

# GLUE Schema Specification

## version 1.3

Draft 3 - 16 Jan 2007\*

Sergio Andreozzi (INFN)<sup>†</sup>   Stephen Burke (RAL)   Flavia Donno (CERN)  
Laurence Field (CERN/RAL)   Steve Fisher (RAL)   Jens Jensen (RAL)  
Balazs Kónya (Lund University)   Maarten Litmaath (CERN)  
Marco Mambelli (University of Chicago)  
Jennifer M. Schopf (ANL and UK National eScience Centre)   Matt Viljoen (RAL)  
Antony Wilson (RAL)   Riccardo Zappi (INFN)   TO BE COMPLETED

### **Abstract**

Resources available in Grid systems must be described in a precise and systematic manner if they are to be able to be discovered for subsequent management or use. This document presents an abstract modeling for Grid resources that can be used to define mapping to concrete schemas for Grid Information Services.

---

\*The last version of this document is available at <http://glueschema.forge.cnaf.infn.it/Spec/V13>

<sup>†</sup>Editor of this document

# Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
1.1	Conventions and Terminology . . . . .	3
<b>2</b>	<b>Core Entities</b>	<b>4</b>
2.1	Site . . . . .	4
2.2	Service . . . . .	4
<b>3</b>	<b>Computing Resources</b>	<b>7</b>
3.1	Cluster . . . . .	8
3.2	Computing Element . . . . .	9
3.3	SubCluster . . . . .	11
<b>4</b>	<b>Storage Resources</b>	<b>13</b>
4.1	Storage Element . . . . .	13
4.2	Storage Area . . . . .	14
4.3	Access Protocol . . . . .	15
4.4	Control Protocol . . . . .	15
4.5	Storage Library . . . . .	16
4.6	SRM-based SE Profile . . . . .	16
4.7	GridFTP-based Profile . . . . .	16
<b>5</b>	<b>Computing and Storage relationship</b>	<b>18</b>
<b>6</b>	<b>Change Log</b>	<b>20</b>
6.1	To Do . . . . .	20
<b>A</b>	<b>Description of the template</b>	<b>20</b>
<b>B</b>	<b>Datatypes</b>	<b>20</b>
B.1	ACBR_t . . . . .	20
<b>C</b>	<b>Host</b>	<b>22</b>

# 1 Introduction

The Grid is a new paradigm of distributed computing that enables the coordination of resources and services not subject to centralized control. These resources are geographically dispersed, span multiple trust domains and are heterogenous. They can be dynamically contributed by different owner institutions, thus forming virtual pools accessible to users showing the appropriate credentials.

A key component of these systems is the Grid Information Service (GIS) [1] that offers functionalities as discovery of existence and characteristics of resources available in a certain moment for subsequent management or use. A precise and shared description of resources among information consumers and resource providers is necessary. This description should also be common to different Grid infrastructures in order to contribute to interoperability among them.

This document presents a description of core Grid resources at the conceptual level by defining an information model, that is an abstraction of the real world into constructs that can be represented in computer systems (e.g., objects, properties, behavior, and relationships). The proposed information model is not tied to any particular implementation and can be profitably used to exchange information among different knowledge domains. It can also be mapped on data models that are specific of GIS's. This description is called GLUE schema [2]. Other projects maintain additional documentation on mapping and usage experience [3, 4, 5, 6]. Among the related works, we mention [7].

## 1.1 Conventions and Terminology

The UML class diagrams describing the information model have attributes in three different colors: black for attributes that are unmodified (U) with respect to the previous specification, blue for attributes that were introduced in GLUE Schema version 1.2 (N), green for attributes that are introduced in GLUE Schema version 1.3 (NN), red with smaller font for attributes that are deprecated (D). Attributes marked as deprecated are still part of schema, but should not be used as they will be removed in a future major revision of the GLUE schema.

Several entities have an attribute called UniqueID or LocalID. These attributes are opaque, in the sense that they MUST not be interpreted by the user or the system as having any meaning other than as an identifier. In particular there is no relationship between and ID and a network endpoint. As regards UniqueID, the suggestion is that they SHOULD be based on a DNS entry to assure global uniqueness. LocalID SHOULD instead be compatible with a DNS syntax, in the sense that they can be part of a DNS entry. Attributes which type is an enumeration of possible values are provided with an initial set in Appendix B. Updates can be found at the URL in [8].

Concerning the UML Class diagrams, dotted attribute names are related to a refinement of the design from previous GLUE Schema version. In GLUE Schema 1.2, the prefix was a different class containing the related attributes in the suffix. Such a design was used to isolate attributes of the same category (e.g., Status, Policy). The class was not related to a real entity with a UniqueID or LocalID. In this version, the classes have been merged in the entity to which they refer to. The class name has been kept for backwards compatibility and will likely to be removed in GLUE Schema major version. This change in this schema version is performed in order to improve the legibility of diagrams.

## 2 Core Entities

In this section, the core entities of the GLUE Schema are presented. They include the site concept (see Section 2.1) and an abstraction for the service concept (see Section 2.2). We also include the Computing Element and the Storage Element because of their relationship with the Site concept. In the major revision of the GLUE Schema they are expected to be a specialization of an higher level concept such as service or service group.

### 2.1 Site

The site is an administrative concept used to aggregate a set of services and resources that are installed and managed by the same set of persons. It does not have any constraints as regards the Domain Name System (DNS) in the sense that multiple sites can be part of the same DNS domain or a single site can span multiple DNS domains.

Entity	Inherits from	Description		
Site		Set of resources that are installed and managed by the same organization/set of persons (N)		
Property	Type	Mult.	Unit	Description
UniqueID	string	1		Unique Identifier of the Site (N)
Name	string	1		Human-readable name (N)
Description	string	1		Short description of this site (N)
EmailContact	string	1		The main email contact for the site. Syntax rule: "mailto:" followed by a list of email addresses separated by a comma (e.g.: mailto: email1, email2, email3) (N)
UserSupportContact	string	1		E-mail addresses of the support service. Syntax rule: "mailto:" followed by a list of email addresses separated by a comma (e.g.: mailto: email1, email2, email3) (N)
SysAdminContact	string	1		E-mail addresses of the system administrator. Syntax rule: "mailto:" followed by a list of email addresses separated by a comma (e.g.: mailto: email1, email2, email3) (N)
SecurityContact	string	1		E-mail addresses of the security manager. Syntax rule: "mailto:" followed by a list of email addresses separated by a comma (e.g.: mailto: email1, email2, email3) (N)
Location	string	1		Geographical location of this site (e.g., city, state, country) (N)
Latitude	real32	1	Degree	the position of a place north or south of the equator measured from $-90^{\circ}$ to $90^{\circ}$ with positive values going north and negative values going south (N)
Longitude	real32	1	Degree	the position of a place east or west of Greenwich, England measured from $-180^{\circ}$ to $180^{\circ}$ with positive values going east and negative values going west (N)
Web	uri	1		The URI identifying a web page with more information about this site (N)
Sponsor	string	*		VO sponsoring the site; the syntax should allow the expression of the percentage of sponsorship (N)
OtherInfo	string	*		This attribute is to be used to publish info that does not fit in any other attribute of the site entity. A name=value pair syntax or an XML structure are example of usage (N)
Association Endpoint (Entity.Property)		Mult.		Description
Service.UniqueID		*		A site can hosts zero or more services
Cluster.UniqueID		*		A site can hosts zero or more Clusters
StorageElement.UniqueID		*		A site can hosts zero or more Storage Element

The contact information attributes are to be used by applications. Other contact information can be placed in the web concerning the site which URL is in the Web attribute. Other contact information that should be searchable can be placed in the OtherInfo attribute.

