Pegasus- Advanced Features and Optimizations

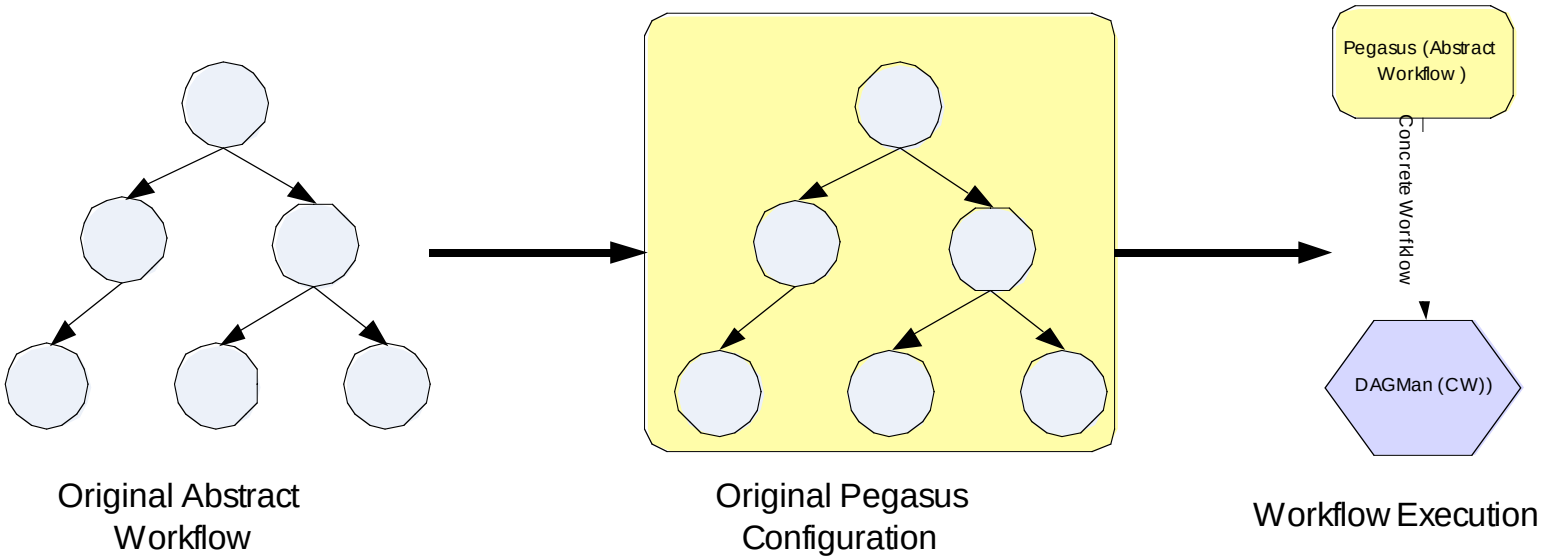
Griphyn-LIGO Meeting,
Caltech
July 20th, 2006

Karan Vahi, Ewa Deelman, Gaurang Mehta,
Center for Grid Technologies
USC Information Sciences Institute
vahi, deelman,gmehta@isi.edu

