CENTER FOR COMPUTATION
& TECHNOLOGY

SAGA

A Simple API for Grid Applications

Introduction to the SAGA API

omii-uk
www.omii.ac.uk

Outline

- API structure and scope
- API walkthrough
- implementation details
- API extensions

SAGA Design Principles

- SAGA: Simple API for Grid Applications
  - OGF approach to a uniform API layer (facade)
- governing principle: 80:20 rule
  - simplicity versus control!
- top-down approach
  - use case driven!
  - defines application level abstractions
- extensible
  - stable look & feel
  - API packages
- API Specification is language independent (IDL)
  - Renderings exist in C++, Python, Java
  - Examples here are in C++

SAGA Intro: Example 1

```
// SAGA: File Management example

saga::filesystem::directory dir ("any://remote.host.net//data/");

if ( dir.exists ("a") && ! dir.is_dir ("a") )
{
  dir.copy ("a", "b", Overwrite);
}

list <saga::url> names = dir.find ("*-{123}.txt");

saga::filesystem::directory tmp  = dir.open_dir ("tmp/", Create);
saga::filesystem::file      file = dir.open     ("tmp/data.txt");
```

SAGA Intro: Example 1

- API is clearly POSIX (libc + shell) inspired
- where is my security??
- what is 'any://' ???
- usage should be intuitive (hopefully)

SAGA Intro: Example 2

```
// SAGA: Job Submission example

saga::job::description jd;
// details left out

saga::job::service js ("any://remote.host.net/");
saga::job::job     j = js.create_job (jd);

j.run ();

cout << "Job State: " << j.get_state () << endl;

j.wait ();

cout << "Retval " << j.get_attribute ("ExitCode") << endl;
```

SAGA Intro: Example 2'

```
// SAGA: Job Submission example



saga::job::service js ("any://remote.host.net");
saga::job::job     j = js.run_job ("touch /tmp/touch.me");



cout << "Job State: " << j.get_state () << endl;

j.wait ();

cout << "Retval " << j.get_attribute ("ExitCode") << endl;
```

