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SAGA API Extension: Advert API

Status of This Document

This document provides information to the grid community, proposing a standard for an extension package to the Simple API for Grid Applications (SAGA). That extension provides access to persistent storage for serialized SAGA objects, and application level meta data (adverts). As SAGA extension, it depends upon the SAGA Core API Specification [?]. This document is supposed to be used as input to the definition of language specific bindings for this API extension, and as reference for implementors of these language bindings. Distribution of this document is unlimited.

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Abstract

This document specifies an Advert API extension to the Simple API for Grid Applications (SAGA), a high level, application-oriented API for grid application development. This Advert API is motivated by a number of use cases collected by the OGF SAGA Research Group in GFD.70 [?], and by requirements derived from these use cases, as specified in GFD.71 [?]). It allows to persistently store application specific meta data in a name space hierarchy, along with serialized `saga::object` instances.

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1 Introduction

A significant number of SAGA use cases [?] ask for the possibility to persistently store application level meta data¹. In difference to data storage in files, these meta data are usually small, and structured as key-value-pairs. The main use case for this API extension is that an application stores some state information, and that these state information are either used by other applications, or by a later running instance of the same application.

For example, an application which allows to stream data (i.e. uses the SAGA Stream API [?]), may store its `saga::stream::service` endpoint URL as an advert, along with information about the protocol to be used, and another application which wants to connect to the first one may obtain the service object, and the protocol information, from the advert service. This allows, amongst others, for simple and environment independent bootstrapping of distributed ensembles of applications. The persistent nature of the advert service also allows applications to cooperate even if their actual application run time does not overlap.

Adverts are defined as an entry in the adverts name space, i.e. as an entry in an `saga::advert_directory`. Similar to `saga::logical_file`, each advert can have meta data attached (i.e. has key-value based attributes). As described above, an `saga::advert` can also store one (serialized) `saga::object` instance. In some sense, that object instance can be considered to be the *content* of the advert, and the attributes can be considered the *meta data* of the advert, usually describing the content. Neither element needs to exist however – even completely empty adverts can be useful in some circumstances, e.g. to simply flag specific conditions.

1.1 Notational Conventions

In structure, notation and conventions, this documents follows those of the SAGA Core API specification [?], unless noted otherwise.

1.2 Security Considerations

As the SAGA API is to be implemented on different types of Grid (and non-Grid) middleware, it does not specify a single security model, but rather provides

¹The distinction between data and meta data is usually not very well defined. In this document, we refer to meta data as small pieces of information which are used to manage the overall functionality of the application. They are, usually, not the data which are the object of the the applications core algorithms. In particular, for the purpose of this document, we consider meta data *not* to be binary data.

hooks to interface to various security models – see the documentation of the `saga::context` class in the SAGA Core API specification [?] for details.

A SAGA implementation is considered secure if and only if it fully supports (i.e. implements) the security models of the middleware layers it builds upon, and neither provides any (intentional or unintentional) means to by-pass these security models, nor weakens these security models' policies in any way.

2 SAGA Advert API

2.1 Introduction

Several SAGA use cases [?], and also several current and past SAGA and GAT [?] base projects, declared the need for a simple interface to storage of small sets of persistent application data. Further, as distributed applications have an inherent need of coordination [?], the state for SAGA object instances is considered to count amongst those information. The advert API extension to SAGA, which is presented and specified in this document, is designed to accommodate those needs.

In its core, the advert package represents a `saga::namespace` derivative which allows to store, search and retrieve `saga::attribute` sets and `saga::object` derivatives in its leaf nodes. The notion of namespace is repeatedly used throughout the SAGA API [?], as is the notion of attributes. By combining both, the structure of the advert API package should actually be immediately clear. The novel addition to the package is the ability to store SAGA object instances, which should be considered as serialized representation of the respective object's state.

