Architecture of the gLite Data Management System

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Outline

- Grid Data Management Challenge
- Storage Elements and SRM
- File Catalogs and DM tools
- File Transfer Service

The Grid DM Challenge

CYCLOPS

The Grid DM Challenge

- Heterogeneity

Information Society and Media

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  - Several replicas of one file in different sites
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- Also…
  - WMS can send (small amounts of) data to/from jobs: Input and Output Sandbox
  - Files may be copied from/to local filesystems (WNs, UIs) to the Grid (SEs)

gLite Grid Storage Requirements

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- Support a native I/O (remote file) access protocol
  - POSIX (like) I/O client library for direct access of data (GFAL)

SRM in an example

She is running a job which needs:
Data for physics event reconstruction
Simulated Data
Some data analysis files
She will write files remotely too

They are at CERN
In dCache

They are at Fermilab
In a disk array

They are at Nikhef
in a classic SE

SRM in an example

dCache
Own system, own protocols and parameters

gLite DPM
Independent system from dCache or Castor

Castor
No connection with dCache or DPM

You as a user need to know all the systems!!!

SRM in an example

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SRM

I talk to them on your behalf
I will even allocate space for your files
And I will use transfer protocols to send your files there

Storage Resource Management

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  - Life time management

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- In gLite, interactions with the SRM is hidden by higher level services (DM tools and APIs)

gLite SE types

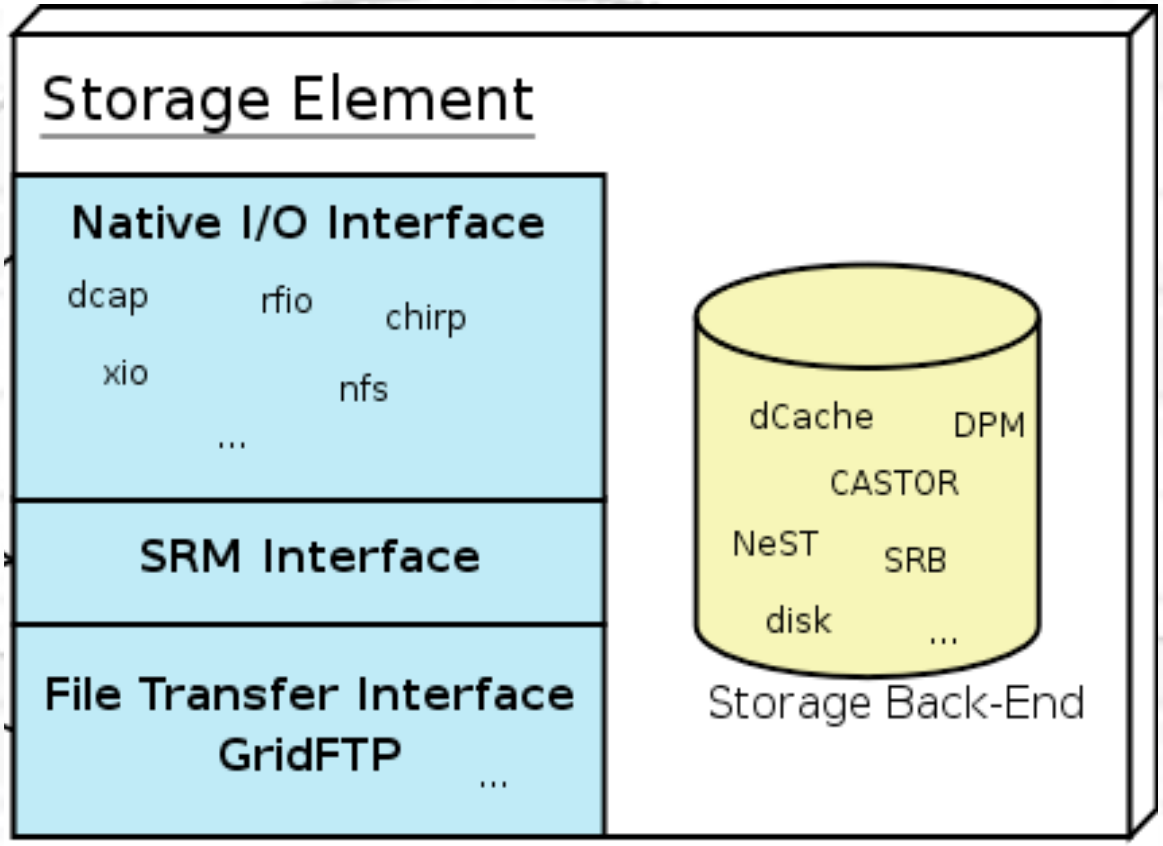
- gLite 3.0 data access protocols:
  - File Transfer: GSIFTP (GridFTP)
  - File I/O (Remote File access):
    - gsidcap
    - insecure RFIO
    - secured RFIO (gsirfio)

