OpenGridForum

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SAGA – a Simple API for Grid Applications

Introduction to the API

Agenda

- SAGA API structure and scope
- walkthrough
- SAGA extensions

Grid APIs and Frameworks

- coding applications for Grids is notoriously difficult:
  - complex infrastructure,
  - diversity of middlewares
  - invironment evolves very quickly
- diversity of Grid Middleware implies diversity of APIs
- difficult to keep up with MW development, and to stay **simple**
- few APIs try to generalize Grid programming concepts

OGF: Summary

- some API standards exist in OGF, and are successfull
- OGF APIs do **not** cover the complete OGF scope
- the various API standards are disjunct
- WSDL as service interface specification cannot replace an application level API (wrong level of abstraction)

- **SAGA tries to address these issues**

OGF: top-down vs. bottom-up

- bottom-up often agrees on (semantic) LCD + backend specific extensions
- top-down usually focuses on semantics of application requirements

- bottom-up APIs tend to be more powerful
- top-down APIs tend to be simplier and more concise

- **we very much prefer top-down!**

SAGA

Simple API for Grid Applications

SAGA Design Principles

- **SAGA**: **S**imple **A**PI for **G**rid **A**pplications
- OGF approach to a uniform API layer (facade)
- **governing principle: 80:20 rule**
  simplicity versus control!
- **top-down approach:** use case driven!
  $\rightarrow$ defines **application level** abstractions
- **extensible:** stable look & feel + API packages
- **influenced by:** DRMAA, GridRPC, OREP, JSDL, POSIX, GAT, CoG, LSF, Globus, ...
- API Specification is **Language Independent** (IDL)
  Renderings exist in C++, Python, Java
  Examples here are in C++

SAGA Intro: Example 1

SAGA: File Management

```
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://' ???

SAGA Intro: Example 2

SAGA: Job Submission

```
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

```
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;
```

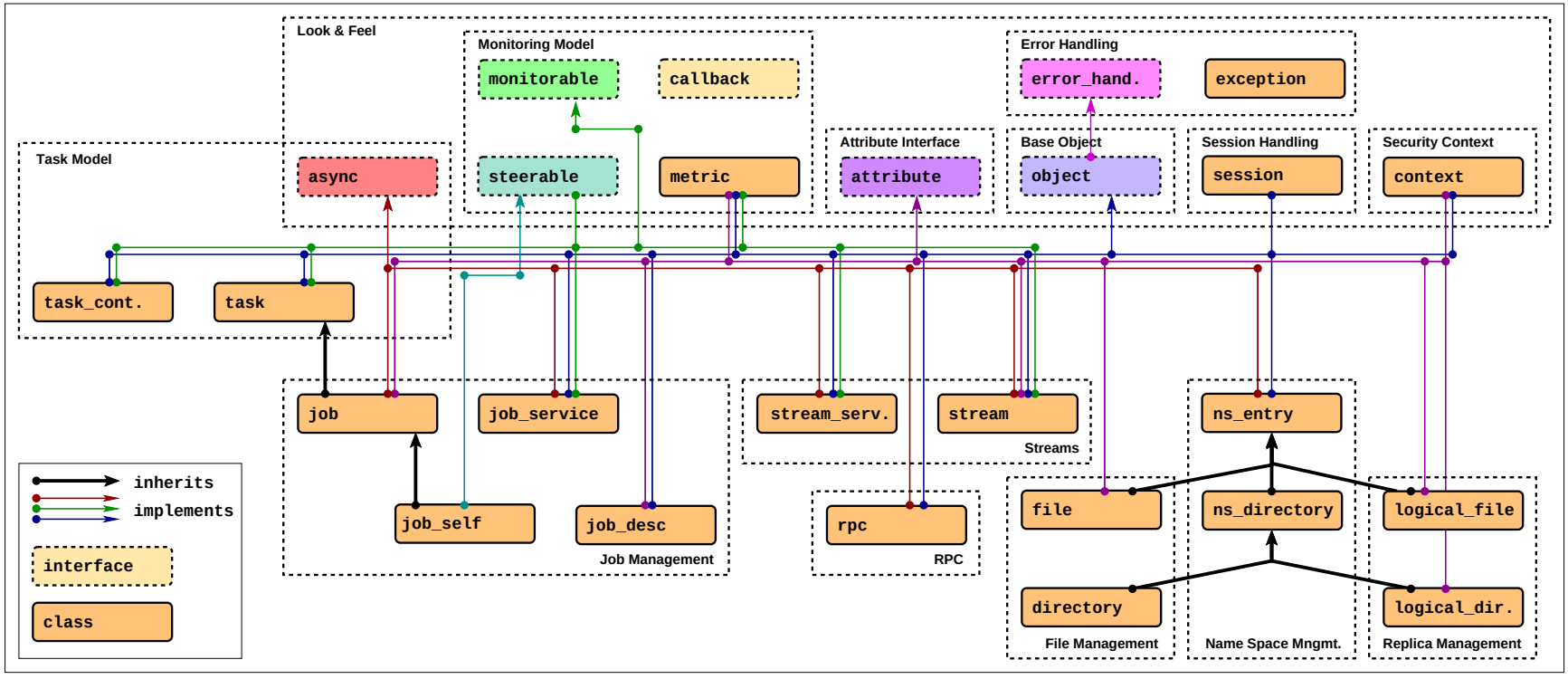
SAGA Intro: Example 2

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

SAGA Intro: 10.000 feet

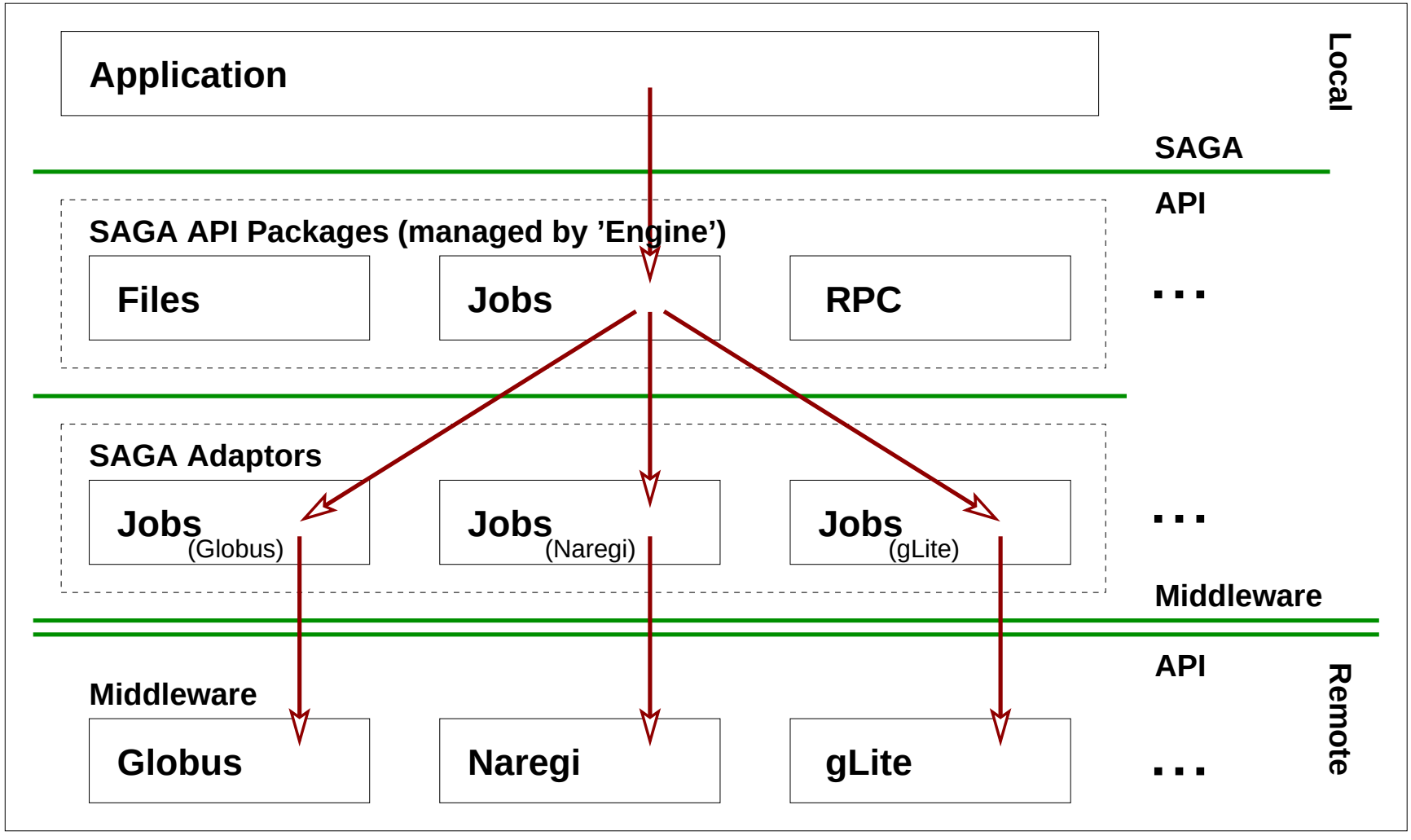
- **object oriented:** inheritance, interfaces
  very moderate use of templates though!
- functional and non-functional elements strictly separated
  - *non-functional API:* look & feel- orthogonal to functional API
    often not mappable to remote operations
  - *functional API:* API 'Packages' - extensible
    typically mappable to remote operations
- few inter-package dependencies - allows for partial implementations

SAGA: Class hierarchy

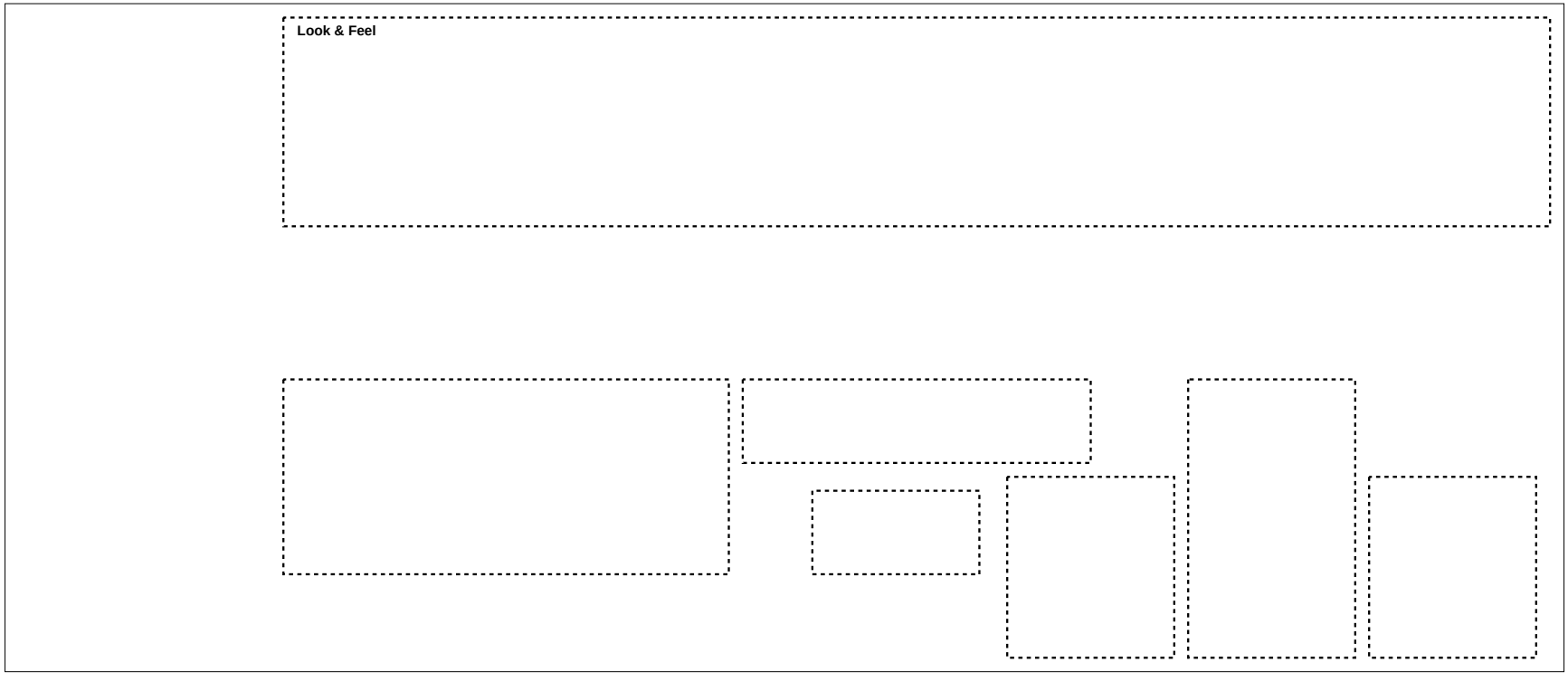


SAGA API Structure: look & feel (top) + API packages (bottom)

