GridWay

Submission, Monitoring and Control of Jobs

<EVENT>
<City>, <Country>
<Month> <day>, <year>

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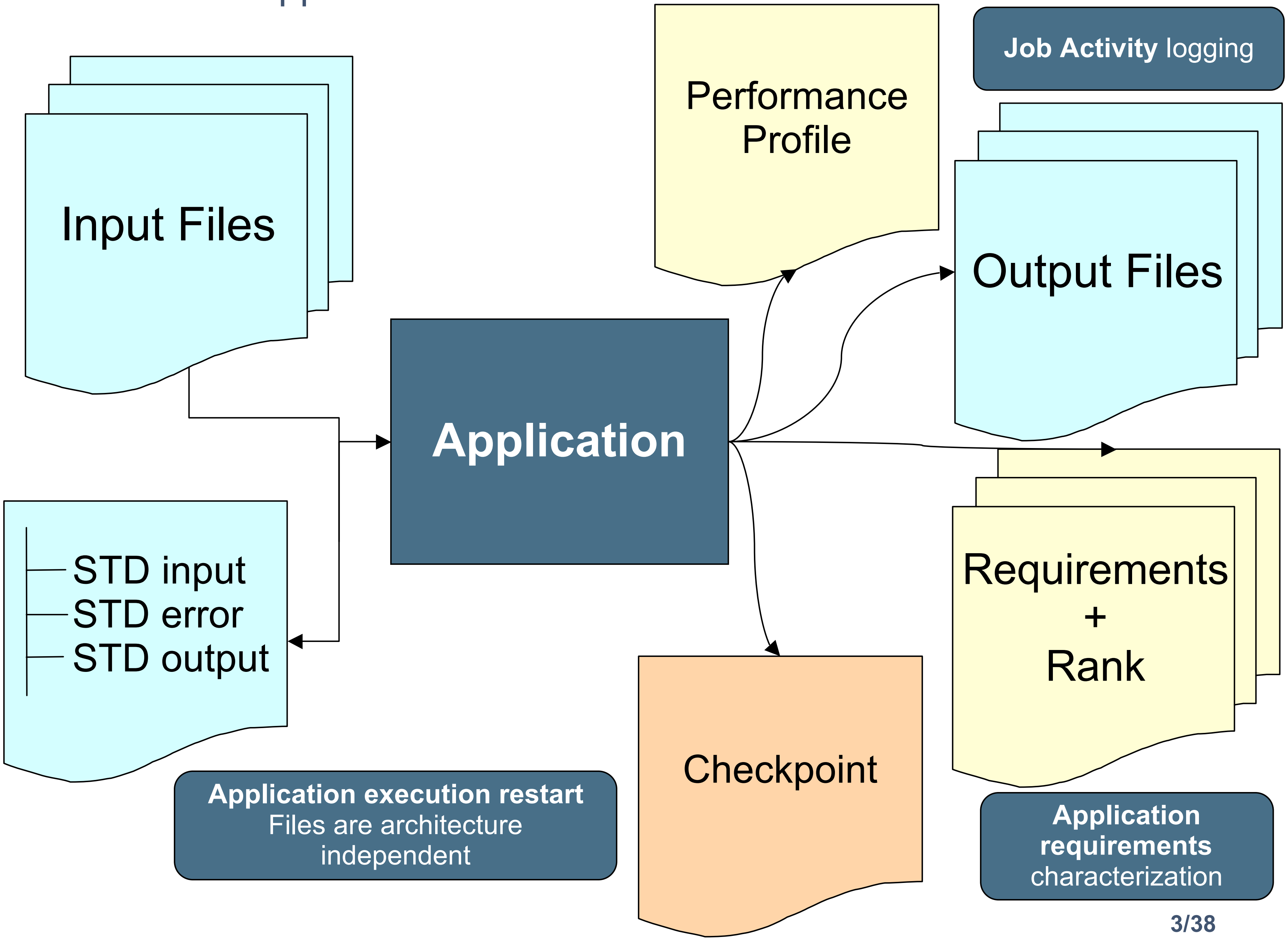
Contents

1. **User Model Overview**
2. Usage Scenarios
3. Job Definition
4. Commands in detail
5. JSDL

