Grid Compute Resources and Job Management

Job and compute resource management

- This module is about running jobs on remote compute resources

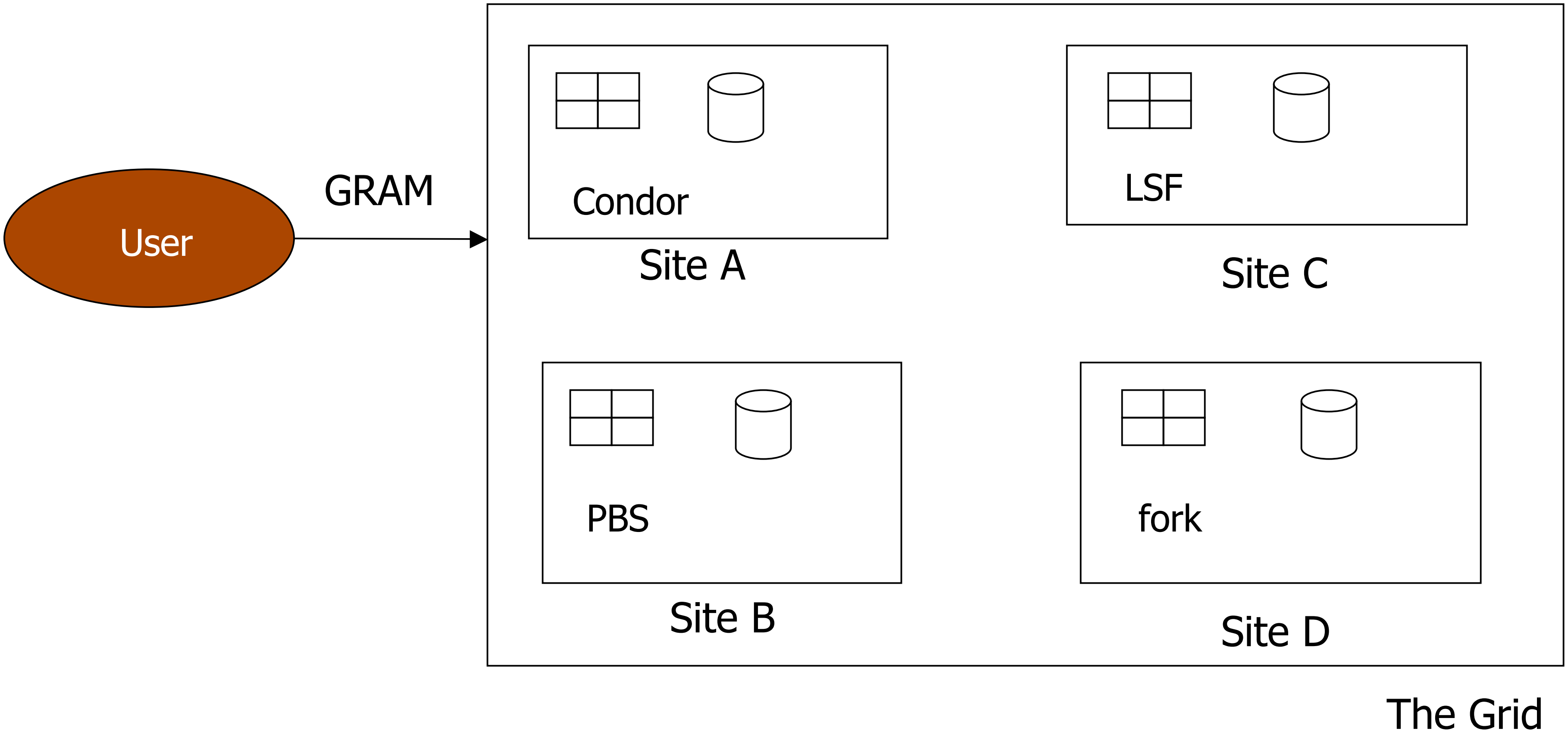
Job and resource management

- Compute resources have a local resource manager
    - This controls who is allowed to run jobs and how they run, on a resource
- GRAM
    - Helps us run a job on a remote resource
- Condor
    - Manages jobs

Local Resource Managers

- Local Resource Managers (LRMs) – software on a compute resource such a multi-node cluster.
- Control which jobs run, when they run and on which processor they run
- Example policies:
  - Each cluster node can run one job. If there are more jobs, then the other jobs must wait in a queue
  - Reservations – maybe some nodes in cluster reserved for a specific person
- eg. PBS, LSF, Condor

Job Management on a Grid



GRAM

- *Globus Resource Allocation Manager*
- Provides a standardised interface to submit jobs to different types of LRM
- Clients submit a job request to GRAM
- GRAM translates into something the LRM can understand
- Same job request can be used for many different kinds of LRM

GRAM

- Given a job specification:
  - Create an environment for a job
  - Stage files to and from the environment
  - Submit a job to a local resource manager
  - Monitor a job
  - Send notifications of the job state change
  - Stream a job’s stdout/err during execution

