FedStage DRMAA for PBS Professional

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Abstract

This document describes installation, configuration and usage of FedStage DRMAA for PBS Pro library (PBS DRMAA for short).

Contents

1 Introduction

PBS DRMAA is implementation of DRMAA (DRM Application API) for PBS systems: PBS Professional, Torque and OpenPBS. Library covers nearly all DRMAA 1.0 specification. Exceptions are listed in Known bugs and limitations section. All mandatory and some optional job attributes (namely: transfer files, wall clock time limit, job run duration hlimit) are implemented.

Along with the library following tools can be found within distribution:

- Python bindings to DRMAA library (`python/drmaa`),
- DRMAA test-suite (`python/drmaa/testsuite`),
- DRMAA utilities library (`drmaa_utils`).

This manual can be found in HTML and PDF formats in `doc` directory.

2 Installation

To compile the library just go to main source directory and type:

```
$ ./configure [--prefix=/installation/directory] && make
```

If you had installed PBS in a non standard directory pass it in `--with-pbs` configure parameter. There are no unusual requirements for basic usage of library: ANSI C compiler and standard make should suffice. If you have taken sources directly from SVN repository or wish to run test-suite you would need additional developer tools. For further information regarding GNU build system see the INSTALL file.

For Torque it is advised to configure queues so jobs are leaved after the completion. To achieve this simply type the following command for all queues which are intended to use with PBS DRMAA:

```
# qmgr -c "set queue QUEUE_NAME keep_completed = 60"
```

The value of the `keep_completed` parameter denotes a number of seconds jobs will have to wait in the queue after the completion (and should be greater then `pool_delay` value in PBS DRMAA configuration). It enables the DRMAA library to retrieve the information about finished jobs.

3 Configuration

During DRMAA session initialization (`drmaa_init`) library tries to read its configuration parameters from locations: `/etc/pbs_drmaa.conf`, `~/.pbs_drmaa.conf` and from file given in `PBS_DRMAA_CONF` environment variable (if set to non-empty string). If multiple configuration sources are present then all configurations are merged with values from user-defined files taking precedence (in following order: `$PBS_DRMAA_CONF`, `~/.pbs_drmaa.conf`, `/etc/pbs_drmaa.conf`).

Currently recognized configuration parameters are:

pool_delay Amount of time (in seconds) between successive checks of queue(s).
Default: 5

job_categories Dictionary of job categories. It's keys are job categories names mapped to native specification strings. Attributes set by job category can be overridden by corresponding DRMAA attributes or native specification. Special category name `default` is used when `drmaa_job_category` job attribute was not set.

3.1 Configuration file syntax

Configuration file is in form a dictionary. Dictionary is set of zero or more key-value pairs. Key is a string while value could be a string, an integer or another dictionary.

```
configuration: dictionary | dictionary_body
dictionary: '{' dictionary_body '}'
dictionary_body: (string ':' value ',')*
value: integer | string | dictionary
string: unquoted-string | single-quoted-string | double-quoted-string
unquoted-string: [^ \t\n\r:,0-9][^ \t\n\r:,]*
single-quoted-string: '[^']*'
double-quoted-string: "[^"]*"
integer: [0-9]+
```

4 Native specification

DRMAA interface allows to pass DRM dependant job submission options. Those options may be specified by settings `drmaa_native_specification` or `drmaa_job_category` job attribute. `drmaa_native_specification` accepts space delimited `qsub` options while `drmaa_job_category` is name of job category defined in configuration file. `qsub` options which does not set job attributes (`-b`, `-z`, `-C`) as well as meant for submission of interactive jobs (`-I`, `-X`) or to specify directories (`-d`, `-D`) are *not* supported. Also instead of `-W` option following long options are accepted within native specification: `--depend`, `--group-list`, `--stagein` and `--stageout`. For detailed description of each option see PBS documentation.