The potential use cases of the API package are virtually endless, and as implementation of the API in SAGA and other APIs already exist since a number of years, the paradigm has already been proven to be incredibly useful for the development of distributed applications. An example application is thus included to (a) demonstrate that usefulness, and (b) illustrate the structure and purpose of the API. The complete application code can be found in section 3.

Example: Master/Slave Application with Advert Registries

Assume a distributed application wants to employ the Master/Slave paradigm. The Master can then, after creating the slave jobs, publish those in a separate advert directory, which thus serves as this master's job registry. Each job advert contains the serialized job instance. Further, the master can publish work items in yet another advert directory, and assign job id's to each work item. That second advert directory thus acts as a work item queue. The work item adverts contain (a) a serialized SAGA file instance representing the work data, (b) the id of the job assigned to that work item, and (c) the state of that item (e.g. 'assigned'). After all work items have been created and assigned, the jobs are `run()`, and can start to pick up work items.

The started slave processes search the work item registry for items assigned to them, by doing a `find()` on the advert directory, with a pattern which specifies `'work_id=<my_id>'`, with `my_id` being their own job id. They then

work on each item, marking it as `'accepted'` when starting the work, and as `'completed'` when done.

A separate master process could decide to check the overall progress of the work. To do that, it retrieves all job and work item adverts, and checks the respective status: for the jobs, it retrieves the job instances from the job adverts, and calls `get_state()` on them; for the work items, it checks the `'work_state'` attribute of the work item adverts. If jobs are in a final state, and all work items are completed, the master can safely purge the advert directories.

That example obviously is very simplistic in respect to scheduling of work items, and also in respect to error recovery, but is nevertheless fully functional. Creating an application with similar functionality without the help of the advert service requires significantly more, and also more complex, operations. In particular, the application is immediately resilient against master failures: once the job and work item registries exist, they are persistent, and can be utilized by any application component with the respective permissions. Further, the communication between the individual application components (i.e. processes) is immediately asynchronous, secure, and persistent (no `'messages'` get lost). Also, the registries allow to easily infer the overall state of the distributed application. Finally, the communication via the advert service completely solves the application bootstrapping problem: there is no need for any application component to directly contact any other component. Thus, no component needs to know where any other component is actually being executed. The only shared information are the URLs of the job and work item registries (or, in our code base, the single URL of the directory containing these registries).

2.1.1 Classes

The SAGA Advert API consists of two classes: the `advert::advert` class, which inherits `namespace::entry` and encapsulates the application information to be stored persistently; and the `advert::directory` class, which inherits the `namespace::directory` and represents the directories adverts are organized in. The `advert::advert` class has two additional methods, `store_object()` and `retrieve_object()`, which allow to associate a SAGA object instance with that specific advert. Also, an overloaded constructor allows to specify an associated SAGA object on construction time. The `advert::directory` has an overloaded `find()` method, which allows to also search object types, and for meta data pattern (i.e. attribute patterns), similar to the find of the SAGA replica package. Additionally, the `advert::flags` enum is inherited from the SAGA namespace package, and extended by the `Truncate` flag which empties both the associated object and the attributes of the advert to be opened.

2.1.2 SAGA Object Serialization

This document is silent about the details of the object serialization format to be used for storing and retrieving `saga::object` instances in advert entries. That implies that different implementations of the advert service API may not be interoperable, in the sense that objects stored with one implementation may not be retrievable with another implementation. We consider that to be in sync with the other functional SAGA API packages, which also introduce implicit backend dependencies – for example, jobs submitted to one backend can, usually, not be managed by another backend.

We would like to encourage, however, that various language bindings of this API try to exploit existing native object serialization schemas (where they exist) to potentially achieve interoperability, or even to exploit serialization schemes which can cross language boundaries.