- Classic SE:
  - GridFTP server
  - Insecure RFIO daemon (rfiod) – only LAN limited file access
  - Single disk or disk array
  - No quota management
  - Does not support the SRM interface

gLite SE types (II)

- Mass Storage Systems (Castor)
  - Files migrated between front-end disk and back-end tape storage hierarchies
  - GridFTP server
  - Insecure RFIO (Castor)
  - Provide a SRM interface with all the benefits
- Disk pool managers (dCache and gLite DPM)
  - manage distributed storage servers in a centralized way
  - Physical disks or arrays are combined into a common (virtual) file system
  - Disks can be dynamically added to the pool
  - GridFTP server
  - Secure remote access protocols (gsidcap for dCache, gsirfio for DPM)
  - SRM interface

gLite Storage Element

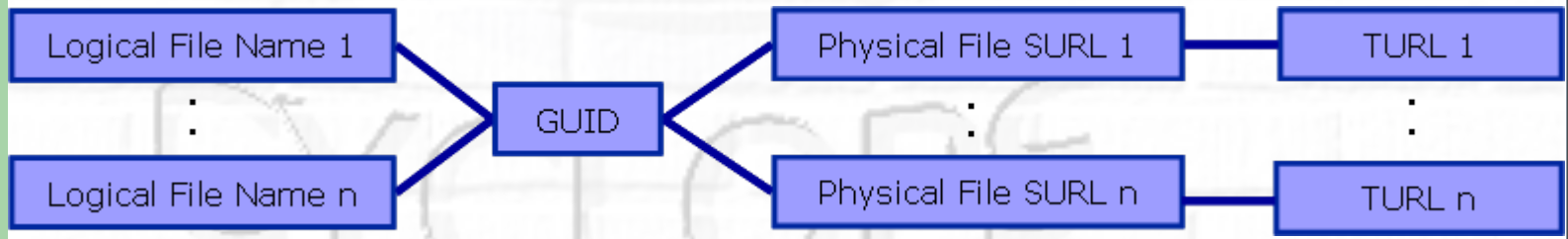


Files Naming conventions

- **Logical File Name (LFN)**
  - An alias created by a user to refer to some item of data, e.g. "lfn:/grid/gilda/20030203/run2/track1"
- **Globally Unique Identifier (GUID)**
  - A non-human-readable unique identifier for an item of data, e.g. "guid:f81d4fae-7dec-11d0-a765-00a0c91e6bf6"
- **Site URL (SURL) (or Physical File Name (PFN) or Site FN)**
  - The location of an actual piece of data on a storage system

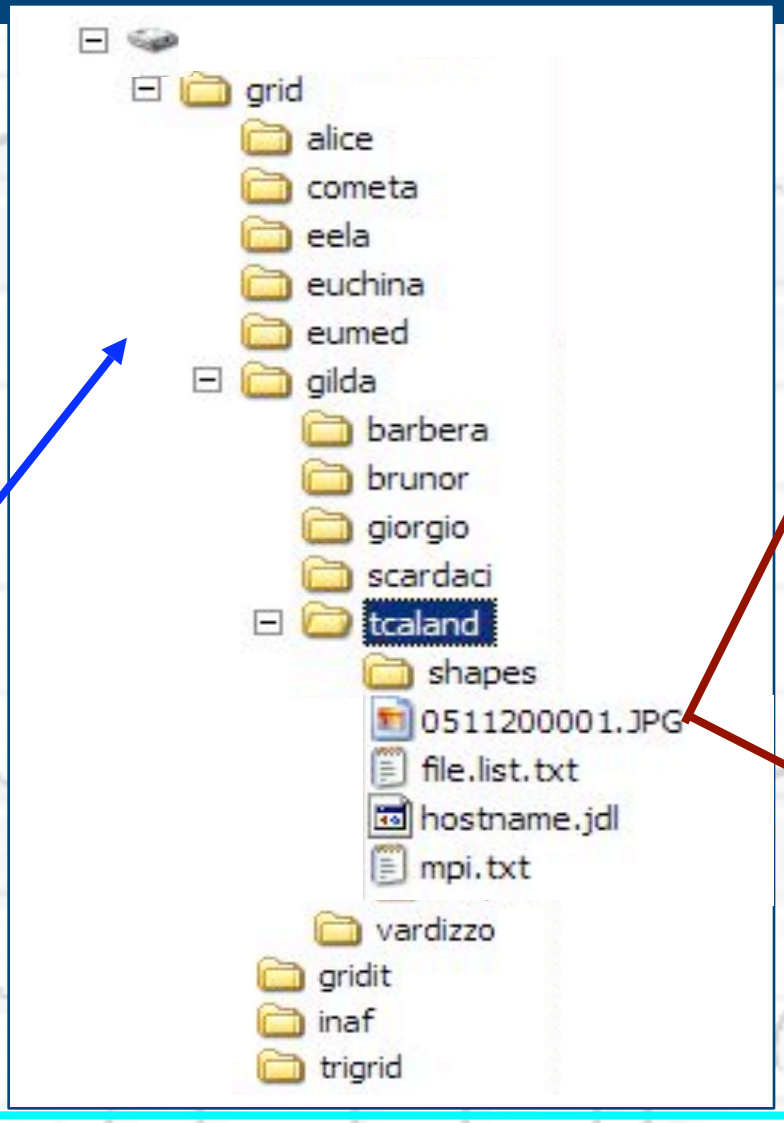
    e.g. "srm://grid009.ct.infn.it/dpm/ct.infn.it/gilda/output10_1" (SRM) "sfn://lxshare0209.cern.ch/data/alice/ntuples.dat" (Classic SE)
- **Transport URL (TURL)**
  - Temporary locator of a replica + access protocol: understood by a SE, e.g.

