The Stork DELIVERS Your Data!

STORK: Making Data Placement a First Class Citizen in the Grid

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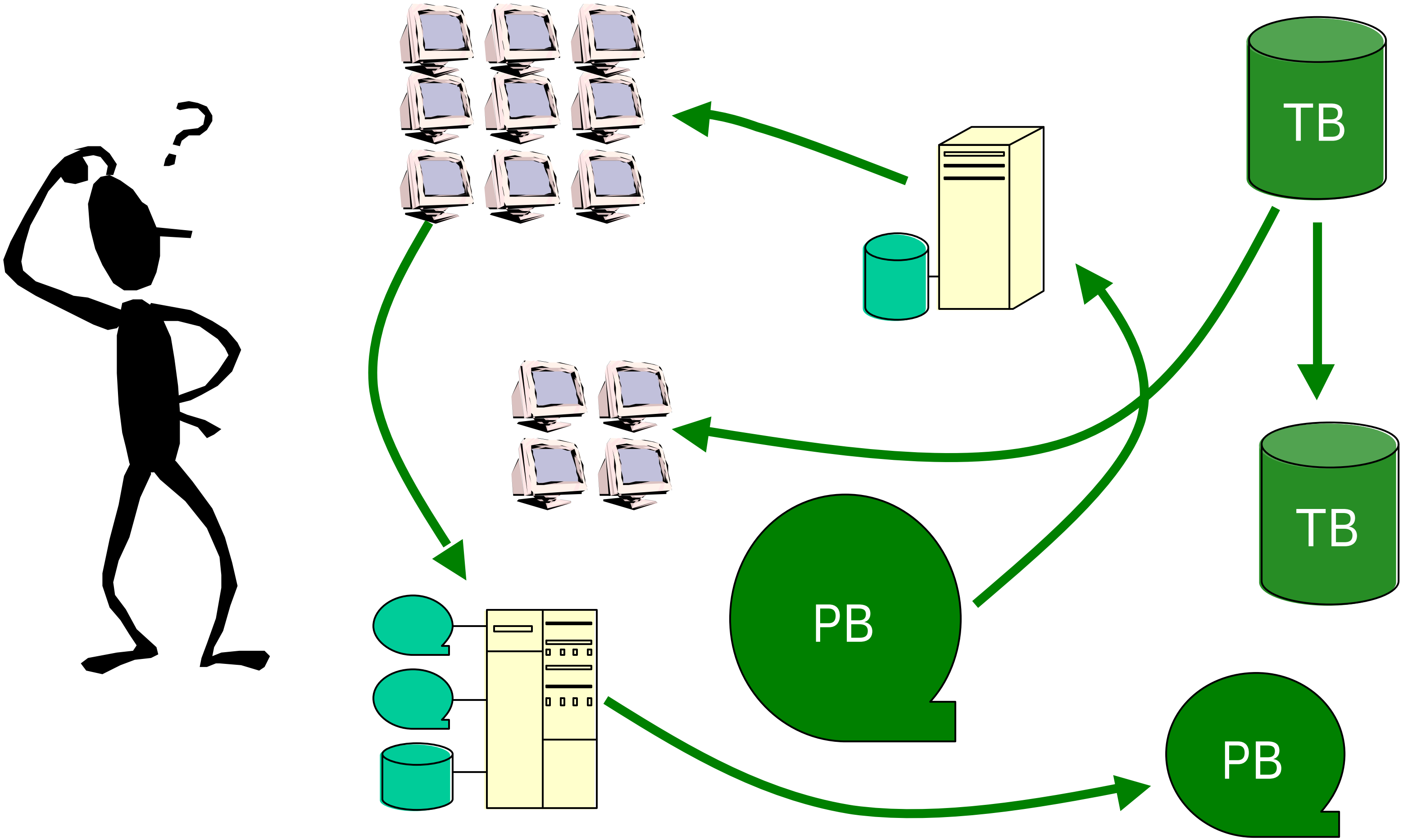
May 25th, 2004
CERN

Need to move data around..



While doing this..

- Locate the data
- Access heterogeneous resources
- Face with all kinds of failures
- Allocate and de-allocate storage
- Move the data
- Clean-up everything

➡ **All of these need to be done reliably and efficiently!**

Stork

- A scheduler for data placement activities in the Grid
- What Condor is for computational jobs, Stork is for data placement
- Stork comes with a new concept:

  "Make data placement a first class citizen in the Grid."

Outline

- Introduction
- The Concept
- Stork Features
- Big Picture
- Case Studies
- Conclusions

