Xcrypt Manual

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Contents

Part I

General

Chapter 1

Introduction

1.1 Overview

In using a high-performance computer, we usually commit job processing to a job scheduler. At this time, we often go through the following procedures:

- to create a script in its writing style depending on the job scheduler,
- to pass the script to the job scheduler, and
- to extract data from its result, create another script from the data, and pass it to the job scheduler.

However, such procedures require manual intervention cost. It therefore seems better to remove manual intervention in mid-processing by using an appropriate script language. Xcrypt is a script language for job parallelization. We can deal with jobs as objects (called *job objects*) in Xcrypt and manipulate the jobs as well as objects in an object-oriented language. Xcrypt provides some functions and modules for facilitating job generation, submission, synchronization, etc. Xcrypt makes it easy to write scripts to process job, and supports users to process jobs easily.

1.2 Environment

Xcrypt requires Perl ($\geq$ 5.10.0) and a superset of Bourne shell.

Xcrypt also requires the following outer modules:

- Marc Lehmann's Coro (where conftest.c is not contained), EV,
- Graham Barr's Error,
- Joshua Nathaniel Pritikin's Event,
- Salvador Fandiño's Net-OpenSSH,
- Daniel Muey's Recursive,

and wants Marc Lehmann's AnyEvent, common::sense, and Guard (warns if none). These modules are bundled with Xcrypt.

Chapter 2

Script

Xcrypt is a script language, and an extension of Perl. Xcrypt provides some functions and modules (not in Perl) which support how to deal with *jobs*.

An Xcrypt script consists of descriptions of

1. module,
2. template, and
3. procedure.

2.1 Module

Modules for job objects are used as follows,

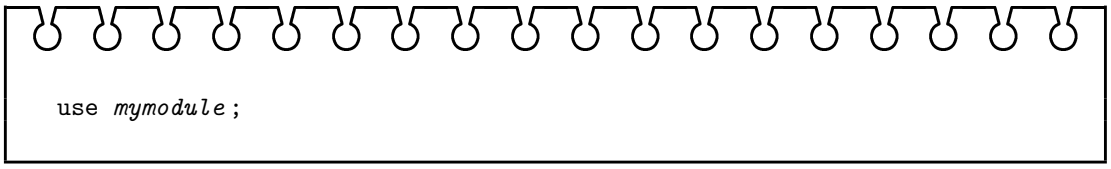
```
use base qw(core);
```

When you use multiple modules, it is enough to write

```
use base qw(mymodule core);
```

Every module should be used in order. The details of the modules are described in Chapter 4.

Commonly-used modules can be loaded as follows,

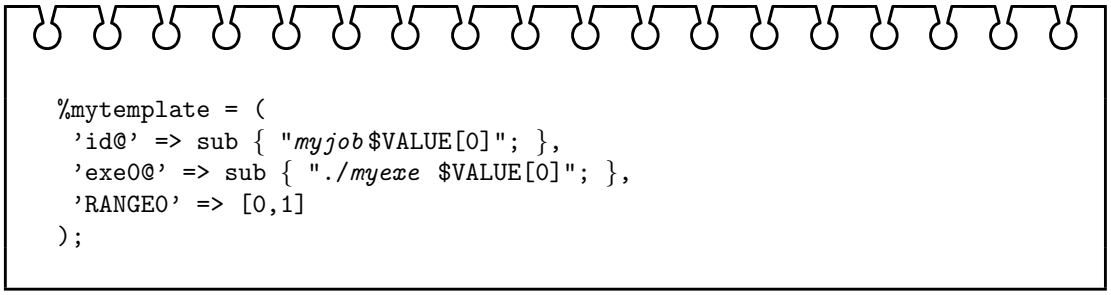


```
use mymodule;
```

similarly to how to use modules in Perl.

2.2 Template

Xcrypt's templates are implemented as Perl's hashes. For example,



```
%mytemplate = (
 'id@' => sub { "myjob$VALUE[0]"; },
 'exe0@' => sub { "./myexe $VALUE[0]"; },
 'RANGE0' => [0,1]
);
```

Keys in templates are described in Chapter 5 in detail.

2.3 Job Object

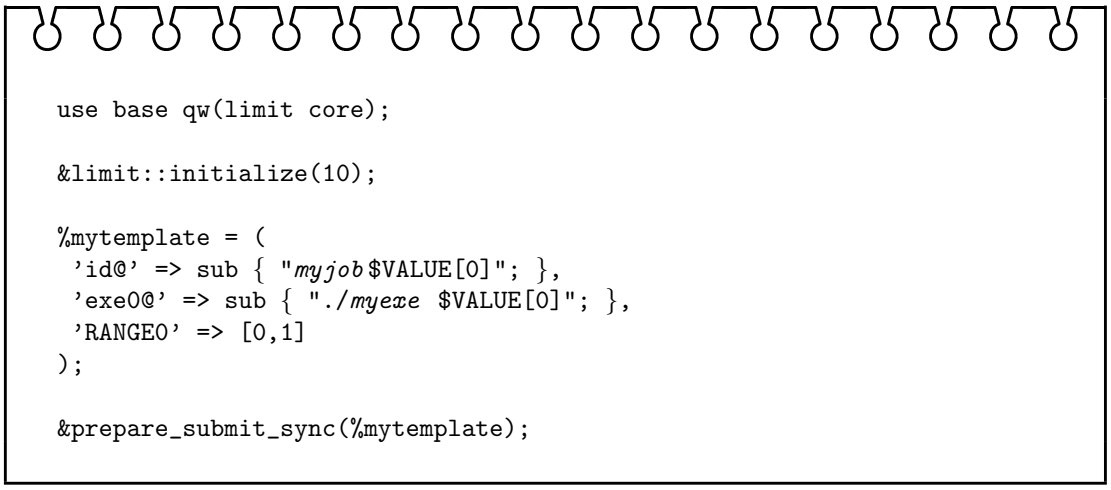
Xcrypt's job object are implemented as Perl's objects (blessed hash references). In Xcrypt, job objects should be typically created from templates by a built-in function `&prepare` (Chapter 6 in detail).