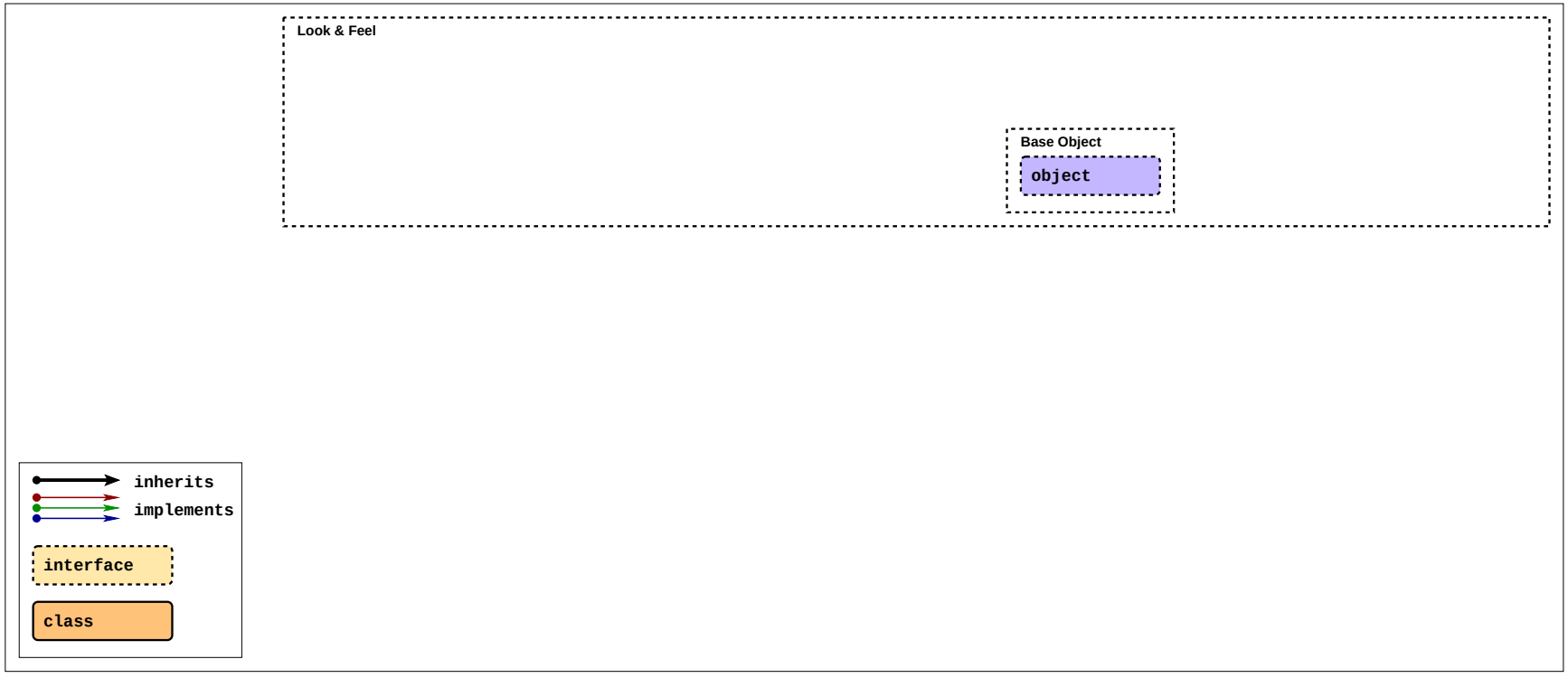
Implementation



SAGA: Class hierarchy



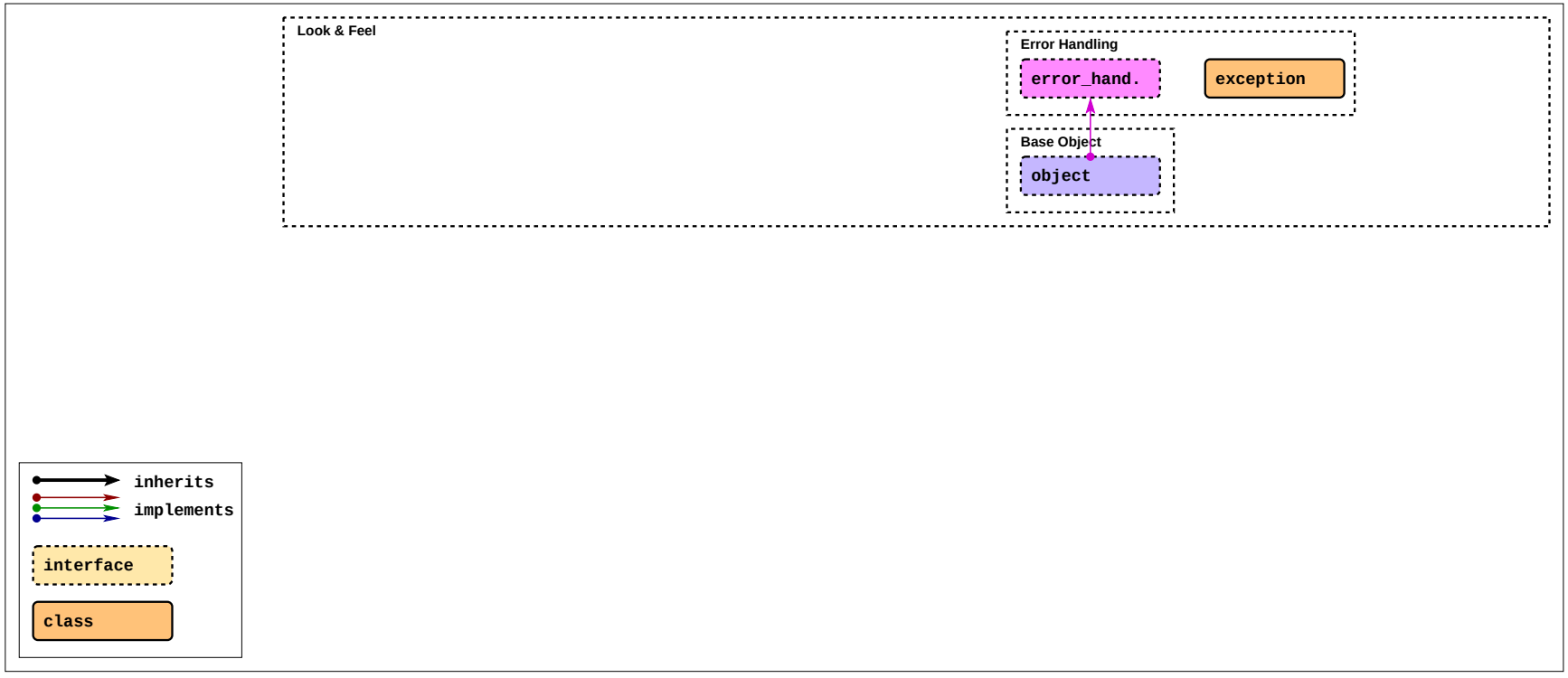
SAGA: Class hierarchy



SAGA Look & Feel:

`saga::object` allows for object uuids, `clone()` etc.

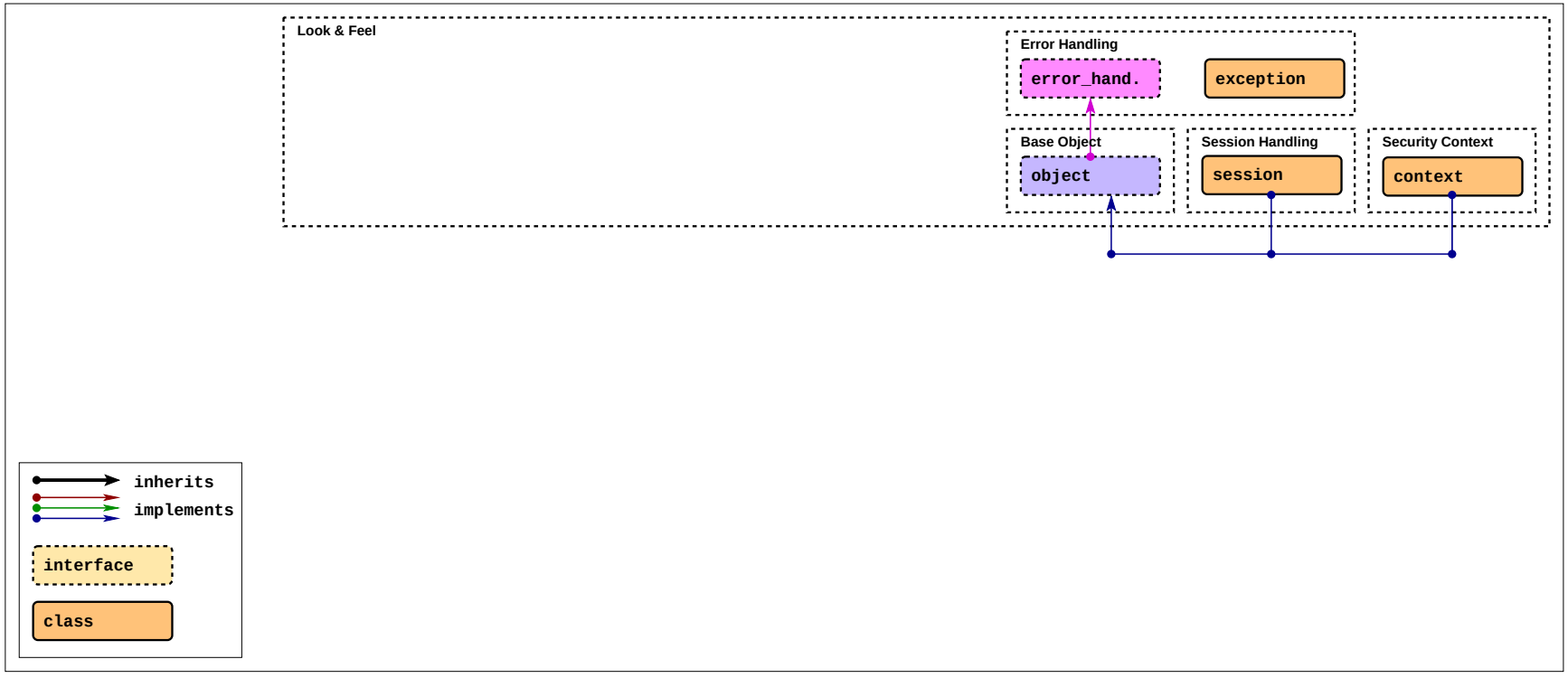
SAGA: Class hierarchy



SAGA Look & Feel:

errors are based on exceptions or error codes.

