Grid Components

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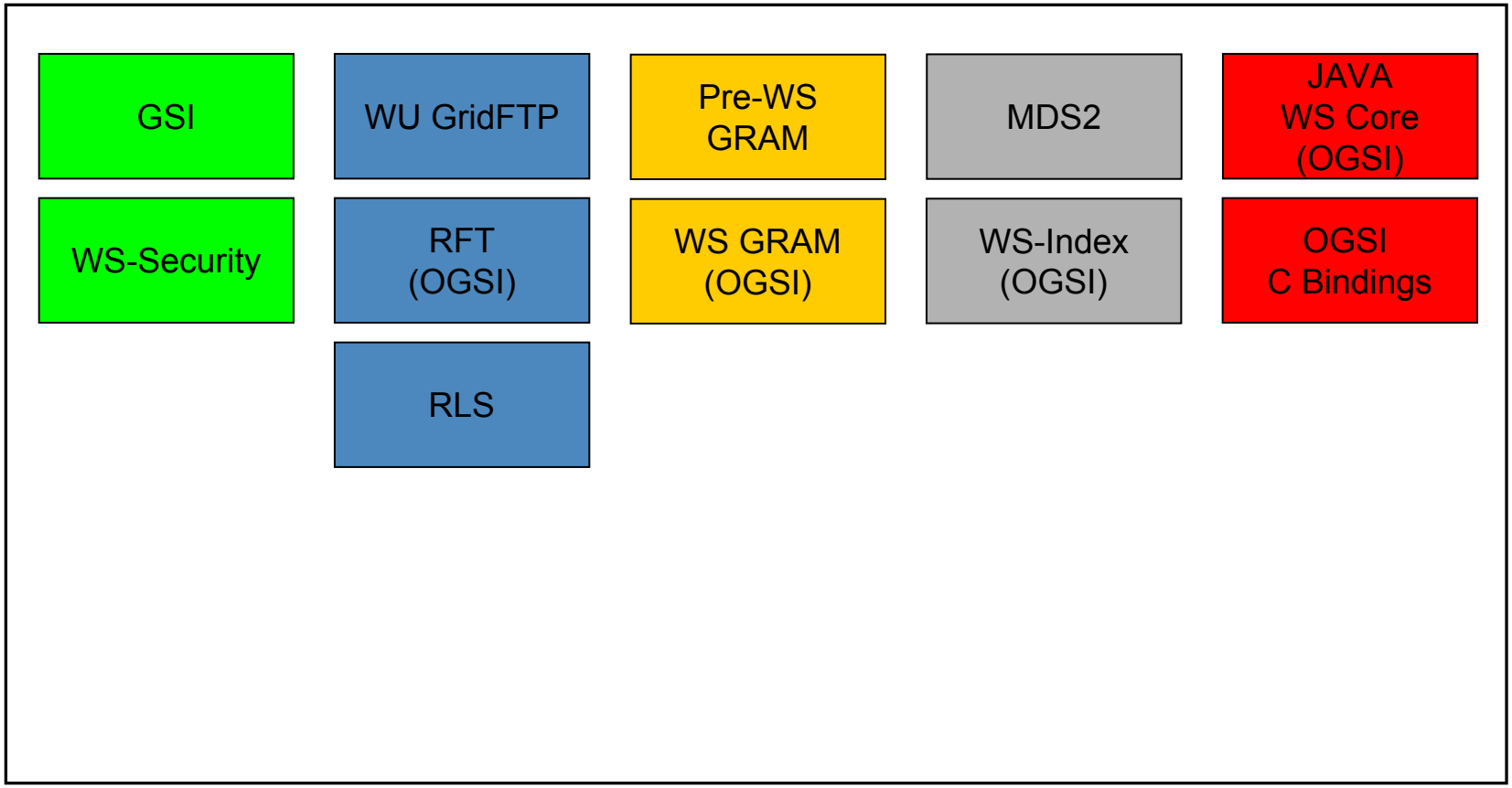
Components in Globus Toolkit 3.0



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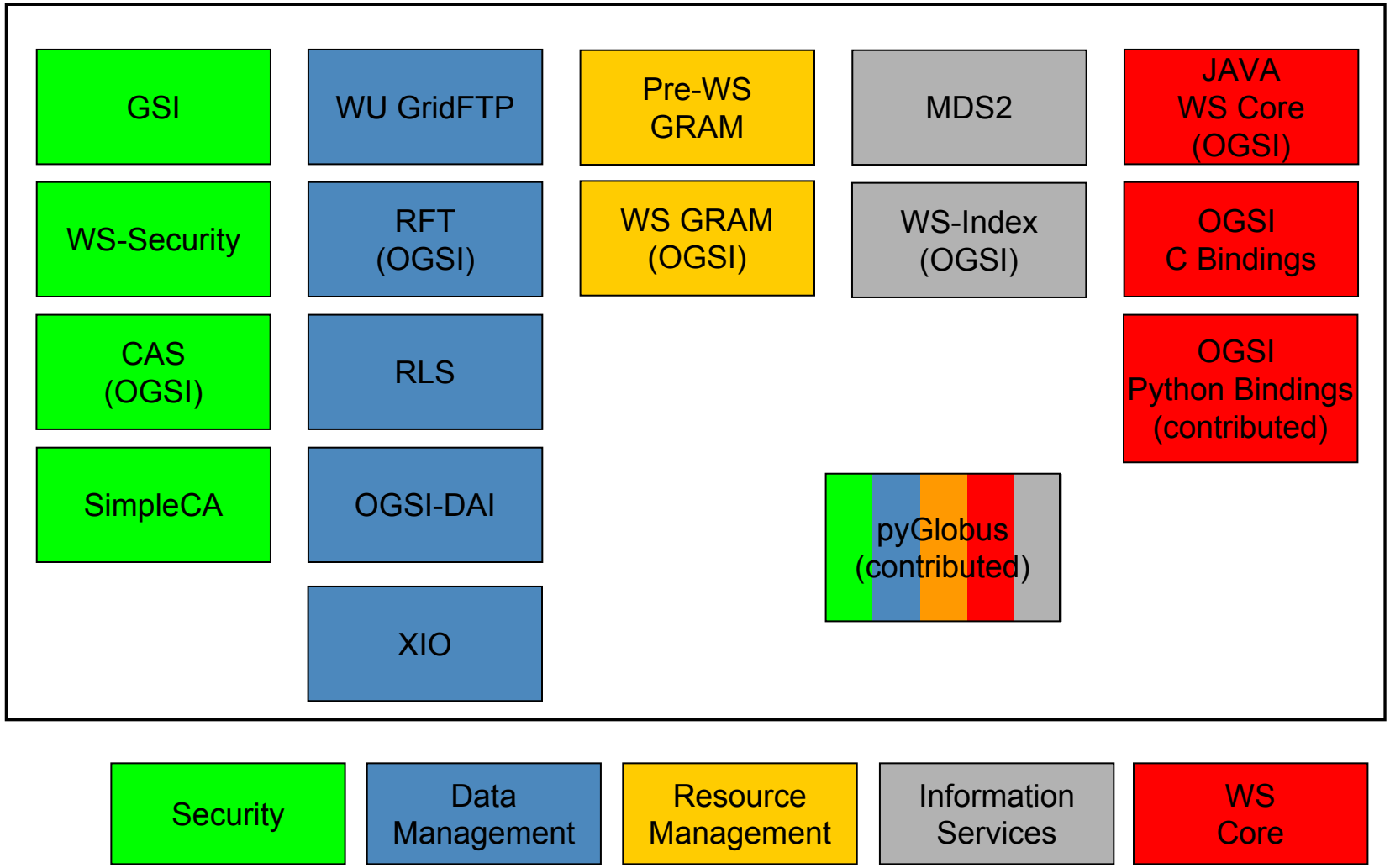
Components in Globus Toolkit 3.2