### 2.2 Service

The Service entity captures all the common attributes to Grid Services and should be used as a base entity for the creation of service-specific schemas.

Entity	Inherits from	Description		
Service		An abstracted, logical view of actual software components that should be formally defined in terms of the messages exchanged between provider entity and requester entity (N)		
Property	Type	Mult.	Unit	Description
UniqueID	string	1		Unique Identifier of this service (N)
Name	string	1		Human-friendly name (N)
Type	serviceType_t	1		The service type (N)
Version	string	1		Version of the service: <major version number>.<minor version number>.<patch version number> (N)
Endpoint	uri	1		Network endpoint for this service (N)
Status	serviceStatus_t	1		Status of the service. String enumeration: OK, Warning, Critical, Unknown, Other (N)
StatusInfo		1		Textual explanation for the status of the service (N)
WSDL	uri	1		URI of the WSDL describing the service (N)
Semantics	uri	1		URL of detailed description (N)
StartTime	dateTime_xs_t	1		The timestamp related to last start time of this service (N)
Owner	string	*		Owner of the service (e.g.: one or more VO's) (N)
AccessControlBase.Rule	ACL_t	*		Authorization rule for this entity (NN)
Association Endpoint (Entity.Property)		Mult.		Description
Site.UniqueID		1		A Service is part of a Site (N)
Service.UniqueID		*		A Service is in relationship with another service (N)
ServiceData.Key		*		A Service has zero or more data specific info (N)

Entity	Inherits from			Description
ServiceData	Key=value pairs to publish service specific information(N)			Description
Property	Type	Mult.	Unit	
Key	string	1		Key identifying the type of data (N)
Value	string	1		Value (N)
Association Endpoint (Entity.Property)		Mult.		Description
Service.UniqueID		1		A (key,value) pair related to a Service