Two versions of GRAM

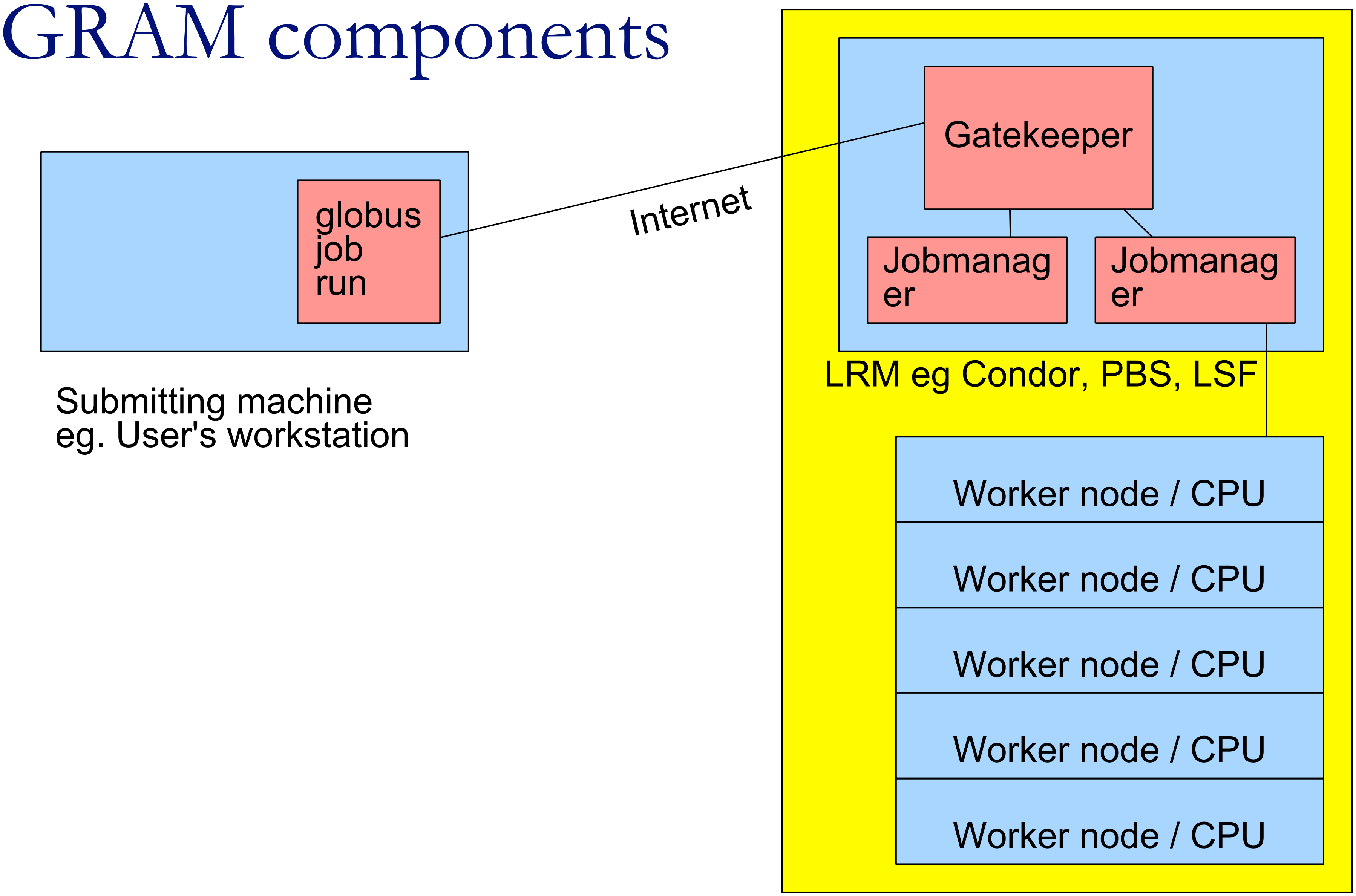
- There are two versions of GRAM
  - GRAM2
    - Own protocols
    - Older
    - More widely used
    - No longer actively developed
  - GRAM4
    - Web services
    - Newer
    - New features go into GRAM4

- In this module, will be using GRAM2

GRAM components

- Clients – eg. Globus-job-submit, globusrun
- Gatekeeper
  - Server
  - Accepts job submissions
  - Handles security
- Jobmanager
  - Knows how to send a job into the local resource manager
  - Different job managers for different LRMs

GRAM components



Submitting a job with GRAM

- Globus-job-run command

-
  ```
  globus-job-run rookery.uchicago.edu /bin/hostname
  rook11
  ```
- Run '/bin/hostname' on the resource rookery.uchicago.edu
- We don't care what LRM is used on 'rookery'. This command works with any LRM.

The client can describe the job with GRAM’s Resource Specification Language (RSL)

- Example:

```
&(executable = a.out)
(directory = /home/nobody )
  (arguments = arg1 "arg 2")
```

- Submit with:

```
 globusrun -f spec.rsl -r
rookery.uchicago.edu
```

Use other programs to generate RSL

- RSL job descriptions can become very complicated
- We can use other programs to generate RSL for us
- Example: Condor-G – next section

Condor

- Globus-job-run submits jobs, but...
  - No job tracking: what happens when something goes wrong?
- Condor:
  - Many features, but in this module:
  - Condor-G for reliable job management

Condor can manage a large number of jobs

- Managing a large number of jobs
  - You specify the jobs in a file and submit them to Condor, which runs them all and keeps you notified on their progress
  - Mechanisms to help you manage huge numbers of jobs (1000's), all the data, etc.
  - Condor can handle inter-job dependencies (DAGMan)
  - Condor users can set job priorities
  - Condor administrators can set user priorities
- Can do this as:
  - a local resource manager on a compute resource
  - a grid client submitting to GRAM (Condor-G)

Condor can manage compute resource

- Dedicated Resources
  - Compute Clusters
- Non-dedicated Resources
  - Desktop workstations in offices and labs
    - Often idle 70% of time
- Condor acts as a Local Resource Manager

