Enabling Grids for E-science in Europe

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Biomed Application Developer's Course
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Grid Data Management

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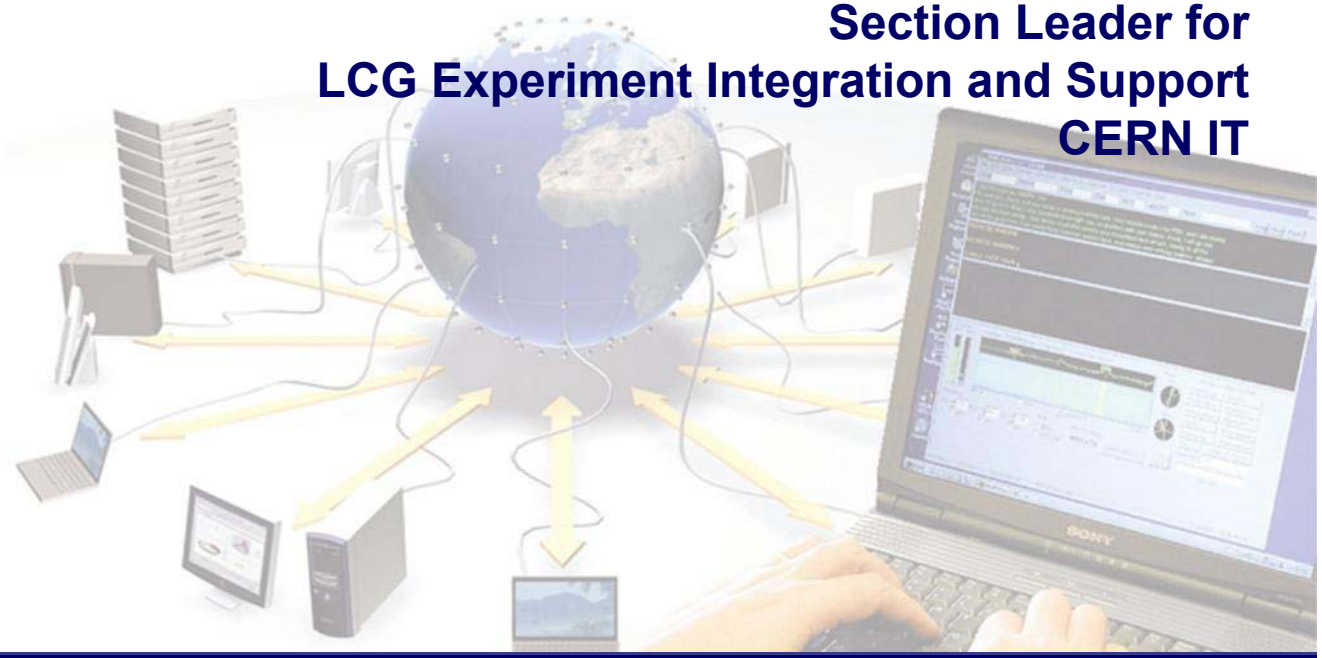

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Enabling Grids for E-science in Europe

- Problem Statement
- Data Management tools overview
- Intro to Basic DM tools
- Walkthrough of several Grid DM scenarios
- Available APIs
- lcg_util APIs usage

Problem Statement: How to connect User/Programs/Data?

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- User
  - logged in to a Grid “User Interface” machine, or
  - Logged in to a “desktop” machine
- Programs
  - On desktop
  - On UI
  - On Grid machines
- Data
  - May need to supply (Grid or non-Grid) data to applications
  - Applications may generate data, need to put it somewhere safe
  - How do you retrieve it from somewhere safe?