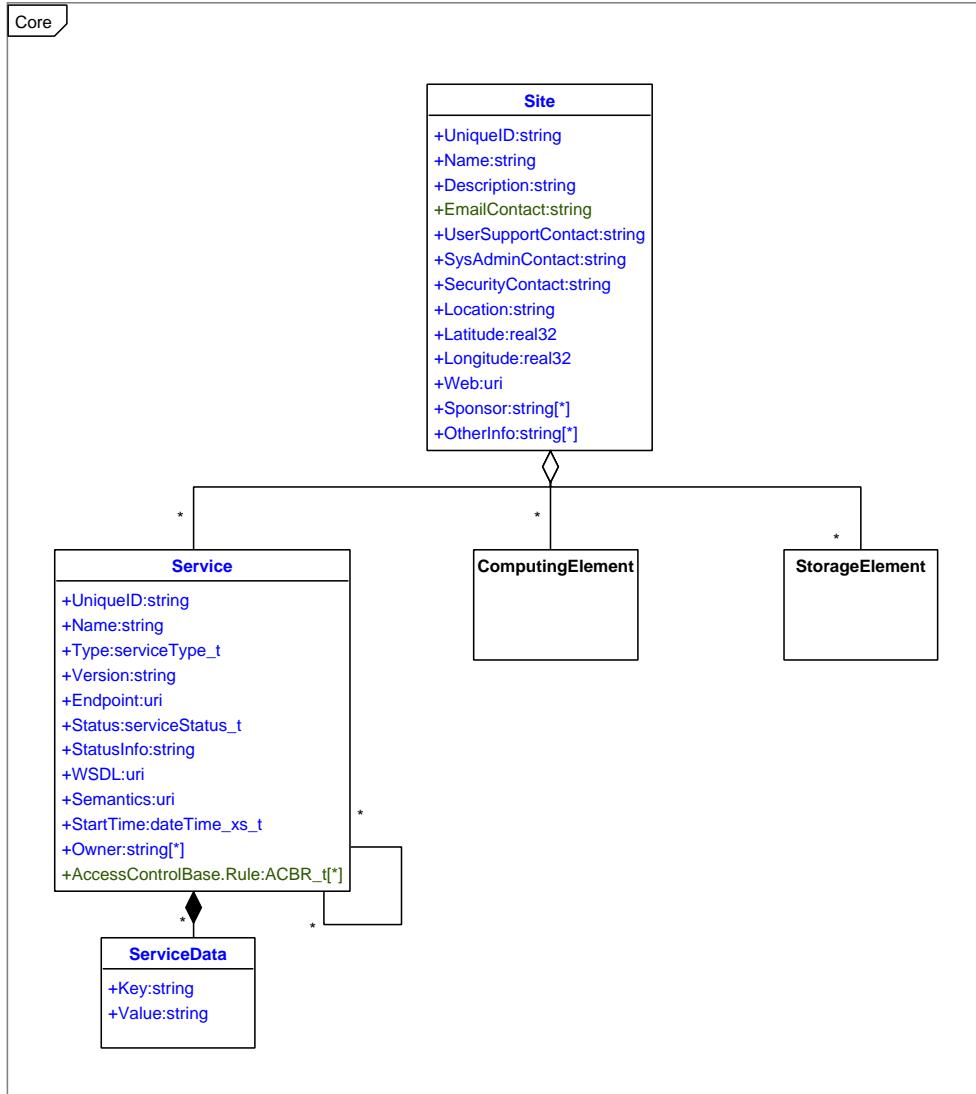


Figure 1: Core (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

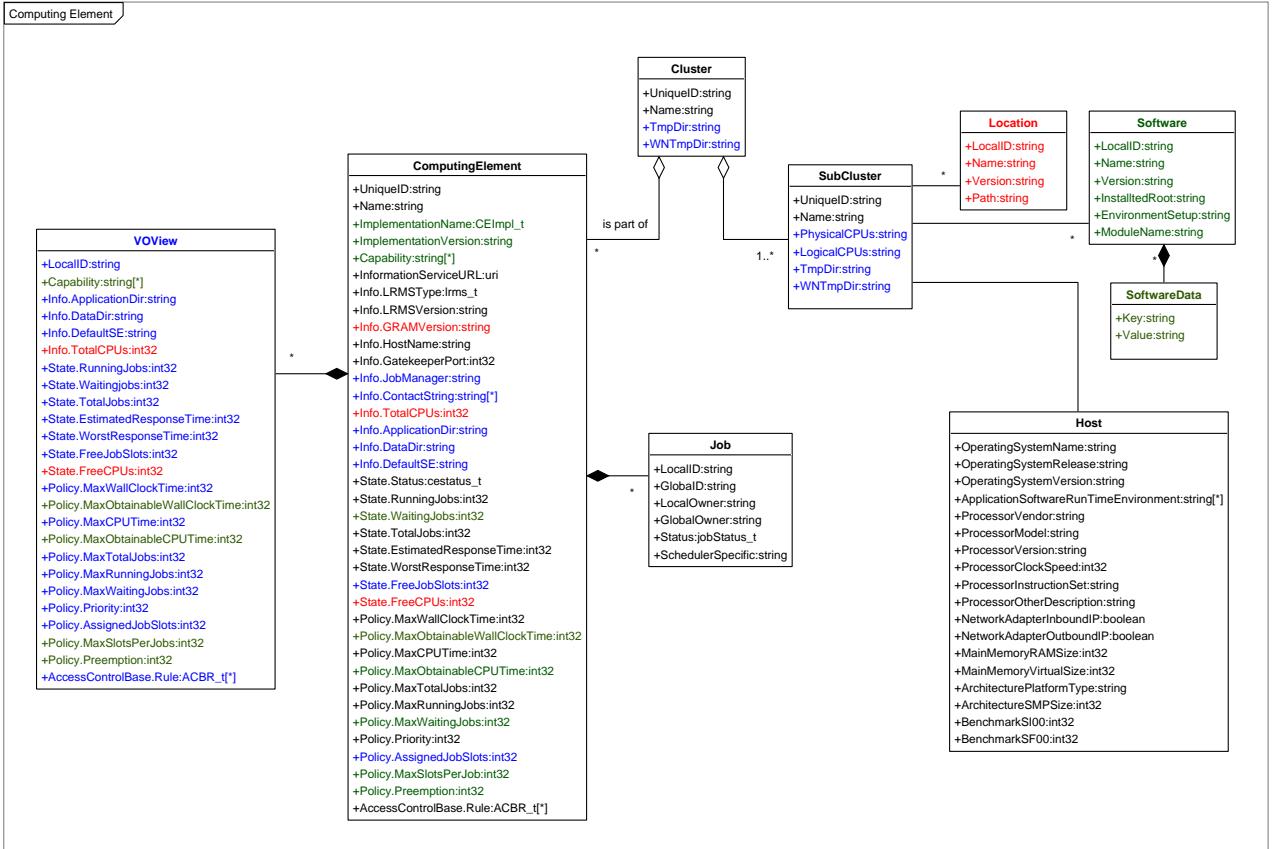


Figure 2: Computing Resources (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

### 3 Computing Resources

In this section, we present a model for an abstract view of computing resources at the Grid level. The Computing Element (CE) is a core concept of this model. It aims to describe the computing service that is offered to a group of users or to users or Virtual Organizations (VO).

Typically, computing resources are contributed to a Grid as set of machines locally managed by systems such as the Portable Batch System (PBS), Load Sharing Facility (LSF) or Condor. These systems offer different capabilities as regards flexibility in configuring and differentiating the access to the computing machines (i.e., worker nodes). All of them use queues to stage the requests and can have sets of policies associated. Moreover, they offer scheduling functionalities to impose the fair share of the resources against the set of requests.

The full set of features and policies for a given resource manager typically is much too large and complex to be represented in a reasonably compact schema. Furthermore, different batch systems have features which vary qualitatively. The aim of the GLUE schema is therefore to model these systems in a way which gives a reasonable description for most practical uses, and which is capable of being implemented for all supported systems. This inevitably means that in some ways the model will be inaccurate; the main goal is usability in practice for common configurations.

As a common abstraction, the Computing Element refers to the characteristics, resource set and policies

of a single queue of the underlying management system. At the Grid level, computing capabilities appear as Computing Elements (each being a set of job slots to which policies and status information are associated) that are reachable from a specific network endpoint. As local resource managers can be configured to assign group-specific policies to queues, different groups of users can perceive the CE in different states. For example, a CE may show free job slots when jobs for a particular VO will not run due to a VO-specific quota, or conversely the EstimatedResponseTime may be non-zero even though jobs for some VOs would start immediately. In order to deal with this possibility, we need to model the different states for different groups of users (typically on a per-VO basis or at a finer grain). This is accomplished by the VOView entity reporting state information specific to a group or VO.

In order to understand when VOView related attributes should be considered instead of the CE ones, the `AccessControlBase.Rule` attribute should be considered (see Section B.1 for the syntax). When user credentials match the ones reported in the `AccessControlBase.Rule`, then the VOView attributes should be considered. The usage of such a feature should be carefully evaluated at deployment time because it may lead to situations where multiple VOView entities match the same set of user credentials. At the moment, there is no middleware support for signaling to the CE which VOView should be used for a certain job submission. As an example, in gLite the association is implicitly made by considering the first VOMS proxy FQAN to be matched in sequential order with the LCMAPS mapping rules.

Like all the attributes in the schema, `AccessControlBase.Rule` contains a description of a CE characteristic. Even if it is expected to be correct and automatic scheduling mechanisms may use it, it is unlikely that the CE will use the GLUE Schema to enforce its authorization policies (it is more likely the opposite, that the Schema content presents the content or configuration of other softwares on the CE). For this reason users should not take it as a guarantee of the described policies and system administrators should expect requests violating the posted limits and enforce them through other mechanisms (e.g., unlisted users normally will have their requests refused).

The attributes `ApplicationDir`, `DataDir` and `DefaultSE` present in both the CE and VOView entities are intended to support common usage in both LCG and OSG. The first two are used for VO-specific areas shared by all WNs which are used for application software and temporary data files respectively. The third is to specify a default Storage Element for output files in the case that a job does not choose an SE explicitly; this will usually be one of the SEs specified in the CESEBind (see section 5). Finally, the attributes which previously had names referring to CPUs are migrated to names referring to JobSlots, as this is clearer and is likely to cause less confusion (many systems run more than one job per CPU concurrently).

A SubCluster refers to a disjoint set of hosts classified by homogeneity and provides a summary description of them. A Cluster can be considered an aggregation of a set of SubClusters and a set of Computing Elements.

### 3.1 Cluster

A cluster is an aggregation entity for representing a complex computing resource in terms of the SubCluster and Computing Element entities. A cluster is a heterogeneous set of resources (computers belonging to the same cluster may have different CPU, RAM and even different OS), while a SubCluster is an homogeneous one (see Section 3.3).

Entity	Inherits from		Description	
Property	Type	Mult.	Unit	Description
Cluster.UniqueID	string	1		Unique ID associated to the cluster (typically refers to the host name of the machine where the LRMS runs (U))
Name	string	1		Name of the cluster. It does not need to be unique and can be used as a human-readable name (U)
TmpDir	string	1		The path of a temporary directory shared across worker nodes. This directory must be available to programs using the normal file access primitives (open/read/write/close) and possibly provide some lock mechanisms. The view provided by this directory on different hosts must be synchronized (e.g., if a host writes some content in a file, a read operation from a different host must be able to access that content. It may be necessary to call an explicit synchronization primitive, depending on the technology used). This directory may be used as shared space by programs running on multiple hosts (e.g. MPI) (N)
WNTmpDir	string	1		The path of a temporary directory local to each Worker Node. This directory must be POSIX compliant. This will probably be the run directory for jobs running on that WN. Applications must be able to perform all the operations supported on local disks by that OS (e.g. open/read/write files or special files like pipes, create locks and change permissions). The Cluster or the CE may take care of providing an empty directory for the job and remove the directory once the job finished (N)
Association Endpoint (Entity.Property)		Mult.		Description
SubCluster.UniqueID		1..*		A cluster can be decomposed in one or more subclusters
ComputingElement.UniqueID		0..*		A cluster offers zero or more Computing Elements
Site.UniqueID		1		A cluster is part of a site (N)

## 3.2 Computing Element

A Computing Element is the common Grid abstraction for a queue of a system managing computing resources. The CE has associated a description of its static characteristics (Info), a status changing frequently (State), a general use policy (Policy), a set of authorized users or groups (AccessControlBase), group-specific attribute values (VOViews) and jobs running on it (Jobs). The entities Info, State, Policy and AccessControlBase present in the previous GLUE Schema version have been merged into the Computing Element. For backwards compatibility, the entity name is included in the attribute name in order to enable the maintenance of a consistent mapping onto concrete data models.

