfsID>`: The internal identifier (i-node) of the file within dCache. The `<pnfsID>` is unique within a single dCache instance and globally unique with a very high probability.
- `<filename>`: is the full path of the local file to be copied to the TSS (for **put**) and respectively into which the file from the TSS should be copied (for **get**).
- `<storage-information>`: the storage information of the file, as explained below.
- `<storage-uri>`: the URI, which was returned by the executable, after the file was written to tertiary storage. In order to get the file back from the TSS the information of the URI is preferred over the information in the `<storage-information>`.
- `<other-options>`: `-<key> = <value>` pairs taken from the TSS configuration commands of the pool 'setup' file. One of the options, always provided is the option `-command=<full path of this executable>`.

Storage Information

The `<storage-information>` is a string in the format

```
-si=size=<bytes>;new=<true/false>;stored=<true/false>;sClass=<StorageClass>;\  
cClass0<CacheClass>;hsm=<StorageType>;<key>=<value>;[<key>=<value>;[...]]
```

Example:

```
-si=size=1048576000;new=true;stored=false;sClass=desy:cms-sc3;cClass=-;hsm=osm;Host=desy;
```

Mandatory storage information's keys

- `<size>`: Size of the file in bytes
- `<new>`: *False* if file already in the dCache; *True* otherwise
- `<stored>`: *True* if file already stored in the TSS; *False* otherwise
- `<sClass>`: HSM depended, is used by the `poolmanager` for pool attraction.
- `<cClass>`: Parent directory tag (`cacheClass`). Used by the `poolmanager` for pool attraction. May be '!'.
!.
- `<hsm>`: Storage manager name (`enstore/osm`). Can be overwritten by the parent directory tag (`hsmType`).

OSM specific storage information's keys

- `<group>`: The storage group of the file to be stored as specified in the `".(tag)(sGroup)"` tag of the parent directory of the file to be stored.

- `<store>`: The store name of the file to be stored as specified in the ".(tag)(OSMTemplate)" tag of the parent directory of the file to be stored.
- `<bfid>`: Bitfile ID (get and remove only) (e.g. 000451243.2542452542.25424524)

Enstore specific storage information's keys

- `<group>`: The storage group (e.g. cdf, cms ...)
- `<family>`: The file family (e.g. sgi2test, h6nxl8, ...)
- `<bfid>`: Bitfile ID (get only) (e.g. B0MS105746894100000)
- `<volume>`: Tape Volume (get only) (e.g. IA6912)
- `<location>`: Location on tape (get only) (e.g. : 0000_000000000_0000117)

There might be more key values pairs which are used by the dCache internally and which should not affect the behaviour of the executable.

Storage URI

The `<storage-uri>` is formatted as follows:

```
hsmType://hsmInstance/?store=<storename>&group=<groupname>&bfid=<bfid>
```

- `<hsmType>`: The type of the Tertiary Storage System
- `<hsmInstance>`: The name of the instance
- `<storename>` and `<groupname>` : The store and group name of the file as provided by the arguments to this executable.
- `<bfid>`: The unique identifier needed to restore or remove the file if necessary.

Example:

A storage-uri:

```
osm://osm/?store=sql&group=chimera&bfid=3434.0.994.1188400818542
```

Summary of return codes

Return Code	Meaning	Behaviour for PUT FILE	Behaviour for GET FILE
30 <= rc < 40	User defined	Deactivates request	Reports problem to poolmanager

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Return Code	Meaning	Behaviour for PUT FILE	Behaviour for GET FILE
41	No space left on device	Pool retries	Disables pool and reports problem to poolmanager
42	Disk read I/O error	Pool retries	Disables pool and reports problem to poolmanager
43	Disk write I/O error	Pool retries	Disables pool and reports problem to poolmanager
other	-	Pool retries	Reports problem to poolmanager

The executable and the STORE FILE operation

Whenever a disk file needs to be copied to a Tertiary Storage System dCache automatically launches an executable on the pool containing the file to be copied. Exactly one instance of the executable is started for each file. Multiple instances of the executable may run concurrently for different files. The maximum number of concurrent instances of the executables per pool as well as the full path of the executable can be configured in the 'setup' file of the pool as described in the section called "The pool 'setup' file".

The following arguments are given to the executable of a STORE FILE operation on startup.

```
put <pnfsID> <filename> -si=<storage-information> <more options>
```

Details on the meaning of certain arguments are described in the section called "Summary of command line options".

With the arguments provided the executable is supposed to copy the file into the Tertiary Storage System. The executable must not terminate before the transfer of the file was either successful or failed.

Success must be indicated by a 0 return of the executable. All non-zero values are interpreted as a failure which means, dCache assumes that the file has not been copied to tape.

In case of a 0 return code the executable has to return a valid storage URI to dCache in format:

```
hsmType://hsmInstance/?store=<storename>&group=<groupname>&bfid=<bfid>
```

Details on the meaning of certain parameters are described above.

The <bfid> can either be provided by the TSS as result of the STORE FILE operation or the pnfsID may be used. The latter assumes that the file has to be stored with exactly that pnfsID within the TSS. Whatever URI is chosen, it must allow to uniquely identify the file within the Tertiary Storage System.

Note

Only the URI must be printed to stdout by the executable. Additional information printed either before or after the URI will result in an error. stderr can be used for additional debug information or error messages.

The executable and the `FETCH FILE` operation

Whenever a disk file needs to be restored from a Tertiary Storage System dCache automatically launches an executable on the pool containing the file to be copied. Exactly one instance of the executable is started for each file. Multiple instances of the executable may run concurrently for different files. The maximum number of concurrent instances of the executable per pool as well as the full path of the executable can be configured in the 'setup' file of the pool as described in the section called "The pool 'setup' file".

The following arguments are given to the executable of a `FETCH FILE` operation on startup:

```
get <pnfsID> <filename> -si=<storage-information> -uri=<storage-uri> <more options>
```

Details on the meaning of certain arguments are described in the section called "Summary of command line options". For return codes see the section called "Summary of return codes".

The executable and the `REMOVE FILE` operation

Whenever a file is removed from the dCache namespace (file system) a process inside dCache makes sure that all copies of the file are removed from all internal and external media. The pool which is connected to the TSS which stores the file is activating the executable with the following command line options:

```
remove -uri=<storage-uri> <more options>
```

Details on the meaning of certain arguments are described in the section called "Summary of command line options". For return codes see the section called "Summary of return codes".

The executable is supposed to remove the file from the TSS and report a zero return code. If a non-zero error code is returned, the dCache will call the script again at a later point in time.

Configuring pools to interact with a Tertiary Storage System

The executable interacting with the Tertiary Storage System (TSS), as described in the chapter above, has to be provided to dCache on all pools connected to the TSS. The executable, either a script or a binary, has to be made "executable" for the user, dCache is running as, on that host.

The following files have to be modified to allow dCache to interact with the TSS.

- The `/var/lib/dcache/config/poolmanager.conf` file (one per system)
- The pool layout file (one per pool host)
- The pool 'setup' file (one per pool)
- The namespaceDomain layout file (one per system)

After the layout files and the various 'setup' files have been corrected, the following domains have to be restarted :

- pool services

- dCacheDomain
- namespaceDomain

The dCache layout files

The `/var/lib/dcache/config/poolmanager.conf` file

To be able to read a file from the tape in case the cached file has been deleted from all pools, enable the `restore-option`. The best way to do this is to log in to the Admin Interface and run the following commands:

```
[example.dcache.org] (local) admin > cd PoolManager
[example.dcache.org] (PoolManager) admin > pm set -stage-allowed=yes
[example.dcache.org] (PoolManager) admin > save
```

A restart of the `dCacheDomain` is not necessary in this case.

Alternatively, if the file `/var/lib/dcache/config/poolmanager.conf` already exists then you can add the entry

```
pm set -stage allowed=yes
```

and restart the `dCacheDomain`.

Warning

Do not create the file `/var/lib/dcache/config/poolmanager.conf` with this single entry! This will result in an error.

The pool layout

The dCache layout file must be modified for each pool node connected to a TSS. If your pool nodes have been configured correctly to work without TSS, you will find the entry `lfs=precious` in the layout file (that is located in `/etc/dcache/layouts` and in the file `/etc/dcache/dcache.conf` respectively) for each pool service. This entry is a disk-only-option and has to be removed for each pool which should be connected to a TSS. This will default the `lfs` parameter to `hsm` which is exactly what we need.

The pool 'setup' file

The pool 'setup' file is the file `poolHomeDir/poolName/setup`. It mainly defines 3 details related to TSS connectivity.

- Pointer to the executable which is launched on storing and fetching files.
- The maximum number of concurrent `STORE FILE` requests allowed per pool.
- The maximum number of concurrent `FETCH FILE` requests allowed per pool.

Define the executable and Set the maximum number of concurrent `PUT` and `GET` operations:

```
hsm set <hsmType> [<hsmInstanceName>] [-command=</path/to/executable>] [-key=<value>]
#
# PUT operations
# set the maximum number of active PUT operations >= 1
#
st set max active <numberOfConcurrentPUTS>
```

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```
#  
# GET operations  
# set the maximum number of active GET operations >= 1  
#  
rh set max active <numberOfConcurrentGETs>
```

- `<hsmType>`: the type of the TSS system. Must be set to “osm” for basic setups.
- `<hsmInstanceName>`: the instance name of the TSS system. Must be set to “osm” for basic setups.
- `</path/to/executable>`: the full path to the executable which should be launched for each TSS operation.

Setting the maximum number of concurrent PUT and GET operations.

Both numbers must be non zero to allow the pool to perform transfers.

Example:

We provide a script to simulate a connection to a TSS. To use this script place it in the directory `/usr/share/dcache/lib`, and create a directory to simulate the base of the TSS.

```
[root] # mkdir -p /hsmTape/data
```

Login to the Admin Interface to change the entry of the pool 'setup' file for a pool named `pool_1`.

```
(local) admin > cd pool_1  
(pool_1) admin > hsm set osm osm  
(pool_1) admin > hsm set osm -command=/usr/share/dcache/lib/hsmscript.sh  
(pool_1) admin > hsm set osm -hsmBase=/hsmTape  
(pool_1) admin > st set max active 5  
(pool_1) admin > rh set max active 5  
(pool_1) admin > save
```

The namespace layout

In order to allow dCache to remove files from attached TSSes, the “`cleaner.enable.hsm = true`” must be added immediately underneath the `[namespaceDomain/cleaner]` service declaration:

```
[namespaceDomain]  
... other services ...  
[namespaceDomain/cleaner]  
cleaner.enable.hsm = true  
.. more ...
```

What happens next

After restarting the necessary dCache domains, pools, already containing files, will start transferring them into the TSS as those files only have a disk copy so far. The number of transfers is determined by the configuration in the pool 'setup' file as described above in the section called “The pool 'setup' file”.

How to Store-/Restore files via the Admin Interface

In order to see the state of files within a pool, login into the pool in the admin interface and run the command `rep ls`.

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```
[example.dcache.org] (<poolname>) admin > rep ls
```

The output will have the following format:

```
PNFSID <MODE-BITS(LOCK-TIME)[OPEN-COUNT]> SIZE si={STORAGE-CLASS}
```

- **PNFSID:** The pnfsID of the file
- **MODE-BITS:**

```
CPCScsRDXEL
|||||||
|||||||+-- (L) File is locked (currently in use)
|||||||+--- (E) File is in error state
|||||||+---- (X) File is pinned (aka "sticky")
|||||||+----- (D) File is in process of being destroyed
|||||||+----- (R) File is in process of being removed
|||||+----- (s) File sends data to back end store
|||||+----- (c) File sends data to client (dCap,FTP...)
|||+----- (S) File receives data from back end store
||+----- (C) File receives data from client (dCap,FTP)
|+----- (P) File is precious, i.e., it is only on disk
+----- (C) File is on tape and only cached on disk.
```

- **LOCK-TIME:** The number of milli-seconds this file will still be locked. Please note that this is an internal lock and not the pin-time (SRM).
- **OPEN-COUNT:** Number of clients currently reading this file.
- **SIZE:** File size
- **STORAGE-CLASS:** The storage class of this file.

Example:

```
[example.dcache.org] (pool_1) admin > rep ls
00008F276A952099472FAD619548F47EF972 <-P-----L(0)[0]> 291910 si={dteam:STATIC}
00002A9282C2D7A147C68A327208173B81A6 <-P-----L(0)[0]> 2011264 si={dteam:STATIC}
0000EE298D5BF6BB4867968B88AE16BA86B0 <C-----L(0)[0]> 1976 si={dteam:STATIC}
```

In order to flush a file to the tape run the command **flush pnfsid**.

```
[example.dcache.org] (<poolname>) admin > flush pnfsid <pnfsid>
```

Example:

```
[example.dcache.org] (pool_1) admin > flush pnfsid 00002A9282C2D7A147C68A327208173B81A6
Flush Initiated
```

A file that has been flushed to tape gets the flag 'C'.

Example:

```
[example.dcache.org] (pool_1) admin > rep ls
00008F276A952099472FAD619548F47EF972 <-P-----L(0)[0]> 291910 si={dteam:STATIC}
00002A9282C2D7A147C68A327208173B81A6 <C-----L(0)[0]> 2011264 si={dteam:STATIC}
0000EE298D5BF6BB4867968B88AE16BA86B0 <C-----L(0)[0]> 1976 si={dteam:STATIC}
```

To remove such a file from the repository run the command **rep rm**.

```
[example.dcache.org] (<poolname>) admin > rep rm <pnfsid>
```

Example:

```
[example.dcache.org] (pool_1) admin > rep rm 00002A9282C2D7A147C68A327208173B81A6  
Removed 00002A9282C2D7A147C68A327208173B81A6
```

In this case the file will be restored when requested.

To restore a file from the tape you can simply request it by initializing a reading transfer or you can fetch it by running the command **rh restore**.

```
[example.dcache.org] (<poolname>) admin > rh restore [-block] <pnfsid>
```

Example:

```
[example.dcache.org] (pool_1) admin > rh restore 00002A9282C2D7A147C68A327208173B81A6  
Fetch request queued
```

How to monitor what's going on

This section briefly describes the commands and mechanisms to monitor the TSS PUT, GET and REMOVE operations. dCache provides a configurable logging facility and a Command Line Admin Interface to query and manipulate transfer and waiting queues.

Log Files

By default dCache is configured to only log information if something unexpected happens. However, to get familiar with Tertiary Storage System interactions you might be interested in more details. This section provides advice on how to obtain this kind of information.

The executable log file

Since you provide the `executable`, interfacing dCache and the TSS, it is in your responsibility to ensure sufficient logging information to be able to trace possible problems with either dCache or the TSS. Each request should be printed with the full set of parameters it receives, together with a timestamp. Furthermore information returned to dCache should be reported.

dCache log files in general

In dCache, each domain (e.g. `dCacheDomain`, `<pool>Domain` etc) prints logging information into its own log file named after the domain. The location of those log files is typically the `/var/log` or `/var/log/dCache` directory depending on the individual configuration. In the default logging setup only errors are reported. This behavior can be changed by either modifying `/etc/dcache/logback.xml` or using the dCache CLI to increase the log level of particular components as described below.

Increase the dCache log level by changes in `/etc/dcache/logback.xml`

If you intend to increase the log level of all components on a particular host you would need to change the `/etc/dcache/logback.xml` file as described below. dCache components need to be restarted to activate the changes.

The dCache Tertiary Storage System Interface

```
<threshold>
  <appender>stdout</appender>
  <logger>root</logger>
  <level>warn</level>
</threshold>
```

needs to be changed to

```
<threshold>
  <appender>stdout</appender>
  <logger>root</logger>
  <level>info</level>
</threshold>
```

Important

The change might result in a significant increase in log messages. So don't forget to change back before starting production operation. The next section describes how to change the log level in a running system.

Increase the dCache log level via the Command Line Admin Interface

Example:

Login into the dCache Command Line Admin Interface and increase the log level of a particular service, for instance for the `poolmanager` service:

```
[example.dcache.org] (local) admin > cd PoolManager
[example.dcache.org] (PoolManager) admin > log set stdout ROOT INFO
[example.dcache.org] (PoolManager) admin > log ls
stdout:
  ROOT=INFO
  dmg.cells.nucleus=WARN*
  logger.org.dcache.cells.messages=ERROR*
  .....
```

Obtain information via the dCache Command Line Admin Interface

The dCache Command Line Admin Interface gives access to information describing the process of storing and fetching files to and from the TSS, as there are:

- The *Pool Manager Restore Queue*. A list of all requests which have been issued to all pools for a `FETCH FILE` operation from the TSS (`rc ls`)
- The *Pool Collector Queue*. A list of files, per pool and storage group, which will be scheduled for a `STORE FILE` operation as soon as the configured trigger criteria match.
- The *Pool STORE FILE Queue*. A list of files per pool, scheduled for the `STORE FILE` operation. A configurable amount of requests within this queue are active, which is equivalent to the number of concurrent store processes, the rest is inactive, waiting to become active.
- The *Pool FETCH FILE Queue*. A list of files per pool, scheduled for the `FETCH FILE` operation. A configurable amount of requests within this queue are active, which is equivalent to the number of concurrent fetch processes, the rest is inactive, waiting to become active.

The dCache Tertiary Storage System Interface

For evaluation purposes, the *pinboard* of each component can be used to track down dCache behavior. The pinboard only keeps the most recent 200 lines of log information but reports not only errors but informational messages as well.

Example:

Check the pinboard of a service, here the poolmanager service.

```
[example.dcache.org] (local) admin > cd PoolManager
[example.dcache.org] (PoolManager) admin > show pinboard 100
08.30.45 [Thread-7] [pool_1 PoolManagerPoolUp] sendPoolStatusRelay: ...
08.30.59 [writeHandler] [NFSv41-dcachetogo PoolMgrSelectWritePool ...
....
```

Example:

The PoolManager Restore Queue. Remove the file `test.root` with the pnfs-ID `00002A9282C2D7A147C68A327208173B81A6`.

```
[example.dcache.org] (pool_1) admin > rep rm 00002A9282C2D7A147C68A327208173B81A6
```

Request the file `test.root`

```
[user] $ dccp dcap://example.dcache.org:/data/test.root test.root
```

Check the PoolManager Restore Queue:

```
[example.dcache.org] (local) admin > cd PoolManager
[example.dcache.org] (PoolManager) admin > rc ls
0000AB1260F474554142BA976D0ADAF78C6C@0.0.0.0/0.0.0.0-*/ m=1 r=0 [pool_1] [Staging 08.15
17:52:16] {0,}
```

Example:

The Pool Collector Queue.

```
[example.dcache.org] (local) admin > cd pool_1
[example.dcache.org] (pool_1) admin > queue ls -l queue
      Name: chimera:alpha
      Class@Hsm: chimera:alpha@osm
Expiration rest/defined: -39 / 0 seconds
Pending rest/defined: 1 / 0
Size rest/defined: 877480 / 0
Active Store Procs. : 0
      00001BC6D76570A74534969FD72220C31D5D

[example.dcache.org] (pool_1) admin > flush ls
Class Active Error Last/min Requests Failed
dteam:STATIC@osm 0 0 0 1 0
```

Example:

The pool STORE FILE Queue.

```
[example.dcache.org] (local) admin > cd pool_1
[example.dcache.org] (pool_1) admin > st ls
0000EC3A4BFCA8E14755AE4E3B5639B155F9 1 Fri Aug 12 15:35:58 CEST 2011
```

Example:

The dCache Tertiary Storage System Interface

```
    result=`echo $si | awk -v hallo=$1 -F; '{ for(i=1;i<=NF;i++){ split($i,a,"=") ; if( a[1] ==
hallo )print a[2]} }'`
    if [ -z "$result" ] ; then return 1 ; fi
    echo $result
    exit 0
}
##.....
#
# find a key in the storage info
#
printStorageInfo() {
#-----
    printout "storageinfo.StoreName : $storeName"
    printout "storageinfo.store : $store"
    printout "storageinfo.group : $group"
    printout "storageinfo.hsm : $hsmName"
    printout "storageinfo.accessLatency : $accessLatency"
    printout "storageinfo.retentionPolicy : $retentionPolicy"
    return 0
}
##.....
#
# assign storage info the keywords
#
assignStorageInfo() {
#-----
    store=`findKeyInStorageInfo "store"`
    group=`findKeyInStorageInfo "group"`
    storeName=`findKeyInStorageInfo "StoreName"`
    hsmName=`findKeyInStorageInfo "hsm"`
    accessLatency=`findKeyInStorageInfo "accessLatency"`
    retentionPolicy=`findKeyInStorageInfo "retentionPolicy"`
    return 0
}
##.....
#
# split the arguments into the options -<key>=<value> and the
# positional arguments.
#
splitArguments() {
#-----
#
    args=""
    while [ $# -gt 0 ] ; do
        if expr "$1" : "-.*" >/dev/null ; then
            a=`expr "$1" : "-\(.*)" 2>/dev/null`
            key=`echo "$a" | awk -F= '{print $1}' 2>/dev/null`
            value=`echo "$a" | awk -F= '{for(i=2;i<=NF;i++)x=x $i "=" ; x=x $NF ; print x}' 2>/dev/
null`
            if [ -z "$value" ] ; then a="{key}=" ; fi
            eval "${key}=\${value}\""
            a="export ${key}"
            eval "$a"
        else
            args="{args} $1"
        fi
        shift 1
    done
    if [ ! -z "$args" ] ; then
        set `echo "$args" | awk '{ for(i=1;i<=NF;i++)print $i }'`
    fi
    return 0
}
#
#
##.....
#
splitUri() {
```

The dCache Tertiary Storage System Interface

```
#-----
#
uri_hsmName=`expr "$1" : "\(.*)\|:.*"`
uri_hsmInstance=`expr "$1" : ".*\|/\|(\.*)\|/.*"`
uri_store=`expr "$1" : ".*\|/?store=(.*)&group.*"`
uri_group=`expr "$1" : ".*group=(.*)&bfid.*"`
uri_bfid=`expr "$1" : ".*bfid=(.*)"`
#
if [ \(\ -z "${uri_store}" \) -o \(\ -z "${uri_group}" \) -o \(\ -z "${uri_bfid}" \) \
  -o \(\ -z "${uri_hsmName}" \) -o \(\ -z "${uri_hsmInstance}" \) ] ; then
  printerror "Illegal URI format : $1"
  return 1
fi
return 0
}
#####
#
echo "----- $* `date`" >>${logFile}
#
#####
#
createEnvironment() {
  if [ -z "${hsmBase}" ] ; then
    printerror "hsmBase not set, can't continue"
    return 1
  fi
  BASE=${hsmBase}/data
  if [ ! -d ${BASE} ] ; then
    printerror "${BASE} is not a directory or doesn't exist"
    return 1
  fi
}
##
#-----
doTheGetFile() {
  splitUri $1
  [ $? -ne 0 ] && return 1

  createEnvironment
  [ $? -ne 0 ] && return 1

  pnfsdir=${BASE}/${uri_hsmName}/${uri_store}/${uri_group}
  pnfsfile=${pnfsdir}/${pnfsid}

  cp $pnfsfile $filename 2>/dev/null
  if [ $? -ne 0 ] ; then
    printerror "Couldn't copy file $pnfsfile to $filename"
    return 1
  fi

  return 0
}
##
#-----
doTheStoreFile() {
  splitUri $1
  [ $? -ne 0 ] && return 1

  createEnvironment
  [ $? -ne 0 ] && return 1

  pnfsdir=${BASE}/${hsmName}/${store}/${group}
  mkdir -p ${pnfsdir} 2>/dev/null
  if [ $? -ne 0 ] ; then
    printerror "Couldn't create $pnfsdir"
    return 1
  fi
}
```

The dCache Tertiary Storage System Interface

```
fi
pnfsfile=${pnfsdir}/${pnfsid}

cp $filename $pnfsfile 2>/dev/null
if [ $? -ne 0 ] ; then
    printerror "Couldn't copy file $filename to $pnfsfile"
    return 1
fi

return 0
}
##
#-----
doTheRemoveFile() {

    splitUri $1
    [ $? -ne 0 ] && return 1

    createEnvironment
    [ $? -ne 0 ] && return 1

    pnfsdir=${BASE}/${uri_hsmName}/${uri_store}/${uri_group}
    pnfsfile=${pnfsdir}/${uri_bfid}

    rm $pnfsfile 2>/dev/null
    if [ $? -ne 0 ] ; then
        printerror "Couldn't remove file $pnfsfile"
        return 1
    fi

    return 0
}
#####
#
# split arguments
#
args=""
while [ $# -gt 0 ] ; do
    if expr "$1" : "-.*" >/dev/null ; then
        a=`expr "$1" : "-\(.*\)" 2>/dev/null`
        key=`echo "$a" | awk -F= '{print $1}' 2>/dev/null`
        value=`echo "$a" | awk -F= '{for(i=2;i<NF;i++)x=x $i "=" ; x=x $NF ; print x}' 2>/dev/
null`
        if [ -z "$value" ] ; then a="{key}=" ; fi
        eval "${key}=\${value}\""
        a="export ${key}"
        eval "$a"
    else
        args="${args} $1"
    fi
    shift 1
done
if [ ! -z "$args" ] ; then
    set `echo "$args" | awk '{ for(i=1;i<=NF;i++)print $i }'`
fi
#
#
if [ $# -lt 1 ] ; then
    printerror "Not enough arguments : ... put/get/remove ..."
    exit 1
fi
#
command=$1
pnfsid=$2
#
# !!!!! Hides a bug in the dCache HSM remove
#
if [ "$command" = "remove" ] ; then pnfsid="0000000000000000000000000000000000000000000000000000000000000000" ; fi
#
```

The dCache Tertiary Storage System Interface

```
#
printout "Request for $command started `date`"
#
#####
#
if [ "$command" = "put" ] ; then
#
#####
#
filename=$3
#
if [ -z "$si" ] ; then
    printerror "StorageInfo (si) not found in put command"
    exit 5
fi
#
assignStorageInfo
#
printStorageInfo
#
if [ \( -z "${store}" \) -o \( -z "${group}" \) -o \( -z "${hsmName}" \) ] ; then
    printerror "Didn't get enough information to flush : hsmName = $hsmName store=$store group=
$group pnfsid=$pnfsid "
    exit 3
fi
#
uri="$hsmName://$hsmName/?store=${store}&group=${group}&bfid=${pnfsid}"

printout "Created identifier : $uri"

doTheStoreFile $uri
rc=$?
if [ $rc -eq 0 ] ; then echo $uri ; fi

printout "Request 'put' finished at `date` with return code $rc"
exit $rc
#
#
#####
#
elif [ "$command" = "get" ] ; then
#
#####
#
filename=$3
if [ -z "$uri" ] ; then
    printerror "Uri not found in arguments"
    exit 3
fi
#
printout "Got identifier : $uri"
#
doTheGetFile $uri
rc=$?
printout "Request 'get' finished at `date` with return code $rc"
exit $rc
#
#####
#
elif [ "$command" = "remove" ] ; then
#
#####
#
if [ -z "$uri" ] ; then
    printerror "Illegal Argument error : URI not specified"
    exit 4
fi
#
printout "Remove uri = $uri"
doTheRemoveFile $uri
```

The dCache Tertiary Storage System Interface

```
rc=$?  
#  
  printout "Request 'remove' finished at `date` with return code $rc"  
  exit $rc  
#  
else  
#  
  printerror "Expected command : put/get/remove , found : $command"  
  exit 1  
#  
fi
```

Chapter 9. File Hopping

File hopping is a collective term in dCache, summarizing the possibility of having files being transferred between dCache pools triggered by a variety of conditions. The most prominent examples are:

- If a file is requested by a client but the file resides on a pool from which this client, by configuration, is not allowed to read data, the dataset is transferred to an “allowed” pool first.
- If a pool encounters a steady high load, the system may, if configured, decide to replicate files to other pools to achieve an equal load distribution.
- HSM restore operations may be split into two steps. The first one reads data from tertiary storage to an “HSM connected” pool and the second step takes care that the file is replicated to a general read pool. Under some conditions this separation of HSM and non-HSM pools might become necessary for performance reasons.
- If a dataset has been written into dCache it might become necessary to have this file replicated instantly. The reasons can be, to either have a second, safe copy, or to make sure that clients don’t access the file for reading on the write pools.

File Hopping on arrival from outside dCache

File Hopping on arrival is a term, denoting the possibility of initiating a pool to pool transfer as the result of a file successfully arriving on a pool from some external client. Files restored from HSM or arriving on a pool as the result of a pool to pool transfer will not yet be forwarded.

Forwarding of incoming files can be enabled by setting the `pool.destination.replicate` property in the `/etc/dcache/dcache.conf` file or per pool in the layout file. It can be set to `on`, `PoolManager` or `HoppingManager`, where `on` does the same as `PoolManager`.

The pool is requested to send a `replicateFile` message to either the `PoolManager` or to the `HoppingManager`, if available. The different approaches are briefly described below and in more detail in the subsequent sections.

- The `replicateFile` message is sent to the `PoolManager`. This happens for all files arriving at that pool from outside (no restore or p2p). No intermediate `HoppingManager` is needed. The restrictions are
 - All files are replicated. No pre-selection, e.g. on the storage class can be done.
 - The mode of the replicated file is determined by the destination pool and cannot be overwritten. See the section called “File mode of replicated files”
- The `replicateFile` message is sent to the `HoppingManager`. The `HoppingManager` can be configured to replicate certain storage classes only and to set the mode of the replicated file according to rules. The file mode of the source file cannot be modified.

File mode of replicated files

The mode of a replicated file can either be determined by settings in the destination pool or by the `HoppingManager`. It can be `cached` or `precious`.

- If the `PoolManager` is used for replication, the mode of the replicated file is determined by the destination pool. The default setting is `cached`.
- If a `HoppingManager` is used for file replication, the mode of the replicated file is determined by the `HoppingManager` rule responsible for this particular replication. If the destination mode is set to `keep` in the rule, the mode of the destination pool determines the final mode of the replicated file.

File Hopping managed by the `PoolManager`

To enable replication on arrival by the `PoolManager` set the property `pool.destination.replicate` to `PoolManager` for the particular pool

```
[<exampleDomain>]
[<exampleDomain>/pool]
...
pool.destination.replicate=PoolManager
```

or for several pools in the `/etc/dcache/dcache.conf` file.

```
...
pool.destination.replicate=PoolManager
```

File hopping configuration instructs a pool to send a `replicateFile` request to the `PoolManager` as the result of a file arriving on that pool from some external client. All arriving files will be treated the same. The `PoolManager` will process this transfer request by trying to find a matching link (Please find detailed information at Chapter 7, *The poolmanager Service*).

It is possible to configure the `PoolManager` such that files are replicated from this pool to a special set of destination pools.

Example:

Assume that we want to have all files, arriving on pool `ocean` to be immediately replicated to a subset of read pools. This subset of pools is described by the poolgroup `ocean-copies`. No other pool is member of the poolgroup `ocean-copies`.

Other than that, files arriving at the pool `mountain` should be replicated to all read pools from which farm nodes on the `131.169.10.0/24` subnet are allowed to read.

The layout file defining the pools `ocean` and `mountain` should read like this:

```
[exampleDomain]
[exampleDomain/pool]

name=ocean
path=/path/to/pool-ocean
pool.wait-for-files=${path}/data
pool.destination.replicate=PoolManager

name=mountain
path=/path/to/pool-mountain
pool.wait-for-files=${path}/data
```

```
pool.destination.replicate=PoolManager
```

In the layout file it is defined that all files arriving on the pools ocean or mountain should be replicated immediately. The following PoolManager.conf file contains instructions for the PoolManager how to replicate these files. Files arriving at the ocean pool will be replicated to the ocean-copies subset of the read pools and files arriving at the pool mountain will be replicated to all read pools from which farm nodes on the 131.169.10.0/24 subnet are allowed to read.

```
#
# define the units
#
psu create unit -protocol  */*
psu create unit -net      0.0.0.0/0.0.0.0
psu create unit -net      131.169.10.0/255.255.255.0
# create the faked net unit
psu create unit -net      192.1.1.1/255.255.255.255
psu create unit -store     *@*
psu create unit -store     ocean:raw@osm
#
#
# define unit groups
#
psu create ugroup  any-protocol
psu create ugroup  any-store
psu create ugroup  ocean-copy-store
psu create ugroup  farm-network
psu create ugroup  ocean-copy-network
#
psu addto ugroup  any-protocol  */*
psu addto ugroup  any-store     *@*
psu addto ugroup  ocean-copy-store  ocean:raw@osm
psu addto ugroup  farm-network  131.169.10.0/255.255.255.0
psu addto ugroup  ocean-copy-network  192.1.1.1/255.255.255.255
psu addto ugroup  allnet-cond  0.0.0.0/0.0.0.0
psu addto ugroup  allnet-cond  131.169.10.0/255.255.255.0
psu addto ugroup  allnet-cond  192.1.1.1/255.255.255.255
#
#
# define the write-pools
#
psu create pool  ocean
psu create pool  mountain
#
#
# define the write-pools poolgroup
#
psu create pgroup  write-pools
psu addto pgroup  write-pools  ocean
psu addto pgroup  write-pools  mountain
#
#
# define the write-pools-link, add write pools and set transfer preferences
#
psu create link  write-pools-link  any-store any-protocol allnet-cond
psu addto link  write-pools-link  write-pools
psu set link  farm-read-link  -readpref=0 -writepref=10 -cachepref=0 -p2ppref=-1
#
#
# define the read-pools
#
psu create pool  read-pool-1
psu create pool  read-pool-2
psu create pool  read-pool-3
psu create pool  read-pool-4
#
#
# define the farm-read-pools poolgroup and add pool members
#
```

```
psu create pgroup farm-read-pools
psu addto pgroup farm-read-pools read-pool-1
psu addto pgroup farm-read-pools read-pool-2
psu addto pgroup farm-read-pools read-pool-3
psu addto pgroup farm-read-pools read-pool-4
#
#
# define the ocean-copy-pools poolgroup and add a pool
#
psu create pgroup ocean-copy-pools
psu addto pgroup ocean-copy-pools read-pool-1
#
#
# define the farm-read-link, add farm-read-pools and set transfer preferences
#
psu create link farm-read-link any-store any-protocol farm-network
psu addto link farm-read-link farm-read-pools
psu set link farm-read-link -readpref=10 -writepref=0 -cachepref=10 -p2ppref=-1
#
#
# define the ocean-copy-link, add ocean-copy-pools and set transfer preferences
#
psu create link ocean-copy-link ocean-copy-store any-protocol ocean-copy-network
psu addto link ocean-copy-link ocean-copy-pools
psu set link ocean-copy-link -readpref=10 -writepref=0 -cachepref=10 -p2ppref=-1
#
#
```

While 131.169.10.1 is a legal IP address e.g. of one of your farm nodes, the 192.1.1.1 IP address must not exist anywhere at your site.

File Hopping managed by the HoppingManager

With the HoppingManager you have several configuration options for file hopping on arrival, e.g.:

- With the HoppingManager you can define a rule such that only the files with a specific storage class should be replicated.
- You can specify the protocol the replicated files can be accessed with.
- You can specify from which ip-addresses it should be possible to access the files.

Starting the FileHopping Manager service

Add the hoppingmanager service to a domain in your layout file and restart the domain.

```
[<DomainName>]
[<DomainName>/hoppingmanager]
```

Initially no rules are configured for the HoppingManager. You may add rules by either edit the file `/var/lib/dcache/config/HoppingManager.conf` and restart the hoppingmanager service, or use the admin interface and save the modifications by the `save` command into the `HoppingManager.conf`

Configuring pools to use the HoppingManager

To enable replication on arrival by the HoppingManager set the property `pool.destination.replicate` to `HoppingManager` for the particular pool

```
[<exampleDomain>]
```

```
[<exampleDomain>/pool]
...
pool.destination.replicate=HoppingManager
```

or for several pools in the `/etc/dcache/dcache.conf` file.

```
...
pool.destination.replicate=HoppingManager
```

HoppingManager Configuration Introduction

- The `HoppingManager` essentially receives `replicateFile` messages from pools, configured to support file hopping, and either discards or modifies and forwards them to the `PoolManager`, depending on rules described below.
- The `HoppingManager` decides on the action to perform, based on a set of configurable rules. Each rule has a name. Rules are checked in alphabetic order concerning their names.
- A rule is triggered if the storage class matches the storage class pattern assigned to that rule. If a rule is triggered, it is processed and no further rule checking is performed. If no rule is found for this request the file is not replicated.
- If for whatever reason, a file cannot be replicated, NO RETRY is being performed.
- Processing a triggered rule can be :
 - The message is discarded. No replication is done for this particular storage class.
 - The rule modifies the `replicateFile` message, before it is forwarded to the `PoolManager`.

An ip-number of a farm-node of the farm that should be allowed to read the file can be added to the `replicateFile` message.

The mode of the replicated file can be specified. This can either be `precious`, `cached` or `keep`. `keep` means that the pool mode of the source pool determines the replicated file mode.

The requested protocol can be specified.

HoppingManager Configuration Reference

```
define hop OPTIONS <name> <pattern> precious|cached|keep
  OPTIONS
  -destination=<cellDestination> # default : PoolManager
  -overwrite
  -continue
  -source=write|restore|* # !!!! for experts only StorageInfoOptions
  -host=<destinationHostIp>
  -protType=dCap|ftp...
  -protMinor=<minorProtocolVersion>
  -protMajor=<majorProtocolVersion>
```

name

This is the name of the hopping rule. Rules are checked in alphabetic order concerning their names.

pattern

`pattern` is a storage class pattern. If the incoming storage class matches this pattern, this rule is processed.

precious|cached|keep

precious | cached | keep determines the mode of the replicated file. With keep the mode of the file will be determined by the mode of the destination pool.

-destination

This defines which cell to use for the pool to pool transfer. By default this is the PoolManager and this should not be changed.

-overwrite

In case, a rule with the same name already exists, it is overwritten.

-continue

If a rule has been triggered and the corresponding action has been performed, no other rules are checked. If the continue option is specified, rule checking continues. This is for debugging purposes only.

-source

-source defines the event on the pool which has triggered the hopping. Possible values are restore and write. restore means that the rule should be triggered if the file was restored from a tape and write means that it should be triggered if the file was written by a client.

-host

Choose the id of a node of the farm of worker-nodes that should be allowed to access the file. Configure the poolmanager respectively.

-protType, -protMajor, -protMinor

Specify the protocol which should be used to access the replicated files.

HoppingManager configuration examples

In order to instruct a particular pool to send a replicateFile message to the hoppingmanager service, you need to add the line pool.destination.replicate=HoppingManager to the layout file.

Example:

```
[exampleDomain]
[exampleDomain/pool]

name=write-pool
path=/path/to/write-pool-exp-a
pool.wait-for-files=${path}/data
pool.destination.replicate=HoppingManager
...
```

Assume that all files of experiment-a will be written to an expensive write pool and subsequently flushed to tape. Now some of these files need to be accessed without delay. The files that need fast access possibility will be given the storage class exp-a:need-fast-access@osm.

In this example we will configure the file hopping such that a user who wants to access a file that has the above storage info with the NFSv4.1 protocol will be able to do so.

Define a rule for hopping in the /var/lib/dcache/config/HoppingManager.conf file.

```
define hop nfs-hop exp-a:need-fast-access@osm cached -protType=nfs -protMajor=4 -protMinor=1
```

This assumes that the storage class of the file is `exp-a:nfs@osm`. The mode of the file, which was precious on the write pool will have to be changed to cached on the read pool.