It is important to realize that the actual serialization does not need to comprise the complete binary representation of the object instance. In fact, that binary representation may be the least usable version when crossing process and OS boundaries. Instead, only the state of the respective object instance needs to be saved. This specification does not prescribe the set of required state information for the individual SAGA object types, but we again would like to encourage the various language bindings to try to specify that set as concisely as possible. As an example, we consider the following elements to be necessary and sufficient to serialize a `saga::filesystem::file` instance (C++ rendering):

```
saga::url url      // the file url
int      flags    // the file open flags
off_t    pos      // the file pointer position
           //      for I/O operations
```

Using `open()` and `seek()`, the retrieving application instance (i.e. the retrieving SAGA implementation) should be able to re-create a `saga::file` instance which represents the same physical file entity, in the same state.

Implementations of the advert package SHOULD strive to provide support for all SAGA objects types. Language bindings MAY allow to associate other types, such as primitive data types like `int` or `string`, or even complex application level data types such as custom classes, with advert entries. It should be noted though that this will reduce the portability of applications, as it becomes less likely that the respective serializations can be interpreted by (a) other implementations in the same language, and (b) by implementations in other languages.

Again, implementors SHOULD thus follow the guideline that not the binary representation of objects is serialized, but rather the minimal set of information which represents the complete state of the object, as far as the application is

concerned.

Note that the `advert.retrieve_object()` method is able to return different object types. It thus uses the same type templatization signature as employed in the SAGA core specification, for example for the `task.get_result()` method. Language bindings MAY utilize the same technique for `advert` constructor and the `advert.store_object()`, if the argument's type cannot automatically be inferred in that language.

2.1.3 Advert Persistency and Lifetime Management

Adverts have, by default, an unspecified lifetime, and can thus in particular survive the application which created the advert. It should be noted that this can, however, lead to garbage, i.e. to an increasing number of entries which are not needed anymore. It is the responsibility of the end user to avoid garbage. For that, the `set_ttl (int)` methods on the `advert` and `advert_dir` classes can be used to specify a minimal advert lifetime (time to live, TTL) – beyond that time, the advert can be considered as garbage, and MAY be purged out automatically.

If the TTL of an advert is expired, the result of any call accessing that advert is undefined. Implementations MAY be able to open expired adverts, but no guarantees are given on their content. Implementations SHOULD throw an 'IncorrectState' exception for expired adverts.

2.1.4 Advert URLs

The exact rendering of the advert namespace is up to the respective implementation, and it is thus not specified in this document how valid URLs are formed (i.e. what schemas are supported). Implementations SHOULD, however, strive to support the generic URL schema 'any', as motivated in [?]. Otherwise, the rules specified for file system URLs in [?] SHOULD be followed.

2.2 Specification

```
package saga.adverts
{
    enum flags : extends saga::namespace::flags
    {
        None          =    0,    // from saga::namespace
```

```
    Overwrite      = 1,    // from saga::namespace
    Recursive      = 2,    // from saga::namespace
    Dereference    = 4,    // from saga::namespace
    Create         = 8,    // from saga::namespace
    Exclusive      = 16,   // from saga::namespace
    Lock           = 32,   // from saga::namespace
    CreateParents  = 64,   // from saga::namespace
    Truncate       = 128,
    Read           = 512,   // from saga::namespace
    Write          = 1024, // from saga::namespace
    ReadWrite      = 1536 // from saga::namespace
}

class advert_directory : extends saga::ns_directory
                        extends saga::attributes
                        // from ns_directory saga::ns_entry
                        // from ns_entry    saga::object
                        // from ns_entry    saga::async
                        // from ns_entry    saga::permissions
                        // from object      saga::error_handler
{
    CONSTRUCTOR      (in session          session,
                     in string           url,
                     out advert_directory obj);
    DESTRUCTOR       (in advert_directory obj);

    // set estimated life time
    set_ttl          (in int              ttl = 2500000);

    // find adverts based on name, object type, and meta data
    find             (in string           name_pattern,
                     in array<string>    attr_pattern,
                     in saga::object::type type = 0,
                     in int              flags = Recursive,
                     out array<saga::url> names );

    // Attributes (extensible):
}

class advert : extends saga::ns_entry
               extends saga::attributes
               // from ns_entry saga::object
               // from ns_entry saga::async
               // from ns_entry saga::permissions
```

```
        // from object    saga::error_handler
    {
        CONSTRUCTOR      (in    session    session,
                        in    string     url,
                        out   advert     obj);
        CONSTRUCTOR      (in    session    session,
                        in    string     url,
                        in    saga::object content,
                        out   advert     obj);
        DESTRUCTOR       (in    advert     obj);

        // set estimated life time
        set_ttl          (in    int       ttl = 2500000);

        // attach saga::object instances
        store_object     (in    saga::object content);
        retrieve_object   <type>
                        (out   saga::object content);

        // Attributes (extensible):
    }
}
```