Advanced Features Outline

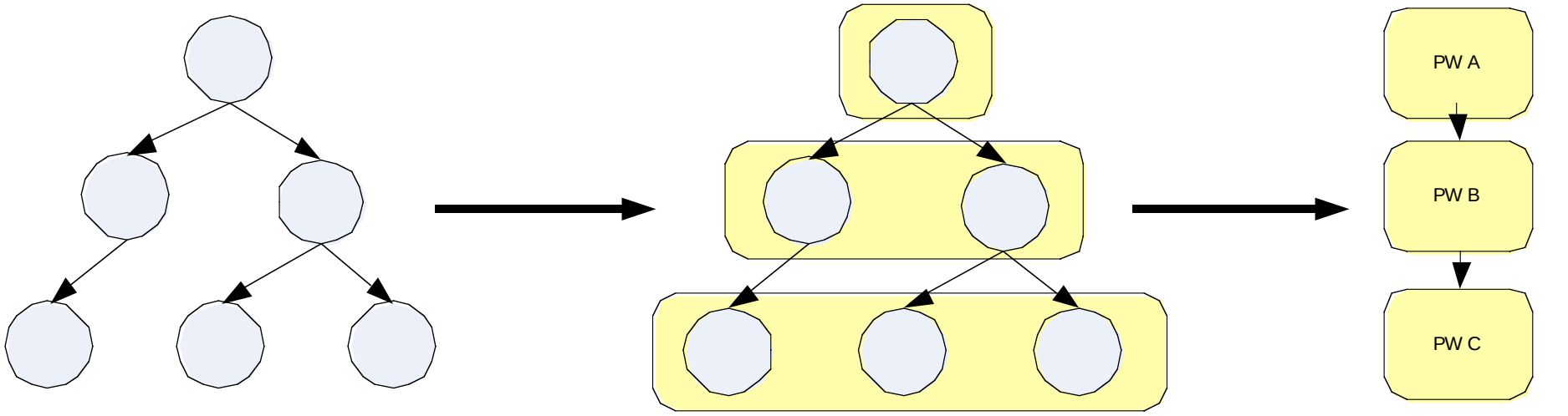
- Deferred Planning
- Job Clustering
- Transfer Configurations
- Transfer of Executables
- Replica Selection
- Running in different GRID setups

Original Pegasus configuration



Simple scheduling: random or round robin using well-defined scheduling interfaces.

Deferred Planning through Partitioning



A Particular Partitioning

New Abstract Workflow

Partitioning techniques implemented

- Breadth First
- Label based (User specifies in the DAX what his partitions are)
- Node by Node (Each Node is a separated partition)

Label Based Partitioning(1)

- The partitions are explicitly tagged in the DAX by the user.
  - Tagging is done by associating VDS profiles with the jobs.
  - Jobs with the same profile value are considered to belong to the same partition.
  - Profiles can either by added in DAX generator or in the VDL.

- Which VDS profile key to use for partitioning ?
  - > You can specify any key to be used.
  - > Set the property vds.label.key

Label Based Partitioning (2)

IN THE DAX:

```
<adag >
…
  <job id="ID000004" namespace="vahi" name="analyze" version="1.0" level="1" >
    <argument>-a bottom -T60  -i <filename file="vahi.f.c1"/>  -o <filename file="vahi.f.d"/></argument>
    <profile namespace="vds" key="ligo_label">p1</profile>
    <uses file="vahi.f.c1" link="input" dontRegister="false" dontTransfer="false"/>
    <uses file="vahi.f.c2" link="input" dontRegister="false" dontTransfer="false"/>
    <uses file="vahi.f.d" link="output" dontRegister="false" dontTransfer="false"/>
  </job>
…
</adag>
```