User Model Overview

A Grid-aware Application Model



Input Files

STD input
STD error
STD output

Application

Performance Profile

Output Files

Requirements + Rank

Checkpoint

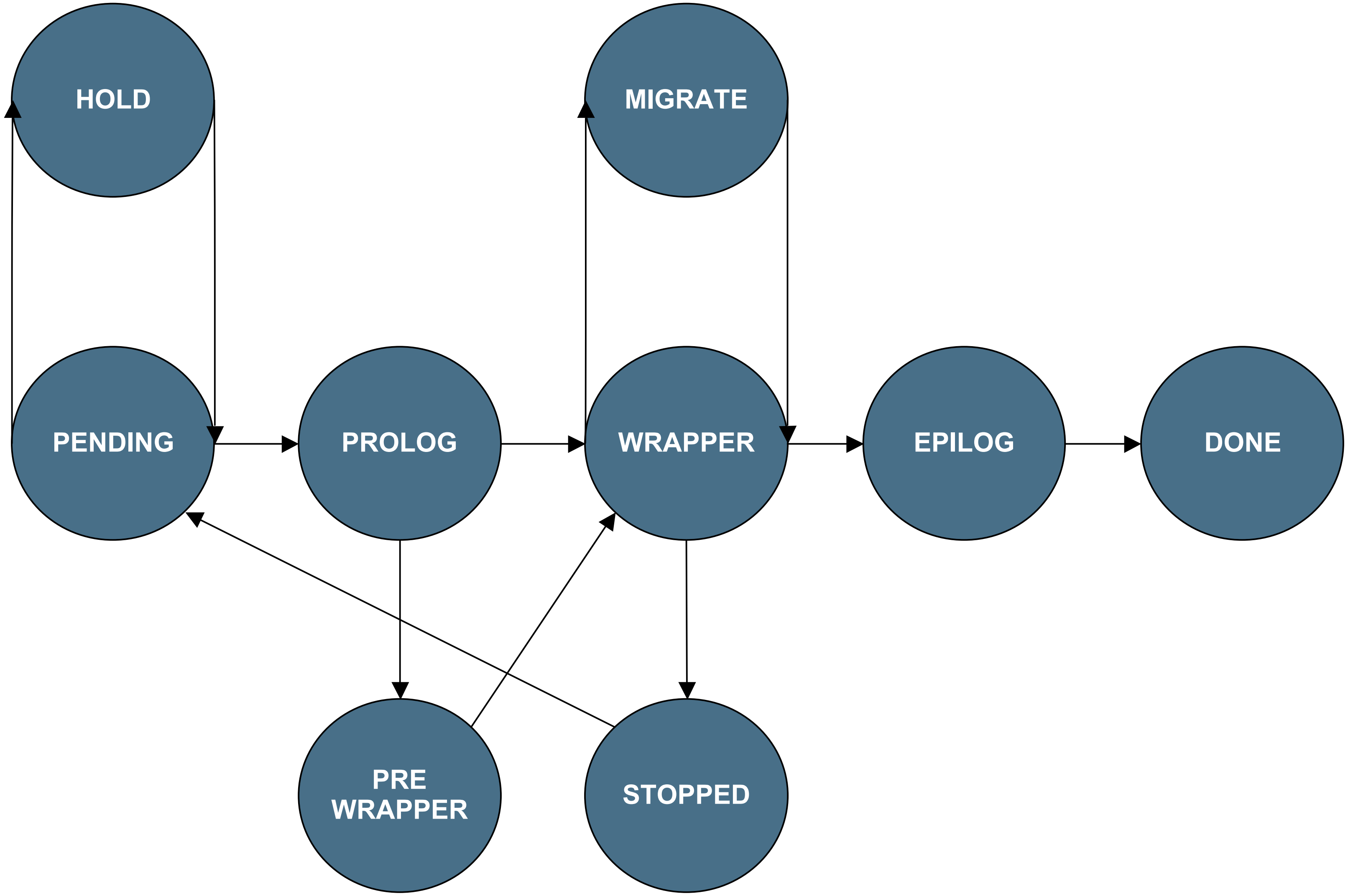
Job Activity logging

Application execution restart
Files are architecture independent

Application requirements
characterization

User Model Overview

Life-cycle



User Model Overview

Main Commands

- **gwps**: Shows job information and state
- **gwhistory**: Shows execution history
- **gwkill**: Sends signals to a job (kill, stop, resume, reschedule)
- **gwsubmit**: Submits a job or array
- **gwwait**: Waits for job's end (any, all, set)
- **gwuser**: User Monitoring
- **gwhost**: Host Monitoring
- **gwacct**: Accounting