Entity	Inherits from	Description		
Computing Element		Service that manages jobs and offers them execution environments provided by computing resources. The considered computing resources are those assigned to a single batch queue.		
Property	Type	Mult.	Unit	Description
UniqueID	string	1		Unique Identifier for this computing element (U)
Name	string	1		The name of the underlying batch queue (U)
ImplementationName	CImpl.t	1		The name of the implementation (NN)
ImplementationVersion	string	1		The version of the implementation (NN)
Capability	string	*		General way to advertise functions supported by this entity (NN)
InformationServiceURL	uri	1		Contact URI of the service providing for status and characteristics information (e.g., the URI of the MDS GRIS that is the primary source for the class instance information, this is useful to locate such an endpoint from a top-level GIIS) (U)
Info.LRMSType	lrms.t	1		Type of the underlying local resource management system (U)
Info.LRMSVersion	string	1		Version of the local resource management system (U)
Info.GRAMVersion	string	1		Version of Globus GRAM protocol (D)
Info.HostName	string	1		Host name of the machine running this service (U)
Info.GatekeeperPort	int32	1		Gatekeeper port (U)
Info.JobManager	string	1		The job manager used by the gatekeeper (e.g.: jobmanager-pbs). Generally speaking, it is a string that allows to distinguish between different queues accessible using the same host and port. (N)
Info.ContactString	string	*		String specifying how to contact the service. A default value can be HostName:GatekeeperPort/Jobmanager. It identifies an endpoint for computing resources in given protocol (usually GRAM) (N)
Info.TotalCPUs	int32	1		Number of CPUs available to the service (it does not necessarily represent the total available resources in the underlying system as more computing elements can share the same computing resources (D)
Info.ApplicationDir	string	1		The path of the directory available for application installation. Typically a POSIX accessible disk space with transient to permanent allocation to the users (N)
Info.DataDir	string	1		The path of a shared directory available for application data. Typically a POSIX accessible transient disk space shared between the Worker Nodes. It may be used by MPI applications or to store intermediate files that need further processing by local jobs or as staging area, specially if the Worker Node have no internet connectivity (N)
Info.DefaultSE	uri	1		Unique identifier of the default Storage Element. Unique identifier of the default Storage Element to be used to store files from jobs in the CE in cases where no destination SE is explicitly stated (N)
State.Status	cestatus.t	1		The queue status: 'Queueing' the queue can accept job submission, but can not be served by the scheduler; 'Production' the CE can accept job submissions and is served by a scheduler; 'Closed' the CE can not accept job submission and can not be served by a scheduler; 'Draining' the CE can not accept job submission, but can be served by a scheduler. (U)
State.RunningJobs	int32	1		The number of jobs in running state (U)
State.WaitingJobs	int32	1		The number of jobs in waiting state (N)
State.TotalJobs	int32	1		The number of jobs in any state (U)
State.EstimatedResponseTime	int32	1	s	Based on the accepted jobs, estimated time to last for a new job from the acceptance to the start of its execution (U)
State.WorstResponseTime	int32	1	s	Among the accepted jobs, the worst time from the job being accepted by the service to the start of its execution (U)
State.FreeJobSlots	int32	1		Number of free job slots (sometimes called logical CPUs), i.e., number of single-processor jobs which could be started if no other jobs are submitted and no jobs finish in the interim. This could be the size of the queue less the used resources, but a policy could influence this number (N)
State.FreeCPUs	int32	1		Number of free CPUs available to a scheduler (D, use FreeJobSlots instead)
Policy.MaxWallClockTime	int32	1	min	The default maximum wall clock time allowed to each job by the batch system if no limit is requested. Once this time has expired the job will most likely be killed or removed from the queue (U)
Policy.MaxObtainableWallClockTime	int32	1	min	The maximum obtainable wall clock time that can be granted to the job upon user request (NN)
Policy.MaxCPUTime	int32	1	min	The default maximum CPU time allowed to each job by the batch system (U)
Policy.MaxObtainableCPUTime	int32	1	min	The maximum obtainable CPU time that can be granted to the job upon user request (NN)
Policy.MaxTotalJobs	int32	1		The maximum allowed number of jobs in the CE (U)
Policy.MaxRunningJobs	int32	1		The maximum allowed number of jobs in running state in the CE (U)
Policy.MaxWaitingJobs	int32	1		The maximum number of jobs that can be in waiting state (NN)
Policy.Priority	int32	1		The priority given to jobs in this CE. The lower the number, the higher the priority (U)
Policy.AssignedJobSlots	int32	1		Number of slots for jobs to be in running state (it represents the maximum number of single-processor jobs that can be running at a given time) (N)
Policy.MaxSlotsPerJobs	int32	1		The maximum number of slots which could be allocated to a single job (defined to be 1 for a site accepting only standard jobs). (NN)
Policy.Preemption	boolean	1		If true, the batch system enables preemption of jobs (NN)
AccessControlBase.Rule	ACL.t	1		Authorization rule for this entity (U)
Association Endpoint (Entity.Property)		Mult.		Description
Job.LocalID		*		A Computing Element is managing this job
VOView.LocalID		*		A Computing Element provides partitioned views of resources on a VO basis
Cluster.UniqueID		1		A Computing Element is part of a cluster

Entity	Inherits from			Description
VOView	VO view of available resources of a Computing Element			
Property	Type	Mult.	Unit	Description
LocalID	string	1		Local identifier of the VO (or VO subgroup) within the CE (N)
Capability	string	*		General way to advertise functions supported by this entity (NN)
Info.TotalCPUs	int32	1		see definition in ComputingElement entity (D)
Info.ApplicationDir	string	1		see definition in ComputingElement entity (N)
Info.DataDir	string	1		see definition in ComputingElement entity (N)
Info.DefaultSE	uri	1		see definition in ComputingElement entity (N)
Info.TotalCPUs	int32	1		see definition in ComputingElement entity (D)
State.RunningJobs	int32	1		see definition in ComputingElement entity (N)
State.WaitingJobs	int32	1		see definition in ComputingElement entity (N)
State.TotalJobs	int32	1		see definition in ComputingElement entity (N)
State.EstimatedResponseTime	int32	1	s	see definition in ComputingElement entity (N)
State.WorstResponseTime	int32	1	s	see definition in ComputingElement entity (N)
State.FreeJobSlots	int32	1		see definition in ComputingElement entity (N)
State.FreeCPUs	int32	1		see definition in ComputingElement entity (D, use FreeJobSlots instead)
Policy.MaxWallClockTime	int32	1	min	see definition in ComputingElement entity (N)
Policy.MaxObtainableWallClockTime	int32	1	min	see definition in ComputingElement entity (NN)
Policy.MaxCPUTime	int32	1	min	see definition in ComputingElement entity (N)
Policy.MaxObtainableCPUTime	int32	1	min	see definition in ComputingElement entity (NN)
Policy.MaxTotalJobs	int32	1		see definition in ComputingElement entity (N)
Policy.MaxRunningJobs	int32	1		see definition in ComputingElement entity (N)
Policy.MaxWaitingJobs	int32	1		see definition in ComputingElement entity (NN)
Policy.Priority	int32	1		see definition in ComputingElement entity (N)
Policy.AssignedJobSlots	int32	1		see definition in ComputingElement entity (N)
Policy.MaxSlotsPerJobs	int32	1		see definition in ComputingElement entity (NN)
Policy.Preemption	boolean	1		see definition in ComputingElement entity (NN)
AccessControlBase.Rule	ACL.t	1		see definition in ComputingElement entity (N)
Association Endpoint (Entity.Property)		Mult.		Description
ComputingElement.UniqueID		1		Computing Element to which this view is related

As regards the **ApplicationDir** and **DataDir** attributes, it should be considered that the view provided by these directories on different hosts must be synchronized. For instance, when a host writes some content in a file, a read operation from a different host must be able to access that content. It may be necessary to call an explicit synchronization primitive, depending on the used technology. As regards **ApplicationDir**, the CE may provide differentiated privileges, that allow read/write to a VO's software managers and read-only access to the other users of the VO (suggested extra feature).