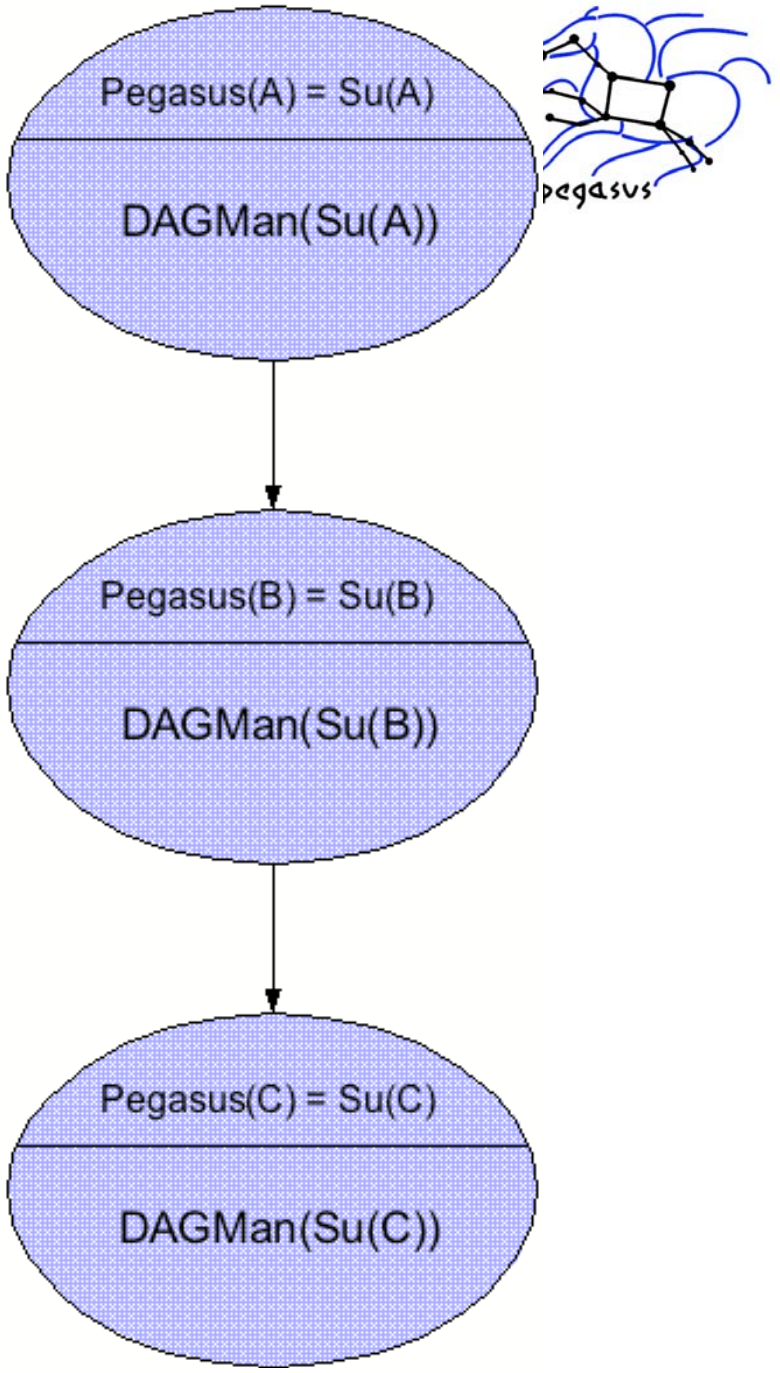
PROPERTY FILE:

```
vds.label.key = ligo_label
```

- The above states that the VDS profiles with key as ligo_label are to be used for designating partitions.
- Each job with the same value for VDS profile key ligo_label appears in the same partition.

Pegasus(X): Pegasus generated the concrete workflow and the submit files for Partition X -- Su(X)

DAGMan(Su(X): DAGMan executes the concrete workflow for X



Mega D
by Pega
submitt

Partitioned Workflow Processing

- Create workflow partitions
  - partition the abstract workflow into smaller workflows using partitiondax.
  - create the xml partition graph (pdax) that lists out the dependencies between partitions.
- Create the MegaDAG (creates the dagman submit files)
  - transform the xml partition graph to it's corresponding condor representation.
- Submit the MegaDAG
  - Each job invokes Pegasus on a partition and then submits the plan generated back to condor.

Job Clustering (1)