2.4 Procedure

Procedures of job processing are described in Xcrypt (and Perl) instead of manually carried out. Xcrypt's functions are described in Chapter 6.

2.5 Example

An example script is as follows,



```
use base qw(limit core);

&limit::initialize(10);

%mytemplate = (
 'id@' => sub { "myjob$VALUE[0]"; },
 'exe0@' => sub { "./myexe $VALUE[0]"; },
 'RANGE0' => [0,1]
);

&prepare_submit_sync(%mytemplate);
```

Chapter 3

Flow

In this chapter, we introduce how jobs are processed.

3.1 State

Any job has one of the following states:

initialized:	the job is initialized or canceled,
prepared:	the job object is generated and being submitted,
submitted:	the job is submitted,
queued:	the job is queued,
running:	the job is running,
done:	the job is done,
finished:	the job is finished or invalidated,
aborted:	the job is aborted.

3.2 Execution

Edit `xcrypt/source-me.sh` in order to set some environment variables where `XCRJOBSCHED`[1] should be set to your job scheduler, and

```
$ source source-me.sh
```

In addition, continue the following installation procedure:

```
$ cd $XCRYPT/cpan; ./do-install.sh
```

Next, move to the working directory (e.g., `$HOME/wd`)

```
$ cd $HOME/wd
```

and write an Xcrypt script (e.g., `sample.xcr`). See Section 2.5 in order to know how to write.

Finally, execute Xcrypt with the script:

[1] `SGE`, `TSUKUBA`, `TOKYO`, `KYOTO`, and `sh` are available. In the case of `sh`, jobs are dealt with as processes in OS. The default is `sh`

```
$ $XCRYPT/bin/xcrypt sample.xcr
```

3.3 Interactive Usage

```
$ $XCRYPT/bin/xcryptstat
```

shows states of jobs.

```
$ $XCRYPT/bin/xcryptclean
```

forgets states of all jobs.

```
$ $XCRYPT/bin/xcryptdel myjob
```

makes states of unfinished jobs aborted.

```
$ $XCRYPT/bin/xcryptcancel myjob
```

makes states of (not necessarily unfinished) jobs aborted.

```
$ $XCRYPT/bin/xcryptinvalidate myjob
```

makes states of jobs finished.

```
$ $XCRYPT/bin/xcryptdelall
```

```
$ $XCRYPT/bin/xcryptcancelall
```

```
$ $XCRYPT/bin/xcryptinvalidateall
```

are commands for all jobs, respectively.

3.4 Product

Xcrypt creates the following in the working directory during and after its execution.

*myjob*_$XCRJOBSCHED.sh

is a job script passed to a job scheduler or a Bourne shell script executed, regarding OS as a job scheduler, respectively.

`stdout`

is a file storing the job's standard output. When `stdofile` is defined, the file is renamed as its value.

`stderr`

is a file storing the job's standard error. When `stdefile` is defined, the file is renamed as its value.

`inv_watch`

is a directory containing log, lock, and other files.

Part II

Details

Chapter 4

Module

In this chapter, we introduce some modules available in Xcrypt scripts.

4.1 core

This module is the Xcrypt core module, and required to be read in order to use anything particular to Xcrypt.

It creates a job script file of the name `$myjob->{id}.sh` under the job working directory, where `$myjob` is a job object.

4.2 sandbox

A directory of the name

```
join('_', ($myjob->{id}, @VALUE))
```

is created for each job (called a *job working directory*). Job-processing is done in the job working directory.

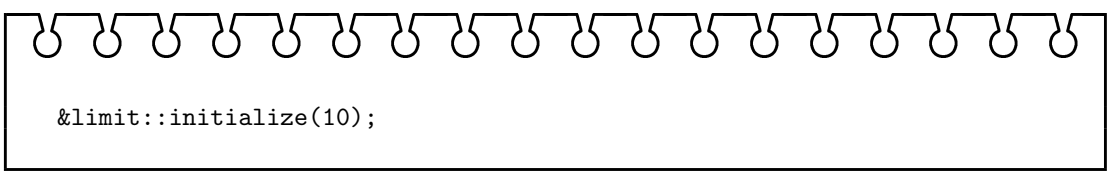
The following can be defined in templates.

`linkedfile`i: a soft link of the file (whose name is its value) is created in the job working directory.

`copiedfile`i: the indicated file is copied to the job working directory.