The corresponding `/var/lib/dcache/config/poolmanager.conf` file could read like this:

```
#
# define the units
#
psu create unit -protocol  */*
psu create unit -net      0.0.0.0/0.0.0.0
psu create unit -store    exp-a:need-fast-access@osm
#
#
# define unit groups
#
psu create ugroup any-protocol
psu create ugroup exp-a-copy-store
psu create ugroup allnet-cond
#
psu addto ugroup any-protocol */*
psu addto ugroup exp-a-copy-store exp-a:need-fast-access@osm
psu addto ugroup allnet-cond 0.0.0.0/0.0.0.0
#
#
# define the write-pool
#
psu create pool write-pool
#
#
# define the read-pool
#
psu create pool read-pool
#
#
# define the exp-a-read-pools poolgroup and add a pool
#
psu create pgroup exp-a-read-pools
psu addto pgroup exp-a-read-pools read-pool
#
#
# define the exp-a-write-pools poolgroup and add a pool
#
psu create pgroup exp-a-write-pools
psu addto pgroup exp-a-write-pools write-pool
#
#
# define the exp-a-read-link, add exp-a-read-pools and set transfer preferences
#
psu create link exp-a-read-link exp-a-copy-store any-protocol allnet-cond
psu addto link exp-a-read-link exp-a-read-pools
psu set link exp-a-read-link -readpref=10 -writepref=0 -cachepref=10 -p2ppref=-1
#
#
# define the exp-a-write-link, add exp-a-write-pools and set transfer preferences
#
psu create link exp-a-write-link exp-a-copy-store any-protocol allnet-cond
psu addto link exp-a-write-link exp-a-write-pools
psu set link exp-a-write-link -readpref=0 -writepref=10 -cachepref=0 -p2ppref=-1
#
#
#
```

Chapter 10. Authorization in dCache

To limit access to data, dCache comes with an authentication and authorization interface called gPlazma2. gPlazma is an acronym for Grid-aware PLuggable AuthorZation Management. Earlier versions of dCache worked with gPlazma1 which has now been completely removed from dCache. So if you are upgrading, you have to reconfigure gPlazma if you used gPlazma1 until now.

Basics

Though it is possible to allow anonymous access to dCache it is usually desirable to authenticate users. The user then has to connect to one of the different doors (e.g., GridFTP door, dCap door) and login with credentials that prove his identity. In Grid-World these credentials are very often X.509 certificates, but dCache also supports other methods like username/password and kerberos authentication.

The door collects the credential information from the user and sends a login request to the configured authorization service (i.e., gPlazma) Within gPlazma the configured plug-ins try to verify the users identity and determine his access rights. From this a response is created that is then sent back to the door and added to the entity representing the user in dCache. This entity is called `subject`. While for authentication usually more global services (e.g., ARGUS) may be used, the mapping to site specific UIDs has to be configured on a per site basis.

Configuration

gPlazma2 is configured by the PAM-style configuration file `/etc/dcache/gplazma.conf`. Each line of the file is either a comment (i.e., starts with #, is empty, or defines a plugin. Plugin defining lines start with the plugin stack type (one of `auth`, `map`, `account`, `session` `identity`), followed by a PAM-style modifier (one of `optional`, `sufficient`, `required`, `requisite`), the plugin name and an optional list of key-value pairs of parameters. During the login process they will be executed in the order `auth`, `map`, `account` and `session`. The `identity` plugins are not used during login, but later on to map from UID +GID back to user names (e.g., for NFS). Within these groups they are used in the order they are specified.

```
auth|map|account|session|identity optional|required|requisite|sufficient <plug-in>
["<key>=<value>" ...]
```

A complete configuration file will look something like this:

Example:

```
# Some comment
auth optional x509
auth optional voms
map requisite vorolemap
map requisite authzdb authzdb=/etc/grid-security/authzdb
session requisite authzdb
```

Login Phases

`auth`

`auth`-plug-ins are used to read the users public and private credentials and ask some authority, if those are valid for accessing the system.

map

map-plugin-ins map the user information obtained in the `auth` step to UID and GIDs. This may also be done in several steps (e.g., the `vorolemap` plug-in maps the users DN+FQAN to a username which is then mapped to UID/GIDs by the `authzdb` plug-in).

account

account-plugin-ins verify the validity of a possibly mapped identity of the user and may reject the login depending on information gathered within the map step.

session

session plug-ins usually enrich the session with additional attributes like the user's home directory.

identity

identity plug-ins are responsible for mapping UID and GID to user names and vice versa during the work with dCache.

The meaning of the modifiers follow the PAM specification:

Modifiers

optional

The success or failure of this plug-in is only important if it is the only plug-in in the stack associated with this type.

sufficient

Success of such a plug-in is enough to satisfy the authentication requirements of the stack of plug-ins (if a prior required plug-in has failed the success of this one is ignored). A failure of this plug-in is not deemed as fatal for the login attempt. If the plug-in succeeds `gPlazma2` immediately proceeds with the next plug-in type or returns control to the door if this was the last stack.

required

Failure of such a plug-in will ultimately lead to `gPlazma2` returning failure but only after the remaining plug-ins for this type have been invoked.

requisite

Like `required`, however, in the case that such a plug-in returns a failure, control is directly returned to the door.

Plug-ins

`gPlazma2` functionality is configured by combining different types of plug-ins to work together in a way that matches your requirements. For this purpose there are five different types of plug-ins. These types correspond to the keywords `auth`, `map`, `account`, `session` and `identity` as described in the previous section. The plug-ins can be configured via properties that may be set in `dcache.conf`, the layout-file or in `gplazma.conf`.

auth Plug-ins

kpwd

The `kpwd` plug-in authorizes users by username and password, by pairs of DN and FQAN and by Kerberos principals.

Properties

`gplazma.kpwd.file`

Path to `dcache.kpwd`

Default: `/etc/dcache/dcache.kpwd`

voms

The voms plug-in is an auth plug-in. It can be used to verify X.509 credentials. It takes the certificates and checks their validity by testing them against the trusted CAs. The verified certificates are then stored and passed on to the other plug-ins in the stack.

Properties

`gplazma.vomsdir.ca`

Path to ca certificates

Default: `/etc/grid-security/certificates`

`gplazma.vomsdir.dir`

Path to vomsdir

Default: `/etc/grid-security/vomsdir`

X.509 plug-in

The X.509 plug-in is a auth plug-in that extracts X.509 certificate chains from the credentials of a user to be used by other plug-ins.

map Plug-ins

kpwd

As a map plug-in it maps usernames to UID and GID. And as a session plug-in it adds root and home path information to the session based on the user's username.

Properties

`gplazma.kpwd.file`

Path to `dcache.kpwd`

Default: `/etc/dcache/dcache.kpwd`

authzdb

The authzdb plug-in takes a username and maps it to UID+GID using the `storage-authzdb` file.

Properties

`gplazma.authzdb.file`

Path to `storage-authzdb`

Default: `/etc/grid-security/storage-authzdb`

GridMap

The `gridmap` plug-in maps GLOBUS identities and Kerberos identities to usernames.

Properties

`gplazma.gridmap.file`
Path to `grid-mapfile`

Default: `/etc/grid-security/grid-mapfile`

vorolemap

The `voms` plug-in maps pairs of DN and FQAN to usernames via a `vorolemap` file.

Properties

`gplazma.vorolemap.file`
Path to `grid-vorolemap`

`/etc/grid-security/grid-vorolemap`

krb5

The `krb5` plug-in maps a kerberos principal to a username by removing the domain part from the principal.

Example:

```
user@KRB-DOMAIN.EXAMPLE.ORG to user
```

nsswitch

The `nsswitch` plug-in uses the system's `nsswitch` configuration to provide mapping.

Typically `nsswitch` plug-in will be combined with `vorolemap` plug-in, `gridmap` plug-in or `krb5` plug-in:

Example:

```
# Map grid users to local accounts
auth optional x509 #1
auth optional voms #2
map requisite vorolemap #3
map requisite nsswitch #4
session requisite nsswitch #5
```

In this example following is happening: extract user's DN (1), extract and verify VOMS attributes (2), map DN+Role to a local account (3), extract uid and gids for a local account (4) and, finally, extract users home directory (5).

nis

The `nis` plug-in uses an existing NIS service to map `username+password` to a username.

Properties

`gplazma.nis.server`

NIS server host

Default: `nisserv.domain.com`

`gplazma.nis.domain`

NIS domain

Default: `domain.com`

The result of `nis` plug-in can be used by other plug-ins:

Example:

```
# Map grid or kerberos users to local accounts
auth optional x509 #1
auth optional voms #2
map requisite vorolemap #3
map optional krb5 #4
map optional nis #5
session requisite nis #6
```

In this example two access methods are considered: grid based and kerberos based. If user comes with grid certificate and VOMS role: extract user's DN (1), extract and verify VOMS attributes (2), map DN+Role to a local account (3). If user comes with Kerberos ticket: extract local account (4). After this point in both cases we talk to NIS to get uid and gids for a local account (5) and, finally, adding users home directory (6).

account Plug-ins

argus

The `argus` plug-in bans users by their DN. It talks to your site's ARGUS system (see <https://twiki.cern.ch/twiki/bin/view/EGEE/AuthorizationFramework> [<https://twiki.cern.ch/twiki/bin/view/EGEE/AuthorizationFramework>]) to check for banned users.

Properties

`gplazma.argus.hostcert`

Path to host certificate

Default: `/etc/grid-security/hostcert.pem`

`gplazma.argus.hostkey`

Path to host key

Default: `/etc/grid-security/hostkey.pem`

`gplazma.argus.hostkey.password`

Password for host key

Default:

`gplazma.argus.ca`

Path to CA certificates

Default: `/etc/grid-security/certificates`

`gplazma.argus.endpoint`

URL of PEP service

Default: `https://localhost:8154/authz`

banfile

The banfile plug-in bans users by their principal class and the associated name. It is configured via a simple plain text file.

Example:

```
# Ban users by principal
alias dn=org.globus.gsi.jaas.GlobusPrincipal
alias kerberos=javax.security.auth.kerberos.KerberosPrincipal
alias fqan=org.dcache.auth.FQANPrincipal
alias name=org.dcache.auth.LoginNamePrincipal

ban name:ernie
ban kerberos:BERT@EXAMPLE.COM
ban com.example.SomePrincipal:Samson
```

In this example the first line is a comment. Lines 2 to 5 define aliases for principal class names that can then be used in the following banning section. The four aliases defined in this example are actually hard coded into `gPlazma`, therefore you can use these short names without explicitly defining them in your configuration file. Line 7 to 9 contain ban definitions. Line 9 directly uses the class name of a principal class instead of using an alias.

Please note that the plug-in only supports principals whose associated name is a single line of plain text. In programming terms this means the constructor of the principal class has to take exactly one single string parameter.

For the plugin to work, the configuration file has to exist even if it is empty.

Properties

`gplazma.banfile.path`

Path to configuration file

Default: `/etc/dcache/ban.conf`

To activate the banfile plug-in it has to be added to `gplazma.conf`:

Example:

```
# Map grid or kerberos users to local accounts
auth optional x509
auth optional voms
map requisite vorolemap
map optional krb5
map optional nis
session requisite nis
account requisite banfile
```

session Plug-ins

kpwd

The kpwd plug-in adds root and home path information to the session, based on the username.

Properties

`gplazma.kpwd.file`
Path to `dcache.kpwd`

Default: `/etc/dcache/dcache.kpwd`

authzdb

The authzdb plug-in adds root and home path information to the session, based and username using the `storage-authzdb` file.

Properties

`gplazma.authzdb.file`
Path to `storage-authzdb`

Default: `/etc/grid-security/storage-authzdb`

nsswitch

The nsswitch plug-in adds root and home path information to the session, based on the username using your system's nsswitch service.

Typically nsswitch plug-in will be combined with vorolemap plug-in, gridmap plug-in or krb5 plug-in:

Example:

```
# Map grid users to local accounts
auth optional x509 #1
auth optional voms #2
```

```
map    requisite vorolemap #3
map    requisite nsswitch #4
session requisite nsswitch #5
```

In this example following is happening: extract user's DN (1), extract and verify VOMS attributes (2), map DN+Role to a local account (3), extract uid and gids for a local account (4) and, finally, extract users home directory (5).

nis

The `nis` plug-in adds root and home path information to the session, based on the username using your site's NIS service.

Properties

```
gplazma.nis.server
  NIS server host
```

Default: `nisserv.domain.com`

```
gplazma.nis.domain
  NIS domain
```

Default: `domain.com`

The result of `nis` plug-in can be used by other plug-ins:

Example:

```
# Map grid or kerberos users to local accounts
auth    optional  x509 #1
auth    optional  voms #2
map     requisite vorolemap #3
map     optional  krb5 #4
map     optional  nis #5
session requisite  nis #6
```

In this example two access methods are considered: grid based and kerberos based. If user comes with grid certificate and VOMS role: extract user's DN (1), extract and verify VOMS attributes (2), map DN+Role to a local account (3). If user comes with Kerberos ticket: extract local account (4). After this point in both cases we talk to NIS to get uid and gids for a local account (5) and, finally, adding users home directory (6).

ldap

The `ldap` plug-in is a map, session and identity plugin. As a map plugin it maps user names to UID and GID. As a session plugin it adds root and home path information to the session. As an identity plugin it supports reverse mapping of UID and GID to user and group names respectively.

Properties

```
gplazma.ldap.url
```

LDAP server url. Use `ldap://` prefix to connect to plain LDAP and `ldaps://` for secured LDAP.

Example: `ldaps://example.org:389`

`gplazma.ldap.organization`

Top level (base DN) of the LDAP directory tree

Example: `o="Example, Inc.", c=DE`

`gplazma.ldap.tree.people`

LDAP subtree containing user information. The path to the user records will be formed using the base DN and the value of this property as a organizational unit (ou) subdirectory.

Default: `People`

Example: Setting `gplazma.ldap.organization=o="Example, Inc.", c=DE` and `gplazma.ldap.tree.people=People` will have the plugin looking in the LDAP directory `ou=People, o="Example, Inc.", c=DE` for user information.

`gplazma.ldap.tree.groups`

LDAP subtree containing group information. The path to the group records will be formed using the base DN and the value of this property as a organizational unit (ou) subdirectory.

Default: `Groups`

Example: Setting `gplazma.ldap.organization=o="Example, Inc.", c=DE` and `gplazma.ldap.tree.groups=Groups` will have the plugin looking in the LDAP directory `ou=Groups, o="Example, Inc.", c=DE` for group information.

`gplazma.ldap.userfilter`

LDAP filter expression to find user entries. The filter has to contain the `%s` exactly once. That occurrence will be substituted with the user name before the filter is applied.

Default: `(uid=%s)`

`gplazma.ldap.home-dir`

the user's home directory. LDAP attribute identifiers surrounded by `%` will be expanded to their corresponding value. You may also use a literal value or mix literal values and attributes.

Default: `%homeDirectory%`

`gplazma.ldap.root-dir`

the user's root directory. LDAP attribute identifiers surrounded by `%` will be expanded to their corresponding value. You may also use a literal value or mix literal values and attributes.

Default: `/`

As a session plugin the ldap plug-in assigns two directories to the user's session: the root directory and the home directory. The root directory is the root of the directory hierarchy visible to the user, while the home directory is the directory the user starts his session in. In default mode, the root directory is set to `/` and the home directory is set to `%homeDirectory%`, thus the user starts his session in the home directory, as it is stored on the LDAP server, and is able to go up in the directory hierarchy to `/`. For a different use-case, for example if dCache is used as a cloud storage, it may be desirable for the users to see only their own

storage space. For this use case `home-dir` can be set to `/` and `root-dir` be set to `%homeDirectory%`. In both path properties any `%val%` expression will be expanded to the the value of the attribute with the name `val` as it is stored in the user record on the LDAP server.

identity Plug-ins

nsswitch

The `nsswitch` plug-in provides forward and reverse mapping for NFSv4.1 using your system's `nsswitch` service.

nis

The `nis` plug-in forward and reverse mapping for NFSv4.1 using your site's NIS service.

Properties

`gplazma.nis.server`

NIS server host

Default: `nisserv.domain.com`

`gplazma.nis.domain`

NIS domain

Default: `domain.com`

Using X.509 Certificates

Most plug-ins of `gPlazma` support X.509 certificates for authentication and authorisation. X.509 certificates are used to identify entities (e.g., persons, hosts) in the Internet. The certificates contain a DN (Distinguished Name) that uniquely describes the entity. To give the certificate credibility it is issued by a CA (Certificate Authority) which checks the identity upon request of the certificate (e.g., by checking the persons id). For the use of X.509 certificates with dCache your users will have to request a certificate from a CA you trust and you need host certificates for every host of your dCache instance.

CA Certificates

To be able to locally verify the validity of the certificates, you need to store the CA certificates on your system. Most operating systems come with a number of commercial CA certificates, but for the *Grid* you will need the certificates of the Grid CAs. For this, CERN packages a number of CA certificates. These are deployed by most grid sites. By deploying these certificates, you state that you trust the CA's procedure for the identification of individuals and you agree to act promptly if there are any security issues.

To install the CERN CA certificates follow the following steps:

```
[root] # cd /etc/yum.repos.d/
[root] # wget http://grid-deployment.web.cern.ch/grid-deployment/glite/repos/3.2/lcg-CA.repo
[root] # yum install lcg-CA
```


This will create the directory `/etc/grid-security/certificates` which contains the Grid CA certificates.

Certificates which have been revoked are collected in certificate revocation lists (CRLs). To get the CRLs install the **fetch-crl** command as described below.

```
[root] # yum install fetch-crl
[root] # /usr/sbin/fetch-crl
```

fetch-crl adds X.509 CRLs to `/etc/grid-security/certificates`. It is recommended to set up a cron job to periodically update the CRLs.

User Certificate

If you do not have a valid grid user certificate yet, you have to request one from your CA. Follow the instructions from your CA on how to get a certificate. After your request was accepted you will get a URL pointing to your new certificate. Install it into your browser to be able to access grid resources with it. Once you have the certificate in your browser, make a backup and name it `userCertificate.p12`. Copy the user certificate to the directory `~/ .globus/` on your worker node and convert it to `usercert.pem` and `userkey.pem` as described below.

```
[user] $ openssl pkcs12 -clcerts -nokeys -in <userCertificate>.p12 -out usercert.pem
Enter Import Password:
MAC verified OK
```

During the backup your browser asked you for a password to encrypt the certificate. Enter this password here when asked for a password. This will create your user certificate.

```
[user] $ openssl pkcs12 -nocerts -in <userCertificate>.p12 -out userkey.pem
Enter Import Password:
MAC verified OK
Enter PEM pass phrase:
```

In this step you need to again enter the backup password. When asked for the PEM pass phrase choose a secure password. If you want to use your key without having to type in the pass phrase every time, you can remove it by executing the following command.

```
[root] # openssl rsa -in userkey.pem -out userkey.pem
Enter pass phrase for userkey.pem:
writing RSA key
```

Now change the file permissions to make the key only readable by you and the certificate world readable and only writable by you.

```
[root] # chmod 400 userkey.pem
[root] # chmod 644 usercert.pem
```

Host Certificate

To request a host certificate for your server host, follow again the instructions of your CA.

The conversion to `hostcert.pem` and `hostkey.pem` works analogous to the user certificate. For the `hostkey` you have to remove the pass phrase. How to do this is also explained in the previous section. Finally copy the `host*.pem` files to `/etc/grid-security/` as root and change the file permissions in favour of the user running the grid application.

VOMS Proxy Certificate

For very large groups of people, it is often more convenient to authorise people based on their membership of some group. To identify that they are a member of some group, the certificate owner can create a new short-lived X.509 certificate that includes their membership of various groups. This short-lived certificate is called a proxy-certificate and, if the membership information comes from a VOMS server, it is often referred to as a VOMS-proxy.

```
[root] # cd /etc/yum.repos.d/
[root] # wget http://grid-deployment.web.cern.ch/grid-deployment/glite/repos/3.2/glite-UI.repo
[root] # yum install glite-security-voms-clients
```

Creating a VOMS proxy

To create a VOMS proxy for your user certificate you need to execute the **voms-proxy-init** as a user.

Example:

```
[user] $ export PATH=/opt/glite/bin/:$PATH
[user] $ voms-proxy-init
Enter GRID pass phrase:
Your identity: /C=DE/O=GermanGrid/OU=DESY/CN=John Doe

Creating proxy .....Done
Your proxy is valid until Mon Mar  7 22:06:15 2011
```

Certifying your membership of a VO

You can certify your membership of a VO by using the command **voms-proxy-init -voms <yourVO>**. This is useful as in dCache authorization can be done by VO (see the section called “Authorizing a VO”). To be able to use the extension **-voms <yourVO>** you need to be able to access VOMS servers. To this end you need the the VOMS server’s and the CA’s DN. Create a file `/etc/grid-security/vomsdir/<VO>/<hostname>.lsc` per VOMS server containing on the 1st line the VOMS server’s DN and on the 2nd line, the corresponding CA’s DN. The name of this file should be the fully qualified hostname followed by an `.lsc` extension and the file must appear in a subdirectory `/etc/grid-security/vomsdir/<VO>` for each VO that is supported by that VOMS server and by the site.

At <http://operations-portal.egi.eu/vo> you can search for a VO and find this information.

Example:

For example, the file `/etc/grid-security/vomsdir/desy/grid-voms.desy.de.lsc` contains:

```
/C=DE/O=GermanGrid/OU=DESY/CN=host/grid-voms.desy.de
/C=DE/O=GermanGrid/CN=GridKa-CA
```

where the first entry is the DN of the DESY VOMS server and the second entry is the DN of the CA which signed the DESY VOMS server’s certificate.

In addition, you need to have a file `/opt/glite/etc/vomses` containing your VO’s VOMS server.

Example:

For DESY the file `/opt/glite/etc/vomses` should contain the entry

```
"desy" "grid-voms.desy.de" "15104" "/C=DE/O=GermanGrid/OU=DESY/CN=host/grid-voms.desy.de" "desy"
"24"
```

The first entry “desy” is the real name or a nickname of your VO. “grid-voms.desy.de” is the hostname of the VOMS server. The number “15104” is the port number the server is listening on. The fourth entry is the DN of the server’s VOMS certificate. The fifth entry, “desy”, is the VO name and the last entry is the globus version number which is not used anymore and can be omitted.

Example:

Use the command **voms-proxy-init -voms** to create a VOMS proxy with VO “desy”.

```
[user] $ voms-proxy-init -voms desy
Enter GRID pass phrase:
Your identity: /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
Creating temporary proxy ..... Done
Contacting grid-voms.desy.de:15104 [/C=DE/O=GermanGrid/OU=DESY/CN=host/grid-voms.desy.de] "desy"
Done
Creating proxy ..... Done
Your proxy is valid until Mon Mar 7 23:52:13 2011
```

View the information about your VOMS proxy with **voms-proxy-info**

```
[user] $ voms-proxy-info
subject : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe/CN=proxy
issuer  : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
identity : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
type    : proxy
strength : 1024 bits
path    : /tmp/x509up_u500
timeleft : 11:28:02
```

The last line tells you how much longer your proxy will be valid.

If your proxy is expired you will get

```
[user] $ voms-proxy-info
subject : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe/CN=proxy
issuer  : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
identity : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
type    : proxy
strength : 1024 bits
path    : /tmp/x509up_u500
timeleft : 0:00:00
```

The command **voms-proxy-info -all** gives you information about the proxy and about the VO.

```
[user] $ voms-proxy-info -all
subject : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe/CN=proxy
issuer  : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
identity : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
type    : proxy
strength : 1024 bits
path    : /tmp/x509up_u500
timeleft : 11:24:57
=== VO desy extension information ===
VO      : desy
subject : /C=DE/O=GermanGrid/OU=DESY/CN=John Doe
issuer  : /C=DE/O=GermanGrid/OU=DESY/CN=host/grid-voms.desy.de
attribute : /desy/Role=NULL/Capability=NULL
attribute : /desy/test/Role=NULL/Capability=NULL
```

```
timeleft : 11:24:57
uri      : grid-voms.desy.de:15104
```

Use the command **voms-proxy-destroy** to destroy your VOMS proxy.

```
[user] $ voms-proxy-destroy
[user] $ voms-proxy-info

Couldn't find a valid proxy.
```

Configuration files

In this section we explain the format of the `storage-authzdb`, `kpwd` and `vorolemap` files. They are used by the `authzdb` plug-in, `vorolemap` plug-in, and `kpwd` plug-in.

storage-authzdb

In gPlazma, except for the `kpwd` plug-in, authorization is a two-step process. First, a username is obtained from a mapping of the user's DN or his DN and role, then a mapping of username to UID and GID with optional additional session parameters like the root path is performed. For the second mapping usually the file called `storage-authzdb` is used.

Preparing storage-authzdb

The default location of the `storage-authzdb` is `/etc/grid-security`. Before the mapping entries there has to be a line specifying the version of the used file format.

Example:

```
version 2.1
```

dCache supports versions 2.1 and to some extent 2.2.

Except for empty lines and comments (lines start with #) the configuration lines have the following format:

```
authorize <username> (read-only|read-write) <UID> <GID>[,<GID>]* <homedir> <rootdir>
```

For legacy reasons there may be a third path entry which is ignored by dCache. The username here has to be the name the user has been mapped to in the first step (e.g., by his DN).

Example:

```
authorize john read-write 1001 100 / /data/experiments /
```

In this example user `<john>` will be mapped to UID 1001 and GID 100 with read access on the directory `/data/experiments`. You may choose to set the user's root directory to `/`.

Example:

```
authorize adm read-write 1000 100 / / /
```

In this case the user `<adm>` will be granted read/write access in any path, given that the file system permissions in Chimera also allow the transfer.

The first path is nearly always left as “/”, but it may be used as a home directory in interactive session, as a subdirectory of the root path. Upon login, the second path is used as the user’s root, and a “cd” is performed to the first path. The first path is always defined as being relative to the second path.

Multiple GIDs can be assigned by using comma-separated values for the GID file, as in

Example:

```
authorize john read-write 1001 100,101,200 / / /
```

The lines of the `storage-authzdb` file are similar to the “login” lines of the `dcache.kpwd` file. If you already have a `dcache.kpwd` file, you can easily create `storage-authzdb` by taking the lines from your `dcache.kpwd` file that start with the word `login`, for example,

Example:

```
login john read-write 1001 100 / /data/experiments /
```

and replace the word `login` with `authorize`. The following line does this for you.

```
[root] # sed "s/^ *login/authorize/" dcache.kpwd | grep "^authorize" > storage-authzdb
```

The gplazmalite-vorole-mapping plug-in

The second is the `storage-authzdb` used in other plug-ins. See the above documentation on `storage-authzdb` for how to create the file.

Preparing `grid-vorolemap`

The file is similar in format to the `grid-mapfile`, however there is an additional field following the DN (Certificate Subject), containing the FQAN (Fully Qualified Attribute Name).

```
"/C=DE/O=GermanGrid/OU=DESY/CN=John Doe" "/some-vo" doegroup
"/C=DE/DC=GermanGrid/O=DESY/CN=John Doe" "/some-vo/Role=NULL" doegroup
"/C=DE/DC=GermanGrid/O=DESY/CN=John Doe" "/some-vo/Role=NULL/Capability=NULL" doegroup
```

Therefore each line has three fields: the user’s DN, the user’s FQAN, and the username that the DN and FQAN combination are to be mapped to.

The FQAN is sometimes semantically referred to as the “role”. The same user can be mapped to different usernames depending on what their FQAN is. The FQAN is determined by how the user creates their proxy, for example, using `voms-proxy-init`. The FQAN contains the user’s Group, Role (optional), and Capability (optional). The latter two may be set to the string “NULL”, in which case they will be ignored by the plug-in. Therefore the three lines in the example above are equivalent.

Example:

If a user is authorized in multiple roles, for example

```
"/DC=org/DC=doegrids/OU=People/CN=John Doe" "/some-vo/sub-grp" vo_sub_grp_user
"/DC=org/DC=doegrids/OU=People/CN=John Doe" "/some-vo/sub-grp/Role=user" vouser
"/DC=org/DC=doegrids/OU=People/CN=John Doe" "/some-vo/sub-grp/Role=admin" voadmin
"/DC=org/DC=doegrids/OU=People/CN=John Doe" "/some-vo/sub-grp/Role=prod" voprod
```

he will get the username corresponding to the FQAN found in the proxy that the user creates for use by the client software. If the user actually creates several roles in his proxy, authorization (and subsequent check of path and file system permissions) will be attempted for each role in the order that they are found in the proxy.

In a GridFTP URL, the user may also explicitly request a username.

```
gsiftp://doeprod@ftp-door.example.org:2811/testfile1
```

in which case other roles will be disregarded.

Authorizing a VO

Instead of individual DNs, it is allowed to use * or "*" as the first field, such as

Example:

```
"*" "/desy/Role=production/" desyprod
```

In that case, any DN with the corresponding role will match. It should be noted that a match is first attempted with the explicit DN. Therefore if both DN and "*" matches can be made, the DN match will take precedence. This is true for the revocation matches as well (see below).

Thus a user with subject /C=DE/O=GermanGrid/OU=DESY/CN=John Doe and role /desy/Role=production will be mapped to username desyprod via the above storage-authzdb line with "*" for the DN, except if there is also a line such as

```
"/C=DE/O=GermanGrid/OU=DESY/CN=John Doe" "/desy/Role=production" desyprod2
```

in which case the username will be desyprod2.

Revocation Entries

To create a revocation entry, add a line with a dash (-) as the username, such as

```
"/C=DE/O=GermanGrid/OU=DESY/CN=John Doe" "/desy/production" -
```

or modify the username of the entry if it already exists. The behaviour is undefined if there are two entries which differ only by username.

Since DN is matched first, if a user would be authorized by his VO membership through a "*" entry, but is matched according to his DN to a revocation entry, authorization would be denied. Likewise if a whole VO were denied in a revocation entry, but some user in that VO could be mapped to a username through his DN, then authorization would be granted.

More Examples

Example:

Suppose that there are users in production roles that are expected to write into the storage system data which will be read by other users. In that case, to protect the data the non-production users would be given read-only access. Here in `/etc/grid-security/grid-vorolemap` the production role maps to username `cmsprod`, and the role which reads the data maps to `cmsuser`.

```
"*" "/cms/uscms/Role=cmsprod" cmsprod "*" "/cms/uscms/Role=cmsuser" cmsuser
```

The read-write privilege is controlled by the third field in the lines of `/etc/grid-security/storage-authzdb`

```
authorize cmsprod read-write 9811 5063 / /data /
authorize cmsuser read-only 10001 6800 / /data /
```

Example:

Another use case is when users are to have their own directories within the storage system. This can be arranged within the `gPlazma` configuration files by mapping each user's DN to a unique username and then mapping each username to a unique root path. As an example, lines from `/etc/grid-security/grid-vorolemap` would therefore be written

```
"/DC=org/DC=doe grids/OU=People/CN=Selby Booth" "/cms" cms821
"/DC=org/DC=doe grids/OU=People/CN=Kenja Kassi" "/cms" cms822
"/DC=org/DC=doe grids/OU=People/CN=Ameil Fauss" "/cms" cms823
```

and the corresponding lines from `/etc/grid-security/storage-authzdb` would be

```
authorize cms821 read-write 10821 7000 / /data/cms821 /
authorize cms822 read-write 10822 7000 / /data/cms822 /
authorize cms823 read-write 10823 7000 / /data/cms823 /
```

The kpwd plug-in

The section in the `gPlazma` policy file for the `kpwd` plug-in specifies the location of the `dcache.kpwd` file, for example

Example:

```
# dcache.kpwd
kpwdPath="/etc/dcache/dcache.kpwd"
```

To maintain only one such file, make sure that this is the same location as defined in `/usr/share/dcache/defaults/dcache.properties`.

Use `/usr/share/dcache/examples/gplazma/dcache.kpwd` to create this file.

To be able to alter entries in the `dcache.kpwd` file conveniently the `dcache` script offers support for doing this.

Example:

```
[user] $dcache kpwd dcuseradd testuser -u 12345 -g 1000 -h / -r / -f / -w read-write -p password
```

adds this to the `kpwd` file:

```
passwd testuser ae39aec3 read-write 12345 1000 / /
```

There are many more commands for altering the `kpwd`-file, see the `dcache-script` help for further commands available.

The `gridmap` plug-in

Two file locations are defined in the policy file for this plug-in:

```
# grid-mapfile
gridMapFilePath="/etc/grid-security/grid-mapfile"
storageAuthzPath="/etc/grid-security/storage-authzdb"
```

Preparing the `grid-mapfile`

The `grid-mapfile` is the same as that used in other applications. It can be created in various ways, either by connecting directly to VOMS or GUMS servers, or by hand.

Each line contains two fields: a DN (Certificate Subject) in quotes, and the username it is to be mapped to.

Example:

```
"/C=DE/O=GermanGrid/OU=DESY/CN=John Doe" johndoe
```

When using the `gridmap` plug-in, the `storage-authzdb` file must also be configured. See the section called “`storage-authzdb`” for details.

gPlazma specific dCache configuration

dCache has many parameters that can be used to configure the systems behaviour. You can find all these parameters well documented and together with their default values in the properties files in `/usr/share/dcache/defaults/`. To use non-default values, you have to set the new values in `/etc/dcache/dcache.conf` or in the layout file. Do not change the defaults in the properties files! After changing a parameter you have to restart the concerned cells.

Refer to the file `gplazma.properties` for a full list of properties for gPlazma. One commonly used property is `gplazma.cell.limits.threads`, which is used to set the maximum number of concurrent requests to gPlazma. The default value is 30.

Setting the value for `gplazma.cell.limits.threads` too high may result in large spikes of CPU activity and the potential to run out of memory. Setting the number too low results in potentially slow login activity.

Enabling Username/Password Access for WebDAV

This section describes how to activate the Username/Password access for WebDAV. It uses `dcache.kwpd` file as an example format for storing Username/Password information. First make sure gPlazma2 is enabled in the `/etc/dcache/dcache.conf` or in the layout file.

Example:

Check your WebDAV settings: enable the HTTP access, disallow the anonymous access, disable requesting and requiring the client authentication and activate basic authentication.

```
webdav.authn.protocol=http
webdav.authz.anonymous-operations=NONE
webdav.authn.accept-client-cert=false
webdav.authn.require-client-cert=false
webdav.authn.basic=true
```

Adjust the `/etc/dcache/gplazma.conf` to use the `kpwd` plug-in (for more information see also the section called “Plug-ins”).

It will look something like this:

```
auth optional kpwd
map requisite kpwd
session requisite kpwd
```

The `/etc/dcache/dcache.kpwd` file is the place where you can specify the username/password record. It should contain the username and the password hash, as well as UID, GID, access mode and the home, root and fsroot directories:

```
# set passwd
passwd tanja 6a4cd089 read-write 500 100 / / /
```

The `passwd`-record could be automatically generated by the dCache `kpwd`-utility, for example:

```
[root] # dcache kpwd dcuseradd -u 500 -g 100 -h / -r / -f / -w read-write -p dickerelch tanja
```

Some file access examples:

```
curl -u tanja:dickerelch http://webdav-door.example.org:2880/pnfs/
```

```
wget --user=tanja --password=dickerelch http://webdav-door.example.org:2880/pnfs/
```

gPlazma config example to work with authenticated webadmin

This section describes how to configure `gplazma` to enable the `webadmin` servlet in authenticated mode with a grid certificate as well as with a username/password and how to give a user administrator access.

Example:

In this example for the `/etc/dcache/gplazma.conf` file the `X.509` plug-in plugin is used for the authentication step with the grid certificate and the `kpwd` plug-in plugin is used for the authentication step with username/password.

```
auth optional x509
auth optional kpwd
map requisite kpwd
session requisite kpwd
```

The following example will show how to set up the `/etc/dcache/dcache.kpwd` file:

```
version 2.1

mapping "/C=DE/O=ExampleOrganisation/OU=EXAMPLE/CN=John Doe" john
# the following are the user auth records
login john read-write 1700 1000 / / /
/C=DE/O=ExampleOrganisation/OU=EXAMPLE/CN=John Doe

# set pwd
passwd john 8402480 read-write 1700 1000 / / /
```

This maps the DN of a grid certificate `subject=/C=DE/O=ExampleOrganisation/OU=EXAMPLE/CN=John Doe` to the user `john` and the entry

```
login john read-write 1700 1000 / / /
/C=DE/O=GermanGrid/OU=DESY/CN=John Doe
```

applies unix-like values to `john`, most important is the `1000`, because it is the assigned GID. This must match the value of the `httpd.authz.admin-gid` configured in your webadmin. This is sufficient for login using a certificate. The entry:

```
passwd john 8402480 read-write 1700 1000 / / /
```

enables username/password login, such as a valid login would be user `john` with some password. The password is encrypted with the `kpwd`-algorithm (also see the section called “The `kpwd` plug-in”) and then stored in the file. Again the `1000` here is the assigned GID.

Chapter 11. dCache as xRootd-Server

This chapter explains how to configure dCache in order to access it via the xrootd protocol, allowing xrootd-Clients like ROOT's TXNetfile and xrscp to do file operations against a dCache instance in a transparent manner. dCache implements version 2.1.6 of xrootd protocol.

Setting up

To allow file transfers in and out of dCache using xrootd, a new xrootd door must be started. This door acts then as the entry point to all xrootd requests. Compared to the native xrootd server-implementation (produced by SLAC), the xrootd door corresponds to the `redirector` node.

To enable the xrootd door, you have to change the layout file corresponding to your dCache-instance. Enable the xrootd-service within the domain that you want to run it by adding the following line

```
..
[<domainName>/xrootd]
..
```

Example:

You can just add the following lines to the layout file:

```
..
[xrootd-${host.name}Domain]
[xrootd-${host.name}Domain/xrootd]
..
```

After a restart of the domain running the xrootd door, done e.g. by executing

```
[root] # ${dCacheHome}/bin/dcache restart xrootd-babelfishDomain
Stopping xrootd-babelfishDomain (pid=30246) 0 1 2 3 4 5 6 7 done
Starting xrootd-babelfishDomain done
```

the xrootd door should be running. A few minutes later it should appear at the web monitoring interface under "Cell Services" (see the section called "The Web Interface for Monitoring dCache").

Parameters

The default port the xrootd door is listening on is 1094. This can be changed two ways:

1. *Per door:* Edit your instance's layout file, for example `/etc/dcache/layouts/example.conf` and add the desired port for the xrootd door in a separate line (a restart of the domain(s) running the xrootd door is required):

```
..
[xrootd-${host.name}Domain]
[xrootd-${host.name}Domain/xrootd]
    port = 1095
..
```

2. *Globally:* Edit `/etc/dcache/dcache.conf` and add the variable `xrootd.net.port` with the desired value (a restart of the domain(s) running the xrootd door is required):

```
..
xrootd.net.port=1095
..
```

For controlling the TCP-portrange within which xrootd-movers will start listening in the `<pool>` Domain, you can add the properties `dcache.net.lan.port.min` and `dcache.net.lan.port.max` to `/etc/dcache/dcache.conf` and adapt them according to your preferences. The default values can be viewed in `/usr/share/dcache/defaults/dcache.properties`.

```
..
dcache.net.lan.port.min=30100
dcache.net.lan.port.max=30200
..
```

Quick tests

The subsequent paragraphs describe a quick guide on how to test xrootd using the xrdcp and ROOT clients.

Copying files with xrdcp

A simple way to get files in and out of dCache via xrootd is the command xrdcp. It is included in every xrootd and ROOT distribution.

To transfer a single file in and out of dCache, just issue

```
[user] $ xrdcp /bin/sh root://<xrootd-door.example.org>/pnfs/<example.org>/data/xrd_test
[user] $ xrdcp root://<xrootd-door.example.org>/pnfs/<example.org>/data/xrd_test /dev/null
```

Accessing files from within ROOT

This simple ROOT example shows how to write a randomly filled histogram to a file in dCache:

```
root [0] TH1F h("testhisto", "test", 100, -4, 4);
root [1] h->FillRandom("gaus", 10000);
root [2] TFile *f = new TXNetFile("root://<door_hostname>/pnfs/<example.org>/data/test.root", "new");
061024 12:03:52 001 Xrd: Create: (C) 2004 SLAC INFN XrdClient 0.3
root [3] h->Write();
root [4] f->Write();
root [5] f->Close();
root [6] 061101 15:57:42 14991 Xrd: XrdClientSock::RecvRaw: Error reading from socket: Success
061101 15:57:42 14991 Xrd: XrdClientMessage::ReadRaw: Error reading header (8 bytes)
```

Closing remote xrootd files that live in dCache produces this warning, but has absolutely no effect on subsequent ROOT commands. It happens because dCache closes all TCP connections after finishing a file transfer, while xrootd expects to keep them open for later reuse.