2.3 Specification Details

2.4 Enum flags

The flags describe the properties of several operations on advert directories and entries. This package inherits the flags from the namespace package, and uses the same ag semantics unless specied otherwise. The `Truncate` flags is added, which is to be used when opening an `advert::entry` instance shall completely empty that entry. The `Truncate` flag does not imply a reset of the creation time, but it causes the entry's time-to-live (TTL) counter to be restarted.

2.4.1 Class `advert::directory`

The `advert::directory` class follows the purpose and semantics of the inherited `saga::namespace::directory` class.

It has one additional method, to set the directories TTL. If that time is passed (i.e. the directories creation-time plus its TTL is smaller than 'now'), it can

be considered to be 'garbage'. It MAY be automatically cleaned out by the backend, if and only if it contains only expired entries. The TLL counter starts on object creation, and is restarted whenever the `set_ttl()` method is called.

Another namespace method, `find()`, is overloaded, and allows to extends the search pattern to (a) the type of objects associated with adverts, and (b) the attributes associated with adverts.

- CONSTRUCTOR

Purpose: create the object
 Format: CONSTRUCTOR (in session s,
 in saga::url name,
 in int flags = Read,
 out directory obj)
 Inputs: s: session handle
 name: location of directory
 flags: open mode
 InOuts: -
 Outputs: obj: the newly created object
 PreCond: -
 PostCond: - the directory is opened.
 - 'Owner' of directory is the id of the context
 use to perform the operation, if the
 directory gets created.
 - the TTL timer of the object is resetted on
 Creation, and if the Truncate flag is
 specified.
 Perms: Exec for parent directory.
 Write for parent directory if Create is set.
 Write for name if Write is set.
 Read for name if Read is set.
 Throws: NotImplemented
 IncorrectURL
 BadParameter
 DoesNotExist
 AlreadyExists
 PermissionDenied
 AuthorizationFailed
 AuthenticationFailed
 Timeout
 NoSuccess
 Notes: - if the 'Truncate' flag is given, the returned
 object MUST NOT have an associated object, and
 MUST have an empty attribute set.

- the 'Truncate' flag requires that the entry exists, or that the 'Create' flag is given, too. Otherwise, a DoesNotExist exception is thrown.

- DESTRUCTOR
 - Purpose: destroy the object
 - Format: DESTRUCTOR (in entry obj)
 - Inputs: obj: the object to destroy
 - InOuts: -
 - Outputs: -
 - PreCond: -
 - PostCond: - the directory is closed.
 - Perms: -
 - Throws: -
 - Notes: -

- set_ttl
 - Purpose: set a time to life, and restart the ttl timer.
 - Format: store_object (in int ttl = 2500000);
 - Inputs: ttl: time to live in seconds
 - InOuts: -
 - Outputs: -
 - PreCond: -
 - PostCond: - the instance's ttl timer is restarted.
- the instance's ttl is set to ttl.
 - Perms: - Write
 - Throws: NotImplemented
IncorrectState
Timeout
NoSuccess
 - Notes: - A negative ttl just restarts the ttl timer,
but does not actually change the ttl value.