Attributes set in native specification overrides corresponding DRMAA job attributes which overrides those set by job category. Vector attributes: resource list (`-l`), mail list (`-M`), environment variables (`-v`), job dependency (`--depend`), stagein (`--stagein`), and stageout (`--stageout`) which comes from various sources are not overridden but merged together. Other vector attributes are hard to merge correctly therefore their values are overridden in usual way. Those options are: list of shell interpreters (`-S`), user list (`-u`), group list (`--group-list`), input path (`-i`), output path (`-o`) and error path (`-e`).

Table 1: Native specification strings with corresponding DRMAA attributes.

DRMAA attribute	PBS attribute	PBS resource	native specification
Attributes which get overridden			
drmaa_job_name	Job_Name		`-N` job name
drmaa_output_path	Output_Path		`-o` output path
drmaa_error_path	Error_Path		`-e` error path
drmaa_join_files	Join_Path		`-j` join options
drmaa_block_email	Mail_Points		`-m` mail options
drmaa_start_time	Execution_Time		`-a` start time
drmaa_js_state	Hold_Types		`-h`
	Account_Name		`-A` account string
	Checkpoint		`-c` interval
	Keep_Files		`-k` keep
	Priority		`-p` priority
	destination		`-q` queue
	Rerunable		`-r` y/n
	Shell_Path_List		`-S` path list

Table 1: Native specification strings with corresponding DRMAA attributes.

DRMAA attribute	PBS attribute	PBS resource	native specification
	User_List		`-u` user list
	group_list		`--group-list=` groups
Attributes which values are merged			
drmaa_v_env	Variable_List		`-v` variable list
	Variable_List		`-V`
drmaa_v_email	Mail_Users		`-M` user list
drmaa_duration_hlimit	Resource_List	cput	`-l cput=` limit
drmaa_wct_hlimit	Resource_List	walltime	`-l walltime=` limit
	Resource_List		`-l` resources
	depend		`--depend=` dependency
	stagein		`--stagein=` stagein
	stageout		`--stageout=` stageout

4.1 Example

Source code (`test.c`):

```
#include <stdio.h>
#include <drmaa.h>

int main( int argc, const char *argv[] )
{
  int rc = DRMAA_ERRNO_SUCCESS;
  drmaa_job_template_t *jt = NULL;
  char err[ DRMAA_ERROR_STRING_BUFFER ];
  char jobid[ DRMAA_JOBNAME_BUFFER ];
  const char *env[] = {
    "CLASSPATH=./lib",
    NULL
  };

  rc = drmaa_init( NULL, err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_allocate_job_template( &jt, err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_set_attribute( jt, DRMAA_REMOTE_COMMAND, "java",
        err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_set_vector_attribute( jt, DRMAA_V_ARGV, argv+1,
        err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_set_vector_attribute( jt, DRMAA_V_ENV, env,
        err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_set_attribute( jt, DRMAA_DURATION_HLIMIT,
        "10:00", err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
```

```
    rc = drmaa_set_attribute( jt, DRMAA_NATIVE_SPECIFICATION,
        "-p 0 -V -l nodes=1:ppn=4", err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_set_attribute( jt, DRMAA_JOB_CATEGORY, "java",
        err, sizeof(err) );
  if( rc == DRMAA_ERRNO_SUCCESS )
    rc = drmaa_run_job( jobid, sizeof(jobid), jt, err, sizeof(err) );
  if( jt != NULL )
    drmaa_delete_job_template( jt, NULL, 0 );
  drmaa_exit( NULL, 0 );
  if( rc != DRMAA_ERRNO_SUCCESS )
    fprintf( stderr, "DRMAA error: %s\n", err );
  return rc;
}
```

Configuration file (`/etc/pbs_drmaa.conf` or `~/.pbs_drmaa.conf`):

```
job_categories: {
  default: "-l pmem=100mb",
  java: "-l software=java,pmem=300mb -p -10 -v PATH=/opt/sun-jdk-1.6/bin:/usr/bin:/bin",
}
```