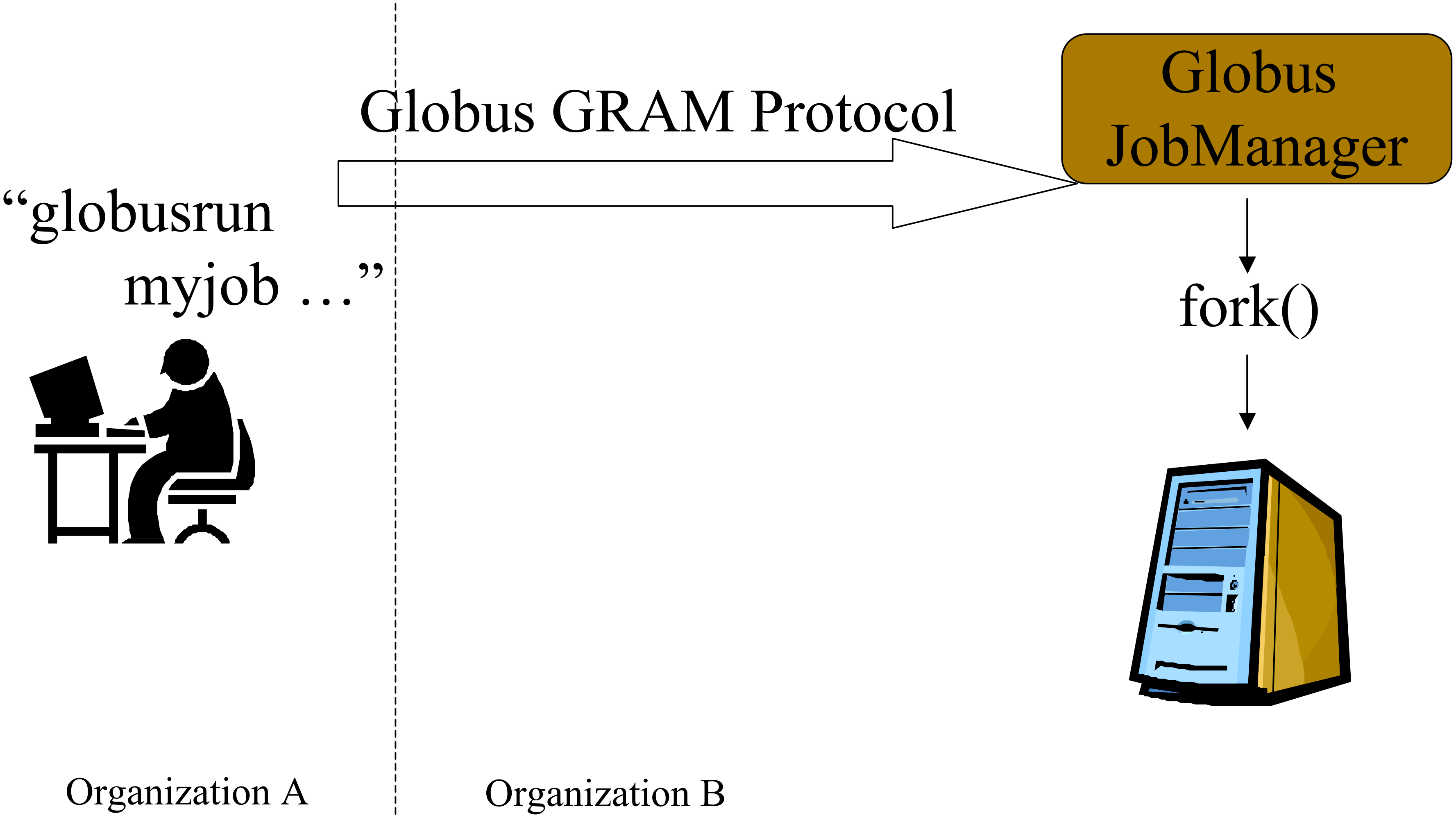
… and Condor Can Manage Grid jobs

- Condor-G is a specialization of Condor. It is also known as the “Grid universe”.
- Condor-G can submit jobs to Globus resources, just like globus-job-run.
- Condor-G benefits from Condor features, like a job queue.

Some Grid Challenges

- Condor-G does whatever it takes to run your jobs, even if …
  - The gatekeeper is temporarily unavailable
  - The job manager crashes
  - Your local machine crashes
  - The network goes down

Remote Resource Access: Globus



“globusrun myjob …”