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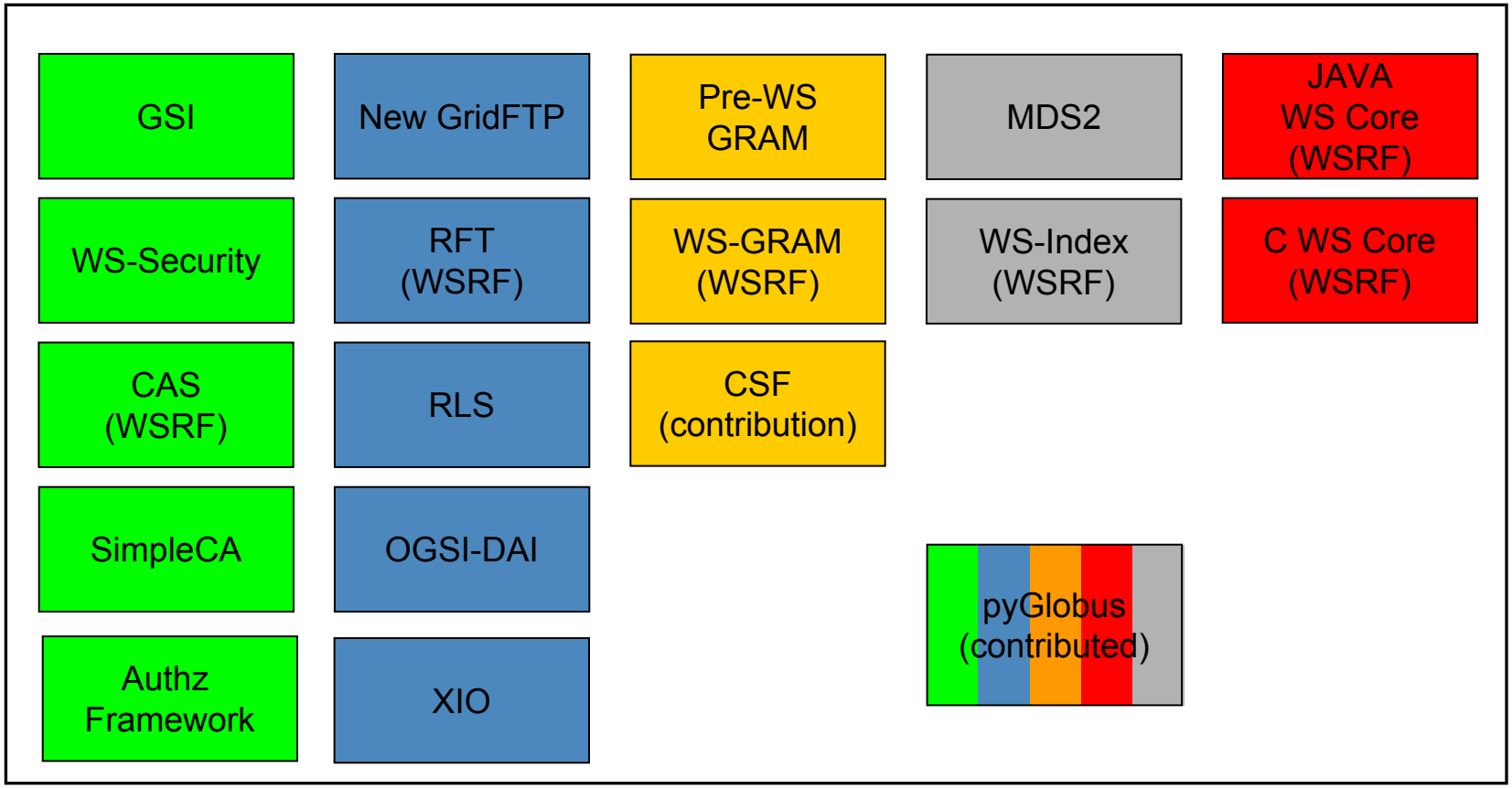
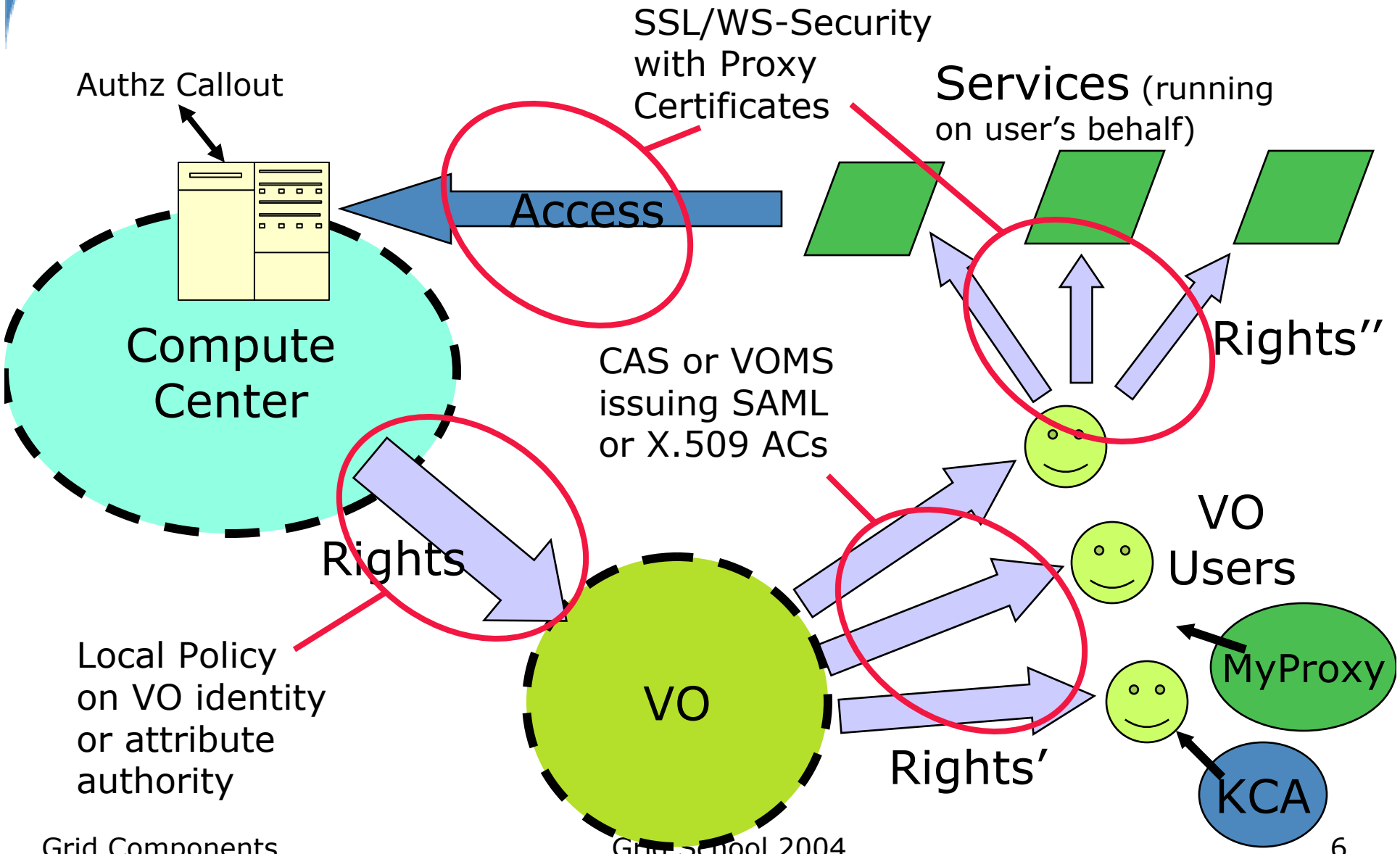
Planned Components in GT 4.0



Component to be covered

- Credential management and authorization
- Job submission and management
- Data discovery and data transfer

GSI Implementation



KX.509 and KCA

- Institutions that already have a Kerberos realm can use KX.509 and KCA to provide local users with Grid proxy certificates without using a Certificate Authority.
- When users authenticate with Kerberos, they may obtain proxy certificates in addition to their Kerberos tickets.
- KCA is a Kerberized certification service, and KX.509 is a Kerberized client that generates and stores proxy certificates.
- Unlike MyProxy, KX.509 and KCA create credentials for users, so remote sites must be configured to trust the local KCA service's certification authority.

PKINIT

- PKINIT is a service that allows users to use Grid certificates to authenticate to a Kerberos realm.
- For sites that use Kerberized services (like AFS), this allows remote Grid users to obtain the necessary Kerberos tickets to use the site's local facilities properly.
- PKINIT replaces the Kerberos "klog" command and uses the user's Grid certificate to eliminate the need for a Kerberos passphrase.

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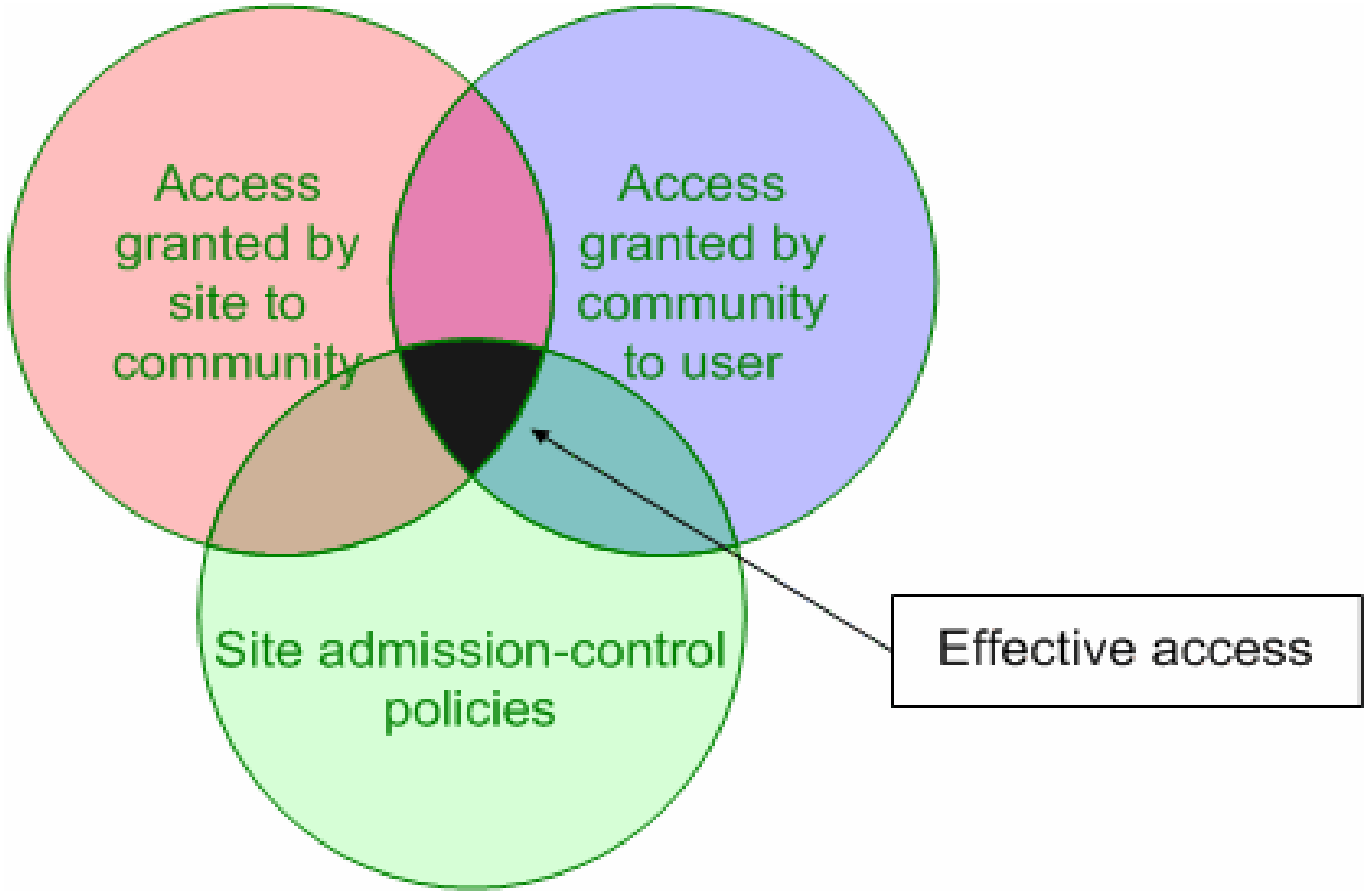
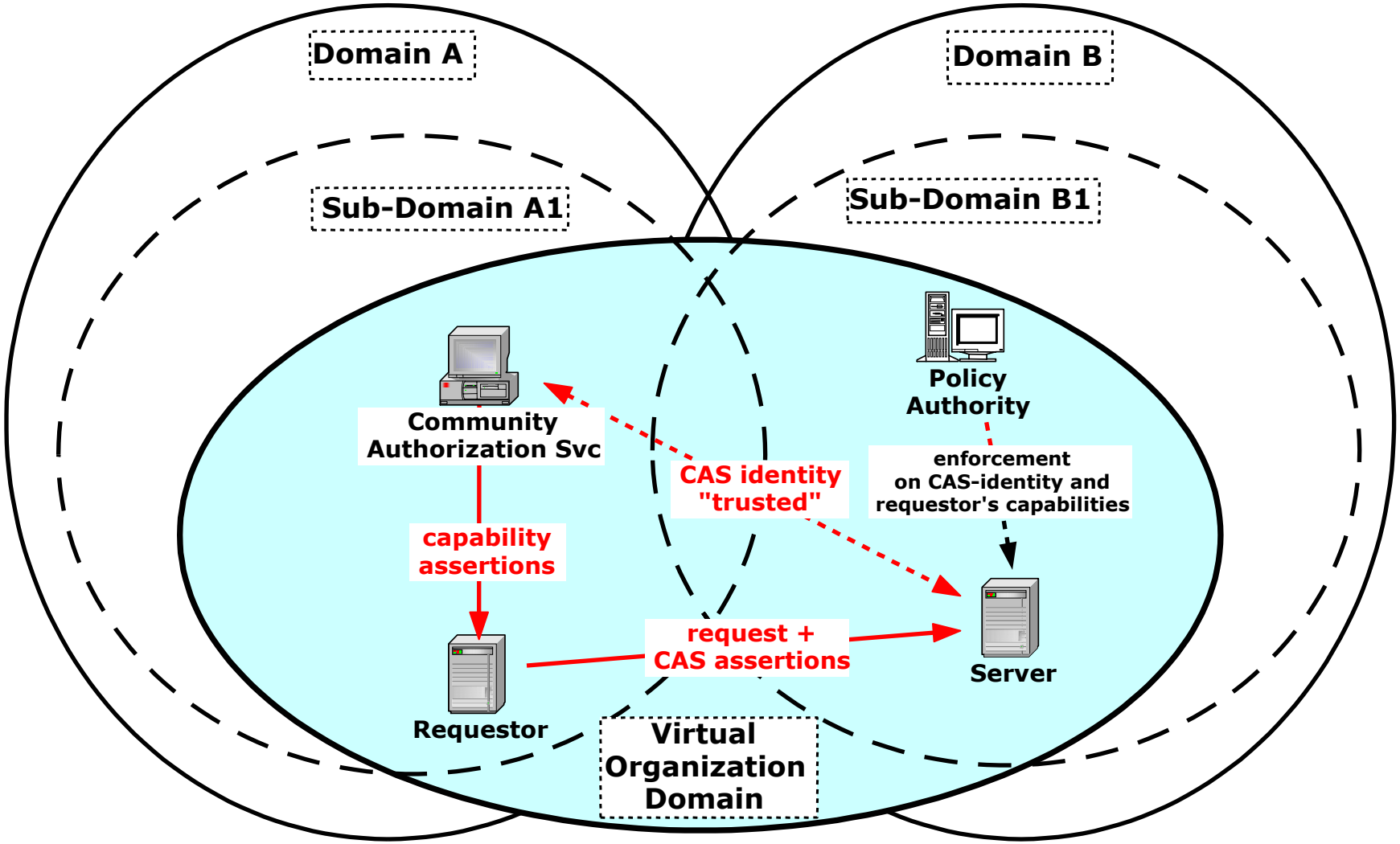
Effective Policy Governing Access Within A Collaboration