Contents

1. User Model Overview
2. **Usage Scenarios**
3. Job Definition
4. Commands in detail
5. JSDL

Usage Scenarios

Single Job

- Create your proxy.
- Create a simple Job Template:

```
EXECUTABLE = /bin/ls
```

- and save it as **jt** in directory example.
- Use *gwsubmit* command to submit the job:

```
$ gwsubmit -t example/jt
```

- Use *gwhost* command to see available resources:

```
HID PRIO  OS              ARCH   MHZ %CPU  MEM(F/T)     DISK(F/T)     N(U/F/T) LRMS                 HOSTNAME
0   1     Linux2.6.17-2-6 x86    3216    0   44/2027  76742/118812      0/0/2 Fork                 cygnus.dacya.ucm.es
1   1                               0    0       0/0           0/0      0/0/0                      orion.dacya.ucm.es
2   1     Linux2.6.18-4-a x86_6 2211  100  819/1003   77083/77844      0/2/4 PBS                  hydrus.dacya.ucm.es
3   1     Linux2.6.17-2-6 x86    3216  163 1393/2027 101257/118812      0/2/2 Fork                 draco.dacya.ucm.es
4   1     Linux2.6.18-4-a x86_6 2211   66  943/1003   72485/77844      0/5/5 SGE                  aquila.dacya.ucm.es
```

- and get more detailed information specifying a Host ID:

```
$ gwhost 0
HID PRIO  OS              ARCH   MHZ %CPU  MEM(F/T)     DISK(F/T)     N(U/F/T) LRMS                 HOSTNAME
0   1     Linux2.6.17-2-6 x86    3216    0   50/2027  76393/118812      0/0/2 Fork                 cygnus.dacya.ucm.es

QUEUENAME            SL(F/T) WALLT CPUT  COUNT MAXR  MAXQ  STATUS   DISPATCH   PRIORITY
default              0/2     0     -1    0     -1    0     enabled  NULL       0
```

Usage Scenarios

Single Job

- Check the resources that match job requirements with *gwhost -m 0*:

```
$ gwhost -m 0
HID QNAME      RANK  PRIO  SLOTS HOSTNAME
0   default    0     1     0     cygnus.dacya.ucm.es
2   default    0     1     3     hydrus.dacya.ucm.es
2   qlong      0     1     3     hydrus.dacya.ucm.es
2   qsmall     0     1     3     hydrus.dacya.ucm.es
3   default    0     1     0     draco.dacya.ucm.es
4   all.q      0     1     3     aquila.dacya.ucm.es
```

- Follow the evolution of the job with *gwps* command:

```
$ gwps
USER         JID DM   EM   START    END      EXEC    XFER    EXIT NAME  HOST
gwtutorial00 0   done ---- 20:16:28 20:18:16 0:00:55 0:00:08 0    stdin aquila.dacya.ucm.es/SGE
tinova       1   done ---- 12:26:46 12:31:15 0:03:55 0:00:08 0    stdin hydrus.dacya.ucm.es/PBS
tinova       2   pend ---- 12:38:38 --:--:-- 0:00:00 0:00:00 --   t.jt  --
```

- HINT: Use *gwps -c <seconds>* for continuous output.

Usage Scenarios

Single Job

- See the job history with *gwhistory* command:

```
$ gwhistory 4
HID START    END      PROLOG  WRAPPER EPILOG  MIGR    REASON QUEUE    HOST
2   12:58:04 12:58:16 0:00:06 0:00:04 0:00:02 0:00:00 ----   default  hydrus.dacya.ucm.es/PBS
```

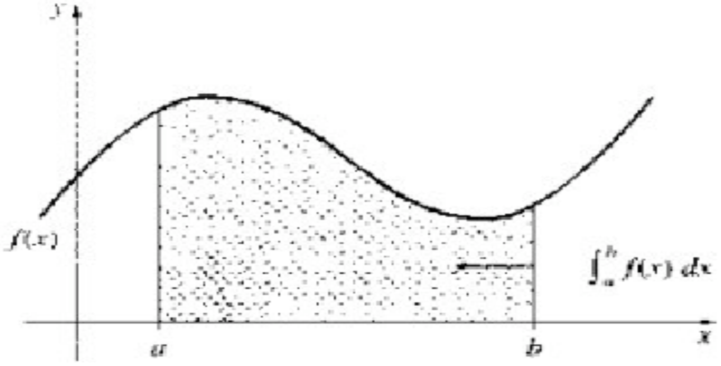
- Once finished... time to retrieve the results:

