University of Zurich[UZH]

S3IT

Application control and post-processing

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S3IT: Services and Support for Science IT

University of Zurich

January 23–27, 2017

Application run states

Application lifecycle

```
$ ./grayscale.py bfly.jpg
[...]
        NEW   1/1  (100.0%)
    RUNNING   0/1    (0.0%)
    STOPPED   0/1    (0.0%)
  SUBMITTED   0/1    (0.0%)
 TERMINATED   0/1    (0.0%)
TERMINATING   0/1    (0.0%)
    UNKNOWN   0/1    (0.0%)
      total   1/1  (100.0%)
```

`Application` objects can be in one of several states.

(A session-based script prints a table of all managed applications and their states.)

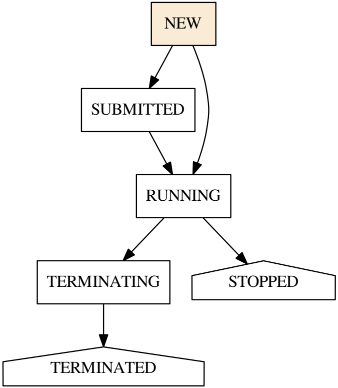
```
>>> print(app.execution.state)
'TERMINATED'
```

The current state is stored in the `.execution.state` instance attribute.

Reference:

http://gc3pie.readthedocs.io/en/master/programmers/api/gc3libs.html#gc3libs.Run.state

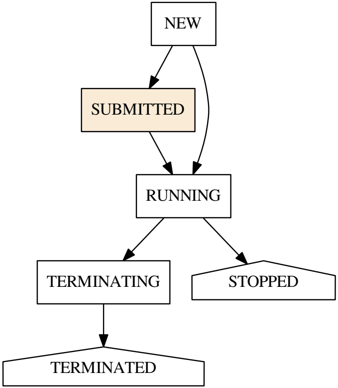
Application lifecycle: state NEW



NEW is the state of "just created" Application objects.

The Application has not yet been sent off to a compute resource: it only exists locally.

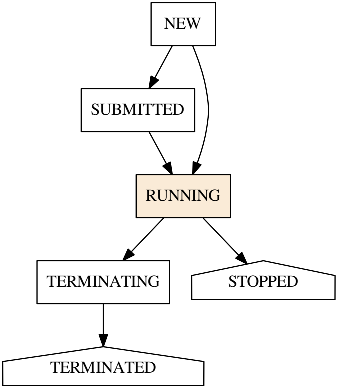
Application lifecycle: state SUBMITTED



SUBMITTED applications have been successfully sent to a computational resource.

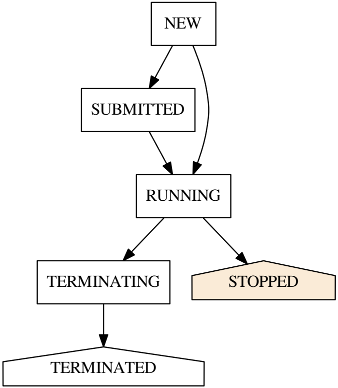
(The transition to *RUNNING* happens automatically, as we do not control the remote execution.)

Application lifecycle: state RUNNING



RUNNING state happens when the computational job associated to an application starts executing on the computational resource.

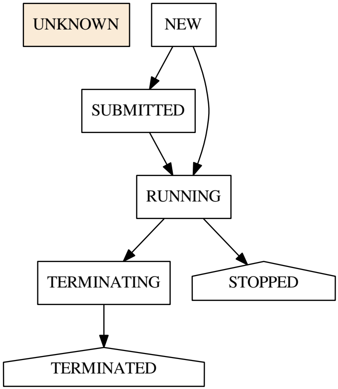
Application lifecycle: state STOPPED



A task is in *STOPPED* state when its execution has been blocked at the remote site and GC3Pie cannot recover automatically.

User or sysadmin intervention is required for a task to get out of *STOPPED* state.

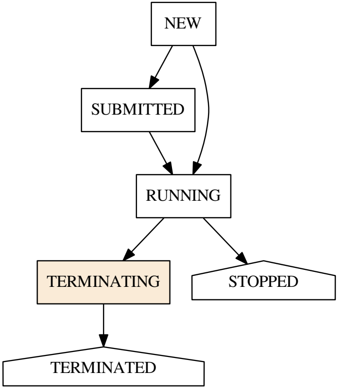
Application lifecycle: state UNKNOWN



A task is in *UNKNOWN* state when GC3Pie can no longer monitor it at the remote site.