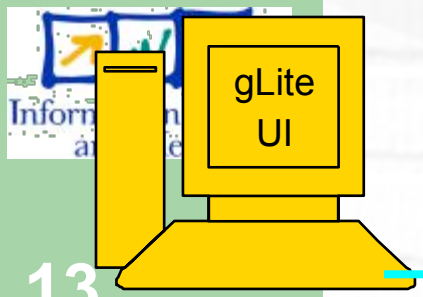
    "rfio://lxshare0209.cern.ch//data/alice/ntuples.dat"



What is a file catalog

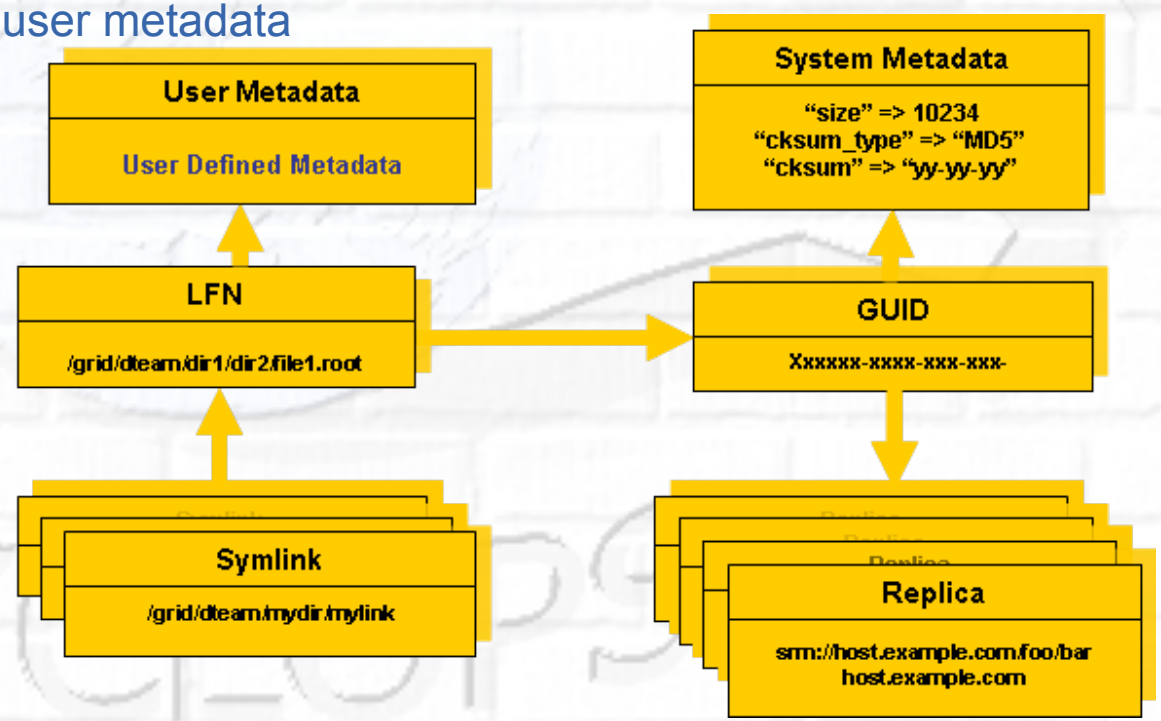
File Catalog





The LFC (LCG File Catalog)