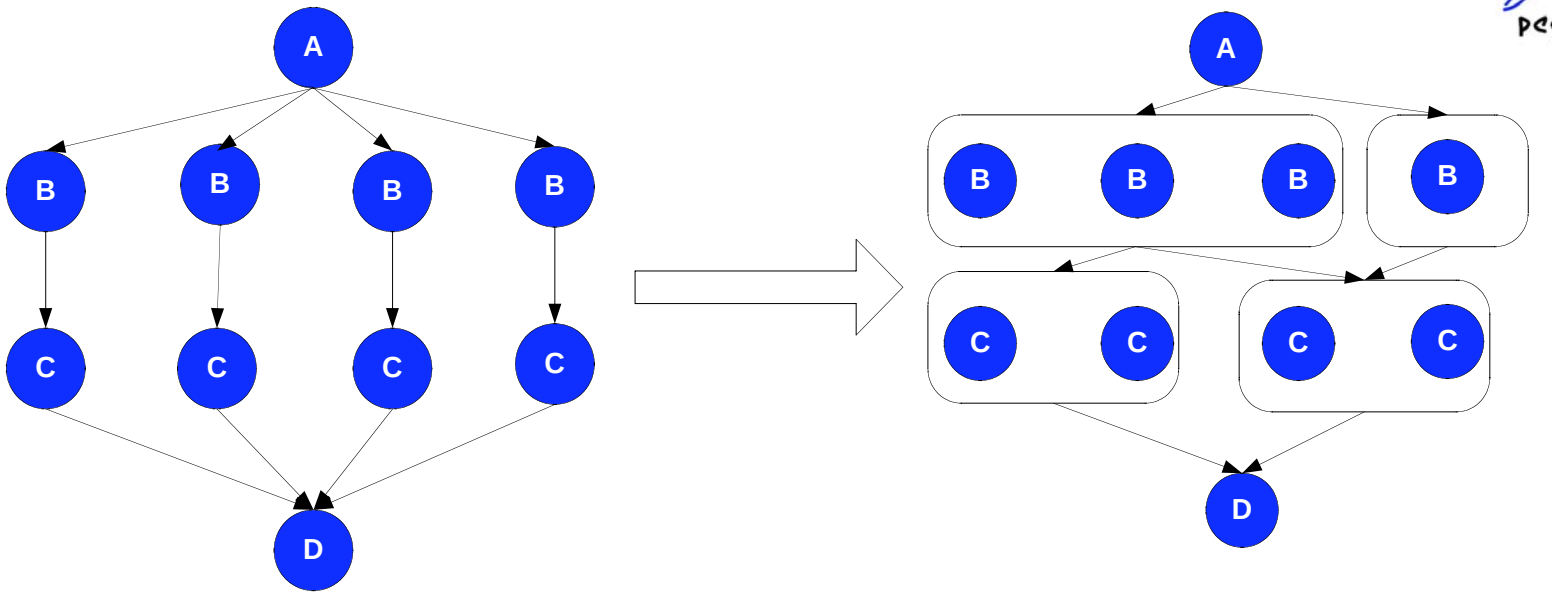
- Cluster small running jobs together to achieve better performance.

- Why?
  - Each job has scheduling overhead
  - Need to make this overhead worthwhile.
  - Ideally users should run a job on the grid that takes at least 10 minutes to execute

More at http://vds.uchicago.edu/vds/doc/userguide/html/H_PegasusJobClustering.html

Or $VDS_HOME/doc/userguide/VDSUG_PegasusJobClustering.xml

Job Clustering(2)



1. Original Workflow

Clustered Workflow

- Horizontal Clustering
  - Jobs on the same level are clustered into larger jobs
  - Clustering parameters can be configured by associating profiles in Transformation Catalog or Site Catalog.
- Vertical Clustering (Soon)
- The clustered job can be run on the remote site
  - Sequentially using VDS tool seqexec.
  - In Parallel using using VDS MPI wrapper mpiexec

Planning & Scheduling Granularity

- Partitioning
  - Allows to set the granularity of planning ahead
- Node aggregation
  - Allows to combine nodes in the workflow and schedule them as one unit (minimizes the scheduling overheads)
  - May reduce the overheads of making scheduling and planning decisions
- Related but separate concepts
  - Small jobs
    - > High-level of node aggregation
    - > Large partitions
  - Very dynamic system
    - > Small partitions

