# CONDOR And The GRID

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# Abstract

- Origination of the Condor Project
- Condor as Grid Middleware
- Condor working mechanism
- Matchmaking in Condor
- Condor-G- Interoperability with Globus
- Condor working Universe
  (Shadow, Sandbox, Remote I/O)

# Condor

## High Throughput Computing

- Resource Management System for Compute Intensive Jobs
- Job Management
- Scheduling Policies
- Resource Monitoring
- Priority Schemes

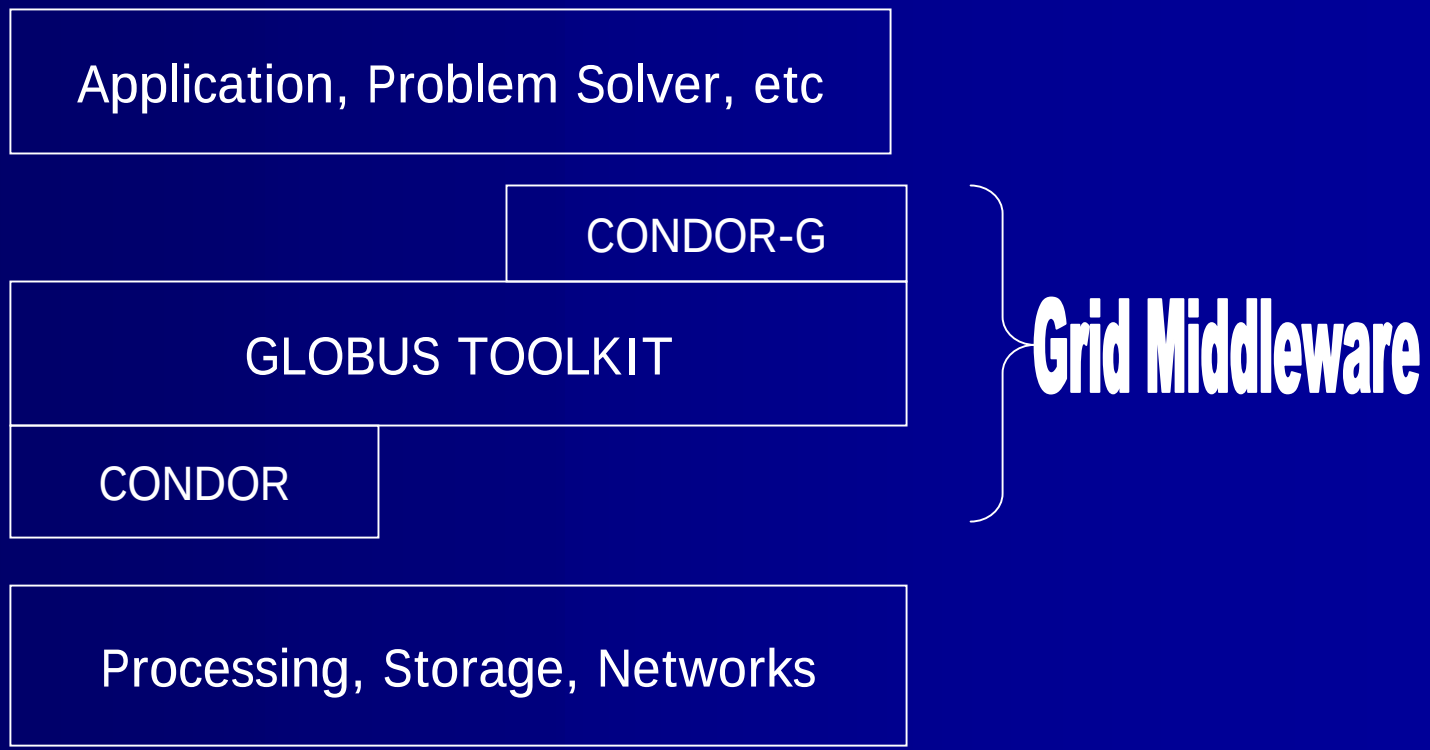
# How does it work??