- It keeps track of the location of copies (replicas) of Grid files
- LFN acts as main key in the database. It has:
  - Symbolic links to it (additional LFNs)
  - Unique Identifier (GUID)
  - System metadata
  - Information on replicas
  - One field of user metadata



LFC Features

- Cursors for large queries
- Timeouts and retries from the client
- User exposed transactional API (+ auto rollback on failure)
- Hierarchical namespace and namespace operations (for LFNs)
- Integrated GSI Authentication + Authorization
- Access Control Lists (Unix Permissions and POSIX ACLs)
- Checksums
- Integration with VOMS (VirtualID and VirtualGID)

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LFC commands

Summary of the LFC Catalog commands

lfc-chmod	Change access mode of the LFC file/directory
lfc-chown	Change owner and group of the LFC file-directory
lfc-delcomment	Delete the comment associated with the file/directory
lfc-getacl	Get file/directory access control lists
lfc-ln	Make a symbolic link to a file/directory
lfc-ls	List file/directory entries in a directory
lfc-mkdir	Create a directory
lfc-rename	Rename a file/directory
lfc-rm	Remove a file/directory
lfc-setacl	Set file/directory access control lists
lfc-setcomment	Add/replace a comment

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lfc-ls

Listing the entries of a LFC directory

lfc-ls *[-cdiLlRTu] [--class] [--comment] [--deleted] [--display_side] [--ds] path…*

where *path* specifies the LFN pathname (mandatory)

- Remember that **LFC has a directory tree structure**
- /grid/<VO_name>/<you create it>

LFC Namespace | **Defined by the user**

- All members of a VO have read-write permissions under their directory
- You can set LFC_HOME to use relative paths

-l : long listing
-R : list the contents of directories recursively: Don't use it!

lfc-mkdir

Creating directories in the LFC

lfc-mkdir [-m mode] [-p] path...

- Where *path* specifies the LFC pathname
- Remember that while registering a new file (using lcg-cr, for example) the corresponding destination directory must be created in the catalog beforehand.
- Examples:

  > lfc-mkdir /grid/gilda/tony/demo

  You can just check the directory with:

  > lfc-ls -l /grid/gilda/tony

  drwxr-xrwx 0 19122 1077 0 Jun 14 11:36 demo

lfc-ln

Creating a symbolic link

lfc-ln -s file linkname

lfc-ln -s directory linkname

Create a link to the specified *file* or *directory* with *linkname*

- *Examples:*

> lfc-ln -s /grid/gilda/tony/demo/test /grid/gilda/tony/aLink

Let's check the link using lfc-ls with long listing (-l):

> lfc-ls -l

lrwxrwxrwx 1 19122 1077 0 Jun 14 11:58 aLink ->/grid/gilda/tony/demo/test

drwxr-xrwx 1 19122 1077 0 Jun 14 11:39 demo

LFC C API

Low level methods (many POSIX-like):

lfc_access
lfc_aborttrans
lfc_addreplica
lfc_apiinit
lfc_chclass
lfc_chdir
lfc_chmod
lfc_chown
lfc_closedir
lfc_creat
lfc_delcomment
lfc_delete
lfc_deleteclass
lfc_delreplica
lfc_endtrans
lfc_enterclass
lfc_errmsg
lfc_getacl
lfc_getcomment
lfc_getcwd
lfc_getpath
lfc_lchown
lfc_listclass
lfc_listlinks
lfc_listreplica
lfc_lstat
lfc_mkdir
lfc_modifyclass
lfc_opendir
lfc_queryclass
lfc_readdir
lfc_readlink
lfc_rename
lfc_rewind
lfc_rmdir
lfc_selectsrvr
lfc_setacl
lfc_setatime
lfc_setcomment
lfc_seterrbuf
lfc_setfsize
lfc_starttrans
lfc_stat
lfc_symlink
lfc_umask
lfc_undelete
lfc_unlink
lfc_utime
send2lfc

GFAL: Grid File Access

Interactions with SE require some components:

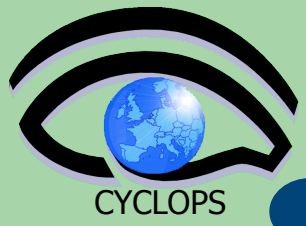
→ File catalog services to locate replicas
→ SRM
→ File access mechanism to access files from the SE on the WN

GFAL does all this tasks for you:

→ Hides all these operations
→ Presents a POSIX interface for the I/O operations
→ Single shared library in threaded and unthreaded versions
libgfal.so, libgfal_pthr.so
→ Single header file: gfal_api.h
→ User can create all commands needed for storage management
→ It offers as well an interface to SRM

Supported protocols:

→ file (local or nfs-like access)
→ dcap, gsidcap and kdcap (dCache access)
→ rfio (castor access) and gsirfio (dpm)