Transfer Configurations

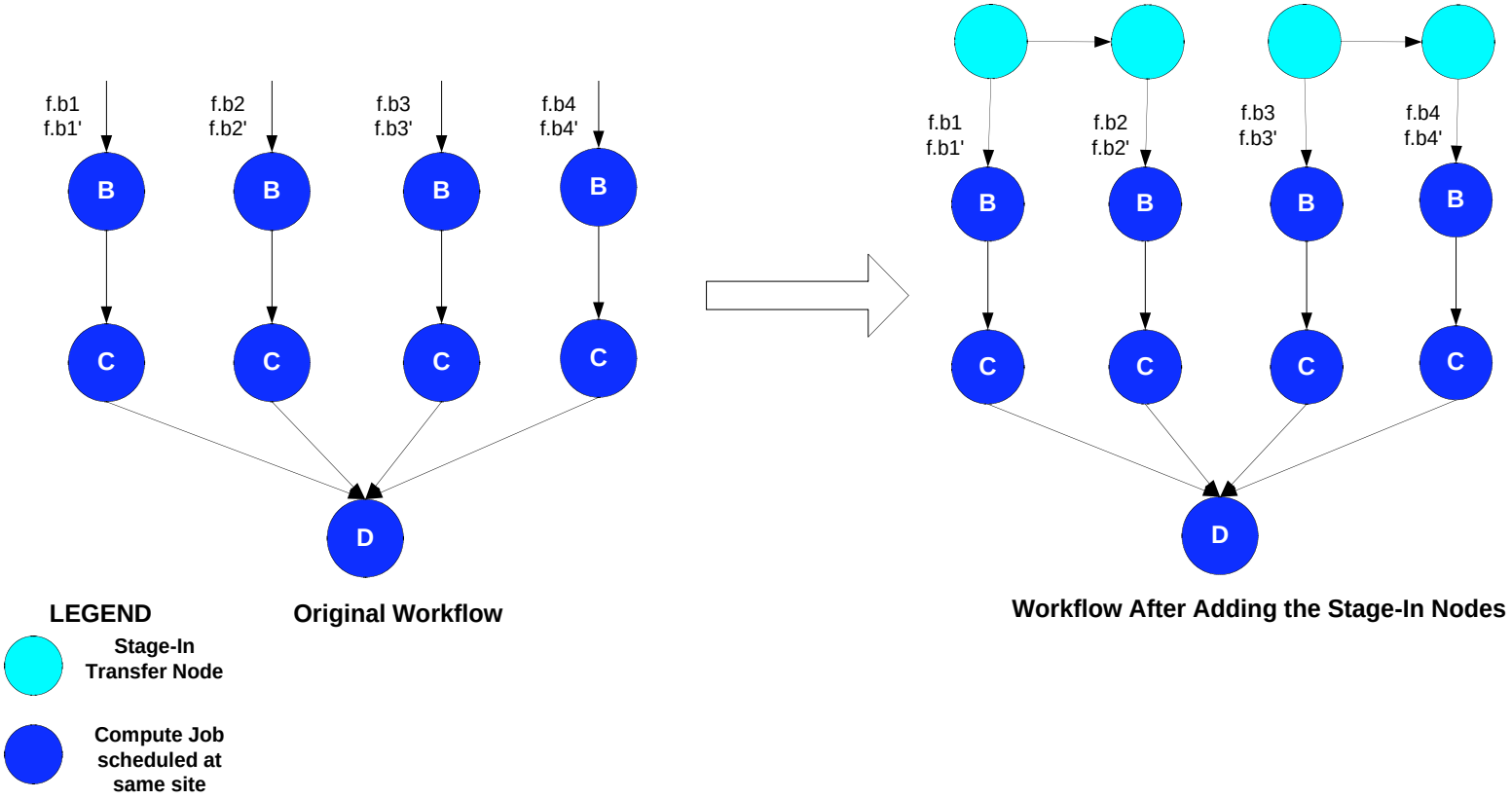
- Variety of transfer clients may be used
  - Set vds.transfer.*.implementation property
  - Support for clients like
    - RFT
    - Stork
    - T2 (VDS client that retries in case of failures)
    - Transfer (VDS client wrapper around g-u-c)
    - SRM (preliminary support)
- Variety of refinement strategies maybe used for adding transfer nodes
  - Set vds.transfer.refiner property.
- Varying third party transfer settings
  - Set vds.transfer.*.thirdparty.sites
  - Allows you to specify for which compute sites you want to use for third party party staging.