4.3 limit

This module limits the number of jobs submitted simultaneously. In order to limit the number of jobs to 10, for example, it is enough to write as follows,



```
&limit::initialize(10);
```

4.4 bulk_simple

This module gathers jobs and returns one job of the same denotation. For bulked jobs, the function `&bulk` ignores any member except `exe`i, `exe`i`_j`, `initially`, `before`, `after`, and `finally`. Typically, you can write as follows,

```
my $template = { 'id' => 'bulked_job_', 'JS_queue' => 'myqueue' };
my @jobs0 = &prepare(%template0);
my @jobs1 = &prepare(%template1);
my @bulk = &bulk_simple::bulk($template, @jobs0, @jobs1);
&submit(@bulk);
```

4.5 successor

This module indicates job objects which can be defined declaratively. For example, in order to define job objects of the name `%x, %y`, write:

```
...
'successor' => ['x', 'y'],
...
```

using the key `successor` in the template.

4.6 convergence

This module provides a function for a Plan-Do-Check-Action (PDCA) cycle, to deal with convergence of difference of job's results. The keys `initialvalue`, `isConvergent`, `inputfile`, `sweepname`, `outputfile`, and `extractrules` can be used in templates.

4.7 n_section_method

This module provides n-section method, a root-finding algorithm. The only difference from bisection method[1] is the number of sections.

The values `partition` and `epsilon` denote a partition number and an error, respectively. An interval is expressed by `x_left` and `x_right`. The values `y_left` and `y_right` are values on `x_left` and `x_right`. Typically, we can call the function `n_section_method` with these keys, e.g.,

[1] `http://en.wikipedia.org/wiki/Bisection_method/`

```
&n_section_method::n_section_method(%job,
    'partition' => 12, 'epsilon' => 0.01,
    'x_left'  => -1,  'x_right' => 10,
    'y_left'  => 0.5, 'y_right' => -5
);
```

4.8 dry

This module provides job-processing in dry mode (skipping any command execution). Description in a template

```
...
'dry' => 1,
...
```

makes any job (derived from this hash) to be processed in dry mode.

4.9 invalidate

This module invalidates jobs of which running time is more than `allotted_time` (can be defined in templates).

Chapter 5

Template

In this chapter, we introduce keys and values available in templates by default.

5.1 RANGE*i*

key@ denotes the one whose postfix is the character @ (e.g., exe0@).
Any word of ASCII printable characters except

@␣"$%&'/:;<=>?[\]‘{|}

is available for RANGE*i*'s values.
@ means
values are array references, function references, (or scalar although not recommended).

5.2 id

Its value is a word. The value is used for creating job objects and identifying the job objects as their prefixes. Any word of ASCII printable characters except

@␣"$%&'/:;<=>?[\]‘{|}

is available.

5.3 exe*i*

Its value denotes a command. The command is executed as follows,

```
$ myexe0 myarg0_0 ...
$ myexe1 myarg1_0 ...
⋮
```

with arg*i*_*j* explained below.

5.4 arg*i*_*j*

Its values are arguments of a command.

5.5 `stdofile`

The standard output is stored in the indicated file. The default is `stdout`.

5.6 `stdefile`

The standard error is stored in the indicated file. The default is `stderr`.

5.7 `JS_`*key*

Chapter 6

Function

In this chapter, we introduce built-in functions.

6.1 prepare

This function takes a job definition hash and parameters of references[1], and returns an array of job objects.

Format

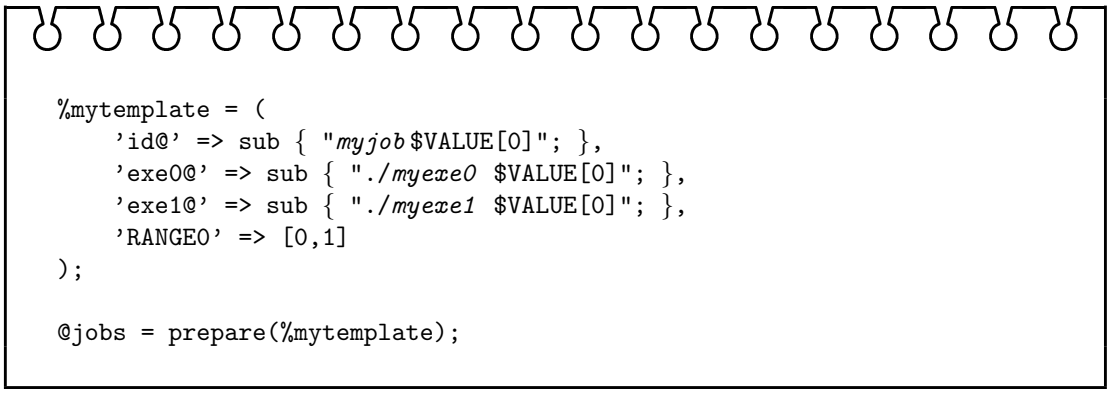
```
prepare(%template);
```

Example

```
@jobs = prepare('id@' => sub { "myjob $VALUE[0]"; },
                'exe0@' => sub { "./myexe0 $VALUE[0]"; },
                'exe1@' => sub { "./myexe1 $VALUE[0]"; },
                'RANGE0' => [0,1]);
```

Declarative description is also available as follows,

[1] In this manual, references do not denote type globs.