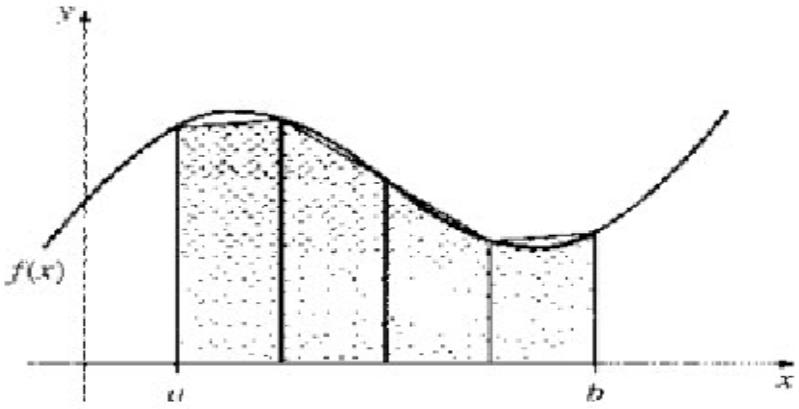
```
$ ls -lt stderr.4 stdout.4
-rw-r--r-- 1 tinova tinova  0 2007-09-07 12:58 stderr.4
-rw-r--r-- 1 tinova tinova 72 2007-09-07 12:58 stdout.4

$ cat stdout.4
job.env
stderr.execution
stderr.wrapper
stdout.execution
stdout.wrapper
```

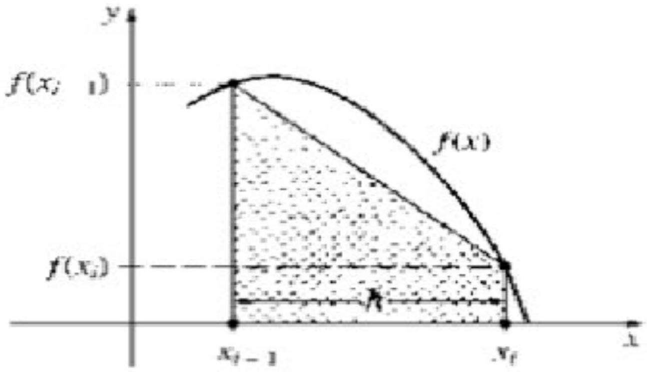
Usage Scenarios

Array Jobs

- Defining the problem - calculation of the **π** Number:







Usage Scenarios

Array Jobs

- pi.c calculates each slice:

```
#include <string.h>
#include <stdlib.h>

int main (int argc, char** args)
{
  int task_id;
  int total_tasks;
  long long int n;
  long long int i;

  double l_sum, x, h;

  task_id = atoi(args[1]);
  total_tasks = atoi(args[2]);
  n = atoll(args[3]);

  fprintf(stderr, "task_id=%d total_tasks=%d n=%lld\n", task_id,
total_tasks, n);

  h = 1.0/n;

  l_sum = 0.0;

  for (i = task_id; i < n; i += total_tasks)
  {
    x = (i + 0.5)*h;
    l_sum += 4.0/(1.0 + x*x);
  }

  l_sum *= h;

  printf("%0.12g\n", l_sum);

  return 0;
}
```

```
$ gcc -O3 pi.c -o pi
```

- pi arguments:
  - Task ID
  - Total tasks
  - Integral intervals

Usage Scenarios

Array Jobs

- Create a job template (pi.jt):

```
EXECUTABLE = pi
ARGUMENTS = $(TASK_ID) $(TOTAL_TASKS) 100000
STDOUT_FILE = stdout_file.$(TASK_ID)↰
STDERR_FILE = stderr_file.$(TASK_ID)↰
RANK = CPU_MHZ
```

- Submit the array of jobs:

```
$ gwsubmit -v -t pi.jt -n 4
ARRAY ID: 0

TASK JOB
0    3
1    4
2    5
3    6
```

- Use the **gwwait** command to wait for the jobs:

```
$ gwwait -v -A 0
0    : 0
1    : 0
2    : 0
3    : 0
```