Globus GRAM Protocol

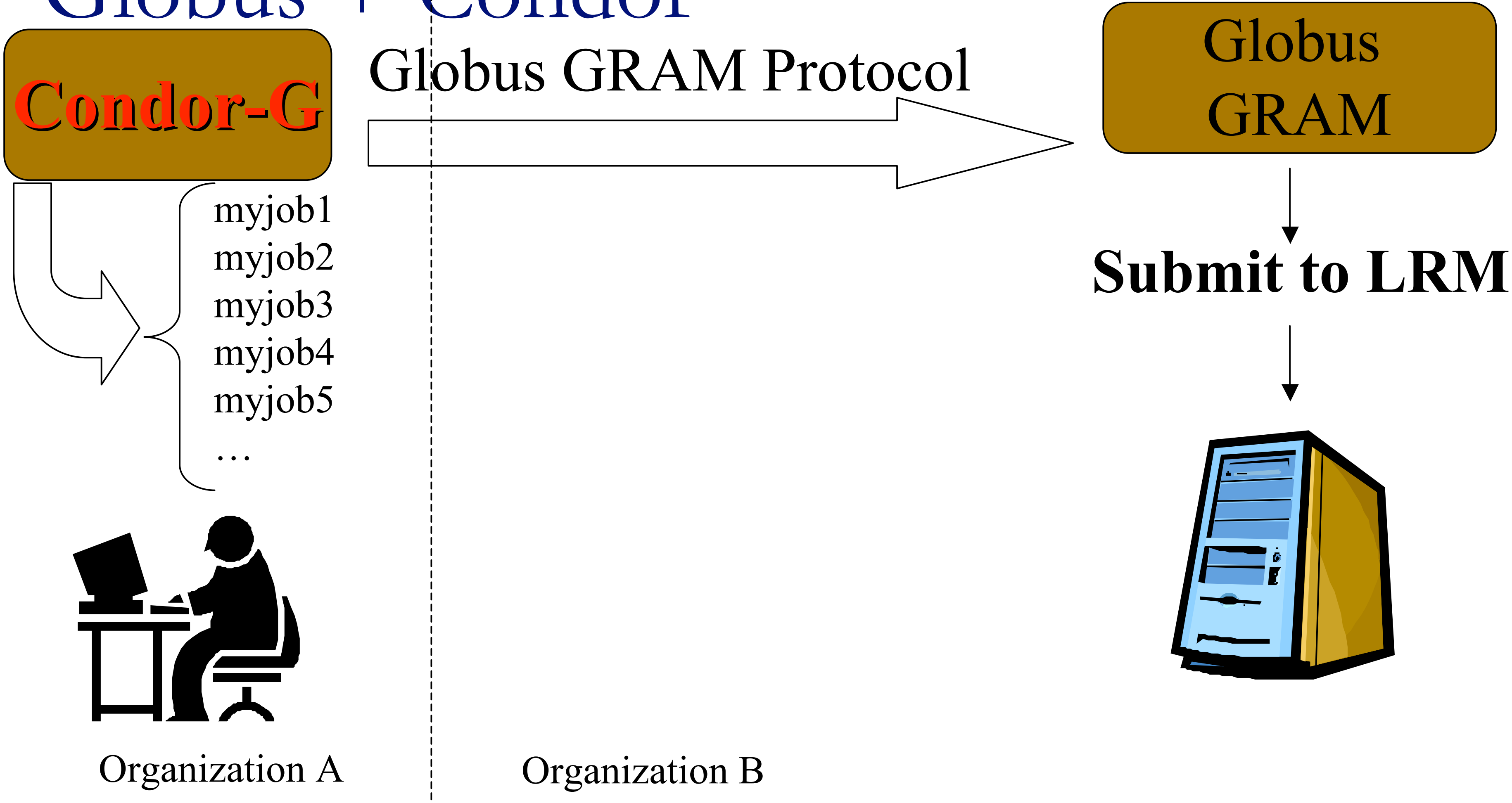
Globus JobManager

fork()

Organization A

Organization B

Remote Resource Access: Condor-G + Globus + Condor



Condor-G

myjob1
myjob2
myjob3
myjob4
myjob5
…

Globus GRAM Protocol

Globus GRAM

Submit to LRM

Organization A

Organization B

Example Application …

Simulate the behavior of **F**(x,y,z) for 20 values of x, 10 values of y and 3 values of z (20*10*3 = 600 combinations)

- **F** takes on the average 3 hours to compute on a "typical" workstation (total = 1800 hours)
- **F** requires a "moderate" (128MB) amount of memory
- **F** performs "moderate" I/O - (x,y,z) is 5 MB and **F**(x,y,z) is 50 MB

- 600 jobs

Creating a Submit Description File

- A plain ASCII text file
- Tells Condor about your job:
  - Which executable, universe, input, output and error files to use, command-line arguments, environment variables, any special requirements or preferences (more on this later)
- Can describe many jobs at once (a "cluster") each with different input, arguments, output, etc.

Simple Submit Description File

```
# Simple condor_submit input file
# (Lines beginning with # are comments)
# NOTE: the words on the left side are not
#       case sensitive, but filenames are!
Universe   = vanilla
Executable = my_job
Queue
```

```
$ condor_submit myjob.sub
```

Other Condor commands

- condor_q – show status of job queue
- condor_status – show status of compute nodes
- condor_rm – remove a job
- condor_hold – hold a job temporarily
- condor_release – release a job from hold