- find
 - Purpose: find adverts in the current directory and below,
with matching names and matching meta data
 - Format: find (in string name_pattern,
in array<string> attr_pattern,
in saga::object::type type = 0,
in int flags = Recursive,
out array <saga::url> names);
 - Inputs: name_pattern: pattern for names of

attr_pattern: entries to be found
pattern for meta data
key/values of entries to be found

type: filter for adverts with
attached saga objects of that
type

flags: flags defining the operation
modus

InOuts: -

Outputs: names: array of names matching all
criteria

PreCond: -

PostCond: -

Perms: Read for cwd.
Query for entries specified by name_pattern.
Exec for parent directories of these entries.
Query for parent directories of these entries.
Read for directories specified by name_pattern.
Exec for directories specified by name_pattern.
Exec for parent directories of these directories.
Query for parent directories of these directories.

Throws: NotImplemented
BadParameter
IncorrectState
PermissionDenied
AuthorizationFailed
AuthenticationFailed
Timeout
NoSuccess

Notes: - the semantics for both the find_attributes()
method in the saga::attributes interface and
for the find() method in the
saga::ns_directory class apply. On
conflicts, the find() semantic supercedes
the find_attributes() semantic. Only entries
matching all attribute patterns, the name
space pattern and the object type are returned.
- the default flags are 'Recursive' (2).
- expired entries (TTL) SHOULD NOT be returned.

2.4.2 Class `advert::advert`

The `advert::advert` class follows the purpose and semantics of the inherited `saga::namespace::entry` class. Two methods allow to manage the `saga::object` instance associated with that advert entry. Along the same lines, an overloaded `CONSTRUCTOR` is added which specifies the associated `saga::object` on creation time. That constructor will only succeed when the `Create` or `Truncate` flag is given, and can succeed.

Advert entry instances do also have a TTL, which follows the same semantics as defined above for the advert directory.

Further, the advert entry implements the `saga::attributes` interface, and can hold an arbitrary set of user define attributes.

```

- CONSTRUCTOR
  Purpose:  create the object
  Format:   CONSTRUCTOR          (in session  s,
                                in saga::url name,
                                in int      flags = Read,
                                out entry  obj)

  Inputs:   s:                  session handle
            name:                initial working dir
            flags:                open mode

  InOuts:   -

  Outputs:  obj:                the newly created object
  PreCond:  -
  PostCond: - the entry is opened.
            - 'Owner' of target is the id of the context
              use to perform the operation, if the
              entry gets created.

  Perms:    Exec for parent directory.
            Write for parent directory if Create is set.
            Write for name if Write is set.
            Read for name if Read is set.

  Throws:   NotImplemented
            IncorrectURL
            BadParameter
            DoesNotExist
            AlreadyExists
            PermissionDenied
            AuthorizationFailed
            AuthenticationFailed
            Timeout

```

```

NoSuccess
Notes:  - semantic as in saga::namespace::entry
        - if the 'Truncate' flag is given, the returned
          object MUST NOT have an associated object, and
          MUST have an empty attribute set.
        - the 'Truncate' flag requires that the entry
          exists, or that the 'Create' flag is given,
          too. Otherwise, a DoesNotExist exception is
          thrown.

- CONSTRUCTOR
Purpose: create the object
Format:  CONSTRUCTOR      (in session  s,
                           in saga::url name,
                           in saga::object content,
                           in int      flags = Read,
                           out entry  obj)
Inputs:  s:                session handle
         name:              initial working dir
         content:           saga::object to be
                           associated with the entry
         flags:             open mode
InOuts:  -
Outputs:  obj:              the newly created object
PreCond:  -
PostCond: - the entry is opened.
         - 'Owner' of target is the id of the context
           use to perform the operation, if the
           entry gets created.
Perms:   Exec for parent directory.
         Write for parent directory if Create is set.
         Write for name if Write is set.
         Read for name if Read is set.
Throws:  NotImplemented
         IncorrectURL
         BadParameter
         DoesNotExist
         AlreadyExists
         PermissionDenied
         AuthorizationFailed
         AuthenticationFailed
         Timeout
         NoSuccess
Notes:   - semantic as in the overloaded CONSTRUCTOR
         - if the 'Truncate' flag is given, the returned