(As this might be due to network failures, jobs *can* get out of *UNKNOWN* automatically.)

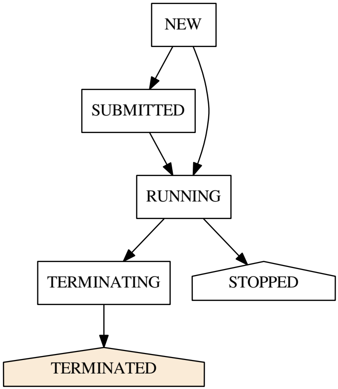
Application lifecycle: state TERMINATING



TERMINATING state when a computational job has finished running, for whatever reason.

(Transition to *TERMINATED* only happens when `fetch_output` is called.)

Application lifecycle: state TERMINATED



A job is *TERMINATED* when its final output has been retrieved and is available locally.

The exit code of *TERMINATED* jobs can be inspected to find out whether the termination was successful or unsuccessful, or if the program was forcibly ended.

Post-processing

Post-processing features, I

When the remote computation is done, the `terminated` method of the application instance is called.

The path to the output directory is available as `self.output_dir`.

If `stdout` and `stderr` have been captured, the **relative** paths to the capture files are available as `self.stdout` and `self.stderr`.

Post-processing features, II

For example, the following code logs a warning message if the standard error output is non-empty:

```
class MyApp(Application):
  # ...
  def terminated(self):
    stderr_file = self.output_dir+"/"+self.stderr
    stderr_size = os.stat(stderr_file).st_size
    if stderr_size > 0:
      gc3libs.log.warn(
        "Application %s reported errors!", self)
```

Useful in post-processing

These attributes are available in the `terminated()` method:

`self.inputs`
Python dictionary, mapping local (absolute) paths to remote paths (relative to execution directory)

`self.outputs`
Python dictionary, mapping remote paths (relative to execution directory) to *URLs* where they have been copied. In particular, `self.outputs.keys()` is the list of output file names.

`self.output_dir`
Path to the local directory where output files have been downloaded.

Exercise 6.A:
In the `colorize.py` script from Exercise 4.A, modify the `ColorizeApp` application to move the output picture file into directory `/home/ubuntu/pictures`. You might need to store the output file name to have it available when the application has terminated running.

(You might want to check out http://stackoverflow.com/a/8858026/459543 if you're unsure how to move/rename a file with Python.)

Termination status

A successful run or not?

There's a *single TERMINATED state*, whatever the task outcome. You have to inspect the "return code" to determine the cause of "task death".

Attribute `.execution.returncode` provides a numeric termination status (with the same format and meaning as the POSIX termination status).

The termination status combines two fields: the "termination signal" and the "exit code".

Termination signal, I

The `.execution.signal` instance attribute is non-zero if the program was killed by a signal (e.g., memory error / segmentation fault).

The `.execution.signal` instance attribute is zero only if the program run until termination. (**Beware!** This does not mean that it run *correctly*: just that it halted by itself.)

Termination signal, II

Read `man 7 signal` for a list of OS signals and their numeric values.

Note that GC3Pie uses some signal codes (not used by the OS) to represent its own specific errors.

For instance, if program `app` was cancelled by the user, `.execution.signal` will take the value 121:

```
>>> print(app.execution.signal)
121
```

Reference: https://github.com/uzh/gc3pie/blob/master/gc3libs/__init__.py#L1579

Exit code

The `.execution.exitcode` instance attribute holds the numeric exitcode of the executed command, or `None` if the command has not finished running yet.

Note that the `.execution.exitcode` is guaranteed to have a valid value only if the `.execution.signal` attribute has the value 0.

The `.execution.exitcode` is the same exitcode that you would see when running a command directly in the terminal shell. (By convention, code 0 is successful termination, every other value indicates an error.)

Exercise 6.B:
Modify the grayscaling script `ex2c` (or the code it depends upon) so that, when a `GrayscaleApp` task has terminated execution, it prints:

- whether the program has been killed by a signal, and the signal number;
- whether the program has terminated by exiting, and the exit code.

Exercise 6.B+: *(Bonus points)* Abstract the verbose `terminated` method from exercise 6.B into an application class `TermStatusApp`.

Use Python class inheritance to add the `TermStatusApp` functionality into `GrayscaleApp`.

Application-specific configuration

Application classes may be tagged so that parts of the configuration file can be overridden just for them.