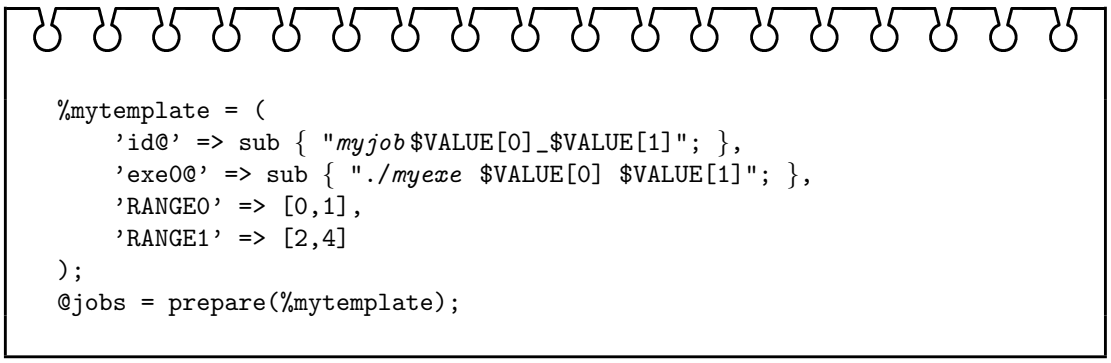


```
%mytemplate = (
    'id@' => sub { "myjob$VALUE[0]"; },
    'exe0@' => sub { "./myexe0 $VALUE[0]"; },
    'exe1@' => sub { "./myexe1 $VALUE[0]"; },
    'RANGE0' => [0,1]
);

@jobs = prepare(%mytemplate);
```

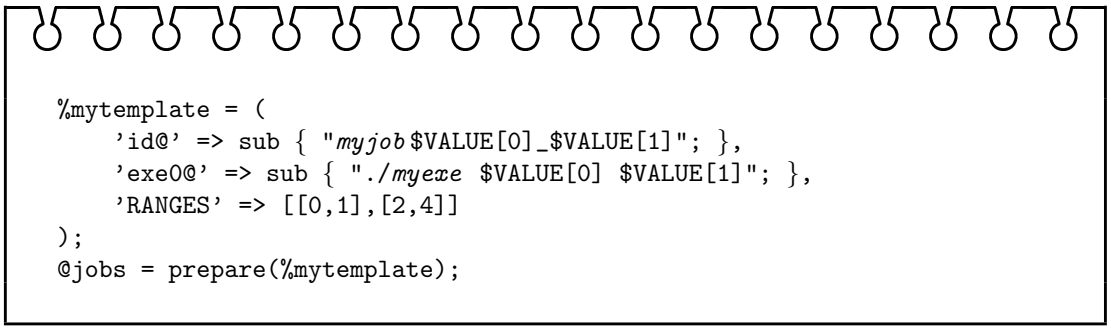
Advanced

It is possible to generate job objects by using multiple parameters. For example,



```
%mytemplate = (
    'id@' => sub { "myjob$VALUE[0]_$VALUE[1]"; },
    'exe0@' => sub { "./myexe $VALUE[0] $VALUE[1]"; },
    'RANGE0' => [0,1],
    'RANGE1' => [2,4]
);
@jobs = prepare(%mytemplate);
```

creates 4 job objects. This is the same as

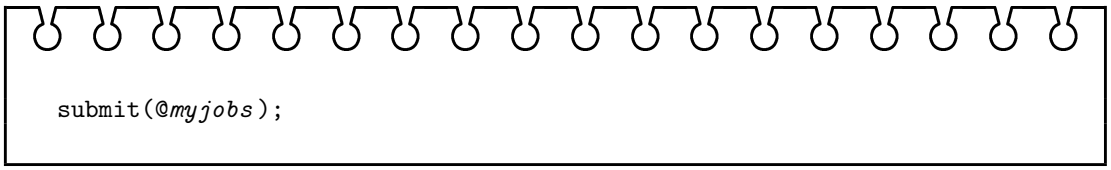


```
%mytemplate = (
    'id@' => sub { "myjob$VALUE[0]_$VALUE[1]"; },
    'exe0@' => sub { "./myexe $VALUE[0] $VALUE[1]"; },
    'RANGES' => [[0,1],[2,4]]
);
@jobs = prepare(%mytemplate);
```

6.2 submit

This function takes an array of job objects and passes the jobs (corresponding to the job objects) to a job scheduler. Its return value is also the array of job objects.

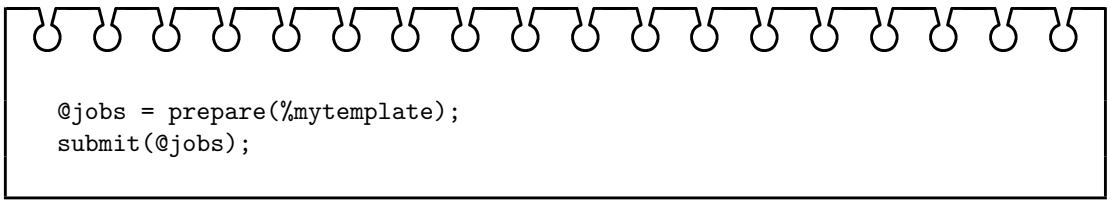
Format



```
submit(@myjobs);
```

Example

Typically, this function takes a return value of `prepare`.