To read it back into ROOT from dCache:

```
root [7] TFile *reopen = TXNetFile ("root://<door_hostname>/pnfs/<example.org>/data/
test.root", "read");
root [8] reopen->ls();
TXNetFile**          //pnfs/<example.org>/data/test.root
TXNetFile*           //pnfs/<example.org>/data/test.root
```

```
KEY: THlF      testhisto;l      test
```

xrootd security

Read-Write access

Per default dCache xrootd is restricted to read-only, because plain xrootd is completely unauthenticated. A typical error message on the clientside if the server is read-only looks like:

```
[user] $ xrdcp -d 1 /bin/sh root://ford.desy.de//pnfs/desy.de/data/xrd_test2
Setting debug level 1
061024 18:43:05 001 Xrd: main: (C) 2004 SLAC INFN xrdcp 0.2 beta
061024 18:43:05 001 Xrd: Create: (C) 2004 SLAC INFN XrdClient kXR_ver002+kXR_asynccap
061024 18:43:05 001 Xrd: ShowUrls: The converted URLs count is 1
061024 18:43:05 001 Xrd: ShowUrls: URL n.1: root://ford.desy.de:1094//pnfs/desy.de/data/asdfas.
061024 18:43:05 001 Xrd: Open: Access to server granted.
061024 18:43:05 001 Xrd: Open: Opening the remote file /pnfs/desy.de/data/asdfas
061024 18:43:05 001 Xrd: XrdClient::TryOpen: doitparallel=1
061024 18:43:05 001 Xrd: Open: File open in progress.
061024 18:43:06 5819 Xrd: SendGenCommand: Server declared: Permission denied. Access is read only.
(error code: 3003)
061024 18:43:06 001 Xrd: Close: File not opened.
Error accessing path/file for root://ford//pnfs/desy.de/data/asdfas
```

To enable read-write access, add the following line to `/${dCacheHome}/etc/dcache.conf`

```
..
xrootdIsReadOnly=false
..
```

and restart any domain(s) running a xrootd door.

Please note that due to the unauthenticated nature of this access mode, files can be written and read to/from any subdirectory in the pnfs namespace (including the automatic creation of parent directories). If there is no user information at the time of request, new files/subdirectories generated through xrootd will inherit UID/GID from its parent directory. The user used for this can be configured via the `xrootd.authz.user` property.

Permitting read/write access on selected directories

To overcome the security issue of uncontrolled xrootd read and write access mentioned in the previous section, it is possible to restrict read and write access on a per-directory basis (including subdirectories).

To activate this feature, a colon-separated list containing the full paths of authorized directories must be added to `/etc/dcache/dcache.conf`. You will need to specify the read and write permissions separately.

```
..
xrootd.authz.read-paths=/pnfs/<example.org>/rpath1:/pnfs/<example.org>/rpath2
xrootd.authz.write-paths=/pnfs/<example.org>/wpath1:/pnfs/<example.org>/wpath2
..
```

A restart of the xrootd door is required to make the changes take effect. As soon as any of the above properties are set, all read or write requests to directories not matching the allowed path lists will be refused. Symlinks are however not restricted to these prefixes.

Token-based authorization

The xrootd dCache implementation includes a generic mechanism to plug in different authorization handlers. The only plugin available so far implements token-based authorization as suggested in <http://people.web.psi.ch/feichtinger/doc/authz.pdf>.

The first thing to do is to setup the keystore. The keystore file basically specifies all RSA-keypairs used within the authorization process and has exactly the same syntax as in the native xrootd tokenauthorization implementation. In this file, each line beginning with the keyword `KEY` corresponds to a certain Virtual Organisation (VO) and specifies the remote public (owned by the file catalogue) and the local private key belonging to that VO. A line containing the statement `"KEY VO: *"` defines a default keypair that is used as a fallback solution if no VO is specified in token-enhanced xrootd requests. Lines not starting with the `KEY` keyword are ignored. A template can be found in `/usr/share/dcache/examples/xrootd/keystore`.

The keys itself have to be converted into a certain format in order to be loaded into the authorization plugin. dCache expects both keys to be binary DER-encoded (Distinguished Encoding Rules for ASN.1). Furthermore the private key must be PKCS #8-compliant and the public key must follow the X.509-standard.

The following example demonstrates how to create and convert a keypair using OpenSSL:

```

Generate new RSA private key
[root] # openssl genrsa -rand 12938467 -out key.pem 1024

Create certificate request
[root] # openssl req -new -inform PEM -key key.pem -outform PEM -out certreq.pem

Create certificate by self-signing certificate request
[root] # openssl x509 -days 3650 -signkey key.pem -in certreq.pem -req -out cert.pem

Extract public key from certificate
[root] # openssl x509 -pubkey -in cert.pem -out pkey.pem
[root] # openssl pkcs8 -in key.pem -topk8 -nocrypt -outform DER -out <new_private_key>
[root] # openssl enc -base64 -d -in pkey.pem -out <new_public_key>

```

Only the last two lines are performing the actual conversion, therefore you can skip the previous lines in case you already have a keypair. Make sure that your keystore file correctly points to the converted keys.

To enable the plugin, it is necessary to add the following two lines to the file `/etc/dcache/dcache.conf`, so that it looks like

```

..
xrootdAuthzPlugin=org.dcache.xrootd.security.plugins.tokenauthz.TokenAuthorizationFactory
xrootdAuthzKeystore=<Path_to_your_Keystore>
..

```

After doing a restart of dCache, any requests without an appropriate token should result in an error saying "authorization check failed: No authorization token found in open request, access denied.(error code: 3010)".

If both tokenbased authorization and read-only access are activated, the read-only restriction will dominate (local settings have precedence over remote file catalogue permissions).

Strong authentication

The `xrootd`-implementation in dCache includes a pluggable authentication framework. To control which authentication mechanism is used by `xrootd`, add the `xrootdAuthNPlugin` option to your dCache configuration and set it to the desired value.

Example:

For instance, to enable GSI authentication in `xrootd`, add the following line to `/etc/dcache/dcache.conf`:

```
..
xrootdAuthNPlugin=gsi
..
```

When using GSI authentication, depending on your setup, you may or may not want dCache to fail if the host certificate chain can not be verified against trusted certificate authorities. Whether dCache performs this check can be controlled by setting the option `dcache.authn.hostcert.verify`:

```
..
dcache.authn.hostcert.verify=true
..
```

Authorization of the user information obtained by strong authentication is performed by contacting the `gPlazma` service. Please refer to Chapter 10, *Authorization in dCache* for instructions about how to configure `gPlazma`.

Security consideration

In general GSI on `xrootd` is not secure. It does not provide confidentiality and integrity guarantees and hence does not protect against man-in-the-middle attacks.

Precedence of security mechanisms

The previously explained methods to restrict access via `xrootd` can also be used together. The precedence applied in that case is as following:

Note

The `xrootd-door` can be configured to use either token authorization or strong authentication with `gPlazma` authorization. A combination of both is currently not possible.

The permission check executed by the authorization plugin (if one is installed) is given the lowest priority, because it can be controlled by a remote party. E.g. in the case of token based authorization, access control is determined by the file catalogue (global namespace).

The same argument holds for many strong authentication mechanisms - for example, both the GSI protocol as well as the Kerberos protocols require trust in remote authorities. However, this only affects user *authentication*, while authorization decisions can be adjusted by local site administrators by adapting the `gPlazma` configuration.

To allow local site's administrators to override remote security settings, write access can be further restricted to few directories (based on the local namespace, the `pnfs`). Setting `xrootd` access to read-only has the highest priority, overriding all other settings.

Other configuration options

The `xrootd-door` has several other configuration properties. You can configure various timeout parameters, the thread pool sizes on pools, queue buffer sizes on pools, the `xrootd` root path, the `xrootd` user and the `xrootd` IO queue. Full descriptions on the effect of those can be found in `/usr/share/dcache/defaults/xrootd.properties`.

Chapter 12. dCache as NFSv4.1 Server

This chapter explains how to configure dCache in order to access it via the NFSv4.1 protocol, allowing clients to mount dCache and perform POSIX IO using standard NFSv4.1 clients.

Important

The pNFS mentioned in this chapter is the protocol NFSv4.1/pNFS and not the namespace pnfs.

Setting up

To allow file transfers in and out of dCache using NFSv4.1/pNFS, a new NFSv4.1 `door` must be started. This door acts then as the mount point for NFS clients.

To enable the NFSv4.1 `door`, you have to change the layout file corresponding to your dCache-instance. Enable the `nfs` within the domain that you want to run it by adding the following line

```
..
[<domainName>/nfs]
nfs.version = 4.1
..
```

Example:

You can just add the following lines to the layout file:

```
..
[nfs-${host.name}Domain]
[nfs-${host.name}Domain/nfs]
nfs.version = 4.1
..
```

In addition to run an NFSv4.1 `door` you need to add exports to the `/etc/exports` file. The format of `/etc/exports` is similar to the one which is provided by Linux:

```
#
<path> [host [(options)]]
```

Where `<options>` is a comma separated combination of:

`ro`

matching clients can access this export only in read-only mode

`rw`

matching clients can access this export only in read-write mode

`sec=krb5`

matching clients must access NFS using RPCSEC_GSS authentication. The Quality of Protection (QOP) is *NONE*, e.g., the data is neither encrypted nor signed when sent over the network. Nevertheless the RPC packets header still protected by checksum.

`sec=krb5i`

matching clients have to access NFS using RPCSEC_GSS authentication. The Quality of Protection (QOP) is *INTEGRITY*. The RPC requests and response are protected by checksum.

sec=krb5p

matching clients have to access NFS using RPCSEC_GSS authentication. The Quality of Protection (QOP) is *PRIVACY*. The RPC requests and response are protected by encryption.

For example:

Example:

```
#
/pnfs/dcache.org/data *.dcache.org (rw,sec=krb5i)
```

Notice, that security flavour used at mount time will be used for client - pool communication as well.

Configuring NFSv4.1 door with GSS-API support

Adding `sec=krb5` into `/etc/exports` is not sufficient to get kerberos authentication to work.

All clients, pool nodes and node running NFSv4.1 door must have a valid kerberos configuration. Each clients, pool node and node running NFSv4.1 door must have a `/etc/krb5.keytab` with `nfs` service principal:

```
nfs/host.domain@<YOUR.REALM>
```

The `/etc/dcache/dcache.conf` on pool nodes and node running NFSv4.1 door must enable kerberos and RPCSEC_GSS:

```
nfs.rpcsec_gss=true
dcache.authn.kerberos.realm=<YOUR.REALM>
dcache.authn.jaas.config=/etc/dcache/gss.conf
dcache.authn.kerberos.key-distribution-center-list=your.kdc.server
```

The `/etc/dcache/gss.conf` on pool nodes and node running NFSv4.1 door must configure Java's security module:

```
com.sun.security.jgss.accept {
com.sun.security.auth.module.Krb5LoginModule required
doNotPrompt=true
useKeyTab=true
keyTab="/etc/${}/krb5.keytab"
debug=false
storeKey=true
principal="nfs/host.domain@<YOUR.REALM>";
};
```

Now your NFS client can securely access dCache.

Configuring principal-id mapping for NFS access

The NFSv4.1 uses utf8 based strings to represent user and group names. This is the case even for non-kerberos based accesses. Nevertheless UNIX based clients as well as dCache internally use numbers to

represent uid and gids. A special service, called `idmapd`, takes care for principal-id mapping. On the client nodes the file `/etc/idmapd.conf` is usually responsible for consistent mapping on the client side. On the server side, in case of dCache mapping done through `gplazma2`. The `identity` type of plug-in required by id-mapping service. Please refer to Chapter 10, *Authorization in dCache* for instructions about how to configure `gPlazma`.

Note, that `nfs4 domain` on clients must match `nfs.domain` value in `dcache.conf`.

To avoid big latencies and avoiding multiple queries for the same information, like ownership of a files in a big directory, the results from `gPlazma` are cached within `NFSv4.1 door`. The default values for cache size and life time are good enough for typical installation. Nevertheless they can be overridden in `dcache.conf` or `layoutfile`:

```
..
# maximal number of entries in the cache
nfs.idmap.cache.size = 512

# cache entry maximal lifetime
nfs.idmap.cache.timeout = 30

# time unit used for timeout. Valid values are:
# SECONDS, MINUTES, HOURS and DAYS
nfs.idmap.cache.timeout.unit = SECONDS
..
```

Chapter 13. dCache Storage Resource Manager

Introduction

Storage Resource Managers (SRMs) are middleware components whose function is to provide dynamic space allocation and file management on shared storage components on the Grid. SRMs support protocol negotiation and a reliable replication mechanism. The SRM specification [<https://sdm.lbl.gov/srm-wg/doc/SRM.v2.2.html>] standardizes the interface, thus allowing for a uniform access to heterogeneous storage elements.

The SRM utilizes the Grid Security Infrastructure (GSI) for authentication. The SRM is a Web Service implementing a published WSDL document. Please visit the SRM Working Group Page [<http://sdm.lbl.gov/srm-wg/>] to see the SRM Version 1.1 and SRM Version 2.2 protocol specification documents.

The SRM protocol uses HTTP over GSI as a transport. The dCache SRM implementation added HTTPS as a transport layer option. The main benefits of using HTTPS rather than HTTP over GSI is that HTTPS is a standard protocol and has support for sessions, improving latency in case a client needs to connect to the same server multiple times. The current implementation does not offer a delegation service. Hence `srmCopy` will not work with SRM over HTTPS. A separate delegation service will be added in a later release.

Configuring the srm service

The Basic Setup

Like other services, the `srm` service can be enabled in the layout file `/etc/dcache/layouts/<mylayout>` of your dCache installation. For an overview of the layout file format, please see the section called “Defining domains and services”.

Example:

To enable SRM in a separate `<srm- $\{$ host.name $\}$ Domain>` in dCache, add the following lines to your layout file:

```
[<srm- $\{$ host.name $\}$ Domain]  
[<srm- $\{$ host.name $\}$ Domain>/srm]
```

The use of the `srm` service requires an authentication setup, see Chapter 10, *Authorization in dCache* for a general description or the section called “Authentication and Authorization in dCache” for an example setup with X.509 certificates.

You can now copy a file into your dCache using the SRM,

Note

Please make sure to use latest `srmcp` client otherwise you will need to specify `-2` in order to use the right version.

```
[user] $ srmcp file:///bin/sh srm://<dcache.example.org>:<8443>/data/world-writable/srm-test-file
```

copy it back

```
[user] $ srmcp srm://<dcache.example.org>:<8443>/data/world-writable/srm-test-file file:///tmp/srmtestfile.tmp
```

and delete it

```
[user] $ srmrm srm://<dcache.example.org>:<8443>/data/world-writable/srm-test-file
```

Important srm configuration options

The defaults for the following configuration parameters can be found in the `.properties` files in the directory `/usr/share/dcache/defaults`.

If you want to modify parameters, copy them to `/etc/dcache/dcache.conf` or to your layout file `/etc/dcache/layouts/<mylayout>` and update their value.

Example:

Change the value for `srm.db.host` in the layout file.

```
[<srm-${host.name}Domain>]
[<srm-${host.name}Domain>/srm]
srm.db.host=hostname
```

The property `srm.request.copy.threads` controls number of copy requests in the running state. Copy requests are 3-rd party srm transfers and therefore the property `transfermanagers.limits.external-transfers` is best to be set to the same value as shown below.

```
srm.request.copy.threads=250
transfermanagers.limits.external-transfers=${srm.request.copy.threads}
```

The common value should be the roughly equal to the maximum number of the SRM - to -SRM copies your system can sustain.

Example:

So if you think about 3 gridftp transfers per pool and you have 30 pools then the number should be $3 \times 30 = 90$.

```
srm.request.copy.threads=90
transfermanagers.limits.external-transfers=90
```

Example:

US-CMS T1 has:

```
srm.request.copy.threads=2000
transfermanagers.limits.external-transfers=2000
```

Note

SRM might produce a lot of log entries, especially if it runs in debug mode. It is recommended to make sure that logs are redirected into a file on a large disk.

Utilization of Space Reservations for Data Storage

SRM version 2.2 introduced a concept of space reservation. Space reservation guarantees that the requested amount of storage space of a specified type is made available by the storage system for a specified amount of time.

Users can create space reservations using an appropriate SRM client, although it is more common for the dCache administrator to make space reservations for VOs (see the section called “SpaceManager configuration”). Each space reservation has an associated ID (or space token). VOs then can copy directly into space tokens assigned to them by the dCache administrator.

When a file is about to be transferred to a storage system, the space available in the space reservation is checked if it can accommodate the entire file. If yes, this chunk of space is marked as allocated, so that it can not be taken by another, concurrently transferred file. If the file is transferred successfully the allocated space becomes used space within the space reservation, else the allocated space is released back to the space reservation as free space.

SRM space reservation can be assigned a non-unique description which can be used to query the system for space reservations with a given description.

dCache only manages write space, i.e. space on disk can be reserved only for write operations. Once files are migrated to tape, and if no copy is required on disk, space used by these files is returned back into space reservation. When files are read back from tape and cached on disk, they are not counted as part of any space.

Properties of Space Reservation

A space reservation has a *retention policy* and an *access latency*.

Retention policy describes the quality of the storage service that will be provided for the data (files) stored in the space reservation and access latency describes the availability of this data. The SRM specification requires that if a space reservation is given on upload, then the specified retention policy and access latency must match those of the space reservation.

The default values for the retention policy and access latency can be changed in the file `/etc/dcache/dcache.conf`.

Retention policy

The values of retention policy supported by dCache are `REPLICA` and `CUSTODIAL`.

- `REPLICA` corresponds to the lowest quality of the service, usually associated with storing a single copy of each file on the disk.
- `CUSTODIAL` is the highest quality service, usually interpreted as storage of the data on tape.

Once a file is written into a given space reservation, it inherits the reservation's retention policy.

If the space reservation request does not specify a retention policy, we will assign a value given by `spacemanager.default-retention-policy`. The default value is `CUSTODIAL`.

Edit the file `/etc/dcache/dcache.conf` to change the default value.

Example:

Change the default value to `REPLICA`.

```
spacemanager.default-retention-policy=REPLICA
```

Note

`spacemanager.default-retention-policy` merely specifies to value to use while allocating space reservations when no value was given by the client or dCache admin. It is not to be confused with `pnfsmanager.default-retention-policy` which specifies the default retention policy of files uploaded outside of any space reservation.

Access latency

The two values allowed for access latency are `NEARLINE` and `ONLINE`.

- `NEARLINE` means that data stored in this reservation is allowed to migrate to permanent media. Retrieving these data may result in delays associated with preparatory steps that the storage system has to perform to make these data available for the user I/O (e.g., staging data from tape to a disk cache).
- `ONLINE` means that data is readily available allowing for faster access.

In case of dCache `ONLINE` means that there will always be a copy of the file on disk, while `NEARLINE` does not provide such guarantee. As with retention policy, once a file is written into a given space reservation, it inherits the reservation's access latency.

If a space reservation request does not specify an access latency, we will assign a value given by `spacemanager.default-access-latency`. The default value is `NEARLINE`.

Edit the file `/etc/dcache/dcache.conf` to change the default value.

Example:

Change the default value to `ONLINE`.

```
spacemanager.default-access-latency=ONLINE
```

Note

`spacemanager.default-access-latency` merely specifies to value to use while allocating space reservations when no value was given by the client or dCache admin. It is not to be confused with `pnfsmanager.default-access-latency` which specifies the default retention policy of files uploaded outside of any space reservation.

Important

Please make sure to use capital letters for REPLICATA, CUSTODIAL, ONLINE and NEARLINE otherwise you will receive an error message.

dCache specific concepts

Activating SRM SpaceManager

In order to enable the SRM SpaceManager you need to add the `spacemanager` service to your layout file

```
[<dCacheDomain>]  
[<dCacheDomain>/spacemanager]
```

and add the following definition in the file `/etc/dcache/dcache.conf`

```
dcache.enable.space-reservation=true
```

Unless you have reason not to, we recommend placing the `spacemanager` service in the same domain as the `poolmanager` service.

Explicit and Implicit Space Reservations for Data Storage in dCache

Explicit Space Reservations

Each SRM space reservation is made against the total available disk space of a particular link group. If dCache is configured correctly each byte of disk space, that can be reserved, belongs to one and only one link group. See the section called “SpaceManager configuration” for a detailed description.

Important

Make sure that no pool belongs to more than one pool group, no pool group belongs to more than one link and no link belongs to more than one link group.

If a space reservation is specified during upload, the file will be stored in it.

Files written into a space made within a particular link group will end up on one of the pools belonging to this link group. The difference between the link group’s free space and the sum of all its space reservation’s unused space is the available space of the link group. The available space of a link group is the space that can be allocated for new space reservations.

The total space in dCache that can be reserved is the sum of the available spaces of all link groups. Note however that a space reservation can never span more than a single link group.

Implicit Space Reservations

dCache can perform implicit space reservations for non-SRM transfers, SRM Version 1 transfers and for SRM Version 2.2 data transfers that are not given the space token explicitly. The parameter that enables this

behavior is `srm.enable.space-reservation.implicit`, which is described in the section called “SRM configuration for experts”. If no implicit space reservation can be made, the transfer will fail.

Implicit space reservation means that the `srm` will create a space reservation for a single upload while negotiating the transfer parameters with the client. The space reservation will be created in a link group for which the user is authorized to create space reservations, which has enough available space, and which is able to hold the type of file being uploaded. The space reservation will be short lived. Once it expires, it will be released and the file it held will live on outside any space reservation, but still within the link group to which it was uploaded. Implicit space reservations are thus a technical means to upload files to link groups without using explicit space reservations.

The reason dCache cannot just allow the file to be uploaded to the link group without any space reservation at all is, that we have to guarantee, that space already allocated for other reservations isn't used by the file being uploaded. The best way to guarantee that there is enough space for the file is to make a space reservation to which to upload it.

In case of SRM version 1.1 data transfers, where the access latency and retention policy cannot be specified, and in case of SRM V2.2 clients, when the access latency and retention policy are not specified, default values will be used. First SRM will attempt to use the values of access latency and retention policy tags from the directory to which a file is being written. If the tags are not present, then the access latency and retention policy will be set on basis of `pnfsmanager` defaults controlled by `pnfsmanager.default-retention-policy` and `pnfsmanager.default-access-latency` variables in `/etc/dcache/dcache.conf`.

You can check if the `AccessLatency` and `RetentionPolicy` tags are present by using the following command:

```
[root] # /usr/bin/chimera lstag /path/to/directory
Total: numberOfTags
tag1
tag2
..
AccessLatency
RetentionPolicy
```

If the output contains the lines `AccessLatency` and `RetentionPolicy` then the tags are already present and you can get the actual values of these tags by executing the following commands, which are shown together with example outputs:

Example:

```
[root] # /usr/bin/chimera readtag /data/experiment-a AccessLatency
ONLINE
[root] # /usr/bin/chimera readtag /data/experiment-a RetentionPolicy
CUSTODIAL
```

The valid `AccessLatency` values are `ONLINE` and `NEARLINE`, valid `RetentionPolicy` values are `REPLICA` and `CUSTODIAL`.

To create/change the values of the tags, please execute :

```
[root] # /usr/bin/chimera writetag /path/to/directory AccessLatency "<New AccessLatency>"
[root] # /usr/bin/chimera writetag /path/to/directory RetentionPolicy "<New RetentionPolicy>"
```

Note

Some clients also have default values, which are used when not explicitly specified by the user. In this case server side defaults will have no effect.

Note

If the implicit space reservation is not enabled, pools in link groups will be excluded from consideration and only the remaining pools will be considered for storing the incoming data, and classical pool selection mechanism will be used.

SpaceManager configuration

SRM SpaceManager and Link Groups

SpaceManager is making reservations against free space available in link groups. The total free space in the given link group is the sum of available spaces in all links. The available space in each link is the sum of all sizes of available space in all pools assigned to a given link. Therefore for the space reservation to work correctly it is essential that each pool belongs to one and only one link, and each link belongs to only one link group. Link groups are assigned several parameters that determine what kind of space the link group corresponds to and who can make reservations against this space.

Making a Space Reservation

Now that the SRM SpaceManager is activated you can make a space reservation. As mentioned above you need link groups to make a space reservation.

Prerequisites for Space Reservations

Login to the admin interface and **cd** to the cell `SrmSpaceManager`.

```
[user] $ ssh -p 22224 -l admin admin.example.org
(local) admin > cd SrmSpaceManager
```

Type **ls link groups** to get information about link groups.

```
(SrmSpaceManager) admin > ls link groups
```

The lack of output tells you that there are no link groups. As there are no link groups, no space can be reserved.

The Link Groups

For a general introduction about link groups see the section called “Link Groups”.

Example:

In this example we will create a link group for the VO `desy`. In order to do so we need to have a pool, a pool group and a link. Moreover, we define unit groups named `any-store`, `world-net` and `any-protocol`. (See the section called “Types of Units”.)

Define a pool in your layout file, add it to your pool directory and restart the poolDomain.

```
[poolDomain]
[poolDomain/pool]
path=/srv/dcache/spacemanager-pool
name=spacemanager-pool
```

```
[root] # mkdir -p /srv/dcache/spacemanager-pool
[root] # /usr/bin/dcache restart
```

In the admin interface, **cd** to the PoolManager and create a pool group, a link and a link group.

```
(SrmSpaceManager) admin > ..
(local) admin > cd PoolManager
(PoolManager) admin > psu create pgroup spacemanager_poolGroup
(PoolManager) admin > psu addto pgroup spacemanager_poolGroup spacemanager-pool
(PoolManager) admin > psu removefrom pgroup default spacemanager-pool
(PoolManager) admin > psu create link spacemanager_WriteLink any-store world-net any-protocol
(PoolManager) admin > psu set link spacemanager_WriteLink -readpref=10 -writepref=10 -cachepref=0
-p2ppref=-1
(PoolManager) admin > psu add link spacemanager_WriteLink spacemanager_poolGroup
(PoolManager) admin > psu create linkGroup spacemanager_WriteLinkGroup
(PoolManager) admin > psu set linkGroup custodialAllowed spacemanager_WriteLinkGroup true
(PoolManager) admin > psu set linkGroup replicaAllowed spacemanager_WriteLinkGroup true
(PoolManager) admin > psu set linkGroup nearlineAllowed spacemanager_WriteLinkGroup true
(PoolManager) admin > psu set linkGroup onlineAllowed spacemanager_WriteLinkGroup true
(PoolManager) admin > psu addto linkGroup spacemanager_WriteLinkGroup spacemanager_WriteLink
(PoolManager) admin > save
(PoolManager) admin > ..
```

Check whether the link group is available. Note that this can take several minutes to propagate to spacemanager.

```
(local) admin > cd SrmSpaceManager
(SrmSpaceManager) admin > ls link groups
FLAGS CNT RESVD AVAIL FREE UPDATED NAME
--rc:no 0 0 + 7278624768 = 7278624768 2011-11-28 12:12:51 spacemanager_WriteLinkGroup
```

The link group `spacemanager_WriteLinkGroup` was created. Here the flags indicate first the status (- indicates that neither the expired [e] nor the released flags [r] are set), followed by the type of reservations allowed in the link group (here replica [r], custodial [c], nearline [n] and online [o] files; output [o] files are not allowed - see **help ls link groups** for details on the format). No space reservations have been created, as indicated by the count field. Since no space reservation has been created, no space in the link group is reserved.

The SpaceManagerLinkGroupAuthorizationFile

Now you need to edit the `LinkGroupAuthorization.conf` file. This file contains a list of the link groups and all the VOs and the VO Roles that are permitted to make reservations in a given link group.

Specify the location of the `LinkGroupAuthorization.conf` file in the `/etc/dcache/dcache.conf` file.

```
spacemanager.authz.link-group-file-name=/path/to/LinkGroupAuthorization.conf
```

The file `LinkGroupAuthorization.conf` has following syntax:

`LinkGroup <NameOfLinkGroup>` followed by the list of the Fully Qualified Attribute Names (FQANs). Each FQAN is on a separate line, followed by an empty line, which is used as a record separator, or by the end of the file.

FQAN is usually a string of the form `<VO>/Role=<VORole>`. Both `<VO>` and `<VORole>` can be set to `*`, in this case all VOs or VO Roles will be allowed to make reservations in this link group. Any line that starts with `#` is a comment and may appear anywhere.

Rather than an FQAN, a mapped user name can be used. This allows clients or protocols that do not provide VOMS attributes to make use of space reservations.

```
#SpaceManagerLinkGroupAuthorizationFile
LinkGroup <NameOfLinkGroup>
/<VO>/Role=<VORole>
```

Note

You do not need to restart the `srm` or `dCache` after changing the `LinkGroupAuthorization.conf` file. The changes will be applied automatically after a few minutes.

Use **update link groups** to be sure that the `LinkGroupAuthorization.conf` file and the link groups have been updated.

```
(SrmSpaceManager) admin > update link groups
Update started.
```

Example:

In the example above you created the link group `spacemanager_WriteLinkGroup`. Now you want to allow members of the VO `desy` with the role `production` to make a space reservation in this link group.

```
#SpaceManagerLinkGroupAuthorizationFile
# this is comment and is ignored

LinkGroup spacemanager_WriteLinkGroup
#
/desy/Role=production
```

Example:

In this more general example for a `SpaceManagerLinkGroupAuthorizationFile` members of the VO `desy` with role `test` are authorized to make a space reservation in a link group called `desy-test-LinkGroup`. Moreover, all members of the VO `desy` are authorized to make a reservation in the link group called `desy-anyone-LinkGroup` and anyone is authorized to make a space reservation in the link group called `default-LinkGroup`.

```
#SpaceManagerLinkGroupAuthorizationFile
# this is a comment and is ignored

LinkGroup desy-test-LinkGroup
/desy/Role=test

LinkGroup desy-anyone-LinkGroup
/desy/Role=*

LinkGroup default-LinkGroup
# allow anyone :-)
*/Role=*
```

Making and Releasing a Space Reservation as dCache Administrator

Making a Space Reservation

Example:

Now you can make a space reservation for the VO `desy`.

```
(SrmSpaceManager) admin > reserve space -owner=/desy/Role=production -desc=DESY_TEST -
lifetime=10000 -lg=spacemanager_WriteLinkGroup 5MB
110000 voGroup:/desy voRole:production retentionPolicy:CUSTODIAL accessLatency:NEARLINE
linkGroupId:0 size:5000000 created:Fri Dec 09 12:43:48 CET 2011 lifetime:10000000ms
expiration:Fri Dec 09 15:30:28 CET 2011 description:DESY_TEST state:RESERVED used:0 allocated:0
```

The space token of the reservation is 110000.

Check the status of the reservation by

```
(SrmSpaceManager) admin > ls spaces -e -h
TOKEN RETENTION LATENCY FILES ALLO USED FREE SIZE EXPIRES DESCRIPTION
110000 CUSTODIAL NEARLINE 0 0B + 0B + 5.0M = 5.0M 2011-12-09 12:43:48 DESY_TEST

(SrmSpaceManager) admin > ls link groups -h
FLAGS CNT RESVD AVAIL FREE UPDATED NAME
--rc:no 1 5.0M + 7.3G = 7.3G 2011-11-28 12:12:51 spacemanager_WriteLinkGroup
```

Here the `-h` option indicates that approximate, but human readable, byte sizes are to be used, and `-e` indicates that ephemeral (time limited) reservations should be displayed too (by default time limited reservations are not displayed as they are often implicit reservations). As can be seen, 5 MB are now reserved in the link group, although with approximate byte sizes, 5 MB do not make a visible difference in the 7.3 GB total size.

You can now copy a file into that space token.

```
[user] $ srmcp file:///bin/sh srm://<dcache.example.org>:8443/data/world-writable/space-token-
test-file -space_token=110000
```

Now you can check via the Webadmin Interface or the Web Interface that the file has been copied to the pool `spacemanager-pool`.

There are several parameters to be specified for a space reservation.

```
(SrmSpaceManager) admin > reserve space [-al=online|nearline] [-desc=<string>] -lg=<name>
[-lifetime=<seconds>] [-owner=<user>|<fqan>] [-rp=output|replica|custodial] <size>
```

`[-owner=<user>|<fqan>]`

The owner of the space is identified by either mapped user name or FQAN. The owner must be authorized to reserve space in the link group in which the space is to be created. Besides the dCache admin, only the owner can release the space. Anybody can however write into the space (although the link group may only allow certain storage groups and thus restrict which file system paths can be written to space reservation, which in turn limits who can upload files to it).

`[-al=<AccessLatency>]`

AccessLatency needs to match one of the access latencies allowed for the link group.

`[-rp=<RetentionPolicy>]`

RetentionPolicy needs to match one of the retention policies allowed for the link group.

`[-desc=<Description>]`

You can chose a value to describe your space reservation.

`-lg=<LinkGroupName>`

Which link group to create the reservation in.

`<size>`

The size of the space reservation should be specified in bytes, optionally using a byte unit suffix using either SI or IEEE prefixes.

`[-lifetime=<lifetime>]`

The life time of the space reservation should be specified in seconds. If no life time is specified, the space reservation will not expire automatically.

Releasing a Space Reservation

If a space reservation is not needed anymore it can be released with

```
(SrmSpaceManager) admin > release space <spaceTokenId>
```

Example:

```
(SrmSpaceManager) admin > reserve space -owner=/desy -desc=DESY_TEST -lifetime=600 5000000
110042 voGroup:/desy voRole:production retentionPolicy:CUSTODIAL accessLatency:NEARLINE
linkGroupId:0 size:5000000 created:Thu Dec 15 12:00:35 CET 2011 lifetime:600000ms expiration:Thu
Dec 15 12:10:35 CET 2011 description:DESY_TEST state:RESERVED used:0 allocated:0
(SrmSpaceManager) admin > release space 110042
110042 voGroup:/desy voRole:production retentionPolicy:CUSTODIAL accessLatency:NEARLINE
linkGroupId:0 size:5000000 created:Thu Dec 15 12:00:35 CET 2011 lifetime:600000ms expiration:Thu
Dec 15 12:10:35 CET 2011 description:DESY_TEST state:RELEASED used:0 allocated:0
```

You can see that the value for `state` has changed from `RESERVED` to `RELEASED`.

Making and Releasing a Space Reservation as a User

If so authorized, a user can make a space reservation through the SRM protocol. A user is authorized to do so using the `LinkGroupAuthorization.conf` file.

VO based Authorization Prerequisites

In order to be able to take advantage of the virtual organization (VO) infrastructure and VO based authorization and VO based access control to the space in dCache, certain things need to be in place:

- User needs to be registered with the VO.
- User needs to use **voms-proxy-init** to create a VO proxy.
- dCache needs to use `gPlasma` with modules that extract VO attributes from the user's proxy. (See Chapter 10, *Authorization in dCache*, have a look at `voms` plugin and see the section called "Authentication and Authorization in dCache" for an example with `voms`.)

Only if these 3 conditions are satisfied the VO based authorization of the SpaceManager will work.

VO based Access Control Configuration

As mentioned above dCache space reservation functionality access control is currently performed at the level of the link groups. Access to making reservations in each link group is controlled by the `SpaceManagerLinkGroupAuthorizationFile`.

This file contains a list of the link groups and all the VOs and the VO Roles that are permitted to make reservations in a given link group.

When a SRM Space Reservation request is executed, its parameters, such as reservation size, lifetime, access latency and retention policy as well as user's VO membership information is forwarded to the SRM `SpaceManager`.

Once a space reservation is created, no access control is performed, any user can store the files in this space reservation, provided he or she knows the exact space token.

Making and Releasing a Space Reservation

A user who is given the rights in the `SpaceManagerLinkGroupAuthorizationFile` can make a space reservation by

```
[user] $ srm-reserve-space -retention_policy=<RetentionPolicy> -lifetime=<lifetimeInSecs> -
desired_size=<sizeInBytes> -guaranteed_size=<sizeInBytes> srm://<example.org>:8443
Space token =SpaceTokenId
```

and release it by

```
[user] $ srm-release-space srm://<example.org>:8443 -space_token=SpaceTokenId
```

Note

Please note that it is obligatory to specify the retention policy while it is optional to specify the access latency.

Example:

```
[user] $ srm-reserve-space -retention_policy=REPLICA -lifetime=300 -desired_size=5500000 -
guaranteed_size=5500000 srm://srm.example.org:8443
Space token =110044
```

The space reservation can be released by:

```
[user] $ srm-release-space srm://srm.example.org:8443 -space_token=110044
```

Space Reservation without VOMS certificate

If a client uses a regular grid proxy, created with `grid-proxy-init`, and not a VO proxy, which is created with the `voms-proxy-init`, when it is communicating with SRM server in dCache, then the VO attributes can not be extracted from its credential. In this case the name of the user is extracted from the Distinguished Name (DN) to use name mapping. For the purposes of the space reservation the name of the user as mapped by `gplazma` is used as its VO Group name, and the VO Role is left empty. The entry in the `SpaceManagerLinkGroupAuthorizationFile` should be:

```
#LinkGroupAuthorizationFile
```

```
#
<userName>
```

Space Reservation for non SRM Transfers

Edit the file `/etc/dcache/dcache.conf` to enable space reservation for non SRM transfers.

```
spacemanager.enable.reserve-space-for-non-srm-transfers=true
```

If the `spacemanager` is enabled, `spacemanager.enable.reserve-space-for-non-srm-transfers` is set to `true`, and if the transfer request comes from a door, and there was no prior space reservation made for this file, the `SpaceManager` will try to reserve space before satisfying the request.

Possible values are `true` or `false` and the default value is `false`.

This is analogous to implicit space reservations performed by the `srn`, except that these reservations are created by the `spacemanager` itself. Since an SRM client uses a non-SRM protocol for the actual upload, setting the above option to `true` while disabling implicit space reservations in the `srn`, will still allow files to be uploaded to a link group even when no space token is provided. Such a configuration should however be avoided: If the `srn` does not create the reservation itself, it has no way of communicating access latency, retention policy, file size, nor lifetime to `spacemanager`.

SRM configuration for experts

There are a few parameters in `/usr/share/dcache/defaults/*.properties` that you might find useful for nontrivial SRM deployment.

dcache.enable.space-reservation

`dcache.enable.space-reservation` tells if the space management is activated in SRM.

Possible values are `true` and `false`. Default is `true`.

Usage example:

```
dcache.enable.space-reservation=true
```

srn.enable.space-reservation.implicit

`srn.enable.space-reservation.implicit` tells if the space should be reserved for SRM Version 1 transfers and for SRM Version 2 transfers that have no space token specified.

Possible values are `true` and `false`. This is enabled by default. It has no effect if `dcache.enable.space-reservation` is set to `true`.

Usage example:

```
srn.enable.space-reservation.implicit=true
```

dcache.enable.overwrite

`dcache.enable.overwrite` tells SRM and GridFTP servers if the overwrite is allowed. If enabled on the SRM node, should be enabled on all GridFTP nodes.

Possible values are `true` and `false`. Default is `false`.

Usage example:

```
dcache.enable.overwrite=true
```

srms.enable.overwrite-by-default

`srms.enable.overwrite-by-default` Set this to `true` if you want `overwrite` to be enabled for SRM v1.1 interface as well as for SRM v2.2 interface when client does not specify desired `overwrite` mode. This option will be considered only if `dcache.enable.overwrite` is set to `true`.

Possible values are `true` and `false`. Default is `false`.

Usage example:

```
srms.enable.overwrite-by-default=false
```

srms.db.host

`srms.db.host` tells SRM which database host to connect to.

Default value is `localhost`.

Usage example:

```
srms.db.host=database-host.example.org
```

spaceManagerDatabaseHost

`spaceManagerDatabaseHost` tells SpaceManager which database host to connect to.

Default value is `localhost`.

Usage example:

```
spaceManagerDatabaseHost=database-host.example.org
```

pinmanager.db.host

`pinmanager.db.host` tells PinManager which database host to connect to.

Default value is `localhost`.

Usage example:

```
pinmanager.db.host=database-host.example.org
```

srms.db.name

`srms.db.name` tells SRM which database to connect to.

Default value is `srms`.

Usage example:

```
srm.db.name=srm
```

srm.db.user

`srm.db.user` tells SRM which database user name to use when connecting to database. Do not change unless you know what you are doing.

Default value is `dcache`.

Usage example:

```
srm.db.user=dcache
```

srm.db.password

`srm.db.password` tells SRM which database password to use when connecting to database. The default value is an empty value (no password).

Usage example:

```
srm.db.password=NotVerySecret
```

srm.db.password.file

`srm.db.password.file` tells SRM which database password file to use when connecting to database. Do not change unless you know what you are doing. It is recommended that MD5 authentication method is used. To learn about file format please see <http://www.postgresql.org/docs/8.1/static/libpq-pgpass.html>. To learn more about authentication methods please visit <http://www.postgresql.org/docs/8.1/static/encryption-options.html>, Please read "Encrypting Passwords Across A Network" section.

This option is not set by default.

Usage example:

```
srm.db.password.file=/root/.pgpass
```

srm.request.enable.history-database

`srm.request.enable.history-database` enables logging of the transition history of the SRM request in the database. The request transitions can be examined through the command line interface. Activation of this option might lead to the increase of the database activity, so if the PostgreSQL load generated by SRM is excessive, disable it.