After compilation (`gcc -o test test.c -ldrmaa`) running above code as `./test foo.jar` is equivalent to following invocation of `qsub`:

```
$ echo "java foo.jar" | \
> qsub -v PATH=/opt/sun-jdk-1.6/bin:/usr/bin:/bin,CLASSPATH=./lib -V \
> -l software=java,pmem=300mb,cput=10:00,nodes=1:ppn=4 -p 0
```

5 Release notes

5.1 Changes in 1.0 release

- number of attributes implemented:
  - `drmaa_start_time`
  - `drmaa_duration_hlimit`
  - `drmaa_wct_hlimit`
  - `drmaa_native_specification`
  - `drmaa_job_category`
- configuration file(s)
- separate wait thread
- lot of bug fixes
- more robust code
- separated DRMAA utilities library
- Python driven test-suite

5.2 Known bugs and limitations

The PBS DRMAA library is meant to be compliant with the Open Grid Forum DRMAA 1.0 specification. Although PBS APIs impose some limitations:

- With PBS Pro (and OpenPBS) retrieving of job termination status is impossible. For this DRM finished jobs are marked as done with 0 return code unless job was terminated through library when they are treated as aborted and killed after receiving SIGTERM.
- Library accepts job identifiers only of those jobs which were submitted under current session (specification says it should also accept job identifiers from previous sessions and even of jobs submitted in former execution of DRMAA enabled application). This could only be partially fixed as job state needs to be kept by library in order to cope with PBS shortcomings.
- Job termination (when job is running) is realized by PBS by sending SIGTERM and/or SIGKILL therefore retrieving those signals cannot be distinguished from abort using `drmaa_control(DRMAA_CONTROL_TERMINATE)`. Then job termination state is marked as "aborted" and "signaled" whatever is the state.
- drmaa_wcoredump() always returns `false`.
- Waiting functions (`drmaa_wait()` and `drmaa_synchronize()`) must pool DRM to find out whether job finished.

5.3 Test-suite

The PBS DRMAA library was successfully tested with PBS Pro 8 (8.0.0.63106) and Torque 2.1.8 on Linux OS. Following table presents results of Python written tests and tests from Official DRMAA test-suite (originally developed for Sun Grid Engine).

Test name	**PBS Pro 8**	**Torque 2.1.8**	**OpenPBS 2.3.16**
test_mt_exit_during_submit	passed	passed	passed
test_mt_exit_during_submit_or_wait	passed	passed	passed
test_mt_submit_before_init_wait	passed	passed	passed
test_mt_submit_mt_wait	passed	passed	passed
test_mt_submit_wait	passed	passed	passed
test_st_attribute_change	passed	passed	passed
test_st_bulk_singlesubmit_wait_individual	passed	passed	passed
test_st_bulk_submit_in_hold_session_delete	passed	passed	passed
test_st_bulk_submit_in_hold_session_release	passed	passed	passed
test_st_bulk_submit_in_hold_single_delete	passed	passed	passed
test_st_bulk_submit_in_hold_single_release	passed	passed	passed
test_st_bulk_submit_wait	passed	passed	passed
test_st_contact	passed	passed	passed
test_st_drm_system	passed	passed	passed
test_st_drmaa_impl	passed	passed	passed
test_st_empty_session_control	passed	passed	passed
test_st_empty_session_synchronize_dispose	passed	passed	passed
test_st_empty_session_synchronize_nodispose	passed	passed	passed
test_st_empty_session_wait	passed	passed	passed
test_st_error_file_failure	FAILED[1]	passed	FAILED[1]
test_st_exit_status	FAILED[1]	passed	FAILED[1]
test_st_input_file_failure	FAILED[1]	passed	FAILED[1]
test_st_mult_exit	passed	passed	passed