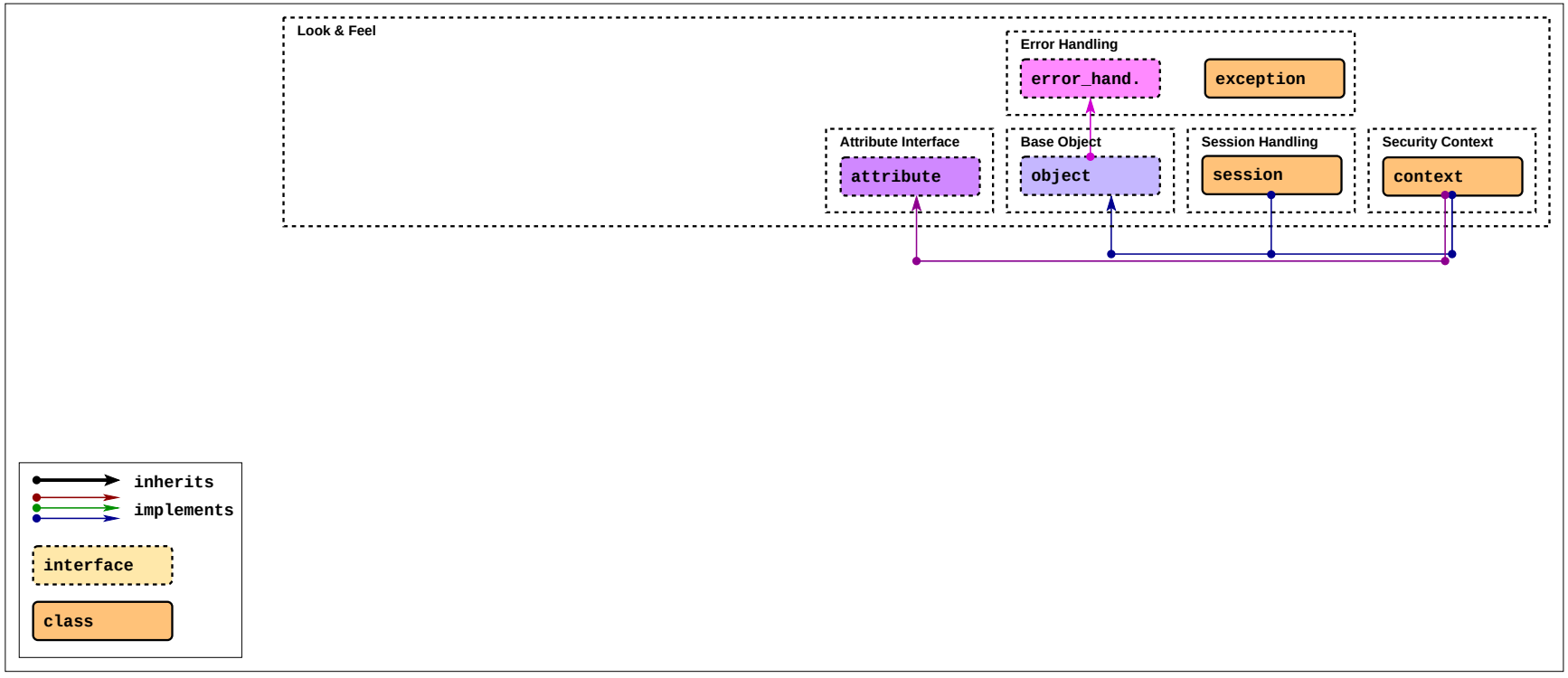
SAGA: Class hierarchy



SAGA Look & Feel:

session and credential management is hidden.

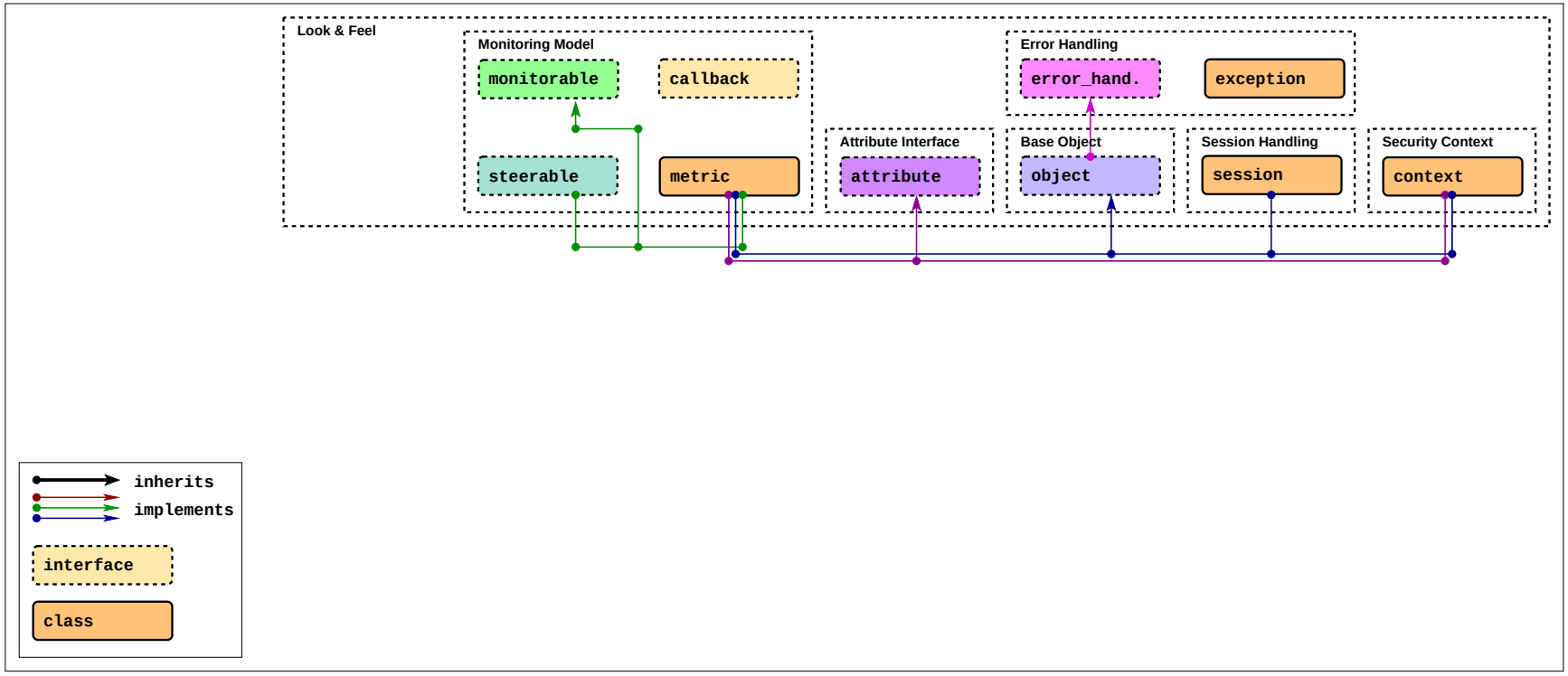
SAGA: Class hierarchy



SAGA Look & Feel:

Attribute interface for meta data.

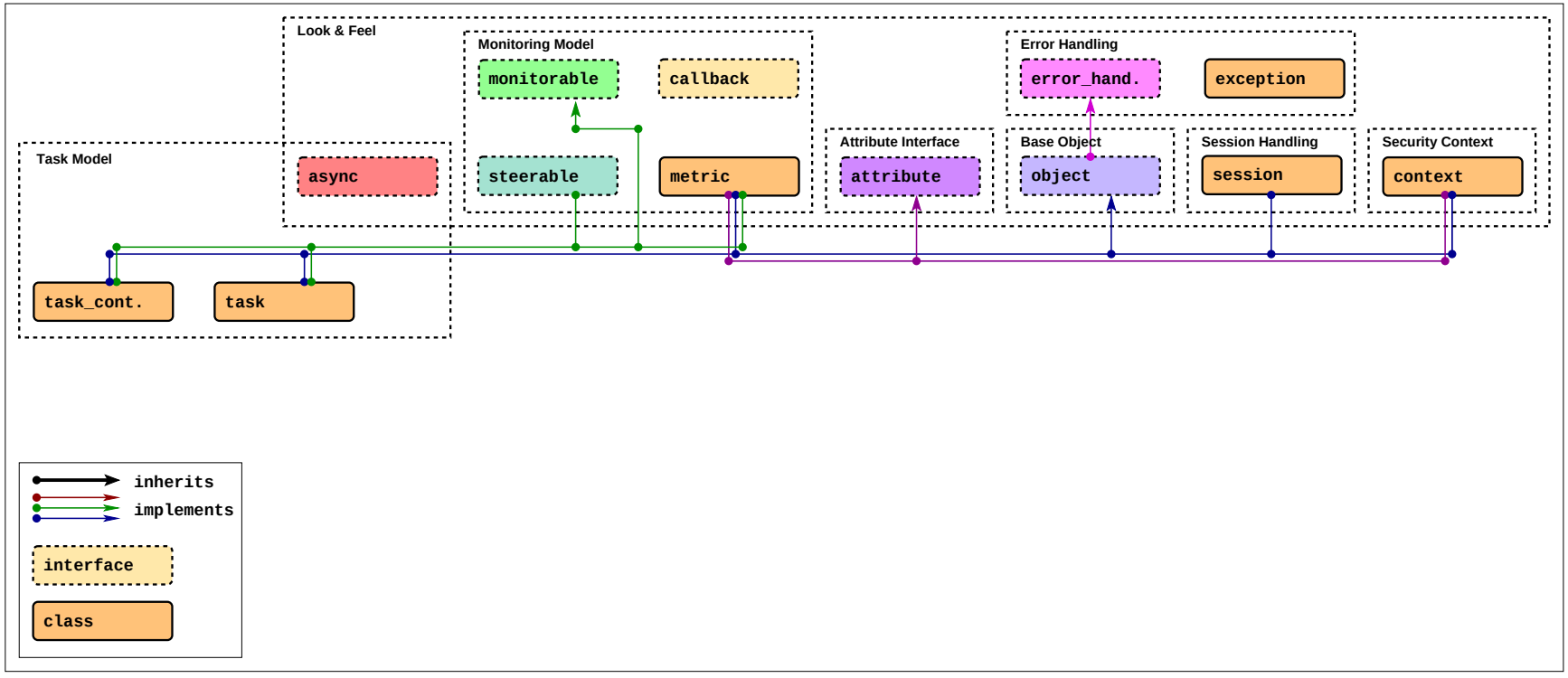
SAGA: Class hierarchy



SAGA Look & Feel:

Monitoring includes asynchronous notifications.

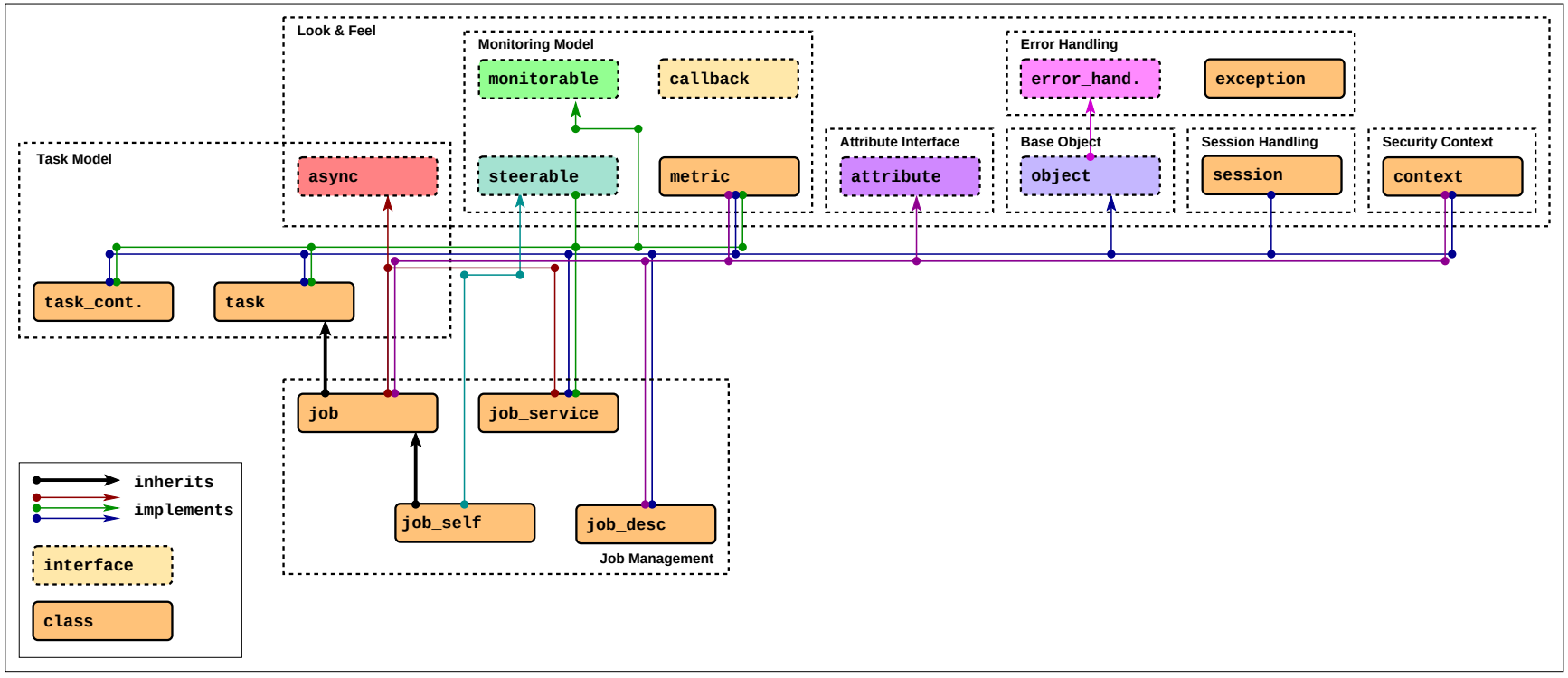
SAGA: Class hierarchy



SAGA Look & Feel:

the task model adds asynchronous operations.