```

- object MUST have an empty attribute set.
 - the 'Truncate' flag requires that the entry exists, or that the 'Create' flag is given, too. Otherwise, a DoesNotExist exception is thrown.
 - if the entry is newly created, a default TTL timer MAY be started by the implementation.
 - the 'Truncate' flags restarts the entries TTL timer, but does not reset its creation time.
 - if the implementation does not support the association of the specified object type, a 'BadParameter' exception is thrown.
-
- DESTRUCTOR
 - Purpose: destroy the object
 - Format: DESTRUCTOR (in entry obj)
 - Inputs: obj: the object to destroy
 - InOuts: -
 - Outputs: -
 - PreCond: -
 - PostCond: - the entry is closed.
 - Perms: -
 - Throws: -
 - Notes: - semantic as in saga::namespace::entry

 - set_ttl
 - Purpose: set a time to life, and restart the ttl timer.
 - Format: store_object (in int ttl = 2500000);
 - Inputs: ttl: time to live in seconds
 - InOuts: -
 - Outputs: -
 - PreCond: -
 - PostCond: - the instance's ttl timer is restarted.
- the instance's ttl is set to ttl.
 - Perms: - Write
 - Throws: NotImplemented
IncorrectState
Timeout
NoSuccess
 - Notes: - A negative ttl just restarts the ttl timer,
but does not actually change the ttl value.

 - store_object

of the object. Depending on the implementation, these copies may or may not share state.

3 Example Code

For a high level description of these examples, see section 2.1.

————— Master Code - Startup —————

```
1
2 #define BASE_URL std::string ("any://advert.db.net/my_app")
3 #define JOBNUM 100 // size of worker pool
4 #define WORKNUM 1000 // number of work items
5
6 // the master spawns jobs, and assigns them work items. These info
7 // are stored in the advert service, waiting for the jobs to pick
8 // them up, and report back.
9 int main ()
10 {
11 // create the job service used to spawn the slaves
12 saga::job::service js ("any://job.service.net");
13
14 // create the job registry in the advert data base
15 saga::advert::advert_dir jobs (BASE_URL + "jobs/",
16                               saga::advert::Create);
17
18 // keep track of jobs and job_ids
19 saga::task_container tc;
20 std::vector <std::string> job_ids;
21
22 // spawn the slaves
23 for ( int i = 0; i < JOBNUM; i++ )
24 {
25     saga::job::job j = js.create_job (jd);
26
27     // register the slaves in the registry
28     saga::advert a = jobs.open (j.get_jobid (), j,
29                               saga::advert::Create);
30
31     // keep job and jobid
32     tc.add_task (j);
33     job_ids.push_back (j.get_jobid ());
34 }
35
36 // create the work item registry in the advert data base
37 saga::advert::advert_dir works ("BASE_URL + "works/",
38                               saga::advert::Create);
39
40 // publish work items, and assign them to the slaves
41 for ( int i = 0; i < WORKNUM; i++ )
42 {
43     // open file representing the work item (pseudo code)
44     saga::filesystem::file f ("any://data.src.net/data/set_[i].dat");
```

```

45     // publish it in the work item queue
46     saga::advert a = works.open (f.get_name (), f,
47                                 saga::advert::Create);
48
49
50     // assign it to a job (pseudo code)
51     a.set_attribute ("worker_id",    job_ids[j % JOBNUM]);
52     a.set_attribute ("worker_state", "assigned");
53 }
54
55 // work items are created and assigned, now we can start the jobs,
56 // so that they can begin to pick up work
57 tc.run ();
58
59 // the master can safely exit here, as all job and work item info
60 // are persistently stored in the advert service
61 return 0;
62 }