Explained in more detail at $VDS_HOME/doc/properties.pdf

Transfer Throttling

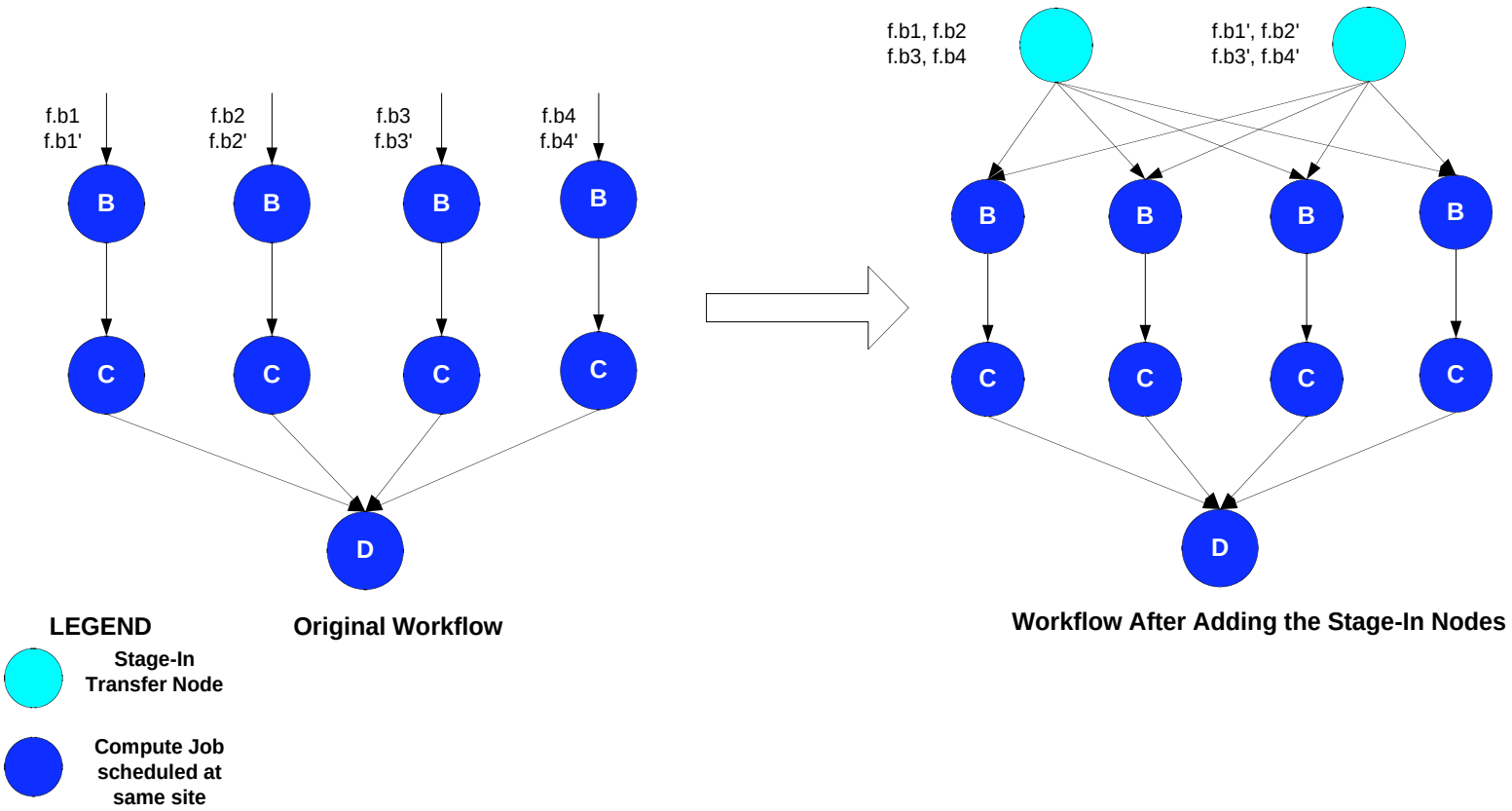
- Large Sized Workflows result in large number of transfer jobs being executed at once. Results in
  - Grid FTP server overload (connection refused errors etc)
  - May result in a high load on the head node if transfers are not configured for being executed as third party transfers
- Need to throttle transfers
  - Set vds.transfer.refiner property.
  - Allows you to create chained transfer jobs or bundles of transfer jobs

Transfer Throttling by Chaining



Explained in more detail at $VDS_HOME/doc/properties.pdf

Transfer Throttling by Bundling



Explained in more detail at $VDS_HOME/doc/properties.pdf

Transfer of Executables

- Allows the user to dynamically deploy scientific code on remote sites
- Makes for easier debugging of scientific code.
- The executables are transferred as part of the workflow
- Currently, only statically compiled executables can be transferred
- Selection of what executable to transfer
  - Set vds.transformation.selector property.