Community Authorization Service

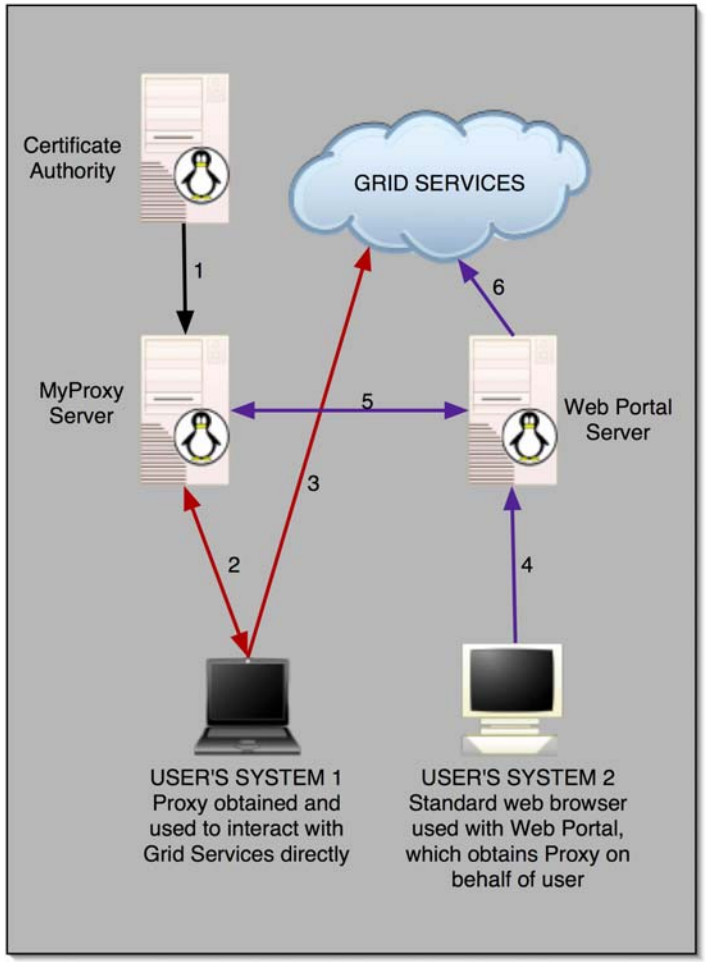
- Question: How does a large community grant its users access to a large set of resources?
- Community Authorization Service (CAS)
  - Outsource policy admin to VO sub-domain
  - Enables fine-grained policy
- Resource owner sets course-grained policy rules for foreign domain on "CAS-identity"
- CAS sets policy rules for its local users
- Requestors obtain capabilities from their local CAS that get enforced at the resource

Community Authorization Service

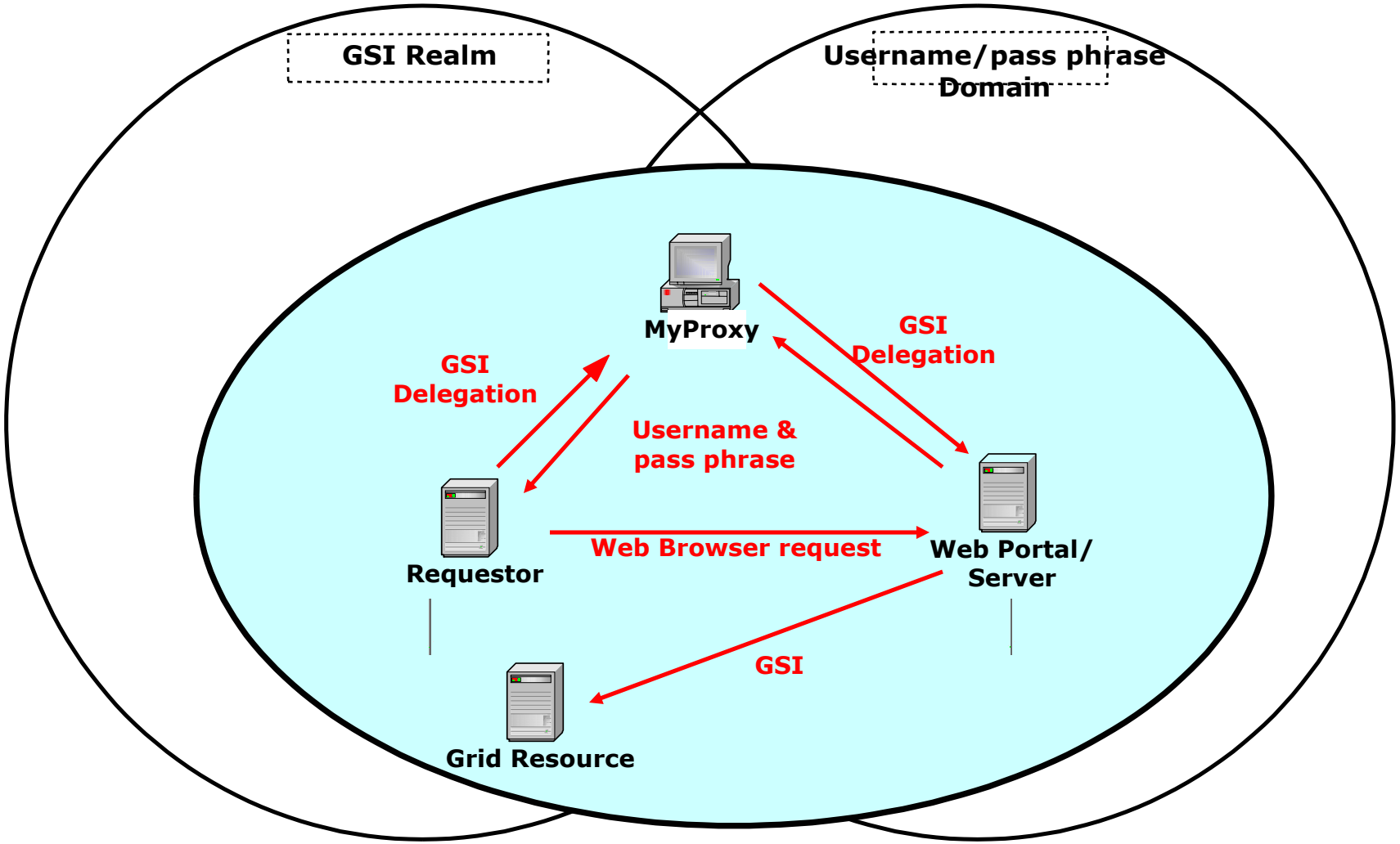


MyProxy

- MyProxy is a remote service that stores user credentials.
  - Users can request proxies for local use on any system on the network.
  - Web Portals can request user proxies for use with back-end Grid services.
- Grid administrators can pre-load credentials in the server for users to retrieve when needed.
- Also handle credential renewal for long-running tasks
- Greatly simplifies certificate management!



MyProxy: Passphrase-X.509 Federation Service



Beyond Local Identity for Authorization

- Mapping to local identity works ok, but has limitations
  - Scalability, granularity, consistency…
- Requirement for greater flexibility
- GT2 has simple API callout to deployment-time libraries/services
- GT3 implement standardized version based on GGF/OASIS work

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Remove Authz from Applications

- Allow deployment-time selection of supported mechanisms and policies
- OGSA resource virtualization allows for policy on application-independent operation invocation
- Place as much security functionality as possible into sophisticated hosting environments

Resource Management

GRAM Motivation

- Given a job specification, provide a service that can:
  - Create an environment for a job
  - Stage files to/from the environment
  - Submit a job to a local scheduler
  - Monitor a job
  - Send job state change notifications
  - Stream a job's stdout/err during execution

GRAM Overview

- Resource Specification Language (RSL) is used to communicate requirements
- A set of client interfaces enabling programs to be started on remote resources, despite local heterogeneity
- A set of service components for mapping to local scheduling systems
- Two versions:
  - Pre-WS GRAM
  - WS-GRAM

Important Notice!!