Possible values are `true` and `false`. Default is `false`.

Usage example:

```
srm.request.enable.history-database=true
```

transfermanagers.enable.log-to-database

`transfermanagers.enable.log-to-database` tells SRM to store the information about the remote (copy, `srmCopy`) transfer details in the database. Activation of this option might lead to the increase of the database activity, so if the PostgreSQL load generated by SRM is excessive, disable it.

Possible values are `true` and `false`. Default is `false`.

Usage example:

```
transfermanagers.enable.log-to-database=false
```

srnVersion

`srnVersion` is not used by SRM; it was mentioned that this value is used by some publishing scripts.

Default is `version1`.

srn.root

`srn.root` tells SRM what the root of all SRM paths is in pnfs. SRM will prepend path to all the local SURL paths passed to it by SRM client. So if the `srn.root` is set to `/pnfs/fnal.gov/THISISTHEPNFSSRMPATH` and someone requests the read of `srn://srn.example.org:8443/file1`, SRM will translate the SURL path `/file1` into `/pnfs/fnal.gov/THISISTHEPNFSSRMPATH/file1`. Setting this variable to something different from `/` is equivalent of performing Unix **chroot** for all SRM operations.

Default value is `/`.

Usage example:

```
srn.root="/pnfs/fnal.gov/data/experiment"
```

srn.limits.parallel-streams

`srn.limits.parallel-streams` specifies the number of the parallel streams that SRM will use when performing third party transfers between this system and remote GSI-FTP servers, in response to SRM v1.1 copy or SRM V2.2 `srnCopy` function. This will have no effect on `srnPrepareToPut` and `srnPrepareToGet` command results and parameters of GridFTP transfers driven by the SRM clients.

Default value is 10.

Usage example:

```
srn.limits.parallel-streams=20
```

srn.limits.transfer-buffer.size

`srn.limits.transfer-buffer.size` specifies the number of bytes to use for the in memory buffers for performing third party transfers between this system and remote GSI-FTP servers, in response to SRM v1.1 copy or SRM V2.2 `srnCopy` function. This will have no effect on `srnPrepareToPut` and `srnPrepareToGet` command results and parameters of GridFTP transfers driven by the SRM clients.

Default value is 1048576.

Usage example:

```
srn.limits.transfer-buffer.size=1048576
```

srm.limits.transfer-tcp-buffer.size

`srm.limits.transfer-tcp-buffer.size` specifies the number of bytes to use for the tcp buffers for performing third party transfers between this system and remote GSI-FTP servers, in response to SRM v1.1 copy or SRM V2.2 `srmCopy` function. This will have no effect on `srmPrepareToPut` and `srmPrepareToGet` command results and parameters of GridFTP transfers driven by the SRM clients.

Default value is 1048576.

Usage example:

```
srm.limits.transfer-tcp-buffer.size=1048576
```

srm.service.gplazma.cache.timeout

`srm.service.gplazma.cache.timeout` specifies the duration that authorizations will be cached. Caching decreases the volume of messages to the `gPlazma` cell or other authorization mechanism. To turn off caching, set the value to 0.

Default value is 120.

Usage example:

```
srm.service.gplazma.cache.timeout=60
```

srm.limits.request.bring-online.lifetime, srm.limits.request.put.lifetime and srm.limits.request.copy.lifetime

`srm.limits.request.bring-online.lifetime`, `srm.limits.request.put.lifetime` and `srm.limits.request.copy.lifetime` specify the lifetimes of the `srmPrepareToGet` (`srmBringOnline`) `srmPrepareToPut` and `srmCopy` requests lifetimes in millisecond. If the system is unable to fulfill the requests before the request lifetimes expire, the requests are automatically garbage collected.

Default value is 14400000 (4 hours)

Usage example:

```
srm.limits.request.bring-online.lifetime=14400000  
srm.limits.request.put.lifetime=14400000  
srm.limits.request.copy.lifetime=14400000
```

srm.limits.request.scheduler.ready.max, srm.limits.request.put.scheduler.ready.max, srm.limits.request.scheduler.ready-queue.size and srm.limits.request.put.scheduler.ready-queue.size

`srm.limits.request.scheduler.ready.max` and `srm.limits.request.put.scheduler.ready.max` specify the maximum number of the

files for which the transfer URLs will be computed and given to the users in response to SRM get (`srmPrepareToGet`) and put (`srmPrepareToPut`) requests. The rest of the files that are ready to be transferred are put on the Ready queues, the maximum length of these queues are controlled by `srm.limits.request.scheduler.ready-queue.size` and `srm.limits.request.put.scheduler.ready-queue.size` parameters. These parameters should be set according to the capacity of the system, and are usually greater than the maximum number of the GridFTP transfers that this dCache instance GridFTP doors can sustain.

Usage example:

```
srm.limits.request.scheduler.ready-queue.size=10000
srm.limits.request.scheduler.ready.max=2000
srm.limits.request.put.scheduler.ready-queue.size=10000
srm.limits.request.put.scheduler.ready.max=1000
```

srm.limits.request.copy.scheduler.thread.pool.size and transfermanagers.limits.external-transfers

`srm.limits.request.copy.scheduler.thread.pool.size` and `transfermanagers.limits.external-transfers`.

`srm.limits.request.copy.scheduler.thread.pool.size` is used to specify how many parallel `srmCopy` file copies to execute simultaneously. Once the SRM contacted the remote SRM system, and obtained a Transfer URL (usually GSI-FTP URL), it contacts a Copy Manager module (usually `RemoteGSIFTPTransferManager`), and asks it to perform a GridFTP transfer between the remote GridFTP server and a dCache pool. The maximum number of simultaneous transfers that `RemoteGSIFTPTransferManager` will support is `transfermanagers.limits.external-transfers`, therefore it is important that `transfermanagers.limits.external-transfers` is greater than or equal to `srm.limits.request.copy.scheduler.thread.pool.size`.

Usage example:

```
srm.limits.request.copy.scheduler.thread.pool.size=250
transfermanagers.limits.external-transfers=260
```

srm.enable.custom-get-host-by-address

`srm.enable.custom-get-host-by-address` `srm.enable.custom-get-host-by-address` enables using the BNL developed procedure for host by IP resolution if standard `InetAddress` method failed.

Usage example:

```
srm.enable.custom-get-host-by-address=true
```

srm.enable.recursive-directory-creation

`srm.enable.recursive-directory-creation` allows or disallows automatic creation of directories via SRM. Set this to `true` or `false`.

Automatic directory creation is allowed by default.

Usage example:

```
srm.enable.recursive-directory-creation=true
```

hostCertificateRefreshPeriod

This option allows you to control how often the SRM door will reload the server's host certificate from the filesystem. For the specified period, the host certificate will be kept in memory. This speeds up the rate at which the door can handle requests, but also causes it to be unaware of changes to the host certificate (for instance in the case of renewal).

By changing this parameter you can control how long the host certificate is cached by the door and consequently how fast the door will be able to detect and reload a renewed host certificate.

Please note that the value of this parameter has to be specified in seconds.

Usage example:

```
hostCertificateRefreshPeriod=86400
```

trustAnchorRefreshPeriod

The `trustAnchorRefreshPeriod` option is similar to `hostCertificateRefreshPeriod`. It applies to the set of CA certificates trusted by the SRM door for signing end-entity certificates (along with some metadata, these form so called *trust anchors*). The trust anchors are needed to make a decision about the trustworthiness of a certificate in X.509 client authentication. The GSI security protocol used by SRM builds upon X.509 client authentication.

By changing this parameter you can control how long the set of trust anchors remains cached by the door. Conversely, it also influences how often the door reloads the set of trusted certificates.

Please note that the value of this parameter has to be specified in seconds.

Tip

Trust-anchors usually change more often than the host certificate. Thus, it might be sensible to set the refresh period of the trust anchors lower than the refresh period of the host certificate.

Usage example:

```
trustAnchorRefreshPeriod=3600
```

Configuring the PostgreSQL Database

We highly recommend to make sure that PostgreSQL database files are stored on a separate disk that is not used for anything else (not even PostgreSQL logging). BNL Atlas Tier 1 observed a great improvement in srm-database communication performance after they deployed PostgreSQL on a separate dedicated machine.

SRM or srm monitoring on a separate node

If SRM or srm monitoring is going to be installed on a separate node, you need to add an entry in the file `/var/lib/pgsql/data/pg_hba.conf` for this node as well:

host	all	all	<monitoring node>	trust
host	all	all	<srn node>	trust

The file `postgresql.conf` should contain the following:

```
#to enable network connection on the default port
max_connections = 100
port = 5432
...
shared_buffers = 114688
...
work_mem = 10240
...
#to enable autovacuuming
stats_row_level = on
autovacuum = on
autovacuum_vacuum_threshold = 500 # min # of tuple updates before
# vacuum
autovacuum_analyze_threshold = 250 # min # of tuple updates before
# analyze
autovacuum_vacuum_scale_factor = 0.2 # fraction of rel size before
# vacuum
autovacuum_analyze_scale_factor = 0.1 # fraction of rel size before
#
# setting vacuum_cost_delay might be useful to avoid
# autovacuum penalize general performance
# it is not set in US-CMS T1 at Fermilab
#
# In IN2P3 add_missing_from = on
# In Fermilab it is commented out

# - Free Space Map -
max_fsm_pages = 500000

# - Planner Cost Constants -
effective_cache_size = 16384 # typically 8KB each
```

General SRM Concepts (for developers)

The SRM service

dCache SRM is implemented as a Web Service running in a Jetty servlet container and an Axis Web Services engine. The Jetty server is executed as a cell, embedded in dCache and started automatically by the SRM service. Other cells started automatically by SRM are SpaceManager, PinManager and RemoteGSIFTPTransferManager. Of these services only SRM and SpaceManager require special configuration.

The SRM consists of the five categories of functions:

- Space Management Functions
- Data Transfer Functions
- Request Status Functions
- Directory Functions
- Permission Functions

Space Management Functions

SRM version 2.2 introduces a concept of space reservation. Space reservation guarantees that the requested amount of storage space of a specified type is made available by the storage system for a specified amount of time.

We use three functions for space management:

- `srmReserveSpace`
- `SrmGetSpaceMetadata`
- `srmReleaseSpace`

Space reservation is made using the `srmReserveSpace` function. In case of successful reservation, a unique name, called *space token* is assigned to the reservation. A space token can be used during the transfer operations to tell the system to put the files being manipulated or transferred into an associated space reservation. A storage system ensures that the reserved amount of the disk space is indeed available, thus providing a guarantee that a client does not run out of space until all space promised by the reservation has been used. When files are deleted, the space is returned to the space reservation.

dCache only manages write space, i.e. space on disk can be reserved only for write operations. Once files are migrated to tape, and if no copy is required on disk, space used by these files is returned back into space reservation. When files are read back from tape and cached on disk, they are not counted as part of any space. SRM space reservation can be assigned a non-unique description that can be used to query the system for space reservations with a given description.

Properties of the SRM space reservations can be discovered using the `SrmGetSpaceMetadata` function.

Space Reservations might be released with the function `srmReleaseSpace`.

For a complete description of the available space management functions please see the SRM Version 2.2 Specification [http://sdm.lbl.gov/srm-wg/doc/SRM.v2.2.html#_Toc241633085].

Data Transfer Functions

SURLs and TURLs

SRM defines a protocol named SRM, and introduces a way to address the files stored in the SRM managed storage by site URL (*SURL* of the format `srm://<host>:<port>/[<web service path>?SFN=]<path>`).

Example:

Examples of the SURLs a.k.a. SRM URLs are:

```
srm://fap1110.fnal.gov:8443/srm/managerv2?SFN=//pnfs/fnal.gov/data/test/file1
srm://fap1110.fnal.gov:8443/srm/managerv1?SFN=//pnfs/fnal.gov/data/test/file2
srm://srm.cern.ch:8443/castor/cern.ch/cms/store/cmsfile23
```

A transfer URL (*TURL*) encodes the file transport protocol in the URL.

Example:

```
gsiftp://gridftpdoor.fnal.gov:2811/data/test/file1
```

SRM version 2.2 provides three functions for performing data transfers:

- `srmPrepareToGet`
- `srmPrepareToPut`
- `srmCopy`

(in SRM version 1.1 these functions were called `get`, `put` and `copy`).

All three functions accept lists of SURLS as parameters. All data transfer functions perform file/directory access verification and `srmPrepareToPut` and `srmCopy` check if the receiving storage element has sufficient space to store the files.

`srmPrepareToGet` prepares files for read. These files are specified as a list of source SURLS, which are stored in an SRM managed storage element. `srmPrepareToGet` is used to bring source files online and assigns transfer URLs (TURLs) that are used for actual data transfer.

`srmPrepareToPut` prepares an SRM managed storage element to receive data into the list of destination SURLS. It prepares a list of TURLs where the client can write data into.

Both functions support transfer protocol negotiation. A client supplies a list of transfer protocols and the SRM server computes the TURL using the first protocol from the list that it supports. Function invocation on the Storage Element depends on implementation and may range from simple SURL to TURL translation to stage from tape to disk cache and dynamic selection of transfer host and transfer protocol depending on the protocol availability and current load on each of the transfer server load.

The function `srmCopy` is used to copy files between SRM managed storage elements. If both source and target are local to the SRM, it performs a local copy. There are two modes of remote copies:

- **PULL mode** : The target SRM initiates an `srmCopy` request. Upon the client's `srmCopy` request, the target SRM makes a space at the target storage, executes `srmPrepareToGet` on the source SRM. When the TURL is ready at the source SRM, the target SRM transfers the file from the source TURL into the prepared target storage. After the file transfer completes, `srmReleaseFiles` is issued to the source SRM.
- **PUSH mode** : The source SRM initiates an `srmCopy` request. Upon the client's `srmCopy` request, the source SRM prepares a file to be transferred out to the target SRM, executes `srmPrepareToPut` on the target SRM. When the TURL is ready at the target SRM, the source SRM transfers the file from the prepared source into the prepared target TURL. After the file transfer completes, `srmPutDone` is issued to the target SRM.

When a specified target space token is provided, the files will be located in the space associated with the space token.

SRM Version 2.2 `srmPrepareToPut` and `srmCopy` PULL mode transfers allow the user to specify a space reservation token or a retention policy and access latency. Any of these parameters are optional, and

it is up to the implementation to decide what to do, if these properties are not specified. The specification requires that if a space reservation is given, then the specified access latency or retention policy must match those of the space reservation.

The Data Transfer Functions are asynchronous, an initial SRM call starts a request execution on the server side and returns a request status that contains a unique request token. The status of request is polled periodically by SRM get request status functions. Once a request is completed and the client receives the TURLs the data transfers are initiated. When the transfers are completed the client notifies the SRM server by executing `srmReleaseFiles` in case of `srmPrepareToGet` or `srmPutDone` in case of `srmPrepareToPut`. In case of `srmCopy`, the system knows when the transfers are completed and resources can be released, so it requires no special function at the end.

Clients are free to cancel the requests at any time by execution of `srmAbortFiles` or `srmAbortRequest`.

Request Status Functions

The functions for checking the request status are:

- `srmStatusOfReserveSpaceRequest`
- `srmStatusOfUpdateSpaceRequest`
- `srmStatusOfChangeSpaceForFilesRequest`
- `srmStatusOfChangeSpaceForFilesRequest`
- `srmStatusOfBringOnlineRequest`
- `srmStatusOfPutRequest`
- `srmStatusOfCopyRequest`

Directory Functions

SRM Version 2.2, interface provides a complete set of directory management functions. These are

- `srmLs`, `srmRm`
- `srmMkdir`, `srmRmdir`
- `srmMv`

Permission functions

SRM Version 2.2 supports the following three file permission functions:

- `srmGetPermission`
- `srmCheckPermission` and

- `srmSetPermission`

dCache contains an implementation of these functions that allows setting and checking of Unix file permissions.

Chapter 14. The statistics Service

The `statistics` service collects information on the amount of data stored on all pools and the total data flow including streams from and to tertiary storage systems.

Once per hour an ASCII file is produced, containing a table with information on the amount of used disk space and the data transferred starting midnight up to this point in time. Data is sorted per pool and storage class.

In addition to the hourly statistics, files are produced reporting on the daily, monthly and yearly dCache activities. An HTML tree is produced and updated once per hour allowing to navigate through the collected statistics information.

The Basic Setup

Define the `statistics` service in the domain, where the `httpd` is running.

```
[httpdDomain]
[httpdDomain/httpd]
...
[httpdDomain/statistics]
```

The `statistics` service automatically creates a directory tree, structured according to years, months and days.

Once per hour, a `total.raw` file is produced underneath the active year, month and day directories, containing the sum over all pools and storage classes of the corresponding time interval. The day directory contains detailed statistics per hour and for the whole day.

```
/var/lib/dcache/statistics/YYYY/total.raw
/var/lib/dcache/statistics/YYYY/MM/total.raw
/var/lib/dcache/statistics/YYYY/MM/DD/total.raw
/var/lib/dcache/statistics/YYYY/MM/DD/YYYY-MM-DD-day.raw
/var/lib/dcache/statistics/YYYY/MM/DD/YYYY-MM-DD-HH.raw
```

In the same directory tree the HTML files are created for each day, month and year.

```
/var/lib/dcache/statistics/YYYY/index.html
/var/lib/dcache/statistics/YYYY/MM/index.html
/var/lib/dcache/statistics/YYYY/MM/DD/index.html
```

By default the path for the statistics data is `/var/lib/dcache/statistics`. You can modify this path by setting the property `dcache.paths.statistics` to a different value.

The Statistics Web Page

Point a web browser to your dCache webpage at `http://<head-node.example.org>:2288/`. On the bottom you find the link to `Statistics`.

The statistics data needs to be collected for a day before it will appear on the web page.

Note

You will get an error if you try to read the statistics web page right after you enabled the statistics as the web page has not yet been created.

Create data and the web page by logging in to the admin interface and running the commands **create stat** and **create html**.

```
(local) admin > cd PoolStatistics@<httpdDomain>
(PoolStatistics@)<httpdDomain> admin > create stat
Thread started for internal run
(PoolStatistics@)<httpdDomain> admin > create html
java.lang.NullPointerException
```

Now you can see a statistics web page.

Statistics is calculated once per hour at <HH>:55. The daily stuff is calculated at 23:55. Without manual intervention, it takes two midnights before all HTML statistics pages are available. There is a way to get this done after just one midnight. After the first midnight following the first startup of the statistics module, log into the PoolStatistics cell and run the following commands in the given sequence. The specified date has to be the Year/Month/Day of today.

```
(PoolStatistics@)<httpdDomain> admin > create html <YYYY> <MM> <DD>
done
(PoolStatistics@)<httpdDomain> admin > create html <YYYY> <MM>
done
(PoolStatistics@)<httpdDomain> admin > create html <YYYY>
done
(PoolStatistics@)<httpdDomain> admin > create html
done
```

You will see an empty statistics page at <http://<head-node.example.org>:2288/statistics/>.

On the Statistics Help Page <http://<head-node.example.org>:2288/docs/statisticsHelp.html> you find an explanation for the colors.

Explanation of the File Format of the xxx.raw Files

The file formats of the `/var/lib/dcache/statistics/YYYY/MM/DD/YYYY-MM-DD-HH.raw` and the `/var/lib/dcache/statistics/YYYY/MM/DD/YYYY-MM-DD-day.raw` files are similar. The file `/var/lib/dcache/statistics/YYYY/MM/DD/YYYY-MM-DD-HH.raw` does not contain columns 2 and 3 as these are related to the day and not to the hour.

Example:

The file format of the `/var/lib/dcache/statistics/YYYY/MM/DD/YYYY-MM-DD-day.raw` files:

```
#
# timestamp=1361364900897
# date=Wed Feb 20 13:55:00 CET 2013
#
```

```
pool1 StoreA:GroupB@osm 21307929 10155 2466935 10155 0 925 0 0 0 0 85362 0
```

Format of YYYY-MM-DD-day.raw files.

Column Number	Column Description
0	Pool Name
1	Storage Class
2	Bytes stored on this pool for this storage class at beginning of day — green bar
3	Number of files stored on this pool for this storage class at beginning of day
4	Bytes stored on this pool for this storage class at this hour or end of day — red bar
5	Number of files stored on this pool for this storage class at this hour or end of day
6	Total Number of transfers (in and out, dCache-client)
7	Total Number of restores (HSM to dCache)
8	Total Number of stores (dCache to HSM)
9	Total Number errors
10	Total Number of bytes transferred from client into dCache — blue bar
11	Total Number of bytes transferred from dCache to clients — yellow bar
12	Total Number of bytes tranferred from HSM to dCache — pink bar
13	Total Number of bytes tranferred from dCache to HSM — orange bar

The YYYY/MM/DD/YYYY-MM-DD-HH.raw files do not contain line 2 and 3.

Chapter 15. The billing Service

dCache has built-in monitoring capabilities which provide an overview of the activity and performance of the installation's doors and pools. There are two options for how this data can be represented and stored:

- a set of log files written to a known location
- a database (the billing database).

These options can be enabled simultaneously. If the database option is selected, the data in those tables will also be displayed as a set of histogram plots on the installation's web page.

The billing log files

If you installed dCache following the instructions in the Chapter Installing dCache you enabled the billing in the domain where the httpd service is running (see the extract of the layout file).

```
...
[httpdDomain]
[httpdDomain/billing]
[httpdDomain/httpd]
...
```

Use the property `billing.text.dir` to set the location of the log files and the property `billing.enable.text` to control whether the plain-text log files are generated.

By default the log files are located in the directory `/var/lib/dcache/billing`. Under this directory the log files are organized in a tree data structure based on date (YYYY/MM). A separate file is generated for errors. The log file and the error file are tagged with the date.

Example:

```
log file: /var/lib/dcache/billing/2012/09/billing-2012.09.25
```

```
error file: /var/lib/dcache/billing/2012/09/billing-error-2012.09.25
```

The log files may contain information about the time, the pool, the pnfsID and size of the transferred file, the storage class, the actual number of bytes transferred, the number of milliseconds the transfer took, the protocol, the subject (identity of the user given as a collection of principals), the data transfer listen port, the return status and a possible error message. The logged information depends on the protocol.

A log entry for a write operation has the default format:

```
<MM.dd> <HH:mm:ss> [pool:<pool-name>:transfer]
[<pnfsId>,<filesize>] [<path>]
<StoreName>:<StorageGroup>@<type-of-storage-system>
<transferred-bytes> <connectionTime> <true/false> {<protocol>}
<initiator> {<return-status>:"<error-message>"}
```

Example:

A typical logging entry would look like this for writing. In the log file each entry is in one line. For readability we split it into separate lines in this documentation.:

```
12.10 14:19:42 [pool:pool2@poolDomain-1:transfer]
[0000062774D07847475BA78AC99C60F2C2FC,10475] [Unknown]
<Unknown>:<Unknown>@osm 10475 40 true {GFtp-1.0 131.169.72.103 37850}
[door:WebDAV-example.org@webdavDomain:1355145582248-1355145582485] {0:""}
```

The formatting of the log messages can be customized by redefining the `<billing.format.someInfoMessage>` properties in the layout configuration, where `<billing.format.someInfoMessage>` can be replaced by

- `billing.text.format.mover-info-message`
- `billing.text.format.remove-file-info-message`
- `billing.text.format.door-request-info-message`
- `billing.text.format.storage-info-message`

A full explanation of the formatting is given in the `/usr/share/dcache/defaults/billing.properties` file. For syntax questions please consult StringTemplate v3 documentation [[http://www.antlr.org/wiki/display/ST/StringTemplate+3+Documentation](http://wwwantlr.org/wiki/display/ST/StringTemplate+3+Documentation)] or the cheat sheet [<http://www.antlr.org/wiki/display/ST/StringTemplate+cheat+sheet>].

On the web page generated by the `httpd` service (default port 2288), there is a link to `Action Log`. The table which appears there gives a summary overview extracted from the data contained in the billing log files.

The billing database

In order to enable the database, the following steps must be taken.

1. If the billing database does not already exist (see further below on migrating from an existing one), create it (we assume PostgreSQL here):

```
[root] # createdb -O dcache -U postgres billing
```

If you are using a version of PostgreSQL prior to 8.4, you will also need to do:

```
[root] # createlang -U dcache plpgsql billing
```

No further manual preparation is needed, as the necessary tables, indices, functions and triggers will automatically be generated when you (re)start the domain with the billing database logging turned on (see below).

2. The property `billing.enable.db` controls whether the billing cell sends billing messages to the database. By default the option is disabled. To activate, set the value to `true` and restart the domain in which the `httpd` service is running.

Note

Please take care to define the `billing` service before the `httpd` service in your layout file. If the `billing` service is defined in a separate domain, this domain should be defined before the domain in which the `httpd` service is running.

Example:

Extract from the layout file:

```
[httpdDomain]
    billing.enable.db=true
[httpdDomain/billing]
[httpdDomain/httpd]
...
```

```
[root] # dcache restart httpdDomain
Stopping httpdDomain 0 1 done
Starting httpdDomain done
```

Customizing the database

In most cases, the billing service will be run out-of-the-box; nevertheless, the administrator does have control, if this is desired, over the database configuration.

- Database name, host, user, and password can be easily modified using the properties:
 - `billing.db.name`
 - `billing.db.host`
 - `billing.db.user`
 - `billing.db.password`

The current database values can be checked with the **dcache database ls** command.

Example:

```
# dcache database ls
DOMAIN          CELL          DATABASE HOST      USER      MANAGEABLE AUTO
namespaceDomain PnfsManager  chimera  localhost dcache    Yes       Yes
namespaceDomain cleaner      chimera  localhost dcache    No        No
httpdDomain      billing      billing  localhost dcache    Yes       Yes
```

- Database inserts are batched for performance. Since 2.8, improvements have been made to the way the billing service handles these inserts. As a consequence, the older in-memory caching threshold properties are now obsolete:
 - `billing.db.inserts.max-before-commit` (defaults to 10000)
 - `billing.db.inserts.timeout-before-commit` (defaults to 5)

Inserts can now be tuned by adjusting the queue sizes (there are four of them, each mapped to the four main tables: `billinginfo`, `storageinfo`, `doorinfo`, `hitinfo`), and the maximum database batch size.

- `billing.db.inserts.max-queue-size` (defaults to 100000)
- `billing.db.inserts.max-batch-size` (defaults to 1000)

There is further the option as to whether to drop messages (default is true) or block when the queue maximum is exceeded.

- `billing.db.inserts.drop-messages-at-limit` (defaults to `true`)

The property which sets the delegate class is merely there for potentially future use; currently there is only one option.

- `billing.db.inserts.queue-delegate.type` (defaults to `org.dcache.services.billing.db.impl.DirectQueueDelegate`)

The default settings should usually be sufficient.

You can now obtain statistics (printed to the billing log and pinboard) via the dcache admin command: **display insert statistics <on/off>** command. Activating this command logs the following once a minute:

Example:

```
insert queue (last 0, current 0, change 0/minute)
commits (last 0, current 0, change 0/minute)
dropped (last 0, current 0, change 0/minute)
total memory 505282560; free memory 482253512
```

"insert queue" refers to how many messages actually were put on the queue; "commits" are the number of messages committed to the database; "dropped" are the number of lost messages. "last" refers to the figures at the last iteration. For insert queue, this is the actual size of the queue; for commits and dropped, these are cumulative totals.

You can also generate a Java thread dump by issuing the "**dump threads**" command.

- Should finer control over the DataNucleus layer (which talks to the database) be needed, then a new `datanucleus.properties` file must be provided. The path to this file, which will override the internal settings, should be indicated using:

- `billing.db.config.path` (defaults to `" "`)

Changing this configuration requires an understanding of DataNucleus [<http://www.datanucleus.org>] , and we expect it will be rather uncommon to utilize this option (it is suggested that the administrator in this case consult with a member of the dCache team).

- Changing the database type (which defaults to PostgreSQL) to something else would entail the above-mentioned necessary modification of the `datanucleus.properties` as well as changing the `billing.db.driver` and `billing.db.url` properties appropriately. This is not a recommended procedure, though in certain exceptional circumstances, it may be desirable or necessary. Once again, consultation with the dCache team is suggested in this case.

Generating and Displaying Billing Plots

If you have selected to store billing messages to the database, it is also possible to generate and display a set of histograms from the data in these tables. To turn on plot generation, set the property `httpd.enable.plots.billing` to `true` and restart the domain in which the `httpd` is running.

Example:

Extract from the layout file:

```
[httpDomain]
    billing.enable.db=true
    httpd.enable.plots.billing=true
[httpDomain/httpd]
[httpDomain/billing]
...
```

The the frequency of plot refreshing and the type of plot produced can be controlled by:

- `billingPlotsTimeoutInMins` (defaults to 30)
- `httpd.plots.billing.type` (defaults to `png` and can be set to `gif`)

The plots provide aggregate views of the data for 24-hour, 7-day, 30-day and 365-day periods.

The plot types are:

- (Giga)bytes read and written for both dCache and HSM backend (if any)
- Number of transactions/transfers for both dCache and HSM backend (if any)
- Maximum, minimum and average connection time
- Cache hits and misses

Note

The data for this last histogram is not automatically sent, since it contributes significantly to message traffic between the pool manager and the billing service. To store this data (and thus generate the relevant plots), the `poolmanager.enable.cache-hit-message` property must be set either in `dcache.conf` or in the layout file for the domain where the `poolmanager` runs:

```
poolmanager.enable.cache-hit-message=true
```

Each individual plot can be magnified by clicking on it.

Upgrading a Previous Installation

Because it is possible that the newer version may be deployed over an existing installation which already uses the billing database, the Liquibase change-set has been written in such a way as to look for existing tables and to modify them only as necessary.

If you start the domain containing the `billing` service over a pre-existing installation of the billing database, depending on what was already there, you may observe some messages like the following in the domain log having to do with the logic governing table initialization.

Example:

```
INFO 8/23/12 10:35 AM:liquibase: Successfully acquired change log lock
INFO 8/23/12 10:35 AM:liquibase: Reading from databasechangelog
```

```
INFO 8/23/12 10:35 AM:liquibase: Reading from databasechangelog
INFO 8/23/12 10:35 AM:liquibase: Successfully released change log lock
INFO 8/23/12 10:35 AM:liquibase: Successfully released change log lock
INFO 8/23/12 10:35 AM:liquibase: Successfully acquired change log lock
INFO 8/23/12 10:35 AM:liquibase: Reading from databasechangelog
INFO 8/23/12 10:35 AM:liquibase: Reading from databasechangelog
INFO 8/23/12 10:35 AM:liquibase: ChangeSet org/dcache/services/billing/
db/sql/billing.changelog-1.9.13.xml::4.1.7::arossi ran successfully in 264ms
INFO 8/23/12 10:35 AM:liquibase: Marking ChangeSet: org/dcache/services/
billing/db/sql/billing.changelog-1.9.13.xml::4.1.8::arossi:(Checksum:
3:faff07731c4ac867864824ca31e8ae81) ran despite precondition failure due
to onFail='MARK_RAN': classpath:org/dcache/services/billing/db/sql/
billing.changelog-master.xml : SQL Precondition failed. Expected '0' got '1'
INFO 8/23/12 10:35 AM:liquibase: ChangeSet org/dcache/services/billing/db/sql/
billing.changelog-1.9.13.xml::4.1.9::arossi ran successfully in 14ms
INFO 8/23/12 10:35 AM:liquibase: Successfully released change log lock
INFO 8/23/12 10:35 AM:liquibase: Successfully released change log lock
```

Anything logged at a level lower than ERROR is usually entirely normal. Liquibase regularly reports when the preconditions determining whether it needs to do something are not met. All this means is that the update step was not necessary and it will be skipped in the future.

If, on the other hand, there is an ERROR logged by Liquibase, it is possible there may be some other conflict resulting from the upgrade (this should be rare). Such an error will block the domain from starting. One remedy which often works in this case is to do a clean re-initialization by dropping the Liquibase tables from the database:

```
[root] # psql -U dcache billing
billing=> drop table databasechangelog
billing=> drop table databasechangeloglock
billing-> \q
[root] #
```

and then restarting the domain.

Note

If the billing database already exists, but contains tables other than the following:

```
[root] # psql -U dcache billing
billing=> \dt
          List of relations
 Schema |          Name          | Type  | Owner
-----+-----+-----+-----
 public | billinginfo            | table | dcache
 public | billinginfo_rd_daily  | table | dcache
 public | billinginfo_tm_daily  | table | dcache
 public | billinginfo_wr_daily  | table | dcache
 public | databasechangelog     | table | dcache
 public | databasechangeloglock | table | dcache
 public | doorinfo              | table | dcache
 public | hitinfo               | table | dcache
 public | hitinfo_daily         | table | dcache
 public | storageinfo           | table | dcache
 public | storageinfo_rd_daily  | table | dcache
 public | storageinfo_wr_daily  | table | dcache

billing-> \q
[root] #
```

that is, if it has been previously modified by hand or out-of-band to include custom tables not used directly by dCache, the existence of such extraneous tables should not impede dCache from working

correctly, provided those other tables are `READ`-accessible by the database user for billing, which by default is `dcache`. This is a requirement imposed by the use of Liquibase. You thus may need explicitly to grant `READ` privileges to the billing database user on any such tables if they are owned by another database user.

Chapter 16. The alarms Service

dCache has an `alarms` service which records errors (*alarms*) requiring more or less urgent intervention. The `webadmin` servlet running inside the `httpd` service has a special page for querying, displaying and tracking these alarms. There is also an option for sending alarm notifications via email. The alarms data can be stored either in an XML file or in a database. The alarms service is turned off by default.

The Basic Setup

It is not necessary to run the `alarms` service in a separate domain, though depending on the individual system configuration it may still be advisable not to embed the service in a domain already burdened with higher memory requirements. To handle alarms under a relatively high load (100Hz on the server end) requires only about 2% more of the cpu, but about 75-100 MiB of additional space. In order to capture any alarms from other domains at startup, it is also necessary to arrange for the alarm service to start before the other doors and pools.

While there is nothing strictly preventing the use of multiple `alarms` services, under normal circumstances this should not be necessary. The only constraint on the service set-up has to do with the storage option. Unlike for the RDBMS (relational database) back-end, there is currently no option for remote access of the XML file. Since the alarms storage needs to be written to by the `alarms` service but also read by the `httpd` service, it is thus necessary for that file to exist on a shared or mounted partition visible to both. Obviously, no such requirement exists for the RDBMS option.

Add the `alarms` service to a domain in the layout file:

```
[alarmsDomain]
[alarmsDomain/alarms]
alarms.db.type=rdbms
...
```

OR

```
[someotherDomain]
[someotherDomain/alarms]
alarms.db.type=rdbms
[someotherDomain/someotherservice]
...
```

Note that the storage type setting `alarms.db.type` must be defined either in the layout or `/etc/dcache/dcache.conf` file because its default value is `off`; this can be set to either `xml`, or `rdbms`. In the latter case, the standard set of properties can be used to configure the connection url, db user, and so forth. Before using the `rdbms` option for the first time, be sure to run:

```
createdb -U alarms.db.user alarms
```

to create the database; as usual, the actual schema will be initialized automatically when the service is started.

For the XML option, the storage file is usually found in the shared directory for alarms (corresponding to `alarms.dir`); the usual path is `/var/lib/dcache/store.xml`, but the location can be changed

by setting `alarms.db.xml.path`. This will automatically be propagated to `alarms.db.url` and consequently to `httpd.alarms.db.url` if the two domains are on the same host; if they are not (and share this file path via a mount, for instance), be sure to set the `httpd` property in the layout or `/etc/dcache/dcache.conf` on the `httpd` host to correspond to the new `alarms.db.url`.

As a rule of thumb, the choice between XML and RDBMS is dictated by two factors: whether it is feasible to share the XML file between the two services as noted, and how much history is to be preserved. While the XML option is more lightweight and easier to configure, it is limited by performance, experiencing considerable read and write slowdown as the file fills (beyond 1000 entries or so). If you do not need to maintain records of alarms (and either manually delete alarms which have been serviced, or use the built-in cleanup feature – see below), then this option should be sufficient. Otherwise, the extra steps of installing PostgreSQL on the appropriate node and creating the alarms database (as above) may be worth the effort.

Configure where the alarms service is Running

The alarms infrastructure is actually a wrapper around the logging layer and makes use of a simple tcp socket logger to transmit logging events to the server. In each domain, the `/etc/dcache/logback.xml` configuration references the following properties to control remote logging:

```
dcache.log.level.remote=off
dcache.log.server.host=localhost
dcache.log.server.port=9867
```

As with the `alarms` service database type, remote logging is turned off by default. Under normal circumstances it should be sufficient to set this to `error` in order to receive alarms. All internally generated alarms (see below) are in fact guaranteed to be sent at this logging level. Remote transmission of events at lower logging levels is possible, but caution should be taken inasmuch anything below `warn` significantly increases network traffic and could risk overloading the server or creating a bottleneck. This service was not designed to provide robust centralized debugging.

If all of your `dCache` domains run on the same host, then the default (`localhost` value will work. But usually your `dCache` will not be configured to run on a single node, so each node will need to know the destination of the remote logging events. On all the nodes except where the actual `alarms` service resides, you will thus need to modify the `/etc/dcache/dcache.conf` file or the layout file to set the `dcache.log.server.host` property (and restart `dCache` if it is already up). The default port should usually not need to be modified; in any case, it needs to correspond to whatever port the service is running on. From inspection of the `/usr/share/dcache/alarms.properties` file, you can see that the `alarms`-specific properties mirror the logger properties:

```
# ---- Host on which this service is running
alarms.net.host=${dcache.log.server.host}
# ---- TCP port the alarms service listens on
alarms.net.port=${dcache.log.server.port}
```

The first property should not need any adjustment, but if `alarms.net.port` is modified, be sure to modify the `dcache.log.server.port` property on the other nodes to correspond to it. In general, it is advisable to work directly with the `dcache.log.server` properties everywhere.

Example:

An example of a dCache which consists of a head node, some door nodes and some pool nodes. Assume that the `httpd` service and the `alarms` service are running on the head node. Then you would need to set the property `dcache.log.server.host` on the pool nodes and on the door nodes to the host on which the `alarms` service is running.

```
dcache.log.server.host=<head-node>
```

Types of Alarms

As stated previously, the dCache alarm system runs on top of the logging system (and more specifically, depends on the `ch.qos.logback` logging library). It promotes normal logging events to alarm status in one of two ways.

BUILT-IN (MARKED) ALARMS

Some alarms are already coded into dCache. These bear the general logging marker `ALARM` and also can carry sub-markers for type and uniqueness identifiers. They also carry information indicating the host, domain and service which emits them. All such alarms are logged at the `ERROR` event level.

SERVER-SIDE (OPTIONAL) ALARMS

Logging events which arrive at the alarm server, but which do not carry a specific alarm type marker (these may be events at any logging level, not just `ERROR`), can nevertheless be redefined as a specific type of alarm via a set of filters provided by the administrator. These filters or custom alarm definitions reside in a special XML file usually written to the alarms space. Further explanation as to how to create such filters is given in another section below.

Alarm Priority

The notion of alarm or alert carries the implication that this particular error or condition requires user attention/intervention; there may be, however, differences in urgency which permit the ordering of such notices in terms of degree of importance. dCache allows the administrator complete control over this prioritization.

The available priority levels are:

- `CRITICAL`
- `HIGH`
- `MODERATE`
- `LOW`

Any alarm can be set to whatever priority level is deemed appropriate. This can be done through the admin interface commands (see below). Without any customization, all alarms (of both types) are given a default priority level. This level can be changed via the value of `<variable>alarms.priority-mapping.default</variable>`, which by default is `critical`.

Filtering based on priority is possible both in the webadmin page (see below), and for alarms sent via email (

`<variable>alarms.email.threshold</variable>`

; fuller discussion of how to enable email alarms is given in a later section).

Note

There also exists the possibility of filtering out only alarms from the main database into a separate log file. This option is enabled using

`<variable>alarms.enable.history</variable>`

, and similarly has a priority threshold,

`<variable>alarms.history.threshold</variable>`

. This is particularly useful in tandem with the XML storage option; it allows preservation of a condensed record of the alarms even after their full entries have been deleted from the database.

Working with Alarms: Shell Commands

Some basic alarm commands are available as part of the dCache shell. The following is an abbreviated description; for fuller information, see the dCache man page.