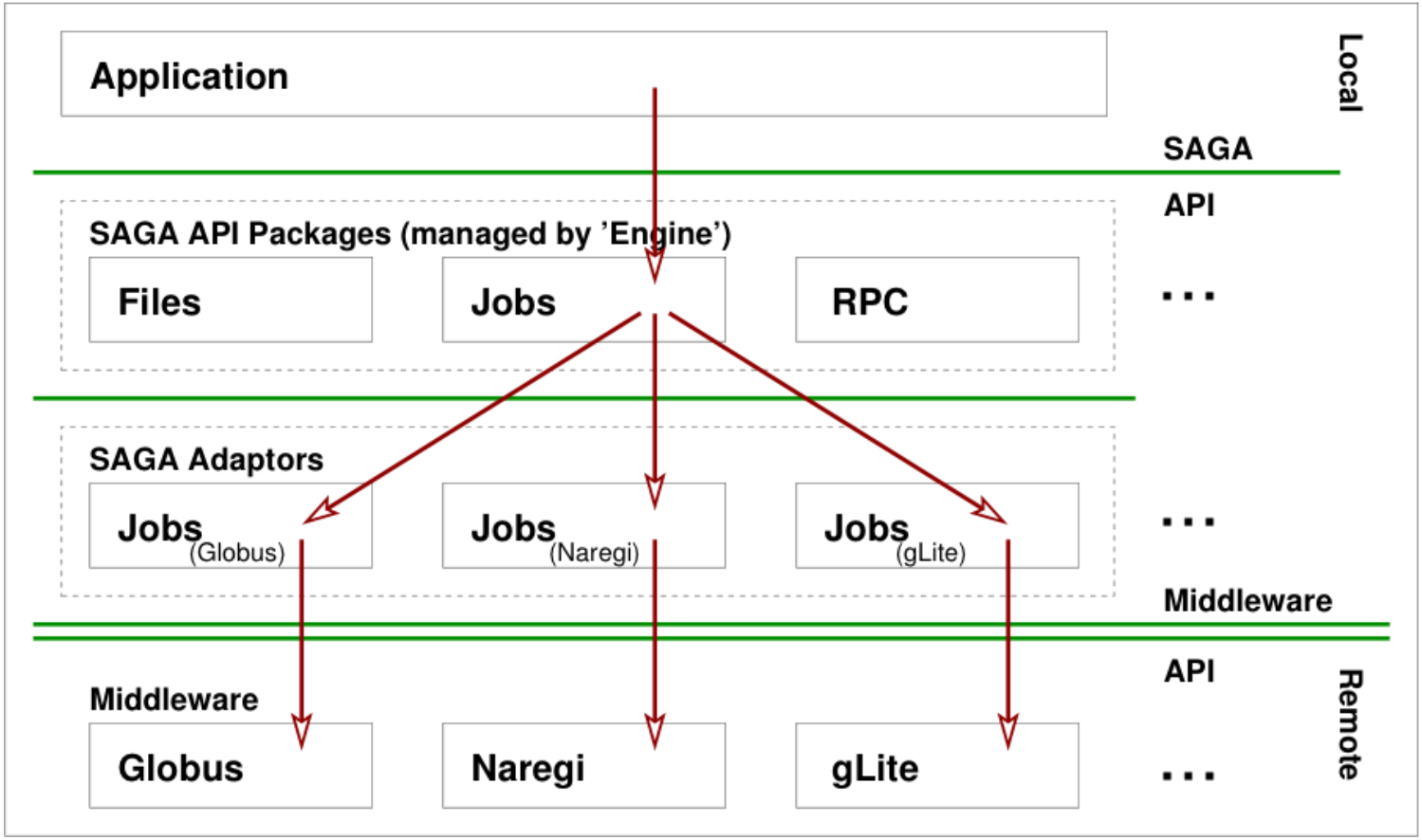
SAGA Intro: Example 2

- stateful objects!
- yet another job description language? :-(
- many hidden/default parameters
  - keeps call signatures small
- 'any://' again!
- TIMTOWTDI (there is more than one way to do it)