- Our goals are:
  - Highly functional interface
    - grid service GWSDLs
    - C API
    - Java API
  - Expressive RSL
  - Only basic command line clients
  - Collaborate with others to create more capable and complete clients
    - E.g. Condor-G grid manager, Platform's CSF

GRAM Features

- Standard protocol for building high-level tools
  - Brokers, metaschedulers, …
- File staging
- At most once submission
- Job status monitoring and control

Resource Specification Language

- Much of the power of GRAM is in the RSL
- Schema defined language for specifying job requests
  - XML based in WS-GRAM
  - LDAP query syntax based in Pre-WS GRAM
  - GRAM translates this common language into scheduler specific language
- GRAM service understands a well defined set of elements
  - executable, arguments, directory, …

RSL-2 Schema

- Use standard XML parsing tools to parse and validate an RSL specification
  - xmlns:http://www.globus.org/namespaces/2003/04/rsl/gram"
  - Functions to process the DOM representation of RSL specification
    - Extracting RSL attributes
    - RSL substitutions
    - Can be used to assist in writing brokers or filters which refine an RSL specification

RSL-2 Example

```
*GNS = "http://www.globus.org/namespaces"
<?xml version="1.0" encoding="UTF-8"?>
<rsl:rsl
    xmlns:rsl="GNS/2003/04/rsl"
    xmlns:gram="GNS/2003/04/rsl/gram"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="
            GNS/2003/04/rsl
            ./schema/base/gram/rsl.xsd
            GNS/2003/04/rsl/gram
            ./schema/base/gram/gram_rsl.xsd">
   <gram:job>
    <gram:executable><rsl:path>
       <rsl:stringElement value="/bin/ls"/>
    </rsl:path></gram:executable>
  </gram:job>
</rsl:rsl>
```

RSL Elements For GRAM

- <gram:executable> (type = rsl:pathType)
  - Program to run
  - A file path (absolute or relative) or URL
- <directory> (type = rsl:pathType)
  - Directory in which to run (default is HOME)
- <arguments> (type = rsl:stringArrayType)
  - List of string arguments to program
- <environment> (type = rsl:hashtableType)
  - List of environment variable name/value pairs

RSL Attributes For GRAM

- <stdin> (type = rsl:pathType)
  - Stdin for program
  - A file path (absolute or relative) or URL
  - If remote, entire file is pre-staged before execution
- <stdout> (type = rsl:pathArrayType)
  - stdout for program
  - Multiple file paths (absolute or relative) or URL's
  - If remote, file is incrementally transferred
- <stderr> (type = rsl:pathArrayType)
  - stderr for program
  - Multiple file paths (absolute or relative) or URL's
  - If remote, file is incrementally transferred

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RSL Attributes For GRAM

- <count> (type = rsl:integerType)
  - Number of processes to run (default is 1)
- <hostCount> (type = rsl:integerType)
  - On SMP multi-computers, number of nodes to distribute the "count" processes across
  - count/hostCount = number of processes per host
- <project> (type = rsl:stringType)
  - Project (account) against which to charge
- <queue> (type = rsl:stringType)
  - Queue into which to submit job
  - Queue properties reflected in the MDS resource description

RSL Attributes For GRAM

- <maxWallTime> (type = rsl:longType)
  - Maximum wall clock runtime in minutes
- <maxCpuTime> (type = rsl:longType)
  - Maximum CPU runtime in minutes
- <maxTime> (type = rsl:longType)
  - Only applies if above are not used
  - Maximum wall clock or cpu runtime (schedulers's choice) in minutes
    - CPU runtime makes sense on a time shared machine
    - Wall clock runtime makes sense on a space shared machine

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RSL Attributes For GRAM

- <maxMemory> (type = rsl:integerType)
  - Maximum amount of memory for each process in megabytes
- <minMemory> (type = rsl:integerType)
  - Minimum amount of memory for each process in megabytes

RSL Attributes For GRAM

- <jobType> (type = gram:jobRunEnumerationType)
  - Value is one of “mpi”, “single”, “multiple”, or “condor”
    - mpi: Run the program using “mpirun -np <count>”
    - single: Only run a single instance of the program, and let the program start the other count-1 processes/threads
      - Good for scripts, and for multi-threaded programs
    - multiple: default value - Start <count> instances of the program using the appropriate scheduler mechanism
    - condor: Start a <count> Condor processes running in “standard universe” (I.e. linked with Condor libraries for remote I/O, checkpoint/restart, etc.)

RSL Attributes for GRAM

- <scratchDir> (type = rsl:pathType)
  - A unique subdir under <path> is created for job
  - If path is relative, it is relative to:
    - First - A site configured scratch directory
    - Second – Users HOME directory on JM host
  - The job may use SCRATCH_DIRECTORY in RSL substitutions
- <gassCache> (type = rsl:pathType)
  - Overrides the default GASS cache directory
  - Default is site configurable, or ~/.globus/.gasscache if not configured
- <libraryPath> (type = rsl:pathArrayType)
  - Set job environment so apps built to use shared libraries will run properly

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RSL Attributes for GRAM

- <fileStageIn> (type = rsl:fileInputArrayType)
  - List of remote url to local file pairs to be staged to host where job will run
- <fileStageInShared> (type=rsl:fileInputArrayType)
  - List files to be staged to the GASS cache
  - Links from cache to local file will be made
- <fileStageOut> (type = rsl:fileOutputArrayType)
  - List files to be staged out after job completes
- <fileCleanUp> (type = rsl:pathArrayType)
  - List files to be removed after job completes

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RSL Substitutions

- RSL supports variable substitutions
  - Definition example
    - <rsl:substitutionDef name="MY HOME">
      <rsl:stringElement value="/home/user1"/>
      </rsl:substitutionDef>
  - Reference example
    - <gram:executable>
      <rsl:substitutionRef name="MY HOME"/>
      <rsl:stringElement path="/a.out"/>
      </gram:executable>
- Allows for late binding of values
  - Can refer to something that is not yet defined

GRAM Defined RSL Substitutions

- GRAM defines a set of RSL substitutions before processing the job request
  - Client submitted RSL can assume these substitutions are defined and refer to them
- Allows for generic RSL expressions to adapt to site and resource configurations
  - Goal: Clients should not have to do manual configuration of resources before they submit jobs to them
  - GRAM defined RSL substitutions define minimal information necessary to bootstrap

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GRAM Defined RSL Substitutions

- Machine Information
  - GLOBUS_HOST_MANUFACTURER
  - GLOBUS_HOST_CPUTYPE
  - GLOBUS_HOST_OSNAME
  - GLOBUS_HOST_OSVERSION

GRAM Defined RSL Substitutions

- Path to Globus installation
  - GLOBUS_LOCATION
- Miscellaneous
  - HOME
  - LOGNAME
  - GLOBUS_ID
  - SCRATCH_DIRECTORY

GRAM RSL Examples

*GNS = "http://www.globus.org/namespaces"

```
<!--- GRAM RSL Namespace --->
<?xml version="1.0" encoding="UTF-8"?>
<rsl:rsl
    xmlns:rsl="GNS/2003/04/rsl"
    xmlns:gram="GNS/2003/04/rsl/gram"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="
            GNS/2003/04/rsl
            ./schema/base/gram/rsl.xsd
            GNS/2003/04/rsl/gram
            ./schema/base/gram/gram_rsl.xsd">
```

GRAM RSL Examples

```
<rsl: rsl <!--- insert GRAM RSL Namespace --->
  <gram:job>
    <gram:executable><rsl:path>
      <rsl:stringElement value="/bin/ls"/>
    </rsl:path></gram:executable>
    <gram:directory><rsl:stringElement value="/tmp"/>
    </gram:directory>
    <gram:arguments><rsl:stringArray>
      <rsl:string><rsl:stringElement value="-l"></rsl:string>
      <rsl:string><rsl:stringElement value="-a"></rsl:string>
    </rsl:stringArray></gram:arguments>
  </gram:job>
</rsl:rsl>
```

GRAM RSL Examples

```
<rsl: rsl <!--- insert GRAM RSL Namespace --->
    <rsl:substitutionDef name="EXE">
      <rsl:stringElement value="my_exe"/>
    </rsl:substitutionDef>
    <gram:job>
      <gram:executable><rsl:path>
        <rsl:substitutionRef name="HOME"/>
        <rsl:substitutionRef name="EXE"/>
      </rsl:path></gram:executable>
    </gram:job>
</rsl:rsl>
```

GT3 GRAM Client Interfaces

- Java & C client stubs for GT3 Services
- C client library for Pre-OGSI GRAM
- Java & C Pre-OGSI GRAM client API for OGSI GRAM services
  - APIs use the stubs mentioned above
  - GT2 API compatibility for GT3 services
  - Ease transition from GT2 to GT3
  - managed-job-globusrun uses the Java API
- Java & C GT2-3 RSL Translator API
  - Accepts a GT2 RSL and translates to GT3 RSL (XML)
- PyGlobus (Keith Jackson, krjackson@lbl.gov)
  - GT2 and GT3 GRAM Python bindings

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Gram Clients

- globusrun command line
  - Useful for ***simple*** scripting and testing
- Functions:
  - Submit RSL string to specified host
  - Create GASS server for staging of local files
  - List jobs
  - Manage jobs

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pyGlobus GRAM Interface

- cancel_job(self, jobContact)
  - Cancels a job.
- check_status(self, jobContact)
  - Checks the status of a current job.
- refresh_credentials(self, jobContact, cred)
  - Refresh credentials associated with a job.
- submit_request(self, resourceManager, description, jobStateMask, callbackContact)
  - Submits a job request to a resource manger.
- Asynchronous versions also available

gramClient Example

```
from pyGlobus.gramClient import *
from threading import *
cond = 0
rm = "host.lbl.gov"
rsl = "&(executable=/bin/date)"

def done(cv,contact,state,err):
    global cond
    if state == JOB_STATE_FAILED:
        print "Job failed"
    elif state == JOB_STATE_DONE:
        print "Job is done"
    else:
        print "ERROR: ", err
    cv.acquire()
    cond = 1
    cv.notify()
    cv.release()
```

```
def main(rm, rsl):
    condV = Condition(Lock())
    try:
        gC = GramClient()
        cbContact =
           gC.set_callback(done, condV)
        jobContact =
           gC.submit_request(rm, rsl,
              JOB_STATE_ALL, cbContact)
        while cond == 0:
            condV.acquire()
            condV.wait()
            condV.release()
       gC.remove_callback(cbContact)
    except GramClientException, ex:
        print ex
```

C Job Submission Example

```
callback_func(void *user_arg, char *job_contact,
              int state, int errorcode)
{
    globus_i_globusrun_gram_monitor_t *monitor;
    monitor = (globus_i_globusrun_gram_monitor_t *) user_arg;
    globus_mutex_lock(&monitor->mutex);
    monitor->job_state = state;
    switch(state)
    {
    case GLOBUS_GRAM_PROTOCOL_JOB_STATE_PENDING:
{
    globus_i_globusrun_gram_monitor_t *monitor;
    monitor = (globus_i_globusrun_gram_monitor_t *) user_arg;
    globus_mutex_lock(&monitor->mutex);
    monitor->job_state = state;
    switch(state)
    {
    case GLOBUS_GRAM_PROTOCOL_JOB_STATE_FAILED:
        if(monitor->verbose)
        {
globus_libc_printf("GLOBUS_GRAM_PROTOCOL_JOB_STATE_FAILED\n");
        }
        monitor->done = GLOBUS_TRUE;
        break;
    case GLOBUS_GRAM_PROTOCOL_JOB_STATE_DONE:
        if(monitor->verbose)
        {
globus_libc_printf("GLOBUS_GRAM_PROTOCOL_JOB_STATE_DONE\n");
        }
        monitor->done = GLOBUS_TRUE;
        break;
 }
  globus_cond_signal(&monitor->cond);
  globus_mutex_unlock(&monitor->mutex);
}
```

```
globus_l_globusrun_gramrun(char * request_string,
                           unsigned long options,
                           char *rm_contact)
{
    char *callback_contact = GLOBUS_NULL;
    char *job_contact = GLOBUS_NULL;
    globus_i_globusrun_gram_monitor_t monitor;
    int err;
    monitor.done = GLOBUS_FALSE;
    monitor.verbose=verbose;
    globus_mutex_init(&monitor.mutex, GLOBUS_NULL);
    globus_cond_init(&monitor.cond, GLOBUS_NULL);

    err = globus_module_activate(GLOBUS_GRAM_CLIENT_MODULE);
    if(err != GLOBUS_SUCCESS)
    { … }
    err = globus_gram_client_callback_allow(
            globus_l_globusrun_gram_callback_func,
            (void *) &monitor,
            &callback_contact);
        if(err != GLOBUS_SUCCESS)
        { … }
  err = globus_gram_client_job_request(rm_contact,
            request_string, GLOBUS_GRAM_PROTOCOL_JOB_STATE_ALL,
             callback_contact, &job_contact);
  if(err != GLOBUS_SUCCESS)
        { … }
 globus_mutex_lock(&monitor.mutex);
   while(!monitor.done)  {
      globus_cond_wait(&monitor.cond, &monitor.mutex);
   }
 globus_mutex_unlock(&monitor.mutex);
   globus_gram_client_callback_disallow(callback_contact);
   globus_free(callback_contact);
```