Condor-G: Access non-Condor Grid resources

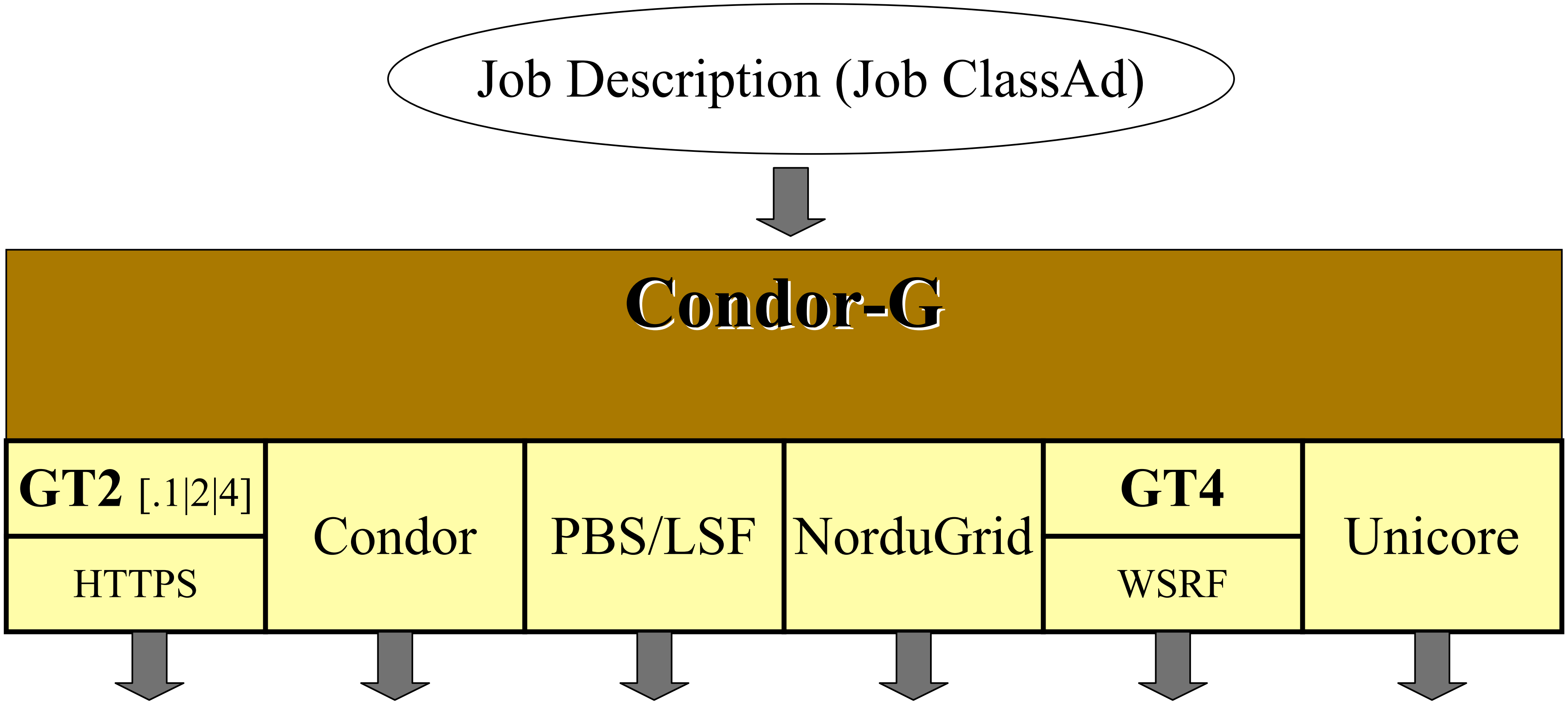
the globus project
www.globus.org

- middleware deployed across entire Grid
- remote access to computational resources
- dependable, robust data transfer

Condor
High Throughput Computing

- job scheduling across multiple resources
- strong fault tolerance with checkpointing and migration
- layered over Globus as "personal batch system" for the Grid

Condor-G



Job Description (Job ClassAd)

Condor-G

GT2 [.1|2|4]