- User code is re-linked with condor binaries
- Users submit jobs to the condor daemon (with job preferences)
- ClassAd mechanism matches resource requests in queue with machines in the pool.
- Job is executed remotely, with remote system calls if any.

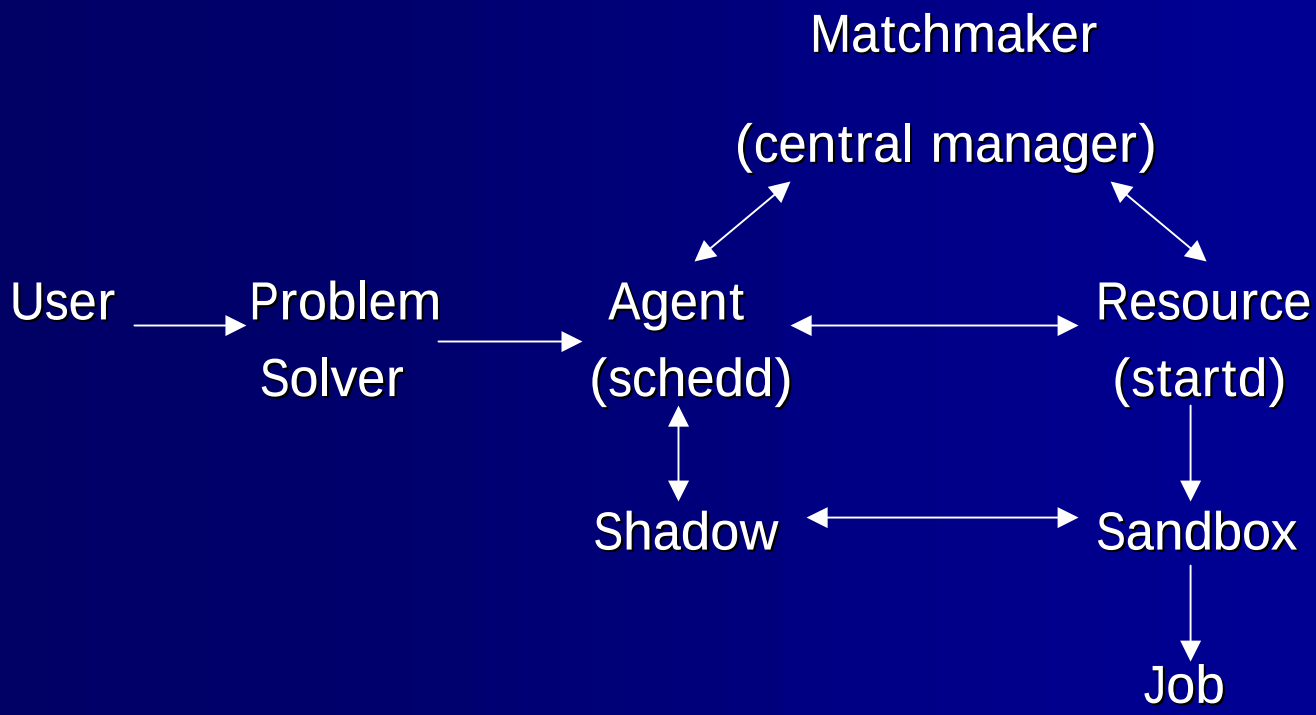
# Grid Architecture

| | |
|---|---|
| User Applications | (4) |
| Brokering, Diagnostics, Monitoring (Collective Services) | (3) |
| Secure Access to Resources and Services (Resource and Connectivity Protocols) | (2) |
| Computers, Storage Media, Networks (FABRIC) | (1) |