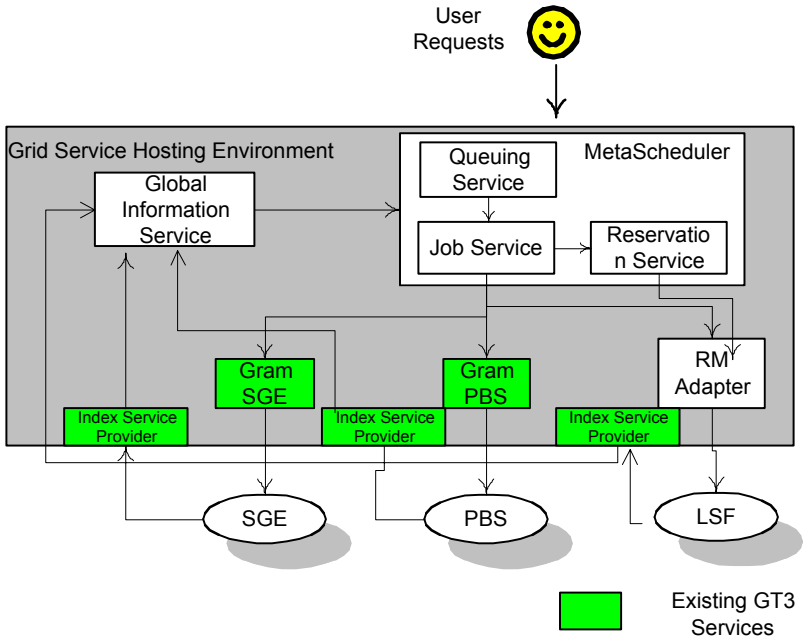
Condor, Condor-G, DAGman

- Condor addresses many workflow challenges for Grid applications.
  - Managing sets of subtasks
  - Getting the tasks done reliably and efficiently
  - Managing computational resources
- Similar to a distributed batch processing system, but with some interesting twists.
  - Scheduling policy
  - ClassAds
  - DAGman
  - Checkpointing and Migration
  - Grid-aware & Grid-enabled
  - Flocking (linking pools of resources) & Glide-ins

Condor
High Throughput Computing

Platform CSF

- An open source implementation of OGSA-based metascheduler for VOs.
  - Supports emerging WS-Agreement spec
  - Supports GT GRAM
  - Uses GT Index Service
- Fills in gaps in existing resource management picture
  - Integrated with Platform LSF and Platform Multicluster
  - Anticipated for inclusion in GT 4.0 release



GRAM in GT3 Releases

- Two versions of resource management services
  - OGSI compliant
    - MMJFS, MJFS
  - Pre-OGSI
    - Gatekeeper, jobmanager

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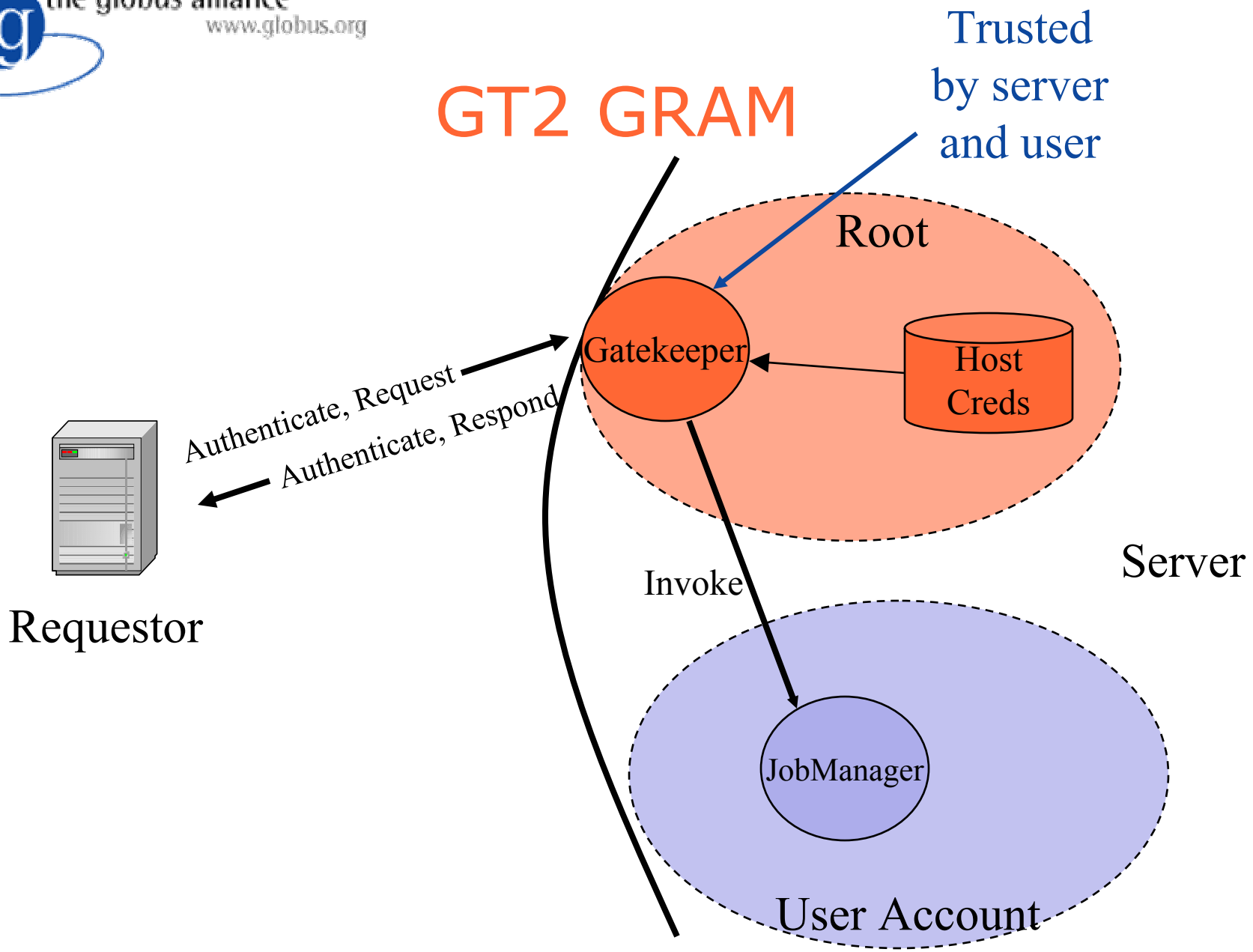
OGSI Compliant GRAM

- A set of OGSI compliant services that provide remote job execution
  - (Master) Managed Job Factory Service (MJFS)
  - Managed Job Service (MJS)
  - File Stream Factory Service (FSFS)
  - File Stream Service (FSS)
- Resource Specification Language (RSL-2) schema is used to communicate job requirements
- Remote jobs run under local users account
- Client to service credential delegation is done user to user, *not* through a third party

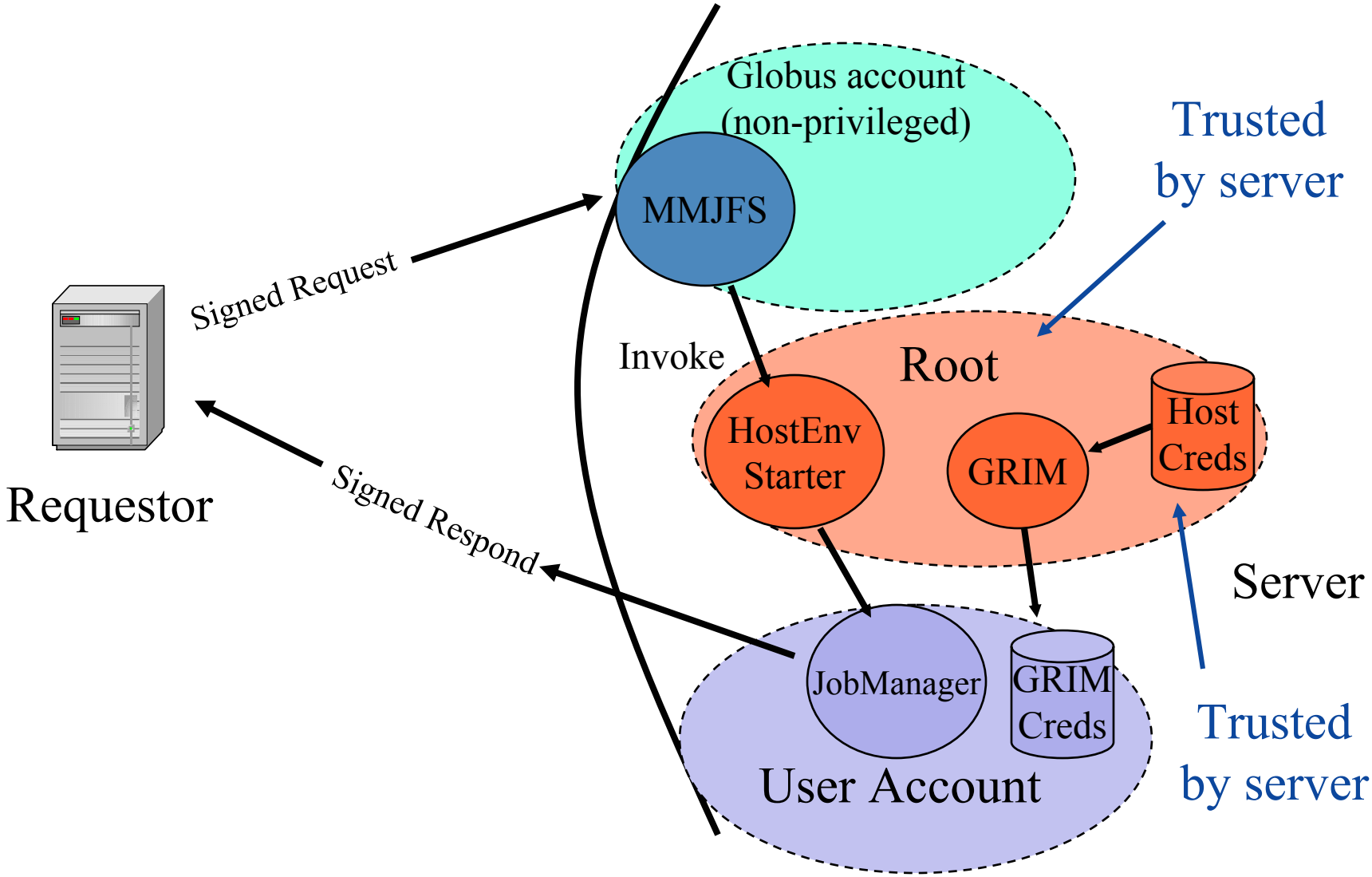
Pre-OGSI GRAM

- A set of non-OGSI compliant services that provide remote job execution
  - Gatekeeper
  - Jobmanager
- Resource Specification Language (RSL) is used to communicate job requirements
- Remote jobs run under local users account
- *Client to service credential delegation is done through a third party (gatekeeper)