SAGA Intro: 10.000 feet

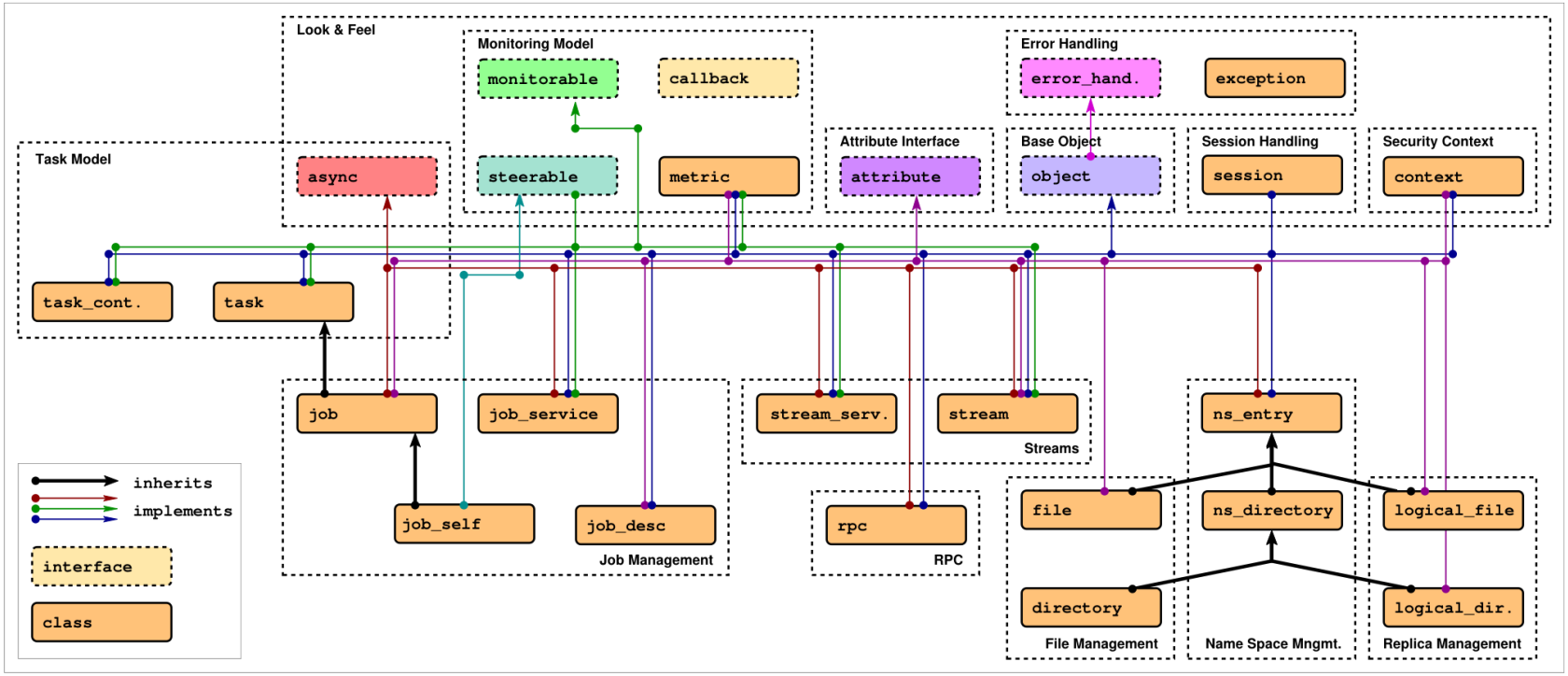
- object oriented:
  - uses inheritance and interfaces
  - very moderate use of templates though!
- functional and non-functional elements strictly separated
  - functional API:
    - typically mappable to remote operations
    - ordered in API 'Packages': extensible
  - non-functional API:
    - typically not mappable to explicit remote operations
    - "look & feel": orthogonal to functional API
    - security, asynchronous ops, notifications, ...
- few inter-package dependencies - allows for partial implementations