# Condor In The Grid



# The Condor kernel



# Kernel Daemons

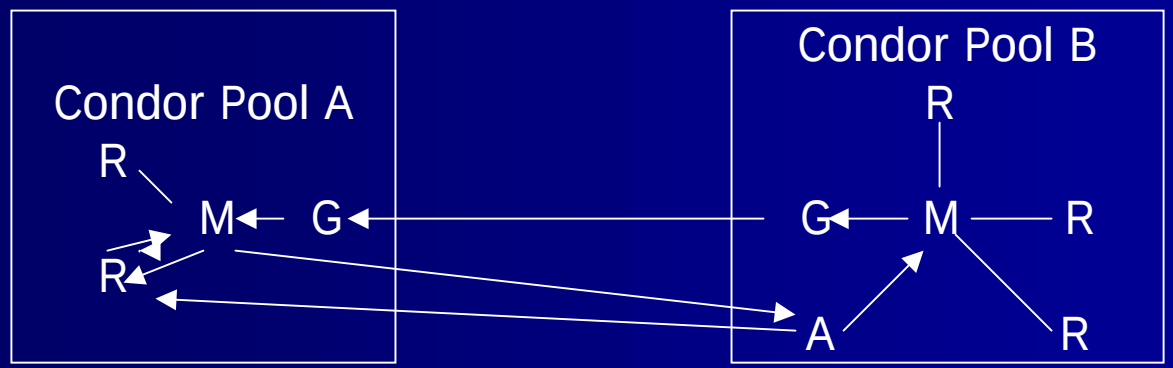
- Users submit jobs to *agents*
- *Agent* keeps job in persistent storage
- *Agents* and *resources* advertise to *matchmaker*
- *Matchmaker* introduces potentially compatible *agents* and *resources*
- At the *resource,* a sandbox ensures safe execution environment for the job

# Condor Pools
## (agents, resources and matchmakers)

- Machine running both *agent* and *resource* daemons is capable of submitting and running jobs.
- Multiple instances of *agents* can be run on the same machine
- *Agents, resources* and *matchmakers* are independent (individually enforce their owners policy)
- *Matchmaker* enforces the community policy

# Flocking

- Facilitates sharing across organizations
- Allows jobs that cannot be run immediately to run in a different condor pool.
- Gateway Flocking

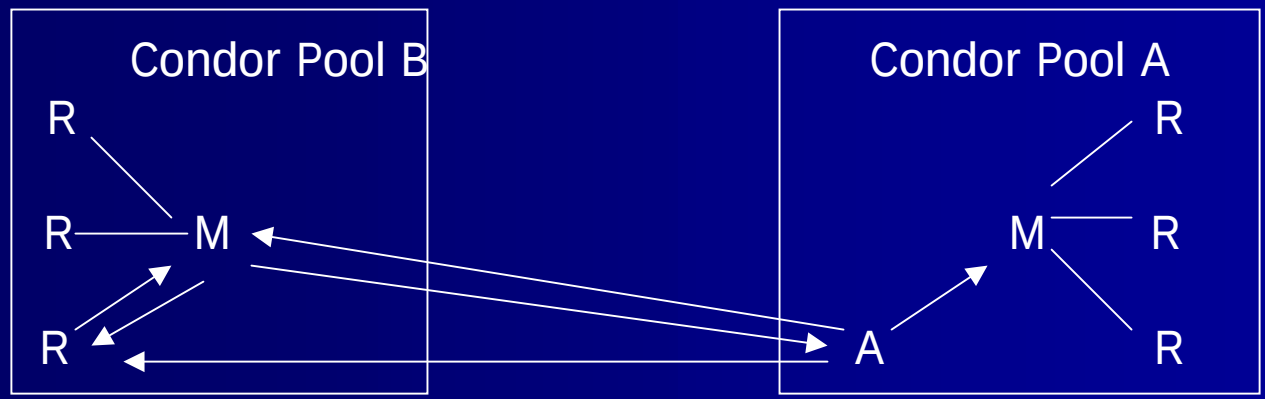


# Gateway Flocking

- Structure of existing pools is preserved
- Gateways advertise free resources between themselves
- Flocking is subject to *matchmaker* policies. (may not be bidirectional)
- Flocking is transparent to participants
- Sharing is only at organizational level
- Individual user cannot join multiple pools.