GFAL: File I/O API (I)

```
int gfal_access (const char *path, int amode);
int gfal_chmod (const char *path, mode_t mode);
int gfal_close (int fd);
int gfal_creat (const char *filename, mode_t mode);
off_t gfal_lseek (int fd, off_t offset, int whence);
int gfal_open (const char * filename, int flags, mode_t mode);
ssize_t gfal_read (int fd, void *buf, size_t size);
int gfal_rename (const char *old_name, const char *new_name);
ssize_t gfal_setfilchg (int, const void *, size_t);
int gfal_stat (const char *filename, struct stat *statbuf);
int gfal_unlink (const char *filename);
ssize_t gfal_write (int fd, const void *buf, size_t size);
```

GFAL: File I/O API (II)

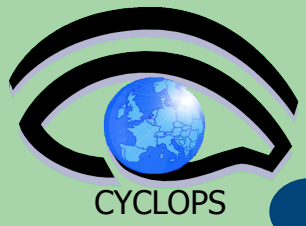
```
int gfal_closedir (DIR *dirp);

int gfal_mkdir (const char *dirname, mode_t mode);

DIR *gfal_opendir (const char *dirname);

struct dirent *gfal_readdir (DIR *dirp);

int gfal_rmdir (const char *dirname);
```



GFAL: Catalog API

int **create_alias** (const char *guid, const char *lfn, long long size)

int **guid_exists** (const char *guid)

char ***guidforpfn** (const char *surl)

char ***guidfromlfn** (const char *lfn)

char ****lfnsforguid** (const char *guid)

int **register_alias** (const char *guid, const char *lfn)

int **register_pfn** (const char *guid, const char *surl)

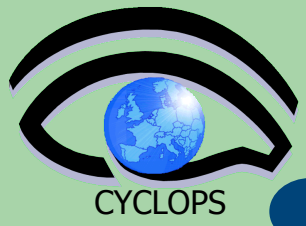
int **setfilesize** (const char *surl, long long size)

char ***surlfromguid** (const char *guid)

char ****surlsfromguid** (const char *guid)

int **unregister_alias** (const char *guid, const char *lfn)

int **unregister_pfn** (const char *guid, const char *surl)



GFAL: Storage API

int **deletesurl** (const char *surl)

int **getfilemd** (const char *surl, struct stat64 *statbuf)

int **set_xfer_done** (const char *surl, int reqid, int fileid, char *token, int oflag)

int **set_xfer_running** (const char *surl, int reqid, int fileid, char *token)

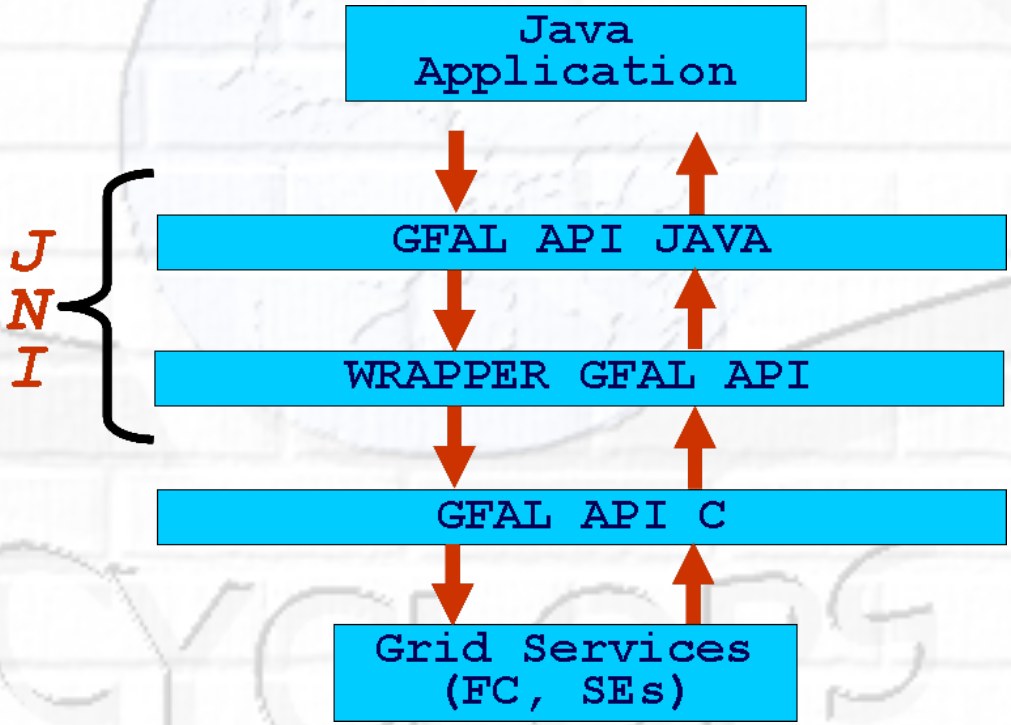
char ***turlfromsurl** (const char *surl, char **protocols, int oflag, int *reqid, int *fileid, char **token)

int **srm_get** (int nbfiles, char **surls, int nbprotocols, char **protocols, int *reqid, char **token, struct srm_filestatus **filestatuses)

int **srm_getstatus** (int nbfiles, char **surls, int reqid, char *token, struct srm_filestatus **filestatuses)