Entity	Inherits from			Description
Job	Information about a job currently managed by the Computing Element			
Property	Type	Mult.	Unit	Description
LocalID	string	1		Batch job ID given by the batch system, unique within the CE (U)
GlobalID	string	1		Batch job ID given by the grid system (should be a URI) (U)
GlobalOwner	string	1		The owner of this job for the Grid system, e.g. the DN of the user submitting the job (U)
ExecutionTarget	string	1		The current target where the job is executed (typically the host name) (U)
Status	jobStatus.t	1		Status of the job: 'queued', 'running' (U)
SchedulerSpecific	string	1		Scheduler specific info (U)
Association Endpoint (Entity.Property)		Mult.		Description
ComputingElement.UniqueID		1		A job is managed by a Computing Element

### 3.3 SubCluster

The SubCluster entity provides details of the machines that offer execution environments to jobs. It refers to a homogeneous set of hosts as regards the selected attributes. The set of attributes that are used for the summary description are present in the **Host** entity (see Fig. 2). This has not to be confused with the **Host** entity in Figure 7 of Section C. The separation is made in order to differentiate matchmaking-related attributes from the monitoring-related ones. Moreover, for backwards compatibility the two entities have the same name (this overlapping can be resolved during a major revision of the schema). A **Software** entity has been added in order to provide a mechanism to describe what software packages are available in the worker nodes part of the **SubCluster**. This new entity replaces the one for **Location**.

Entity	Inherits from			Description
SubCluster	Information about an homogeneous set of hosts as regards a selected number of host attributes			
Property	Type	Mult.	Unit	Description
UniqueID	string	1		Unique ID of the subcluster (U)
Name	string	1		Name of the subcluster (U)
PhysicalCPUs	int32	1		The total number of real CPUs in the subcluster (N)
LogicalCPUs	int32	1		The effective number of CPUs in the subcluster, including the effect of hyper-threading and the effects of virtualization due to the queuing system (N)
Association Endpoint (Entity.Property)		Mult.		Description
Cluster.UniqueID		1		A subcluster is part of a cluster
Location.LocalID		*		A subcluster has associated a set of locations
Host		1		A subcluster has associated a summary description of the offered execution environment

Entity	Inherits from	Description	
Location		General mechanism that models name, version and path of installed software. It may be useful if some users (e.g., VO software managers) are allowed to modify these entries directly (D)	
Property	Type	Mult.	Unit
LocalID	string	1	
Name	string	1	A local identifier for the location (suggested value: concatenation of Name and Version attributes separated by the + character) (D)
Version	string	1	A name for this location (e.g., VDT.LOCATION) (D)
Path	string	1	Version, following the syntax adopted by that software (e.g., 1.3.6) (D) The related path. The strings \$ApplicationDir, \$DataDir, \$DefaultSE, \$TmpDir, and \$WNTmpDir are reserved. They can be used only at the beginning of Path and are a reference to the directories named respectively by the ApplicationDir, DataDir, DefaultSE attributes in the VOView entity and by the TmpDir, WNTmpDir attributes in the Cluster entity (e.g., /opt/grid) (D)
Association Endpoint (Entity.Property)		Mult.	Description
SubCluster.UniqueID		1	A location is associated to a subcluster

Entity	Inherits from	Description	
Software		Information about an installed software package. (NN)	
Property	Type	Mult.	Unit
LocalID	string	1	A local identifier for the location (suggested value: concatenation of Name and Version attributes separated by the + character) (NN)
Name	string	1	A name for this software package (NN)
Version	string	1	Version, following the syntax adopted by the software (NN)
InstalledRoot	string	1	The directory where the software is installed on the file system (NN)
EnvironmentSetup	string	1	Fully qualified script for the setting of the application environment (NN)
ModuleName	string	1	The name of the module that gets loaded (to set the environment) before the job runs (NN)
Association Endpoint (Entity.Property)		Mult.	Description
SubCluster.UniqueID		1	A software is associated to a subcluster
SoftwareData.Key		*	A software has zero or more data specific info

Entity	Inherits from	Description	
SoftwareData		Key=value pairs to publish software specific information (NN)	
Property	Type	Mult.	Unit
Key	string	1	
Value	string	1	Key identifying the type of data (NN) Value (NN)
Association Endpoint (Entity.Property)		Mult.	Description
Software.LocalID		1	A (key,value) pair related to a software

Entity	Inherits from	Description	
Host		Summary description of the hosts part of the subcluster (N)	
Property	Type	Mult.	Unit
OperatingSystemName	string	1	
OperatingSystemRelease	string	1	Name of the operating system (U)
OperatingSystemVersion	string	1	Release of the operating system (U)
ProcessorModel	string	1	Version of the operating system (U)
ProcessorVersion	string	1	Processor model as defined by the vendor (U)
ProcessorVendor	string	1	Processor version (U)
ProcessorClockSpeed	int32	1	Name of the processor vendor (U)
ProcessorInstructionSet	string	1	MHz
ProcessorOtherDescription	string	1	The clock speed (U)
MainMemoryRAMSize	int32	1	The processor instruction set; use comma-separated values (e.g.: mmx,cisc) (U)
MainMemoryVirtualSize	int32	1	Other description for the processor (U)
NetworkAdapterOutboundIP	boolean	1	The amount of RAM (U)
NetworkAdapterInboundIP	boolean	1	The amount of Virtual Memory (RAM+Swap) (U)
ArchitecturePlatformType	string	1	Permission for direct outbound connectivity, even if limited (U)
ArchitectureSMPSize	int32	1	Permission for inbound connectivity, even if limited (U)
BenchmarkSI00	int32	1	Platform type of the host (U)
BenchmarkSF00	int32	1	number of physical CPUs in the host (U)
App.Soft.RunTimeEnvironment	string	*	SpecInt2000 (U)
			SpecFloat2000 (U)
Association Endpoint (Entity.Property)		Mult.	Description
SubCluster.UniqueID		1	ApplicationSoftwareRunTimeEnvironment: environment variable associated to an installed software package (U)
			Describing a subcluster

For measuring the attributes related to the operating system (i.e., name, release and version), we provide a recommendation for Linux-related environments. We suggest to rely on the commands related to the Linux Standard Base (LSB) specification[9]. In particular, we propose to use the command `lsb_release -d` and to extract the output as follows: the name is given by the content between `Description:` and `Release` (or `release`); the release is given by the content between `Release` (or `release`) and the open parenthesis ( ; the version is given by the content between the character ( and the parentheses ). For instance, if the output of the command `/usr/bin/lsb_release -d` is `Description: Fedora Core release 4 (Stentz)`, then the operating system related attributes should be filled as follows: `GlueHostOperatingSystemName: Fedora Core`, `GlueHostOperatingSystemRelease: 4` and `GlueHostOperatingSystemVersion: Stentz`.

## 4 Storage Resources

In this section, we present a model for abstracting storage resources. Storage resources contributed to a Grid system can vary from simple disk servers managed via GridFTP to complex massive storage systems managed via SRM. These resources can be managed by different services, each of them taking care of a certain management aspect (e.g., data access, quota management or space management).

The **Storage Element** (SE) is the core concept of this model and identifies the group of services responsible for the storage resource. At the virtual level, the storage resource is abstracted using the concept of **Storage Area** that can be made accessible to groups of users or VOs by using the `AccessControlBase.Rule` attribute (see Section B.1 for the syntax). The entities `AccessProtocol` and `ControlProtocol` are used to publish endpoints of protocols related to the storage resource.