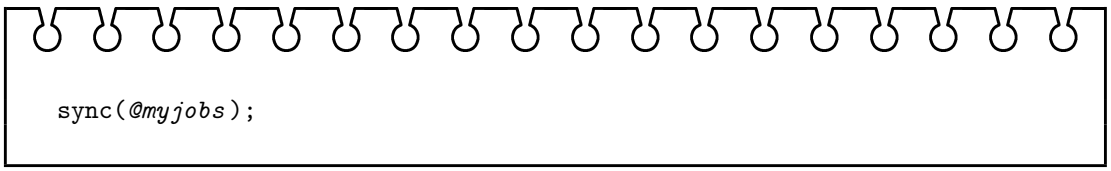
```
@jobs = prepare(%mytemplate);
submit(@jobs);
```

It is possible to define job references without using `prepare` (although not recommended).

6.3 sync

This function takes an array of job objects and synchronizes the job objects. Its return value is the array of job objects.

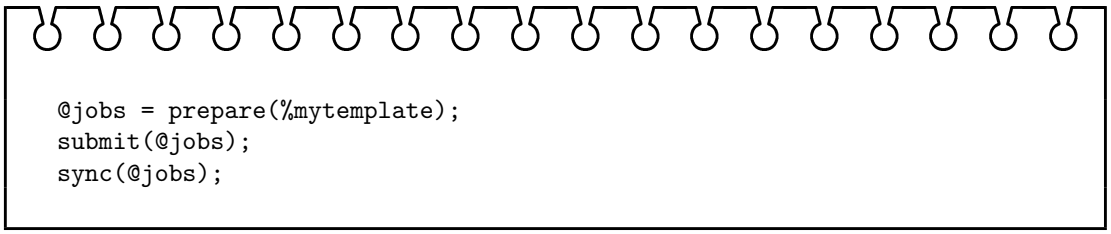
Format



```
sync(@myjobs);
```

Example

Typically, this function takes a return value of `prepare` (same as `submit`).

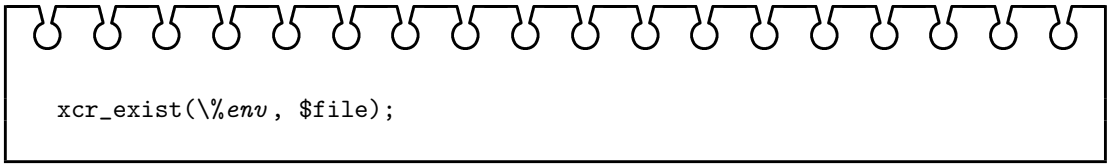


```
@jobs = prepare(%mytemplate);
submit(@jobs);
sync(@jobs);
```

6.4 xcr_exist

This function returns 1 if `$file` exists (0 unless) at `$env{location}`.

Format

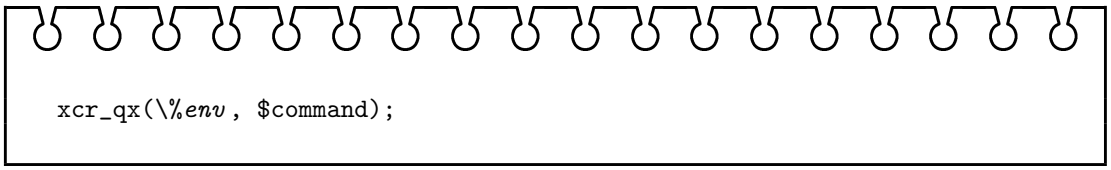


```
xcr_exist(\%env, $file);
```

6.5 xcr_qx

This function returns `$command`'s standard output at `$env{location}` as an array.

Format

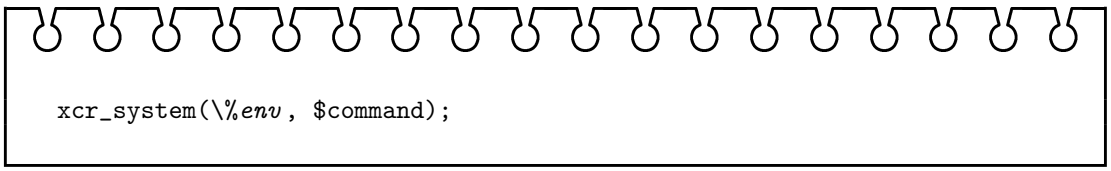


```
xcr_qx(\%env, $command);
```

6.6 xcr_system

This function returns `$command`'s return value at `$env{location}`.

Format

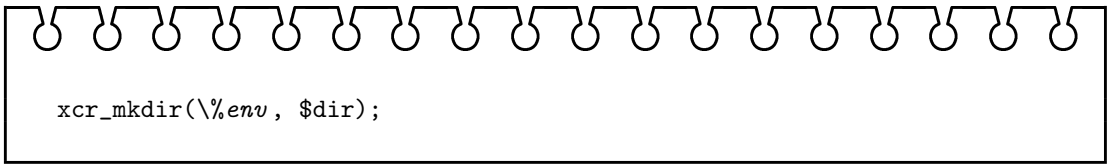


```
xcr_system(\%env, $command);
```

6.7 xcr_mkdir

This function makes a directory of the name `$dir` at `$env{location}`.