Implementation



SAGA Class Hierarchy

SAGA: Class hierarchy



SAGA: Class hierarchy

Functional API Packages

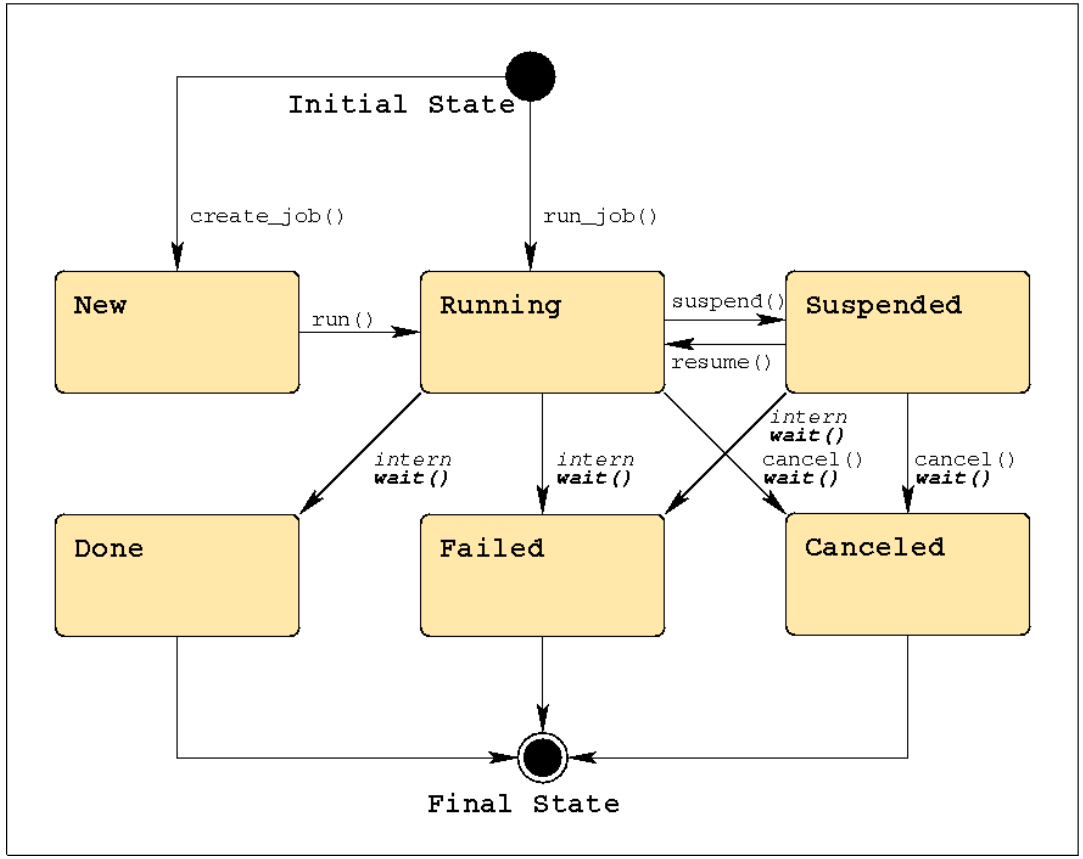
SAGA Job Package: Overview

- running jobs is **use case #1**
- all middlewares support it, one way or the other
- well stablished patterns exist
  - job description
  - job state
  - submission endpoint
  - ...

SAGA Job Package: Example 1

```
saga::job::description jd;
saga::job::service     js ("gram://remote.host.net");
saga::job              j = js.create_job (jd);

j.run ();

cout << "Job State: " << j.get_state () << endl;

j.wait ();

cout << "Retval " << j.get_attribute ("ExitCode") << endl;
```

SAGA Job Package: job states



SAGA Job Package: job operations

```
j.run     ();
j.wait    ();
j.cancel  ();

j.suspend ();
j.resume  ();

j.signal     (SIGUSR1);
j.checkpoint ();
j.migrate    (jd);
```

SAGA Job Package: job description

```
saga::job::description jd;

jd.set_attribute ("Executable",       "/bin/tail");
jd.set_attribute ("WorkingDirectory", "data/");
jd.set_attribute ("Cleanup",          "False");

// pseudo code *blush*
jd.set_vector_attribute ("Arguments",    ["-f", "my_log"]);
jd.set_vector_attribute ("Environment",  ["TMPDIR=/tmp/"]);
jd.set_vector_attribute ("FileTransfer", ["my_log >> all_logs"]);
```

SAGA
A Simple API for Grid Applications

SAGA Job Package: job description

Executable	WorkingDirectory	TotalPhysicalMemory
Arguments	*Interactive*	CPUArchitecture
Environment	Cleanup	OperatingSystemType
CandidateHosts	Input	*Queue*
SPMDVariation	Output	JobProject
TotalCPUCount	Error	*JobContact*
NumberOfProcesses	*JobStartTime*	FileTransfer
ProcessesPerHost	WallTimeLimit	
ThreadsPerProcess	TotalCPUTime	

SAGA Job Package: job description

- leaning heavily on JSDL, but flat
- borrowing from DRMAA
- mixes hardware, software and scheduling attributes!
- cannot be extended
- no support for 'native' job descriptions (RSL, JDL, ...)
- only 'Executable' is required
- backend MAY ignore unsupported keys

  cd /tmp/data && rm -rf *

SAGA Job Package: job service

```
saga::job::service js ("gram://remote.host.net/");

vector <string> ids = js.list ();  // list known jobs

while ( ids.size () )
{
  string    id = ids.pop_back ();  // fetch one job id
  saga::job j  = js.get_job (id);  // reconnect to job

  cout << id << " : " << j.get_state () << endl;
}
```