Grid Data Management Tools Overview

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- Replica Location Service (RLS) keeps track of where various copies of “grid datasets” (files) are located
- LCG Replica Management Tools (RM) are the primary user tools
  - Data Transfer mostly uses gridftp behind the scenes
    - Like good old FTP except uses grid auth(oriza)(entica)tion
    - No passwords!
    - Can also use multiple streams for faster transfer
  - RM handles interaction with gridftp & RLS to ease instantiation, registration, and replication of grid datasets
- Resource Broker
  - can send (small amounts of) data to/from jobs
  - can use RLS to find your data, and send your job to it, if your data is in the RLS and you tell RB about it

Grid Data Management Tools

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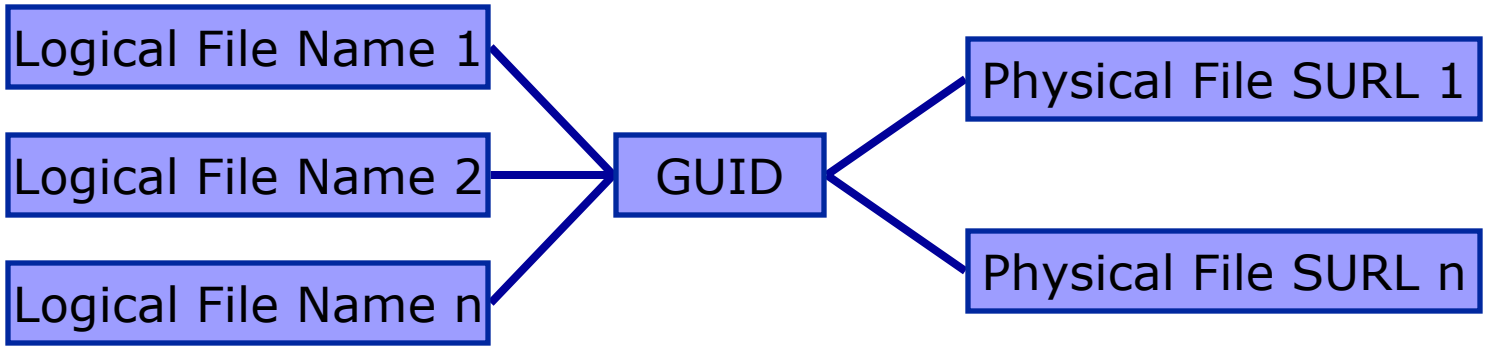
- Tools for
  - Locating data
  - Copying data
  - Managing and replicating data
  - Meta Data management
- On GILDA/LCG-2 you have
  - EDG Replica Location Service (RLS)
    - Local Replica Catalog
    - Replica MetaData Catalog
  - globus-url-copy (GridFTP)
  - LCG Replica Manager
  - Grid File Access Library
  - Various client protocol libraries rfio, dcap, etc.