HTTPS

Condor

PBS/LSF

NorduGrid

GT4

WSRF

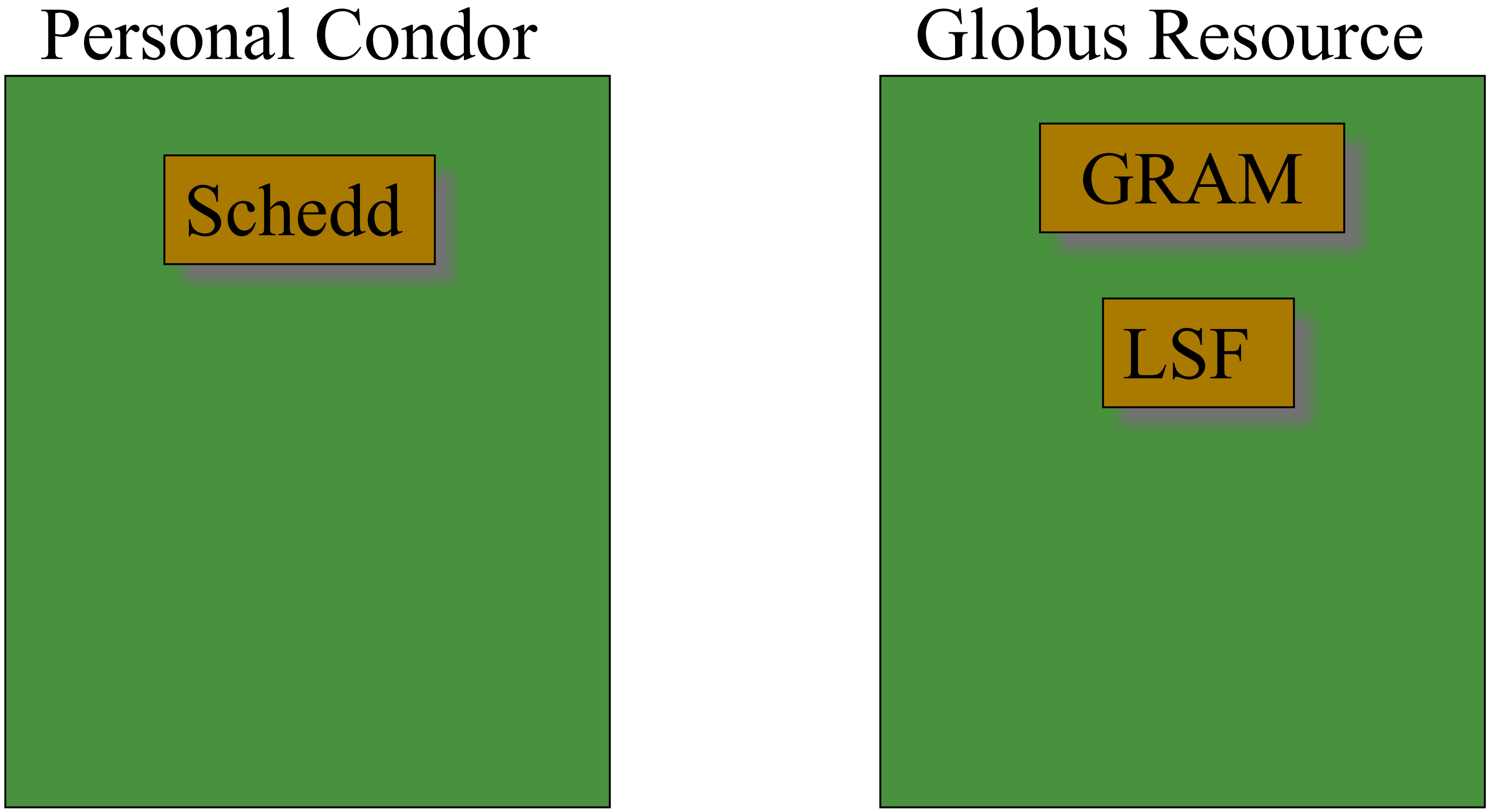
Unicore

Submitting a GRAM Job

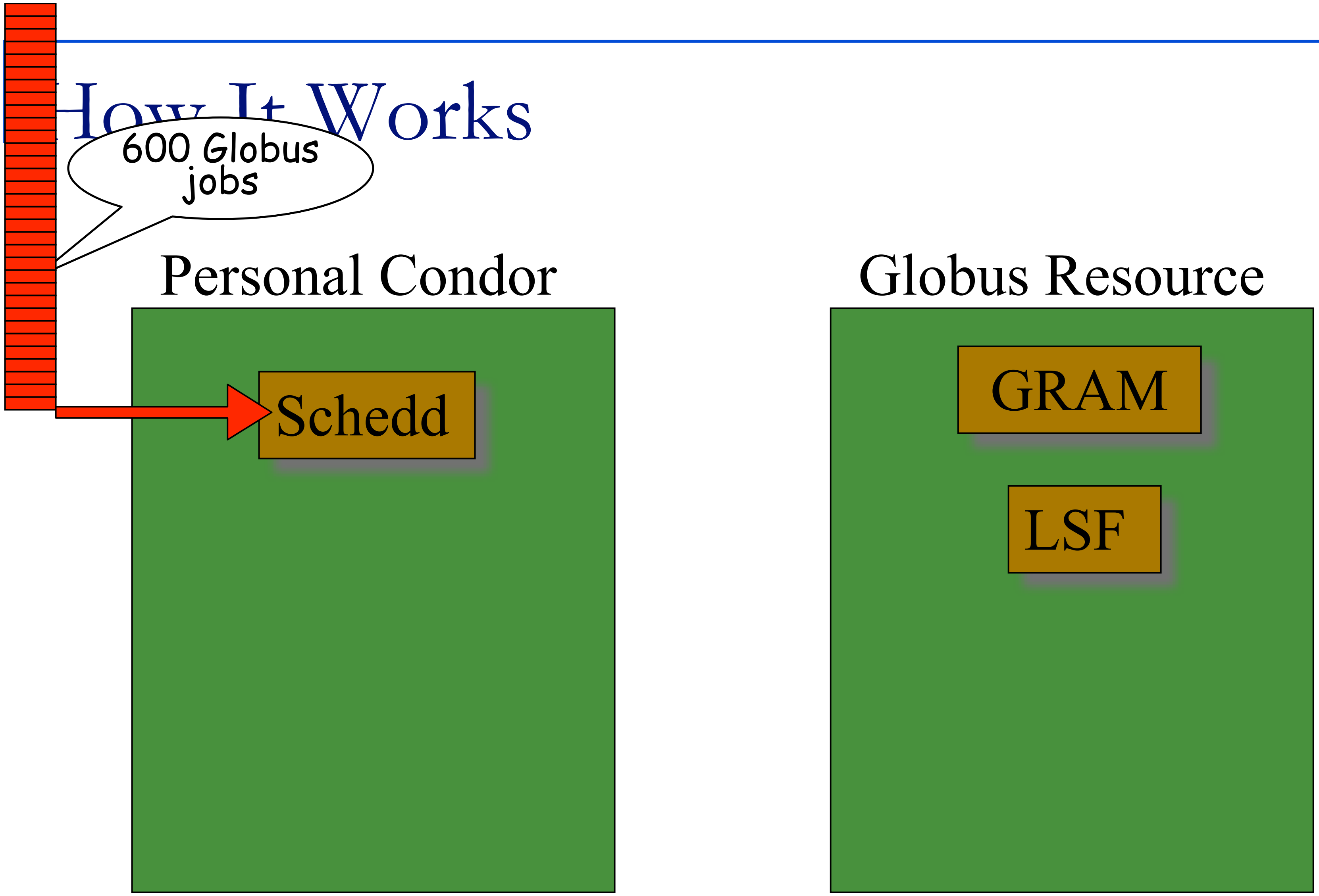
- In submit description file, specify:
  - Universe = grid
  - Grid_Resource = gt2 <gatekeeper host>
    - ‘gt2’ means GRAM2
  - Optional: Location of file containing your X509 proxy

```
universe      = grid
grid_resource = gt2 beak.cs.wisc.edu/jobmanager-pbs
executable    = progname
queue
```

How It Works



How It Works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Personal Condor
Schedd
Globus Resource
GRAM
LSF