GFAL Java API

- GFAL API are available for C/C++ programmers
- We wrote a wrapper around the C APIs using Java Native Interface and a the Java APIs on top of it
- More information can be found here:
  https://grid.ct.infn.it/twiki/bin/view/GILDA/APIGFAL



lcg-utils DM tools

- High level interface (CL tools and APIs) to
  - Upload/download files to/from the Grid (UI,CE and WN <---> SEs)
  - Replicate data between SEs and locate the best replica available
  - Interact with the file catalog

- ***Definition***: A file is considered to be a Grid File if it is both physically present in a SE and registered in the File Catalog

- lcg-utils ensure the consistency between files in the Storage Elements and entries in the File Catalog

lcg-utils commands

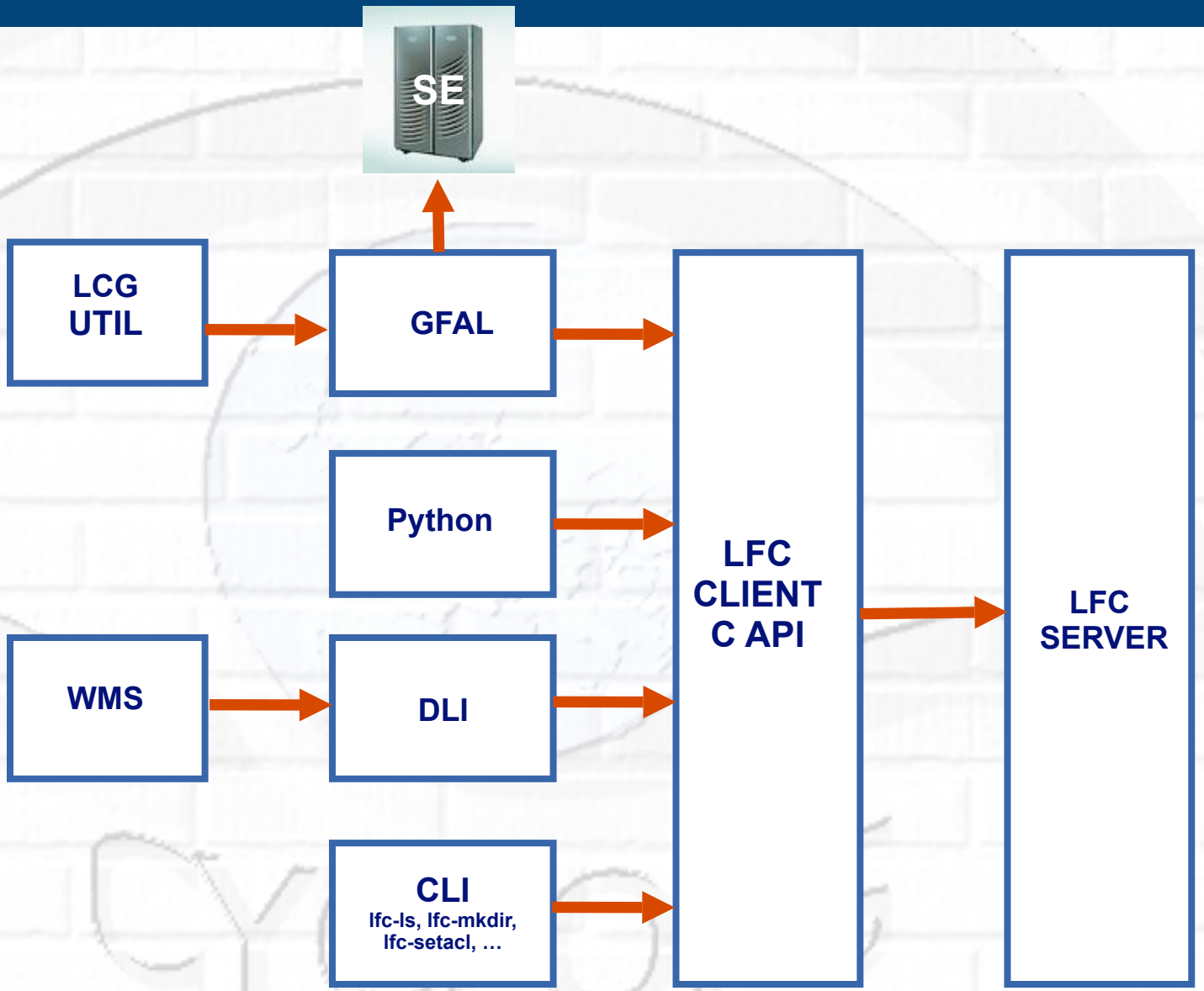
Replica Management

lcg-cp	Copies a grid file to a local destination
lcg-cr	Copies a file to a SE and registers the file in the catalog