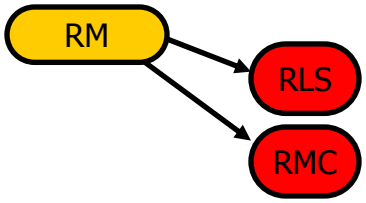
Naming Conventions

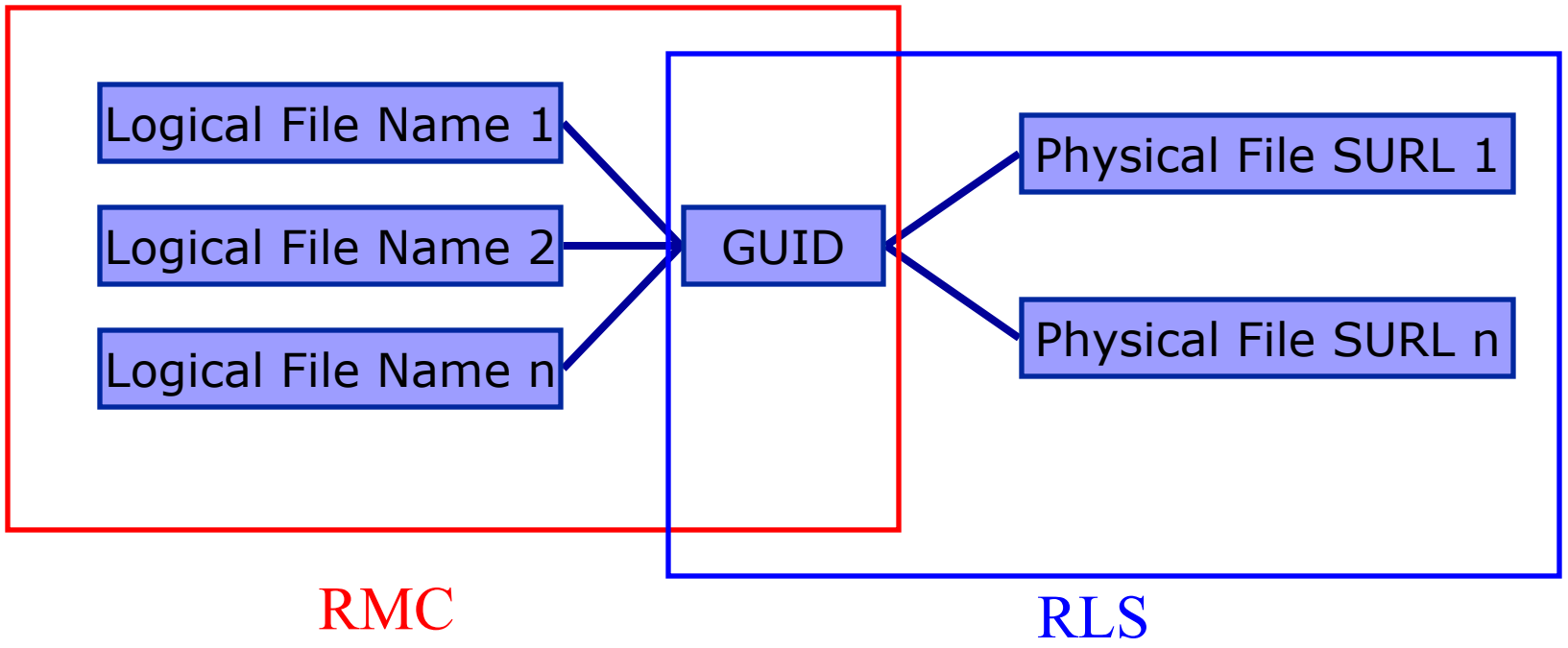
- Logical File Name (LFN)
  - An alias created by a user to refer to some item of data e.g. “lfn:cms/20030203/run2/track1”
- Site URL (SURL) (or Physical File Name (PFN))
  - The location of an actual piece of data on a storage system e.g. “srm://pcrd24.cern.ch/flatfiles/cms/output10_1” “sfn://lxshare0209.cern.ch/data/alice/ntuples.dat
- Globally Unique Identifier (GUID)
  - A non-human readable unique identifier for an item of data e.g. “guid:f81d4fae-7dec-11d0-a765-00a0c91e6bf6”



RLS: LRC and RMC

- RMC:
  - Stores LFN-GUID mappings
- RLS:
  - Stores GUID-SURL mappings





Basic RM Commands (I)

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- Putting data on the Grid
  - Put the file `/home/flavia/fd.awk` (on the local computer) onto the *storage element* `(find an SE on GILDA!)` and register it with the *logical file name* `flavia.example`
  - `lcg-cr --vo gilda -d <did you find GILDA SE?> -l lfn:flavia.example file:/home/flavia/fd.awk`

    `> guid:6ac491ea-684c-11d8-8f12-9c97cebf582a`
- Storage Element – grid-aware computer with support for data storage
- Logical File Name – symbolic file name with which you can refer to a grid file without specifying actual location
- Above command returned a “guid”:
  - `guid:6ac491ea-684c-11d8-8f12-9c97cebf582a`
- Guids are unique, LFNs are not!!