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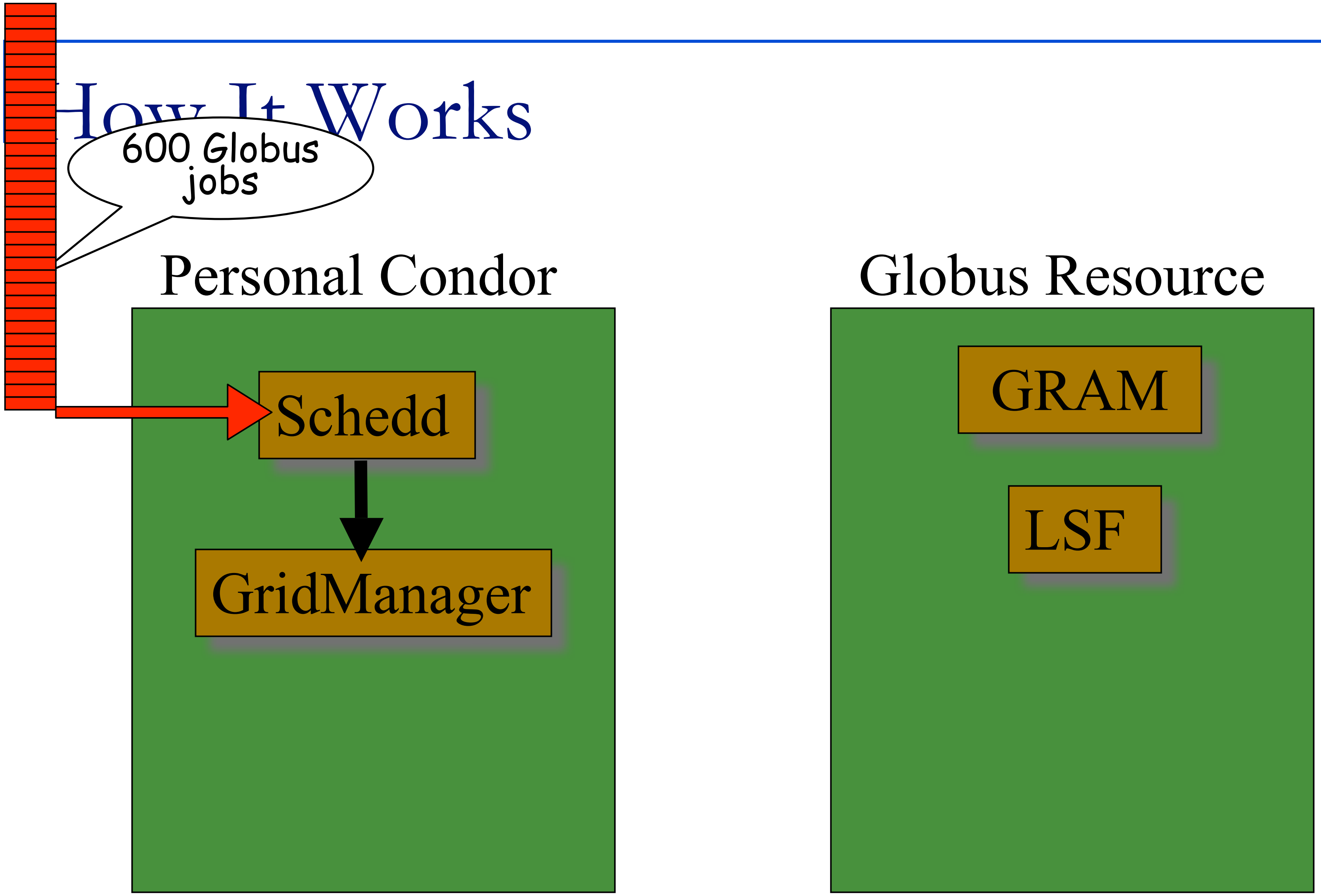