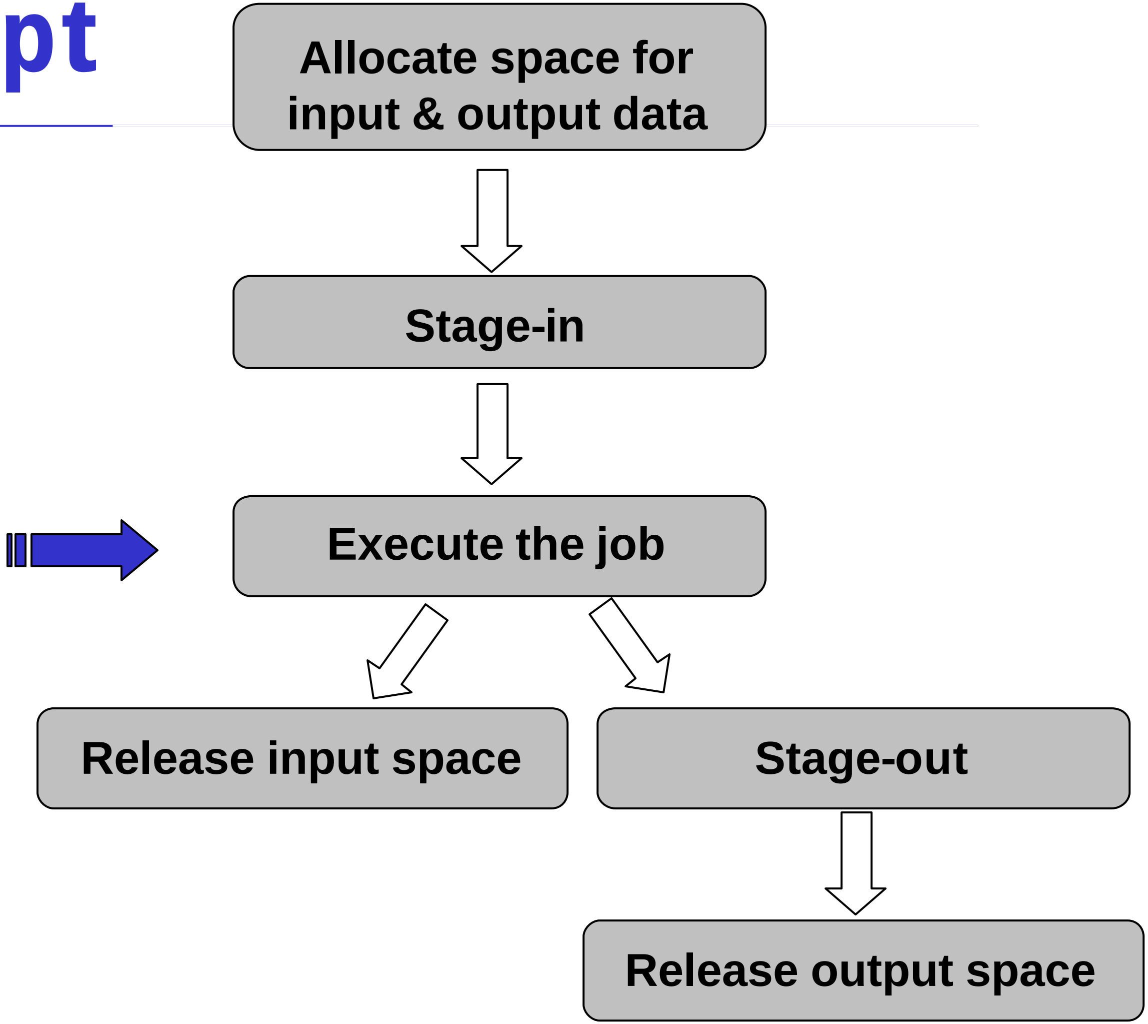
The Concept

- Stage-in
- Execute the Job
- Stage-out

▨ Individual Jobs

The Concept

- Stage-in
- Execute the Job
- Stage-out



▨ Individual Jobs

The Concept

- Stage-in
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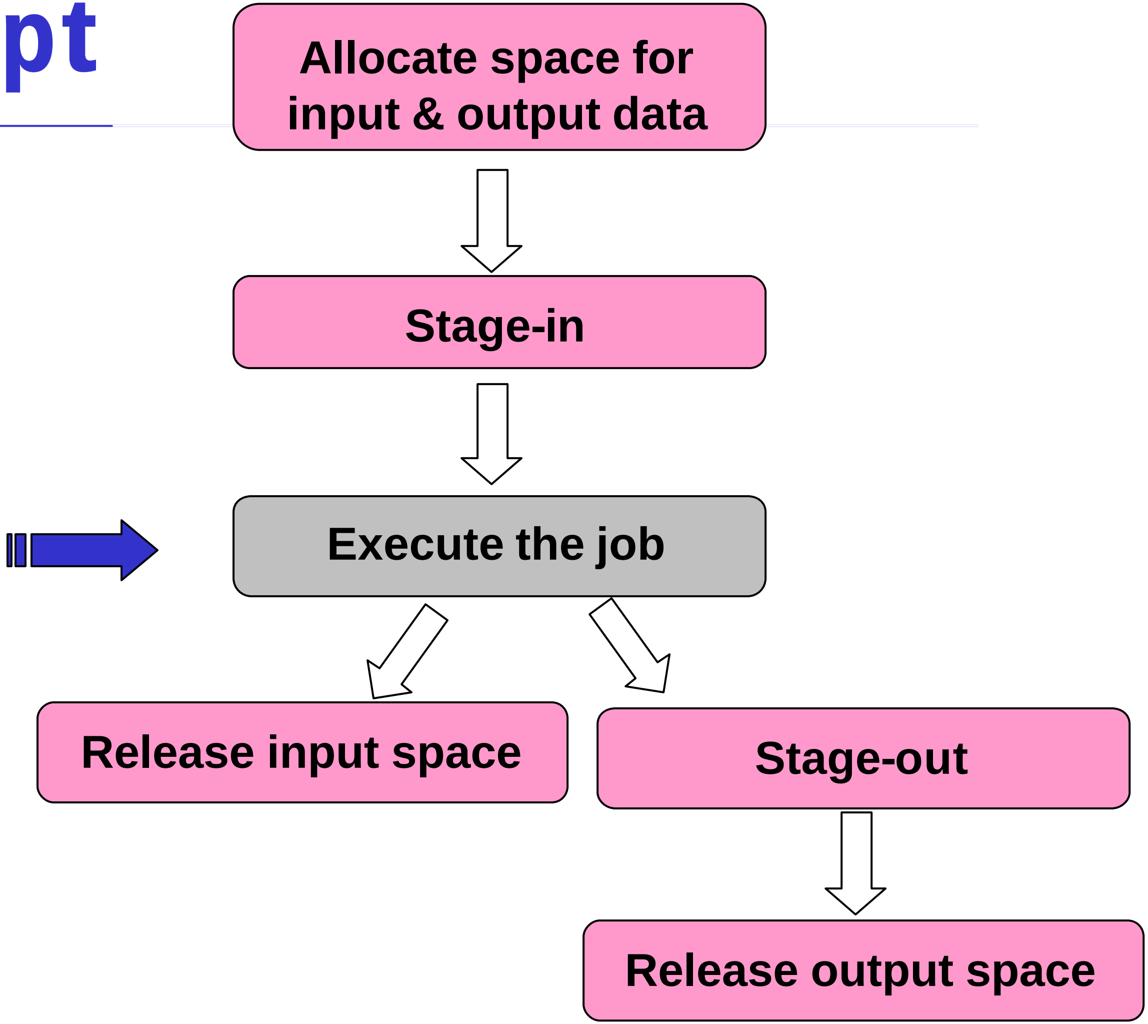
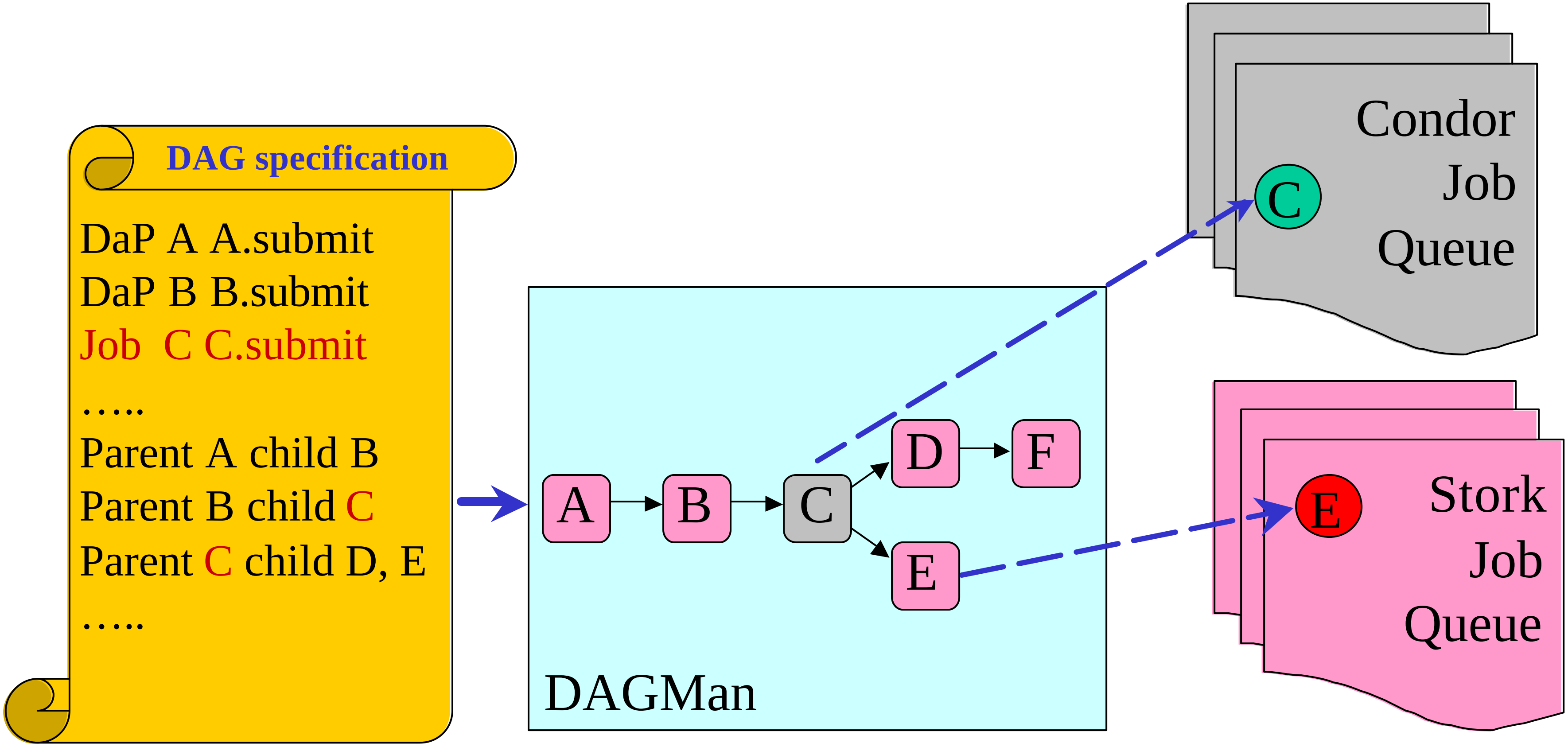


🟥 Data Placement Jobs

▨ Computational Jobs

The Concept



DAG specification

DaP A A.submit
DaP B B.submit
Job C C.submit
…..
Parent A child B
Parent B child C
Parent C child D, E
…..