`alarm send`

Send an arbitrary alarm message to the alarm server. The remote server address is taken from the local values for

`<variable>dcache.log.server.host</variable>`

and

`<variable>dcache.log.server.port</variable>`

. If the `[-t=TYPE]` option is used, it must be a predefined (internal) alarm type.

`alarm list`

Displays a list of all alarm types currently defined in dCache code (i.e., predefined, internal types). Since these types can be modified with any incremental release, a listing in this manual would be of limited value. It is easy enough to check which ones currently are defined using this command, the `predefined ls` admin command, or the auto-completing `Alarm Type` combo box on the webadmin alarms page.

`alarm [add | modify | remove]`

Activates an interpreter for adding, modifying or removing a filter definition. The interpreter walks you through the steps and choices. The results are written to the definitions file given by the local value for

`<variable>alarms.custom-definitions.path</variable>`

.

Working with Alarms: Admin Commands

A similar set of commands is available through the admin interface. To see fuller information for each of these, do `help [command]`.

`definition add [OPTIONS]`

Add a new custom definition; if a definition of this type already exists, the new definition will overwrite it.

`definition keywords`

Print the list of attribute names whose values can be used as keyword identifiers for the alarm.

definition ls [type]

Print a single definition or sorted list of definitions.

definition reload [path]

Reinitialize the definitions from the saved changes.

definition rm type

Remove the existing alarm definition.

definition save [path]

Save the current definitions to persistent back-up.

definition set type name value

Set the attribute of an existing alarm definition.

definition unset type name

Unset (remove) the attribute of an existing alarm definition.

predefined ls

Print a list of all internally defined alarms.

priority get default

Get the current default alarm priority value.

priority ls [type]

Print a single priority level or sorted list of priority levels for all known alarms.

priority reload [path]

Reinitialize priority mappings from saved changes.

priority restore all

Set all defined alarms to the current default priority value.

priority save [path]

Save the current priority mappings to persistent back-up.

priority set type low|moderate|high|critical

Set the priority of the alarm type.

priority set default low|moderate|high|critical

Set the default alarm priority value.

send [OPTIONS] message

Send an alarm to the alarm service.

Note

Custom definitions and priority mappings are backed by files corresponding to the properties

`<variable>alarms.custom-definitions.path</variable>`

and

`<variable>alarms.priority-mapping.path</variable>`

, respectively. It is always possible to modify these files directly by hand. These by default are mapped to `/var/lib/dcache/alarms.custom-definitions.xml` and `/var/lib/dcache/alarms-priority.properties`. In order for the changes to take effect, either restart the alarms domain, or use the respective `reload` admin command. It should be understood that when using the admin commands, any modifications are done in memory only and are not flushed automatically to the underlying file, so any permanent changes need to be made via the `save` command.

Note

It is possible to change the file locations by setting the above-mentioned properties in the layout or `/etc/dcache/dcache.conf`. As can be seen from the admin commands, it is also possible to specify the path as an option on the respective `save` and `reload` commands. Note, however, that this is meant mainly for temporary or back-up purposes, as the path defined in the local `dcache` configuration will remain unaltered after that command completes and the priority map or definitions will be reloaded from there once again whenever the domain is restarted.

Note

Any changes made via the `priority set default` command are in-memory only. To change this default permanently, set the

`<variable>alarms.priority-mapping.default</variable>`

property in the layout or `/etc/dcache/dcache.conf`.

Working with Alarms: The Webadmin Alarms Page

The Alarms Web Page is an admin page and thus requires authentication. You must enable HTTPS and set an admin gid (0 by default):

Note

For the authenticated mode you need to generate a pk12 hostcert for SSL. This can be done by running the `dcache` command: `import hostcert [--hostcert=FILE] [--hostkey=FILE] [--out=FILE] [--password=PASSWORD]` after obtaining a hostcert and hostkey, which are by default placed in `/etc/grid-security`.

```
[httpdDomain]
  httpd.enable.authn=true
  httpd.authz.admin-gid=<1234>
[httpdDomain/httpd]
```

QUERY FILTER

Include	D	All <input checked="" type="radio"/> Only Alarms <input type="radio"/> No Alarms <input type="radio"/>	Show Closed <input type="checkbox"/> M
Last Update Range	D	Beginning <input type="text"/> <input type="text"/>	Ending <input type="text"/> <input type="text"/>
Priority		HIGH <input type="text"/> M	Refresh <input type="button"/>
Type (Alarm) or Level (Warning)		<input type="text"/> D	
Match Expression		<input type="text"/> M	Regular Expression <input type="checkbox"/>
Limit		From <input type="text"/> Up To <input type="text"/> D	

ALARMS / WARNINGS

Delete	Close	First	Last	Type	Count	Host	Domain	Service	Info	Notes
<input type="checkbox"/>	<input type="checkbox"/>	Tue Sep 16 09:52:47 CDT 2014	Tue Sep 16 09:52:47 CDT 2014	GENERIC	1	otfrid.fnal.gov	<na>	user-command	TEST ALARM 4	...
<input type="checkbox"/>	<input type="checkbox"/>	Tue Sep 16 09:52:45 CDT 2014	Tue Sep 16 09:52:45 CDT 2014	GENERIC	1	otfrid.fnal.gov	<na>	user-command	TEST ALARM 3	...
<input type="checkbox"/>	<input type="checkbox"/>	Tue Sep 16 09:52:43 CDT 2014	Tue Sep 16 09:52:43 CDT 2014	GENERIC	1	otfrid.fnal.gov	<na>	user-command	TEST ALARM 2	...
<input type="checkbox"/>	<input type="checkbox"/>	Tue Sep 16 09:52:41 CDT 2014	Tue Sep 16 09:52:41 CDT 2014	GENERIC	1	otfrid.fnal.gov	<na>	user-command	TEST ALARM 1	...
<input type="checkbox"/>	<input type="checkbox"/>	Tue Sep 16 09:10:59 CDT 2014	Tue Sep 16 09:10:59 CDT 2014	WARN	1	otfrid.fnal.gov	alarmsDomain	System	Was expecting a 0-sized socketNodeList after server shutdown	...

- A. The QUERY FILTER form can be used to limit the display of alarms in the table. The underlying query to the database is based on whether the entry has been marked as an alarm (the radio buttons indicating undefined, yes and no, respectively), the time interval in which to search, the alarm type, and the result range; these are marked by 'D' on the example screenshot above. The date referred to in after and before is that of the latest update to that entry, not the timestamp of its original arrival. Each click of the Refresh button will reload the data from the database based on these parameters. The default behavior is ALL ALARMS ONLY (unspecified type or range). Placing a single date in the Beginning box will give you all entries from that date up to today (inclusive); a single date in the Ending box will give all entries up to that date (inclusive). The other options, marked by 'M', all do in-memory filtering.
- B. The Priority choice works like a debugging level, such that choosing MODERATE will expose all alarms of that priority or above, thus including HIGH and CRITICAL, but excluding LOW. Note that non-alarms are unaffected by this setting.
- C. The Match Expression filters by appending all fields to a single string and searching for a matching substring. If the Regular Expression box is checked, the expression to match is compiled as a (Java) regex.
- D. The header of the result table contains two checkboxes which allow you to check or uncheck the respective columns for all displayed items. Checking Delete and then clicking Refresh will actually eliminate the entry from persistent store.
- E. Closed is a way of marking the alarm as having been dealt with while maintaining a record of it. The Show Closed Alarms checkbox allows you to display them (turned off by default).
- F. All column titles appearing in white can be clicked to sort the table by that column. While there is no column indicating alarm priority (as this attribute is external to the alarm schema), alarms are sorted by

priority first. Non-alarms follow alarms. If both alarms and non-alarms are displayed, alarms are colored dark red.

G. Notes is an editable field to be used for any special remarks.

When Refresh is clicked, any updates to Closed and Notes are first saved, then any Deletes are processed, and finally, the table is repopulated using the current query filter. The entire form is set to auto-refresh every 60 seconds.

Advanced Service Configuration: Enabling Automatic Cleanup

An additional feature of the alarms infrastructure is automatic cleanup of processed alarms. An internal thread runs every so often, and purges all alarms marked as closed with a timestamp earlier than the given window. This daemon can be configured using the properties `alarms.enable.cleaner`, `alarms.cleaner.timeout`, `alarms.cleaner.timeout.unit`, `alarms.cleaner.delete-entries-before` and `alarms.cleaner.delete-entries-before.unit`. The cleaner is off by default. This feature is mainly useful when running over an XML store, to mitigate slow-down due to bloat; nevertheless, there is nothing prohibiting its use with RDBMS.

Advanced Service Configuration: Enabling Email Alerts

To configure the server to send alarms via email, you need to set a series of alarm properties. No changes are necessary to any `logback.xml` file. The most important properties:

```
alarms.enable.email, alarms.email.threshold
```

Off (false) and `critical` by default.

```
alarms.email.smtp-host, alarms.email.smtp-port
```

Email server destination. The port defaults to 25.

SMTP authentication and encryption

The SMTP client used by dCache supports authentication via plain user passwords as well as both the STARTTLS and SSL protocols. Note that STARTTLS differs from SSL in that, in STARTTLS, the connection is initially non-encrypted and only after the STARTTLS command is issued by the client (if the server supports it) does the connection switch to SSL. In SSL mode, the connection is encrypted right from the start. Which of these to use is usually determined by the server.

If username and password are left undefined, unauthenticated sends will be attempted, which may not be supported by the server.

The values to use for plain user/password authentication default to undefined. NOTE: while using SSL will guarantee encryption over the wire, there is currently no way of storing an encrypted password. Two possible workarounds: a. Set up an admin account with a plaintext password that is protected by root privileges but which can be shared among administrators or those with access to the host containing

this file; b. Set up a host-based authentication to the server; the email admin will usually require the client IP, and it will need to be static in that case.

sender and recipient

Only one sender may be listed, but multiple recipients can be indicated by a comma-separated list of email addresses.

See the shared defaults `/usr/share/dcache/alarms.properties` file for additional settings.

Advanced Service Configuration: Custom Alarm Definitions

It should be fairly straightforward to add or modify custom definitions via either the interpreter from the dcache shell, or the `admin definition` commands.

An alarm definition consists of the following:

Property	Possible values	Required
type	Name of this alarm type (settable only once).	YES
keyWords	Whitespace-delimited concatenation of key field names (see below).	YES
regex	A pattern to match the message with. Note It is advisable to place the regex pattern in double quotes, e.g., "[=].[w]*"	YES
regex-flags	A string representation of the (Java) regex flags options, joined by the 'or' pipe symbol: e.g., <code>CASE_INSENSITIVE DOTALL</code> . For fuller explanation, see the Java Tutorial on Regular Expressions [http://docs.oracle.com/javase/tutorial/essential/regex].	NO
match-exception	<i>True</i> = recur over embedded exception messages when applying the regex match (default is <i>False</i>).	NO
depth	Integer # 0, = depth of exception trace to examine when applying match-exception; undefined means unbounded (default).	NO

For example:

```
<alarmType>
<type>SERVICE_CREATION_FAILURE</type>
<regex>(.) from ac_create</regex>
<keyWords>group1 type host domain service</keyWords>
</alarmType>
```

The alarm key (the property `keyWords`) is the set of attributes whose values uniquely identify the alarm instance. For example, an alarm defined using `message`, but without including `timestamp` in its key, would suggest that all events with exactly the same message content are to be considered duplicates of the first such alarm. The key field names which can be used to constitute the key include the attributes defined for all alarms, plus the parsing of the message field into regex groups:

- `timestamp`
- `domain`

- `service`
- `host`
- `message (= group0)`
- `groupN`

These attribute names should be delimited by (an arbitrary number of) whitespace characters. Note that `timestamp` and `message` derive from the logging event, while `host`, `domain` and `service` are properties added to the event's diagnostic context map.

The key field name `groupN`, where `N` is an integer, means that the `N`th substring (specified by parentheses) will be included. For `N=0`, `group0` is identical to `message`, which means that the whole message string should be included as an identifier.

Alarms that are generated by the code at the origin of the problem may carry with them other arbitrary unique identifier values, but custom definitions are limited to the values associated with these fixed fields.

Miscellaneous Properties of the `alarms` Service

There are a number of other settings available for customization; check the files `/usr/share/dcache/alarms.properties` and `/usr/share/dcache/httpd.properties` for the complete list with explanations.

Chapter 17. dCache Webadmin Interface

This part describes how to configure the `webadmin` service which runs inside the `httpdDomain` and offers additional features to admins like sending admin-commands equal to those of admin interface (CLI) to chosen cells or displaying billing plots.

For authentication and authorisation it offers usage of username/password (currently the `kpwd-Plugin`) or grid certificate talking to `gPlazma2`. It also offers a non-authenticated read-only mode.

If you are logged in as admin it is possible to send a command to multiple pools or a whole poolgroup in one go. It is even possible to send a command to any dCache cell. Also, there is information like their size, their id and used space on linkgroups and spacetokens available.

From the technical point of view the `webadmin` service uses a Jetty-Server which is embedded in an ordinary `httpd` cell. It is using `apache-wicket` (a webfrontend-framework) and `YAML` (a CSS-Template Framework).

Installation

For the authenticated mode a configured `gPlazma` is required (see also the section called “`gPlazma` config example to work with authenticated webadmin”). The user may either authenticate by presenting his grid certificate or by entering a valid username/password combination. This way it is possible to login even if the user does not have a grid certificate. For a non-authenticated `webadmin` service you just need to start the `httpd` service.

For the authenticated mode using a grid certificate the host certificate has to be imported into the `dCache-keystore`. In the grid world host certificates are usually signed by national Grid-CAs. Refer to the documentation provided by the Grid-CA to find out how to request a certificate. To import them into the `dCache-keystore` use this command:

```
[root] # dcache import hostcert
```

Now you have to initialise your truststore (this is the certificate-store used for the SSL connections) by using this command:

```
[root] # dcache import cacerts
```

The `webadmin` service uses the same truststore as `webdav` service, so you can skip this step if you have `webdav` configured with SSL.

The default instance name is the name of the host which runs the `httpdDomain` and the default `http` port number is 2288 (this is the default port number of the `httpd` service). Now you should be able to have a read-only access to the webpage `http://example.com:2288/webadmin`.

In the following example we will enable the authenticated mode.

Example:


```
[httpdDomain]
  authenticated=true
```

The most important value is `httpd.authz.admin-gid`, because it configures who is allowed to alter dCache behaviour, which certainly should not be everyone:

```
# # When a user has this GID he can become an admin for the webadmin interface #
httpd.authz.admin-gid=0
```

To see all webadmin specific property values have a look at `/usr/share/dcache/defaults/httpd.properties`.

For information on gPlazma configuration have a look at Chapter 10, *Authorization in dCache* and for a special example the section called “gPlazma config example to work with authenticated webadmin”.

Chapter 18. ACLs in dCache

dCache includes support for Access Control Lists (ACLs). This support is conforming to the NFS version 4 Protocol specification [<http://www.nfsv4-editor.org/draft-25/draft-ietf-nfsv4-minorversion1-25.html>].

This chapter provides some background information and details on configuring dCache to use ACLs and how to administer the resulting system.

ACLs and `pnfs`

ACLs are only supported with the Chimera name space backend. Versions before 1.9.12 had partial support for ACLs with the `pnfs` backend, however due to the limitations of that implementation ACLs were practically useless with `pnfs`.

Introduction

dCache allows control over namespace operations (e.g., creating new files and directories, deleting items, renaming items) and data operations (reading data, writing data) using the standard Unix permission model. In this model, files and directories have both owner and group-owner attributes and a set of permissions that apply to the owner, permissions for users that are members of the group-owner group and permissions for other users.

Although Unix permission model is flexible enough for many deployment scenarios there are configurations that either cannot be configured easily or are impossible. To satisfy these more complex permission handling dCache has support for ACL-based permission handling.

An Access Control List (ACL) is a set of rules for determining whether an end-user is allowed to undertake some specific operation. Each ACL is tied to a specific namespace entry: a file or directory. When an end-user wishes to undertake some operation then the ACL for that namespace entry is checked to see if that user is authorised. If the operation is to create a new file or directory then the ACL of the parent directory is checked.

File- and directory- ACLs

Each ACL is associated with a specific file or directory in dCache. Although the general form is the same whether the ACL is associated with a file or directory, some aspects of an ACL may change. Because of this, we introduce the terms *file-ACL* and *directory-ACL* when talking about ACLs associated with a file or a directory respectively. If the term *ACL* is used then it refers to both file-ACLs and directory-ACLs.

Each ACL contains a list of one or more Access Control Entries (ACEs). The ACEs describe how dCache determines whether an end-user is authorised. Each ACE contains information about which group of end users it applies to and describes whether this group is authorised for some subset of possible operations.

The order of the ACEs within an ACL is significant. When checking whether an end-user is authorised each ACE is checked in turn to see if it applies to the end-user and the requested operation. If it does then that ACE determines whether that end-user is authorised. If not then the next ACE is checked. Thus an ACL can have several ACEs and the first matched ACE “wins”.

One of the problems with traditional Unix-based permission model is its inflexible handling of newly created files and directories. With transitional filesystems, the permissions that are set are under the control of the user-process creating the file. The sysadmin has no direct control over the permissions that newly files or directories will have. The ACL permission model solves this problem by allowing explicit configuration using inheritance.

ACL inheritance is when a new file or directory is created with an ACL containing a set of ACEs from the parent directory's ACL. The inherited ACEs are specially marked so that only those that are intended will be inherited.

Inheritance only happens when a new file or directory is created. After creation, the ACL of the new file or directory is completely decoupled from the parent directory's ACL: the ACL of the parent directory may be altered without affecting the ACL of the new file or directory and visa versa.

Inheritance is optional. Within a directory's ACL some ACEs may be inherited whilst others are not. New files or directories will receive only those ACEs that are configured; the remaining ACEs will not be copied.

Database configuration

ACL support requires database tables to store ACL and ACE information. These tables are part of the Chimera name space backend and for a new installation no additional steps are needed to prepare the database.

Early versions of Chimera (before dCache 1.9.3) did not create the ACL table during installation. If the database is lacking the extra table then it has to be created before enabling ACL support. This is achieved by applying two SQL files:

```
[root] # psql chimera < /usr/share/dcache/chimera/sql/addACLtoChimeraDB.sql
[root] # psql chimera < /usr/share/dcache/chimera/sql/pgsql-procedures.sql
```

Configuring ACL support

The `dcache.conf` and layout files contain a number of settings that may be adjusted to configure dCache's permission settings. These settings are are described in this section.

Enabling ACL support

To enable ACL support set `pnfsmanager.enable.acl=true` in the layout file.

```
..
[<domainName>]/pnfsmanager]
pnfsmanager.enable.acl=true
..
```

Administrating ACLs

Altering dCache ACL behaviour is achieved by connecting to the `PnfsManager` *well-known cell* using the administrator interface. For further details about how to use the administrator interface, see the section called "The Admin Interface".

The **info** and **help** commands are available within `PnfsManager` and fulfil their usual functions.

How to set ACLs

The **setfacl** command is used to set a new ACL. This command accepts arguments with the following form:

```
setfacl <ID> <ACE> [<ACE>...]
```

The **<ID>** argument is either a `pnfs-ID` or the absolute path of some file or directory in dCache. The **setfacl** command requires one or more **<ACE>** arguments separated by spaces.

The **setfacl** command creates a new ACL for the file or directory represented by **<ID>**. This new ACL replaces any existing ACEs for **<ID>**.

An ACL has one or more ACEs. Each ACE defines permissions to access this resource for some Subject. The ACEs are space-separated and the ordering is significant. The format and description of these ACE values are described below.

Description of the ACE structure

The **<ACE>** arguments to the **setfacl** command have a specific format. This format is described below in Extended Backus-Naur Form (EBNF).

- ```
[1] ACE ::= Subject ':' Access |
 Subject ':' Access ':' Inheritance
[2] Subject ::= 'USER:' UserID |
 'GROUP:' GroupID |
 'OWNER@' |
 'GROUP@' |
 'EVERYONE@' |
 'ANONYMOUS@' |
 'AUTHENTICATED@'
[3] Access ::= '+' Mask |
 '-' Mask
[4] Mask ::= Mask MaskItem |
 MaskItem
[5] MaskItem ::= 'r' | 'l' | 'w' | 'f' | 's' | 'a' | 'n' | 'N' | 'x' | 'd' | 'D' | 't' | 'T' | 'c' | 'C' | 'o'
[6] Inheritance ::= Inheritance Flag |
 Flag
[7] Flag ::= 'f' | 'd' | 'o'
[8] UserID ::= INTEGER
[9] GroupID ::= INTEGER
```

The various options are described below.

### The Subject

The Subject defines to which user or group of users the ACE will apply. It acts as a filter so that only those users that match the Subject will have their access rights affected.

As indicated by the EBNF above, the Subject of an ACE can take one of several forms. These are described below:

**USER:<id>**

The **USER:** prefix indicates that the ACE applies only to the specific end-user: the dCache user with ID <id>. For example, **USER:0:+w** is an ACE that allows user 0 to write over a file's existing data.

**GROUP:<id>**

The **GROUP:** prefix indicates that the ACE applies only to those end-users who are a member of the specific group: the dCache group with ID <id>. For example, **GROUP:20:+a** is an ACE that allows any user who is a member of group 20 to append data to the end of a file.

**OWNER@**

The **OWNER@** subject indicates that the ACE applies only to whichever end-user owns the file or directory. For example, **OWNER@:+d** is an ACE that allows the file's or directory's owner to delete it.

**GROUP@**

The **GROUP@** subject indicates that the ACE applies only to all users that are members of the group-owner of the file or directory. For example, **GROUP@:+l** is an ACE that allows any user that is in a directory's group-owner to list the directory's contents.

**EVERYONE@**

The **EVERYONE@** subject indicates that the ACE applies to all users. For example, **EVERYONE@:+r** is an ACE that makes a file world-readable.

**ANONYMOUS@**

The **ANONYMOUS@** Subject indicates that the ACE applies to all users who have not authenticated themselves. For example, **ANONYMOUS@:-l** is an ACE that prevents unauthenticated users from listing the contents of a directory.

**AUTHENTICATED@**

The **AUTHENTICATED@** Subject indicates that an ACE applies to all authenticated users. For example, **AUTHENTICATED@:+r** is an ACE that allows any authenticated user to read a file's contents.

**Authenticated or anonymous**

An end user of dCache is either authenticated or is unauthenticated, but never both. Because of this, an end user operation will either match ACEs with **ANONYMOUS@** Subjects or **AUTHENTICATED@** Subjects but the request will never match both at the same time.

**Access mask**

Access (defined in the ACE EBNF above) describes what kind of operations are being described by the ACE and whether the ACE is granting permission or denying it.

An individual ACE can either grant permissions or deny them, but never both. However, an ACL may be composed of any mixture of authorising- and denying- ACEs. The first character of Access describes whether the ACE is authorising or denying.

If Access begins with a plus symbol (+) then the ACE authorises the Subject some operations. The ACE **EVERYONE@:+r** authorises all users to read a file since the Access begins with a +.

If the Access begins with a minus symbol (-) then the ACE denies the Subject some operations. The ACE **EVERYONE@:-r** prevents any user from reading a file since the Access begins with a -.

The first character of Access must be + or -, no other possibility is allowed. The initial + or - of Access is followed by one or more operation letters. These letters form the ACE's *access mask* (Mask in ACE EBNF above).

The access mask describes which operations may be allowed or denied by the ACE. Each type of operation has a corresponding letter; for example, obtaining a directory listing has a corresponding letter `l`. If a user attempts an operation of a type corresponding to a letter present in the access mask then the ACE may affect whether the operation is authorised. If the corresponding letter is absent from the access mask then the ACE will be ignored for this operation.

The following table describes the access mask letters and the corresponding operations:

### **File- and directory- specific operations**

Some operations and, correspondingly, some access mask letters only make sense for ACLs attached to certain types of items. Some operations only apply to directories, some operations are only for files and some operations apply to both files and directories.

When configuring an ACL, if an ACE has an operation letter in the access mask that is not applicable to whatever the ACL is associated with then the letter is converted to an equivalent. For example, if `l` (list directory) is in the access mask of an ACE that is part of a file-ACL then it is converted to `r`. These mappings are described in the following table.

|                |                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>r</code> | reading data from a file. Specifying <code>r</code> in an ACE's access mask controls whether end-users are allowed to read a file's contents. If the ACE is part of a directory-ACL then the letter is converted to <code>l</code> .                                                                                                                                                  |
| <code>l</code> | listing the contents of a directory. Specifying <code>l</code> in an ACE's access mask controls whether end-users are allowed to list a directory's contents. If the ACE is part of a file-ACL then the letter is converted to <code>r</code> .                                                                                                                                       |
| <code>w</code> | overwriting a file's existing contents. Specifying <code>w</code> in an ACE's access mask controls whether end-users are allowed to write data anywhere within the file's current offset range. This includes the ability to write to any arbitrary offset and, as a result, to grow the file. If the ACE is part of a directory-ACL then the letter is converted to <code>f</code> . |
| <code>f</code> | creating a new file within a directory. Specifying <code>f</code> in an ACE's access mask controls whether end-users are allowed to create a new file. If the ACE is part of an file-ACL then then the letter is converted to <code>w</code> .                                                                                                                                        |
| <code>s</code> | creating a subdirectory within a directory. Specifying <code>s</code> in an ACE's access mask controls whether end-users are allowed to create new subdirectories. If the ACE is part of a file-ACL then the letter is converted to <code>a</code> .                                                                                                                                  |
| <code>a</code> | appending data to the end of a file. Specifying <code>a</code> in an ACE's access mask controls whether end-users are allowed to add data to the end of a file. If the ACE is part of a directory-ACL then the letter is converted to <code>s</code> .                                                                                                                                |

n

reading attributes. Specifying n in an ACE's access mask controls whether end-users are allowed to read attributes. This letter may be specified in ACEs that are part of a file-ACL and those that are part of a directory-ACL.

N

write attributes. Specifying N in an ACE's access mask controls whether end-users are allowed to write attributes. This letter may be specified in ACEs that are part of a file-ACL and those that are part of a directory-ACL.

x

executing a file or entering a directory. x may be specified in an ACE that is part of a file-ACL or a directory-ACL; however, the operation that is authorised will be different.

Specifying x in an ACEs access mask that is part of a file-ACL will control whether end users matching the ACE Subject are allowed to execute that file.

Specifying x in an ACEs access mask that is part of a directory-ACL will control whether end users matching ACE Subject are allowed to search a directory for a named file or subdirectory. This operation is needed for end users to change their current working directory.

d

deleting a namespace entry. Specifying d in an ACE's access mask controls whether end-users are allowed to delete the file or directory the ACL is attached. The end user must be also authorised for the parent directory (see D).

D

deleting a child of a directory. Specifying D in the access mask of an ACE that is part of a directory-ACL controls whether end-users are allowed to delete items within that directory. The end user must be also authorised for the existing item (see d).

t

reading basic attributes. Specifying t in the access mask of an ACE controls whether end users are allowed to read basic (i.e., non-ACL) attributes of that item.

T

altering basic attributes. Specifying T in an ACE's access mask controls whether end users are allowed to alter timestamps of the item the ACE's ACL is attached.

c

reading ACL information. Specifying c in an ACE's access mask controls whether end users are allowed to read the ACL information of the item to which the ACE's ACL is attached.

C

writing ACL information. Specifying C in an ACE's access mask controls whether end users are allowed to update ACL information of the item to which the ACE's ACL is attached.

o

altering owner and owner-group information. Specifying o controls whether end users are allowed to change ownership information of the item to which the ACE's ACL is attached.

## ACL inheritance

To enable ACL inheritance, the optional inheritance flags must be defined. The flag is a list of letters. There are three possible letters that may be included and the order doesn't matter.

### ACE Inheritance Flags

f

This inheritance flag only affects those ACEs that form part of an directory-ACL. If the ACE is part of a file-ACL then specifying f has no effect.

If a file is created in a directory with an ACE with f in inheritance flags then the ACE is copied to the newly created file's ACL. This ACE copy will not have the f inheritance flag.

Specifying f in an ACE's inheritance flags does not affect whether this ACE is inherited by a newly created subdirectory. See d for more details.

d

This inheritance flag only affect those ACEs that form part of an directory-ACL. If the ACE is part of a file-ACL then specifying d has no effect.

Specifying d in an ACE's inheritance flags does not affect whether this ACE is inherited by a newly created file. See f for more details.

If a subdirectory is created in a directory with an ACE with d in the ACE's inheritance flag then the ACE is copied to the newly created subdirectory's ACL. This ACE copy will have the d inheritance flag specified. If the f inheritance flag is specified then this, too, will be copied.

o

The o flag may only be used when the ACE also has the f, d or both f and d inheritance flags.

Specifying o in the inheritance flag will suppress the ACE. No user operations will be authorised or denied as a result of such an ACE.

When a file or directory inherits from an ACE with o in the inheritance flags then the o is *not* present in the newly created file or directory's ACE. Since the newly created file or directory will not have the o in it's inheritance flags the ACE will take effect.

An o in the inheritance flag allows child files or directories to inherit authorisation behaviour that is different from the parent directory.

## Examples

This section gives some specific examples of how to set ACLs to achieve some specific behaviour.



## Example 18.1. ACL allowing specific user to delete files in a directory

This example demonstrates how to configure a directory-ACL so user 3750 can delete any file within the directory `/pnfs/example.org/data/exampleDir`.

```
(PnfsManager) admin > setfacl /pnfs/example.org/data/exampleDir EVERYONE@:+l USER:3750:D
(...line continues...) USER:3750:+d:of
(PnfsManager) admin > setfacl /pnfs/example.org/data/exampleDir/existingFile1
(...line continues...) USER:3750:+d:f
(PnfsManager) admin > setfacl /pnfs/example.org/data/exampleDir/existingFile2
(...line continues...) USER:3750:+d:f
```

The first command creates an ACL for the directory. This ACL has three ACEs. The first ACE allows anyone to list the contents of the directory. The second ACE allows user 3750 to delete content within the directory in general. The third ACE is inherited by all newly created files and specifies that user 3750 is authorised to delete the file independent of that file's ownership.

The second and third commands creates an ACL for files that already exists within the directory. Since ACL inheritance only applies to newly created files or directories, any existing files must have an ACL explicitly set.

## Example 18.2. ACL to deny a group

The following example demonstrates authorising all end users to list a directory. Members of group 1000 can also create subdirectories. However, any member of group 2000 can do neither.

```
(PnfsManager) admin > setfacl /pnfs/example.org/data/exampleDir GROUP:2000:-s1
(...line continues...) EVERYONE@:+l GROUP:1000:+s
```

The first ACE denies any member of group 2000 the ability to create subdirectories or list the directory contents. As this ACE is first, it takes precedence over other ACEs.

The second ACE allows everyone to list the directory's content. If an end user who is a member of group 2000 attempts to list a directory then their request will match the first ACE so will be denied. End users attempting to list a directory that are not a member of group 2000 will not match the first ACE but will match the second ACE and will be authorised.

The final ACE authorises members of group 1000 to create subdirectories. If an end user who is a member of group 1000 and group 2000 attempts to create a subdirectory then their request will match the first ACE and be denied.

### Example 18.3. ACL to allow a user to delete all files and subdirectories

This example is an extension to Example 18.1, “ACL allowing specific user to delete files in a directory”. The previous example allowed deletion of the contents of a directory but not the contents of any subdirectories. This example allows user 3750 to delete all files and subdirectories within the directory.

```
(PnfsManager) admin > setfacl /pnfs/example.org/data/exampleDir USER:3750:+D:d
(...line continues...) USER:3750:+d:odf
```

The first ACE is `USER:3750:+D:d`. This authorises user 3750 to delete any contents of directory `/pnfs/example.org/data/exampleDir` that has an ACL authorising them with `d` operation.

The first ACE also contains the inheritance flag `d` so newly created subdirectories will inherit this ACE. Since the inherited ACE will also contain the `d` inheritance flag, this ACE will be copied to all subdirectories when they are created.

The second ACE is `USER:3750:+d:odf`. The ACE authorises user 3750 to delete whichever item the ACL containing this ACE is associated with. However, since the ACE contains the `o` in the inheritance flags, user 3750 is *not* authorised to delete the directory `/pnfs/example.org/data/exampleDir`

Since the second ACE has both the `d` and `f` inheritance flags, it will be inherited by all files and subdirectories of `/pnfs/example.org/data/exampleDir`, but without the `o` flag. This authorises user 3750 to delete these items.

Subdirectories (and files) will inherit the second ACE with both `d` and `f` inheritance flags. This implies that all files and sub-subdirectories within a subdirectory of `/pnfs/example.org/data/exampleDir` will also inherit this ACE, so will also be deletable by user 3750.

## Viewing configured ACLs

The `getfacl` is used to obtain the current ACL for some item in dCache namespace. It takes the following arguments.

```
getfacl [<pnfsId>] | [<globalPath>]
```

The `getfacl` command fetches the ACL information of a namespace item (a file or directory). The item may be specified by its `pnfs-ID` or its absolute path.

### Example 18.4. Obtain ACL information by absolute path

```
(PnfsManager) admin > getfacl /pnfs/example.org/data/exampleDir
ACL: rsId = 00004EEFE7E59A3441198E7EB744B0D8BA54, rsType = DIR
order = 0, type = A, accessMsk = lfsD, who = USER, whoID = 12457
order = 1, type = A, flags = f, accessMsk = lfd, who = USER, whoID = 87552
In extra format:
USER:12457:+lfsD
USER:87552:+lfd:f
```

The information is provided twice. The first part gives detailed information about the ACL. The second part, after the `In extra format:` heading, provides a list of ACEs that may be used when updating the ACL using the `setfacl` command.

---

# Chapter 19. GLUE Info Provider

The GLUE information provider supplied with dCache provides the information about the dCache instance in a standard format called GLUE. This is necessary so that WLCG infrastructure (such as FTS) and clients using WLCG tools can discover the dCache instance and use it correctly.

The process of configuring the info-provider is designed to have the minimum overhead so you can configure it manually; however, you may prefer to use an automatic configuration tool, such as YAIM.

## Note

Be sure you have at least v2.0.8 of glue-schema RPM installed on the node running the info-provider.

This chapter describes how to enable and test the dCache-internal collection of information needed by the info-provider. It also describes how to configure the info-provider and verify that it is working correctly. Finally, it describes how to publish this information within BDII, verify that this is working and troubleshoot any problems.

## Warning

Please be aware that changing information provider may result in a brief interruption to published information. This may have an adverse affect on client software that make use of this information.

## Internal collection of information

The info-provider takes as much information as possible from dCache. To achieve this, it needs the internal information-collecting service, `info`, to be running and a means to collect that information: `httpd`. Make sure that both the `httpd` and `info` services are running within your dCache instance. By default, the `info` service is started on the admin-node; but it is possible to configure dCache so it runs on a different node. You should run only one `info` service per dCache instance.

The traditional (pre-1.9.7) allocation of services to domains has the `info` cell running in the `infoDomain` domain. A dCache system that has been migrated from this old configuration will have the following fragment in the node's layout file:

```
[infoDomain]
[infoDomain/info]
```

It is also possible to run the `info` service inside a domain that runs other services. The following example show the `information` domain that hosts the `admin`, `httpd`, `topo` and `info` services.

```
[information]
[information/admin]
[information/httpd]
[information/topo]
[information/info]
```

For more information on configuring dCache layout files, see the section called “Defining domains and services”.

Use the `dcache services` command to see if a particular node is configured to run the `info` service. The following shows the output if the node has an `information` domain that is configured to run the `info` cell.

```
[root] # dcache services | grep info
information info info /var/log/dCache/information.log
```

If a node has no domain configured to host the `info` service then the above `dcache services` command will give no output:

```
[root] # dcache services | grep info
```

If no running domain within *any* node of your dCache instance is running the `info` service then you must add the service to a domain and restart that domain.

### Example:

In this example, the `info` service is added to the `example` domain. Note that the specific choice of domain (`example`) is just to give a concrete example; the same process may be applied to a different domain.

The layouts file for this node includes the following definition for the `example` domain:

```
[example]
[example/admin]
[example/httpd]
[example/topo]
```

By adding the extra line `[example/info]` to the layouts file, in future, the `example` domain will host the `info` service.

```
[example]
[example/admin]
[example/httpd]
[example/topo]
[example/info]
```

To actually start the `info` cell, the `example` domain must be restarted.

```
[root] # dcache restart example
Stopping example (pid=30471) 0 done
Starting example done
```

With the `example` domain restarted, the `info` service is now running.

You can also verify both the `httpd` and `info` services are running using the `wget` command. The specific command assumes that you are logged into the node that has the `httpd` service (by default, the `admin` node). You may run the command on any node by replacing `localhost` with the hostname of the node running the `httpd` service.

The following example shows the output from the `wget` when the `info` service is running correctly:

```
[root] # wget -O/dev/null http://localhost:2288/info
--17:57:38-- http://localhost:2288/info
Resolving localhost... 127.0.0.1
Connecting to localhost[127.0.0.1]:2288... connected.
HTTP request sent, awaiting response... 200 Document follows
Length: 372962 (364K) [application/xml]
Saving to: `/dev/null'

100%[=====]
===>] 372,962 --.-K/s in 0.001s
```

```
17:57:38 (346 MB/s) - `/dev/null' saved [372962/372962]
```

If the `httpd` service isn't running then the command will generate the following output:

```
[root] # wget -O/dev/null http://localhost:2288/info
--10:05:35-- http://localhost:2288/info
=> `/dev/null'
Resolving localhost... 127.0.0.1
Connecting to localhost|127.0.0.1|:2288... failed: Connection refused.
```

To fix the problem, ensure that the `httpd` service is running within your dCache instance. This is the service that provides the web server monitoring within dCache. To enable the service, follow the same procedure for enabling the `info` cell, but add the `httpd` service within one of the domains in dCache.

If running the `wget` command gives an error message with `Unable to contact the info cell`. Please ensure the `info` cell is running:

```
[root] # wget -O/dev/null http://localhost:2288/info
--10:03:13-- http://localhost:2288/info
=> `/dev/null'
Resolving localhost... 127.0.0.1
Connecting to localhost|127.0.0.1|:2288... connected.
HTTP request sent, awaiting response... 503 Unable to contact the info cell. Please ensure the info cell is running.
10:03:13 ERROR 503: Unable to contact the info cell. Please ensure the info cell is running..
```

This means that the `info` service is not running. Follow the instructions for starting the `info` service given above.

## Configuring the info provider

In the directory `/etc/dcache` you will find the file `info-provider.xml`. This file is where you configure the `info-provider`. It provides information that is difficult or impossible to obtain from the running dCache directly.

You must edit the `info-provider.xml` to customise its content to match your dCache instance. In some places, the file contains place-holder values. These place-holder values must be changed to the correct values for your dCache instance.

### Careful with < and & characters

Take care when editing the `info-provider.xml` file! After changing the contents, the file must remain valid, well-formed XML. In particular, be very careful when writing a less-than symbol (`<`) or an ampersand symbol (`&`).

- Only use an ampersand symbol (`&`) if it is part of an entity reference. An entity reference is a sequence that starts with an ampersand symbol and is terminated with a semi-colon (`;`), for example `&gt;` and `&apos;` are entity markups.

If you want to include an ampersand character in the text then you must use the `&amp;` entity; for example, to include the text “me & you” the XML file would include `me &amp; you`.

- Only use a less-than symbol (`<`) when starting an XML element; for example, `<constant id="TEST">A test value</constant>`.

If you want to include a less-than character in the text then you must use the `&lt;` entity; for example, to include the text “1 < 2” the XML file would include `1 &lt; 2`.

**Example:**

The following example shows the `SE-NAME` constant (which provides a human-readable description of the dCache instance) from a well-formed `info-provider.xml` configuration file:

```
<constant id="SE-NAME">Simple & small dCache instance for small VOs
(typically < 20 users)</constant>
```

The `SE-NAME` constant is configured to have the value “Simple & small dCache instance for small VOs (typically < 20 users)”. This illustrates how to include ampersand and less-than characters in an XML file.

When editing the `info-provider.xml` file, you should *only* edit text between two elements or add more elements (for lists and mappings). You should *never* alter the text inside double-quote marks.

**Example:**

This example shows how to edit the `SITE-UNIQUE-ID` constant. This constant has a default value `EXAMPLESITE-ID`, which is a place-holder value and must be edited.

```
<constant id="SITE-UNIQUE-ID">EXAMPLESITE-ID</constant>
```

To edit the constant’s value, you must change the text between the start- and end-element tags: `EXAMPLESITE-ID`. You *should not* edit the text `SITE-UNIQUE-ID` as it is in double-quote marks. After editing, the file may read:

```
<constant id="SITE-UNIQUE-ID">DESY-HH</constant>
```

The `info-provider.xml` contains detailed descriptions of all the properties that are editable. You should refer to this documentation when editing the `info-provider.xml`.