Basic RM Commands (II)

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- Finding your data: the listReplicas (lr) method
  - `lcg-rep --vo gilda lfn:flavia.example  # via LFN`

```
>sfn://lxb0707.cern.ch/flatfiles/SE00/dteam/generated/2004
  -07-09/file79aee616-6cd7-4b75- 8848-f09110ade178 >
  sfn://lxb0710.cern.ch/flatfiles/SE00/dteam/generated/200
  4-07-08/file0dcabb46-2214-4db8- 9ee8-2930de1a6bef
```

  - `lcg-rep --vo gilda \  # via GUID`
    `guid:76373236-b4c7-11d8-bb5e-eba42b5000d0`
  - `sfn://gridkap02.fzk.de/grid/fzk.de/mounts/nfs/data/lcg1/SE00/lhcb/generated/2004-06-02/file7115df45-b4c7-11d8-bb5e-eba42b5000d0`
- "replicas" because someone (or some application) may make a copy on a different storage element (SE) – the LFN and GUID refer to *all* copies

Basic RM Commands (III)

- Finding information about RLS or “DMS”
  - How did we know that `<SE on GILDA>` was a storage element?
  - `lcg-infosites --vo gilda all nousedspace`

```
LRC endpoint for dteam: http://rlsdteam.cern.ch:7777/dteam/v2.2/edg-local-replica-catalog
/services/edg-local-replica-catalog
RMC endpoint for dteam: http://rlsdteam.cern.ch:7777/dteam/v2.2/edg-replica-metadata-cata
log/services/edg-replica-metadata-catalog
****************************************************************
These are the related data for gilda: (in terms of CPUs)
****************************************************************
#CPU Free Total Jobs Running Waiting ComputingElement
------------------------------------------------------------
6      6      0     0     0 ce01.lip.pt:2119/jobmanager-lcgpbs-dteam
9      9      0     0     0 lcg-ce.ecm.ub.es:2119/jobmanager-pbs-long
****************************************************************
These are the related data for dteam: (in terms of SE)
****************************************************************
Avail Space(Kb) SEs
----------------------------------------------------------
72982236 se01.lip.pt
7549980 se00.inta.es
```

  - Lots more information printed
  - Locations of RLS components
  - Locations of all computing resources

Common Grid Data Management Tasks

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- Dealing with Data Your Job Generates
  - Getting the data back to your desktop
  - Putting the data “on the Grid”
- Getting Data to your Job
  - Submitting data along with your job
  - Putting your data onto the Grid (from outside)
  - Sending your Grid job to your Grid data
- Moving Data on the Grid
- How to find your data if you don’t remember where you put it
- Examples and documentation can be found:
  https://edms.cern.ch/file/454439//LCG-2-UserGuide.html

Hand-on time!

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- Check lcg-utils commands described in LCG-2 User Guide

- What is a Storage Element ?

- What are the available SEs on GILDA ?
- Bring your on private file on GILDA
- Replicate it
- Interrogate the RLS on its location
- Remove all physical instances of the file from GILDA GRID

Grid Application -> Data on your desktop

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- You can set up your job for “data pickup”
  - Job generates data in current working directory on WN
  - At job end, the data files are placed in temp storage at RB
  - You get them back via “edg-job-get-output”
- Key items:
  - You need to know names of files you want to get back
  - OutputSandbox = {“higgs.root",“graviton.HDF"};
  - not intended for large files (> hundred MB) – storage limitation on Resource Broker machine
- Example: output-sandbox.{jdl,sh}

Grid Application -> data “on Grid”

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- Your program generates data to some local file
- Program has to know (or be able to figure out) what the local file name is
- Program uses the lcg-utils commands to
  - Put the data onto Grid storage
  - Register the data as a Grid dataset
- A couple optional, but useful, extras:
  - On which SE should the data be stored (or even in which directory on which SE!). Default: “local” SE
  - A logical file name. Default: no LFN!