More at "Pegasus: a Framework for Mapping Complex Scientific Workflows onto Distributed Systems" Scientific Programming Journal,January 2005

Also explained in the properties file at $VDS_HOME/doc/properties.pdf

Replica Selection

- Default replica selection
  - Always prefer data present at the compute site, else select randomly a replica
- Restricted Replica Selection
  - Can specify preferred sites from which to stage in data per compute site.
  - Can specify sites to ignore for staging in data per compute site.
- Properties to Set (* in name replaced by site name. * means all sites)
  - vds.replica.selector
  - vds.replica.*.ignore.stagein.sites
  - vds.replica.*.ignore.stagein.sites

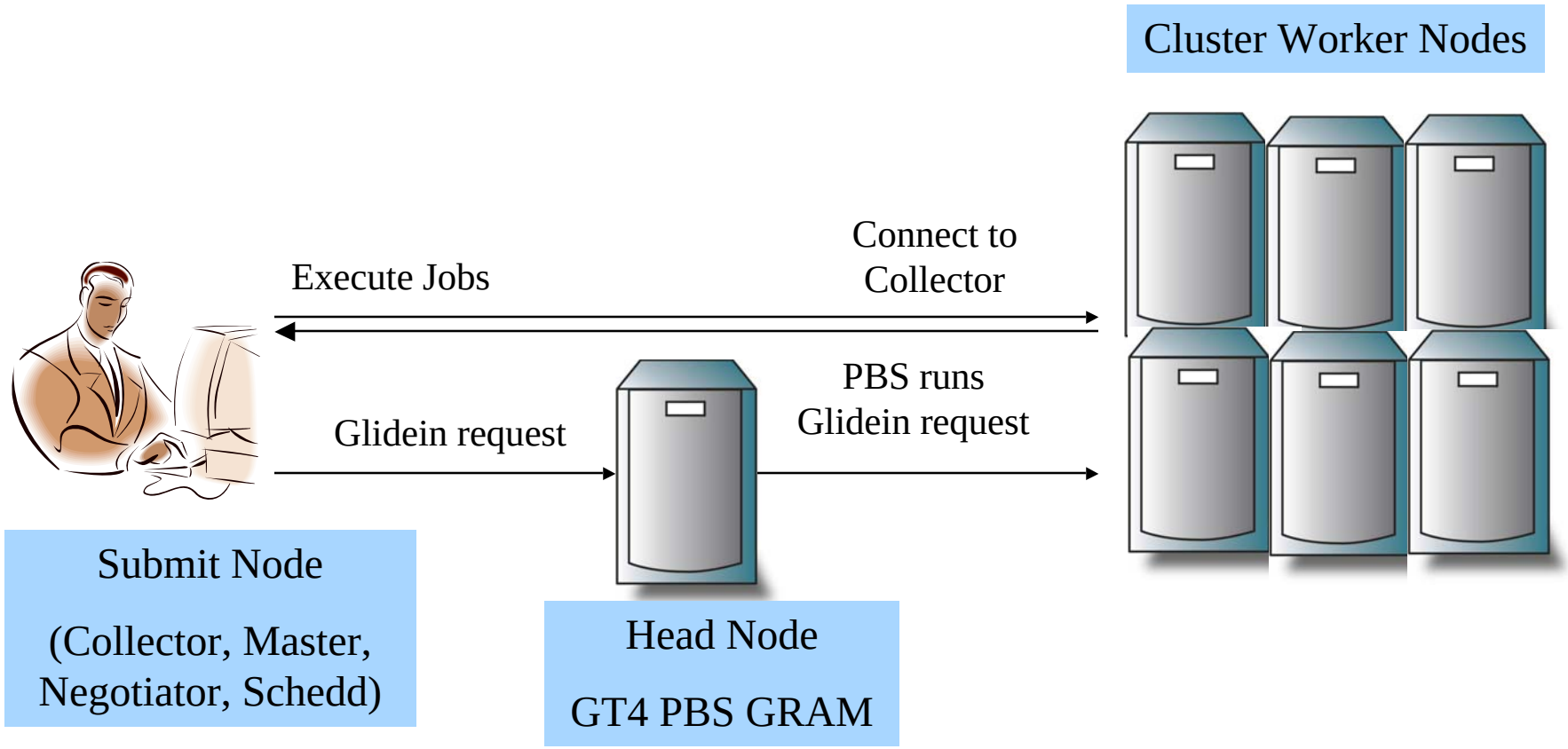
Explained in more detail at $VDS_HOME/doc/properties.pdf