## Testing the info provider

Once you have configured `info-provider.xml` to reflect your site’s configuration, you may test that the info provider produces meaningful results.

Running the `info-provider` script should produce GLUE information in LDIF format; for example:

```
[root] # dcache-info-provider | head -20
#
LDIF generated by Xylophone v0.2
#
XSLT processing using SAXON 6.5.5 from Michael Kay 1 (http://saxon.sf.net/)
at: 2011-05-11T14:08:45+02:00
#
dn: GlueSEUniqueID=dcache-host.example.org,mds-vo-name=resource,o=grid
objectClass: GlueSETop
objectClass: GlueSE
objectClass: GlueKey
```

```
objectClass: GlueSchemaVersion
GlueSEStatus: Production
GlueSEUniqueID: dcache-host.example.org
GlueSEImplementationName: dCache
GlueSEArchitecture: multidisk
GlueSEImplementationVersion: 3.1.0 (ns=Chimera)
GlueSESizeTotal: 86
```

The actual values you see will be site-specific and depend on the contents of the `info-provider.xml` file and your `dCache` configuration.

To verify that there are no problems, redirect standard-out to `/dev/null` to show only the error messages:

```
[root] # dcache-info-provider >/dev/null
```

If you see error messages (which may be repeated several times) of the form:

```
[root] # dcache-info-provider >/dev/null
Recoverable error
Failure reading http://localhost:2288/info: no more input
```

then it is likely that either the `httpd` or `info` service has not been started. Use the above `wget` test to check that both services are running. You can also see which services are available by running the `dcache services` and `dcache status` commands.

## Decommissioning the old info provider

Sites that were using the old (pre-1.9.5) info provider should ensure that there are no remnants of this old info-provider on their machine. Although the old info-provider has been removed from `dCache`, it relied on static LDIF files, which might still exist. If so, then `BDII` will obtain some information from the current info-provider and some out-of-date information from the static LDIF files. `BDII` will then attempt to merge the two sources of information. The merged information may provide a confusing description of your `dCache` instance, which may prevent clients from working correctly.

The old info provider had two static LDIF files and a symbolic link for `BDII`. These are:

- The file `lcg-info-static-SE.ldif`,
- The file: `lcg-info-static-dSE.ldif`,
- The symbolic link `/opt/glite/etc/gip/plugin`, which points to `/opt/d-cache/jobs/infoDynamicSE-plugin-dcache`.

The two files (`lcg-info-static-SE.ldif` and `lcg-info-static-dSE.ldif`) appear in the `/opt/lcg/var/gip/ldif` directory; however, it is possible to alter the location `BDII` will use. In `BDII v4`, the directory is controlled by the `static_dir` variable (see `/opt/glite/etc/gip/glite-info-generic.conf` or `/opt/lcg/etc/lcg-info-generic.conf`). For `BDII v5`, the `BDII_LDIF_DIR` variable (defined in `/opt/bdii/etc/bdii.conf`) controls this behaviour.

You must delete the above three entries: `lcg-info-static-SE.ldif`, `lcg-info-static-dSE.ldif` and the `plugin` symbolic link.

The directory with the static LDIF, `/opt/lcg/var/gip/ldif` or `/opt/glite/etc/gip/ldif` by default, may contain other static LDIF entries that are relics of previous info-providers. These may have filenames like `static-file-SE.ldif`.

Delete any static LDIF file that contain information about dCache. With the info-provider, all LDIF information comes from the info-provider; there should be no static LDIF files. Be careful not to delete any static LDIF files that come as part of BDII; for example, the `default.ldif` file, if present.

## Publishing dCache information

BDII obtains information by querying different sources. One such source of information is by running an info-provider command and taking the resulting LDIF output. To allow BDII to obtain dCache information, you must allow BDII to run the dCache info-provider. This is achieved by symbolically linking the `dcache-info-provider` script into the BDII plugins directory:

```
[root] # ln -s /usr/sbin/dcache-info-provider
/opt/glite/etc/gip/provider/
```

If the BDII daemons are running, then you will see the information appear in BDII after a short delay; by default this is (at most) 60 seconds.

You can verify that information is present in BDII by querying BDII using the `ldapsearch` command. Here is an example that queries for GLUE v1.3 objects:

```
[root] # ldapsearch -LLL -x -H ldap://<dcache-host>:2170 -b o=grid \
'(objectClass=GlueSE)'
dn: GlueSEUniqueID=dcache-host.example.org,Mds-Vo-name=resource,o=grid
GlueSEStatus: Production
objectClass: GlueSETop
objectClass: GlueSE
objectClass: GlueKey
objectClass: GlueSchemaVersion
GlueSETotalNearlineSize: 0
GlueSEArchitecture: multidisk
GlueSchemaVersionMinor: 3
GlueSEUsedNearlineSize: 0
GlueChunkKey: GlueSEUniqueID=dcache-host.example.org
GlueForeignKey: GlueSiteUniqueID=example.org
GlueSchemaVersionMajor: 1
GlueSEImplementationName: dCache
GlueSEUniqueID: dcache-host.example.org
GlueSEImplementationVersion: 3.1-3 (ns=Chimera)
GlueSESizeFree: 84
GlueSEUsedOnlineSize: 2
GlueSETotalOnlineSize: 86
GlueSESizeTotal: 86
```

### Careful with the hostname

You must replace `<dcache-host>` in the URI `ldap://<dcache-host>:2170/` with the actual hostname of your node.

It's tempting to use `localhost` in the URI when executing the `ldapsearch` command; however, BDII binds to the ethernet device (e.g., `eth0`). Typically, `localhost` is associated with the loopback device (`lo`), so querying BDII with the URI `ldap://localhost:2170/` will fail.

The LDAP query uses the `o=grid` object as the base; all reported objects are descendant objects of this base object. The `o=grid` base selects only the GLUE v1.3 objects. To see GLUE v2.0 objects, the base object must be `o=glue`.

The above `ldapsearch` command queries BDII using the `(objectClass=GlueSE)` filter. This filter selects only objects that provide the highest-level summary information about a storage-element. Since each



storage-element has only one such object and this BDII instance only describes a single dCache instance, the command returns only the single LDAP object.

To see all GLUE v1.3 objects in BDII, repeat the above **ldapsearch** command but omit the `(objectClass=GlueSE)` filter: **ldapsearch -LLL -x -H ldap://<dcache-host>:2170 -b o=grid**. This command will output all GLUE v1.3 LDAP objects, which includes all the GLUE v1.3 objects from the info-provider.

Searching for all GLUE v2.0 objects in BDII is achieved by repeating the above **ldapsearch** command but omitting the `(objectClass=GlueSE)` filter and changing the search base to `o=glue`: **ldapsearch -LLL -x -H ldap://<dcache-host>:2170 -b o=glue**. This command returns a completely different set of objects from the GLUE v1.3 queries.

You should be able to compare this output with the output from running the info-provider script manually: BDII should contain all the objects that the dCache info-provider is supplying. Unfortunately, the order in which the objects are returned and the order of an object's properties is not guaranteed; therefore a direct comparison of the output isn't possible. However, it is possible to calculate the number of objects in GLUE v1.3 and GLUE v2.0.

First, calculate the number of GLUE v1.3 objects in BDII and compare that to the number of GLUE v1.3 objects that the info-provider supplies.

```
[root] # ldapsearch -LLL -x -H ldap://<dcache-host>:2170 -b o=grid \
'(objectClass=GlueSchemaVersion)' | grep ^dn | wc -l
10
[root] # dcache-info-provider | \
grep -i "objectClass: GlueSchemaVersion" | wc -l
10
```

Now calculate the number of GLUE v2.0 objects in BDII describing your dCache instance and compare that to the number provided by the info-provider:

```
[root] # ldapsearch -LLL -x -H ldap://<dcache-host>:2170 -b o=glue | perl -p00e 's/\n //g' | \
grep dn.*GLUE2ServiceID | wc -l
27
[root] # dcache-info-provider | perl -p00e 's/\n //g' | \
grep ^dn.*GLUE2ServiceID | wc -l
27
```

If there is a discrepancy in the pair of numbers obtained in the above commands then BDII has rejected some of the objects. This is likely due to malformed LDAP objects from the info-provider.

## Troubleshooting BDII problems

The BDII log file should explain why objects are not accepted; for example, due to a badly formatted attribute. The default location of the log file is `/var/log/bdii/bdii-update.log`, but the location is configured by the `BDII_LOG_FILE` option in the `/opt/bdii/etc/bdii.conf` file.

The BDII log files may show entries like:

```
2011-05-11 04:04:58,711: [WARNING] dn: o=shadow
2011-05-11 04:04:58,711: [WARNING] ldapadd: Invalid syntax (21)
2011-05-11 04:04:58,711: [WARNING] additional info: objectclass: value #1 invalid per syntax
```

This problem comes when BDII is attempting to inject new information. Unfortunately, the information isn't detailed enough for further investigation. To obtain more detailed information from BDII, switch

the `BDII_LOG_LEVEL` option in `/opt/bdii/etc/bdii.conf` to `DEBUG`. This will provide more information in the BDII log file.

Logging at `DEBUG` level has another effect; BDII no longer deletes some temporary files. These temporary files are located in the directory controlled by the `BDII_VAR_DIR` option. This is `/var/run/bdii` by default.

There are several temporary files located in the `/var/run/bdii` directory. When BDII decides which objects to add, modify and remove, it creates LDIF instructions inside temporary files `add.ldif`, `modify.ldif` and `delete.ldif` respectively. Any problems in the attempt to add, modify and delete LDAP objects are logged to corresponding error files: errors with `add.ldif` are logged to `add.err`, `modify.ldif` to `modify.err` and so on.

Once information in BDII has stabilised, the only new, incoming objects for BDII come from those objects that it was unable to add previously. This means that `add.ldif` will contain these badly formatted objects and `add.err` will contain the corresponding errors.

## Updating information

The information contained within the `info` service may take a short time to achieve a complete overview of dCache's state. For certain gathered information it may take a few minutes before the information stabilises. This delay is intentional and prevents the gathering of information from adversely affecting dCache's performance.

The information presented by the LDAP server is updated periodically by BDII requesting fresh information from the `info-provider`. The `info-provider` obtains this information by requesting dCache's current status from `info` service. By default, BDII will query the `info-provider` every 60 seconds. This will introduce an additional delay between a change in dCache's state and that information propagating.

Some information is hard-coded within the `info-provider.xml` file; that is, you will need to edit this file before the published value(s) will change. These values are ones that typically a site-admin must choose independently of dCache's current operations.

---

# Chapter 20. Stage Protection

Irina Kozlova

A dCache system administrator may specify a list of DNs/FQANs which are allowed to trigger tape restores for files not being available on disk. Users, requesting tape-only files, and not being on that *white list*, will receive a permission error and no tape operation is launched. Stage protection can be enhanced to allow authorization specific to a dCache storage group. The additional configuration parameter is optional allowing the stage protection to be backwards compatible when stage authorization is not specific to a storage group.

## Configuration of Stage Protection

Stage protection can optionally be configured in the `poolmanager` rather than on the `doors` and the `pinmanager`. Thus the white list needs to be present on a single node only. To enable this, define the following parameter in `/etc/dcache/dcache.conf`:

```
dcache.authz.staging.pep=PoolManager
```

The file name of the white list must be configured by setting the `dcache.authz.staging` parameter in `/etc/dcache/dcache.conf`:

```
dcache.authz.staging=/etc/dcache/StageConfiguration.conf
```

The parameter needs to be defined on all nodes which enforce the stage protection, i.e., either on the `doors` and the `pinmanager`, or in the `poolmanager` depending on the stage policy enforcement point.

## Definition of the White List

The Stage Configuration File will contain a white list. Each line of the white list may contain up to three regular expressions enclosed in double quotes. The regular expressions match the DN, FQAN, and the Storage Group written in the following format:

```
"<DN>" ["<FQAN>" ["<StorageGroup>"]]
```

Lines starting with a hash symbol `#` are discarded as comments.

The regular expression syntax follows the syntax defined for the `Java Pattern` class [<http://java.sun.com/javase/6/docs/api/java/util/regex/Pattern.html>].

### Example:

Here are some examples of the White List Records:

```
".*" "/atlas/Role=production"
"/C=DE/O=DESY/CN=Kermit the frog"
"/C=DE/O=DESY/CN=Beaker" "/desy"
"/O=GermanGrid/.*" "/desy/Role=.*"
```

This example authorizes a number of different groups of users:

- Any user with the FQAN `/atlas/Role=production`.

- The user with the DN `/C=DE/O=DESY/CN=Kermit the frog`, irrespective of which VOMS groups he belongs to.
- The user with the DN `/C=DE/O=DESY/CN=Beaker` but only if he is also identified as a member of VO `desy` (FQAN `/desy`)
- Any user with DN and FQAN that match `/O=GermanGrid/.*` and `/desy/Role=.*` respectively.

If a storage group is specified all three parameters must be provided. The regular expression `".*"` may be used to authorize any DN or any FQAN. Consider the following example:

**Example:**

```
"*" "/atlas/Role=production" "hl:raw@osm"
"/C=DE/O=DESY/CN=Scooter" "*" "sql:chimera@osm"
```

In the example above:

- Any user with FQAN `/atlas/Role=production` is allowed to stage files located in the storage group `hl:raw@osm`.
- The user `/C=DE/O=DESY/CN=Scooter`, irrespective of which VOMS groups he belongs to, is allowed to stage files located in the storage group `sql:chimera@osm`.

With the plain dCap protocol the DN and FQAN are not known for any users.

**Example:**

In order to allow all dCap users to stage files the white list should contain the following record:

```
" " "
```

In case this line is commented or not present in the white list, all dCap users will be disallowed to stage files.

It is possible to allow all dCap users to stage files located in a certain storage group.

**Example:**

In this example, all dCap users are allowed to stage files located in the storage group `hl:raw@osm`:

```
" " "hl:raw@osm"
```

---

# Chapter 21. Using Space Reservations without SRM

If you are using space reservations, i.e. you set

```
dcache.enable.space-reservation=true
```

in your configuration file and all of your pools are in link groups, then you can only write into dCache if a link group is available for your transfer. Using the SRM you can specify the link group to write into. If you want to use another protocol like `curl` or `xrootd` you cannot specify a link group. In this case you need to use the `WriteToken` directory tag.

## The Space Reservation

Before you can create a `WriteToken` tag you need to have a space reservation.

Space reservations are made for link groups. The file `LinkGroupAuthorization.conf` needs to contain the link groups that can be used for space reservations. You need to specify the location of the file in the `/etc/dcache/dcache.conf` file.

```
spacemanager.authz.link-group-file-name=/etc/dcache/LinkGroupAuthorization.conf
```

### Example:

In this example we will create the link group `WriteTokenLinkGroup`. Login to the admin interface, `cd` to the `SrmSpaceManager` and list the current space reservations.

```
(local) admin > cd SrmSpaceManager
(SrmSpaceManager) admin > ls
Reservations:
total number of reservations: 0
total number of bytes reserved: 0

LinkGroups:
total number of linkGroups: 0
total number of bytes reservable: 0
total number of bytes reserved : 0
last time all link groups were updated: Wed Aug 07 15:20:48 CEST 2013(1375881648312)
```

Currently there are no space reservations and no link groups. We create the link group `WriteTokenLinkGroup`.

```
(SrmSpaceManager) admin > ..
(local) admin > cd PoolManager
(PoolManager) admin > psu create pgroup WriteToken_poolGroup
(PoolManager) admin > psu addto pgroup WriteToken_poolGroup pool1
(PoolManager) admin > psu removefrom pgroup default pool1
(PoolManager) admin > psu create link WriteToken_Link any-store world-net any-protocol
(PoolManager) admin > psu set link WriteToken_Link -readpref=10 -writepref=10 -cachepref=0 -
p2ppref=-1
(PoolManager) admin > psu add link WriteToken_Link WriteToken_poolGroup
(PoolManager) admin > psu create linkGroup WriteToken_LinkGroup
(PoolManager) admin > psu set linkGroup custodialAllowed WriteToken_LinkGroup true
(PoolManager) admin > psu set linkGroup replicaAllowed WriteToken_LinkGroup true
(PoolManager) admin > psu set linkGroup nearlineAllowed WriteToken_LinkGroup true
(PoolManager) admin > psu set linkGroup onlineAllowed WriteToken_LinkGroup true
(PoolManager) admin > psu addto linkGroup WriteToken_LinkGroup WriteToken_Link
```

## Using Space Reservations without SRM

```
(PoolManager) admin > save
(PoolManager) admin > ..
(local) admin >

(local) admin > cd SrmSpaceManager
(SrmSpaceManager) admin > ls
Reservations:
total number of reservations: 0
total number of bytes reserved: 0

LinkGroups:
0 Name:WriteToken_LinkGroup FreeSpace:6917935104 ReservedSpace:0 AvailableSpace:6917935104
 VOs: onlineAllowed:true nearlineAllowed:true replicaAllowed:true custodialAllowed:true
 outputAllowed:true UpdateTime:Wed Aug 07 15:42:03 CEST 2013(1375882923234)
total number of linkGroups: 1
total number of bytes reservable: 6917935104
total number of bytes reserved : 0
last time all link groups were updated: Wed Aug 07 15:42:03 CEST 2013(1375882923234)
```

A space reservation can only be made, when there is a link group in the `LinkGroupAuthorization.conf` that can be used for the space reservation. Therefore, we configure the `LinkGroupAuthorization.conf` such that the link group `WriteToken_LinkGroup` can be used.

```
#SpaceManagerLinkGroupAuthorizationFile
this is comment and is ignored

LinkGroup WriteToken_LinkGroup
/Role=
```

Now we can make a space reservation for that link group.

```
(SrmSpaceManager) admin > reserve -desc=WriteToken 6000000 10000
10000 voGroup:null voRole:null retentionPolicy:CUSTODIAL accessLatency:ONLINE linkGroupId:0
size:6000000 created:Fri Aug 09 12:28:18 CEST 2013 lifetime:10000000ms expiration:Fri Aug 09
15:14:58 CEST 2013 description:WriteToken state:RESERVED used:0 allocated:0

(SrmSpaceManager) admin > ls
Reservations:
10000 voGroup:null voRole:null retentionPolicy:CUSTODIAL accessLatency:ONLINE linkGroupId:0
size:6000000 created:Fri Aug 09 12:26:26 CEST 2013 lifetime:10000000ms expiration:Fri Aug 09
15:13:06 CEST 2013 description:WriteToken state:RESERVED used:0 allocated:0
total number of reservations: 1
total number of bytes reserved: 6000000

LinkGroups:
0 Name:WriteToken_LinkGroup FreeSpace:6917849088 ReservedSpace:6000000 AvailableSpace:6911849088
 VOs:{*: *} onlineAllowed:true nearlineAllowed:true replicaAllowed:true custodialAllowed:true
 outputAllowed:true UpdateTime:Fri Aug 09 12:25:57 CEST 2013(1376043957179)
total number of linkGroups: 1
total number of bytes reservable: 6911849088
total number of bytes reserved : 6000000
(SrmSpaceManager) admin >
```

## The WriteToken tag

The `WriteToken` tag is a directory tag. Create the `WriteToken` tag with

```
[root] # /usr/bin/chimera writetag <directory> WriteToken [<IdOfSpaceReservation>]
```

**Example:**

## Using Space Reservations without SRM

In the beginning of the Book we created the directory `/data` and the subdirectory `/data/world-writable`.

```
[root] # /usr/bin/chimera ls /data/
total 3
drwxr-xr-x 3 0 0 512 Jul 23 14:59 .
drwxrwxrwx 3 0 0 512 Jul 24 14:33 ..
drwxrwxrwx 12 0 0 512 Jul 24 14:41 world-writable
```

Now, we create the directory `data/write-token` into which we want to write

```
[root] # /usr/bin/chimera mkdir /data/write-token
[root] # /usr/bin/chimera 777 chmod /data/write-token
[root] # /usr/bin/chimera ls /data/
total 4
drwxr-xr-x 4 0 0 512 Aug 09 12:48 .
drwxrwxrwx 3 0 0 512 Jul 24 14:33 ..
drwxrwxrwx 12 0 0 512 Jul 24 14:41 world-writable
drwxrwxrwx 2 0 0 512 Aug 09 12:48 write-token
```

and echo the space reservation into the `WriteToken` tag.

```
[root] # /usr/bin/chimera writetag /data/write-token WriteToken [10000]
```

## Copy a File into the WriteToken

Given that you have a `WriteToken` tag which contains the id of a valid space reservation, you can copy a file into a space reservation even if you are using a protocol that does not support space reservation.

### Example:

In the above example we echoed the id of a space reservation into the `WriteToken` tag. We can now copy a file into this space reservation.

```
[root] # curl -T test.txt http://webdav-door.example.org:2880/data/write-token/curl-test.txt
[root] #
```

---

# Part III. Cookbook

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This part contains guides for specific tasks a system administrator might want to perform.

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# Chapter 22. dCache Clients.

Owen Syngé

There are many client tools for dCache. These can most easily be classified by communication protocol.

## GSI-FTP

dCache provides a GSI-FTP door, which is in effect a GSI authenticated FTP access point to dCache

### Listing a directory

To list the content of a dCache directory, the GSI-FTP protocol can be used;

```
[user] $ edg-gridftp-ls gsiftp://gridftp-door.example.org/pnfs/example.org/data/dteam/
```

### Checking a file exists

To check the existence of a file with GSI-FTP.

```
[user] $ edg-gridftp-exists gsiftp://gridftp-door.example.org/pnfs/example.org/data/dteam/
filler_test20050819130209790873000
[user] $ echo $?
0
[user] $ edg-gridftp-exists gsiftp://gridftp-door.example.org/pnfs/example.org/data/dteam/
filler_test200508191302097908730002
error the server sent an error response: 451 451 /pnfs/example.org/data/dteam/
filler_test200508191302097908730002 not found
[user] $ echo $?
1
```

#### Use the return code

Please note the `echo $?` show the return code of the last run application. The error message returned from the client this should not be scripted against as it is one of many possible errors.

### Deleting files

To delete files with GSI-FTP use the `edg-gridftp-rm` command.

```
[user] $ edg-gridftp-rm gsiftp://gridftp-door.example.org/pnfs/example.org/data/dteam/
filler_test20050811160948926780000
```

This deletes the file `filler_test20050811160948926780000` from the `/pnfs/example.org/data/dteam` using the door running on the host `gridftp-door.example.org` within the dCache cluster `example.org`

### Copying files

`globus-url-copy` [[command line options]] [`<srcUrl>`] [`<destinationUrl>`] ...

Copying file with **globus-url-copy** follows the syntax source, destination.

### Example:

The following example copies the file `/etc/group` into dCache as the file `/pnfs/example.org/data/dteam/test_GlobusUrlCopy.clinton.504.22080.20071102160121.2`

```
[user] $ globus-url-copy \
file:///etc/group \
gsiftp://gridftp-door.example.org/pnfs/example.org/data/dteam/
test_GlobusUrlCopy.clinton.504.22080.20071102160121.2
```

Please note that the five slashes are really needed.

## dCap

When using **dccp** client or using the interposition library the errors `Command failed!` can be safely ignored.

## dccp

The following example shows **dccp** being used to copy the file `/etc/group` into dCache as the the file `/pnfs/example.org/data/dteam/test6`. The **dccp** program will connect to dCache without authenticating.

```
[user] $ /opt/d-cache/dcap/bin/dccp /etc/group dcap://dcap-door.example.org:22125/pnfs/example.org/
data/dteam/test6
Command failed!
Server error message for [1]: "path /pnfs/example.org/data/dteam/test6 not found" (errno 10001).
597 bytes in 0 seconds
```

The following example shows **dccp** being used to upload the file `/etc/group`. In this example, **dccp** will authenticate with dCache using the GSI protocol.

```
[user] $ /opt/d-cache/dcap/bin/dccp /etc/group gsidcap://gsidcap-door.example.org:22128/pnfs/
example.org/data/dteam/test5
Command failed!
Server error message for [1]: "path /pnfs/example.org/data/dteam/test5 not found" (errno 10001).
597 bytes in 0 seconds
```

The following example shows **dccp** with the debugging enabled. The value 63 controls how much information is displayed.

```
[user] $ /opt/d-cache/dcap/bin/dccp -d 63 /etc/group dcap://dcap-door.example.org:22128/pnfs/
example.org/data/dteam/test3
Dcap Version version-1-2-42 Jul 10 2007 19:56:02
Using system native stat64 for /etc/group.
Allocated message queues 0, used 0

Using environment variable as configuration
Allocated message queues 1, used 1

Creating a new control connection to dcap-door.example.org:22128.
Activating IO tunnel. Provider: [libgsiTunnel.so].
Added IO tunneling plugin libgsiTunnel.so for dcap-door.example.org:22128.
Setting IO timeout to 20 seconds.
Connected in 0.00s.
Removing IO timeout handler.
Sending control message: 0 0 client hello 0 0 2 42 -uid=501 -pid=32253 -gid=501
```

```

Server reply: welcome.
dcap_pool: POLLIN on control line [3] id=1
Connected to dcap-door.example.org:22128
Sending control message: 1 0 client stat "dcap://dcap-door.example.org:22128/pnfs/example.org/data/
dteam/test3" -uid=501
Command failed!
Server error message for [1]: "path //pnfs/example.org/data/dteam/test3 not found" (errno 10001).
[-1] unplugging node
Removing unneeded queue [1]
[-1] destroying node
Real file name: /etc/group.
Using system native open for /etc/group.
extra option: -alloc-size=597
[Fri Sep 7 17:50:56 2007] Going to open file dcap://dcap-door.example.org:22128/pnfs/example.org/
data/dteam/test3 in cache.
Allocated message queues 2, used 1

Using environment variable as configuration
Activating IO tunnel. Provider: [libgsiTunnel.so].
Added IO tunneling plugin libgsiTunnel.so for dcap-door.example.org:22128.
Using existing control connection to dcap-door.example.org:22128.
Setting hostname to dcap-door.example.org.
Sending control message: 2 0 client open "dcap://dcap-door.example.org:22128/pnfs/example.org/data/
dteam/test3" w -mode=0644 -truncate dcap-door.example.org 33122 -timeout=-
1 -onerror=default -alloc-size=597 -uid=501
Polling data for destination[6] queueID[2].
Got callback connection from dcap-door.example.org:35905 for session 2, myID 2.
cache_open -> OK
Enabling checksumming on write.
Cache open succeeded in 0.62s.
[7] Sending IOCMD_WRITE.
Entered sendDataMessage.
Polling data for destination[7] queueID[2].
[7] Got reply 4x12 bytes len.
[7] Reply: code[6] response[1] result[0].
get_reply: no special fields defined for that type of response.
[7] Got reply 4x12 bytes len.
[7] Reply: code[7] response[1] result[0].
get_reply: no special fields defined for that type of response.
[7] Expected position: 597 @ 597 bytes written.
Using system native close for [5].
[7] unplugging node
File checksum is: 460898156
Sending CLOSE for fd:7 ID:2.
Setting IO timeout to 300 seconds.
Entered sendDataMessage.
Polling data for destination[7] queueID[2].
[7] Got reply 4x12 bytes len.
[7] Reply: code[6] response[4] result[0].
get_reply: no special fields defined for that type of response.
Server reply: ok destination [2].
Removing IO timeout handler.
Removing unneeded queue [2]
[7] destroying node
597 bytes in 0 seconds
Debugging

```

## Using the dCache client interposition library.

### Finding the GSI tunnel.

When the LD\_PRELOAD library `libpdcap.so` variable produces errors finding the GSI tunnel it can be useful to specify the location of the GSI tunnel library directly using the following command:

```
[user] $ export
DCACHE_IO_TUNNEL=/opt/d-cache/dcap/lib/libgsiTunnel.so
```

Please see [http://www.dcache.org/manuals/experts\\_docs/tunnel-HOWTO.html](http://www.dcache.org/manuals/experts_docs/tunnel-HOWTO.html) for further details on tunnel setup for the server.

dCap is a POSIX like interface for accessing dCache, allowing unmodified applications to access dCache transparently. This access method uses a proprietary data transfer protocol, which can emulate POSIX access across the LAN or WAN.

Unfortunately the client requires inbound connectivity and so it is not practical to use this protocol over the WAN as most sites will not allow inbound connectivity to worker nodes.

To make non dCache aware applications access files within dCache through dCap all that is needed is set the LD\_PRELOAD environment variable to `/opt/d-cache/dcap/lib/libpdcap.so`.

```
[user] $ export LD_PRELOAD=/opt/d-cache/dcap/lib/libpdcap.so
```

Setting the LD\_PRELOAD environment variable results in the library `libpdcap.so` overriding the operating system calls. After setting this environment variable, the standard shell command should work with dCap and GSIdCap URLs.

### Example:

The following session demonstrates copying a file into dCache, checking the file is present with the `ls` command, reading the first 3 lines from dCache and finally deleting the file.

```
[user] $ cp /etc/group gsidcap://gsidcap-door.example.org:22128/pnfs/example.org/data/dteam/myFile
[user] $ ls gsidcap://gsidcap-door.example.org:22128/pnfs/example.org/data/dteam/DirOrFile
[user] $ head -3 gsidcap://gsidcap-door.example.org:22128/pnfs/example.org/data/dteam/myFile
root:x:0:
daemon:x:1:
bin:x:2:
[user] $ rm gsidcap://gsidcap-door.example.org:22128/pnfs/example.org/data/dteam/MyFile
```

## SRM

dCache provides a series of clients one of which is the SRM client which supports a large number operations, but is just one Java application, the script name is sent to the Java applications command line to invoke each operation.

This page just shows the scripts command line and not the invocation of the Java application directly.

## Creating a new directory.

Usage:

```
srmmkdir [[command line options]] [<srmUrl>]
```

Example:

### Example:

The following example creates the directory `/pnfs/example.org/data/dteam/myDir`.

```
[user] $ srmmkdir srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/myDir
```

## Removing files from dCache

Usage:

```
srmrm [[command line options]] [<srmUrl> ...]
```

### Example:

```
[user] $ srmrm srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/myDir/myFile
```

## Removing empty directories from dCache

It is allowed to remove only empty directories as well as trees of empty directories.

Usage:

```
srmrmdir [command line options] [<srmUrl>]
```

Examples:

### Example:

```
[user] $ srmrmdir srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/myDir
```

### Example:

```
[user] $ srmrmdir -recursive=true srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/myDir
```

## srmcp for SRM v1

Usage:

```
srmcp [command line options] <source>... [<destination>]
```

or

```
srmcp [command line options] [-copyjobfile] <file>
```

## Copying files to dCache

### Example:

```
[user] $ srmcp -webservice_protocol=http \
```

```
file:///etc/group \
srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/
test_Srm.clinton.501.32050.20070907153055.0
```

## Copying files from dCache

```
[user] $ srmcp -webservice_protocol=http \
srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/
test_Srm.clinton.501.32050.20070907153055.0 \
file:///tmp/testfile1 -streams_num=1
```

## srmcp for SRM v2.2

## Getting the dCache Version

The `srmcping` command will tell you the version of dCache. This only works for authorized users and not just authenticated users.

```
[user] $ srmcping -2 srm://srm-door.example.org:8443/pnfs
WARNING: SRM_PATH is defined, which might cause a wrong version of srm client to be executed
WARNING: SRM_PATH=/opt/d-cache/srm
VersionInfo : v2.2
backend_type:dCache
backend_version:production-1-9-1-11
```

## Space Tokens

Space token support must be set up and reserving space with the admin interface this is also documented in the SRM section and in the dCache wiki [[http://trac.dcache.org/projects/dcache/wiki/manuals/SRM\\_2.2\\_Setup](http://trac.dcache.org/projects/dcache/wiki/manuals/SRM_2.2_Setup)].

## Space Token Listing

Usage:

```
get-space-tokens [command line options] [<srmUrl>]
```

### Example 22.1. surveying the space tokens available in a directory.

```
[user] $ srm-get-space-tokens srm://srm-door.example.org:8443/pnfs/example.org/data/dteam -
srm_protocol_version=2
```

A successful result:

```
return status code : SRM_SUCCESS
return status expl. : OK
Space Reservation Tokens:
148241
148311
148317
28839
148253
148227
148229
148289
148231
148352
```

## Example 22.2. Listing the space tokens for a SRM:

```
[user] $ srm-get-space-tokens srm://srm-door.example.org:8443
Space Reservation Tokens:
145614
145615
144248
144249
25099
145585
145607
28839
145589
```

## Space Reservation

Usage:

srm-reserve-space [[command line options]] [[srmUrl](#)]

```
[user] $ srm-reserve-space \
-desired_size 2000 \
-srm_protocol_version=2 \
-retention_policy=REPLICA \
-access_latency=ONLINE \
-guaranteed_size 1024 \
-lifetime 36000 \
srm://srm-door.example.org:8443/pnfs/example.org/data/dteam
```

A successful result:

```
Space token =144573
```

A typical failure

```
SRMClientV2 : srmStatusOfReserveSpaceRequest , contacting service http://srm-door.example.org:8443/
srm/managerv2
status: code=SRM_NO_FREE_SPACE explanantion= at Thu Nov 08 15:29:44 CET 2007 state Failed : no space
available
lifetime = null
access latency = ONLINE
retention policy = REPLICA
guaranteed size = null
total size = 34
```

Also you can get info for this space token 144573:

```
[user] $ srm-get-space-metadata srm://srm-door.example.org:8443/pnfs/example.org/data/dteam -
space_tokens=144573
```

Possible result:

```
Space Reservation with token=120047
 owner:VoGroup=/dteam VoRole=NULL
 totalSize:1024
 guaranteedSize:1024
 unusedSize:1024
 lifetimeAssigned:36000
 lifetimeLeft:25071
 accessLatency:ONLINE
 retentionPolicy:REPLICA
```

## Writing to a Space Token

Usage: srmcp [command line options] source(s) destination

Examples:

```
[user] $ srmcp -protocols=gsiftp -space_token=144573 \
file:///home/user/path/to/myFile \
srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/myFile
```

```
[user] $ srmcp -protocols=gsiftp -space_token=144573 \
file:///home/user/path/to/myFile1 \
file:///home/user/path/to/myFile2 \
srm://srm-door.example.org:8443/pnfs/example.org/data/dteam
```

## Space Metadata

Users can get the metadata available for the space, but the ability to query the metadata of a space reservation may be restricted so that only certain users can obtain this information.

```
[user] $ srm-get-space-metadata srm://srm-door.example.org:8443/pnfs/example.org/data/dteam -
space_tokens=120049
WARNING: SRM_PATH is defined, which might cause a wrong version of srm client to be executed
WARNING: SRM_PATH=/opt/d-cache/srm
Space Reservation with token=120049
 owner:VoGroup=/dteam VoRole=NULL
 totalSize:1024
 guaranteedSize:1024
 unusedSize:1024
 lifetimeAssigned:36000
 lifetimeLeft:30204
 accessLatency:ONLINE
 retentionPolicy:REPLICA
```

## Space Token Release

Removes a space token from the SRM.

```
[user] $ srm-release-space srm://srm-door.example.org:8443 -space_token=15
```

## Listing a file in SRM

SRM version 2.2 has a much richer set of file listing commands.

Usage:

srm ls [command line options] <srmUrl>...

### Example 22.3. Using srm ls -l:

```
[user] $ srm ls srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/testdir -l -2
0 /pnfs/example.org/data/dteam/testdir/
 31 /pnfs/example.org/data/dteam/testdir/testFile1
 31 /pnfs/example.org/data/dteam/testdir/testFile2
 31 /pnfs/example.org/data/dteam/testdir/testFile3
 31 /pnfs/example.org/data/dteam/testdir/testFile4
 31 /pnfs/example.org/data/dteam/testdir/testFile5
```

## Note

The `-l` option results in `srm ls` providing additional information. Collecting this additional information may result in a dramatic increase in execution time.



**Example 22.4. Using `srmls -l`:**

```
[user] $ srmls -l srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/testdir -2
0 /pnfs/example.org/data/dteam/testdir/
storage type:PERMANENT
retention policy:CUSTODIAL
access latency:NEARLINE
locality:NEARLINE
locality: null
 UserPermission: uid=18118 PermissionsRWX
 GroupPermission: gid=2688 PermissionsRWX
 WorldPermission: RX
created at:2007/10/31 16:16:32
modified at:2007/11/08 18:03:39
- Assigned lifetime (in seconds): -1
- Lifetime left (in seconds): -1
- Original SURL: /pnfs/example.org/data/dteam/testdir
- Status: null
- Type: DIRECTORY
 31 /pnfs/example.org/data/dteam/testdir/testFile1
 storage type:PERMANENT
 retention policy:CUSTODIAL
 access latency:NEARLINE
 locality:NEARLINE
 - Checksum value: 84d007af
 - Checksum type: Adler32
 UserPermission: uid=18118 PermissionsRW
 GroupPermission: gid=2688 PermissionsR
 WorldPermission: R
 created at:2007/11/08 15:47:13
 modified at:2007/11/08 15:47:13
 - Assigned lifetime (in seconds): -1
 - Lifetime left (in seconds): -1
 - Original SURL: /pnfs/example.org/data/dteam/testdir/testFile1
- Status: null
- Type: FILE
```

If you have more than 1000 entries in your directory then dCache will return only the first 1000. To view directories with more than 1000 entries, please use the following parameters:

**srmls parameters**

`-count=<integer>`

The number of entries to report.

`-offset=<integer>`

## Example 22.5. Limited directory listing

The first command shows the output without specifying `-count` or `-offset`. Since the directory contains less than 1000 entries, all entries are listed.

```
[user] $ srmls srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/dir1 \
srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/dir2
 0 /pnfs/example.org/data/dteam/dir1/
 31 /pnfs/example.org/data/dteam/dir1/myFile1
 28 /pnfs/example.org/data/dteam/dir1/myFile2
 47 /pnfs/example.org/data/dteam/dir1/myFile3
 0 /pnfs/example.org/data/dteam/dir2/
 25 /pnfs/example.org/data/dteam/dir2/fileA
 59 /pnfs/example.org/data/dteam/dir2/fileB
```

The following examples shows the result when using the `-count` option to listing the first three entries.

```
[user] $ srmls -count=3 srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/testdir -
srm_protocol_version=2
 0 /pnfs/example.org/data/dteam/testdir/
 31 /pnfs/example.org/data/dteam/testdir/testFile1
 31 /pnfs/example.org/data/dteam/testdir/testFile2
 31 /pnfs/example.org/data/dteam/testdir/testFile3
```

In the next command, the `-offset` option is used to view a different set of entries.

```
[user] $ srmls -count=3 -offset=1 srm://srm-door.example.org:8443/pnfs/example.org/data/dteam/testdir
-srm_protocol_version=2
 0 /pnfs/example.org/data/dteam/testdir/
 31 /pnfs/example.org/data/dteam/testdir/testFile2
 31 /pnfs/example.org/data/dteam/testdir/testFile3
 31 /pnfs/example.org/data/dteam/testdir/testFile4
```

## ldap

dCache is commonly deployed with the BDII. The information provider within dCache publishes information to BDII. To querying the dCache BDII is a matter of using the standard command `ldapsearch`. For grid the standard ldap port is set to 2170 from the previous value of 2135.

```
[user] $ ldapsearch -x -H ldap://localhost:2170 -b mds-vo-name=resource,o=grid > /tmp/
ldap.output.ldif
[user] $ wc -l /tmp/ldap.output.ldif
205 /tmp/ldap.output.ldif
```

As can be seen from above even a single node standard install of dCache returns a considerable number of lines and for this reason we have not included the output, in this case 205 lines where written.

## Using the LCG commands with dCache

The `lcg_util` RPM contains many small command line applications which interact with SRM implementations, these were developed independently from dCache and provided by the LCG grid computing effort.

Each command line application operates on a different method of the SRM interface. These applications were not designed for normal use but to provide components upon which operations can be built.

**lcg-gt** queries the BDII information server. This adds an additional requirement that the BDII information server can be found by **lcg-gt**, please only attempt to contact servers found on your user interface using.

```
[user] $ lcg-infosites --vo dteam se
```

## The lcg-gt Application

SRM provides a protocol negotiating interface, and returns a TURL (transfer URL). The protocol specified by the client will be returned by the server if the server supports the requested protocol.