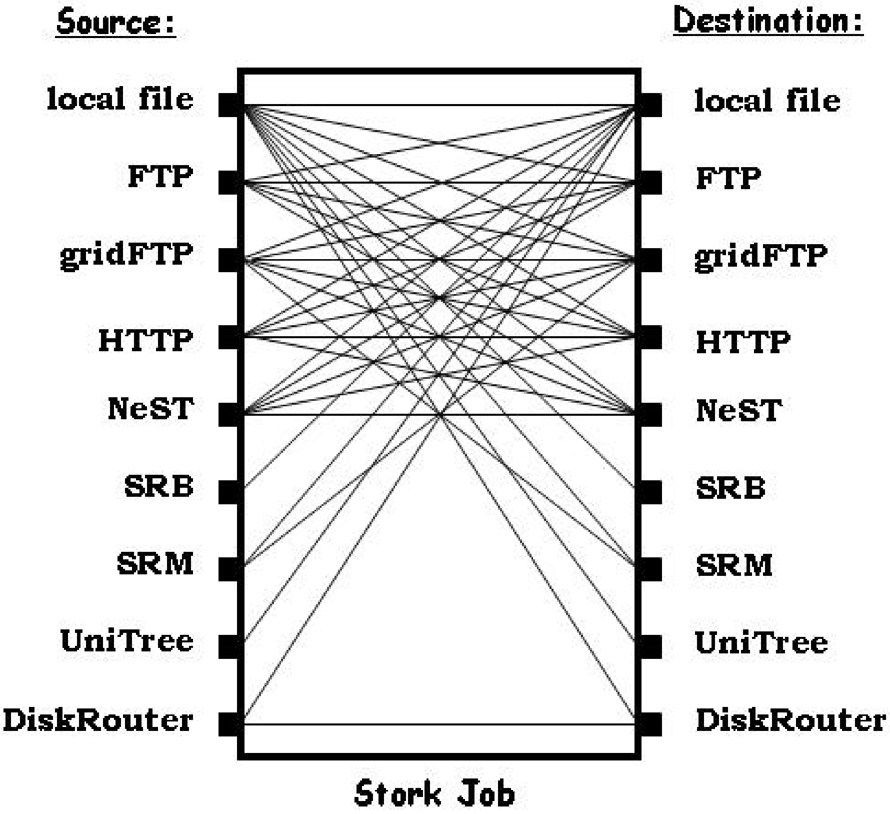
Why Stork?

- Stork understands the characteristics and semantics of data placement jobs.
- Can make smart scheduling decisions, for reliable and efficient data placement.

Understanding Job Characteristics & Semantics

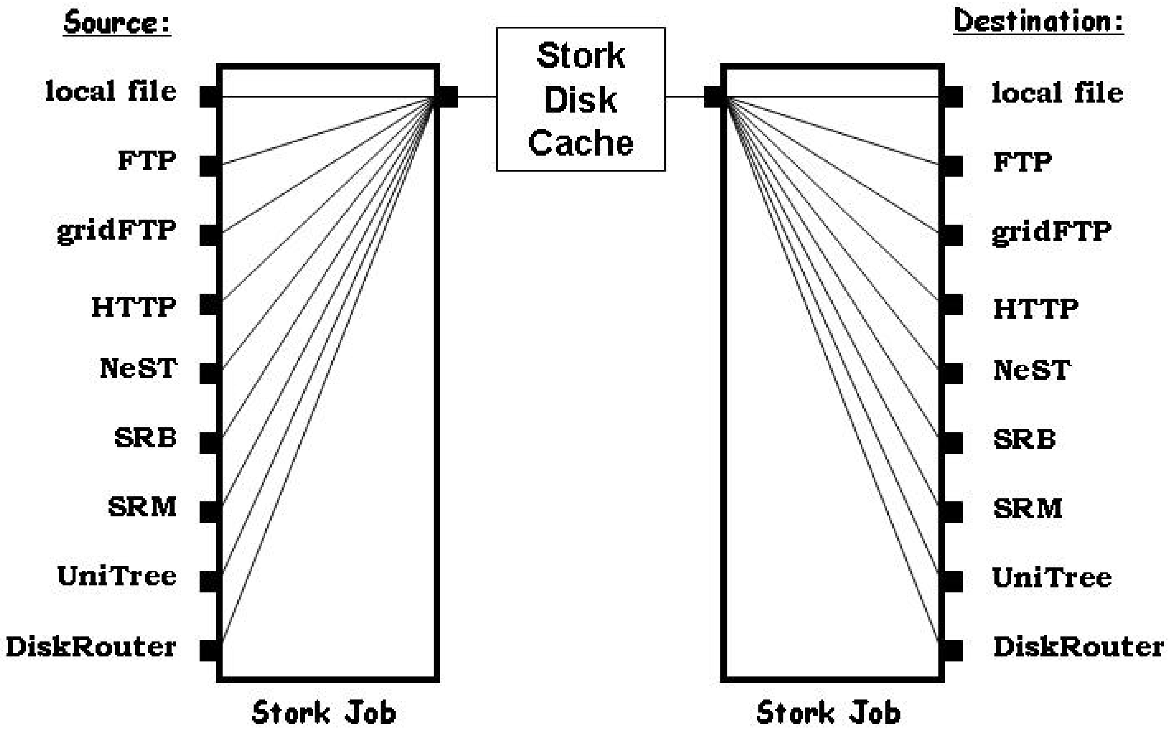
- Job_type = transfer, reserve, release?
- Source and destination hosts, files, protocols to use?
  - Determine concurrency level
  - Can select alternate protocols
  - Can select alternate routes
  - Can tune network parameters (tcp buffer size, I/O block size, # of parallel streams)
  - …

Support for Heterogeneity



Protocol translation using Stork memory buffer.

Support for Heterogeneity



Protocol translation using Stork Disk Cache.

Flexible Job Representation and Multilevel Policy Support

```
[
        Type     = “Transfer”;
        Src_Url = “srb://ghidorac.sdsc.edu/kosart.condor/x.dat”;
        Dest_Url = “nest://turkey.cs.wisc.edu/kosart/x.dat”;
        ……
        ……
        Max_Retry = 10;
        Restart_in = “2 hours”;
]
```

Failure Recovery and Efficient Resource Utilization

- Fault tolerance
  - Just submit a bunch of data placement jobs, and then go away..
- Control number of concurrent transfers from/to any storage system
  - Prevents overloading
- Space allocation and De-allocations
  - Make sure space is available

Run-time Adaptation

- Dynamic protocol selection

```
[
  dap_type = “transfer”;
  src_url    = “drouter://slic04.sdsc.edu/tmp/test.dat”;
  dest_url  = “drouter://quest2.ncsa.uiuc.edu/tmp/test.dat”;
  alt_protocols = “nest-nest, gsiftp-gsiftp”;
]

[
  dap_type = “transfer”;
  src_url    = “any://slic04.sdsc.edu/tmp/test.dat”;
  dest_url  = “any://quest2.ncsa.uiuc.edu/tmp/test.dat”;
]
```

Run-time Adaptation

- Run-time Protocol Auto-tuning

```
[
    link       = “slic04.sdsc.edu – quest2.ncsa.uiuc.edu”;
    protocol = “gsiftp”;

    bs         = 1024KB;        //block size
    tcp_bs    = 1024KB;        //TCP buffer size
    p           = 4;
]
```

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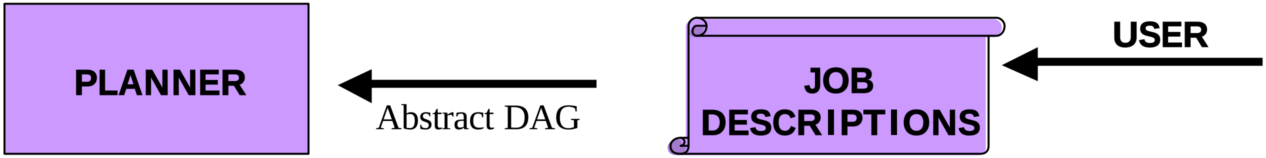
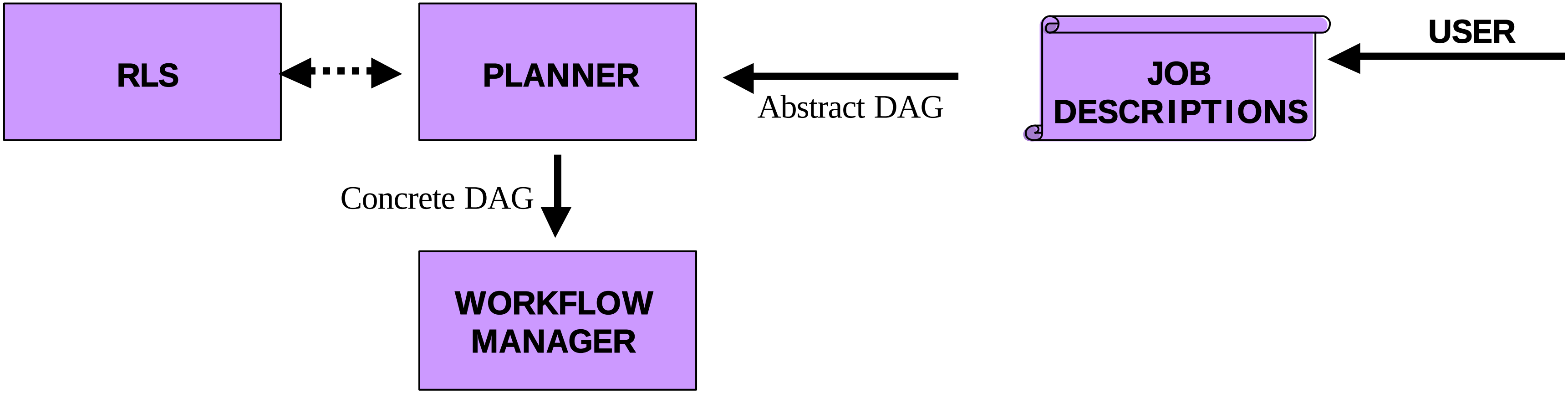