Reminders

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- Reminders:
  - If you want a specific SE, find it using the

    lcg-infosites --vo gilda closeSE --is lxn1178.cern.ch

    command.
  - Put the file on grid storage (in RLS, on SE) using the

    lcg-cr –vo <yourvo>

    command.

Alternate Method: Let WMS do it

- OutputData JDL attribute specifies where files should go
  - If no LFN specified WP2 selects one
  - If no SE is specified, the close SE is chosen
- At the end of the job the files are moved from WN and registered
- File with result of this operation is created and added to the sandbox : DSUpload_<unique jobstring>.out
-
```
OutputData = { [
    OutputFile =  "toto.out" ;
    StorageElement =  "adc0021.cern.ch" ;
    LogicalFileName =  "lfn:theBestTotoEver" ; ],
  [
    OutputFile =  "toto2.out" ;
    StorageElement =  "adc0021.cern.ch" ;
    LogicalFileName =  "lfn:theBestTotoEver2" ; ]
};
```

Submitting Data Along With Your Job

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- This is fairly easy: use the Input Sandbox
- Careful – not a sandbox in the javascript sense
- Careful 2 – not meant for large (multi-megabyte) transfers
- InputSandbox = {“input-ntuple.root"};
- Example files: inp-sbox.{jdl,sh}

Moving Data Onto Grid from Outside

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- Putting data on the Grid
  - Put the file `/home/flavia/fd.awk` (on the local computer) onto the *storage element* `gridkap02.fzk.de` and register it with the *logical file name* `flavia.example`
  - ```
    lcg-cr --vo gilda file:/home/flaiva/fd.awk \
          -l lfn:flavia.example -d gridkap02.fzk.de
    ```
- Above command returned a “guid”:
  - `guid:76373236-b4c7-11d8-bb5e-eba42b5000d0`
- Guids are unique, LFNs are not!!
- Try it with different SEs or no SE, or even with no LFN
    ```

Having Grid Send Job to Your Data

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- Need to have data “on the Grid” == listed in RLS
- Tell your job (JDL) about the grid data:
  - InputData = “lfn:myfile.dat”
- Resource Broker puts info about data matching in “brokerinfo” file on remote execution node
- In your job execution script, use the “edg-brokerinfo” command & edg-rm commands to get job-local copy
- Example files: find-data.{jdl,sh}

Moving Data Around

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- `edg-rep --vo gilda lfn:lfntest.data -d \`
  `lcgse01.gridpp.rl.ac.uk`
- Try the previous test (w/ edg-job-list-match) – should find a new site willing to accept your job

Finding Your Data

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Reminder: the listReplicas (lr) method

- `lcg-lr --vo gild lfn:flavia.example  # via LFN`
- `sfn://gridkap02.fzk.de/grid/fzk.de/mounts/nfs/data/lcg1/SE00/lhcb/generated/2004-06-02/file7115df45-b4c7-11d8-bb5e-eba42b5000d0`
- `lcg-lr --vo lhcb lr \    # via GUID`
  `guid:76373236-b4c7-11d8-bb5e-eba42b5000d0`
- `sfn://gridkap02.fzk.de/grid/fzk.de/mounts/nfs/data/lcg1/SE00/lhcb/generated/2004-06-02/file7115df45-b4c7-11d8-bb5e-eba42b5000d0`

Advanced commands

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- Low level tools for distributed data copying & info
  - globus-url-copy
  - edg-gridftp-ls and friends
- Interaction with RLS components
  - edg-lrc (local replica catalog)
  - edg-rmc (replica metadata catalog, search on metadata)
- Google is your friend

Available APIs

- LCG-2 C APIs available for all lcg-utils functions
  - Man pages are available (try % man lcg_lr)
  - Documentation available soon
- LCG-2 C++ and Java APIs available for all catalog operations

http://edg-wp2.web.cern.ch/edg-wp2/replication/docu/r2.1/edg-lrc-devguide.pdf

http://edg-wp2.web.cern.ch/edg-wp2/replication/docu/r2.1/edg-rmc-devguide.pdf

Examples can be found:

http://isscvs.cern.ch:8180/cgi-bin/cvsweb.cgi/edg-rls-client/test/?cvsroot=lcgware

http://isscvs.cern.ch:8180/cgi-bin/cvsweb.cgi/edg-metadata-catalog client/test/?cvsroot=lcgware

http://grid-deployment.web.cern.ch/grid-deployment/eis/tutorial/RLS_API.tar.gz

Available APIs