# Direct Flocking

- An *agent* can report to multiple *matchmakers*
- Flocking depends on user initiatives.



# CONDOR-G
## Inter-operability with GLOBUS

- Condor Pool is divided into two
  1. Job Management
  2. Resoure Management
- Submit Machine- Job Management
- Execute Machine- Resource Management
- Condor-G is the Job Management part of Condor

# Job Management using CONDOR-G

- Submit jobs into Queue
- Maintain Log files detailing Job life cycle
- Manage Input, Output files
- Monitor queued/running jobs
- Notifications of Job status.
- Fault-Tolerant.

# Condor-G and Globus

- Authentication
- Remote Program Execution, Data Transfer
- Uses Globus protocols to access resources at multiple sites
- Substitute for *globusrun*
- Maintain Globus credentials which might expire while job is running

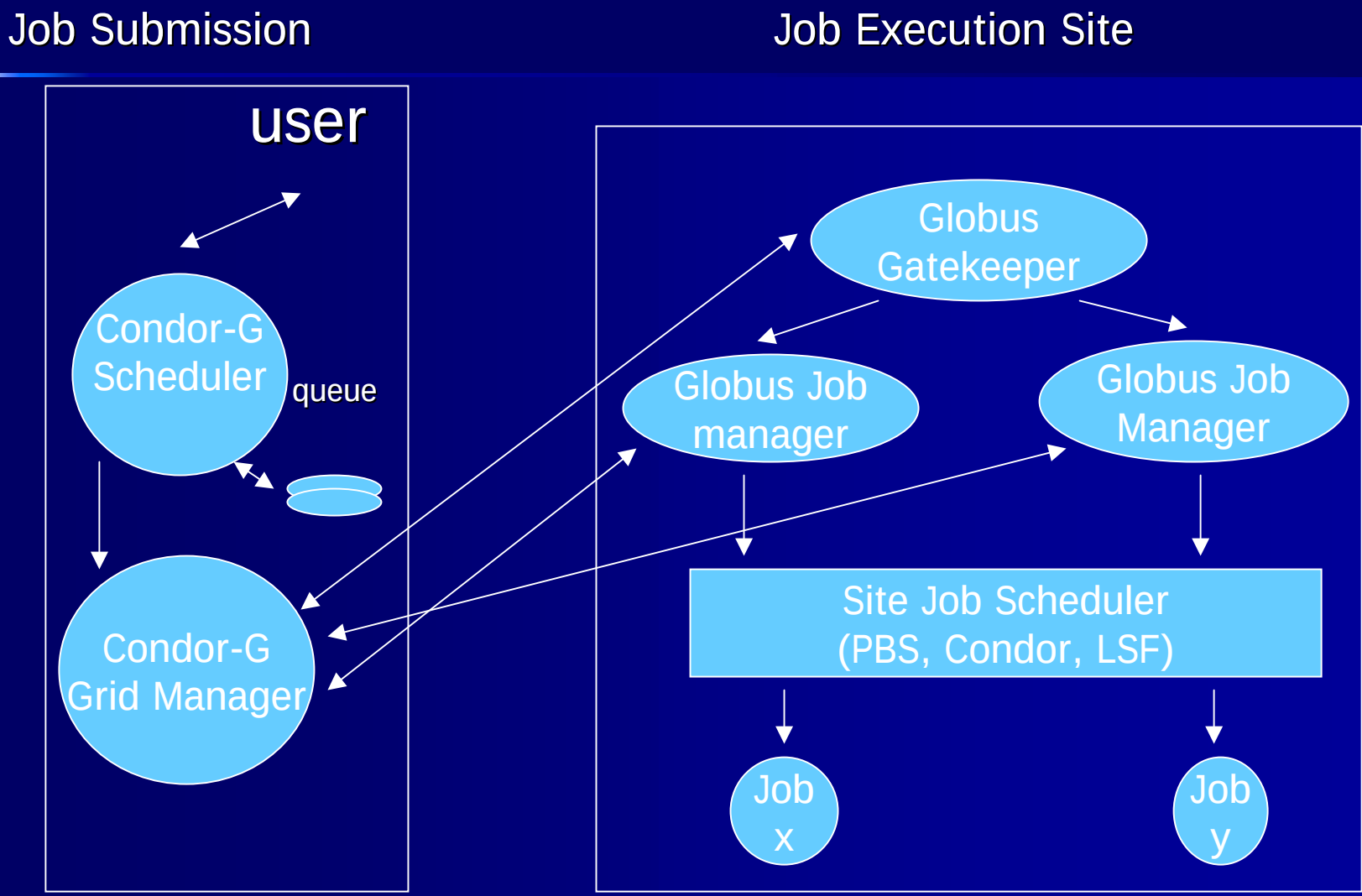
# Condor-G with GLOBUS Protocols

- GSI (Grid Security Infrastructure) for authentication (single sign-on)
- GRAM (Grid Resource Allocation Management)

  Submission of computational request to remote resource and subsequent monitoring
- GASS (Global Access to Secondary Storage)

  Data Transfer to/from remote machine of the executable and stdin, stdout files.
- RSL for Job Specification

# Accessing the Grid with Condor-G



# Condor Planning & Scheduling using *matchmaking*

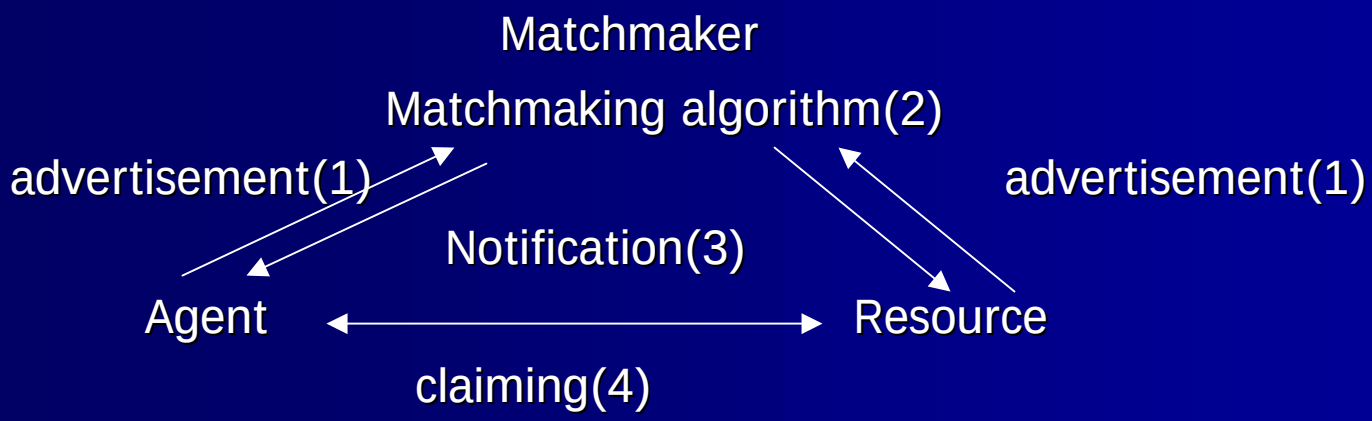
- Centralized scheduling algorithms are inefficient for Grids.
- *Agents and Resources* advertise their characteristics to *matchmakers*
- *Matchmakers* scans *ClassADS* and creates *agent-resource* pairs
- *Agents* then claim the resource in a separate step.