Format

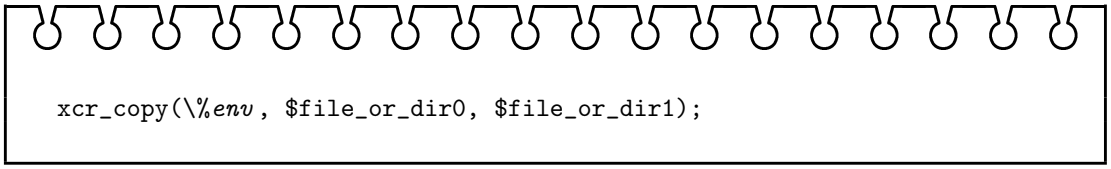


```
xcr_mkdir(\%env, $dir);
```

6.8 xcr_copy

This function copies $file_or_dir0 to $file_or_dir1 at $env{location}.

Format

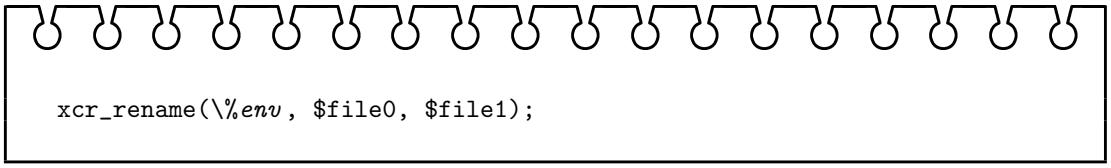


```
xcr_copy(\%env, $file_or_dir0, $file_or_dir1);
```

6.9 xcr_rename

This function rename $file0 to $file1 at $env{location}.

Format

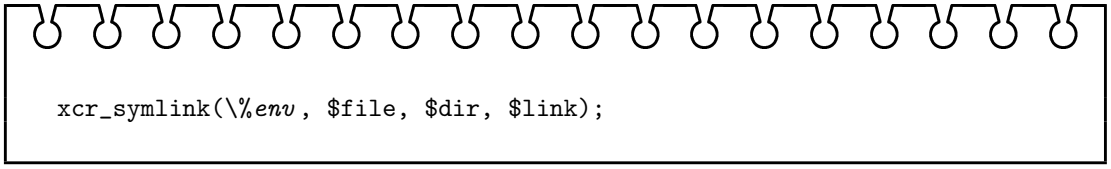


```
xcr_rename(\%env, $file0, $file1);
```

6.10 xcr_symlink

This function links $file as $link in $dir at $env{location}.

Format

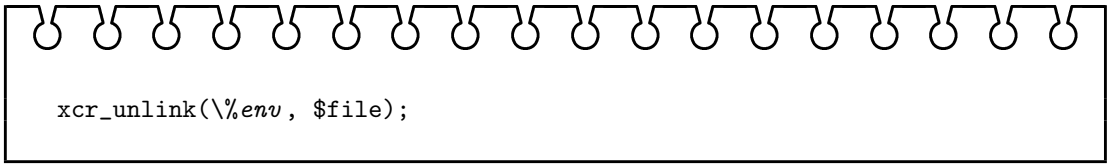


```
xcr_symlink(\%env, $file, $dir, $link);
```

6.11 xcr_unlink

This function removes $file at $env{location}.

Format

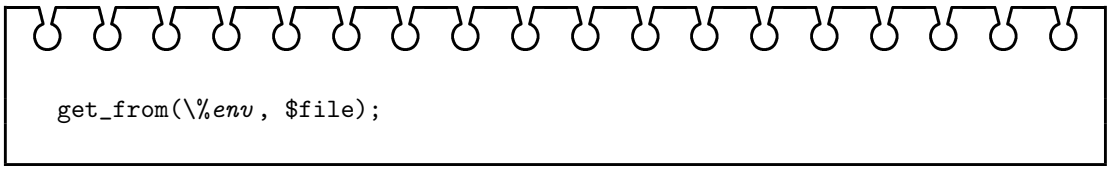


```
xcr_unlink(\%env, $file);
```

6.12 get_from

This function gets $file from $env{wd} in $env{location}.

Format

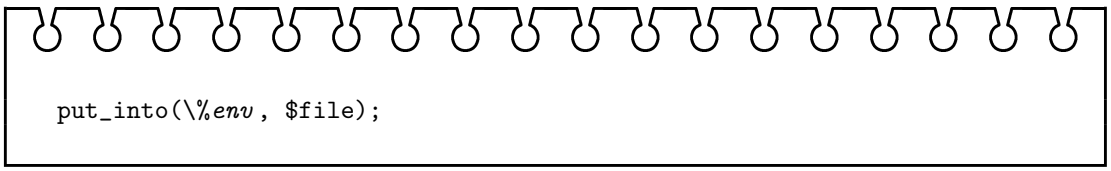


```
get_from(\%env, $file);
```

6.13 put_into

This function puts $file into $env{wd} in $env{location}.

Format



```
put_into(\%env, $file);
```

6.14 add_host

This function takes a hash that denotes a host (containing its environment), and returns a reference that denotes it.

Format

```
add_host(\%env);
```

Example

```
$env = add_host({'host' => 'foo@bar', 'wd' => '/home/foo'});
%template = ('id' => 'myjob', 'exe0' => './myexe', 'env' => $env);
```

6.15 get_local_env

This function returns a reference that denotes the local host (containing its environment).