```
#include <iostream>
#include <stdlib.h>
#include <string.h>
#include <string>
#include <stdio.h>
#include <errno.h>

// lcg_util is a C library. Since we write C++ code here, we need to
// use extern C
//
extern "C"
{
#include <lcg_util.h>
}
using namespace std;
/*****************************************************************************/
/* The folling example code shows you how you can use the lcg_util API for */
/* replica management. We expect that you modify parts of this code in      */
/* to make it work in your environment. This is particularly indicated      */
/* by ACTION, i.e. your action is required.                                 */
/*****************************************************************************/
int main ()
{
cout << "Data Management API Example " << endl;
char *vo = "cms"; // ACTION: fill in your correct VO here: gilda !
cout << "-----------------------------------------------" << endl;
```

C APIs

Available APIs

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```
// Copy a local file to the Storage Element and register it in RLS
//
char *localFile = "file:/tmp/test-file"; // ACTION: create a testfile
char *destSE = "lxb0707.cern.ch"; // ACTION: fill in a specific SE char

*actualGuid = (char*) malloc(50);
int verbose = 2; // we use verbosity level 2
int nbstreams = 8; // we use 8 parallel streams to transfer a file

lcg_cr(localFile, destSE, NULL,
        NULL, vo, NULL, nbstreams,
       NULL, 0, verbose, actualGuid);

if (errno)
{
  perror("Error in copyAndRegister:");
 return -1;
} else {
   cout << "We registered the file with GUID: " << actualGuid << endl;
}
cout << "-----------------------------------------------" << endl;
```

Copy and Register

Available APIs

```
// Call the listReplicas (lcg_lr) method and print the returned URLs
//
// The actualGuid does not contain the prefix "guid:". We add it here and
// then use the new guid as a parameter to list replicas
//
std::string guid = "guid:";
guid.insert(5,actualGuid);
char ***pfns = (char***) malloc(200);

lcg_lr((char*) guid.c_str(), vo, NULL, 0, pfns);

if(errno)
{
   perror("Error in listReplicas:");
  free(pfns);
  return -1;
} else {
  cout << "PFN = " << **pfns << endl;
}

free(pfns);

cout << "----------------------------------------------" << endl;
```

List Replicas

Available APIs

```
// Delete the replica again
//
int rc = lcg_del((char*) guid.c_str(), 1, destSE, vo, NULL, 0, verbose);

if(rc != 0)
{
   perror("Error in delete:");
  return -1;
} else {
  cout << "Delete OK" << endl;
}

return 0;

}
```

Delete Replica

Available APIs

```
CC = g++
GLOBUS_FLAVOR = gcc32

all: data-management

data-management: data-management.o
                $(CC) -o data-management \
                -L${GLOBUS_LOCATION}/lib -lglobus_gass_copy_${GLOBUS_FLAVOR} \
                -L${LCG_LOCATION}/lib -llcg_util -lgfal \
                data-management.o

data-management.o: data-management.cpp
                $(CC) -I ${LCG_LOCATION}/include -c data-management.cpp

clean:
                rm -rf data-management data-management.o
```

Makefile used

Summary

Enabling Grids for E-science in Europe

- We gave an introduction to the LCG-2 Data Management Middleware Components and Tools
- We described how to use the available CLIs
- Use-case scenarios of Data Movement on Grid
- We presented the available APIs
- An example usage of lcg_util library is shown