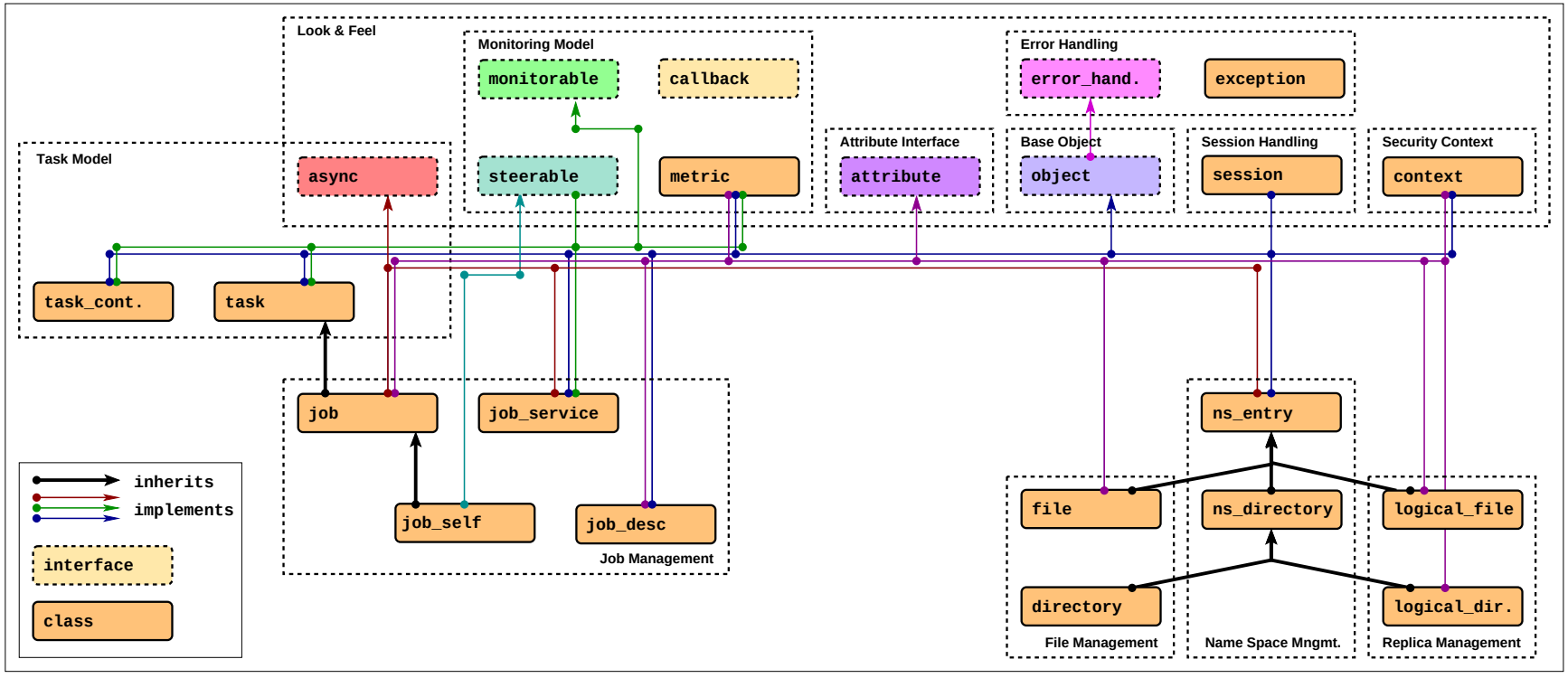
SAGA: Class hierarchy



SAGA API Package 'job':

create and manage remote processes.

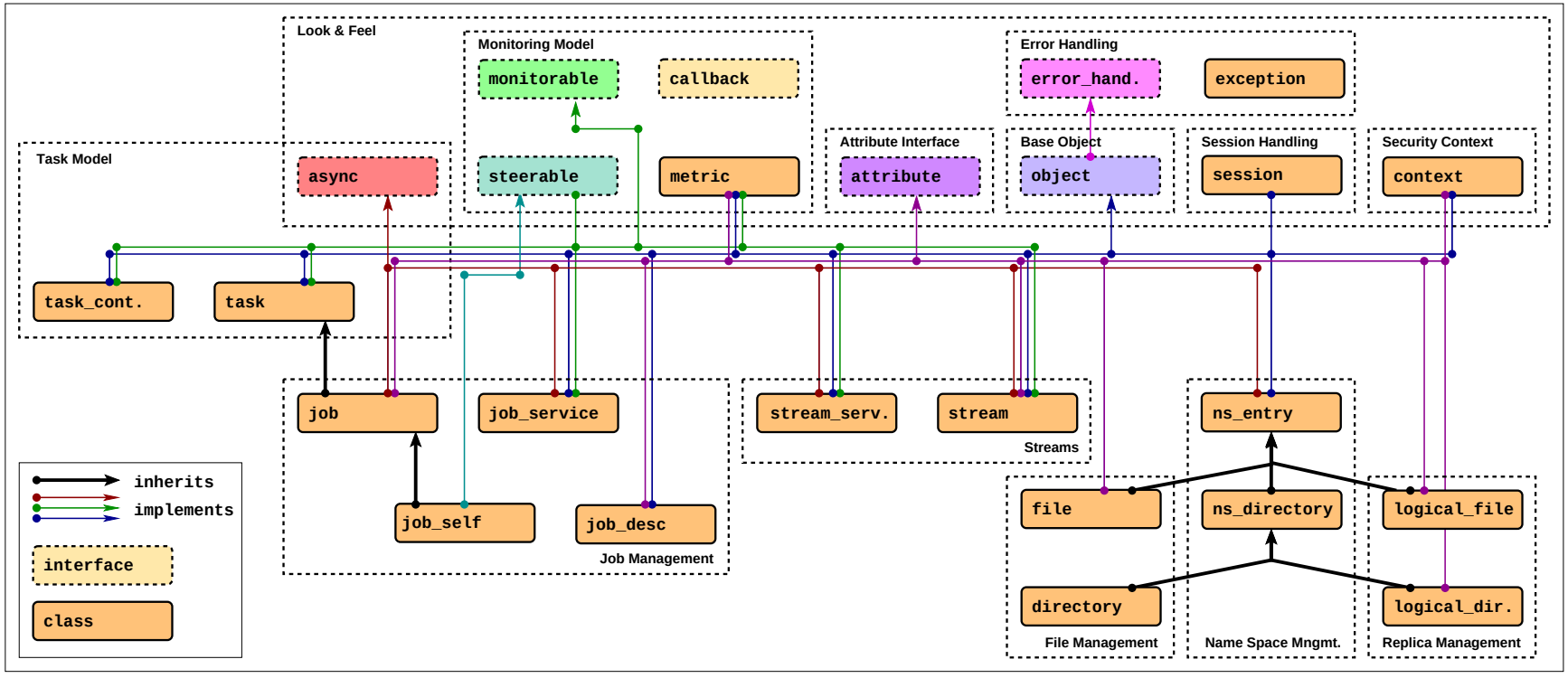
SAGA: Class hierarchy



SAGA API Package 'name_spaces':

manage files, replicas, etc.

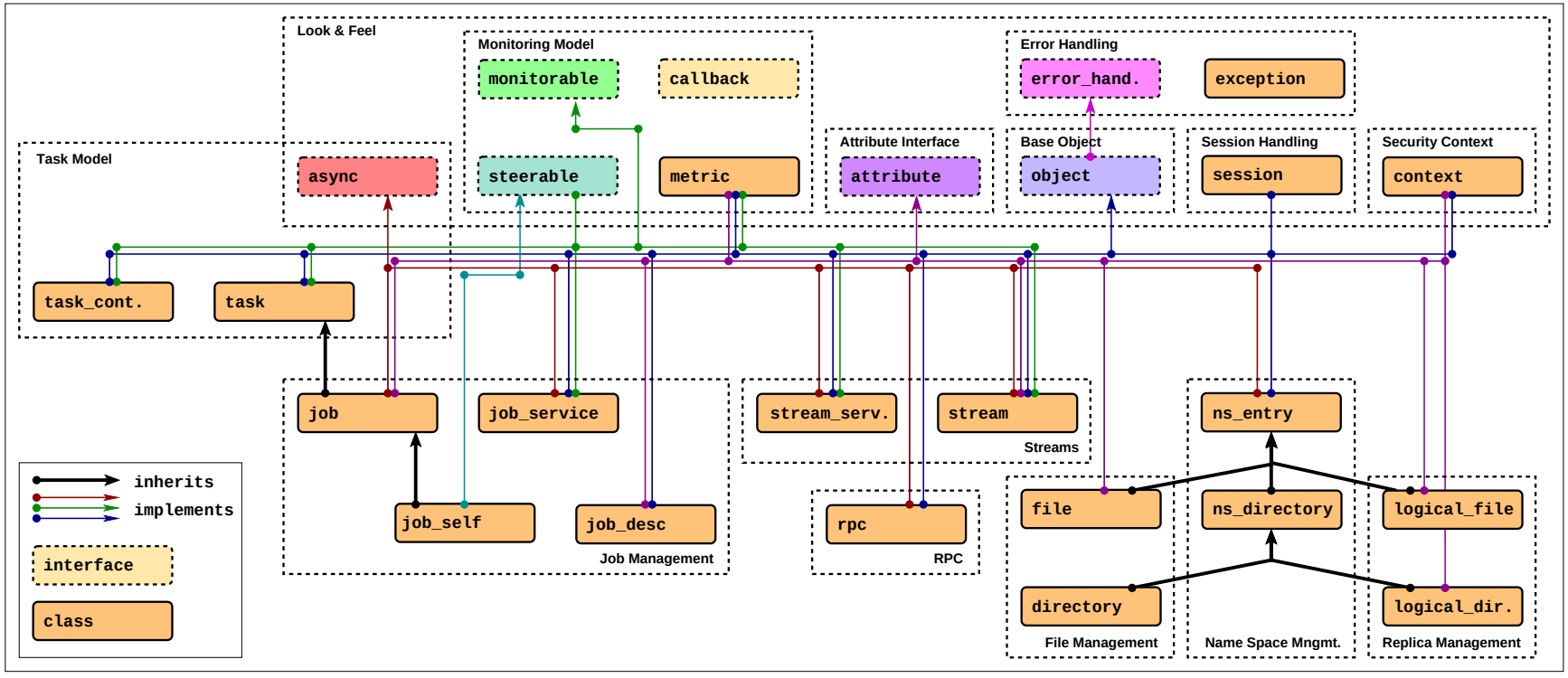
SAGA: Class hierarchy



SAGA API Package 'stream':

SAGA rendering of BSD streams.