# ClassADS

- Set of uniquely named expressions called *attributes*
- No Specific schema
- Each attribute has a *name* and a *value*
- *Attributes* are evaluated using three-valued logic (true, false or undefined)
- *Requirements* and *rank* are pivotal attributes

# ClassAds ...

- *Requirements* indicate constraints and *rank* measures the desirability of a match
- For two ClassAds to match their *requirements* should evaluate to *true*



# Sample ClassAds

Job ClassAd

```
[
MyType="job"
TargetType="machine"
Requirements=
((other.Arch=="INTEL" &&
Other.OpSys=="Linux")
Rank=(Memory *10000)+KFLOPS
Owner="karthik"
]
```

Machine ClassAd

```
[
MyType="Machine"
TargetType="Job"
Machine="xyz.ccr.buff.edu"
Requirements=
(LoadAvg <= 0.300000)
Rank=other.depart==self.depart
OpSys="LINUX"
Arch="INTEL"
]
```

# Condor Problem Solvers

- Higher level structure built on top of the Condor Agent
- Provides a unique programming model for managing jobs
- Blindly trusts *Agents* for reliability
- Deals with only application specific details of ordering and task selection
- Runs as a normal condor job at submission site

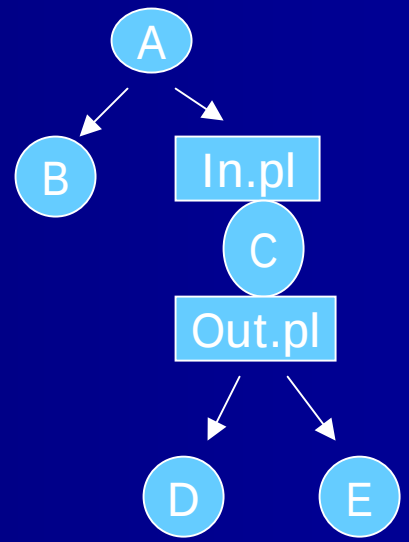
# Master-Worker

- System for problems of indeterminate size on a unreliable workforce.
- Eg. Parameter searches where problem space is huge and can be examined independently.
- Master Process directs the computation, with assistance of worker processes (compute nodes)

# Directed Acyclic Graph Manager

- Service for executing multiple jobs with dependencies
- Similar to *make*, accepts a declaration that lists the work to be done and the constraints.

```
Job A a.condor
Job B b.condor
Job C c.condor
Job D d.condor
Job E e.condor
PARENT A CHILD B C
PARENT C CHILD D E
SCRIPT PRE C in.pl
SCRIPT POST C out.pl
```



# DAGMAN ...

- Job statement associates an abstract name with a .condor file which describes a complete condor job
- PARENT-CHILD statement describes relation between two or more jobs
- PRE and POST jobs are run by DAGMan on the submitting machine