GT2 GRAM


Trusted
by server
and user
Root
Gatekeeper
Host
Creds
Authenticate, Request
Authenticate, Respond
Requestor
Server
Invoke
JobManager
User Account

GT3 GRAM

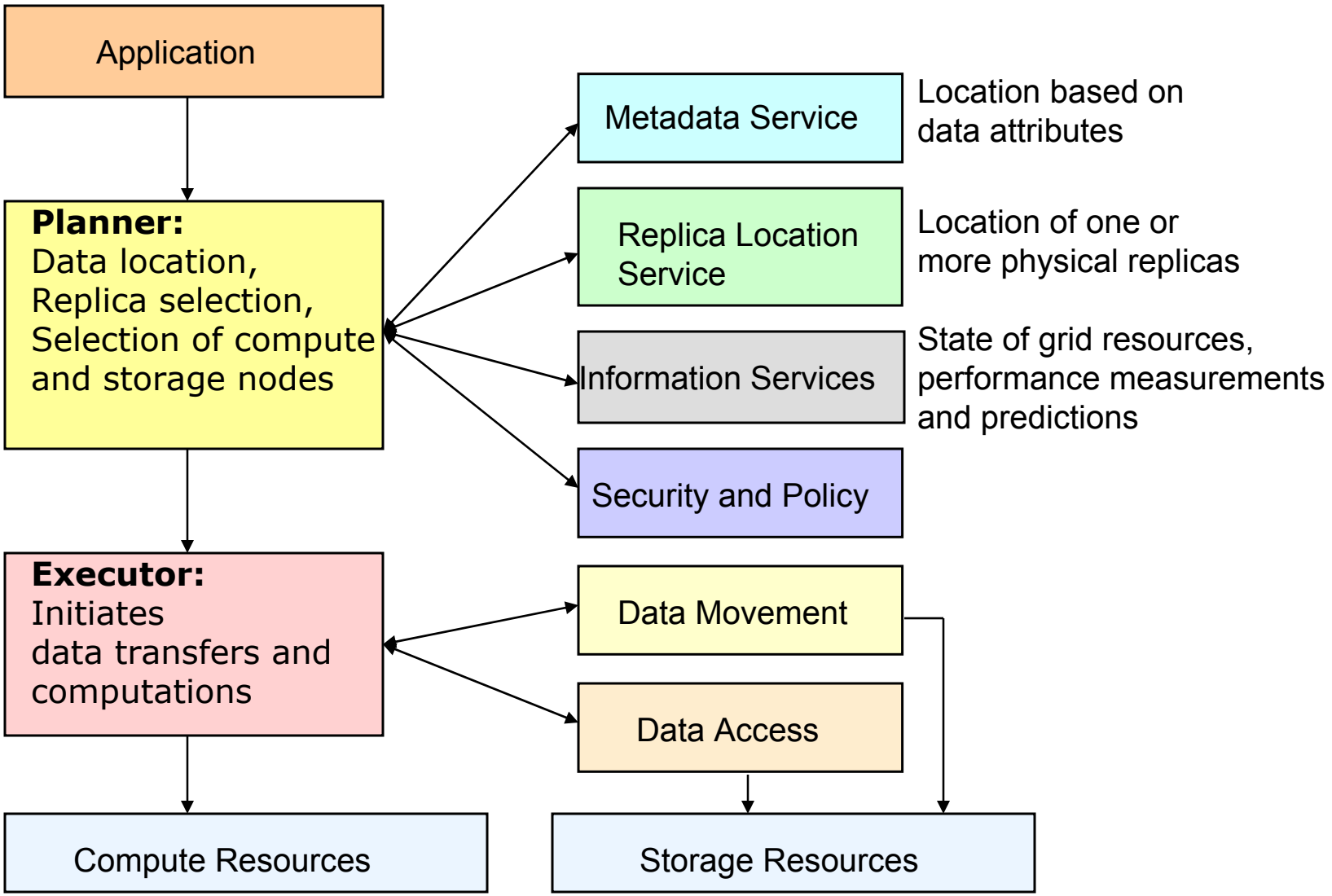

Globus account
(non-privileged)
MMJFS
Trusted
by server
Signed Request
Invoke
Root
HostEnv
Starter
GRIM
Host
Creds
Requestor
Signed Respond
Server
JobManager
GRIM
Creds
User Account
Trusted
by server

GRAM Documentation

- http://www.globus.org/gram

Data Services

Functional View of Grid Data Management



Architecture Layers

Collective 2: Services for coordinating multiple resources that are specific to an application domain or virtual organization (e.g., Authorization, Consistency, Workflow)

Collective 1: General services for coordinating multiple resources (e.g., RLS, MCS, RFT, Federation, Brokering)

Resource: sharing single resources (e.g., GridFTP, SRM, DBMS)

Connectivity (e.g., TCP/IP, GSI)

Fabric (e.g., storage, compute nodes, networks)

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GridFTP

- Data-intensive grid applications transfer and replicate large data sets (terabytes, petabytes)
- GridFTP Features:
  - Third party (client mediated) transfer
  - Parallel transfers
  - Striped transfers
  - TCP buffer optimizations
  - Grid security
- Important feature is separation of control and data channel

What is GridFTP?

- A secure, robust, fast, efficient, standards based, widely accepted data transfer protocol
- A Protocol
  - Multiple Independent implementation can interoperate
    - This works. Both the Condor Project at Uwis and Fermi Lab have home grown servers that work with ours.
    - Lots of people have developed clients independent of the Globus Project.
- We also supply a reference implementation:
  - Server
  - Client tools (globus-url-copy)
  - Development Libraries

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GridFTP: Secure

- Uses GSS security API
- "Normal" Globus uses GSI (X.509 certs / Public Key)
- GSS supports Kerberos bindings
- However, Kerberos and GSS have not kept up with GSI features
- This means certain features don't work (Data Channel Authentication)

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GridFTP: Robust and Reliable

- Our extensions provide for "Restart Markers" that list byte ranges written to disk
- If any remote resource fails, the restart markers can be used to pick up the transfer, including "holey" transfers
- There is a default restart "plug-in" provided, but this can be modified to provide customized restart policy.

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GridFTP: Fast and Efficient

- TCP Buffer size control
  - Current implementation is manual only
  - Wu Feng (LANL) has a prototype of DRS working
- Parallelism (multiple sockets between two endpoints)
  - "works around" TCP limitations
  - Can get 90%+ link utilization
- Striping (multiple network endpoints, I.e. clusters)
  - Mutiple levels of parallelism (CPU, disk, NIC, etc)
- Recent tests at LANL
  - Disk transfers limited by disk speed
  - Memory transfers achieved 100 MBs, per link

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GridFTP: Standards Based

- FTP protocol is defined by several IETF RFCs
- Start with most commonly used subset
  - Standard FTP: get/put etc., 3rd-party transfer
- Implement standard but often unused features
  - GSS binding, extended directory listing, simple restart
- Extend in various ways, while preserving interoperability with existing servers
  - Striped/parallel data channels, partial file, automatic & manual TCP buffer setting, progress monitoring, extended restart

GridFTP: Standards Based (cont)

- Existing standards
  - RFC 959: File Transfer Protocol
  - RFC 2228: FTP Security Extensions
  - RFC 2389: Feature Negotiation for the File Transfer Protocol
  - Draft: FTP Extensions
- New drafts
  - GridFTP: Protocol Extensions to FTP for the Grid
    - Grid Forum GridFTP Working Group
    - Submitted for public comment

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GridFTP: Widely Accepted

- GridFTP is the de facto standard for transport in Grid Computing
- A significant fraction of Grid Projects, both in the US and abroad are using GridFTP
  - ESG, PPDG, EUDG, PPARC, DOE SG, LCG, NorduGrid, NEES, GriPhyN, SDSS, NVO
- Our requirements are gathered from a wide range of communities and applications.

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globus-url-copy

- Copy source URL to destination URL
  - http, https, FTP, gsiftp, and file URLs supported
  - 3rd party transfer
  - Options for restart, window size, parallelism, etc.

```
globus-url-copy
    gsiftp://sourceHostName:port/dir1/dir2/file17
    gsiftp://destHostName:port/dirX/dirY/fileA
```

Demonstration: globus-url-copy Command Line Tool

globus-url-copy [options] sourceURL destURL

OPTIONS

-b | -binary

Do not apply any conversion to the files. *default*

-tcp-bs <size> | -tcp-buffer-size <size>

specify the size (in bytes) of the buffer to be used by the underlying ftp data channels

-bs <block size> | -block-size <block size>

specify the size (in bytes) of the buffer to be used by the underlying transfer methods

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Globus-url-copy (cont.)

-p <parallelism> | -parallel <parallelism>

specify the number of streams to be used in the ftp transfer

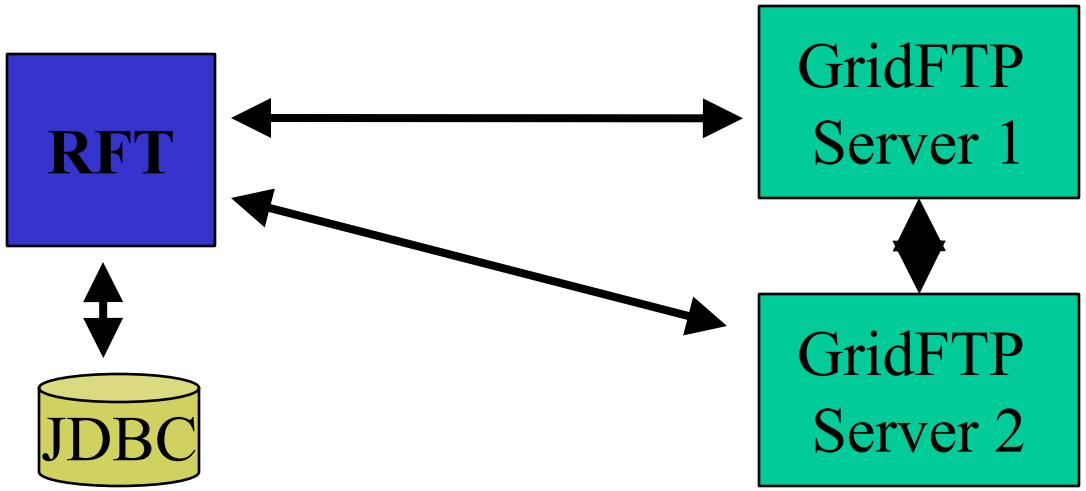
-notpt | -no-third-party-transfers

turn third-party transfers off (on by default)