Format

```
get_local_env();
```

Example

```
$env = get_local_env();
%template = ('id' => 'myjob', 'exe0' => './myexe', 'env' => $env);
```

6.16 add_key

This function takes an array of words and makes it available as keys in job definition hashes.

Format

```
add_key(@words);
```

6.17 add_prefix_of_key

This function takes an array of words and makes it available as prefixes of keys in job definition hashes.

Format

```
add_prefix_of_key(@words);
```

6.18 repeat

This function takes an Xcrypt's script code (denoted as *mystring*) and an integer i, and evaluates it each i seconds.

Format

```
repeat(mystring, i);
```

6.19 set_expander

Format

```
set_expander($string);
```

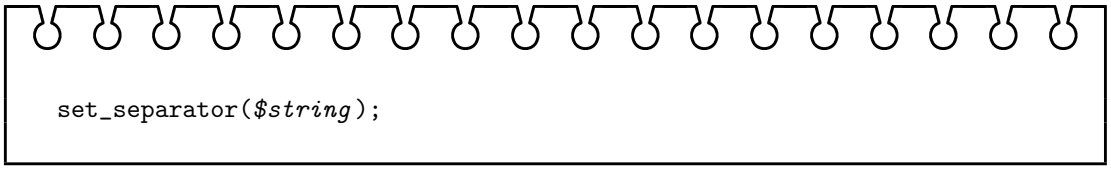
6.20 get_expander

Format

```
get_expander();
```

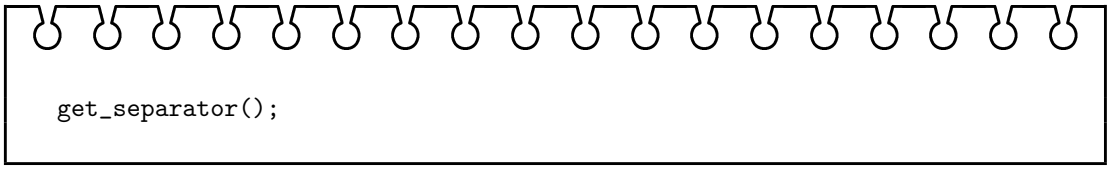
6.21 set_separator

Format



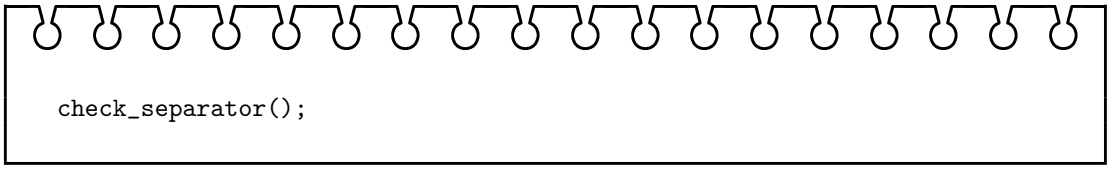
6.22 get_separator

Format



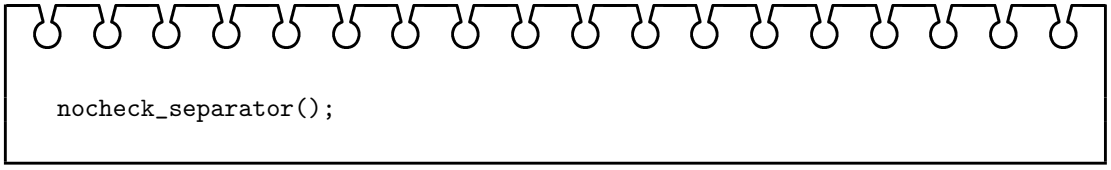
6.23 check_separator

Format



6.24 nocheck_separator

Format



6.25 prepare_submit

This function makes `prepare` and `submit` applied to job objects generated by `prepare`. The composition of `prepare` and `submit` is done at each job object.

6.26 prepare_submit_sync

This function is an abbreviation of `prepare_submit` and `sync`. Its format follows `prepare`.

Chapter 7

Methods of `core` Class

This chapter explains methods defined in `core` class. These methods can be used by end users. The methods that are defined in `core` class but should not be used directly by end users are listed in Appendix A.4.

7.1 `workdir_member_file`

to be written...

7.2 `abort`

to be written...

7.3 `cancel`

to be written...

7.4 `invalidate`

to be written...

Chapter 8

Option

8.1 --scheduler

8.2 --abort_check_interval

an interval of checking whether jobs are aborted or not (sec).

8.3 --left_message_check_interval

an interval of checking what states jobs have (sec).

8.4 --inventory_path

a path at that logs are located.

8.5 --verbose

8.6 --stack_size

8.7 --host

a host to that jobs are submitted.

8.8 --wd

a working directory in that Xcrypt is executed at a remote host.

8.9 --scratch

executes Xcrypt without recovering the states of jobs in the previous execution.

Appendix A

How to Implement Job Class Extension Modules

Any job object generated by the Xcrypt's function `prepare` belongs to the class `core`, defined by `$XCRYPT/lib/core.pm`.Xcrypt users and developers can extend the class `core` by defining modules and consequently expand the function of Xcrypt. In this chapter, we introduce how to implement such extension modules.