PLANNER

Abstract DAG

JOB DESCRIPTIONS

USER



RLS

PLANNER

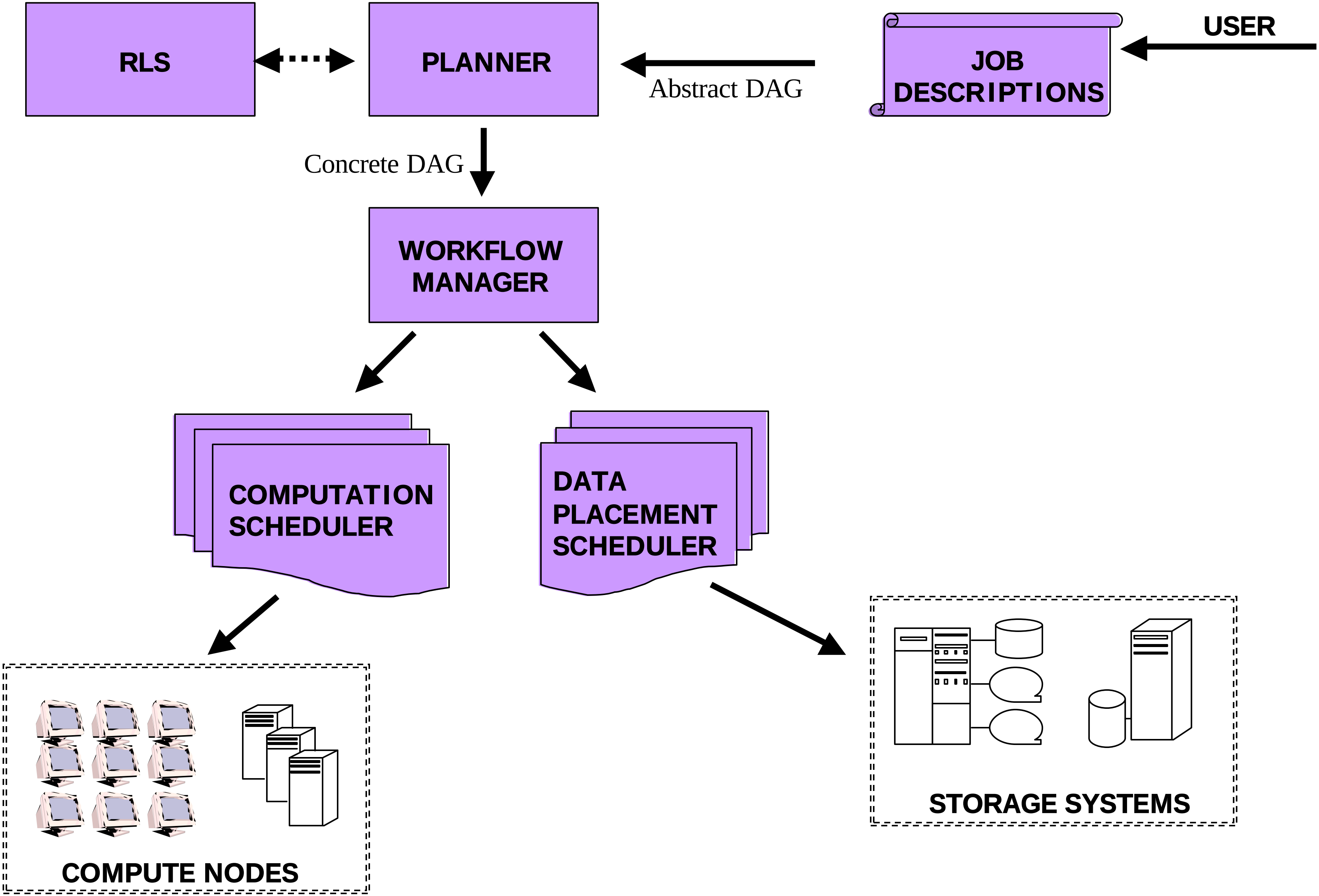
Abstract DAG

JOB DESCRIPTIONS

USER

Concrete DAG

WORKFLOW MANAGER


RLS
PLANNER
Abstract DAG
JOB DESCRIPTIONS
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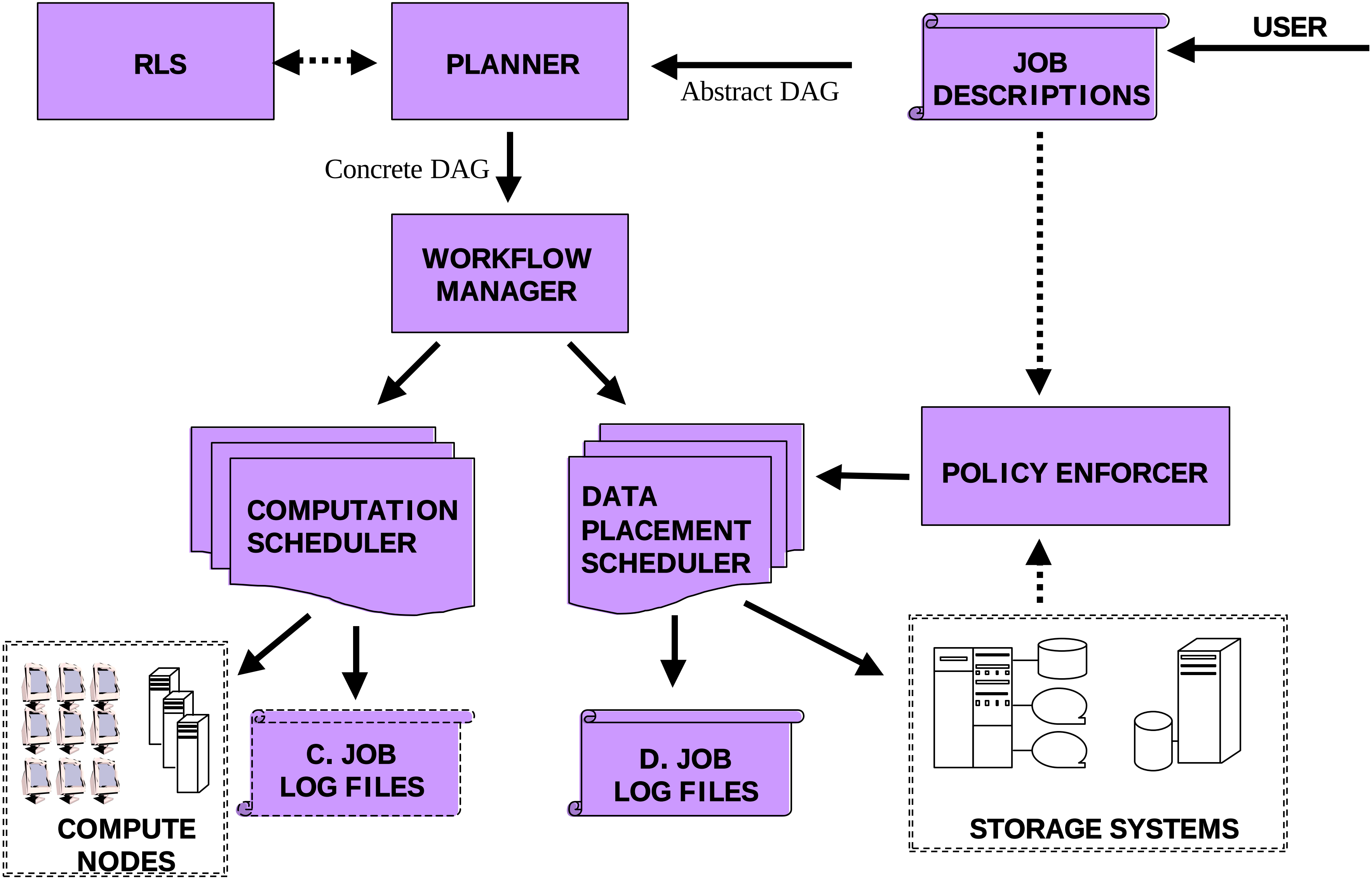
Concrete DAG
WORKFLOW MANAGER
COMPUTATION SCHEDULER
DATA PLACEMENT SCHEDULER