The `Capability` attribute present in `StorageArea`, `AccessProtocol` and `ControlProtocol` is meant to publish implementation specific hints to the client. It can be used to publish key/value pairs. It is suggested that such pairs be published as multi-valued strings of the form  $k_i = v_i$  where  $k_i$  is a key string (which obviously may not contain the character '='), and  $v_i$  is the value string. The order of the key/value strings thus does not matter. See the following example:

```
Capability: ServerTCPBufferSize=10240
Capability: NetworkType=OPN
Capability: RFC1323Support=WindowScale,RTTM,PAWS
```

A Grid middleware or a Grid infrastructure can define its own capabilities. They should be documented to enhance interoperability and prevent collision (i.e., same key used with different semantics).

### 4.1 Storage Element

Entity	Inherits from			Description
Property	Type	Mult.	Unit	Description
StorageElement				Abstraction for a storage resource. Group of services, protocols and data sources.
UniqueID	string	1		Unique Identifier of the Storage Element (U)
Name	string	1		Human-friendly name for the SE (U)
Architecture	SEArch.t	1		Underlying architectural system category. String enumeration: disk, tape, multi-disk, other (N)
SizeTotal	int32	1	GB	the size of the storage capacity managed by this service (D)
SizeFree	int32	1	GB	the size of the storage capacity that is free for new files for any VO/user. (D)
InformationServiceURL	string	1		URL of the information service providing details for this SE (e.g., the URI of the MDS GRIS that is the primary source for the class instance information, this is useful to locate such an endpoint from a top-level GIIS) (U)
Port	int32	1		(D)
StateCurrentIOLoad	string	1		(D)
ImplementationName	SEImpl.t	1		The name of the implementation (NN)
ImplementationVersion	string	1		The version of the implementation (NN)
Status	sestatus.t	1		The status of the whole SE: 'Queuing' the SE can accept new requests, but they will be kept on hold; 'Production' the SE processes old and new requests according to its policies; 'Closed' the SE does not accept new requests and does not process old requests; 'Draining' the SE does not accept new requests, but still processes old requests (NN)
TotalOnlineSize	int32	1	GB	Total size of online storage space (NN)
TotalNearlineSize	int32	1	GB	Total size of nearline storage (NN)
UsedOnlineSize	int32	1	GB	Used online storage (NN)
UsedNearlineSize	int32	1	GB	Used nearline storage (NN)
Association Endpoint (Entity.Property)		Mult.		Description
StorageArea.LocalID	*			A storage element manages zero or more storage areas
ControlProtocol.UniqueID	*			A storage element groups zero or more control protocols
AccessProtocol.UniqueID	1..*			A storage element offers one or more data access protocols
Site.UniqueID	1			A storage element is part of a Site

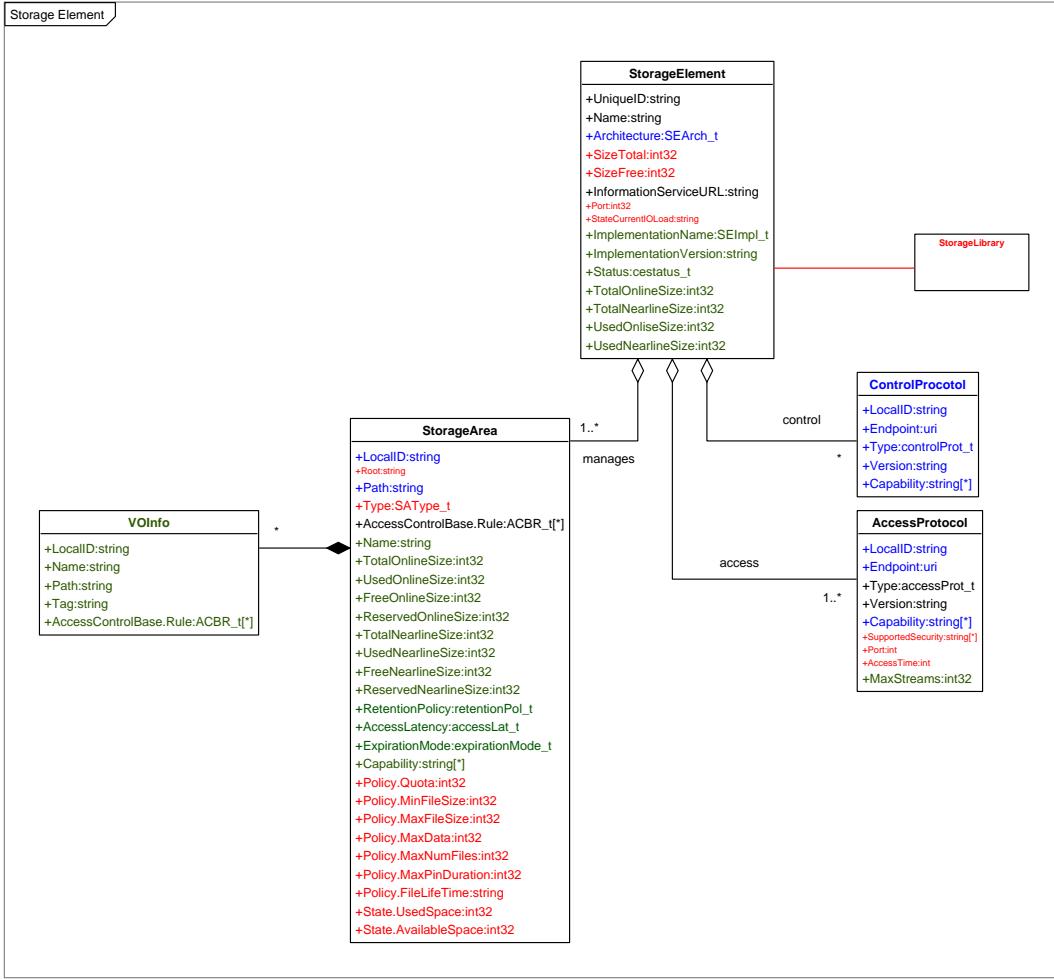


Figure 3: Storage Resources (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

## 4.2 Storage Area

The storage area is a logical portion of storage extent assigned to a VO. Storage areas can overlap the same physical space, thus having contention over the free space among different VO's.

Entity	Inherits from	Description			
		Mult.	Unit	Portion of storage extent to which a uniform set of policies applies	Description
<b>StorageArea</b>					
<b>Property</b>	Type	1			
LocalID	string	1		Local Identifier of this area. It must be unique within the storage element. (N)	
Name	string	1		Human-friendly name for the area (NN)	
Path	string	1		Full path of the root directory for this storage area (N)	
Type	SAType_t	1		Guarantee on the lifetime for the storage area. String enumeration: permanent, durable, volatile, other. (D)	
AccessControlBase.Rule	ACL_t	1		Authorization rule for this entity (U)	
TotalOnlineSize	int32	1	GB	Total online storage space (NN)	
UsedOnlineSize	int32	1	GB	Used online storage space (NN)	
FreeOnlineSize	int32	1	GB	Free online storage space (NN)	
ReservedOnlineSize	int32	1	GB	Reserved online storage space (NN)	
TotalNearlineSize	int32	1	GB	Total nearline storage space (NN)	
UsedNearlineSize	int32	1	GB	Free nearline storage (NN)	
FreeNearlineSize	int32	1	GB	Free nearline storage space (NN)	
ReservedNearlineSize	int32	1	GB	Reserved nearline storage space (NN)	
RetentionPolicy	retentionPol_t	1		Possible values: custodial, output, replica (NN)	
AccessLatency	accessLat_t	1		Possible values: online, nearline, offline (NN)	
ExpirationMode	expirationMode_t	1		Possible values: neverExpire, warnWhenExpired, releaseWhenExpired (NN)	
Capability	string	*		General way to advertise functions supported by this entity (NN)	
Policy.Quota	int32	1	KByte	The quota assigned (D)	
Policy.MinFileSize	int32	1	B	The minimum size for any single file (D)	
Policy.MaxFileSize	int32	1	B	The maximum size for any single file (D)	
Policy.MaxData	int32	1	B	The maximum amount of data that may be stored by one job (D)	
Policy.MaxNumFiles	int32	1	Byte	The max number of files which may be stored by 1 job (D)	
Policy.MaxPinDuration	int32	1	s	The maximum time for a file to be pinned (D)	
Policy.FileLifeTime	enum	1	s	Lifetime policy to be applied to the contained files (Permanent, Durable or Volatile) (D)	
Policy.MaxNumFiles	int32	1	s	(D)	
State.UsedSpace	int32	1	KB	The used space (the guaranteed quota is taken first) (D)	
State.AvailableSpace	int32	1	KByte	The available space (D)	
Root	string	1		The local directory that is the root of the area (D)	
Association Endpoint (Entity.Property)		Mult.			Description
StorageElement.UniqueID		1		A Storage Area is part of a Storage Element	
VOInfo.LocalID		*		A Storage Area has zero or more VOInfo	