SAGA: Class hierarchy

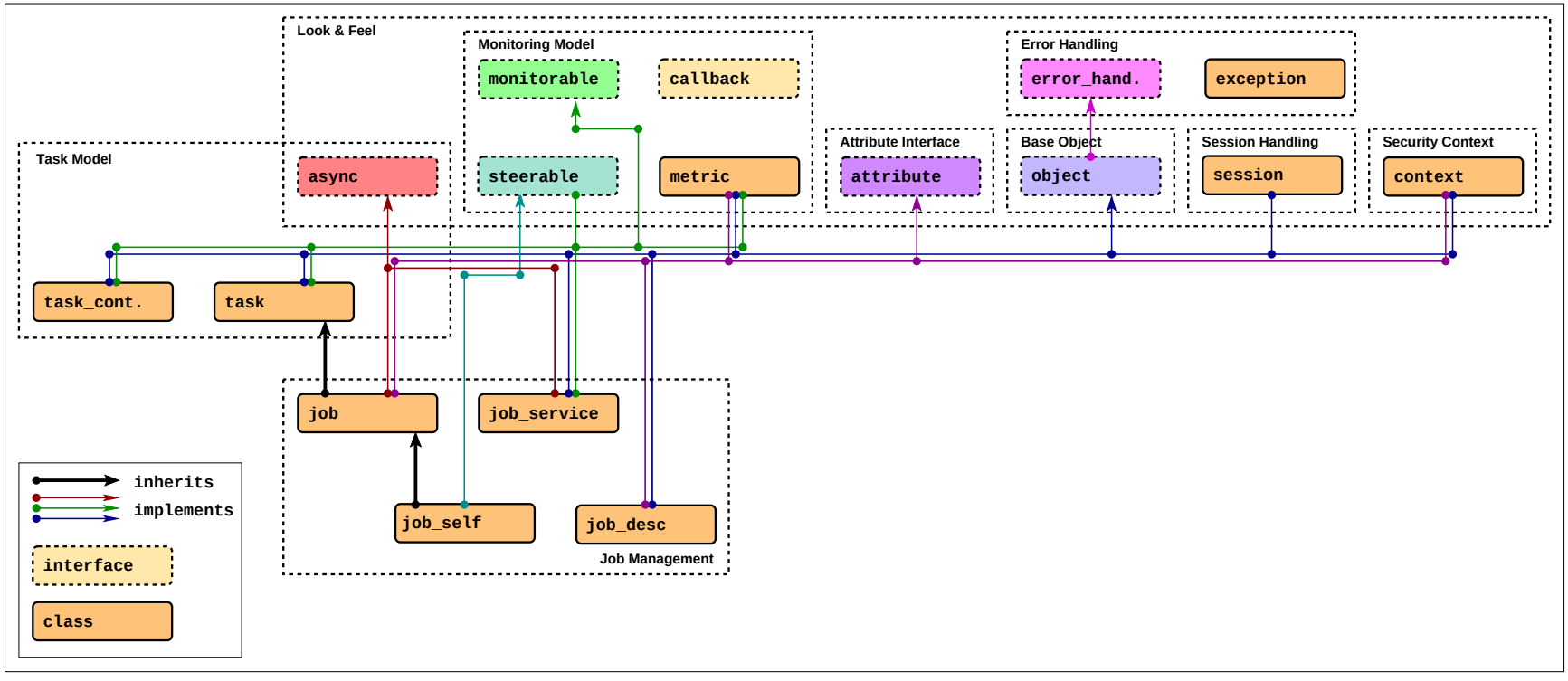


SAGA API Package ’rpc’:

remote procedure calls.

Functional API Packages

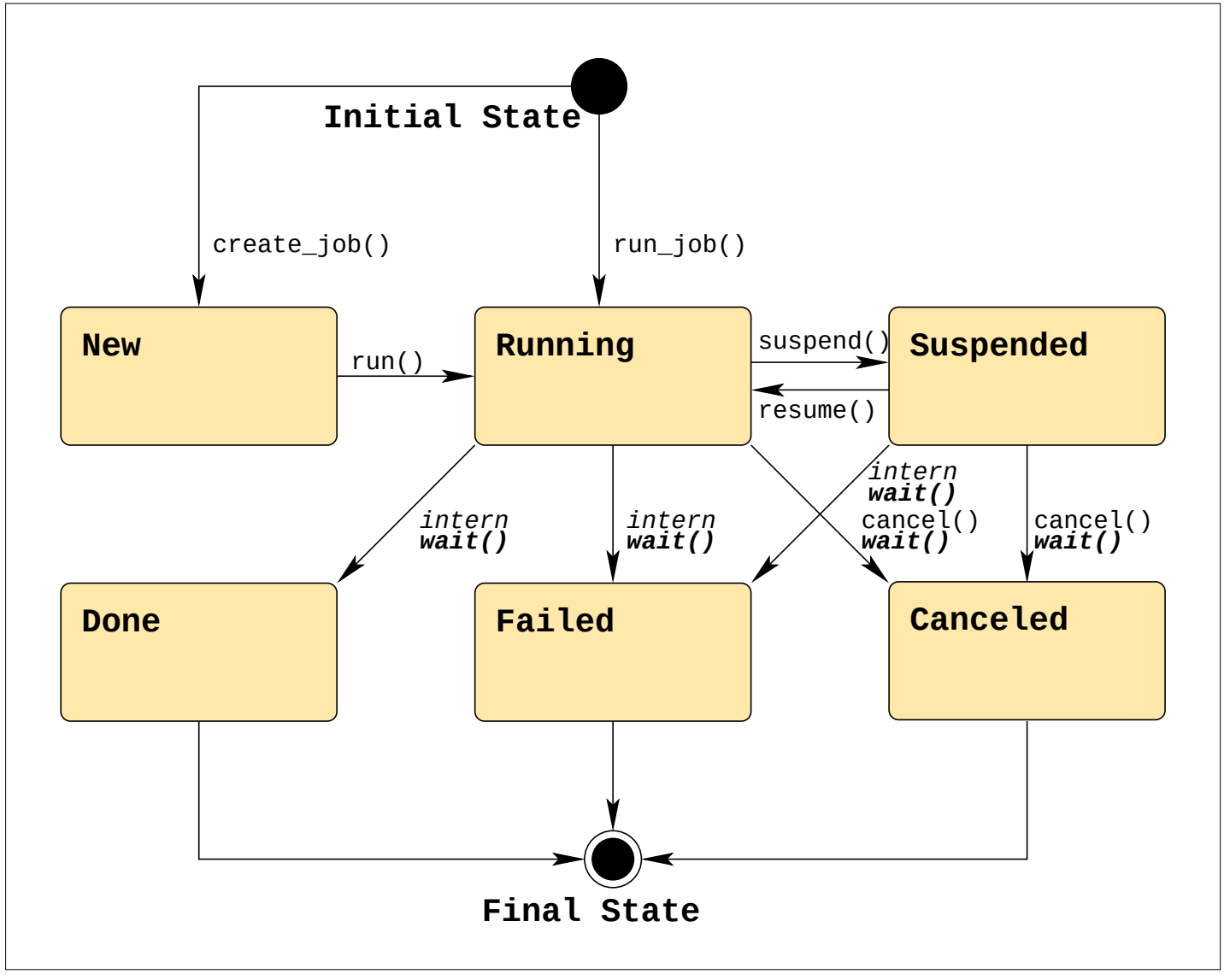
SAGA: Jobs


Look & Feel
Monitoring Model
monitorable
callback
Error Handling
error_hand.
exception
Task Model
async
steerable
metric
Attribute Interface
attribute
Base Object
object
Session Handling
session
Security Context
context
task_cont.
task
job
job_service
job_self
job_desc
Job Management
inherits
implements
interface
class

SAGA: Jobs - Overview

- `job_service` uses `job_description` to create `job` instances
- `job_description` attributes are based on JSDL
- state model is based on / synced with BES
- `job_self` represents the SAGA application
- job submission and management, but no resource discovery, job dependencies, or workflows

SAGA: Job States



SAGA Examples: Jobs

job submission

```
saga::job::service     js ("gram://headnode.gram.net");
saga::job::job         j = js.run_job ("/bin/sleep 10",
                                       "clusternode-2.gram.net");


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

j.wait ();

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

SAGA Examples: Jobs

job submission

```
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 Examples: Jobs

jobs (cont.)

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

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

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

SAGA Examples: Job Descr.

job description - JSDL based

```
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 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 Example: job service

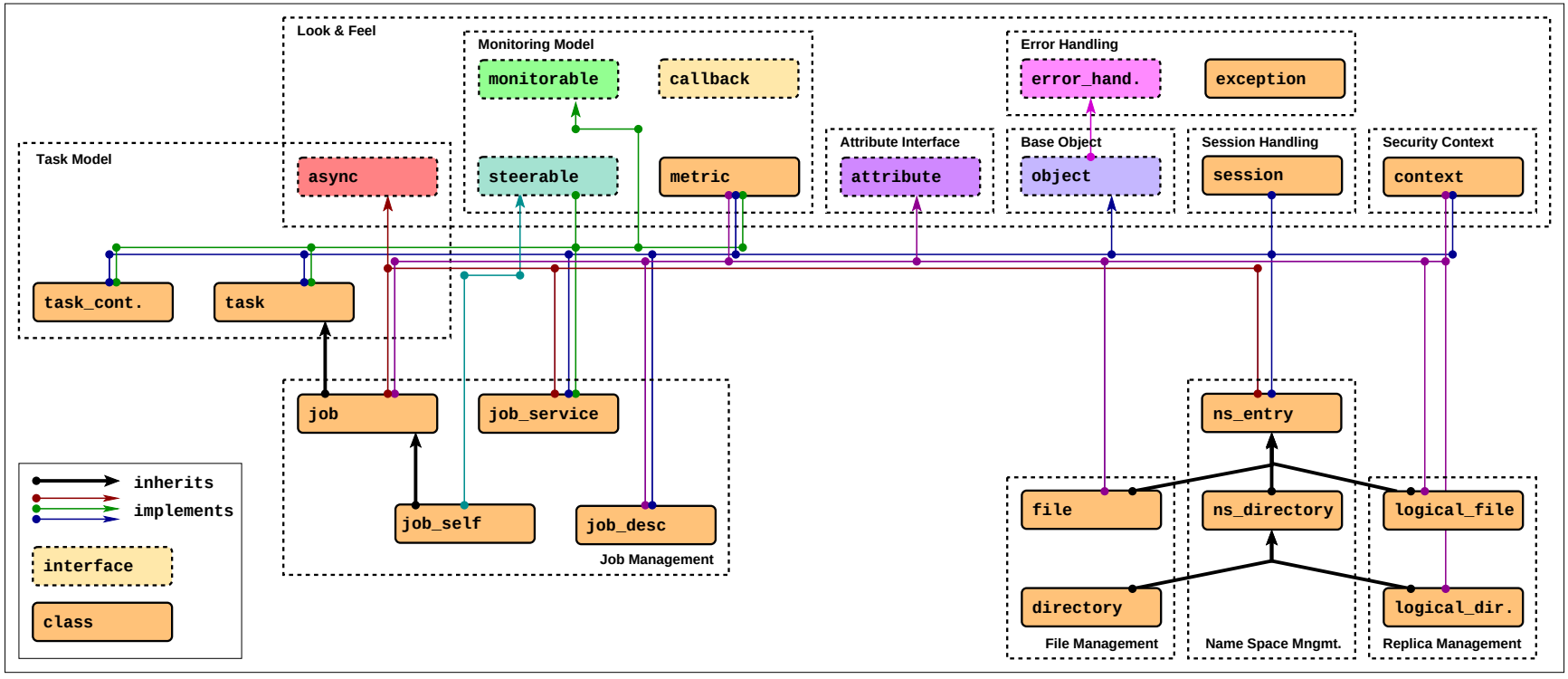
job service

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

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

while ( ids.size () )
{
  string id = ids.pop_back ();

  saga::job j = js.get_job (id);  // reconnect to job

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

SAGA 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: Name Spaces etc.



SAGA: Name Spaces

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

SAGA: Files

- implements name space interface, and adds access to content of NS entries (files)
- Posix oriented: read, write seek
- Grid optimizations: scattered I/O, pattern based I/O, extended I/O

SAGA: Replicas

- implements name space interface, and adds access to properties of NS entries (logical files / replicas)
- O/REP oriented: list, add, remove replicas; manage meta data
- Grid optimizations are hidden (replica placement strategies, consistency and version management, . . .)

SAGA: Adverts

- implements name space interface, and adds access to arbitrary key/value pairs on each entry.
- entries also allow to store a **serialized** SAGA Object!
- utterly useful for application bootstrapping, communication between different application modules, application persistency, etc etc.
- **not part of the SAGA Specification**, but is getting standardized as an extension

SAGA Examples: NameSpaces

name space management

```
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 Name Spaces

- 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 (c'tor, open), copy, link, move, remove`
- **permissions:**
  `permissions_allow, permissions_deny`
- wildcards are supported (remember POSIX influence...)