Usage Scenarios

Array Jobs

- At the end we have the following STDOUT files:

```
stdout_file.0
stdout_file.1
stdout_file.2
stdout_file.3
```

- Sum the contained values to get the value of π:

```
   $  awk 'BEGIN {sum=0} {sum+=$1} END {printf "Pi is %0.12g\n", sum}' stdout_file.*
   Pi is 3.1415926536
```

- IDEA: Embedding all in script? Check the examples directory …

Usage Scenarios

MPI Jobs

- With fine-grain parallelism apps (allow low latency communication)
- Again, we are going to use the π example
  - All the files needed can be found in $GW_LOCATION/examples/mpi
- Assuming an MPI aware pi.c, we use mpicc to compile it:

```
mpicc -O3 mpi.c -o mpi
```

- Now we create a Job Template (mpi.jt)

```
EXECUTABLE    = mpi

STDOUT_FILE    = stdout.${JOB_ID}
STDERR_FILE    = stderr.${JOB_ID}

RANK           = CPU_MHZ
TYPE           = "mpi"
NP             = 2
```

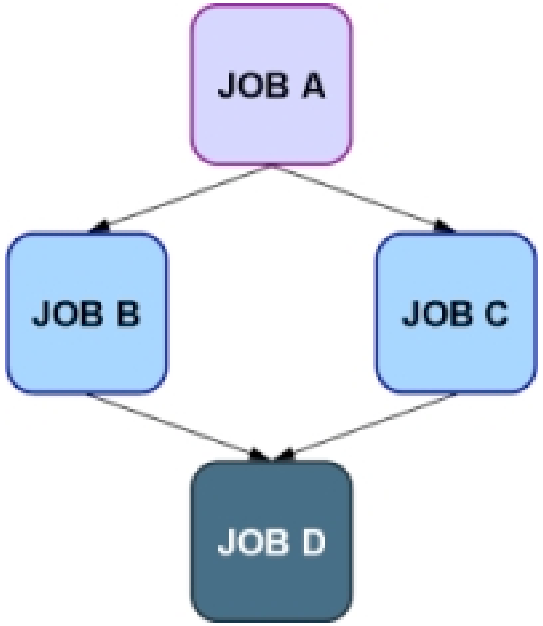
- and then we submit it to GridWay as any other job

Usage Scenarios

Workflow Jobs

- GridWay can handle workflows with the following functionality:
  - Sequence, parallelism, branching and looping structures
  - The workflow can be described in an abstract form without referring to specific resources for task execution
  - Quality of service constraints and fault tolerance are defined at task level
- Job dependencies specified by using the *-d* option of the *gwsubmit* command

```
• $ gwsubmit -v -t A.jt
   JOB ID: 5

• $ gwsubmit -v -t B.jt -d "5"
   JOB ID: 6

• $ gwsubmit -v -t C.jt -d "5"
   JOB ID: 7

• $ gwsubmit -t C.jt -d "6 7"
```



Contents

1. User Model Overview
2. Usage Scenarios
3. **Job Definition**
4. Commands in detail
5. JSDL

Job Definition

Job Template

Generic

- NAME = Name of the job.

Execution

- EXECUTABLE = Executable file.
- ARGUMENTS = Arguments for the executable.
- ENVIRONMENT = User defined, comma-separated, environment variables.
- TYPE = “Single”, “multiple” and “mpi” (like GRAM).
- NP = Number of processors in MPI jobs.

I/O Files

- INPUT_FILES = A comma-separated pair of “local remote” filenames.
- OUTPUT_FILES = A comma-separated pair of “remote local” filenames.

Job Definition

Job Template

Standard Streams

- STDIN_FILE = Standard Input file.
- STDOUT_FILE = Standard Output file.
- STDERR_FILE = Standard Error file.

Check pointing

- RESTART_FILES = Checkpoint files, architecture independent.
- CHECKPOINT_INTERVAL = Seconds for checkpoint files transfer.
- CHECKPOINT_URL = GridFTP URL to store checkpoint files.

Resource Selection

- REQUIREMENTS = Boolean expression. If true, host will be considered for scheduling.
- RANK = Numerical expression evaluated for each host considered for scheduling.