COMPUTE NODES
STORAGE SYSTEMS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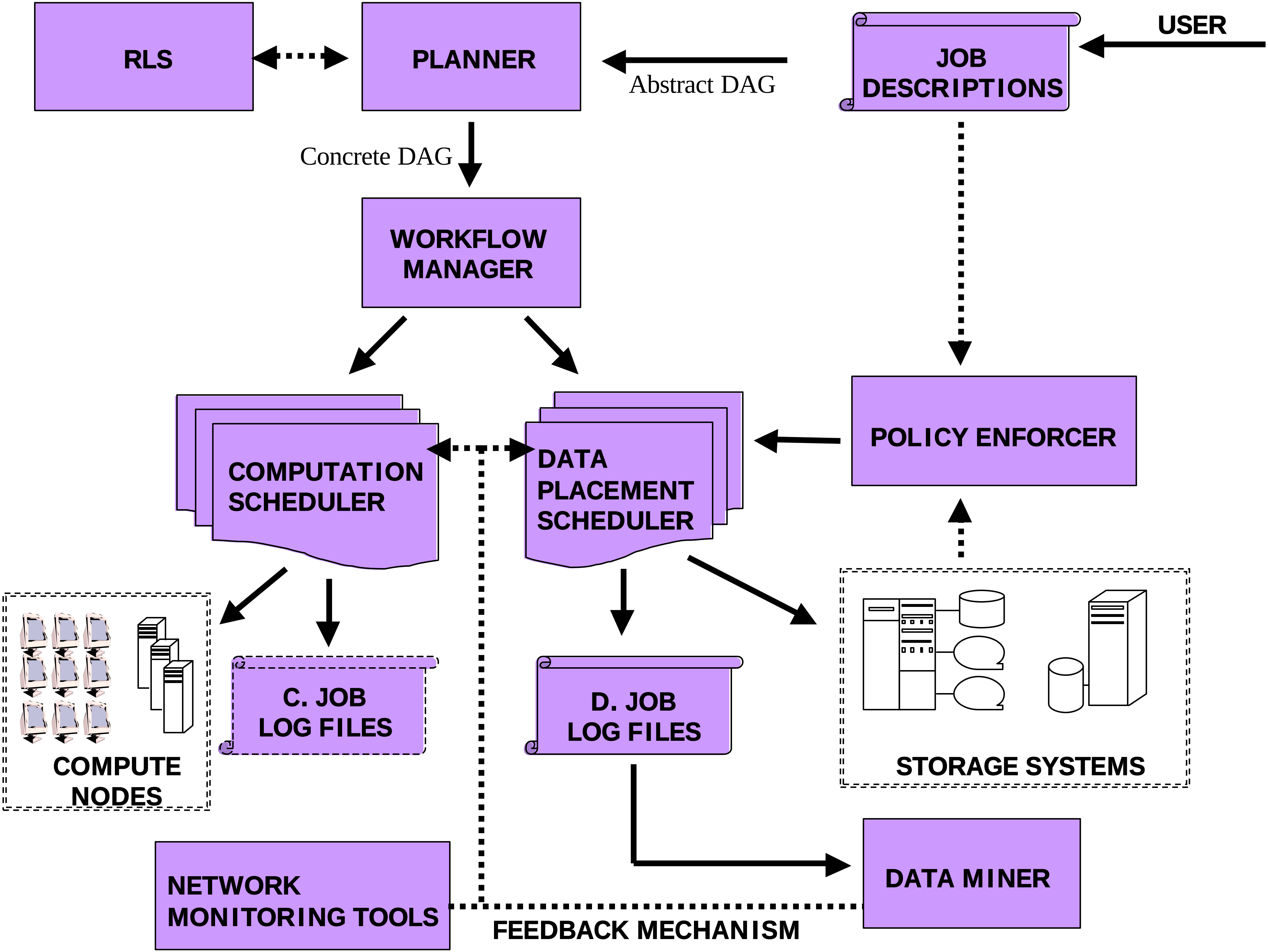
POLICY ENFORCER
COMPUTE NODES
C. JOB LOG FILES
D. JOB LOG FILES
STORAGE SYSTEMS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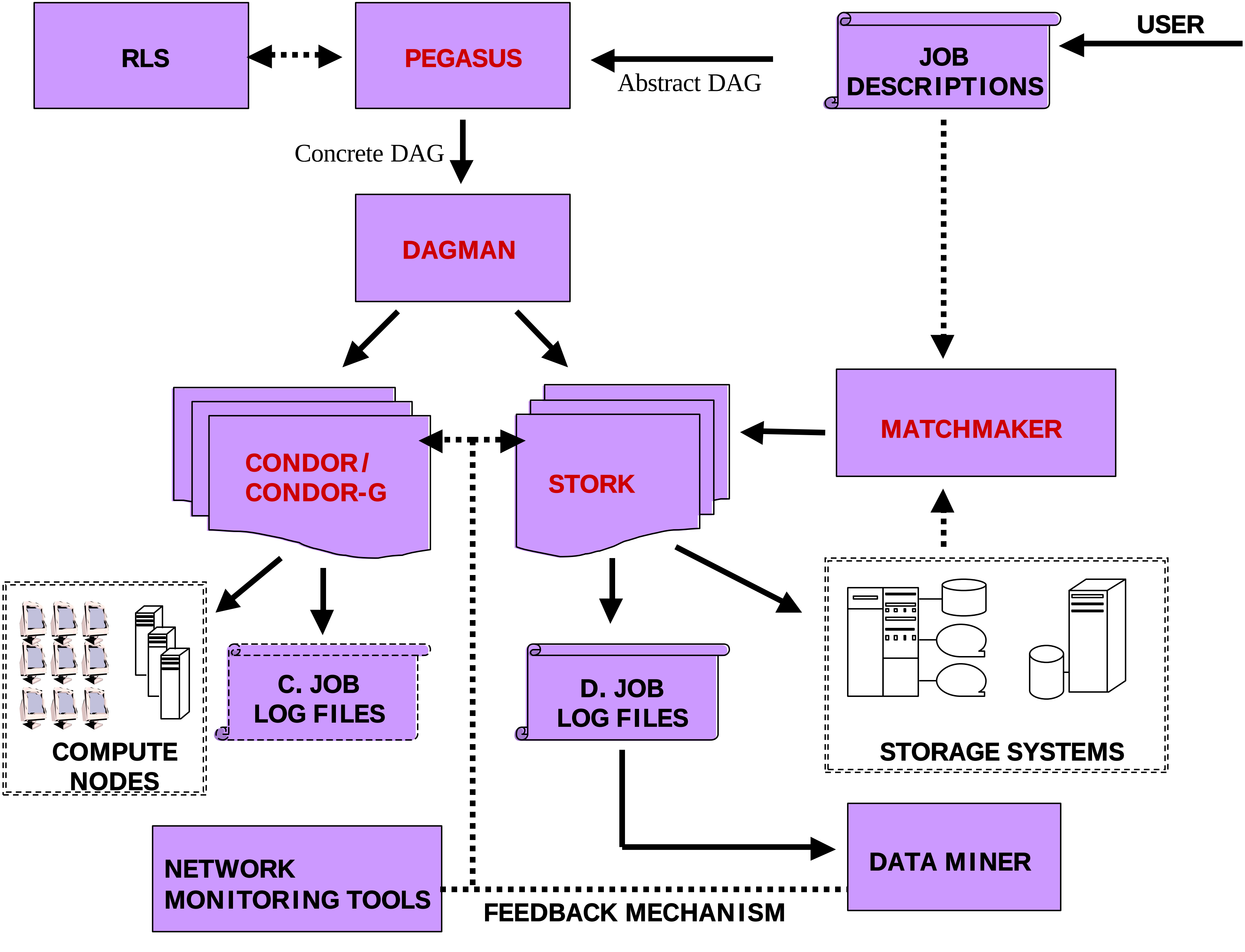
STORAGE SYSTEMS
NETWORK MONITORING TOOLS
DATA MINER
FEEDBACK MECHANISM