To read a file from dCache using **lcg-gt** you must specify two parameters the SURL (storage URL), and the protocol (GSIdCap or GSI-FTP) you wish to use to access the file.

```
[user] $ lcg-gt srm://srm-door.example.org/pnfs/example.org/data/dteam/group gsidcap
gsidcap://gsidcap-door.example.org:22128/pnfs/example.org/data/dteam/group
-2147365977
-2147365976
```

Each of the above three lines contains different information. These are explained below.

gsidcap://gsidcap-door.example.org:22128/pnfs/example.org/data/dteam/group is the transfer URL (TURL).

-2147365977 is the SRM Request Id, Please note that it is a negative number in this example, which is allowed by the specification.

-2147365976 is the Unique identifier for the file with respect to the Request Id. Please note that with this example this is a negative number.

### Remember to return your Request Id

dCache limits the number of Request Ids a user may have. All Request Ids should be returned to dCache using the command **lcg-sd**.

If you use **lcg-gt** to request a file with a protocol that is not supported by dCache the command will block for some time as dCache's SRM interface times out after approximately 10 minutes.

## The lcg-sd Application

This command should be used to return any TURLs given by dCache's SRM interface. This is because dCache provides a limited number of TURLs available concurrently.

**lcg-sd** takes four parameters: the SURL, the Request Id, the File Id with respect to the Request Id, and the direction of data transfer.

The following example is to complete the get operation, the values are taken from the above example of **lcg-gt**.

```
[user] $ lcg-sd srm://srm-door.example.org:22128/pnfs/example.org/data/dteam/group " -2147365977" "
-2147365976" 0
```

### Negative numbers

dCache returns negative numbers for Request Id and File Id. Please note that **lcg-sd** requires that these values are placed in double-quotes with a single space before the - sign.

The `Request Id` is one of the values returned by the **lcg-gt** command. In this example, the value (-2147365977) comes from the above example **lcg-gt**.

The `File Id` is also one of the values returned returned by the **lcg-gt** command. In this example, the value (-2147365976) comes from the above example **lcg-gt**.

The `direction` parameter indicates in which direction data was transferred: 0 for reading data and 1 for writing data.

---

# Chapter 23. Pool Operations

## Checksums

In dCache the storage of a checksum is part of a successful transfer.

- For an incoming transfer a checksum can be sent by the client (*Client Checksum*, it can be calculated during the transfer (*Transfer Checksum*) or it can be calculated on the server after the file has been written to disk (*Server File Checksum*).
- For a pool to pool transfer a Transfer Checksum or a Server File Checksum can be calculated.
- For data that is flushed to or restored from tape a checksum can be calculated before flushed to tape or after restored from tape, respectively.

### Client Checksum

The client calculates the checksum before or while the data is sent to dCache. The checksum value, depending on when it has been calculated, may be sent together with the open request to the door and stored into Chimera before the data transfer begins or it may be sent with the close operation after the data has been transferred.

The dCap protocol provides both methods, but the dCap clients use the latter by default.

The FTP protocol does not provide a mechanism to send a checksum. Nevertheless, some FTP clients can (mis-)use the “site” command to send the checksum prior to the actual data transfer.

### Transfer Checksum

While data is coming in, the server data mover may calculate the checksum on the fly.

### Server File Checksum

After all the file data has been received by the dCache server and the file has been fully written to disk, the server may calculate the checksum, based on the disk file.

The default configuration is that a checksum is calculated on write, i.e. a Server File Checksum.

## How to configure checksum calculation

Configure the calculation of checksums in the admin interface. The configuration has to be done for each pool separately.

```
(local) admin > cd <poolname>
(<poolname>) admin > csm set policy --<option>=<on/off>
(<poolname>) admin > save
```

The configuration will be saved in the file `<path/to/pool>/<nameOfPooldirectory>/setup`.

Use the command **csm info** to see the checksum policy of the pool.

```
(<poolname>) admin > csm info
Policies :
```

```
 on read : false
 on write : true
 on flush : false
 on restore : false
 on transfer : false
 enforce crc : true
 getcrcfromhsm : false
 scrub : false
```

The default configuration is to check checksums on write.

Use the command **help csm set policy** to see the configuration options.

The syntax of the command **csm set policy** is

```
csm set policy [-<option>=on [[off]]]
where <option> can be replaced by
```

## OPTIONS

`ontransfer`

If supported by the protocol, the checksum is calculated during file transfer.

`onwrite`

The checksum is calculated after the file has been written to disk.

`onrestore`

The checksum is calculated after data has been restored from tape.

`onflush`

The checksum is calculated before data is flushed to tape.

`getcrcfromhsm`

If the HSM script supports it, the `<pnfsid>.crcval` file is read and stored in Chimera.

`scrub`

Pool data will periodically be verified against checksums. Use the command **help csm set policy** to see the configuration options.

`enforcecrc`

If no checksum has been calculated after or during the transfer, this option ensures that a checksum is calculated and stored in Chimera.

The option `onread` has not yet been implemented.

If an option is enabled a checksum is calculated as described. If there is already another checksum, the checksums are compared and if they match stored in Chimera.

## Important

Do not change the default configuration for the option `enforcecrc`. This option should always be enabled as this ensures that there will always be a checksum stored with a file.

# Migration Module

The purpose of the migration module is essentially to copy or move the content of a pool to one or more other pools.

Typical use cases for the migration module include:

- Vacating pools, that is, moving all files to other pools before decommissioning the pool.
- Caching data on other pools, thus distributing the load and increasing availability.
- As an alternative to the hopping manager.

## Overview and Terminology

The migration module runs inside pools and hosts a number of migration jobs. Each job operates on a set of files on the pool on which it is executed and can copy or move those files to other pools. The migration module provides filters for defining the set of files on which a job operates.

The act of copying or moving a single file is called a migration task. A task selects a target pool and asks it to perform a pool to pool transfer from the source pool. The actual transfer is performed by the same component performing other pool to pool transfers. The migration module does not perform the transfer; it only orchestrates it.

The state of the target copy (the target state) as well as the source copy (the source state) can be explicitly defined. For instance, for vacating a pool the target state is set to be the same as the original source state, and the source state is changed to removed; for caching files, the target state is set to cached, and the source state is unmodified.

Sticky flags owned by the pin manager are never touched by a migration job, however the migration module can ask the pin manager to move the pin to the target pool. Care has been taken that unless the pin is moved by the pin manager, the source file is not deleted by a migration job, even if asked to do so. To illustrate this, assume a source file marked precious and with two sticky flags, one owned by foobar and the other by the pin manager. If a migration job is configured to delete the source file, but not to move the pin, the result will be that the file is marked cached, and the sticky flag owned by foobar is removed. The pin remains. Once it expires, the file is eligible for garbage collection.

All operations are idempotent. This means that a migration job can be safely rerun, and as long as everything else is unchanged, files will not be transferred again. Because jobs are idempotent they do not need to maintain persistent state, which in turns means the migration module becomes simpler and more robust. Should a pool crash during a migration job, the job can be rerun and the remaining files will be transferred.

### Note

Please notice that a job is only idempotent as long as the set of target pools do not change. If pools go offline or are excluded as a result of a an exclude or include expression, then the idempotent nature of a job may be lost.

It is safe to run migration jobs while pools are in use. Once started, migration jobs run to completion and do only operate on those files that matched the selection filters at the time the migration job started. New

files that arrive on the pool are not touched. Neither are files that change state after a migration job has been initialized, even though the selection filters would match the new state of the file. The exception to the rule is when files are deleted from the pool or change state so that they no longer match the selection filter. Such files will be excluded from the migration job, unless the file was already processed. Rerunning a migration job will force it to pick up any new files. Because the job is idempotent, any files copied before are not copied again.

Permanent migration jobs behave differently. Rather than running to completion, permanent jobs keep running until explicitly cancelled. They monitor the pool for any new files or state changes, and dynamically add or remove files from the transfer queue. Permanent jobs are made persistent when the **save** command is executed and will be recreated on pool restart. The main use case for permanent jobs is as an alternative to using a central hopping manager.

Idempotence is achieved by locating existing copies of a file on any of the target pools. If an existing copy is found, rather than creating a new copy, the state of the existing copy is updated to reflect the target state specified for the migration job. Care is taken to never make a file more volatile than it already is: Sticky flags are added, or existing sticky flags are extended, but never removed or shortened; cached files may be marked precious, but not vice versa. One caveat is when the target pool containing the existing copy is offline. In that case the existence of the copy cannot be verified. Rather than creating a new copy, the task fails and the file is put back into the transfer queue. This behaviour can be modified by marking a migration job as eager. Eager jobs create new copies if an existing copy cannot be immediately verified. As a rule of thumb, permanent jobs should never be marked eager. This is to avoid that a large number of unnecessary copies are created when several pools are restarted simultaneously.

A migration task aborts whenever it runs into a problem. The file will be reinserted at the end of the transfer queue. Consequently, once a migration job terminates, all files have been successfully transferred. If for some reason tasks for particular files keep failing, then the migration job will never terminate by itself as it retries indefinitely.

## Command Summary

Login to the admin interface and **cd** to a pool to use the **migration** commands. Use the command **help migration** to view the possibilities.

```
(local) admin > cd <poolname>
(<poolname>) admin > help migration
migration cache [OPTIONS] TARGET...
migration cancel [-force] JOB
migration clear
migration concurrency ID CONCURRENCY
migration copy [OPTIONS] TARGET...
migration info JOB
migration ls
migration move [OPTIONS] TARGET...
migration resume JOB
migration suspend JOB
```

The commands **migration copy**, **migration cache** and **migration move** create new migration jobs. These commands are used to copy files to other pools. Unless filter options are specified, all files on the source pool are copied. The syntax for these commands is the same; example **migration copy**:

```
migration <copy> [<option>] <target>
```



There are four different types of options. The filter options, transfer options, target options and lifetime options. Please run the command **help migration copy** for a detailed description of the various options.

The commands **migration copy**, **migration move** and **migration cache** take the same options and only differ in default values.

migration move

The command **migration move** does the same as the command **migration copy** with the options:

- -smode=delete (default for **migration copy** is same).
- -pins=move (default for **migration copy** is keep).

additionally it uses the option `-verify`.

migration cache

The command **migration cache** does the same as the command **migration copy** with the option:

- -tmode=cached

Jobs are assigned a job ID and are executed in the background. The status of a job may be queried through the **migration info** command. A list of all jobs can be obtained through **migration ls**. Jobs stay in the list even after they have terminated. Terminated jobs can be cleared from the list through the **migration clear** command.

Jobs can be suspended, resumed and cancelled through the **migration suspend**, **migration resume** and **migration cancel** commands. Existing tasks are allowed to finish before a job is suspended or cancelled.

**Example:**

A migration job can be suspended and resumed with the commands **migration suspend** and **migration resume** respectively.

```
(local) admin > cd <poolname>
(<poolname>) admin > migration copy -pnfsid=000060D40698B4BF4BE284666ED29CC826C7 pool2
[1] INITIALIZING migration copy 000060D40698B4BF4BE284666ED29CC826C7 pool2
[1] SLEEPING migration copy 000060D40698B4BF4BE284666ED29CC826C7 pool2
(<poolname>) admin > migration ls
[1] RUNNING migration copy 000060D40698B4BF4BE284666ED29CC826C7 pool2
(<poolname>) admin > migration suspend 1
[1] SUSPENDED migration copy 000060D40698B4BF4BE284666ED29CC826C7 pool2
(<poolname>) admin > migration resume 1
[1] RUNNING migration copy 000060D40698B4BF4BE284666ED29CC826C7 pool2
(<poolname>) admin > migration info 1
Command : migration copy -pnfsid=000060D40698B4BF4BE284666ED29CC826C7 pool2
State : RUNNING
Queued : 0
Attempts : 1
Targets : pool2
Completed : 0 files; 0 bytes; 0%
Total : 5242880 bytes
Concurrency: 1
Running tasks:
[1] 00007C75C2E635CD472C8A75F5A90E4960D3: TASK.GettingLocations
(<poolname>) admin > migration info 1
Command : migration copy -pnfsid=000060D40698B4BF4BE284666ED29CC826C7 pool2
State : FINISHED
Queued : 0
```

```
Attempts : 1
Targets : pool2
Completed : 1 files; 5242880 bytes
Total : 5242880 bytes
Concurrency : 1
Running tasks:
(<poolname>) admin > migration ls
[1] FINISHED migration copy 000060D40698B4BF4BE284666ED29CC826C7 pool2
```

A migration job can be cancelled with the command **migration cancel** .

```
(local) admin > cd <poolname>
(<poolname>) admin > migration copy -pnfsid=0000D194FBD450A44D3EA606D0434D6D88CD pool2
[1] INITIALIZING migration copy 0000D194FBD450A44D3EA606D0434D6D88CD pool2
(<poolname>) admin > migration cancel 1
[1] CANCELLED migration copy -pnfsid=0000D194FBD450A44D3EA606D0434D6D88CD pool2
```

And terminated jobs can be cleared with the command **migration clear**.

```
(<poolname>) admin > migration ls
[3] FINISHED migration copy -pnfsid=0000D194FBD450A44D3EA606D0434D6D88CD pool2
[2] FINISHED migration copy -pnfsid=00007C75C2E635CD472C8A75F5A90E4960D3 pool2
[1] FINISHED migration copy -pnfsid=0000A48650142CBF4E55A7A26429DFEA27B6 pool2
[5] FINISHED migration move -pnfsid=000028C0C288190C4CE7822B3DB2CA6395E2 pool2
[4] FINISHED migration move -pnfsid=00007C75C2E635CD472C8A75F5A90E4960D3 pool2
(<poolname>) admin > migration clear
(<poolname>) admin > migration ls
```

Except for the number of concurrent tasks, transfer parameters of existing jobs cannot be changed. This is by design to ensure idempotency of jobs. The concurrency can be altered through the **migration concurrency** command.

```
(<poolname>) admin > migration concurrency 4 2
(<poolname>) admin > migration info
Command : migration copy pool2
State : FINISHED
Queued : 0
Attempts : 6
Targets : pool2
Completed : 6 files; 20976068 bytes
Total : 20976068 bytes
Concurrency : 2
Running tasks:
```

## Examples

### Vacating a pool

#### Example:

To vacate the pool `<sourcePool>`, we first mark the pool read-only to avoid that more files are added to the pool, and then move all files to the pool `<targetPool>`. It is not strictly necessary to mark the pool read-only, however if not done there is no guarantee that the pool is empty when the migration job terminates. The job can be rerun to move remaining files.

```
(<sourcePool>) admin > pool disable -rdonly
(<sourcePool>) admin > migration move <targetPool>
```

```
[1] RUNNING migration move <targetPool>
(<sourcePool>) admin > migration info 1
Command : migration move <targetPool>
State : RUNNING
Queued : 0
Attempts : 1
Targets : <targetPool>
Completed : 0 files; 0 bytes; 0%
Total : 830424 bytes
Concurrency: 1
Running tasks:
[0] 000100000000000000000000BF4E0: TASK.Copying -> [<targetPool>@local]
(<sourcePool>) admin > migration info 1
Command : migration move <targetPool>
State : FINISHED
Queued : 0
Attempts : 1
Targets : <targetPool>
Completed : 1 files; 830424 bytes
Total : 830424 bytes
Concurrency: 1
Running tasks:
(<sourcePool>) admin > rep ls
(<sourcePool>) admin >
```

## Caching recently accessed files

### Example:

Say we want to cache all files belonging to the storage group `atlas:default` and accessed within the last month on a set of low-cost cache pools defined by the pool group `cache_pools`. We can achieve this through the following command.

```
(<sourcePool>) admin > migration cache -target=pgroup -accessed=0..2592000 -storage=atlas:default
cache_pools
[1] INITIALIZING migration cache -target=pgroup -accessed=0..2592000 -storage=atlas:default
cache_pools
(<sourcePool>) admin > migration info 1
Command : migration cache -target=pgroup -accessed=0..2592000 -storage=atlas:default
cache_pools
State : RUNNING
Queued : 2577
Attempts : 2
Targets : pool group cache_pools, 5 pools
Completed : 1 files; 830424 bytes; 0%
Total : 2143621320 bytes
Concurrency: 1
Running tasks:
[72] 000100000000000000000000BE10: TASK.Copying -> [pool_2@local]
```

The files on the source pool will not be altered. Any file copied to one of the target pools will be marked cached.

## Renaming a Pool

A pool may be renamed with the following procedure, regardless of the type of files stored on it.

Disable file transfers from and to the pool with

```
(<poolname>) admin > pool disable -strict
```

Then make sure, no transfers are being processed anymore. All the following commands should give no output:

```
(<poolname>) admin > queue ls queue
(<poolname>) admin > mover ls
(<poolname>) admin > p2p ls
(<poolname>) admin > pp ls
(<poolname>) admin > st jobs ls
(<poolname>) admin > rh jobs ls
```

Now the files on the pools have to be unregistered on the namespace server with

```
(<poolname>) admin > pnfs unregister
```

## Note

Do not get confused that the commands **pnfs unregister** and **pnfs register** contain **pnfs** in their names. They also apply to dCache instances with Chimera and are named like that for legacy reasons. Even if the pool contains precious files, this is no problem, since we will register them again in a moment. The files might not be available for a short moment, though. Log out of the pool, and stop the domain running the pool:

```
[root] # dcache stop <poolDomain>
Stopping <poolDomain> (pid=6070) 0 1 2 3 done
[root] #
```

Adapt the name of the pool in the layout files of your dCache installation to include your new pool-name. For a general overview of layout-files see the section called “Defining domains and services”.

## Example:

For example, to rename a pool from `swimmingPool` to `carPool`, change your layout file from

```
[<poolDomain>]
[<poolDomain>/pool]
name=swimmingPool
path=/pool/
```

to

```
[<poolDomain>]
[<poolDomain>/pool]
name=carPool
path=/pool/
```

## Warning

Be careful about renaming pools in the layout after users have already been writing to them. This can cause inconsistencies in other components of dCache, if they are relying on pool names to provide their functionality. An example of such a component is the Chimera cache info.

Start the domain running the pool:

```
[root] # dcache start <poolDomain>
Starting poolDomain done
[root] #
```

Register the files on the pool with

```
(<poolname>) admin > pnfs register
```

## Pinning Files to a Pool

You may pin a file locally within the private pool repository:

```
(<poolname>) admin > rep set sticky <pnfsid> on|off
```

the `sticky` mode will stay with the file as long as the file is in the pool. If the file is removed from the pool and recreated afterwards this information gets lost.

You may use the same mechanism globally: in the command line interface (local mode) there is the command

```
(local) admin > set sticky <pnfsid>
```

This command does:

1. Flags the file as `sticky` in the name space database (Chimera). So from now the filename is globally set `sticky`.
2. Will go to all pools where it finds the file and will flag it `sticky` in the pools.
3. All new copies of the file will become `sticky`.

---

# Chapter 24. PostgreSQL and dCache

PostgreSQL is used for various things in a dCache system: The *SRM*, the *pin manager*, the *space manager*, the *replica manager*, the *billing*, and the *pnfs* server might make use of one or more databases in a single or several separate PostgreSQL servers.

The SRM, the pin manager, the space manager and the replica manager will use the PostgreSQL database as configured at cell start-up in the corresponding batch files. The *billing* will only write the accounting information into a database if it is configured with the option `-useSQL`. The *pnfs* server will use a PostgreSQL server if the `pnfs-posgresql` version is used. It will use several databases in the PostgreSQL server.

## Installing a PostgreSQL Server

The preferred way to set up a PostgreSQL server should be the installation of the version provided by your OS distribution; however, version 8.3 or later is required.

Install the PostgreSQL server, client and JDBC support with the tools of the operating system.

Initialize the database directory (for PostgreSQL version 9.2 this is `/var/lib/pgsql/9.2/data/`), start the database server, and make sure that it is started at system start-up.

```
[root] # service postgresql-9.2 initdb
Initializing database: [OK]
[root] # service postgresql-9.2 start
Starting postgresql-9.2 service: [OK]
[root] # chkconfig postgresql-9.2 on
```

## Configuring Access to PostgreSQL

In the installation guide instructions are given for configuring one PostgreSQL server on the admin node for all the above described purposes with generous access rights. This is done to make the installation as easy as possible. The access rights are configured in the file `<database_directory_name>/data/pg_hba.conf`. According to the installation guide the end of the file should look like

```
...
TYPE DATABASE USER IP-ADDRESS IP-MASK METHOD
local all all trust
host all all 127.0.0.1/32 trust
host all all ::1/128 trust
host all all <HostIP>/32 trust
```

This gives access to all databases in the PostgreSQL server to all users on the admin host.

The databases can be secured by restricting access with this file. E.g.

```
...
TYPE DATABASE USER IP-ADDRESS METHOD
local all postgres ident sameuser
local all pnfsserver password
local all all md5
host all all 127.0.0.1/32 md5
host all all ::1/128 md5
host all all <HostIP>/32 md5
```

To make the server aware of this you need to reload the configuration file as the user `postgres` by:

```
[root] # su - postgres
[postgres] # pg_ctl reload
```

And the password for e.g. the user `pnfsserver` can be set with

```
[postgres] # psql template1 -c "ALTER USER pnfsserver WITH PASSWORD '<yourPassword>'"
```

The `pnfs` server is made aware of this password by changing the variable `dbConnectionString` in the file `/usr/etc/pnfsSetup`:

```
...
export dbConnectionString="user=pnfsserver password=<yourPassword>"
```

User access should be prohibited to this file with

```
[root] # chmod go-rwx /usr/etc/pnfsSetup
```

## Performance of the PostgreSQL Server

On small systems it should never be a problem to use one single PostgreSQL server for all the functions listed above. In the standard installation, the `ReplicaManager` is not activated by default. The `billing` will only write to a file by default.

Whenever the PostgreSQL server is going to be used for another functionality, the impact on performance should be checked carefully. To improve the performance, the functionality should be installed on a separate host. Generally, a PostgreSQL server for a specific functionality should be on the same host as the `dCache` cell accessing that PostgreSQL server, and the PostgreSQL server containing the databases for `Chimera` should run on the same host as `Chimera` and the `PnfManager` cell of the `dCache` system accessing it.

It is especially useful to use a separate PostgreSQL server for the `billing` cell.

### Note

The following is *work-in-progress*.

Create PostgreSQL user with the name you will be using to run `pnfs` server. Make sure it has `CREATEDB` privilege.

```
[user] $ psql -U postgres template1 -c "CREATE USER johndoe with CREATEDB"
[user] $ dropuser pnfsserver
[user] $ createuser --no-adduser --createdb --pwprompt pnfsserver
```

**Table 24.1. Protocol Overview**

| Component      | Database Host                                                                                                      | Database Name           | Database User           | Database Password     |
|----------------|--------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-----------------------|
| SRM            | <code>srmdb.host</code> or if not set: <code>srmdbHost</code><br>or if not set: <code>localhost</code>             | <code>srmdb</code>      | <code>dcache</code>     | <code>--free--</code> |
| PinManager     | <code>pinManagerDatabaseHost</code> or if not set:<br><code>srmdbHost</code> or if not set: <code>localhost</code> | <code>pinmanager</code> | <code>pinmanager</code> | <code>--free--</code> |
| ReplicaManager | <code>replicadb.host</code> or if not set:<br><code>localhost</code>                                               | <code>replica</code>    | <code>dcache</code>     | <code>--free--</code> |

| <b>Component</b> | <b>Database Host</b>                            | <b>Database Name</b>    | <b>Database User</b> | <b>Database Password</b> |
|------------------|-------------------------------------------------|-------------------------|----------------------|--------------------------|
| pnfs server      | localhost                                       | admin, data1, exp0, ... | pnfsserver           | --free--                 |
| billing          | billingDatabaseHost or if not set:<br>localhost | billing                 | dcache               | <b>--free--</b>          |



---

# Chapter 25. Complex Network Configuration

This chapter contains solutions for several non-trivial network configurations. The first section discusses the interoperation of dCache with firewalls and does not require any background knowledge about dCache other than what is given in the installation guide (Chapter 2, *Installing dCache*) and the first steps tutorial (Chapter 3, *Getting in Touch with dCache*). The following sections will deal with more complex network topologies, e.g. private subnets. Even though not every case is covered, these cases might help solve other problems, as well. Intermediate knowledge about dCache is required.

## Warning

The TCP and UDP ports used for dCache internal communication (port 11111 by default) *MUST* be subject to firewall control so that only other dCache nodes can access them. Failure to do this will allow an attacker to issue arbitrary commands on any node within your dCache cluster, as whichever user the dCache process runs.

## Firewall Configuration

The components of a dCache instance may be distributed over several hosts (nodes). Some of these components are accessed from outside and consequently the firewall needs to be aware of that. We contemplate two communication types, the dCache internal communication and the interaction from dCache with clients.

Since dCache is very flexible, most port numbers may be changed in the configuration. The command **dcache ports** will provide you with a list of services and the ports they are using.

## Basic Installation

This section assumes that all nodes are behind a firewall and have full access to each other.

### dCache internal.

- As we assume that all nodes are behind a firewall and have full access to each other there is nothing to be mentioned here.
- On the pool nodes the LAN range ports need to be opened to allow pool to pool communication. By default these are ports 33115–33145 (set by the properties `dcache.net.lan.port.min` and `dcache.net.lan.port.max`).

### dCache communication with client.

- The door ports need to be opened to allow the clients to connect to the doors.
- The WAN/LAN range ports need to be opened to allow the clients to connect to the pools. The default values for the WAN port range are 20000–25000. The WAN port range is defined by the properties `dcache.net.wan.port.min` and `dcache.net.wan.port.max`.

## Multi-Node with Firewalls

Multinode setup with firewalls on the nodes.

### dCache internal.

- The `LocationManager` server runs in the `dCacheDomain`. By default it is listening on UDP port 11111. Hence, on the head node port 11111 needs to be opened in the firewall to allow connections to the `LocationManager`. Remember to limit this so that only other dCache nodes are allowed access.
- On the pool nodes the LAN range ports need to be opened to allow pool to pool communication. By default these are ports 33115–33145 (set by the properties `dcache.net.lan.port.min` and `dcache.net.lan.port.max`).

### dCache communication with client.

- The door ports need to be opened to allow the clients to connect to the doors.
- The WAN/LAN range ports need to be opened to allow the clients to connect to the pools. The default values for the WAN port range are 20000–25000. The WAN port range is defined by the properties `dcache.net.wan.port.min` and `dcache.net.wan.port.max`.

More complex setups are described in the following sections.

## GridFTP Connections via two or more Network Interfaces

### Description

The host on which the `GridFTP` door is running has several network interfaces and is supposed to accept client connections via all those interfaces. The interfaces might even belong to separate networks with no routing from one network to the other.

As long as the data connection is opened by the `GridFTP` server (passive FTP mode), there is no problem with having more than one interface. However, when the client opens the data connection (active FTP mode), the door (FTP server) has to supply it with the correct interface it should connect to. If this is the wrong interface, the client might not be able to connect to it, because there is no route or the connection might be inefficient.

Also, since a `GridFTP` server has to authenticate with an `X.509` grid certificate and key, there needs to be a separate certificate and key pair for each name of the host or a certificate with alternative names. Since each network interface might have a different name, several certificates and keys are needed and the correct one has to be used, when authenticating via each of the interfaces.

### Solution

Define two domains, one for the internal and one for the external use. Start a separate `srm` and `gridftp` service in these domains.

The `srm` and the `gridftp` service have to be configured with the property `listen`, only to listen on the interface they should serve. The locations of the grid host certificate and key files for the interface have to be specified explicitly with the properties `dcache.authn.hostcert.cert` and `dcache.authn.hostcert.key`.

**Example:**

In this example we show a setup for two GridFTP doors serving two network interfaces with the hostnames `door-internal` (111.111.111.5) and `door-external` (222.222.222.5) which are served by two GridFTP doors in two domains.

```
[internalDomain]
listen=111.111.111.5
dcache.authn.hostcert.cert=/etc/dcache/interface-cert-internal.pem
dcache.authn.hostcert.key=/etc/dcache/interface-key-internal.pem
[internalDomain/srm]
srm.cell.name=srm-internal
srm.protocols.loginbroker=loginbroker-internal
srm.net.host=door-internal
[internalDomain/ftp]
ftp.authn.protocol = gsi
ftp.cell.name=GFTP-door-internal
dcache.service.loginbroker=loginbroker-internal

[externalDomain]
listen=222.222.222.5
dcache.authn.hostcert.cert=/etc/dcache/interface-cert-external.pem
dcache.authn.hostcert.key=/etc/dcache/interface-key-external.pem
[externalDomain/srm]
srm.cell.name=srm-external
srm.protocols.loginbroker=loginbroker-external
srm.net.host=door-external
[externalDomain/ftp]
ftp.authn.protocol = gsi
ftp.cell.name=GFTP-door-external
dcache.service.loginbroker=loginbroker-external
```

## GridFTP with Pools in a Private Subnet

### Description

If pool nodes of a dCache instance are connected to a secondary interface of the GridFTP door, e.g. because they are in a private subnet, the GridFTP door will still tell the pool to connect to its primary interface, which might be unreachable.

The reason for this is that the control communication between the door and the pool is done via the network of TCP connections which have been established at start-up. In the standard setup this communication is routed via the dCache domain. However, for the data transfer, the pool connects to the GridFTP door. The IP address it connects to is sent by the GridFTP door to the pool via the control connection. Since the GridFTP door cannot find out which of its interfaces the pool should use, it normally sends the IP address of the primary interface.

## Solution

Tell the GridFTP door explicitly which IP it should send to the pool for the data connection with the `ftp.net.internal` property.

**Example:**

E.g. if the pools should connect to the secondary interface of the GridFTP door host which has the IP address `10.0.1.1`, set

```
ftp.net.internal=10.0.1.1
```

in the `/etc/dcache/dcache.conf` file.

---

# Chapter 26. Advanced Tuning

The use cases described in this chapter are only relevant for large-scale dCache instances which require special tuning according to a longer experience with client behaviour.

## Multiple Queues for Movers in each Pool

### Description

Client requests to a dCache system may have rather diverse behaviour. Sometimes it is possible to classify them into several typical usage patterns. An example are the following two concurrent usage patterns:

#### Example:

Data is copied with a high transfer rate to the dCache system from an external source. This is done via the `GridFTP` protocol. At the same time batch jobs on a local farm process data. Since they only need a small part of each file, they use the `dCap` protocol via the `dCap` library and seek to the position in the file they are interested in, read a few bytes, do a few hours of calculations, and finally read some more data.

As long as the number of active requests does not exceed the maximum number of allowed active requests, the two types of requests are processed concurrently. The `GridFTP` transfers complete at a high rate while the processing jobs take hours to finish. This maximum number of allowed requests is set with `mover set max active` and should be tuned according to capabilities of the pool host.

However, if requests are queued, the slow processing jobs might clog up the queue and not let the fast `GridFTP` request through, even though the pool just sits there waiting for the processing jobs to request more data. While this could be temporarily remedied by setting the maximum active requests to a higher value, then in turn `GridFTP` request would put a very high load on the pool host.

The above example is pretty realistic: As a rule of thumb, `GridFTP` requests are fastest, `dCap` requests with the `dccp` program are a little slower and `dCap` requests with the `dCap` library are very slow. However, the usage patterns might be different at other sites and also might change over time.

### Solution

Use separate queues for the movers, depending on the door initiating them. This easily allows for a separation of requests of separate protocols. (Transfers from and to a *tape backend* and *pool-to-pool transfers* are handled by separate queues, one for each of these transfers.)

A finer grained queue selection mechanism based on, e.g. the IP address of the client or the file which has been requested, is not possible with this mechanism. However, the *pool selection unit (PSU)* may provide a separation onto separate pools using those criteria.

In the above example, two separate queues for fast `GridFTP` transfers and slow `dCap` library access would solve the problem. The maximum number of active movers for the `GridFTP` queue should be set to a lower value compared to the `dCap` queue since the fast `GridFTP` transfers will put a high load on the system while the `dCap` requests will be mostly idle.

## Configuration

For a multi mover queue setup, the pools have to be told to start several queues and the doors have to be configured to use one of these. It makes sense to create the same queues on all pools. This is done by the following change to the file `/etc/dcache/dcache.conf`:

```
pool.queues=queueA,queueB
```

Each door may be configured to use a particular mover queue. The pool, selected for this request, does not depend on the selected mover queue. So a request may go to a pool which does not have the particular mover queue configured and will consequently end up in the default mover queue of that pool.

```
ftp.mover.queue=queueA
dcap.mover.queue=queueB
```

All requests send from this kind of door will ask to be scheduled to the given mover queue. The selection of the pool is not affected.

The doors are configured to use a particular mover queue as in the following example:

### Example:

Create the queues `queueA` and `queueB`, where `queueA` shall be the queue for the `GridFTP` transfers and `queueB` for `dCap`.

```
pool.queues=queueA,queueB
ftp.mover.queue=queueA
dcap.mover.queue=queueB
```

If the pools should not all have the same queues you can define queues for pools in the layout file. Here you might as well define that a specific door is using a specific queue.

### Example:

In this example `queueC` is defined for `pool1` and `queueD` is defined for `pool2`. The `GridFTP` door running in the domain `myDoors` is using the queue `queueB`.

```
[myPools]
[myPools/pool1]
pool.queues=queueC
[myPools/pool2]
pool.queues=queueD

[myDoors]
[myDoors/dcap]
dcap.mover.queue=queueC
[myDoors/ftp]
ftp.authn.protocol = gsi
ftp.mover.queue=queueD
```

There is always a default queue called `regular`. Transfers not requesting a particular mover queue or requesting a mover queue not existing on the selected pool, are handled by the `regular` queue.

The pool cell commands **mover ls** and **mover set max active** have a `-queue` option to select the mover queue to operate on. Without this option, **mover set max active** will act on the default queue while **mover ls** will list all active and waiting client transfer requests.

For the dCap protocol, it is possible to allow the client to choose another queue name than the one defined in the file `dcache.conf`. To achieve this the property `dcap.authz.mover-queue-overwrite` needs to be set to `allowed`.

**Example:**

Create the queues `queueA` and `queue_dccp`, where `queueA` shall be the queue for dCap.

```
pool.queues=queueA,queue_dccp
dcap.mover.queue=queueA
dcap.authz.mover-queue-overwrite=allowed
```

With the `dccp` command the queue can now be specified as follows:

```
[user] $ dccp -X-io-queue=queue_dccp <source> <destination>
```

Since `dccp` requests may be quite different from other requests with the dCap protocol, this feature may be used to use separate queues for `dccp` requests and other dCap library requests. Therefore, the `dccp` command may be changed in future releases to request a special `dccp-queue` by default.

## Tunable Properties for Multiple Queues

| Property                         | Default Value  | Description                                                                      |
|----------------------------------|----------------|----------------------------------------------------------------------------------|
| pool.queues                      | <i>Not set</i> | I/O queue name                                                                   |
| dcap.mover.queue                 | <i>Not set</i> | Insecure dCap I/O queue name                                                     |
| dcap.mover.queue                 | <i>Not set</i> | GSIdCap I/O queue name                                                           |
| dcap.authz.mover-queue-overwrite | denied         | Controls whether an application is allowed to overwrite a queue name             |
| dcap.authz.mover-queue-overwrite | denied         | Controls whether an application is allowed to overwrite a queue name             |
| dcap.authz.mover-queue-overwrite | denied         | Controls whether an application is allowed to overwrite a queue name             |
| ftp.mover.queue                  | <i>Not set</i> | GSI-FTP I/O queue name                                                           |
| nfs.mover.queue                  | <i>Not set</i> | NFS I/O queue name                                                               |
| transfermanagers.mover.queue     | <i>Not set</i> | queue used for SRM third-party transfers (i.e. the <code>srnCopy</code> command) |
| webdav.mover.queue               | <i>Not set</i> | WebDAV and HTTP I/O queue name                                                   |
| xrootd.mover.queue               | <i>Not set</i> | xrootd I/O queue name                                                            |

## Tunable Properties

### dCap

**Table 26.1. Property Overview**

| Property                         | Default Value  | Description                                     |
|----------------------------------|----------------|-------------------------------------------------|
| dcap.mover.queue                 | <i>Not set</i> | GSIdCap I/O queue name                          |
| dcap.mover.queue                 | <i>Not set</i> | Insecure dCap I/O queue name                    |
| dcap.authz.mover-queue-overwrite | denied         | Is application allowed to overwrite queue name? |
| dcap.authz.mover-queue-overwrite | denied         | Is application allowed to overwrite queue name? |

## GridFTP

**Table 26.2. Property Overview**

| Property                        | Default Value                                                 | Description                                    |
|---------------------------------|---------------------------------------------------------------|------------------------------------------------|
| ftp.net.port.gsi                | 2811                                                          | GSI-FTP port listen port                       |
| spaceReservation                | <i>False</i>                                                  | Use the space reservation service              |
| spaceReservationStrict          | <i>False</i>                                                  | Use the space reservation service              |
| ftp.performance-marker-period   | 180                                                           | Performance markers in seconds                 |
| gplazmaPolicy                   | <code>\${ourHomeDir}/etc/<br/>dcachesrm-gplazma.policy</code> | Location of the gPlazma Policy File            |
| ftp.service.poolmanager.timeout | 5400                                                          | Pool Manager timeout in seconds                |
| ftp.service.pool.timeout        | 600                                                           | Pool timeout in seconds                        |
| ftp.service.pnfsmanager.timeout | 300                                                           | Pnfs timeout in seconds                        |
| ftp.limits.retries              | 80                                                            | Number of PUT/GET retries                      |
| ftp.limits.streams-per-client   | 10                                                            | Number of parallel streams per FTP PUT/GET     |
| ftp.enable.delete-on-failure    | <i>True</i>                                                   | Delete file on connection closed               |
| ftp.limits.clients              | 100                                                           | Maximum number of concurrently logged in users |
| ftp.net.internal                | <i>Not set</i>                                                | In case of two interfaces                      |
| ftp.net.port-range              | 20000:25000                                                   | The client data port range                     |
| gplazma.kpwd.file               | <code>\${ourHomeDir}/<br/>etc/dcache.kpwd</code>              | Legacy authorization                           |

## SRM

**Table 26.3. Property Overview**

| Property                                            | Default Value | Description                                         |
|-----------------------------------------------------|---------------|-----------------------------------------------------|
| srm.net.port                                        | 8443          | srm.net.port                                        |
| srm.db.host                                         | localhost     | srm.db.host                                         |
| srm.limits.external-copy-script.timeout             | 3600          | srm.limits.external-copy-script.timeout             |
| srmVacuum                                           | <i>True</i>   | srmVacuum                                           |
| srmVacuumPeriod                                     | 21600         | srmVacuumPeriod                                     |
| srmProxiesDirectory                                 | /tmp          | srmProxiesDirectory                                 |
| srm.limits.transfer-buffer.size                     | 1048576       | srm.limits.transfer-buffer.size                     |
| srm.limits.transfer-tcp-buffer.size                 | 1048576       | srm.limits.transfer-tcp-buffer.size                 |
| srm.enable.external-copy-script.debug               | <i>True</i>   | srm.enable.external-copy-script.debug               |
| srm.limits.request.scheduler.thread.queue.size      | 1000          | srm.limits.request.scheduler.thread.queue.size      |
| srm.limits.request.scheduler.thread.pool.size       | 100           | srm.limits.request.scheduler.thread.pool.size       |
| srm.limits.request.scheduler.waiting.max            | 1000          | srm.limits.request.scheduler.waiting.max            |
| srm.limits.request.scheduler.ready-queue.size       | 1000          | srm.limits.request.scheduler.ready-queue.size       |
| srm.limits.request.scheduler.ready.max              | 100           | srm.limits.request.scheduler.ready.max              |
| srm.limits.request.scheduler.retries.max            | 10            | srm.limits.request.scheduler.retries.max            |
| srm.limits.request.scheduler.retry-timeout          | 60000         | srm.limits.request.scheduler.retry-timeout          |
| srm.limits.request.scheduler.same-owner-running.max | 10            | srm.limits.request.scheduler.same-owner-running.max |
| srm.limits.request.put.scheduler.thread.queue.size  | 1000          | srm.limits.request.put.scheduler.thread.queue.size  |



## Advanced Tuning

---

| Property                                                 | Default Value | Description                                              |
|----------------------------------------------------------|---------------|----------------------------------------------------------|
| srn.limits.request.put.scheduler.thread.pool.size        | 100           | srn.limits.request.put.scheduler.thread.pool.size        |
| srn.limits.request.put.scheduler.waiting.max             | 1000          | srn.limits.request.put.scheduler.waiting.max             |
| srn.limits.request.put.scheduler.ready-queue.size        | 1000          | srn.limits.request.put.scheduler.ready-queue.size        |
| srn.limits.request.put.scheduler.ready.max               | 100           | srn.limits.request.put.scheduler.ready.max               |
| srn.limits.request.put.scheduler.retries.max             | 10            | srn.limits.request.put.scheduler.retries.max             |
| srn.limits.request.put.scheduler.retry-timeout           | 60000         | srn.limits.request.put.scheduler.retry-timeout           |
| srn.limits.request.put.scheduler.same-owner-running.max  | 10            | srn.limits.request.put.scheduler.same-owner-running.max  |
| srn.limits.request.copy.scheduler.thread.queue.size      | 1000          | srn.limits.request.copy.scheduler.thread.queue.size      |
| srn.limits.request.copy.scheduler.thread.pool.size       | 100           | srn.limits.request.copy.scheduler.thread.pool.size       |
| srn.limits.request.copy.scheduler.waiting.max            | 1000          | srn.limits.request.copy.scheduler.waiting.max            |
| srn.limits.request.copy.scheduler.retries.max            | 30            | srn.limits.request.copy.scheduler.retries.max            |
| srn.limits.request.copy.scheduler.retry-timeout          | 60000         | srn.limits.request.copy.scheduler.retry-timeout          |
| srn.limits.request.copy.scheduler.same-owner-running.max | 10            | srn.limits.request.copy.scheduler.same-owner-running.max |

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# Part IV. Reference

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# Chapter 27. dCache Clients

## The SRM Client Suite

An SRM URL has the form `srm://dmx.lbl.gov:6253//srm/DRM/srmv1?SFN=/tmp/try1` and the file URL looks like `file:///tmp/aaa`.