Job Definition

Job Template

Scheduling

- RESCHEDULING_INTERVAL = How often GridWay searches better resources for the job.
- RESCHEDULING_THRESHOLD = Migration will occur when a better resource is discovered and job is running less than this threshold.
- DEADLINE = Deadline of job start.

Performance

- SUSPENSION_TIMEOUT = Max suspension time in local job management system.
- CPULOAD_THRESHOLD = Load threshold for the CPU assigned to job.
- MONITOR = Optional program to monitor job performance.

Fault Tolerance

- RESCHEDULE_ON_FAILURE = Behaviour in case of failure.
- NUMBER_OF_RETRIES = Retries in case of failure.

Job Definition

Job Template

Advanced Job Execution

- WRAPPER = Script for wrapper.
- PRE_WRAPPER = Optional program to be executed before the actual job (i.e. additional remote setup).
- PRE_WRAPPER_ARGUMENTS = Arguments for pre-wrapper program.

Job Definition

File Definition

I/O Files

- General Syntax: SRC1 DST1, SRC2 DST2,…
- Absolute path: `EXECUTABLE   = /bin/ls`
- GridFTP URL: `INPUT_FILES = gsiftp://machine/tmp/input_exp1 input`
- File URL: `INPUT_FILES  = file:///etc/passwd`
- Name: `INPUT_FILES  = test_case.bin`
  - NOTE: The source names for output files MUST be a single name, do not use absolute paths or URLs

Standard Streams

- Any of the above methods except:
  - `STDIN_FILE` : Cannot specify a destination name
  - `{STDOUT,STDERR}_FILE` : Cannot specify a source name (only destination)

Job Definition

Variable Substitution

Generics

- Variables can be used in the value string of each option
  - with the format: `${GW_VARIABLE}`
- These variables are substituted at run time with its corresponding value.
  - For example: `STDOUT_FILE = stdout.${JOB_ID}`

Valid Variables

- `${JOB_ID}` Job ID.
- `${ARRAY_ID}` Job array ID. -1 if job is not in any.
- `${TASK_ID}` Task ID within job array. -1 if job is not in any.
- `${ARCH}` Architecture of selected execution hosts.
- `${PARAM}` Allows assignment of arbitrary start and increment values for array jobs (e.g. file naming patterns).
- `${MAX_PARAM}` Upper bound for the `${PARAM}` variable.

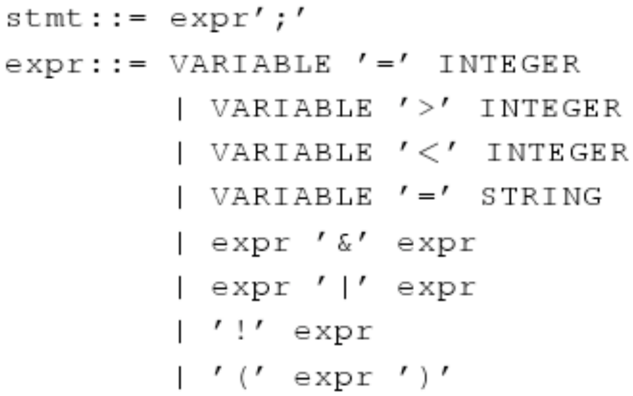
GridWay

Job Definition

Resource Selection

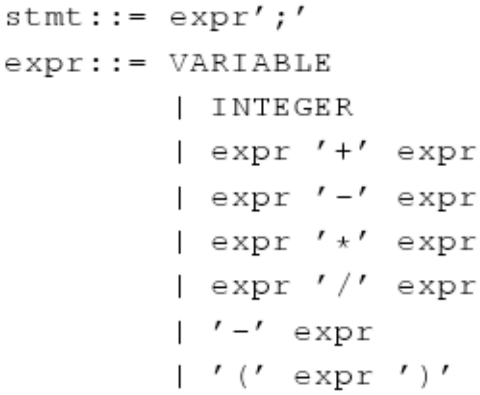
Two variables can be used to define valid resources for a given job.