RLS
PEGASUS
Abstract DAG
JOB DESCRIPTIONS
USER
Concrete DAG
DAGMAN
MATCHMAKER
CONDOR / CONDOR-G
STORK
COMPUTE NODES
C. JOB LOG FILES
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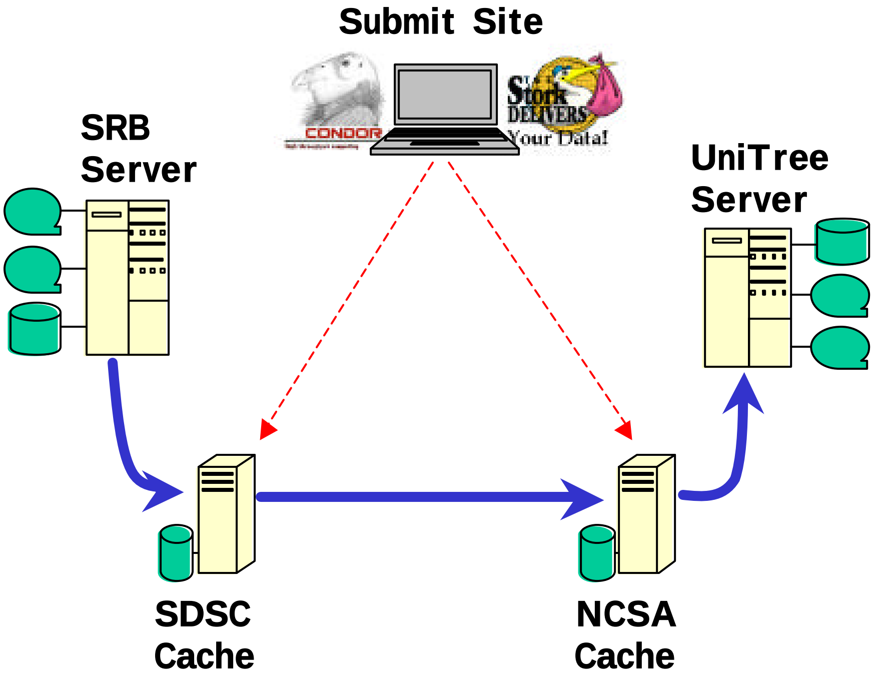
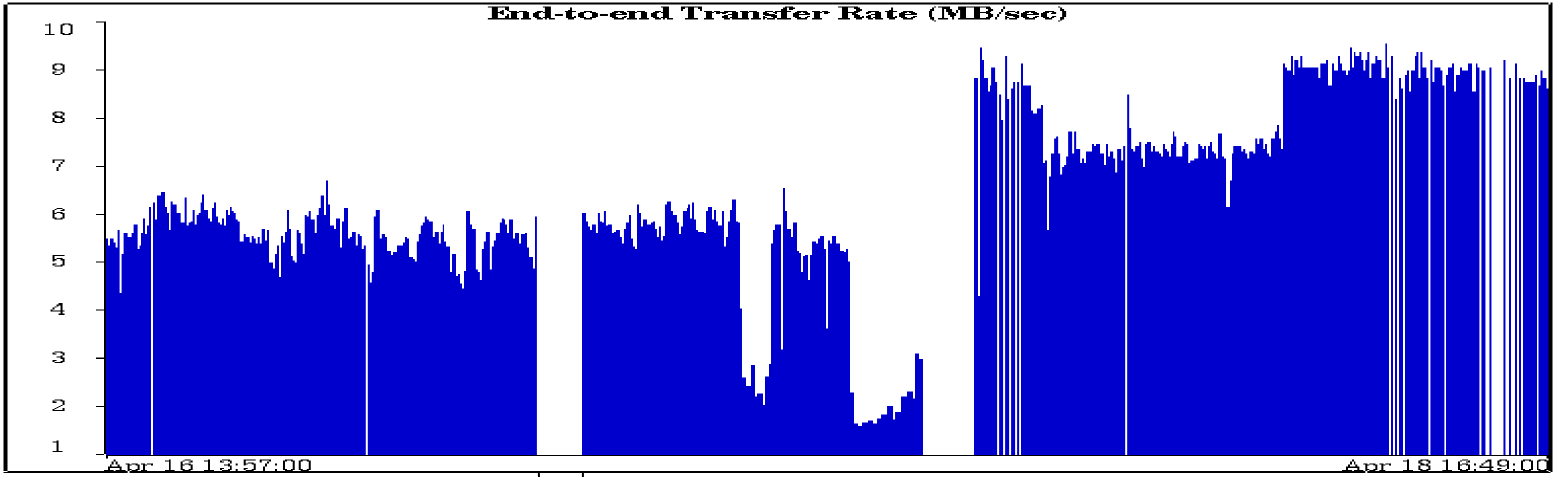
Case Study I:
SRB-UniTree Data Pipeline

- Transfer ~**3 TB** of DPOSS data from SRB @SDSC to UniTree @NCSA
- A data transfer pipeline created with Stork