SAGA Job Package: job service

- represents a specific job submission endpoint
- job states are maintained on that endpoint (usually)
- full reconnect may not be possible (I/O streaming)
- lifetime of state up to backend
- reconnected jobs may have different job description
  (lossy translation)

SAGA Namespace Package

- interfaces for managing entities in name spaces
- files, replicas, information, resources, steering parameter, checkpoints, . . .
- manages hierarchy (mkdir, cd, ls, . . .)
- entries are assumed to be opaque (copy, move, delete, ...)

SAGA Namespace Package: example

```
saga::name_space::directory d ("ssh://remote.host.net//data/");

if ( d.is_entry ("a") && ! d.is_dir ("a") )
{
  d.copy ("a", "../b");
  d.link ("../b", "a", Overwrite);
}

list <saga::url> names = d.find ("*-{123}.text.");

saga::name_space::directory tmp = d.open_dir ("tmp/data/1",
                                    saga::name_space::CreateParents);

saga::name_space::entry data = tmp.open ("data.txt");

data.copy ("data.bak", Overwrite); // uses cwd
```

SAGA Namespace Package

- name space entries are opaque: the name space package can never look inside
- directories *are* entries (inheritance)
- inspection: `get_cwd()`, `get_url()`, `get_name()`, `exists()`, `is_entry()`, `is_dir()`, `is_link()`, `read_link()`
- manipulation: `create()`, `copy()`, `link()`, `move()`, `remove()`
- permissions: `permissions_allow()`, `permissions_deny()`
- wildcards are supported (POSIX influence...)

SAGA Filesystem Package

- implements name space interface
- adds access to **content** of namespace::entries (files)
- POSIX oriented: `read(), write(), seek()`
- optimizations: for distributed file access:
  - scattered I/O
  - pattern based I/O
  - extended I/O (from GridFTP)

SAGA Filesystem Package: Example

```
saga::filesystem::file f ("any://remote.host.net/data/data.bin");

char mem[1024];
saga::mutable_buffer buf (mem);

if ( f.get_size () >= 1024 )
{
  buf.set_data (mem + 0, 512);
  f.seek (512, saga::filesystem::Start);
  f.read (buf);
}

if ( f.get_size () >= 512 )
{
  buf.set_data (mem + 512, 512);
  f.seek (0, saga::filesystem::Start);
  f.read (buf);
}
```

SAGA Filesystem Package

- provides access to the **content** of filesystem entries (sequence of bytes)
- saga buffers are used to wrap raw memory buffers
- saga buffers can be allocated/managed by the SAGA implementation
- several incarnations of read/write: posix style, scattered, pattern based

SAGA Filesystem Package: Flags

```
enum flags {
  None            =    0,
  Overwrite       =    1,
  Recursive       =    2,
  Dereference     =    4,
  Create          =    8,
  Exclusive       =   16,
  Lock            =   32,
  CreateParents   =   64,
  Truncate        =  128,  // not on name_space
  Append          =  256,  // not on name_space
  Read            =  512,
  Write           = 1024,
  ReadWrite       = 1536,  // Read | Write
  Binary          = 2048   // only on filesystem
}
```

SAGA Advert Package

- persistent storage of application level information
- semantics of information defined by application
- allows storage of serialized SAGA objects (object persistency)
- ***very useful for bootstrapping and coordinating distributed application components***

SAGA Advert Package: Example

```
// example for browing my task adverts
saga::advert::directory todo ("any//remote.host.net/my_tasks/");

// pseudo vector code
list <saga::url> urls = todo.find ("*", ["priority=urgent"]);

while ( urls.size () )
{
  saga::advert ad (urls.pop_front ());
  std::cout << ad.get_attribute ("title")       << std::endl;
  std::cout << ad.get_attribute (« deadline")   << std::endl;
  std::cout << ad.get_attribute ("description") << std::endl << std::endl;
}
```