Suppose you tag the `GrayscaleApp` class by giving it this name:

```
class GrayscaleApp(Application):
  application_name = 'grayscale'
  #  [...]
```

then you can provide a specific VM image just for "`grayscale`" applications:

```
# in the GC3Pie config file:
[resource/sciencecloud]
#  [...]
image_id=2b227d15-8f6a-42b0-b744-ede52ebe59f7
grayscale_image_id=0cca5346-ca12-4cb4-8007-8875c10cce02
```

Other configuration items that can be specialized are: `instance_type`, `user_data` (cloud), and `prolog_file`, `epilog_file` (batch-systems).

Exercise 6.C: *(Difficult)*

MATLAB has the annoying habit of exiting with code 0 even when some error occurred.

Write a `MatlabApp` application, which:

- is constructed by giving the path to a MATLAB '`.m`' script file, like this: `app = MatlabApp("ra.m");`
- Runs the following command:

  `matlab -nodesktop -nojvm -r` *`file`*

  where *file.m* is the file given to the `MatlabApp()` constructor.
- captures the standard error output (`stderr`) of the MATLAB script and, if one of the strings "`Out of memory.`" or "`exceeds maximum array size`" occurs in it, sets the application exitcode to 11.

Verify that it works by running MATLAB script `ra.m` many times over. The script initializes a array of random size: for some values, the size exceeds the amount of available memory.

Global post-processing, I

Further options for customizing a session-based script:

`before_main_loop(self)`
to execute some code *before* the main loop starts.

`after_main_loop(self)`
to execute some code *after* the main loop, i.e., before the script quits. A list of all Application objects is available in the `self.session.tasks.values()` list.

Global post-processing, II

Example: compute statistical distribution of termination statuses:

```
def after_main_loop(self):
  # check that all tasks are terminated
  can_postprocess = True
  for task in self.session.tasks.values():
    if task.execution.state != 'TERMINATED':
      can_postprocess = False
      break
  if can_postprocess:
    # do stuff... (see next slide)
```

Global post-processing, III

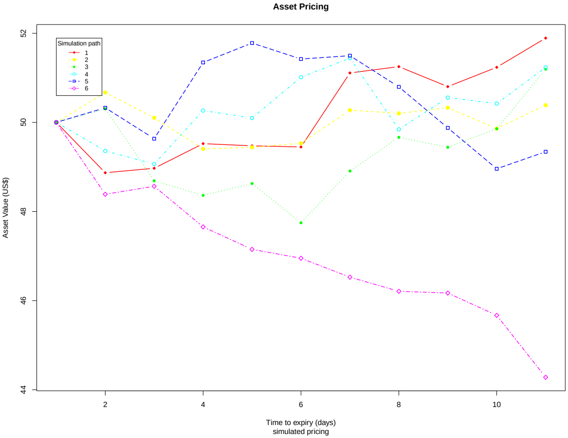
Example: compute statistical distribution of termination statuses (cont'd):

```
def after_main_loop(self):
  # ...  (see prev slide)
  if can_postprocess:
    status_counts = defaultdict(int)
    for app in self.session.tasks.values():
      termstatus = app.execution.returncode
      status_counts[termstatus] += 1
```

Variable `self.session.tasks` holds a mapping `JobID` ⇒ `Application`; thus `self.session.tasks.values()` is a list of all the `Application` instances returned by `new_tasks`

Detour: asset pricing, I

The script `simAsset.R` simulates asset pricing over a certain amount of time. Different pricing paths are generated using a 1D Brownian motion, all starting from the same initial price.



Detour: asset pricing, II

You can run the `simAsset.R` script with these positional parameters:

- S_0 stock price today (e.g., 50)
- μ expected return (e.g., 0.04)
- σ volatility (e.g., 0.1)
- δ size of time steps (e.g., 0.273)
- e days to expiry (e.g., 1000)
- N number of simulation paths to generate

For example:

```
$ Rscript simAsset.R 50 0.04 0.1 0.27 10 4
```

Each run of `simAsset.R` produces two output files:

- **results.csv** table of generated data: each column is a simulation path, each row is a time step;
- **results.pdf** plot of the above.

Exercise 6.D: *(Difficult)*

Write a `sim_asset.py` program that:

- takes the same command-line positional arguments as `simAsset.R`, *plus* an additional integer trailing parameter P;
- runs `simAsset.R` (in parallel) P times with the given arguments (so, effectively simulates $N \cdot P$ price paths);
- reads all the generated `results.csv` files, and
- computes and prints the average value of the asset at the end of the simulated time, across all $N \cdot P$ price paths.

(For easier reading CSV files, you can use the standard `csv` Python module, see: https://docs.python.org/2/library/csv.html)