- **REQUIREMENTS**: Express conditions that *BAN* resources
- **RANK**: Express conditions over the *PREFERENCE* of resources



```
stmt::= expr';'
expr::= VARIABLE '=' INTEGER
      | VARIABLE '>' INTEGER
      | VARIABLE '<' INTEGER
      | VARIABLE '=' STRING
      | expr '&' expr
      | expr '|' expr
      | '!' expr
      | '(' expr ')'
```

Requirements



```
stmt::= expr';'
expr::= VARIABLE
      | INTEGER
      | expr '+' expr
      | expr '-' expr
      | expr '*' expr
      | expr '/' expr
      | '-' expr
      | '(' expr ')'
```

Rank

UNIVERSIDAD COMPLUTENSE MADRID

DSA Group

Job Definition

Resource Selection

- **HOSTNAME** – FQDN.
- **ARCH** – Architecture of execution host.
- **OS_NAME** – Operative System.
- **OS_VERSION** – Operative System version.
- **CPU_MODEL** – CPU model.
- **CPU_MHZ** – CPU speed in MHZ.
- **CPU_FREE** – Percentage of free CPU.
- **CPU_SMP** – CPU SMP size.
- **NODECOUNT** – Number of nodes.
- **SIZE_MEM_MB** – Memory size in MB.
- **FREE_MEM_MB** – Free memory in MB.
- **SIZE_DISK_MB** – Disk space in MB.

Job Definition

Resource Selection

- **FREE_DISK_MB** – Free disk space in MB.
- **LRMS_NAME** – Name of local DRM system.
- **LRMS_TYPE** – Type of local DRM system.
- **QUEUE_NAME** – Name of the queue.
- **QUEUE_NODECOUNT** – Number of queue nodes.
- **QUEUE_FREENODECOUNT** – Free queue nodes.
- **QUEUE_MAXTIME** – Max wall time for jobs in queue.
- **QUEUE_MAXCPUTIME** – Max CPU time of jobs in queue.
- **QUEUE_MAXCOUNT** – Max jobs that can be submitted in one request.
- **QUEUE_MAXRUNNINGJOBS** – Max running jobs in queue.
- **QUEUE_MAXJOBSINQUEUE** – Max queued jobs in queue.
- **QUEUE_DISPATCHTYPE** – Queue dispatch type.
- **QUEUE_PRIORITY** – Priority of queue.
- **QUEUE_STATUS** – Status of queue (i.e. “active”, “production”).

Job Definition

Job Environment

- Job environment variables can be set with the *ENVIRONMENT* parameter.
- The variables defined in the *ENVIRONMENT* are "sourced" in a bash shell
  - **ENVIRONMENT** = VAR = "`expr ${JOB_ID} + 3`" # will set VAR to JOB_ID + 3

- **GW_RESTARTED**
- **GW_EXECUTABLE**
- **GW_ARCH**
- **GW_CPU_MHZ**
- **GW_MEM_MB**
- **GW_RESTART_FILES**
- **GW_CPULOAD_THRESHOLD**
- **GW_ARGUMENTS**
- **GW_TASK_ID**
- **GW_CPU_MODEL**
- **GW_ARRAY_ID**
- **GW_TOTAL_TASKS**
- **GW_JOB_ID**
- **GW_OUTPUT_FILES**
- **GW_INPUT_FILES**
- **GW_OS_NAME**
- **GW_USER**
- **GW_DISK_MB**
- **GW_OS_VERSION**

Contents

1. User Model Overview
2. Usage Scenarios
3. Job Definition
4. **Commands in detail**
5. JSDL

Commands in detail

gwsubmit – submitting jobs

```
gwsubmit <-t template> [-n tasks] [-h] [-v] [-o] [-s start] \
                       [-i increment] [-d "id1 id2 ..."]
```

OPTIONS

- **-h -** Prints help.
- **-t <template> -** The template file describing the job.
- **-n <tasks> -** Submit an array job with the given number of tasks.
  - All the jobs in the array will use the same template.
- **-s <start> -** Start value for custom param in array jobs. Default 0.
- **-i <increment> -** Increment value for custom param in array jobs
  - Each task has associated the value PARAM=start+increment * TASK_ID, and MAX_PARM = start+increment*(tasks-1). Default 1.
- **-d <"id1 id2..."> -** Job dependencies.
  - Submit the job on hold state, and release it once jobs with id1,id2,.. have successfully finished.
- **-v -** Print to stdout the job ids returned by gwd.
- **-o -** Hold job on submission.
- **-p <priority> -** Initial priority for the job.