SAGA Examples: Files

file access

```
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

- 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 by the engine
- several incarnations of read/write: posix style, scattered, pattern based

SAGA Name Spaces: Flags

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         = 204    // only on filesystem
}
```

SAGA Examples: Replicas

replica management

```
saga::replica::directory dir ("raptor://remote.host.net/data/");

if ( dir.is_entry ("a") || dir.is_link ("a") )
{
  dir.copy ("a", "../b");
  dir.link ("../b", "a");
}

saga::replica::file file = dir.open ("tmp/data.txt");
list <string>  locations = file.list_locations ();

file.replicate ("gridftp://other.host.net/tmp/a.dat");
```

SAGA Replica

- provides access to the **content** of replica system entries (list of physical locations, plus attributes)
- saga attribute interface is used for entry meta data. Meta data are maintained by application, and/or backend.
- `replicate()` creates a new copy, and adds new location to list

SAGA Examples: Replicas

replica meta data

```
saga::replica::directory dir ("raptor://remote.host.net/data/");

list <saga::url> files = dir.find ("*", "type=jpg");

while ( file.size () )
{
  saga::logical_file lf (file.pop_front ());

  lf.replicate ("file://localhost/data/images/",
                saga::replica::Overwrite);
}
```

SAGA Adverts

- persistent storage of application level information
- semantics of information defined by application
- allows storage of serialized SAGA objects (object persistency)

SAGA Examples: Adverts

Adverts

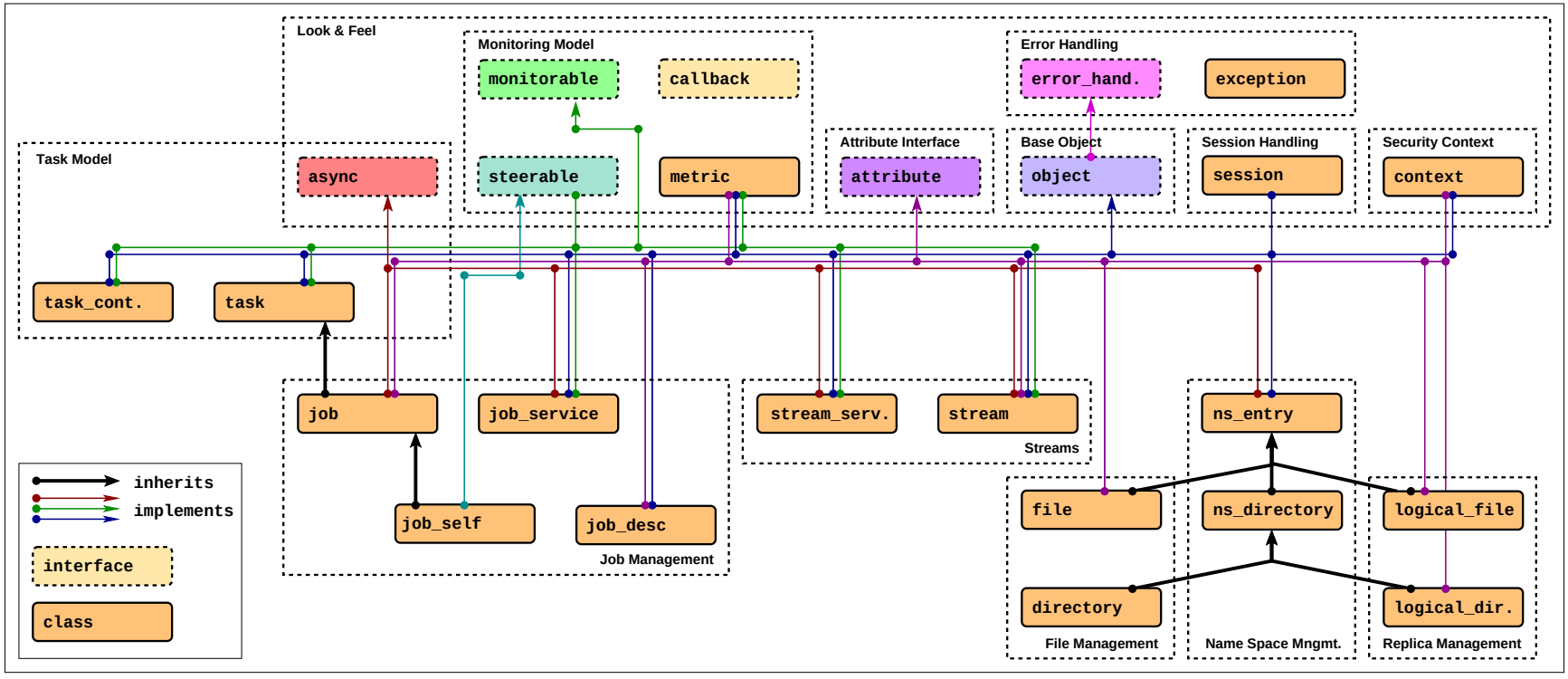
```
saga::advert::directory todo ("any//remote.host.net/my_tasks/");

// 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 ("description") << std::endl;
}
```

SAGA Examples: Adverts

Persistent SAGA Objects

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

ad.store_object (f);

-------------------------------------------------------------------

saga::advert ad ("any//remote.host.net/files/my_file_ad");
saga::file   f = ad.retrieve_object ();
```

SAGA: Streams



SAGA Examples: Streams

stream server

```
saga::stream_service ss ("tcp://localhost:1234");

saga::stream_client sc = ss.serve ();

sc.write ("Hello client", 13);
```

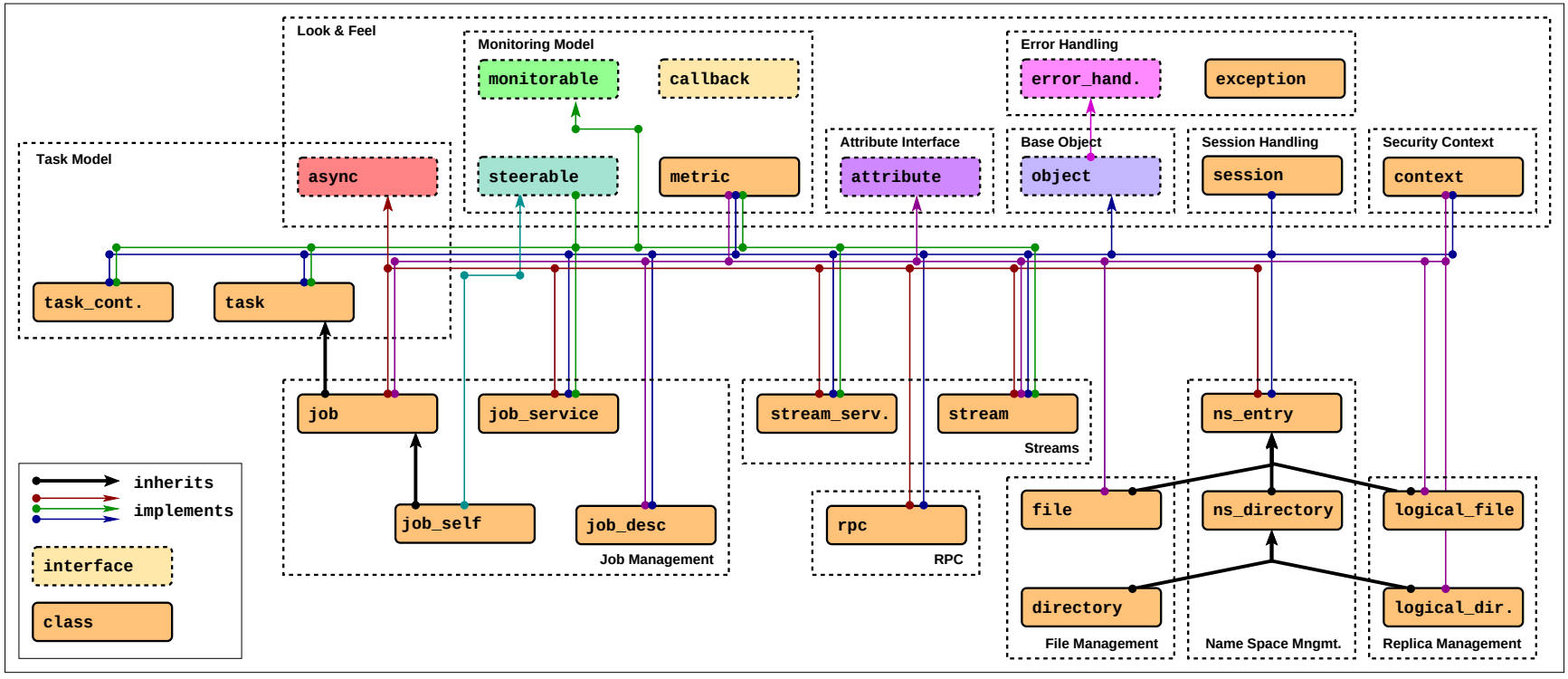
stream client

```
char buf [13];
saga::stream_client sc ("tcp://remote.host.net:1234");

sc.connect ();
sc.read    (buf, 13);

cout << buf << endl;
```

SAGA: Streams

- simple and BSD socket oriented
- not supposed to replace MPI etc, but allows for simple application level communication
- will be superceded by message package

SAGA: RPC


Look & Feel
Monitoring Model
monitorable
callback
Error Handling
error_hand.
exception
Task Model
async
steerable
metric
Attribute Interface
attribute
Base Object
object
Session Handling
session
Security Context
context
task_cont.
task
job
job_service
stream_serv.
stream
Streams
ns_entry
job_self
job_desc
Job Management
rpc
RPC
file
ns_directory
logical_file
directory
logical_dir.
File Management
Name Space Mngmt.
Replica Management
inherits
implements
interface
class

SAGA Examples: RPC

remote procedure call

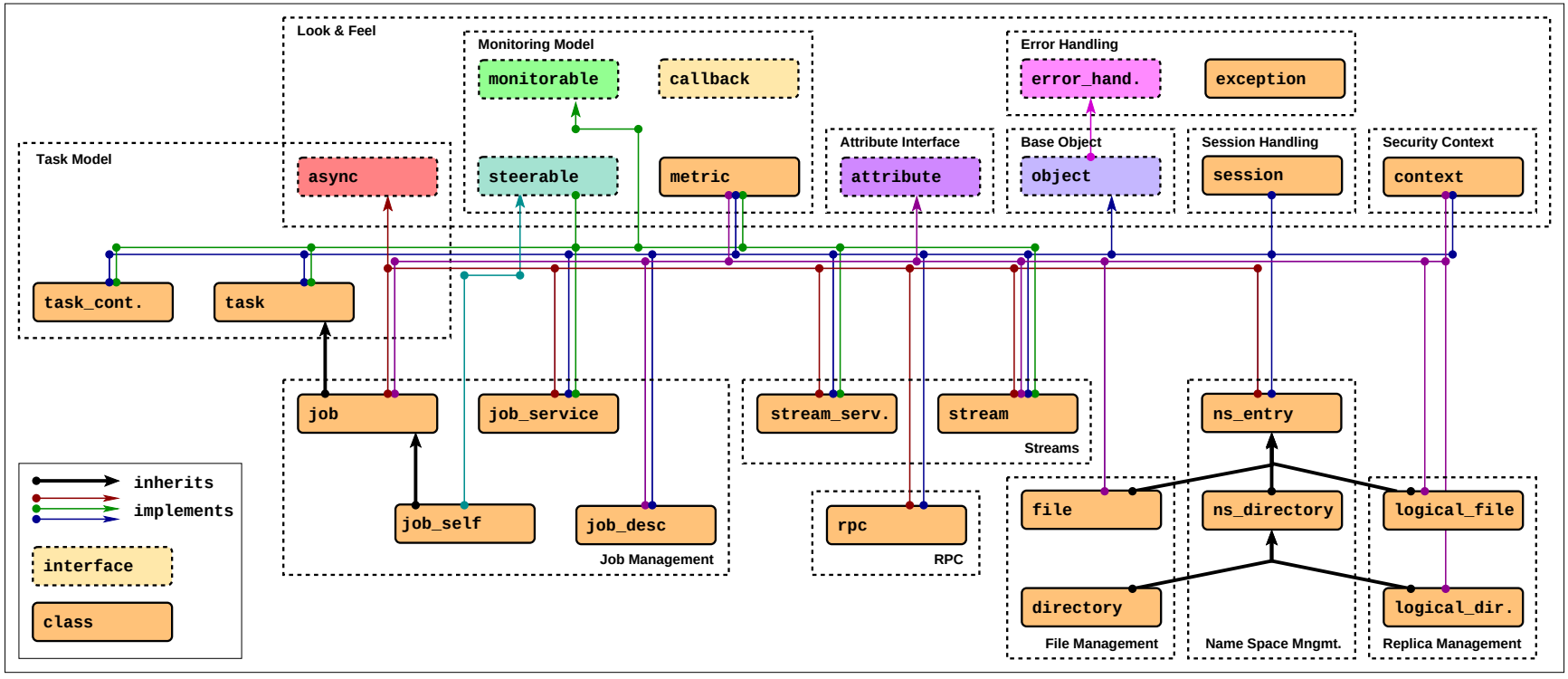
```
saga::rpc rpc ("ninfg://remote.host.net:1234/random");

list <saga::rpc::parameter> params;
params.push_back (new saga::rpc::parameter (Out, 10));

rpc.call (params);

cout << "found random number: " << ::atoi (param.buffer) << endl;

delete (params.pop_front ());
```

SAGA: RPC

- maps GridRPC standard into the SAGA look & feel
- parameters are stack of structures (similar to scattered I/O)
- future revision will work on optimized data handling

Non-Functional API Packages

SAGA: Session and Context



SAGA Examples: Session

default sessions

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

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

SAGA Examples: Session

context management