```

Client Code Code - Work

```

1  #define BASE_URL std::string ("any://advert.db.net/my_app")
2
3  // the client gets its own job_id, and retrieves all work items
4  // assigned to it.  After completing them, it ticks them off in the
5  // registry, and finishes if no further work is pending.
6  int main ()
7  {
8      // get own job id
9      saga::job::service js;
10     saga::job::job    me = js.get_self ();
11     std::string      id = me.get_jobid ();
12
13     // retrieve a data items from the work item queue
14     saga::advert::advert_dir works (BASE_URL + "works/");
15
16     std::vector <std::string pattern;
17     pattern.push_back ("worker_id=" + id);          // pseudo code string ops
18     pattern.push_back ("worker_state=assigned");  // only pick new items
19
20     // this worker type can only work on files
21     std::vector <saga::url> items = works.find ("*", pattern,
22                                               saga::object::File);
23
24     while ( ! items.empty () )
25     {
26         // work on the items
27         for ( int i = 0; i < items.size (); i++ )
28         {

```

```

29     // open the work item
30     saga::advert::advert a = works.open (items[i]);
31
32     // signal that we work on that item
33     a.set_attribute ("worker_state", "accepted");
34
35     // do work, on the file which is 'contained' in the advert
36     do_work (a.get_object <saga::filesystem::file> ());
37
38     // signal that item is completed
39     a.set_attribute ("worker_state", "completed");
40 }
41
42 // refresh work item list
43 items = works.find ("*", pattern, saga::object::File);
44 }
45
46 // done - just finish
47 return 0;
48 }

```

———— Master Code - Check and Finish ————

```

1  #define BASE_URL std::string ("any://advert.db.net/my_app")
2
3  // another master (yes, we have two) checks the status of jobs and
4  // workers, and cleans up if everything is done.
5  int main ()
6  {
7      bool completed = true;
8
9      // open the work item registry in the advert data base, and get
10     // all work items
11     saga::advert::advert_dir works (BASE_URL + "works/");
12     std::vector <saga::url> items = works.list ();
13
14     // check item state
15     for ( int i = 0; i < items.size (); i++ )
16     {
17         saga::advert::advert a = works.open (items[i]);
18         std::cout << " item "      << i
19                 << " handled by " << a.get_attribute ("worker_id")
20                 << " has state "  << a.get_attribute ("work_state")
21                 << std::endl;
22
23         // check global state
24         if ( a.get_attribute ("work_state") != "completed" )
25         {
26             completed = false;

```

```
27     }
28   }
29
30
31   // open the job registry in the advert data base, and get all jobs
32   saga::advert::advert_dir jobs (BASE_URL + "jobs/");
33   std::vector <saga::url> ids = jobs.list ();
34
35   // check item state
36   for ( int i = 0; i < ids.size (); i++ )
37   {
38     saga::advert::advert a = jobs.open (ids[i]);
39     saga::job::job      j = a.get_object <saga::job::job> ();
40
41     std::cout << " job "      << i
42               << " has id "  << ids[i]
43               << " and state " << j.get_attribute ("State")
44               << std::endl;
45
46     // check global state
47     if ( j.get_state != saga::job::Done ||
48         j.get_state != saga::job::Failed )
49     {
50       completed = false;
51     }
52   }
53
54
55   // if everything is done, we can clean up the advert service dirs.
56   // Otherwise, we just wait for the next run to do so, eventually.
57   if ( completed )
58   {
59     works.remove (saga::advert::Recursive);
60     jobs.remove  (saga::advert::Recursive);
61   }
62
63   return (completed ? 0 : 1);
64 }
```

4 Intellectual Property Issues

4.1 Contributors

This document is the result of the joint efforts of many contributors. The author listed here and on the title page is the one taking responsibility for the content of the document, and all errors. The editor (underlined) is committed to taking permanent stewardship for this document and can be contacted in the future for inquiries.

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