A.1 How to Define and Use Extension Modules

In order to define an extension module of the name *mymodule*, it is enough for Xcrypt developers to put it into any directory designated by `$XCRYPT/lib/` (or `$PERL5LIB`).

Then Xcrypt users can use the extension module by simply indicating their name on the header of his/her script as follows:

```
use base (... mymodule ... core);
```

A.2 Scripts of Extension Modules

A definition script for an extension module is typically described as follows,

```
package  mymodule;


use strict;
use ...;

&add_key('my_instance_member', ...);

my $my_class_member;

# special methods
sub new {
  my $class = shift;
  my $self = $class->NEXT::new(@_);
  ...
  return bless $self, $class;
}

sub before { ... }

sub start
{
  my $self = shift;
  ...
  $self->NEXT::start();
  ...
}

sub after { ... }

# general methods
sub another_method
{
  ...
}
```

In the following, we make an explanation for each component of the script.

1. Definition of the module name: is designated by `package`. The module name must coincide with the file name without its extension (`.pm`).
2. Use of Perl modules: is declared by using `use` as in typical Perl programs.
3. Addition of instance variables: is performed by the function `add_key`. The added instance variables are accessible as attributes of the job objects by writing, e.g.,

```
$job->{my_instance_member}
```

in Xcrypt scripts and modules. Also, by writing, e.g.,

`%template = { ..., my_instance_menber=>`*value*`, ...}`

users can set values to them.

4. Definition of class variables: is done in the usual way in object-oriented programming, i.e., class variables are defined as global variables in packages. The variables can be accessed, e.g.,

   `$`*mymodule*`::my_class_member`

5. Definition of methods: is defined in the usual way, i.e., methods added and extended in modules are defined as top-level functions in packages. Note that some methods with particular names have special meanings as explained in the next section.

A.3 Special Methods

Xcrypt gives special meanings to the following class methods.

A.3.1 `new`

The method `new` is a class method, the so-called *constructor*. The method `new` in the most specialized class (the left-most module declared on the script header) is called.

The method `new` takes the following arguments:

1. the package name (= `user`) to which an Xcrypt script belongs,
2. a reference to a job object[1].

Note that `new` is applied to each of multiple objects generated by `prepare`.

In the body of a method, the method `new` in the parent class is called as

```
$class->NEXT::new($self,$obj)
```

where `$class` and `$obj` are the class name and reference to the object, the arguments of `new`, respectively.

Typically, each `new` calls `new` in his parent class with the same two arguments, processes its return value (an object), and returns `bless` *reference to the object*, *the class name* as return values.

In the module `core`, `new` is defined. The `new` creates a job directory, soft links, and copies of files (explained in Section 3.4). Note that this required procedure is skipped unless `new`s in children classes call the `new` in the `core`.

A.3.2 `initially`

to be written...

[1] The object members has values in the template passed to the function `prepare`.

A.3.3 before

In Xcrypt, application of the function submit (cf. Section 6.2) makes a job object's state prepared. The methods befores are applied to a job object of the state prepared (cf. Section 3.1). Its argument is a reference to the job object. The order of calling befores is in such a way from children to parents classes. Return values of the methods are abandoned.

A.3.4 start

The methods starts are applied to a job object after befores to the job objects are applied. Its argument is a reference of the job object. The method start in the most specialized class (the left-most module declared on the script header) is called.

In the body of a method, the method new in the parent class is called as

```
$obj->NEXT::start()
```

where $obj is the reference to the object.

In the module core, start is defined. The start creates a job script and submits the job to a job scheduler. Note that this required procedure is skipped unless starts in children classes call the start in the core.

A.3.5 after

In Xcrypt, a completion notice of a job submitted by the method core::start makes the job object's state done. The methods afters are applied to a job object with the state done (cf. Section 3.1). Its argument is a reference to the job object. The order of calling afters is in such a way from parents to children classes. Return values of the methods are abandoned.

A.3.6 finally

to be written...

A.4 Ordinary methods

A developer of Xcrypt modules can add ordinary methods and extended preexisting ordinary methods defined in core.pm in the manner of the object oriented Perl programming. This section lists the ordinary methods defined in core.pm. Note that the methods that can be called by end users are already listed in Chapter 7, which can be extended by Xcrypt module developers, too.

A.4.1 apply_push_valid_arg

A.4.2 make_jobscript

called by qsub_make.

A.4.3 make_jobscript_header

called by make_jobscript

A.4.4 make_jobscript_body

called by make_jobscript

A.4.5 make_in_jobscript

called by make_before_in_jobscript and make_after_in_jobscript

A.4.6 make_before_in_jobscript

called by qsub_make.

A.4.7 make_after_in_jobscript

called by qsub_make.

A.4.8 update_script_file

called by update_jobscript_file, update_before_in_job_file, and update_after_in_job_file.

A.4.9 update_jobscript_file

calls update_script_file

A.4.10 update_before_in_job_file

calls update_script_file

A.4.11 update_after_in_job_file

calls update_script_file

A.4.12 update_all_script_files

It calls update_jobscript_file, update_before_in_job_file, and update_after_in_job_file.

A.4.13 make_qsub_options

called by qsub_make.

A.4.14 qsub_make

called by qsub.

A.4.15 qsub

A.4.16 qdel

A.4.17 qdel_if_queued_or_running

conditionally calls qdel.