lcg-del	Delete one file
lcg-rep	Replication between SEs and registration of the replica
lcg-gt	Gets the TURL for a given SURL and transfer protocol
lcg-sd	Sets file status to “Done” for a given SURL in a SRM request

File Catalog Interaction

lcg-aa	Add an alias in LFC for a given GUID
lcg-ra	Remove an alias in LFC for a given GUID
lcg-rf	Registers in LFC a file placed in a SE
lcg-uf	Unregisters in LFC a file placed in a SE
lcg-la	Lists the alias for a given SURL, GUID or LFN
lcg-lg	Get the GUID for a given LFN or SURL
lcg-lr	Lists the replicas for a given GUID, SURL or LFN

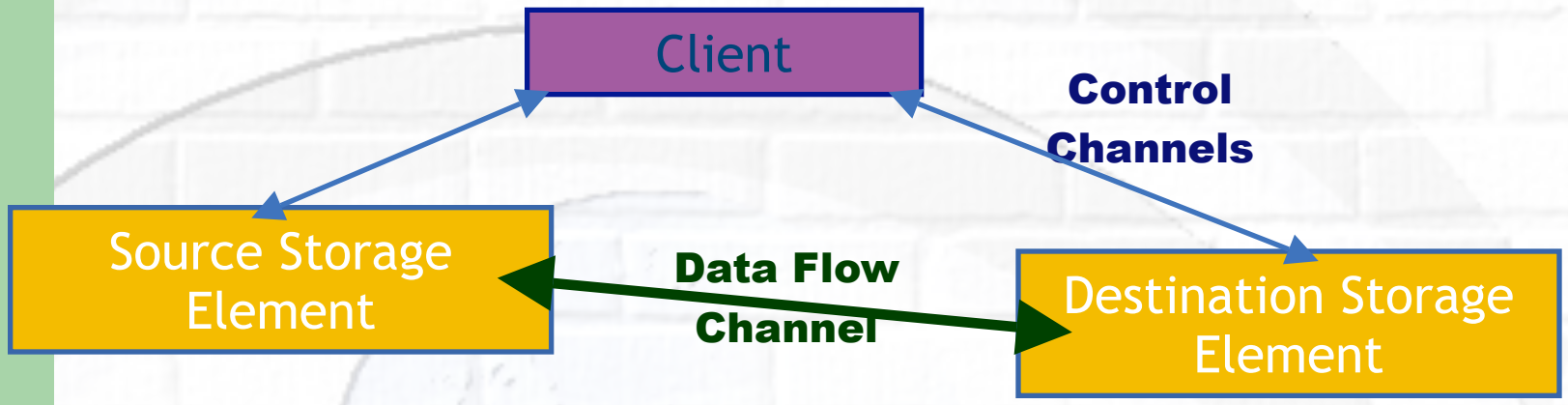
LFC interfaces



Data movement introduction

- Grids are naturally distributed systems
- The means that data also needs to be distributed
  - First generation data distribution mainly concentrated on copy protocols in a grid environment:
    - gridftp
    - http + mod_gridsite
- But copies controlled by clients have problems…