### srmcp

**srmcp** — Copy a file from or to an SRM or between two SRMs.

### Synopsis

```
srmcp [option...] <sourceUrl> <destUrl>
```

### Arguments

`sourceUrl`

The URL of the source file.

`destUrl`

The URL of the destination file.

### Options

`gss_expected_name`

To enable the user to specify the gss expected name in the DN (Distinguished Name) of the srm server. The default value is `host`.

#### Example:

If the CN of host where srm server is running is `CN=srm/tam01.fnal.gov`, then `gss_expected_name` should be `srm`.

```
[user] $ srmcp --gss_expected_name=srm <sourceUrl> <destinationUrl>
```

`globus_tcp_port_range`

To enable the user to specify a range of ports open for tcp connections as a pair of positive integers separated by “:”, not set by default.

This takes care of compute nodes that are behind firewall.

#### Example:

```
globus_tcp_port_range=40000:50000
```

```
[user] $ srmcp --globus_tcp_port_range=<minVal>:<maxVal> <sourceUrl> <destinationUrl>
```

streams\_num

To enable the user to specify the number of streams to be used for data transfer. If set to 1, then stream mode is used, otherwise extended block mode is used.

**Example:**

```
[user] $ srmcp --streams_num=1 <sourceUrl> <destinationUrl>
```

server\_mode

To enable the user to set the (gridftp) server mode for data transfer. Can be active or passive, passive by default.

This option will have effect only if transfer is performed in a stream mode (see streams\_num)

**Example:**

```
[user] $ srmcp --streams_num=1 --server_mode=active <sourceUrl> <destinationUrl>
```

## Description

## srmstage

**srmstage** — Request staging of a file.

## Synopsis

```
srmstage [<srmUrl>...]
```

### Arguments

srmUrl

The URL of the file which should be staged.

## Description

Provides an option to the user to stage files from HSM to dCache and not transfer them to the user right away. This case will be useful if files are not needed right away at user end, but its good to stage them to dcache for faster access later.

## dccp

## dccp

**dccp** — Copy a file from or to a dCache server.

## Synopsis

```
dccp [option...] <sourceUrl> <destUrl>
```

## Arguments

The following arguments are required:

`sourceUrl`

The URL of the source file.

`destUrl`

The URL of the destination file.

## Description

The **dccp** utility provides a **cp(1)** like functionality on the dCache file system. The source must be a single file while the destination could be a directory name or a file name. If the directory is a destination, a new file with the same name as the source name will be created there and the contents of the source will be copied. If the final destination file exists in dCache, it won't be overwritten and an error code will be returned. Files in regular file systems will always be overwritten if the `-i` option is not specified. If the source and the final destination file are located on a regular file system, the **dccp** utility can be used similar to the **cp(1)** program.

## Options

The following arguments are optional:

`-a`

Enable read-ahead functionality.

`-b <bufferSize>`

Set read-ahead buffer size. The default value is 1048570 Bytes. To disable the buffer this can be set to any value below the default. **dccp** will attempt to allocate the buffer size so very large values should be used with care.

`-B <bufferSize>`

Set buffer size. The size of the buffer is requested in each request, larger buffers will be needed to saturate higher bandwidth connections. The optimum value is network dependent. Too large a value will lead to excessive memory usage, too small a value will lead to excessive network communication.

`-d <debug level>`

Set the debug level. `<debug level>` is a integer between 0 and 127. If the value is 0 then no output is generated, otherwise the value is formed by adding together one or more of the following values:

| Value | Enabled output     |
|-------|--------------------|
| 1     | Error messages     |
| 2     | Info messages      |
| 4     | Timing information |
| 8     | Trace information  |
| 16    | Show stack-trace   |

| Value | Enabled output     |
|-------|--------------------|
| 32    | IO operations      |
| 32    | IO operations      |
| 64    | Thread information |

- `-h <replyHostName>`  
Bind the callback connection to the specific hostname interface.
- `-i`  
Secure mode. Do not overwrite the existing files.
- `-l <location>`  
Set location for pre-stage. if the location is not specified, the local host of the door will be used. This option must be used with the `-P` option.
- `-p <first_port>:<last_port>`  
Bind the callback data connection to the specified TCP port/rangeSet port range. Delimited by the ':' character, the `<first_port>` is required but the `<last_port>` is optional.
- `-P`  
Pre-stage. Do not copy the file to a local host but make sure the file is on disk on the dCache server.
- `-r <bufferSize>`  
TCP receive buffer size. The default is 256K. Setting to 0 uses the system default value. Memory usage will increase with higher values, but performance better.
- `-s <bufferSize>`  
TCP send buffer size. The default is 256K. Setting to 0 uses the system default value.
- `-t <time>`  
Stage timeout in seconds. This option must be used with the `-P` option.

## Examples:

To copy a file to dCache:

```
[user] $ dccp /etc/group dcap://example.org/pnfs/desy.de/gading/
```

To copy a file from dCache:

```
[user] $ dccp dcap://example.org/pnfs/desy.de/gading/group /tmp/
```

Pre-Stage request:

```
[user] $ dccp -P -t 3600 -l example.org /acs/user_space/data_file
```

stdin:

```
[user] $ tar cf - data_dir | dccp - /acs/user_space/data_arch.tar
```

stdout:

```
[user] $ dccp /acs/user_space/data_arch.tar - | tar xf -
```

## See also

cp

---

# Chapter 28. dCache Cell Commands

This is the reference to all (important) cell commands in dCache. You should not use any command not documented here, unless you really know what you are doing. Commands not in this reference are used for debugging by the developers.

This chapter serves two purposes: The other parts of this book refer to it, whenever a command is mentioned. Secondly, an administrator may check here, if he wonders what a command does.

## Common Cell Commands

### pin

**pin** — Adds a comment to the pinboard.

### Synopsis

```
pin <comment>
```

### Arguments

comment

A string which is added to the pinboard.

### Description

### info

**info** — Print info about the cell.

### Synopsis

```
info [-a] [-l]
```

### Arguments

-a

Display more information.

-l

Display long information.

### Description

The info printed by **info** depends on the cell class.



## dump pinboard

**dump pinboard** — Dump the full pinboard of the cell to a file.

## Synopsis

```
dump pinboard <filename>
```

### Arguments

filename

The file the current content of the pinboard is stored in.

## Description

## show pinboard

**show pinboard** — Print a part of the pinboard of the cell to STDOUT.

## Synopsis

```
show pinboard [<lines>]
```

### Arguments

lines

The number of lines which are displayed. Default: all.

## Description

# PnfsManager Commands

## pnfsidof

**pnfsidof** — Print the pnfs id of a file given by its global path.

## Synopsis

```
pnfsidof <globalPath>
```

## Description

Print the pnfs id of a file given by its global path. The global path always starts with the “VirtualGlobalPath” as given by the “**info**”-command.

## flags remove

**flags remove** — Remove a flag from a file.

## Synopsis

```
flags remove <pnfsId> <key> ...
```

### Arguments

pnfsId

The pnfs id of the file of which a flag will be removed.

key

flags which will be removed.

## Description

## flags ls

**flags ls** — List the flags of a file.

## Synopsis

```
flags ls <pnfsId>
```

pnfsId

The pnfs id of the file of which a flag will be listed.

## Description

## flags set

**flags set** — Set a flag for a file.

## Synopsis

```
flags set <pnfsId> <key>=<value> ...
```

### Arguments

pnfsId

The pnfs id of the file of which flags will be set.

key

The flag which will be set.

value

The value to which the flag will be set.

## Description

# metadataof

**metadataof** — Print the meta-data of a file.

## Synopsis

```
metadataof [<pnfsId>] | [<globalPath>] [-v] [-n] [-se]
```

### Arguments

pnfsId

The pnfs id of the file.

globalPath

The global path of the file.

## Description

# pathfinder

**pathfinder** — Print the global or local path of a file from its PNFS id.

## Synopsis

```
pathfinder <pnfsId> [[-global] | [-local]]
```

### Arguments

pnfsId

The pnfs Id of the file.

-global

Print the global path of the file.

-local

Print the local path of the file.

## Description

### set meta

**set meta** — Set the meta-data of a file.

## Synopsis

```
set meta [<pnfsId>] | [<globalPath>] <uid> <gid> <perm> <levelInfo>...
```

### Arguments

pnfsId

The pnfs id of the file.

globalPath

The global path of the file.

uid

The user id of the new owner of the file.

gid

The new group id of the file.

perm

The new file permissions.

levelInfo

The new level information of the file.

## Description

### storageinfoof

**storageinfoof** — Print the storage info of a file.

## Synopsis

```
storageinfoof [<pnfsId>] | [<globalPath>] [-v] [-n] [-se]
```

### Arguments

pnfsId

The pnfs id of the file.

globalPath

The global path of the file.

## Description

# cacheinfoof

**cacheinfoof** — Print the cache info of a file.

## Synopsis

```
cacheinfoof [<pnfsId>] [<globalPath>]
```

### Arguments

pnfsId

The `pnfs` id of the file.

globalPath

The global path of the file.

## Description

# Pool Commands

## rep ls

**rep ls** — List the files currently in the repository of the pool.

## Synopsis

```
rep ls [pnfsId...] [-l= s | p | l | u | nc | e ...] [-s= k | m | g | t]
```

pnfsId

The `pnfs` ID(s) for which the files in the repository will be listed.

-l

List only the files with one of the following properties:

|    |                               |
|----|-------------------------------|
| s  | sticky files                  |
| p  | precious files                |
| l  | locked files                  |
| u  | files in use                  |
| nc | files which are not cached    |
| e  | files with an error condition |

-s

Unit, the filesize is shown:

|   |                       |
|---|-----------------------|
| k | data amount in KBytes |
| m | data amount in MBytes |
| g | data amount in GBytes |
| t | data amount in TBytes |

## Description

### st set max active

**st set max active** — Set the maximum number of active store transfers.

## Synopsis

```
st set max active <maxActiveStoreTransfers>
```

maxActiveStoreTransfers

The maximum number of active store transfers.

## Description

Any further requests will be queued. This value will also be used by the *cost module* for calculating the *performance cost*.

### rh set max active

**rh set max active** — Set the maximum number of active restore transfers.

## Synopsis

```
rh set max active <maxActiveRestoreTransfers>
```

maxActiveRestoreTransfers

The maximum number of active restore transfers.

## Description

Any further requests will be queued. This value will also be used by the *cost module* for calculating the *performance cost*.

### mover set max active

**mover set max active** — Set the maximum number of active client transfers.

## Synopsis

```
mover set max active <maxActiveClientTransfers> [-queue=<moverQueueName>]
```

`maxActiveClientTransfers`

The maximum number of active client transfers.

`moverQueueName`

The mover queue for which the maximum number of active transfers should be set. If this is not specified, the default queue is assumed, in order to be compatible with previous versions which did not support multiple mover queues (before version 1.6.6).

## Description

Any further requests will be queued. This value will also be used by the *cost module* for calculating the *performance cost*.

## mover set max active -queue=p2p

**mover set max active -queue=p2p** — Set the maximum number of active pool-to-pool server transfers.

## Synopsis

```
mover set max active -queue=p2p <maxActiveP2PTransfers>
```

`maxActiveP2PTransfers`

The maximum number of active pool-to-pool server transfers.

## Description

Any further requests will be queued. This value will also be used by the *cost module* for calculating the *performance cost*.

## pp set max active

**pp set max active** — Set the value used for scaling the performance cost of pool-to-pool client transfers analogous to the other `set max active`-commands.

## Synopsis

```
pp set max active <maxActivePPTransfers>
```

`maxActivePPTransfers`

The new scaling value for the cost calculation.

## Description

All pool-to-pool client requests will be performed immediately in order to avoid deadlocks. This value will only be used by the *cost module* for calculating the *performance cost*.

## set gap

**set gap** — Set the gap parameter - the size of free space below which it will be assumed that the pool is full within the cost calculations.

## Synopsis

```
set gap <gapPara>
```

gapPara

The size of free space below which it will be assumed that the pool is full. Default is 4GB.

## Description

The gap parameter is used within the space cost calculation scheme described in the section called “The Space Cost”. It specifies the size of free space below which it will be assumed that the pool is full and consequently the least recently used file has to be removed if a new file has to be stored on the pool. If, on the other hand, the free space is greater than gapPara, it will be expensive to store a file on the pool which exceeds the free space.

## set breakeven

**set breakeven** — Set the breakeven parameter - used within the cost calculations.

## Synopsis

```
set breakeven <breakevenPara>
```

breakevenPara

The breakeven parameter has to be a positive number smaller than 1.0. It specifies the impact of the age of the *least recently used file* on space cost. If the LRU file is one week old, the space cost will be equal to  $(1 + \text{breakeven})$ . Note that this will not be true, if the breakeven parameter has been set to a value greater or equal to 1.

## Description

The breakeven parameter is used within the space cost calculation scheme described in the section called “The Space Cost”.

## mover ls

**mover ls** — List the active and waiting client transfer requests.

## Synopsis

```
mover ls [-queue | -queue=<queueName>]
```



queueName

The name of the mover queue for which the transfers should be listed.

## Description

Without parameter all transfers are listed. With `-queue` all requests sorted according to the mover queue are listed. If a queue is explicitly specified, only transfers in that mover queue are listed.

## migration cache

migration cache — Caches replicas on other pools.

### SYNOPSIS

```
migration cache [<options>] <target>...
```

### DESCRIPTION

Caches replicas on other pools. Similar to **migration copy**, but with different defaults. See **migration copy** for a description of all options. Equivalent to: **migration copy** `-smode=same -tmode=cached`

## migration cancel

migration cancel — Cancels a migration job

### SYNOPSIS

```
migration cancel [-force] job
```

### DESCRIPTION

Cancels the given migration job. By default ongoing transfers are allowed to finish gracefully.

## migration clear

migration clear — Removes completed migration jobs.

### SYNOPSIS

```
migration clear
```

### DESCRIPTION

Removes completed migration jobs. For reference, information about migration jobs are kept until explicitly cleared.

## migration concurrency

migration concurrency — Adjusts the concurrency of a job.

### SYNOPSIS

```
migration concurrency <job> <n>
```

### DESCRIPTION

Sets the concurrency of <job> to <n>.

## migration copy

migration copy — Copies files to other pools.

### SYNOPSIS

```
migration copy [<options>] <target>...
```

### DESCRIPTION

Copies files to other pools. Unless filter options are specified, all files on the source pool are copied.

The operation is idempotent, that is, it can safely be repeated without creating extra copies of the files. If the replica exists on any of the target pools, then it is not copied again. If the target pool with the existing replica fails to respond, then the operation is retried indefinitely, unless the job is marked as eager.

Please notice that a job is only idempotent as long as the set of target pools does not change. If pools go offline or are excluded as a result of an exclude or include expression then the job may stop being idempotent.

Both the state of the local replica and that of the target replica can be specified. If the target replica already exists, the state is updated to be at least as strong as the specified target state, that is, the lifetime of sticky bits is extended, but never reduced, and cached can be changed to precious, but never the opposite.

Transfers are subject to the checksum computation policy of the target pool. Thus checksums are verified if and only if the target pool is configured to do so. For existing replicas, the checksum is only verified if the verify option was specified on the migration job.

Jobs can be marked permanent. Permanent jobs never terminate and are stored in the pool setup file with the **save** command. Permanent jobs watch the repository for state changes and copy any replicas that match the selection criteria, even replicas added after the job was created. Notice that any state change will cause a replica to be reconsidered and enqueued if it matches the selection criteria — also replicas that have been copied before.

Several options allow an expression to be specified. The following operators are recognized: <, <=, ==, !=, >=, >, lt, le, eq, ne, ge, gt, ~, !~, +, -, \*, /, %, div, mod, |, &, ^, ~, &&, | |, !, and, or, not, ?:, =. Literals may be integer literals, floating point literals, single or double quoted string literals, and boolean true and false. Depending on the context, the expression may refer to constants.

Please notice that the list of supported operators may change in future releases. For permanent jobs we recommend to limit expressions to the basic operators `<`, `<=`, `=`, `!=`, `>=`, `>`, `+`, `-`, `*`, `/`, `&&`, `|` and `!`.

## Options

`-accessed=<n>[<n>].<m>`

Only copy replicas accessed `<n>` seconds ago, or accessed within the given, possibly open-ended, interval; e.g. `-accessed=0..60` matches files accessed within the last minute; `-accessed=60..` matches files accessed one minute or more ago.

`-al=ONLINE|NEARLINE`

Only copy replicas with the given access latency.

`-pnfsid=<pnfsid>[,<pnfsid>] ...`

Only copy replicas with one of the given PNFS IDs.

`-rp=CUSTODIAL|REPLICA|OUTPUT`

Only copy replicas with the given retention policy.

`-size=<n>[<n>].<m>`

Only copy replicas with size `<n>`, or a size within the given, possibly open-ended, interval.

`-state=cached|precious`

Only copy replicas in the given state.

`-sticky[=<owner>[,<owner>...]]`

Only copy sticky replicas. Can optionally be limited to the list of owners. A sticky flag for each owner must be present for the replica to be selected.

`-storage=<class>`

Only copy replicas with the given storage class.

`-concurrency=<concurrency>`

Specifies how many concurrent transfers to perform. Defaults to 1.

`-order=[-]size|[-]lru`

Sort transfer queue. By default transfers are placed in ascending order, that is, smallest and least recently used first. Transfers are placed in descending order if the key is prefixed by a minus sign. Failed transfers are placed at the end of the queue for retry regardless of the order. This option cannot be used for permanent jobs. Notice that for pools with a large number of files, sorting significantly increases the initialization time of the migration job.

`size`

Sort according to file size.

`lru`

Sort according to last access time.

`-pins=move|keep`

Controls how sticky flags owned by the `PinManager` are handled:

move

Ask `PinManager` to move pins to the target pool.

keep

Keep pins on the source pool.

`-smode=same|cached|precious|removable|delete[+<owner>[(<lifetime>)] ...]`

Update the local replica to the given mode after transfer:

same

does not change the local state (this is the default).

cached

marks it cached.

precious

marks it precious.

removable

marks it cached and strips all existing sticky flags excluding pins.

delete

deletes the replica unless it is pinned.

An optional list of sticky flags can be specified. The lifetime is in seconds. A lifetime of 0 causes the flag to immediately expire. Notice that existing sticky flags of the same owner are overwritten.

`-tmode=same|cached|precious[+<owner>[(<lifetime>)]...]`

Set the mode of the target replica:

same

applies the state and sticky bits excluding pins of the local replica (this is the default).

cached

marks it cached.

precious

marks it precious.

An optional list of sticky flags can be specified. The lifetime is in seconds.

`-verify`

Force checksum computation when an existing target is updated.

`-eager`

Copy replicas rather than retrying when pools with existing replicas fail to respond.

`-exclude=<pool>[,<pool>...]`

Exclude target pools. Single character (?) and multi character (\*) wildcards may be used.

`-exclude-when=<expression>`

Exclude target pools for which the expression evaluates to true. The expression may refer to the following constants:

source.name or target.name  
pool name

source.spaceCost or target.spaceCost  
space cost

source.cpuCost or target.cpuCost  
cpu cost

source.free or target.free  
free space in bytes

source.total or target.total  
total space in bytes

source.removable or target.removable  
removable space in bytes

source.used or target.used  
used space in bytes

-include=<pool>[,<pool>...]

Only include target pools matching any of the patterns. Single character (?) and multi character (\*) wildcards may be used.

-include-when=<expression>

Only include target pools for which the expression evaluates to true. See the description of -exclude-when for the list of allowed constants.

-refresh=<time>

Specifies the period in seconds of when target pool information is queried from the pool manager. The default is 300 seconds.

-select=proportional|best|random

Determines how a pool is selected from the set of target pools:

proportional

selects a pool with a probability inversely proportional to the cost of the pool.

best

selects the pool with the lowest cost.

random

selects a pool randomly.

The default is proportional.

-target=pool|pgroup|link

Determines the interpretation of the target names. The default is 'pool'.

-pause-when=<expression>

Pauses the job when the expression becomes true. The job continues when the expression once again evaluates to false. The following constants are defined for this pool:

queue.files

The number of files remaining to be transferred.

queue.bytes

The number of bytes remaining to be transferred.

source.name

Pool name.

source.spaceCost

Space cost.

source.cpuCost

CPU cost.

source.free

Free space in bytes.

source.total

Total space in bytes.

source.removable

Removable space in bytes.

source.used

Used space in bytes.

targets

The number of target pools.

-permanent

Mark job as permanent.

-stop-when=<expression>

Terminates the job when the expression becomes true. This option cannot be used for permanent jobs. See the description of -pause-when for the list of constants allowed in the expression.

## migration info

migration info — Shows detailed information about a migration job.

## SYNOPSIS

migration info <job>

## DESCRIPTION

Shows detailed information about a migration job. Possible job states are:

### INITIALIZING

Initial scan of repository

**RUNNING**

Job runs (schedules new tasks)

**SLEEPING**

A task failed; no tasks are scheduled for 10 seconds

**PAUSED**

Pause expression evaluates to true; no tasks are scheduled for 10 seconds.

**STOPPING**

Stop expression evaluated to true; waiting for tasks to stop.

**SUSPENDED**

Job suspended by user; no tasks are scheduled

**CANCELLING**

Job cancelled by user; waiting for tasks to stop

**CANCELLED**

Job cancelled by user; no tasks are running

**FINISHED**

Job completed

**FAILED**

Job failed. Please check the log file for details.

Job tasks may be in any of the following states:

**Queued**

Queued for execution

**GettingLocations**

Querying PnfsManager for file locations

**UpdatingExistingFile**

Updating the state of existing target file

**CancellingUpdate**

Task cancelled, waiting for update to complete

**InitiatingCopy**

Request send to target, waiting for confirmation

**Copying**

Waiting for target to complete the transfer

**Pinging**

Ping send to target, waiting for reply

**NoResponse**

Cell connection to target lost

Waiting

Waiting for final confirmation from target

MovingPin

Waiting for pin manager to move pin

Cancelling

Attempting to cancel transfer

Cancelled

Task cancelled, file was not copied

Failed

The task failed

Done

The task completed successfully

## migration ls

migration ls — Lists all migration jobs.

### SYNOPSIS

```
migration ls
```

### DESCRIPTION

Lists all migration jobs.

## migration move

migration move — Moves replicas to other pools.

### SYNOPSIS

```
migration move [<options>] <target>...
```

### DESCRIPTION

Moves replicas to other pools. The source replica is deleted. Similar to **migration copy**, but with different defaults. Accepts the same options as **migration copy**. Equivalent to: **migration copy** -smode=delete -tmode=same -pins=move

## migration suspend

migration suspend — Suspends a migration job.



## SYNOPSIS

`migration suspend job`

## DESCRIPTION

Suspends a migration job. A suspended job finishes ongoing transfers, but it does not start any new transfer.

## migration resume

`migration resume` — Resumes a suspended migration job.

## SYNOPSIS

`migration resume job`

## DESCRIPTION

Resumes a suspended migration job.

# PoolManager Commands

## rc ls

`rc ls` — List the requests currently handled by the PoolManager

## Synopsis

`rc ls [<regularExpression>] [-w]`

## Description

Lists all requests currently handled by the pool manager. With the option `-w` only the requests currently waiting for a response are listed. Only requests satisfying the regular expression are shown.

## cm ls

`cm ls` — List information about the pools in the *cost module* cache.

## Synopsis

`cm ls [-r] [-d] [-s] [<fileSize>]`

`-r`

Also list the tags, the *space cost*, and *performance cost* as calculated by the cost module for a file of size `<fileSize>` (or zero)

-d

Also list the *space cost* and *performance cost* as calculated by the cost module for a file of size `<fileSize>` (or zero)

-t

Also list the time since the last update of the cached information in milliseconds.

## Description

A typical output reads

```
(PoolManager) admin > cm ls -r -d -t 1231243442
<poolName1>={R={a=0;m=2;q=0};S={a=0;m=2;q=0};M={a=0;m=100;q=0};PS={a=0;m=20;q=0};PC={a=0;m=20;q=0};
 (...line continues...) SP={t=2147483648;f=924711076;p=1222772572;r=0;lru=0;{g=20000000;b=0.5}}
<poolName1>={Tag={hostname=<hostname>}};size=543543543;SC=1.7633947200606475;CC=0.0;}
<poolName1>=3180
<poolName2>={R={a=0;m=2;q=0};S={a=0;m=2;q=0};M={a=0;m=100;q=0};PS={a=0;m=20;q=0};PC={a=0;m=20;q=0};
 (...line continues...) SP={t=2147483648;f=2147483648;p=0;r=0;lru=0;{g=4294967296;b=250.0}}
<poolName2>={Tag={hostname=<hostname>}};size=543543543;SC=0.0030372862312942743;CC=0.0;}
<poolName2>=3157
```

## set pool decision

**set pool decision** — Set the factors for the calculation of the total costs of the pools.

## Synopsis

```
set pool decision [-spacecostfactor=<scf>] [-cpucostfactor=<ccf>] [-costcut=<cc>]
```

scf

The factor (strength) with which the *space cost* will be included in the *total cost*.

ccf

The factor (strength) with which the *performance cost* will be included in the *total cost*.

cc

Deprecated since version 5 of the pool manager.

## Description

---

# Chapter 29. dCache Default Port Values

You can use the command **dcache ports** to get the list of ports used by dCache.

| Port number     | Description                                                                                            | Component                                                                            |
|-----------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 32768 and 32768 | is used by the NFS layer within dCache which is based upon rpc. This service is essential for rpc.     | NFS                                                                                  |
| 1939 and 33808  | is used by portmapper which is also involved in the rpc dependencies of dCache.                        | portmap                                                                              |
| 34075           | is for postmaster listening to requests for the PostgreSQL database for dCache database functionality. | Outbound for SRM, PnfsDomain, dCacheDomain and doors; inbound for PostgreSQL server. |
| 33823           | is used for internal dCache communication.                                                             | By default: outbound for all components, inbound for dCache domain.                  |
| 8443            | is the SRM port. See Chapter 13, <i>dCache Storage Resource Manager</i>                                | Inbound for SRM                                                                      |
| 2288            | is used by the web interface to dCache.                                                                | Inbound for httpdDomain                                                              |
| 22223           | is used for the dCache admin interface. See the section called "The Admin Interface"                   | Inbound for adminDomain                                                              |
| 22125           | is used for the dCache dCap protocol.                                                                  | Inbound for dCap door                                                                |
| 22128           | is used for the dCache GSIdCap .                                                                       | Inbound for GSIdCap door                                                             |

---

# Chapter 30. Glossary

The following terms are used in dCache.

**The `dcache.conf` File** This is the primary configuration file of a dCache. It is located at `/etc/dcache/dcache.conf`.

The `dcache.conf` file is initially empty. If one of the default configuration values needs to be changed, copy the default setting of this value from one of the *properties files* in `/usr/share/dcache/defaults` to this file and update the value.

**The `layout` File** The layout file is located in the directory `/etc/dcache/layouts`. It contains lists of the *domains* and the services that are to be run within these domains.

**The `properties` Files** The properties files are located in the directory `/usr/share/dcache/defaults`. They contain the default settings of the dCache.

**Chimera** The Chimera namespace is a core component of dCache. It maps each stored file to a unique identification number and allows storing of metadata against either files or directories.

Chimera includes some features like *levels*, *directory tags* and many of the *dot commands*.

**Chimera ID** A *Chimera* ID is a 36 hexadecimal digit that uniquely defines a file or directory.

**Domain** A domain is a collection of one or more *cells* that provide a set of related services within a dCache instance. Each domain requires its own Java Virtual Machine. A typical domain might provide external connectivity (i.e., a *door*) or manage the *pools* hosted on a machine.

Each domain has at least one cell, called the `System` cell and many tunnel cells for communicating with other Domains. To provide a useful service, a domain will contain other cells that provide specific behaviour.

**Cell** A cell is a collection of Java threads that provide a discrete and simple service within dCache. Each cell is hosted within a *domain*.

Cells have an address derived from concatenating their name, the @ symbol and their containing domain name.

**Well Known Cell** A well-known cell is a *cell* that registers itself centrally. Within the admin interface, a well-known cell may be referred to by just its cell name.

**Door** Door is the generic name for special *cells* that provides the first point of access for end clients to communicate with a dCache instance. There are different door implementations (e.g., `GSIDCap` door and `GridFTP` door), allowing a dCache instance to support multiple communication protocols.

A door will (typically) bind to a well-known port number depending on the protocol the door supports. This allows for only a single door instance per machine for each protocol.

A door will typically identify which *pool* will satisfy the end user's operation and redirect the client to the corresponding pool. In some cases this is not possible; for example, some protocols (such as `GridFTP` version 1) do not allow servers to redirect end-clients, in other cases pool servers may be behind a firewall, so preventing direct access. When direct end-client access is not possible, the door may act as a data proxy, streaming data to the client.

By default, each door is hosted in a dedicated *domain*. This allows easy control of whether a protocol is supported from a particular machine.

Java Virtual Machine (JVM) Java programs are typically compiled into a binary form called Java byte-code. Byte-code is comparable to the format that computers understand native; however, no mainstream processor understands Java byte-code. Instead compiled Java programs typically require a translation layer for them to run. This translation layer is called a Java Virtual Machine (JVM). It is a standardised execution environment that Java programs may run within. A JVM is typically represented as a process within the host computer.

tertiary storage system A mass storage system which stores data and is connected to the dCache system. Each dCache pool will write files to it as soon as they have been completely written to the pool (if the pool is not configured as a *LFS*). The tertiary storage system is not part of dCache. However, it is possible to connect any mass storage system as tertiary storage system to dCache via a simple interface.

tape backend A *tertiary storage system* which stores data on magnetic tapes.

Hierarchical Storage Manager (HSM) See tertiary storage system.

HSM Type The type of HSM which is connected to dCache as a *tertiary storage system*. The choice of the HSM type influences the communication between dCache and the HSM. Currently there are `osm` and `enstore`. `osm` is used for most HSMs (TSM, HPSS, ...).

HSM Instance

Large File Store (LFS) A Large File Store is the name for a dCache instance that is acting as a filesystem independent to, or in cooperation with, an *HSM* system. When dCache is acting as an LFS, files may be stored and later read without involving any HSM system.

Whether a dCache instance provides an LFS depends on whether there are *pools* configured to do so. The `LFS` option, specified for each pool within

the *layout file*, describes how that pool should behave. This option can take three possible values:

none

the pool does not contribute to any LFS capacity. All newly written files are regarded precious and sent to the HSM backend.

precious

Newly create files are regarded as precious but are not scheduled for the HSM store procedure. Consequently, these file will only disappear from the pool when deleted in the *Chimera* namespace.

|                                |                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| to store                       | Copying a file from a dCache pool to the <i>tertiary storage system</i> .                                                                                                                                                                                                                                                                                                                                  |
| to restore                     | Copying a file from the <i>tertiary storage system</i> to one of the dCache pools.                                                                                                                                                                                                                                                                                                                         |
| to stage                       | See to restore.                                                                                                                                                                                                                                                                                                                                                                                            |
| transfer                       | Any kind of transfer performed by a dCache pool. There are <i>store</i> , <i>restore</i> , pool to pool (client and server), read, and write transfers. The latter two are client transfers.<br>See Also mover.                                                                                                                                                                                            |
| mover                          | The process/thread within a <i>pool</i> which performs a <i>transfer</i> . Each pool has a limited number of movers that may be active at any time; if this limit is reached then further requests for data are queued.<br><br>In many protocols, end clients connect to a mover to transfer file contents. To support this, movers must speak the protocol the end client is using.<br>See Also transfer. |
| Location Manager               | The location manager is a <i>cell</i> that instructs a newly started <i>domains</i> to which domain they should connect. This allows domains to form arbitrary network topologies; although, by default, a dCache instance will form a star topology with the <code>dCacheDomain</code> domain at the centre.                                                                                              |
| Pinboard                       | The pinboard is a collection of messages describing events within dCache and is similar to a log file. Each <i>cell</i> will (typically) have its own pinboard.                                                                                                                                                                                                                                            |
| Breakeven Parameter            | The breakeven parameter has to be a positive number smaller than 1.0. It specifies the impact of the age of the least recently used file on space cost. If the LRU file is one week old, the space cost will be equal to (1 + breakeven). Note that this will not be true, if the breakeven parameter has been set to a value greater or equal to 1.                                                       |
| least recently used (LRU) File | The file that has not be requested for the longest.                                                                                                                                                                                                                                                                                                                                                        |
| file level                     | In <i>Chimera</i> , each file can have up to eight independent contents; these file-contents, called levels, may be accessed independently. dCache will store                                                                                                                                                                                                                                              |

some file metadata in levels 1 and 2, but dCache will not store any file data in Chimera.

directory tag

*Chimera* includes the concept of tags. A tag is a keyword-value pair associated with a directory. Subdirectories inherit tags from their parent directory. New values may be assigned, but tags cannot be removed. The *dot command* `.(tag)(<foo>)` may be used to read or write tag `<foo>`'s value. The dot command `.(tags)()` may be read for a list of all tags in that file's subdirectory.

More details on directory tags are given in the section called "Directory Tags".

dot command

To configure and access some of the special features of the *Chimera namespace*, special files may be read, written to or created. These files all start with a dot (or period) and have one or more parameters after. Each parameter is contained within a set of parentheses; for example, the file `.(tag)(<foo>)` is the Chimera dot command for reading or writing the `<foo>` *directory tag* value.

Care must be taken when accessing a dot command from a shell. Shells will often expand parentheses so the filename must be protected against this; for example, by quoting the filename or by escaping the parentheses.

Wormhole

A wormhole is a feature of the *Chimera namespace*. A wormhole is a file that is accessible in all directories; however, the file is not returned when scanning a directory (e.g., using the `ls` command).

Pool to Pool Transfer

A pool-to-pool transfer is one where a file is transferred from one dCache *pool* to another. This is typically done to satisfy a read request, either as a load-balancing technique or because the file is not available on pools that the end-user has access.

Storage Class

The storage class is a string of the form

```
<StoreName>:<StorageGroup>@<type-of-storage-system>
```

containing exactly one @-symbol.

- `<StoreName>:<StorageGroup>` is a string describing the storage class in a syntax which depends on the storage system.
- `<type-of-storage-system>` denotes the type of storage system in use.

In general use `<type-of-storage-system>=osm`.

A storage class is used by a tertiary storage system to decide where to store the file (i.e. on which set of tapes). dCache can use the storage class for a similar purpose, namely to decide on which pools the file can be stored.

|                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Replica                        | <p>It is possible that dCache will choose to make a file accessible from more than one <i>pool</i> using a <i>pool-to-pool</i> copy. If this happens, then each copy of the file is a replica.</p> <p>A file is independent of which pool is storing the data whereas a replica is uniquely specified by the <code>pnfs</code> ID <i>and</i> the pool name it is stored on.</p>                                                                                                                                                                                                                                                             |
| Precious Replica               | A precious replica is a <i>replica</i> that should be stored on tape.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Cached Replica                 | A cached replica is a <i>replica</i> that should not be stored on tape.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Replica Manager                | The replica manager keeps track of the number of <i>replicas</i> of each file within a certain subset of pools and makes sure this number is always within a specified range. This way, the system makes sure that enough versions of each file are present and accessible at all times. This is especially useful to ensure resilience of the dCache system, even if the hardware is not reliable. The replica manager cannot be used when the system is connected to a <i>tertiary storage system</i> . The activation and configuration of the replica manager is described in Chapter 6, <i>The replica Service (Replica Manager)</i> . |
| Storage Resource Manager (SRM) | An SRM provides a standardised webservice interface for managing a storage resource (e.g. a dCache instance). It is possible to reserve space, initiate file storage or retrieve, and replicate files to another SRM. The actual transfer of data is not done via the SRM itself but via any protocol supported by both parties of the transfer. Authentication and authorisation is done with the grid security infrastructure. dCache comes with an implementation of an SRM which can turn any dCache instance into a grid storage element.                                                                                              |
| Billing/Accounting             | Accounting information is either stored in a text file or in a PostgreSQL database by the <code>billing cell</code> usually started in the <code>httpdDomain domain</code> . This is described in Chapter 15, <i>The billing Service</i> .                                                                                                                                                                                                                                                                                                                                                                                                  |
| Pool Manager                   | The pool manager is the <code>cell</code> running in the <code>dCacheDomain domain</code> . It is a central component of a dCache instance and decides which pool is used for an incoming request.                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Cost Module                    | The cost module is a Java class responsible for combining the different types of cost associated with a particular operation; for example, if a file is to be stored, the cost module will combine the storage costs and CPU costs for each candidate target pool. The pool manager will choose the candidate pool with the least combined cost.                                                                                                                                                                                                                                                                                            |
| Pool Selection Unit            | The pool selection unit is a Java class responsible for determining the set of candidate pools for a specific transaction. A detailed account of its configuration and behaviour is given in the section called “The Pool Selection Mechanism”.                                                                                                                                                                                                                                                                                                                                                                                             |
| Pin Manager                    | The pin manager is a <code>cell</code> by default running in the <code>utility domain</code> . It is a central service that can “pin” files to a pool for a certain time. It is used by the SRM to satisfy prestige requests.                                                                                                                                                                                                                                                                                                                                                                                                               |



**Space Manager** The (SRM) Space Manager is a *cell* by default running in the *srn domain*. It is a central service that records reserved space on pools. A space reservation may be either for a specific duration or never expires. The Space Manager is used by the SRM to satisfy space reservation requests.

**Pool** A pool is a *cell* responsible for storing retrieved files and for providing access to that data. Data access is supported via *movers*. A machine may have multiple pools, perhaps due to that machine's storage being split over multiple partitions.

A pool must have a unique name and all pool cells on a particular machine are hosted in a *domain* that derives its name from the host machine's name.

The list of directories that are to store pool data are found in definition of the pools in the *layout Files*, which are located on the pool nodes.

**sweeper** A sweeper is an activity located on a *pool*. It is responsible for deleting files on the pool that have been marked for removal. Files can be marked for removal because their corresponding namespace entry has been deleted or because the local file is a *cache copy* and more disk space is needed.

**HSM sweeper** The HSM sweeper, if enabled, is a component that is responsible for removing files from the *HSM* when the corresponding namespace entry has been removed.

**cost** The pool manager determines the pool used for storing a file by calculating a cost value for each available pool. The pool with the lowest cost is used. The costs are calculated by the cost module as described in the section called "Classic Partitions". The total cost is a linear combination of the performance cost and the space cost. I.e.,

$$\text{cost} = \text{ccf} * \text{performance\_cost} + \text{scf} * \text{space\_cost}$$

where *ccf* and *scf* are configurable with the command **set pool decision**.

**performance cost** See also the section called "The Performance Cost".

**space cost** See also the section called "The Space Cost"..