SAGA Advert Package: Example

```
// master side code: advertise (publish) a saga::file instance
saga::file f (url);

saga::advert ad ("any//remote.host.net/files/my_file_ad", Create);

ad.store_object (f);
```

```
// client side code: retrieve file instance
saga::advert ad ("any//remote.host.net/files/my_file_ad");

saga::file f = ad.retrieve_object ();
```

SAGA: Class hierarchy

Look & Feel Packages

SAGA Session: Example – default session

```
saga::ns_dir dir ("any://remote.host.net//data/");

if ( dir.is_entry ("a") && ! dir.is_dir ("a") )
{
  dir.copy ("a", "../b");
  dir.link ("../b", "a", Overwrite);
}

list <saga::url> names = dir.find ("*-{123}.text.");

saga::name_space::directory sub   = dir.open_dir ("tmp/");
saga::name_space::entry     entry = dir.open     ("data.txt");

entry.copy ("data.bak", Overwrite);
```

SAGA Session: Properties

- by default hidden (default session is used)
- session is identified by lifetime of security credentials, and by objects in this session (jobs etc.)
- session is used on object creation (optional)
- saga::context can attach security tokens to a session
  - the default session has default contexts

SAGA Session: Example – explicit session

```
saga::context c1 (saga::context::X509);
saga::context c2 (saga::context::X509);

c2.set_attribute ("UserProxy", "/tmp/x509up_u123.special");

saga::session s;

s.add_context (c1);
s.add_context (c2);

saga::name_space::dir dir (s, "any://remote.host.net/data/");
```

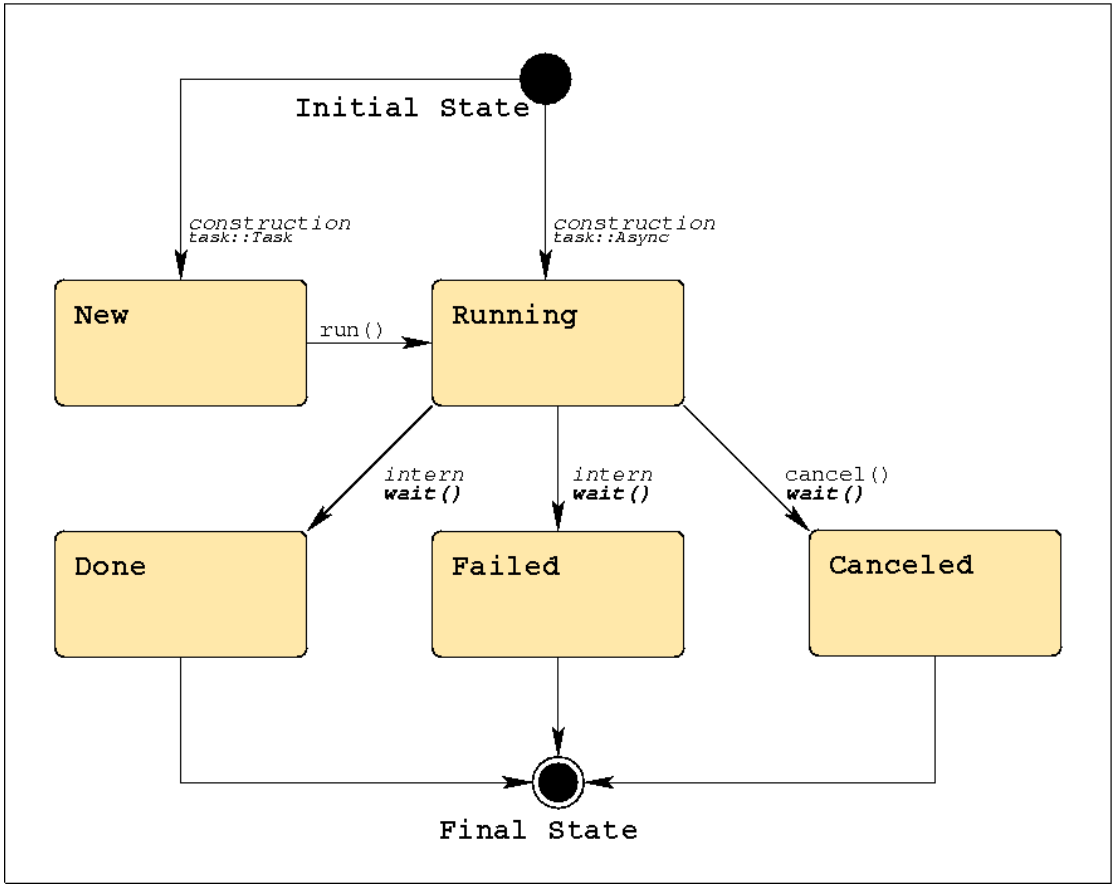
SAGA Session: Lifetime

```
saga::dir  dir (s, "gridftp://remote.host.net/data/");

saga::file file = dir.open ("data.bin");

s.remove_context (c1);
s.remove_context (c2);

file.copy ("data.bin.bak");  // this works – session is sticky!
```