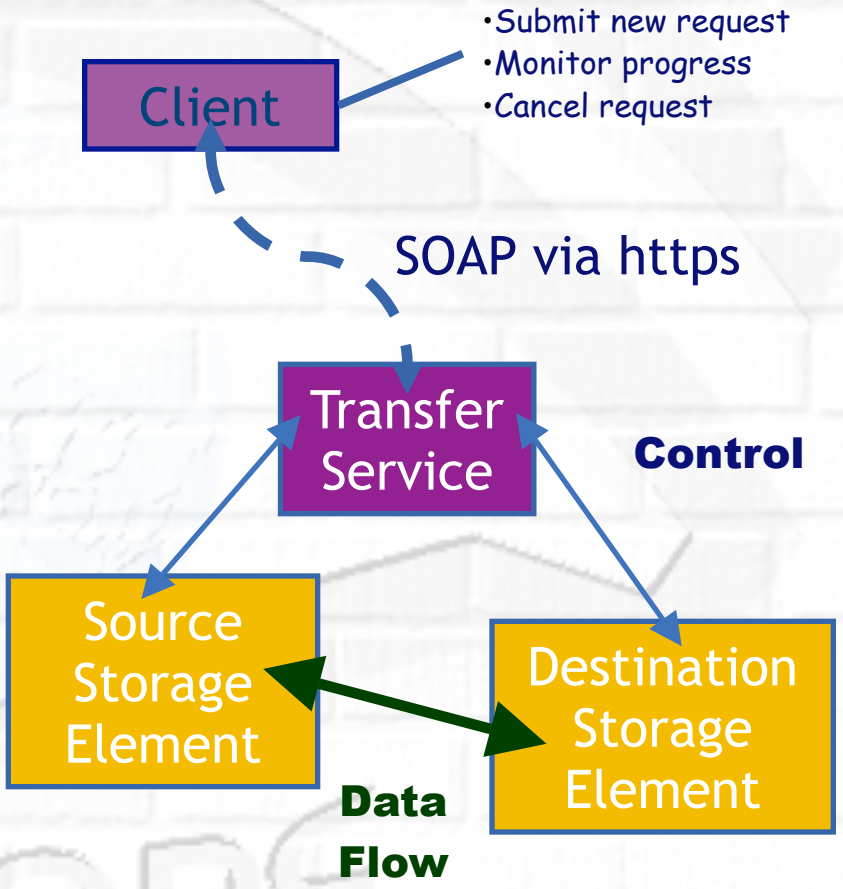
Direct Client Controlled Data Movement



- Although transport protocol may be robust, state is held inside client – inconvenient and fragile.
- Client only knows about local state, no sense of global knowledge about data transfers between storage elements.
  - Storage elements overwhelmed with replication requests
  - Multiple replications of the same data can happen simultaneously
  - Site has little control over balance of network resources - DOS

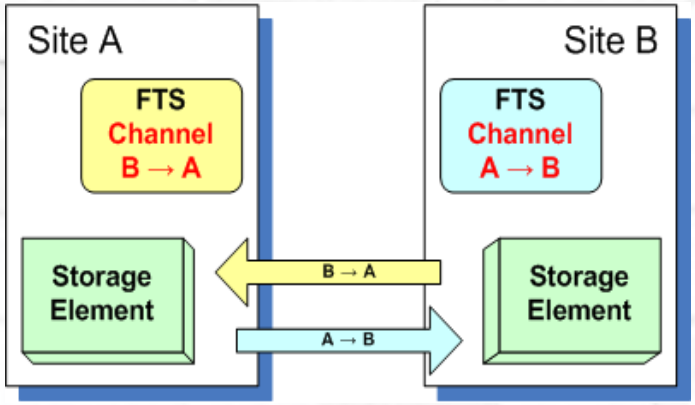
Transfer Service

- Clear need for a ***service*** for data transfer
  - Client connects to service to submit request
  - Service maintains state about transfer
  - Client can periodically reconnect to check status or cancel request
  - Service can have knowledge of global state, not just a single request
    - Load balancing
    - Scheduling



gLite FTS: Channels

- FTS Service has a concept of ***channels***
- A channel is a ***unidirectional*** connection between two sites
- Transfer requests between these two sites are assigned to that channel
- Channels usually correspond to a dedicated network pipe (e.g., OPN) associated with production
- But channels can also take wildcards:
  - * to MY_SITE : All incoming
  - MY SITE to * : All outgoing
  - * to * : Catch all



- Channels control certain transfer properties: transfer concurrency, gridftp streams.
- Channels can be controlled independently: started, stopped, drained.

Data Management Services Summary

- Storage Element – save date and provide a common interface
  - Storage Resource Manager (SRM) Castor, dCache, DPM, …
  - Native Access protocols rfio, dcap, nfs, …
  - Transfer protocols gsiftp, ftp, …
- Catalogs – keep track where data are stored
  - File Catalog
  - Replica Catalog

    LCG File Catalog (LFC)
  - Metadata Catalog **AMGA Metadata Catalogue**
- Data Movement – schedules reliable file transfer
  - File Transfer Service gLite FTS

    (manages physical transfers)

References

- gLite documentation homepage
  - http://glite.web.cern.ch/glite/documentation/default.asp
- DM subsystem documentation
  - http://egee-jra1-dm.web.cern.ch/egee-jra1-dm/doc.htm
- LFC and DPM documentation
  - https://uimon.cern.ch/twiki/bin/view/LCG/DataManagementDocumentation
- FTS user guide
  -

Questions…