Running in different grid setups

- Need to specify vds namespace profile keys with the sites in the site catalog.
- Submitting directly to condor pool
  - The submit host is a part of a local condor pool
  - Bypasses CondorG submissions avoiding Condor/GRAM delays.
- Using Condor GlideIn
  - User glides in nodes from a remote grid site to his local pool
  - Condor is deployed dynamically on glided in nodes for e.g. you glide in nodes from the teragrid site running PBS.
  - Only have to wait in the remote queue once when gliding in nodes.

More at http://vds.uchicago.edu/vds/doc/userguide/html/H_RunningPegasus.htmlOr $VDS_HOME/doc/userguide/VDSUG_RunningPegasus.xml

Condor GlideIn



Cluster on a public network

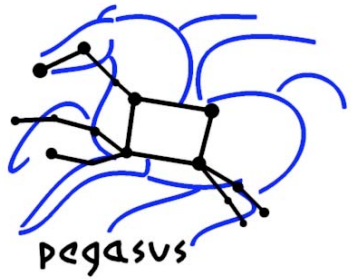
For further information

- VDS and Pegasus:
  - http://vds.isi.edu
  - http://pegasus.isi.edu
- Mailing Lists
  - vds-support@griphyn.org
  - vds-discuss@griphyn.org
- Workflow Management research group in GGF:
  - www.isi.edu/~deelman/wfm-rg
- Workshops
  - Works06 (http://www.isi.edu/works06/) in conjunction with HPDC 2006.
  - NSF Workflow Workshop (http://vtcpc.isi.edu/wiki/index.php/Main_Page)

Pegasus - Further Reading

- VDS Documents in VDS distribution in $VDS_HOME/doc directory
  - configuration via properties $VDS_HOME/doc/properties.pdf
  - Userguide in $VDS_HOME/doc/userguide directory
- On the web (often lags latest release)
  - http://vds.uchicago.edu/twiki/bin/view/VDSWeb/VDSDocs

Pegasus Papers



- Papers on Pegasus (more at http://pegasus.isi.edu)
  - "Pegasus: a Framework for Mapping Complex Scientific Workflows onto Distributed Systems" Scientific Programming Journal,January 2005
  - Mapping Abstract Complex Workflows onto Grid Environments, Ewa Deelman , James Blythe, Yolanda Gil, Carl Kesselman, Gaurang Mehta, Karan Vahi, Kent Blackburn, Albert Lazzarini, Adam Arbree, Richard Cavanaugh, and Scott Koranda, Journal of Grid Computing, Vol.1, no. 1, 2003, pp. 25-39.
  - "Artificial Intelligence and Grids: Workflow Planning and Beyond," Yolanda Gil, Ewa Deelman, Jim Blythe, Carl Kesselman, and Hongsuda Tangmurarunkit. *IEEE Intelligent Systems*, January 2004
  - "Transparent Grid Computing: a Knowledge-Based Approach", Jim Blythe, Ewa Deelman, Yolanda Gil, Carl Kesselman, IAAI 2003
  - "The Montage Architecture for Grid-Enabled Science Processing of Large, Distributed Datasets," J. C. Jacob, D. S. Katz, T. Prince, G. B. Berriman, J. C. Good, A. C. Laity, E. Deelman, G. Singh, and M.-H. Su, *Proceedings of the Earth Science Technology Conference (ESTC) 2004*, June 2004.