Personal Condor

Schedd

GridManager

Globus Resource

GRAM

LSF

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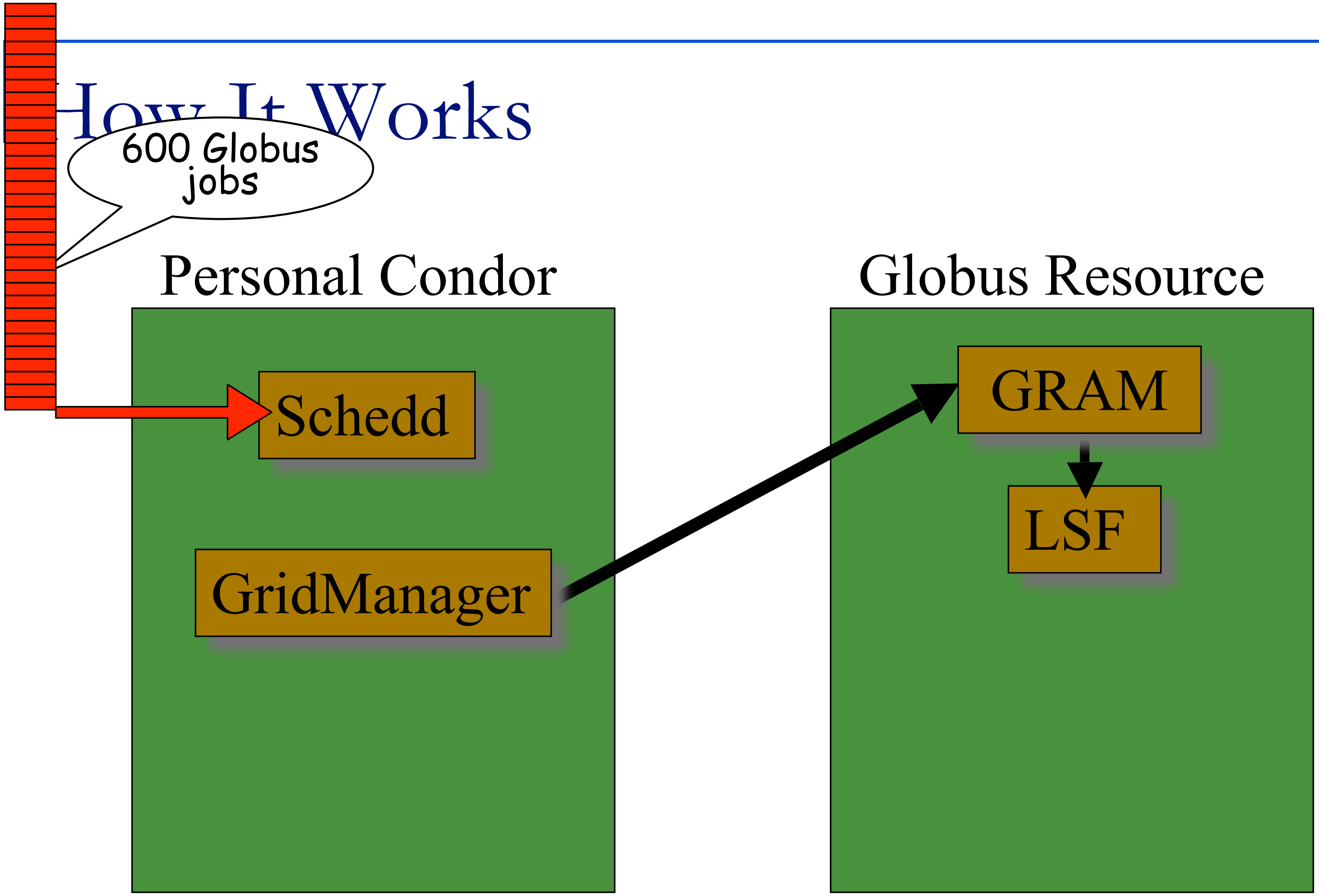
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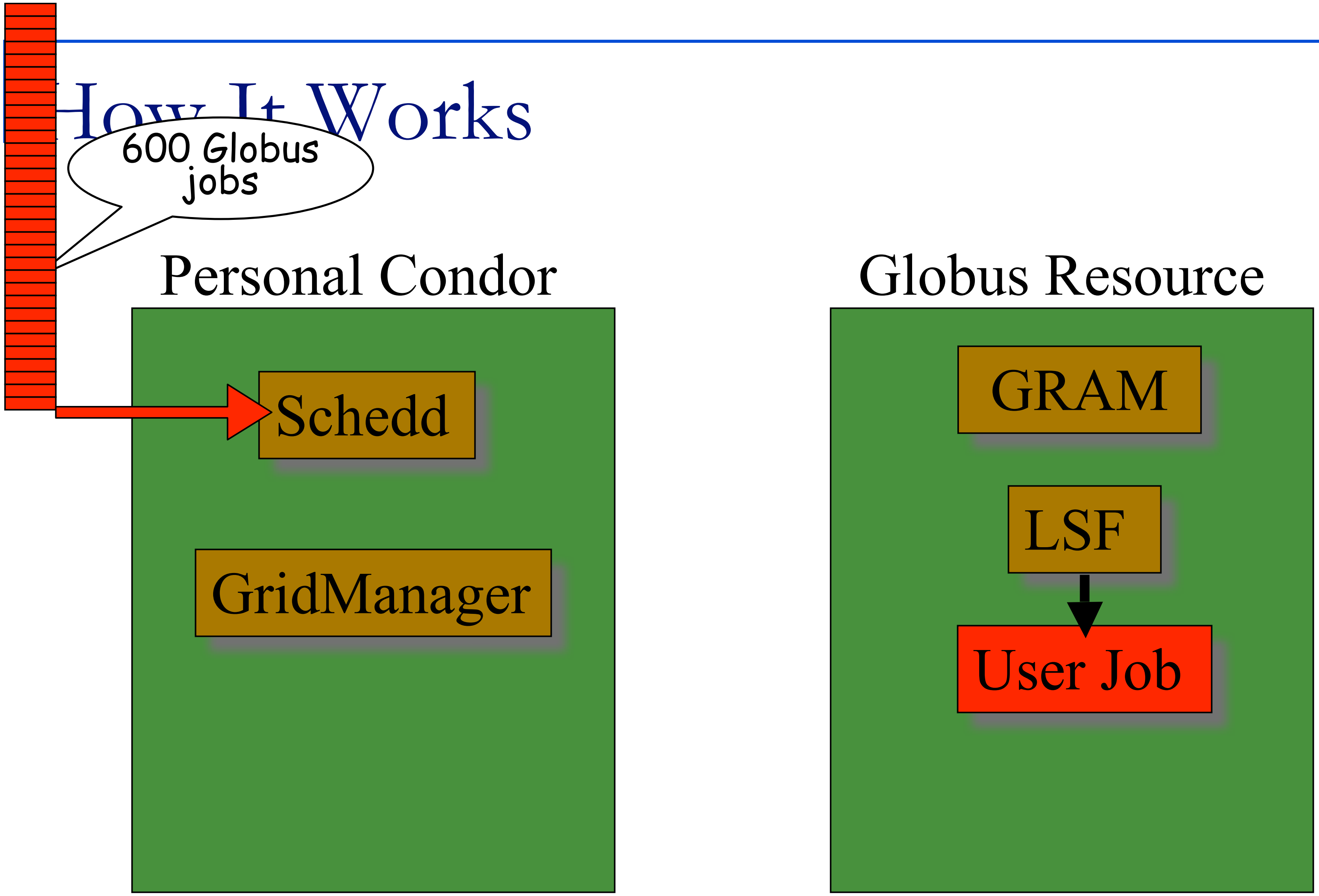
600 Globus jobs
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User Job

Grid Universe Concerns

- What about Fault Tolerance?
  - Local Crashes
    - What if the submit machine goes down?
  - Network Outages
    - What if the connection to the remote Globus jobmanager is lost?
  - Remote Crashes
    - What if the remote Globus jobmanager crashes?
    - What if the remote machine goes down?
- Condor-G's persistent job queue lets it recover from all of these failures
- If a JobManager fails to respond…

This presentation based on: Grid Resources and Job Management

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