```
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 Management

- 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` is used to attach security tokens to a session
- the default session has default contexts

SAGA Examples: Session

session inheritance

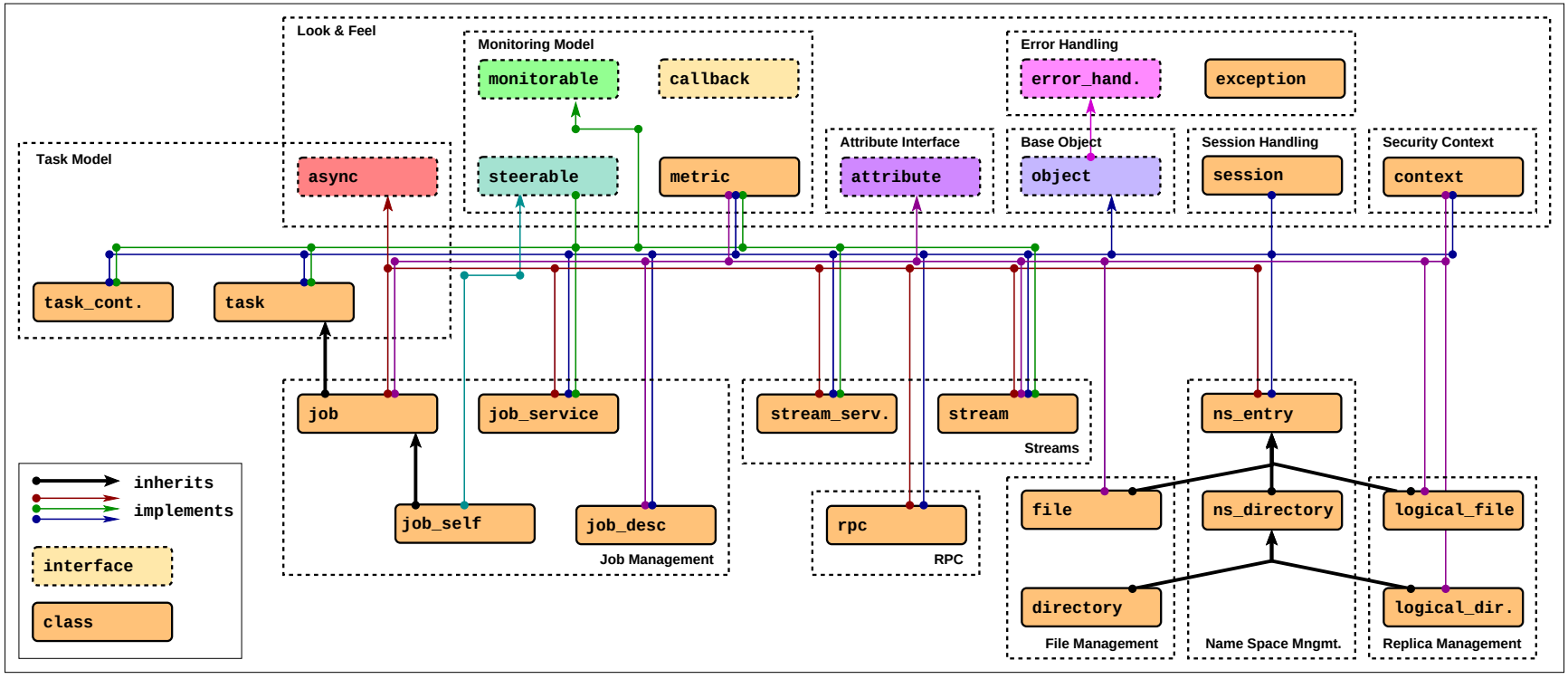
```
saga::dir  dir (s, "gridftp://remote.host.net/data/");

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

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

file.copy ("data.bin.bak");   // works - state is sticky!
```

SAGA Examples: Contexts

authorization

```
// server side code
saga::stream_service ss ("tcp://localhost:1234");

saga::stream_client sc = ss.serve ();

saga::context c = sc.get_context ();

if ( c.get_type == Globus &&
     c.attribute_equals ("RemoteID", "O=MyCA, O=MyOrg, CN=Joe") )
{
  sc.write ("welcome!", 9);
}
else
{
  sc.write ("bugger off!", 12);
  sc.close ();
}
```

SAGA: Monitoring



SAGA: Monitoring

- monitoring of Grid entities (jobs, files, . . .)
- monitoring of interactions (task state, notification, . . .)
- `monitorables` have metrics
- `metrics` can be pulled, or subscribed to (callbacks)
- some metrics can be written (basic steering)

SAGA Examples: Monitoring

pull monitoring

```
saga::job::job j = js.create_job (jd);

j.run ();

saga::metric m = j.get_metric ("MemoryUsage");

while ( 1 )
{
  cout << "Memory Usage: " << m.get_value () << endl;
  sleep (1);
}
```

SAGA Examples: Monitoring

callbacks

```
class my_cb : public saga::callback
{
  public:
    bool cb (saga::monitorable obj,
             saga::metric      m,
             saga::context     c)
    {
      cout << "Memory Usage: " << m.get_value () << endl;
      return (true);
    }
};

my_cb cb;
saga::job::job j = js.create_job (jd);
j.run ();

saga::metric m = j.get_metric ("MemoryUsage");
m.add_callback ("MemoryUsage", cb);
```

SAGA Examples: Monitoring

callbacks

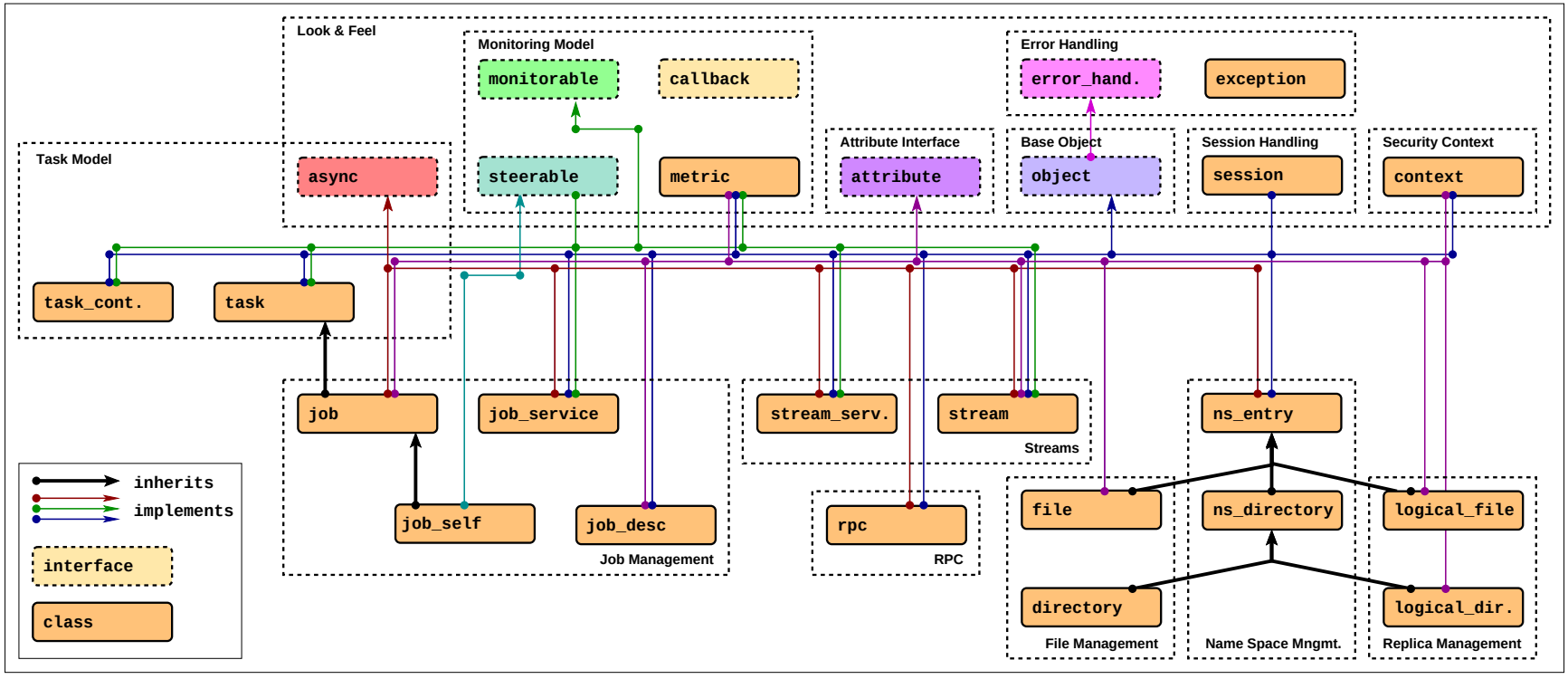
```
class my_cb : public saga::callback
{
  public:
    bool cb (saga::monitorable obj,
             saga::metric      m,
             saga::context     c)
    {
      cout << "Memory Usage: " << m.get_value () << endl;
      return (true);
    }
};

my_cb cb;
saga::job::job j = js.create_job (jd);
j.run ();


j.add_callback ("MemoryUsage", cb);
```

SAGA Examples: Monitoring

callbacks (cont.)

```
class my_cb : public saga::callback
{
  public:
    bool cb (saga::monitorable obj,
             saga::metric      m,
             saga::context     c)
    {
      cout << m.get_name ()  << " : " << m.get_value () << endl;
      return (true);
    }
};

list <string> metrics = j.list_metrics ();

while ( metrics.size () )
{
  j.add_callback (metrics.pop_front (), cb);
}
```