Entity	Inherits from	Description			
		Virtual	Organization specific information for a storage area (NN)	Description	
<b>VOInfo</b>					
<b>Property</b>	Type	Mult.	Unit		
LocalID	string	1		Local Identifier, unique within a specific Storage Element instance (NN)	
Name	string	1		Human-friendly name for the VOInfo (NN)	
Path	string	1		Path used by VO for writing into SA (NN)	
Tag	string	1		A string allowing the VO to select this SA (NN)	
AccessControlBase.Rule	ACL_t	1		Authorization rule for this entity (NN)	
Association Endpoint (Entity.Property)		Mult.		Description	
StorageArea.LocalID		1		Is part of a Storage Area	

### 4.3 Access Protocol

The AccessProtocol describes allowed ways to transfer files to and from an SE. Currently this includes `gridftp`, `rfio` (an HEP-specific protocol), and `file` which implies direct posix access, e.g. with NFS or AFS. The protocol is defined by its Type, which has an enumerated list of allowed values. The main attributes are the endpoint and the protocol version (note that in principle an SE could have multiple AccessProtocol objects for different versions of the same protocol).

In addition there is a multi-valued string called "Capability" which can be used to identify particular features, for example that a GridFTP server supports particular operations or that access is read-only. These values are not defined by the schema but would typically be defined across a grid project, and may in practice be agreed between projects. This usage is similar to the RunTimeEnvironment attribute for the CE.

Entity	Inherits from	Description			
		Protocol	available to access/transport files in/from storage areas	Description	
<b>Access Protocol</b>					
<b>Property</b>	Type	Mult.	Unit		
LocalID	string	1		Local Identifier, unique within a specific Storage Element instance (N)	
Type	accessProt_t	1		Type of access protocol (U)	
Endpoint	uri	1		Network endpoint for this protocol (N)	
Version	string	1		protocol version (U)	
Capability	string	*		Function supported by this access protocol (N)	
AccessTime	int32	1		(D)	
SupportedSecurity	string	*		The security features the protocol can deal with (D)	
Port	int32	1		(D)	
MaxStreams	int32	1		Number of streams for protocols that support this (NN)	
Association Endpoint (Entity.Property)		Mult.		Description	
StorageElement.UniqueID		1		Is part of a Storage Element	

### 4.4 Control Protocol

The ControlProtocol is similar to the AccessProtocol, but orthogonal to it. Current protocols include `srm` and `classic`, although the latter is not a protocol as such but indicates that no control operations are supported and files should simply be read and written directly. Again an SE might support multiple versions of the same control protocol. There is again a Capability attribute which might be used to identify features like file pinning or advance reservation of space.

Entity	Inherits from	Description		
Control Protocol			Protocol available for the control and/or management of the storage resource (N)	Description
Property	Type	Mult.	Unit	
LocalID	string	1		Local Identifier, unique within a specific Storage Element instance (N)
Type	ControlProt_t	1		Type of control protocol (N)
Endpoint	uri	1		Network endpoint for this protocol (N)
Version	string	1		protocol version (N)
Capability	string	*		Function supported by this control protocol (e.g., space reservation, pinning) (N)
Association Endpoint (Entity.Property)		Mult.		Description
StorageElement.UniqueID		1		Is part of a Storage Element

## 4.5 Storage Library

The storage library is deprecated and only the main entity is described. The file system is described in Section C

Entity	Inherits from	Description		
StorageLibrary			The machine providing for the storage service (D)	Description
Property	Type	Mult.	Unit	
UniqueID	string	1		Unique Identifier (D)
Name	string	1		Name (D)
InformationServiceURL	string	1		InformationServiceURL (D)
ArchitectureType	string	1		Architecture (D)
PerformanceMaxIOCapacity	int32	1		IO Capacity (D)
Association Endpoint (Entity.Property)		Mult.		Description
FileSystem.Name		1..*		A Storage Library has one or more file systems

## 4.6 SRM-based SE Profile

In this section, we explain how the GLUE Schema for the Storage Element should be used in case of an SRM-based SE. (TO BE ADDED)

## 4.7 GridFTP-based Profile

In this section, we explain how the GLUE Schema for the Storage Element should be used in case of an GridFTP-based SE (where GridFTP is used also for basic management of the SE). (TO BE ADDED)