GridFTP Command Line Tool

Reliable File Transfer Service

- Reliably performs a third party transfer between two GridFTP servers

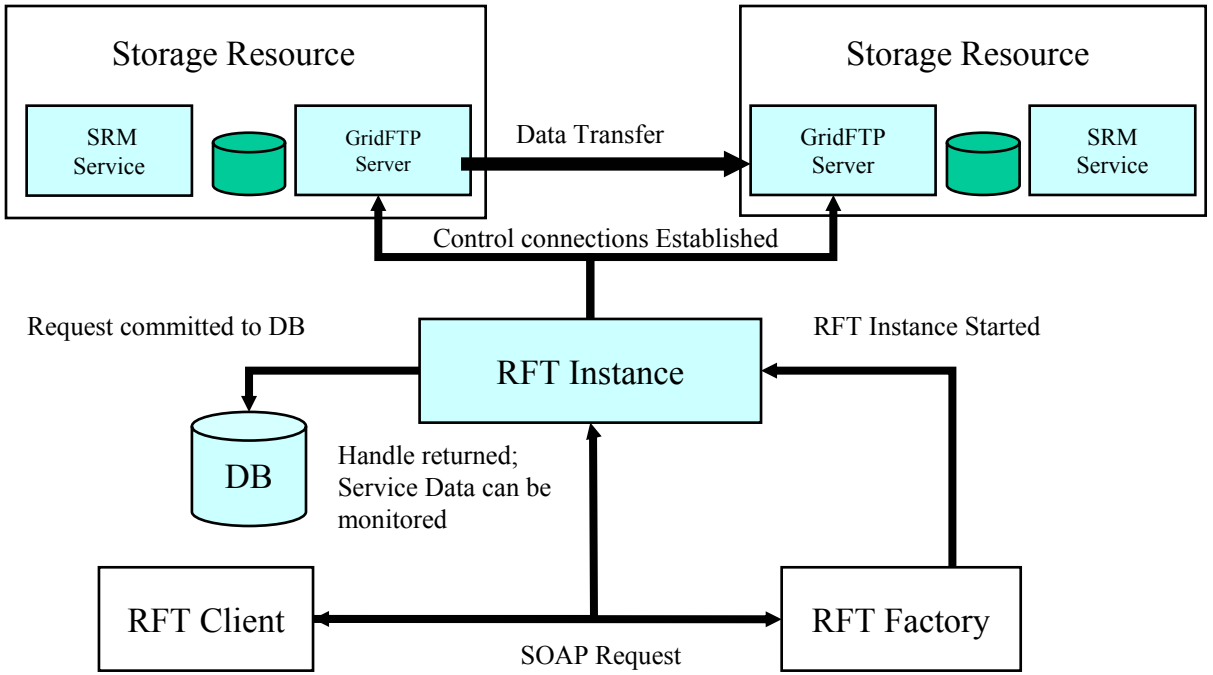


- OGSI-compliant service exposing GridFTP control channel functionality
- Recoverable with progress and restart monitoring
  - Automatically restarts interrupted transfers from the last checkpoint

http://www-unix.globus.org/toolkit/reliable_transfer.html

RFT: Reliable File Transfer

- GT3 service
- Multiple-file version available in current release
- Allows monitoring and control of third-party data transfer operations between two GridFTP servers

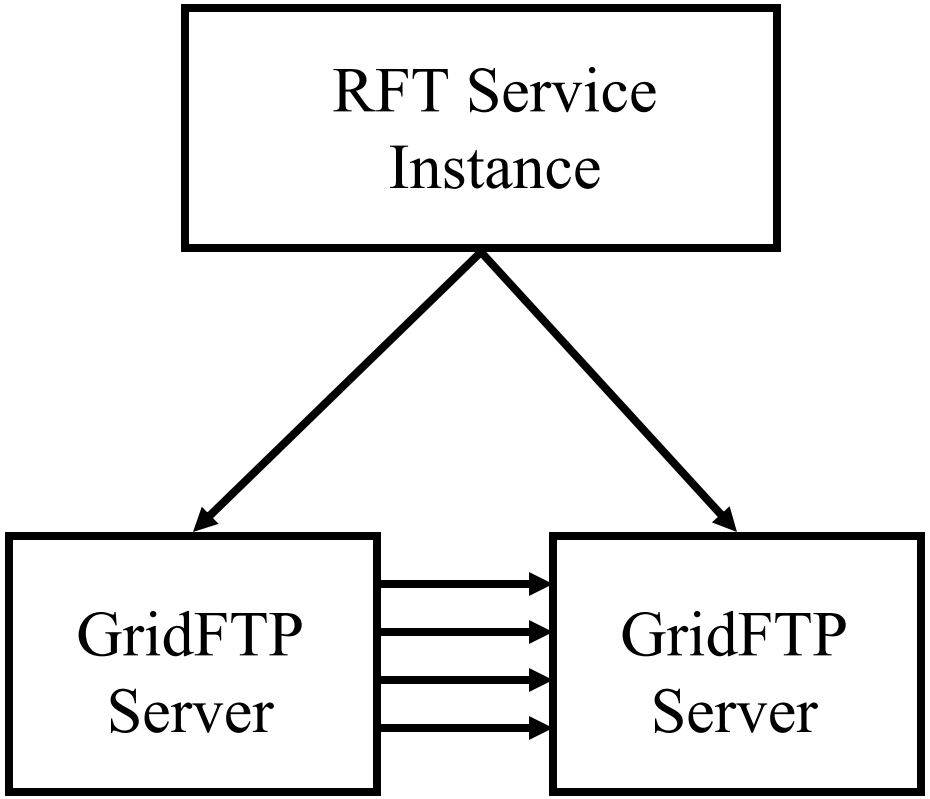


Example TransferRequest

```
true          # type of transfer true=binary false=ascii
16000         # block size in bytes
16000         # TCP buffer size in bytes
false         # No third party transfer (tpt)
1             # Number of parallel streams
true          # Data Channel Authentication (DCAU)
1             # Concurrency - number of concurrent transfers
/DC=org/DC=doegrids/OU=Services/CN=dg0n1.mcs.anl.gov    # Source Host Subject
/DC=org/DC=doegrids/OU=Services/CN=dg0n1.mcs.anl.gov    # Dest Host Subject
gsiftp://dg0n1.mcs.anl.gov/sandbox/madduri/             # Source URL1
gsiftp://dg0n2.mcs.anl.gov/sandbox/madduri/             # Dest URL1
```

RFT in Action

- Service is OGSI compliant
- Uses existing GridFTP (non-OGSI) protocols and tools to execute 3rd Party Transfer for the user
- Provides extensive state transition notification



* The scenarios in this presentation are offered as examples and are not prescriptive

RFT Service Data

- Version
  - version of RFT
- FileTransferProgress
  - Denotes the percentage of file that is transferred
- FileTransferRestartMarker
  - Last restart marker for a particular transfer
- FileTransferJobStatusElement
  - Status of a particular transfer
- FileTransferStatusElement
  - Denotes the status of all the transfers in the request
- GridFTPRestartMarkerElement
  - Raw gridftp restart marker for the transfer
- GridFTPPerfMarkerElement
  - Raw gridftp performance marker for the transfer

RFT Documentation

- http://www.globus.org/toolkit/reliable_transfer.html

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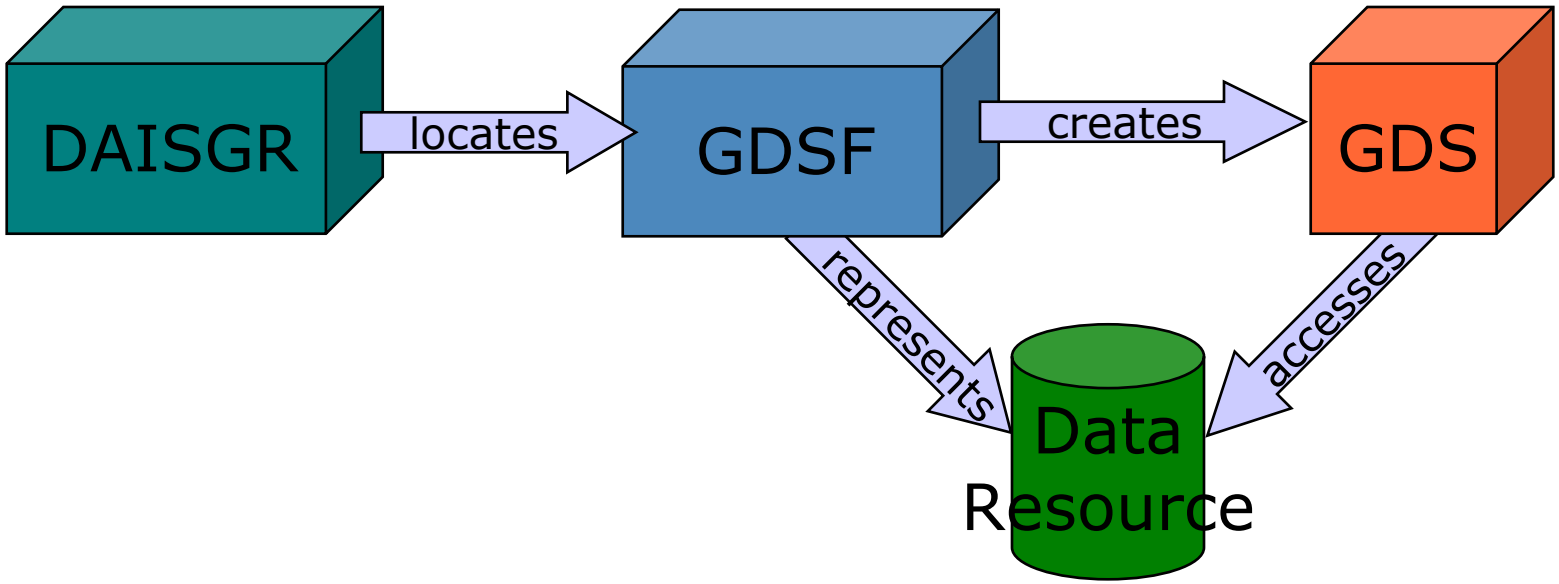
OGSA-DAI

- Provides a common access interface to heterogeneous data resources
  - e.g. RDBMS, XMLDBs, structured files
- Platform and language independent
  - BUT does not hide underlying data model
- Provides base for higher-level services
  - Data integration
  - Data federation
- http://www.ogsadai.org.uk

OGSA-DAI Services

- OGSA-DAI uses three main service types
  - DAISGR (registry) for discovery
  - GDSF (factory) to represent a data resource
  - GDS (data service) to access a data resource



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OGSA-DAI development

- Built around an activity framework
  - Functionality provided in release includes:
    - SQL / XPath statements, Delivery via GridFTP, Compression, XSL Transforms
  - Extensible
    - Developers can add functionality
    - Could import third party trusted activities
  - Allows for optimisation
- Client toolkit for Java provides a quick way to build applications to access OGSA-DAI wrapped data resources