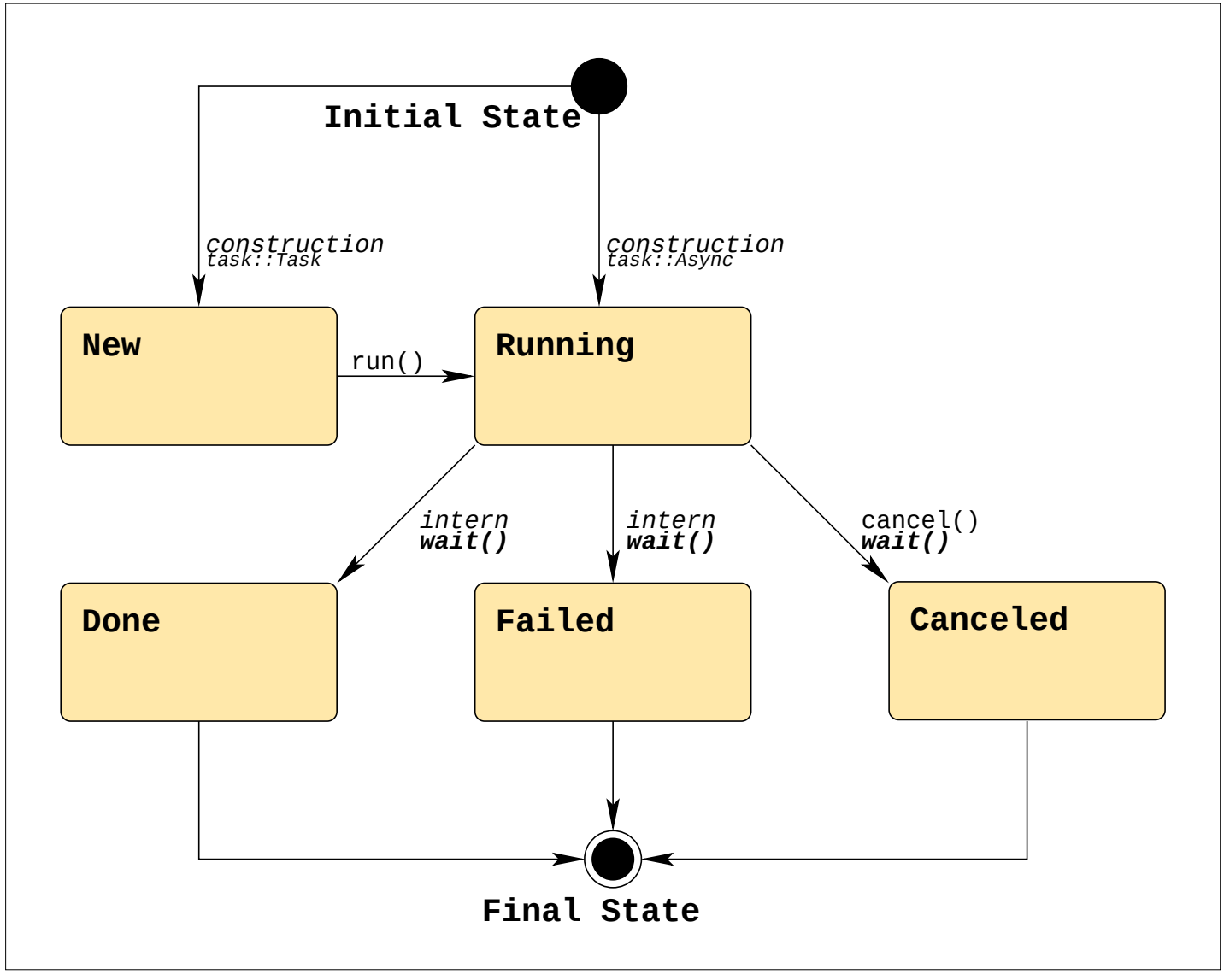
SAGA: Tasks


Look & Feel
Monitoring Model
monitorable
callback
Error Handling
error_hand.
exception
Task Model
async
steerable
metric
Attribute Interface
attribute
Base Object
object
Session Handling
session
Security Context
context
task_cont.
task
job
job_service
stream_serv.
stream
Streams
ns_entry
inherits
implements
interface
class
job_self
job_desc
Job Management
rpc
RPC
file
ns_directory
logical_file
directory
logical_dir.
File Management
Name Space Mngmt.
Replica Management

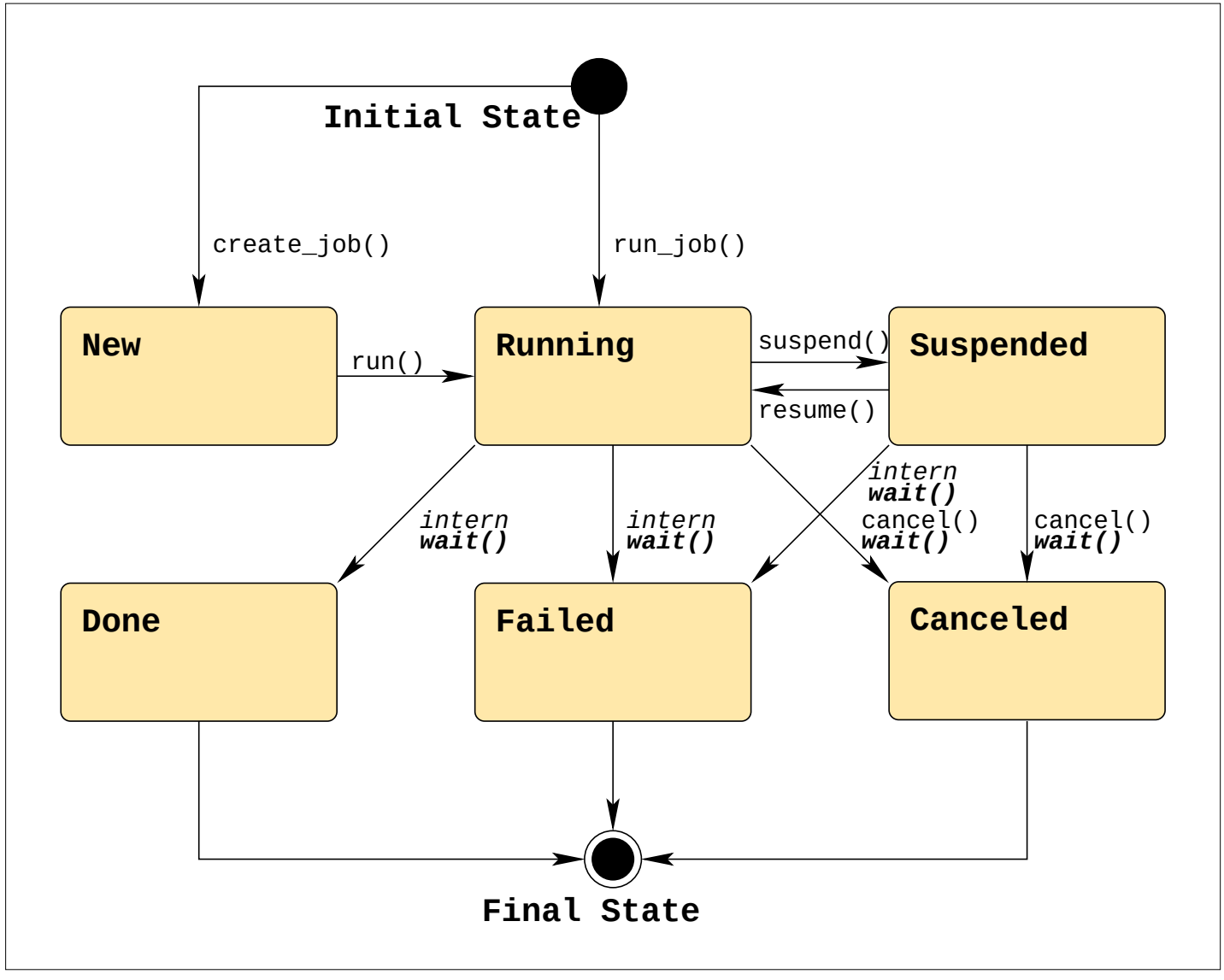
SAGA: Tasks

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

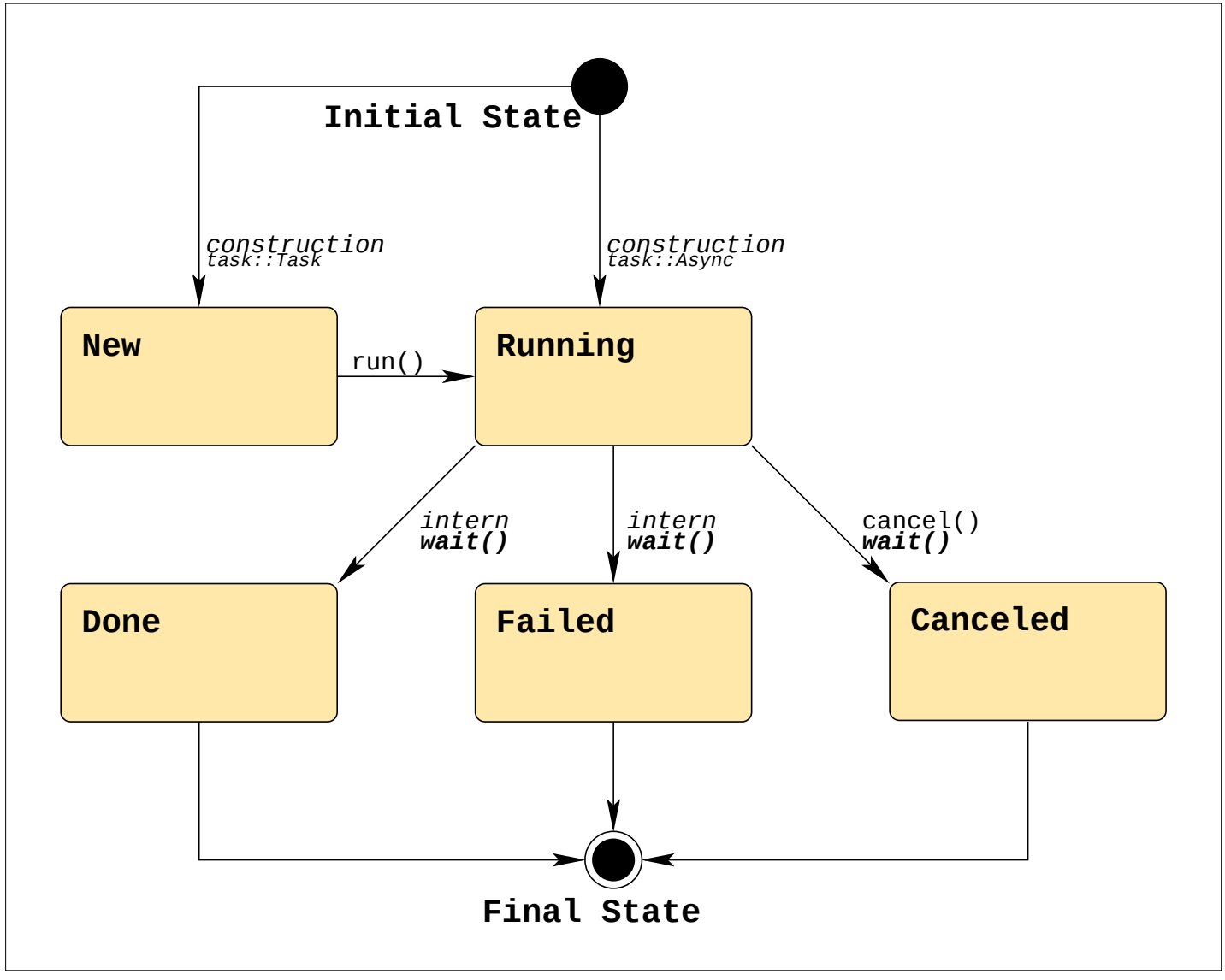
SAGA: Task States



SAGA: Job States



SAGA: Task States



SAGA: Tasks

- different versions for each method call: sync, async, task
- signature basically the same
- differ in state of task returned by that method

SAGA Examples: Tasks

tasks (i)

```
saga::file file ("gsiftp://remote.host.net/data/data.bin");

// normal, synchronous
file.copy ("data.bak");  // void

// 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
```

SAGA Examples: Tasks

tasks (ii)

```
saga::file file ("gsiftp://remote.host.net/data/data.bin");

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

// async versions
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 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 Examples: Tasks

tasks (iii)

```
t3.run ();

cout << t3.get_state () << endl;  // Running

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

// t1, t2, t3: Done (or Failed...)
```

SAGA Examples: Tasks

tasks container

```
saga::task_container tc;

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

tc.run  ();

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

tc.wait (All);
```

SAGA Examples: Tasks

tasks and jobs

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

task.add_callback ("State", my_cb);
job.add_callback  ("State", my_cb);

saga::task_container tc;

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

tc.wait ();
```

- - -

SAGA planned extensions

- service discovery
- message based communication
- information service (Advert Service)
- resource discovery and management
- checkpoint & recovery (GridCPR)

Questions?