Test name	**PBS Pro 8**	**Torque 2.1.8**	**OpenPBS 2.3.16**
test_st_mult_init	passed	passed	passed
test_st_output_file_failure	FAILED[1]	passed	FAILED[1]
test_st_submit_in_hold_delete	passed	passed	passed
test_st_submit_in_hold_release	passed	passed	passed
test_st_submit_kill_sig	FAILED[1]	passed	FAILED[1]
test_st_submit_polling_synchronize_timeout	passed	passed	passed
test_st_submit_polling_synchronize_zerotimeout	passed	passed	passed
test_st_submit_polling_wait_timeout	passed	passed	passed
test_st_submit_polling_wait_zerotimeout	passed	passed	passed
test_st_submit_suspend_resume_wait	passed	passed	passed
test_st_submit_wait	passed	passed	passed
test_st_submitmixture_sync_all_dispose	passed	passed	passed
test_st_submitmixture_sync_all_nodispose	passed	passed	passed
test_st_submitmixture_sync_allids_dispose	passed	passed	passed
test_st_submitmixture_sync_allids_nodispose	passed	passed	passed
test_st_supported_attr	passed	passed	passed
test_st_supported_vattr	passed	passed	passed
test_st_usage_check	passed	passed	passed
test_st_version	passed	passed	passed
Test_multi_threaded.test_control_jobs	passed	passed	passed
Test_multi_threaded.test_stress	passed	passed	passed
Test_multi_threaded.test_submit_terminate_wait	passed	passed	FAILED
Test_no_session.test_control_terminate	passed	passed	passed
Test_no_session.test_exit	passed	passed	passed
Test_no_session.test_job_ps	passed	passed	passed
Test_no_session.test_synchronize	passed	passed	passed
Test_no_session.test_wait	passed	passed	passed
Test_session_opening.test_multi_init	passed	passed	passed
Test_single_threaded.test_empty_session_wait	passed	passed	passed
Test_single_threaded.test_submit_in_hold	passed	passed	passed
Test_single_threaded.test_submit_wait	passed	passed	passed
Configuration_invalid.test_invalid_option_type	passed	passed	passed
Configuration_invalid.test_invalid_syntax	passed	passed	passed
Configuration_merge_job_categories.test_a	passed	passed	passed
Configuration_merge_job_categories.test_b	passed	passed	passed
Configuration_merge_job_categories.test_c	passed	passed	passed
Configuration_valid.test_complex	passed	passed	passed
Configuration_valid.test_minimal	passed	passed	passed
Configuration_valid.test_typical	passed	passed	passed
Native_spec_merging.test_env	passed	passed	passed
Native_test.test_nice	passed	passed	passed
Native_test.test_queue	passed	passed	passed

Test name	PBS Pro 8	Torque 2.1.8	OpenPBS 2.3.16
Native_test.test_user	passed	passed	passed

6 Developers

Core functionality of DRMAA is putted into `drmaa_utils` library. This library was created in order to keep consistent common functionality of PBS DRMAA and SLURM DRMAA library. As it is independent from any particular DRM you may found this library useful for developing other DRMAAs. For detailed information please take a look at source code documentation.

6.1 Developer tools

Although not needed for library user the following tools may be required if you intend to develop PBS DRMAA library or run tests:

- GNU autotools (autoconf, automake, libtool),
- Bison parser generator,
- gperf perfect hash function generator,
- Python for Docutils and running test-suite (at least 2.5 vesion but not Python 3.* which will be incompatible),
- Pyrex — a Language for writing Python extension modules (>=0.9.6),
- Docutils for processing this `README`,
- LaTeX for creating documentation in PDF format,
- Doxygen for generating code documentation.

7 Contact

Please send your comments or questions to the following mailing list:
<drmaa-pbspro-users@lists.fedstage.com>
Please also visit the project webpage to find news and new releases of our software:

http://www.fedstage.com/wiki/FedStage_DRMAA_for_PBS_Pro

8 License

[1] Due to unavailability of job termination status.

8.1 GNU General Public License

Version 3, 29 June 2007

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```
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