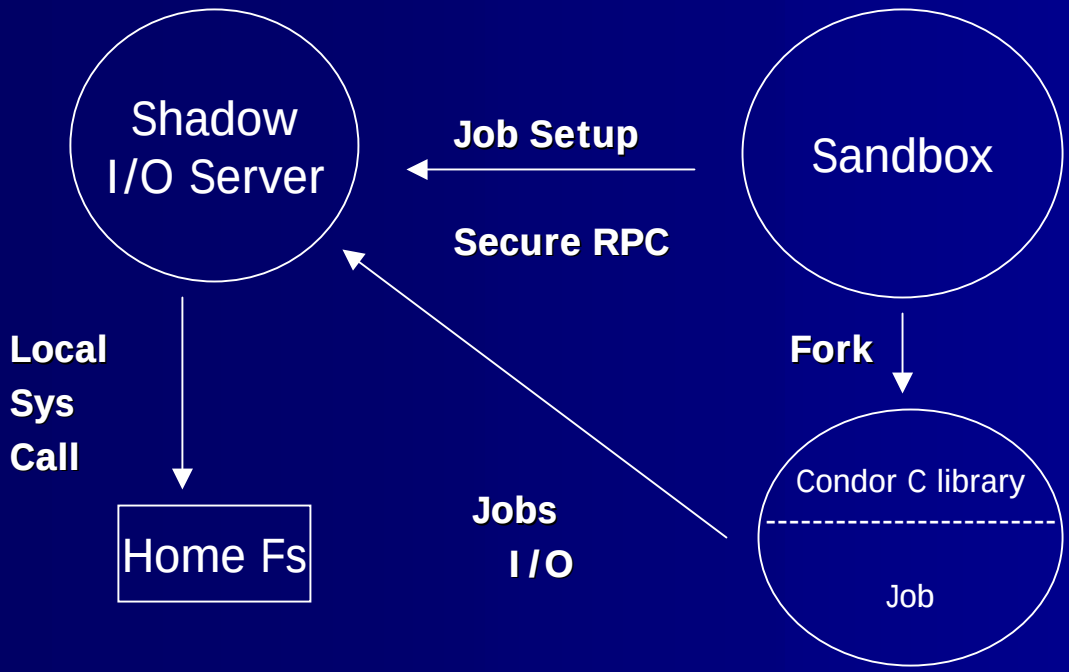
# Split Execution

- Facilitates successful remote execution of jobs.
- Shadow- represents the user to the system. Provides everything needed to specify the job at runtime (executable,
  arguments, input files, environment etc)
- Sandbox- Responsible for providing the a safe execution environment for jobs.
- A matched Sandbox and Shadow form the *universe*

# Standard Universe

- Only universe supplied by early versions of condor
- The goal is to faithfully reproduce users home POSIX environment at remote site
- Emulates vast majority of system calls
- Supports checkpointing, facilitating process migration

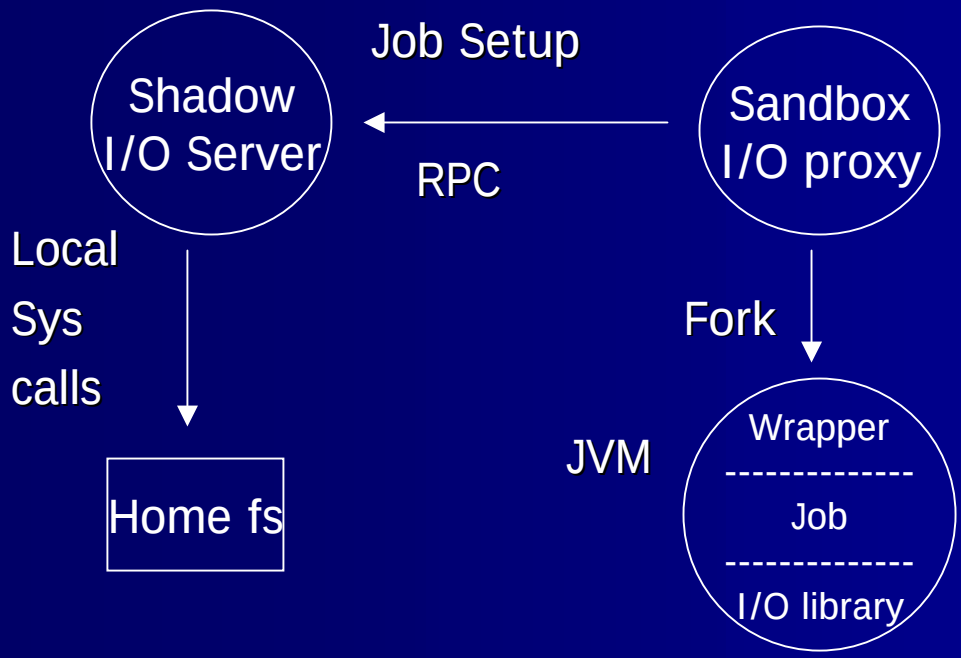
# Standard Universe



# Java Universe

- Recent additions to Condor
- Earlier, entire JVM was submitted as a standard universe job for executing Java Programs
- The new Java universe provides a complete Java environment
- All Java runtime components are placed in a private execution directory along with user credentials.

# Java Universe ...



# References

- Grid Computing

  Fran Berman, Geoffrey Fox, Anthony Hey

- Condor Project

  University of Wisconsin at Madison

  http://www.cs.wisc.edu/condor