SAGA Tasks

- asyncronous operations are a MUST in distributed systems, and thus Grids
- `saga::task` represents an asyncronous operation (e.g. `file.copy ()`)
- `saga::task_container` manages multiple tasks
- tasks are stateful (similar to jobs)

SAGA Tasks: States



SAGA Tasks

- different versions for each method call: `Sync, Async, Task`
- signature basically the same
- differ in state of the task returned by that method
  - `Sync:` task is `Done`
  - `Async:` task is `Running` -> `wait();`
  - `Task:` task is `New` -> `run(); wait();`
- delayed exception delivery

```
if ( saga::task::Failed == task.get_state () )
{
    task.rethrow ();
}
```

SAGA Task: Example

```
// normal method call, synchronous
/* void */ file.copy ("data.bak");

// async versions, never throw (use 'rethrow()' on failure)
saga::task t1 = file.copy     <saga::task::Sync>  ("data.bak.1");
saga::task t2 = file.copy     <saga::task::Async> ("data.bak.2");
saga::task t3 = file.copy     <saga::task::Task>  ("data.bak.3");

// t1: Done
// t2: Running
// t3: New

t3.run ();    // t3 now Running, too

t2.wait ();
t3.wait ();

// t1, t2, t3 are final (Done or Failed)
```

SAGA Task: Example

```
// normal method call, synchronous
size_t s = file.get_size ();

// async versions, never throw (use 'rethrow()' on failure)
saga::task t1 = file.get_size <saga::task::Sync>  ();
saga::task t2 = file.get_size <saga::task::Async> ();
saga::task t3 = file.get_size <saga::task::Task>  ();

// get_result: implies wait() and rethrow(), and thus can throw!
size_t s1 = t1.get_result <size_t> ();
size_t s2 = t2.get_result <size_t> ();
size_t s3 = t3.get_result <size_t> ();
```

SAGA Task Container: Example

```
// create task container
saga::task_container tc;

// add tasks
tc.add (t1);
tc.add (t2);
tc.add (t3);

// collective operations on all tasks in container
tc.run ();

saga::task done_task = tc.wait (saga::task::Any);

tc.wait (saga::task::All);
```

SAGA Task Container: Tasks and Jobs

```
// NOTE:
// class saga::job : public saga::task
// task container can thus manage tasks *and* jobs:

saga::task task = file.copy <saga::task::Async> ("b");
saga::job  job  = js.run_job ("remote.host.net", "/bin/date");

saga::task_container tc;

tc.add (task);
tc.add (job);

tc.wait (saga::task::All);
```