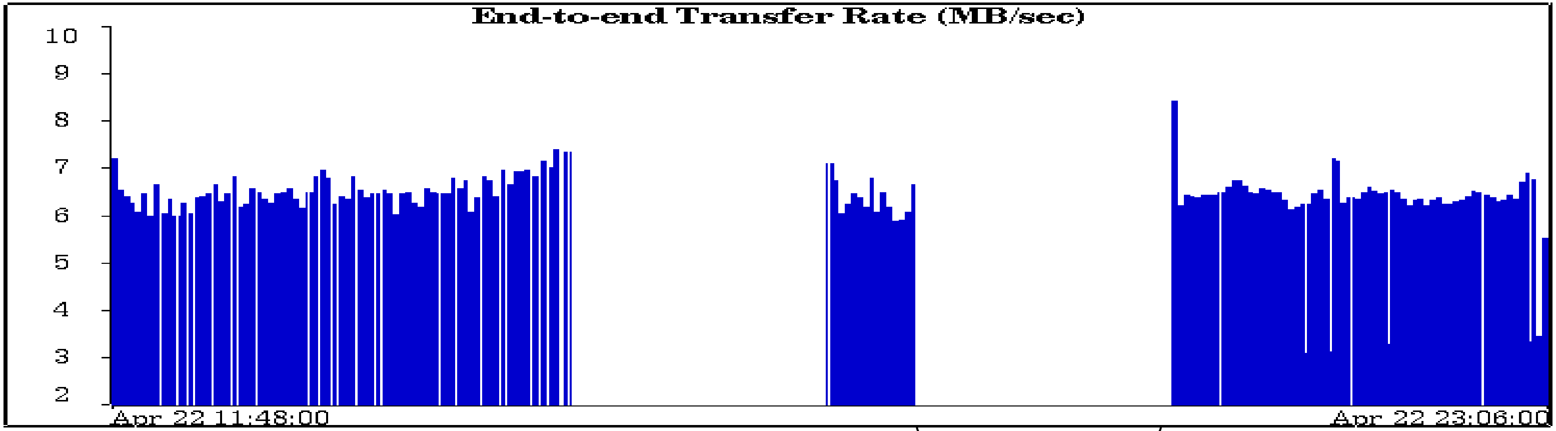


Failure Recovery



UniTree not responding

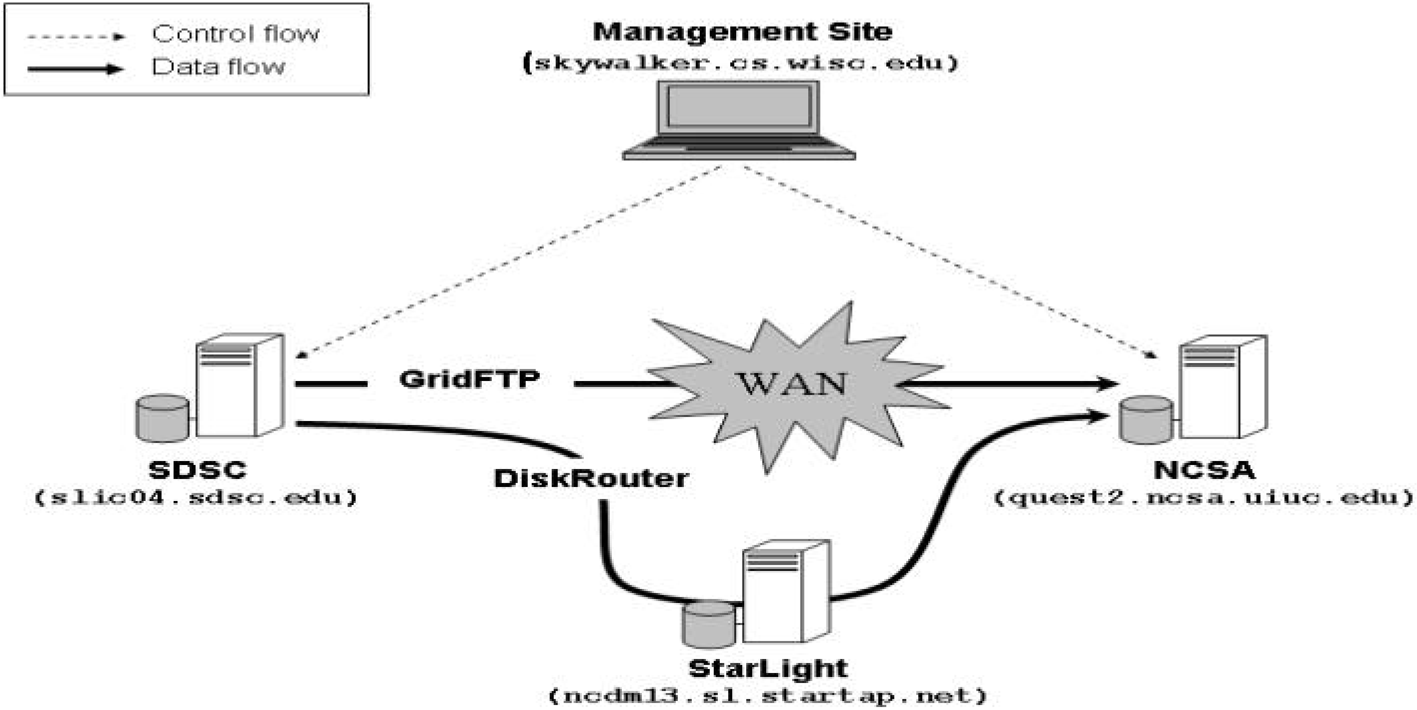
Diskrouter reconfigured
and restarted



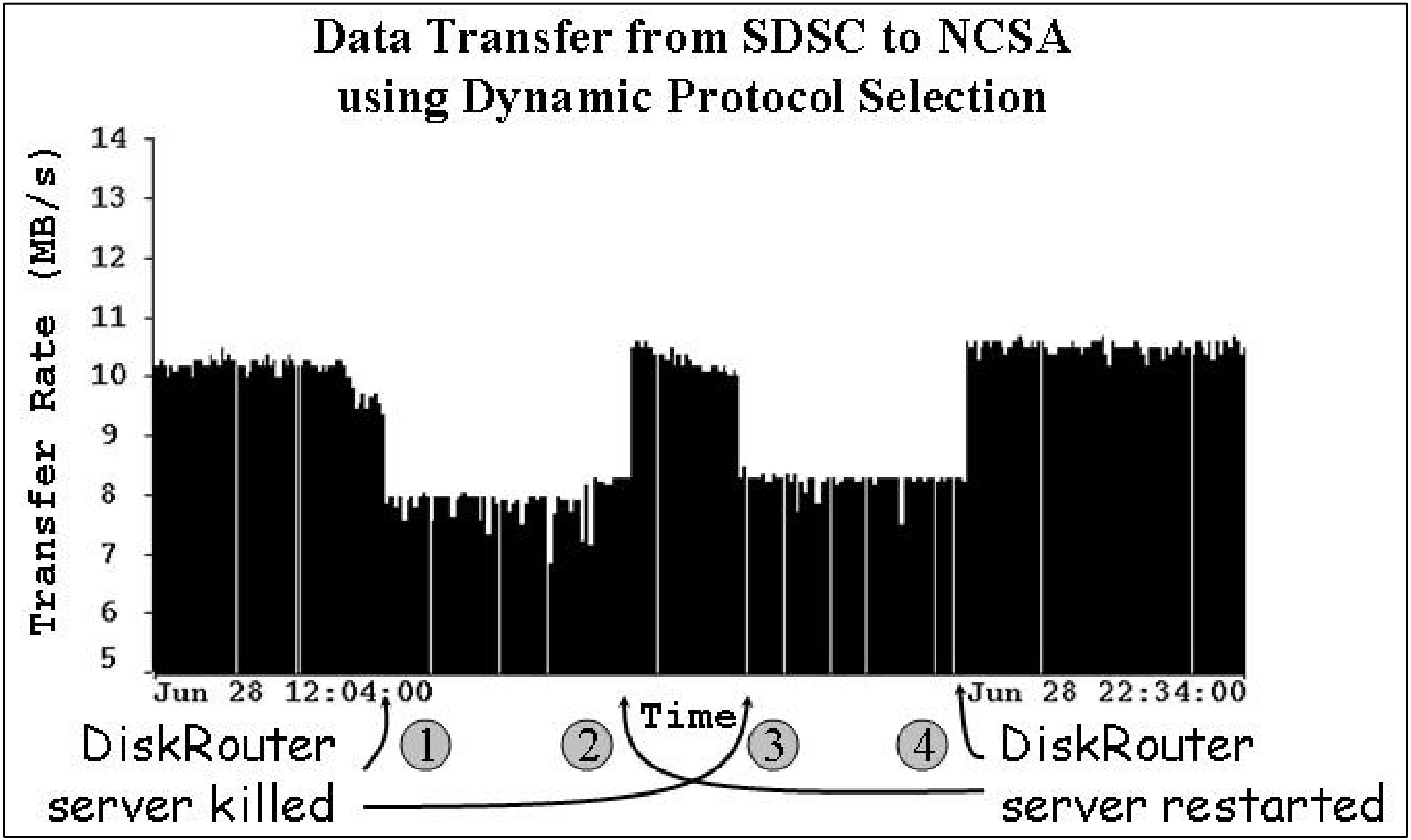
SDSC cache reboot &
UW CS Network outage