Replica Management in Grids

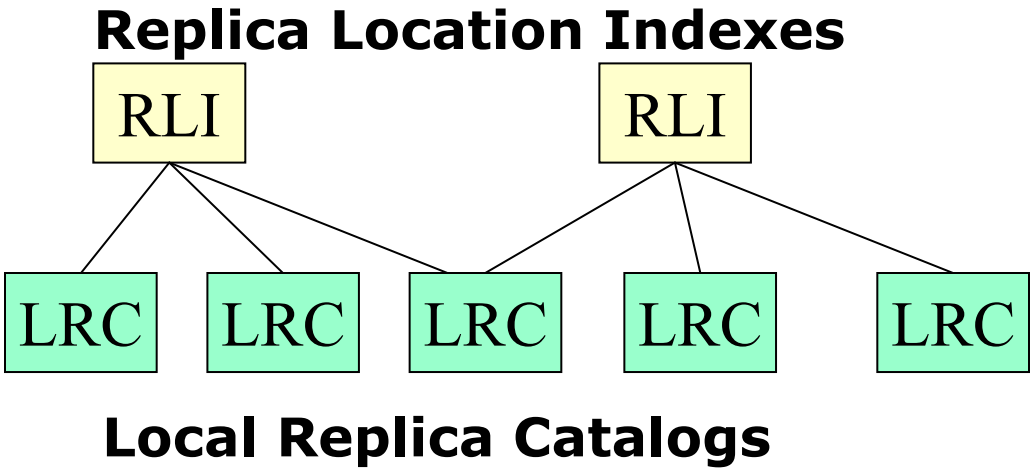
- Data intensive applications
  - Produce Terabytes or Petabytes of data
- Replicate data at multiple locations
  - Fault tolerance
  - Performance: avoid wide area data transfer latencies, achieve load balancing
- Issues:
  - Locating replicas of desired files
  - Creating new replicas and registering their locations
  - Scalability
  - Reliability

A Replica Location Service

- **A Replica Location Service (RLS)** is a distributed registry service that records the locations of data copies and allows discovery of replicas
- Maintains mappings between *logical* identifiers and *target names*
  - Physical targets: Map to exact locations of replicated data
  - Logical targets: Map to another layer of logical names, allowing storage systems to move data without informing the RLS
- RLS was designed and implemented in a collaboration between the Globus project and the DataGrid project

RLS Framework

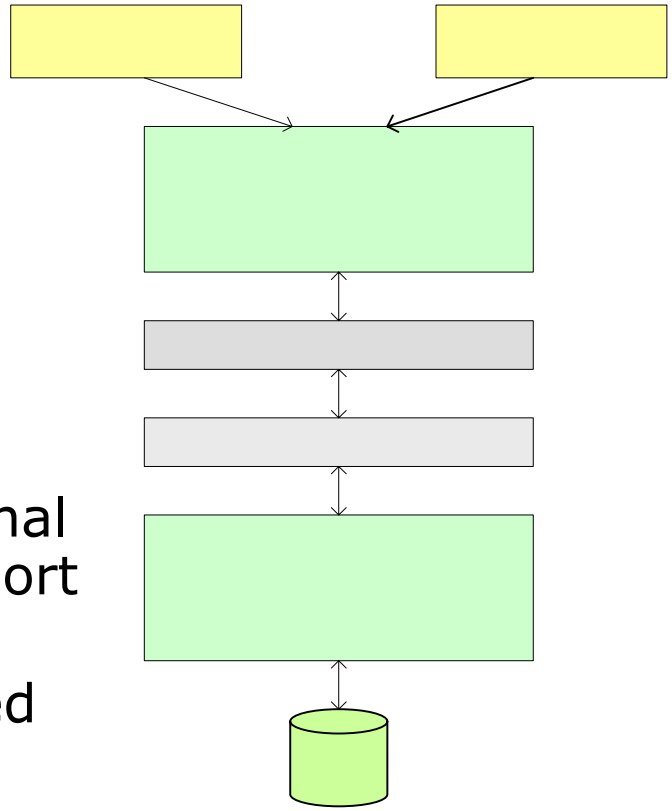
- Local Replica Catalogs (LRCs) contain consistent information about logical-to-target mappings



- Replica Location Index (RLI) nodes aggregate information about one or more LRCs
- LRCs use soft state update mechanisms to inform RLIs about their state: relaxed consistency of index
- Optional compression of state updates reduces communication, CPU and storage overheads
- Membership service registers participating LRCs and RLIs and deals with changes in membership

Components of RLS Implementation

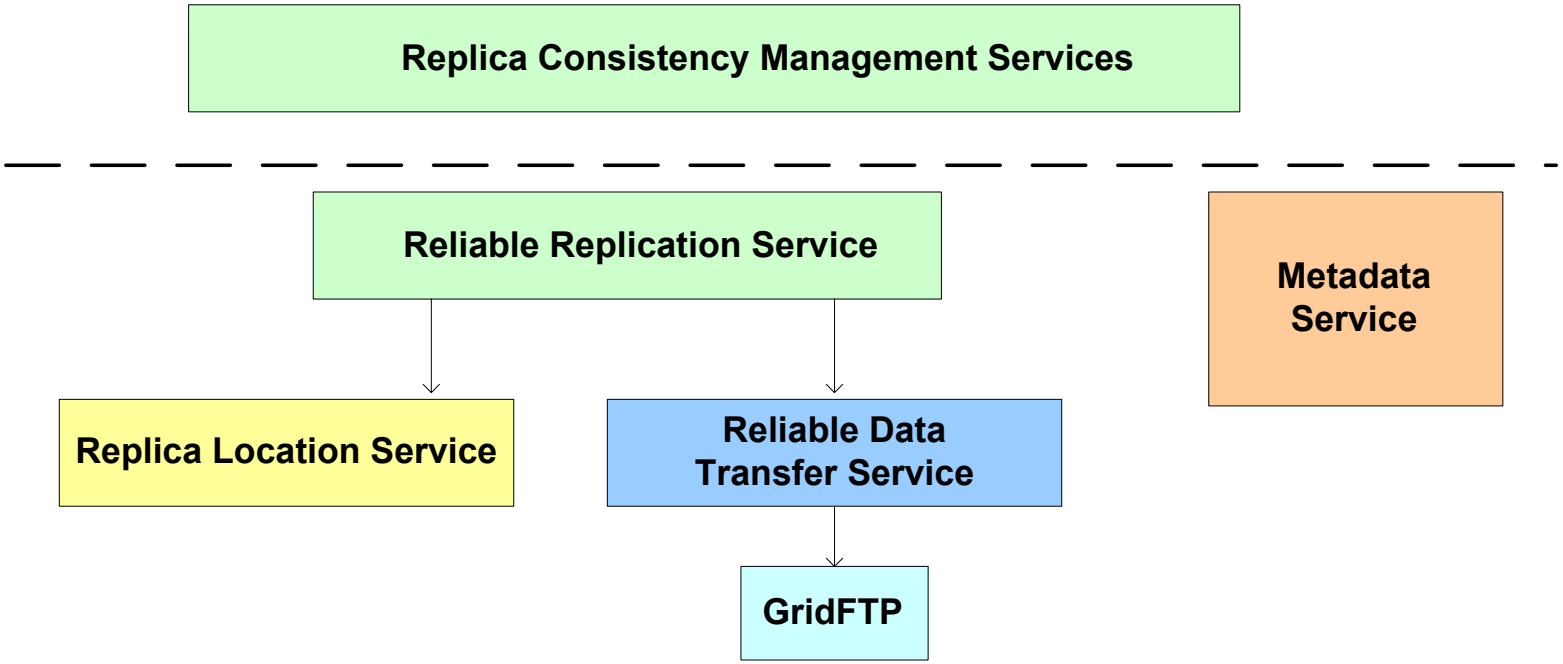
- **Common server implementation for LRC and RLI**
- **Front-End Server**
  - Multi-threaded
  - Written in C
  - Supports GSI Authentication using X.509 certificates
- **Back-end Server**
  - MySQL or PostgreSQL Relational Database (later versions support Oracle)
  - No database back end required for RLIs using Bloom filter compression
- **Client APIs: C and Java**
- **Client Command line tool**



RLS Implementation Features

- Two types of soft state updates from LRCs to RLIs
  - Complete list of logical names registered in LRC
  - Compressed updates: Bloom filter summaries of LRC
- Immediate mode
  - Incremental updates
- User-defined attributes
  - May be associated with logical or target names
- Partitioning (without bloom filters)
  - Divide LRC soft state updates among RLI index nodes using pattern matching of logical names
- Currently, static membership configuration only
  - No membership service

Replica Location Service In Context



- The Replica Location Service is one component in a layered data management architecture
- Provides a simple, distributed registry of mappings
- Consistency management provided by higher-level services

globus-rls-cli: Client Command Line Tool

globus-rls-cli [-c] [-h] [-l reslimit] [-s] [-t timeout] [-u] [command] rls-server

- If command is not specified, enters interactive mode

- Create an initial mapping from a logical name to a target name:

globus-rls-cli create logicalName targetName1 rls://myrls.isi.edu

- Add a mapping from same logical name to a second replica/target name:

globus-rls-cli add logicalName targetName2 rls://myrls.isi.edu

Examples of simple create, add and query operations

```
% globus-rls-cli create ln1 pn1 rls://smarty

% globus-rls-cli query lrc lfn ln1 rls://smarty
  ln1: pn1

% globus-rls-cli add ln1 pn2 rls://smarty

% globus-rls-cli query lrc lfn ln1 rls://smarty
  ln1: pn1
  ln1: pn2
```

globus-rli-client Bulk Operations

- **bulk add <lfn> <pfn> [<lfn> <pfn>**
  - Bulk add lfn, pfn mappings
- **bulk delete <lfn> <pfn> [<lfn> <pfn>**
  - Bulk delete lfn, pfn mappings
- **bulk query lrc lfn [<lfn> ...]**
  - Bulk query lrc for lfns
- **bulk query lrc pfn [<pfn> ...]**
  - Bulk query lrc for pfns
- **bulk query rli lfn [<lfn> ...]**
  - Bulk query rli for lfns
- Others bulk attribute adds, deletes, queries, etc.

Examples of Bulk Operations

```
% globus-rls-cli bulk create ln1 pn1 ln2 pn2 ln3 pn3
    rls://smarty

% globus-rls-cli bulk query lrc lfn ln1 ln2 ln3
    rls://smarty

  ln3: pn3
  ln2: pn2
  ln1: pn1
```

LIGO Data Replication Challenge

- Replicate 200 GB/day of data to multiple sites securely, efficiently, robustly
- Support a number of storage models at sites
  - CIT → SAM-QFS (tape) and large IDE farms
  - UWM → 600 partitions on 300 cluster nodes
  - PSU → multiple 1 TB RAID-5 servers
  - AEI → 150 partitions on 150 nodes with redundancy
- Coherent mechanism for data discovery
- Know what data we have, where it is, and replicate it fast and easy

Lightweight Data Replicator (LDR)

- What data we have…
  - Globus Metadata Catalog Service (MCS)
- Where data is…
  - Globus Replica Location Service (RLS)
- Replicate it fast…
  - Globus GridFTP protocol
  - What client to use? Right now we use our own
- Replicate it easy…
  - pyGlobus daemons

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LDR Roles

- Publisher
  - Provides information about available files, location, metadata
- Provider
  - Makes files available for replication
- Subscriber
  - Replicates data from a provider to itself

LDR Daemons

- LDRMetadata
  - MySQL Backend, replicates metadata catalog using GridFTP
- LDRWant
  - Figures out what files are missing, uses Globus RLS (Replica Locator Service)
- LDRSchedule
  - Queues Transfers
- LDRTransfer
  - Manage transfer of files using GridFTP
- LDRVerify
  - Checks integrity of replicas

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For more information

- Globus Components
  - www.globus.org
- OGSA-DAI
  - http://www.ogsadai.org.uk/
- LDR
  - http://www.lsc-group.phys.uwm.edu/LDR/