Commands in detail

gwps – monitoring jobs

```
gwps [-h] [-u user] [-r host] [-A AID] [-s job_state] \
     [-o output_format] [-c delay] [-n] [job_id]
```

OPTIONS

- **-h -** Prints help.
- **-u user -** Monitor only jobs owned by user.
- **-r host -** Monitor only jobs executed in host.
- **-A AID -** Monitor only jobs part of the array AID.
- **-s job_state -** Monitor only jobs in states matching that of job_state.
- **-o output_format -** Formats output information, allowing the selection of which fields to display.
- **-c <delay> -** This will cause gwps to print job information every <delay> seconds continuously (similar to top command).
- **-n -** Do not print the header.
- **job_id -** Only monitor this job_id.

Commands in detail

gwhistory – accesing job history

```
gwhistory [-h] [-n] <job_id>
```

OPTIONS

- **-h -** Prints help.
- **-n -** Do not print the header lines.
- **job_id -** Job identification as provided by gwps.

Commands in detail

gwhost – monitoring hosts

```
gwhost [-h] [-c delay] [-nf] [-m job_id] [host_id]
```

OPTIONS

- **-h -** Prints help.
- **-c <delay> -** This will cause gwhost to print job information every <delay> seconds continuously (similar to top command).
- **-n -** Do not print the header.
- **-f -** Full format.
- **-m <job_id> -** Prints hosts matching the requirements of a given job.
- host_id - Only monitor this host_id, also prints queue information.

Commands in detail

gwkill – signalling jobs

```
gwkill [-h] [-a] [-k | -t | -o | -s | -r | -l | -9] <job_id \
[job_id2 ...] | -A array_id>
```

OPTIONS

- **-h -** Prints help.
- **-a -** Asynchronous signal, only relevant for KILL and STOP.
- **-k -** Kill (default, if no signal specified).
- **-t -** Stop job.
- **-r -** Resume job.
- **-o -** Hold job.
- **-l -** Release job.
- **-s -** Re-schedule job.
- **-9 -** Hard kill, removes the job from the system without synchronizing remote j execution or cleaning remote host.
- **job_id [job_id2 ...] -** Job identification as provided by gwps. You can specify a blank space separated list of job ids.
- **-A <array_id> -** Array identification as provided by gwps.

Commands in detail

gwwait – waiting for jobs

```
gwwait [-h] [-a] [-v] [-k] <job_id...| -A array_id>
```

OPTIONS

- **-h -** Prints help.
- **-a -** Any, returns when the first job of the list or array finishes.
- **-v -** Prints job exit code.
- **-k -** Keep jobs, they remain in fail or done states in the GridWay system.
  - By default, jobs are killed and their resources freed.
- **-A <array_id> -** Array identification as provided by gwps.
- **job_id ... -** Job ids list (blank space separated).

Commands in detail

gwuser – accesing user information

```
gwuser [-h] [-n]
```

OPTIONS

- **-h -** Prints help.
- **-n -** Do not print the header.

Commands in detail

gwacct – accessing accounting information

```
gwacct [-h] [-n] [<-d n | -w n | -m n | -t s>]\

       <-u user|-r host>
```

OPTIONS

- **-h -** Prints help.
- **-n -** Do not print the header.
- **<-d n | -w n | -m n | -t s> -** Take into account jobs submitted after certain date
  - specified in number of days (-d), weeks (-w), months (-m) or an epoch (-t).
- **-u user -** Print usage statistics for user.
- **-r hostname -** Print usage statistics for host.

Contents

1. User Model Overview
2. Usage Scenarios
3. Job Definition
4. Commands in detail
5. **JSDL**

JSDL

Job Submission Description Language

- describing the job requirements for submission to resources.
- https://forge.gridforum.org/sf/projects/jsdl-wg

- there are equivalences with GridWay Job Templates (GWJT)
  - a tool is packed with GridWay to make the transformation
    - accepts JSDL document via standard input
    - writes in the standard output the equivalent GWJT

```
$ jsdl2gw
USE: JSDLParser JsdlFileName [GwjtFileName]
```

```
#This file was automatically generated by the JSDL2GWJT pa
EXECUTABLE=/bin/ls
ARGUMENTS=-la file.txt
STDIN_FILE=/dev/null
STDOUT_FILE=stdout.${JOB_ID}
STDERR_FILE=stderr.${JOB_ID}
ENVIRONMENT=LD_LIBRARY_PATH=/usr/local/lib
REQUIREMENTS=HOSTNAME="*.dacya.ucm.es" & ARCH="x86_32”
INPUT_FILES=file.txt
```

Thank you
for your attention!