Software problem

Case Study -II



Dynamic Protocol Selection



Data Transfer from SDSC to NCSA
using Dynamic Protocol Selection

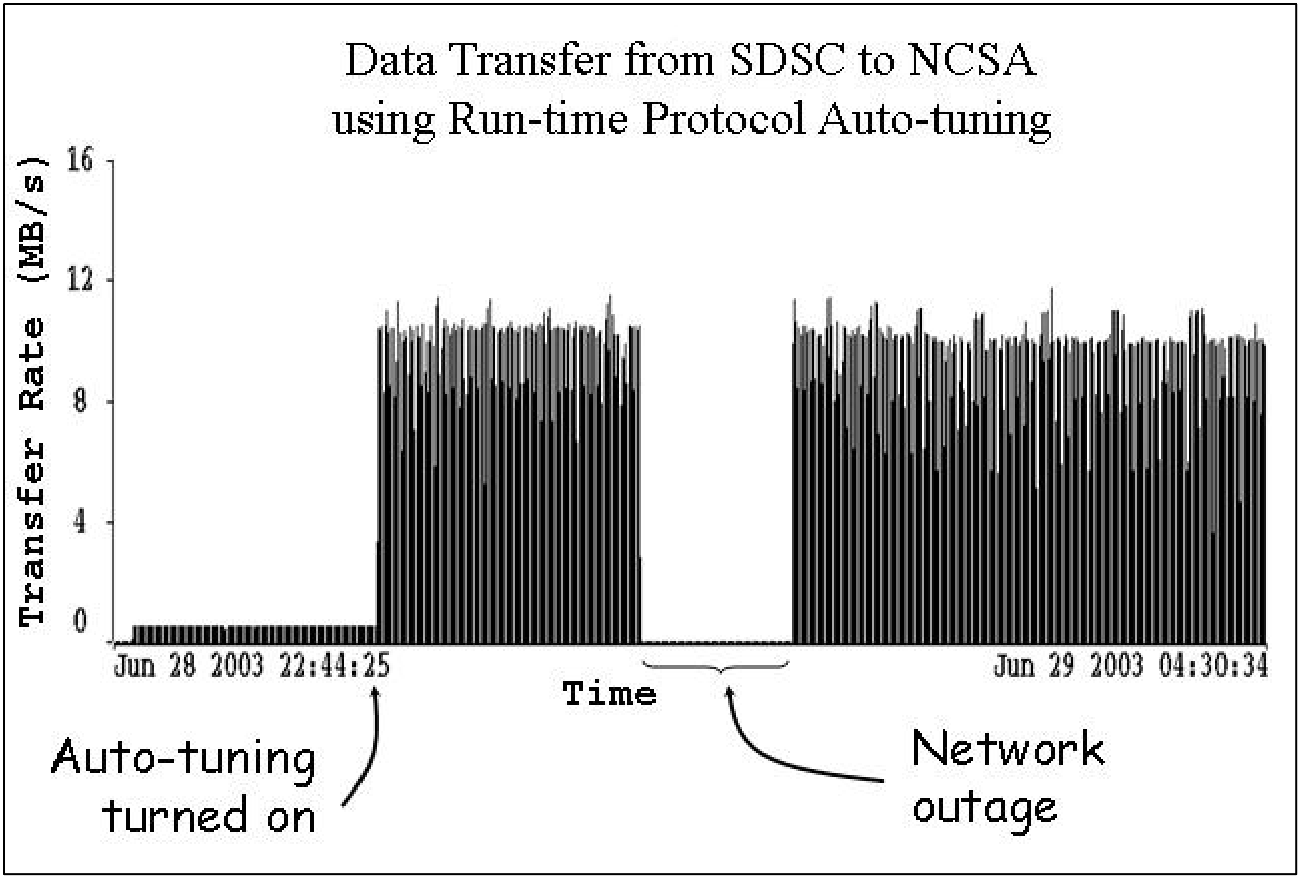
Runtime Adaptation

Before Tuning:

- parallelism = 1
- block_size = 1 MB
- tcp_bs = 64 KB

After Tuning:

- parallelism = 4
- block_size = 1 MB
- tcp_bs = 256 KB

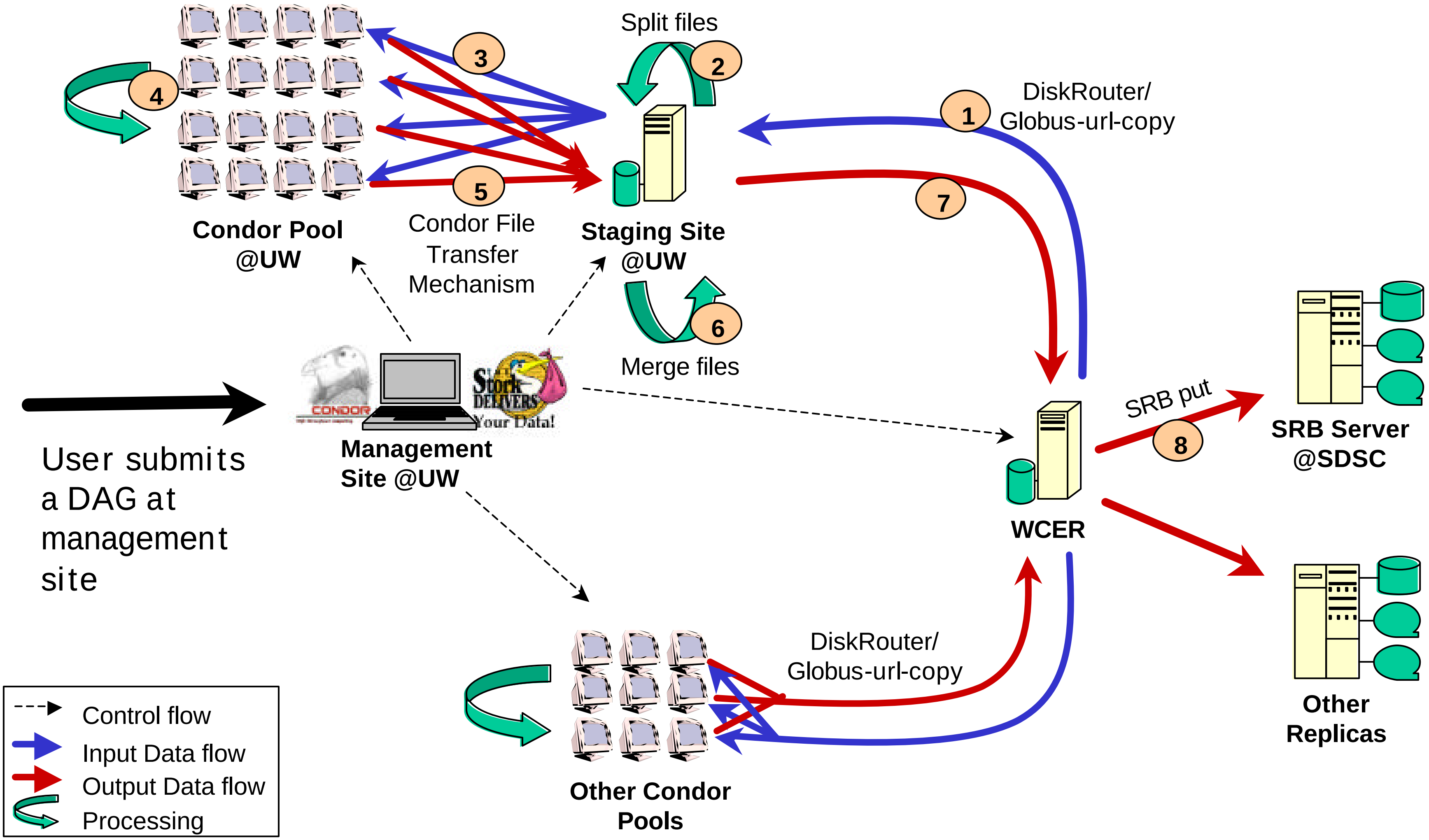


Data Transfer from SDSC to NCSA using Run-time Protocol Auto-tuning

Auto-tuning turned on

Network outage

Case Study - III



User submits a DAG at management site

Management Site @UW

Condor Pool @UW

Condor File Transfer Mechanism

Staging Site @UW

Split files

Merge files

DiskRouter/ Globus-url-copy

WCER

SRB put

SRB Server @SDSC

Other Replicas

Other Condor Pools

DiskRouter/ Globus-url-copy

1 2 3 4 5 6 7 8

Control flow

Input Data flow

Output Data flow

Processing

Conclusions

- Regard data placement as individual jobs.
- Treat computational and data placement jobs differently.
- Introduce a specialized scheduler for data placement.
- Provide end-to-end automation, fault tolerance, run-time adaptation, multilevel policy support, reliable and efficient transfers.

Future work

- Enhanced interaction between Stork and higher level planners
  - better coordination of CPU and I/O
- Interaction between multiple Stork servers and job delegation
- Enhanced authentication mechanisms
- More run-time adaptation

Related Publications

- Tevfik Kosar and Miron Livny. “Stork: Making Data Placement a First Class Citizen in the Grid”. In *Proceedings of 24th IEEE Int. Conference on Distributed Computing Systems (ICDCS 2004),* Tokyo, Japan, March 2004.
- George Kola, Tevfik Kosar and Miron Livny. “A Fully Automated Fault-tolerant System for Distributed Video Processing and Off-site Replication. To appear in *Proceedings of 14th ACM Int. Workshop on etwork and Operating Systems Support for Digital Audio and Video (Nossdav 2004),* Kinsale, Ireland, June 2004.
- Tevfik Kosar, George Kola and Miron Livny. “A Framework for Self-optimizing, Fault-tolerant, High Performance Bulk Data Transfers in a Heterogeneous Grid Environment”. *In Proceedings of 2nd Int. Symposium on Parallel and Distributed Computing (ISPDC 2003),* Ljubljana, Slovenia, October 2003.
- George Kola, Tevfik Kosar and Miron Livny. “Run-time Adaptation of Grid Data Placement Jobs”. In *Proceedings of Int. Workshop on Adaptive Grid Middleware (AGridM 2003)*, New Orleans, LA, September 2003.

You don't have to FedEx your data anymore.. Stork delivers it for you!

- For more information:
  - Email: kosart@cs.wisc.edu
  - http://www.cs.wisc.edu/condor/stork