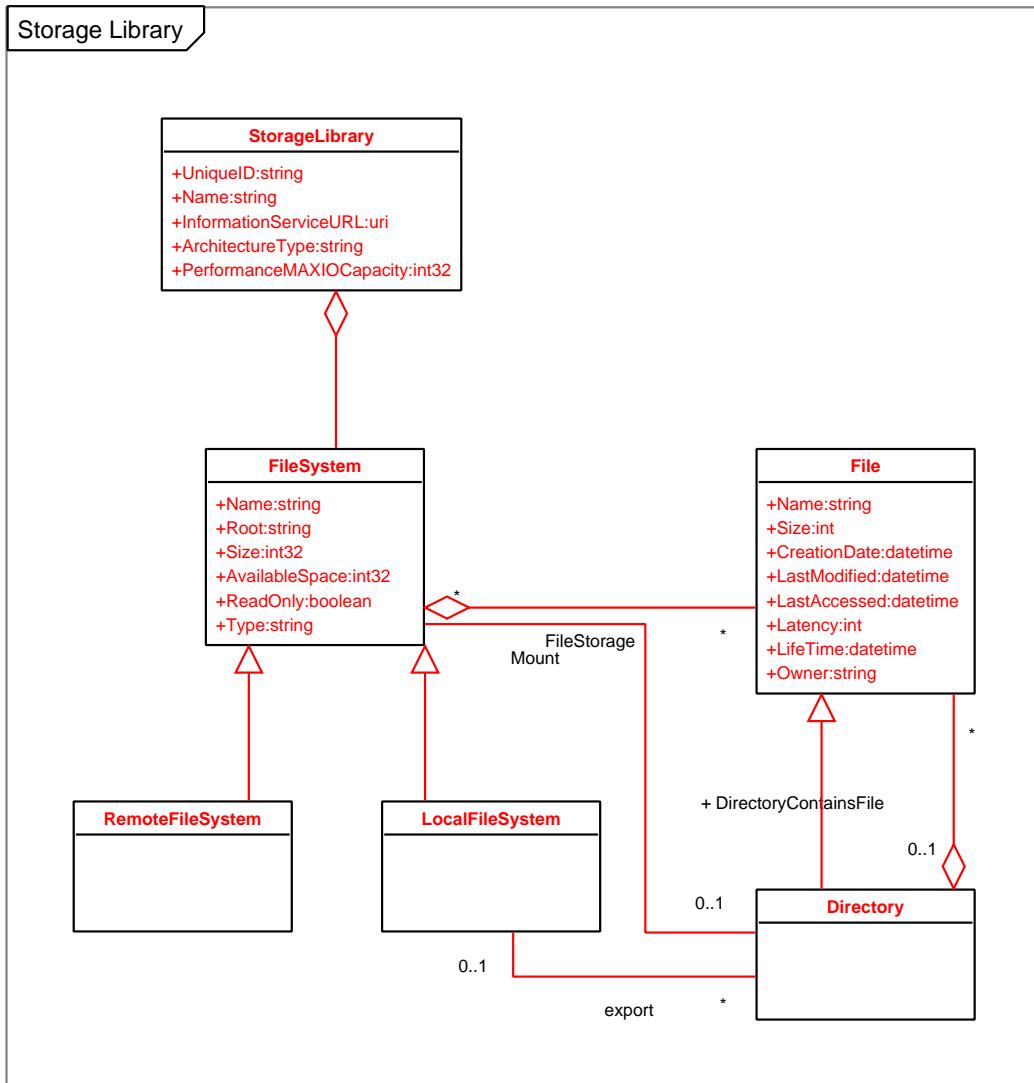


Figure 4: Storage Library (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

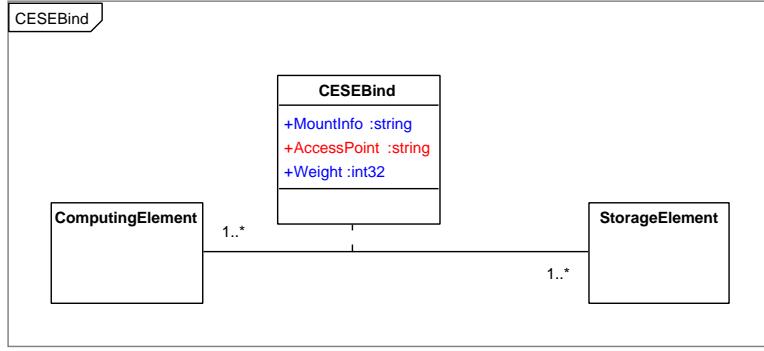


Figure 5: CE and SE relationship (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

## 5 Computing and Storage relationship

Computing and Storage Elements may have relationships implied by the presence of a shared file system (e.g., NFS-mount). Moreover, it is desirable to be able to express a preference relationship among them. Both type of relationships are useful to be discovered from the GIS, since they can be used during Grid-level scheduling. These relationships are intended to be captured by the **CESEBind** concept. Unfortunately this was designed some time ago and several problems have since come to light; this area will be addressed in the next major schema revision.

At present several points need to be borne in mind. The **CESEBind** relation (also known as a "close SE") has traditionally been used in three separate ways: as a way of choosing a CE based on proximity to input files, as a default place to store output files, and as a representation of shared authorisation between CE and SE for rfio and NFS access - with a mount point (AccessPoint) attribute included for the latter.

The first use was intended to be replaced in the longer term by dynamic network monitoring, but this has so far not appeared so this remains the main way to schedule jobs on the basis of fast access to input files. Close SEs should therefore be specified on this basis, and hence may include SEs at different sites if a sufficiently fast network connection is available.

The second use is now largely superseded by the explicit DefaultSE attribute in the CE and VOView objects. However, if the default SE is unusable for some reason, other SEs listed in the **CESEBind** would still be a good choice as a fallback on the basis of fast access.

The third use, direct file access via NFS mounts, is problematic for various reasons and has been dropped by LCG for the time being. The current schema can be used with some limitations, but if continued support for NFS mounts is required a more elaborate schema will be needed. There is no explicit representation of "local" access for e.g. rfio.

There are also two technical issues to be aware of. One is that in the past the AccessPoint in the **CESEBind** was required for "classic" SEs even without an NFS mount, because it was also used to specify the storage area on the SE. This schema revision removes this requirement by introducing the new SAPath attribute in the SE information, which gives the full file path of the storage area, as opposed to the old SARoot which only contained the VO-specific part.

The second point is that the **CESEBind** is generally published with the CE information. Within a site this is not generally a problem, but in some cases it may be desirable to specify relations between CEs and SEs at different sites, and in this case the relation will be under the control of the site running the CE. It is also usually true that if the CE is down the **CESEBind** will not be published, and conversely that if the SE is down and the CE is not the **CESEBind** will still be present, which may represent a degree of inconsistency.

Entity	Inherits from			Description
Bind		Mult.	Unit	Association Class between CE and SE describing preference
MountInfo	string	1		Information about the name of the mount directory common to worker nodes part of the Computing Element and the exported directory from the Storage Element. Its value is a pair of path names (e.g.: /mounted/dir,/exported/dir). If this information is available in an environment variable common to all worker nodes, then the value of this attribute can be the name of such variable (starting with \$)(N)
Weight	uint32	1		It expresses a preference when multiple SE are bound to a CE; the higher, the better. Default is zero
AccessPoint	string	1		(D)
Association Endpoint (Entity.Property)		Mult.		Description
ComputingElement.UniqueID		*		The Computing Element
StorageElement.UniqueID		*		The Storage Element

## 6 Change Log

Date	Version	Description	Contributor
29 Nov 06	1	Initial Draft published	Sergio Andreozzi
8 Jan 07	2	Review	Maarten Litmaath

### 6.1 To Do

1. definitions: TotalOnlineSize and TotalNearlineSize

## A Description of the template

In order to enrich the UML Class Diagrams with additional information, additional tables are associated to each defined class. The structure of each table contains three parts. The first part (1) refers to the whole entity and presents the entity name, the entity from which it inherits (if any) and the description of what the entity is. The second part (2) refers to the attributes that are defined in the UML Class diagram; for each of them, the following properties are described: the attribute name as defined in the UML Class diagram, the data type as defined in B, the multiplicity concerning how many values for the attribute are allowed (\* means zero or more), the unit of measurement and the attribute description with a letter specifying the status of the attribute as regards the previous schema version (N for new, U for unmodified and D for deprecated). The third part (3) refers to the associations (association, composition, aggregation or association class) that the class may hold with other classes. For each association, the associated class endpoint is described in terms of the endpoint name, the multiplicity (i.e., the number of instances of the associated class that are allowed) and a description. This is the template as described above:

Entity	Inherits from			Description
Property	Type	Mult.	Unit	Description
Association Endpoint (Entity.Property)		Mult.		Description

## B Datatypes

In Figure 6, the set of datatypes that are used in this information model are presented. The `dateTime_xs_t` is a timestamp compliant to the XML Schema definition [10]. Where clearly stated, refers to [8] for the complete set of values for the enumeration.

### B.1 ACBR\_t

The type `ACBR_t` is defined as follows: `<PREFIX>:<SNC>`. Both `<PREFIX>` and `<SNC>` are strings containing no colons and no whitespace. Three types of prefix are already reserved:

**VO** to express a VO name

**VOMS** to express a VOMS fully qualified attribute name

**SC** to express a service class

Example of valid values: `VO:atlas`.

Example of not valid values: `VO :atlas`, `VO : cms`, `VOMS:/atlas/Role=sys:admin`.

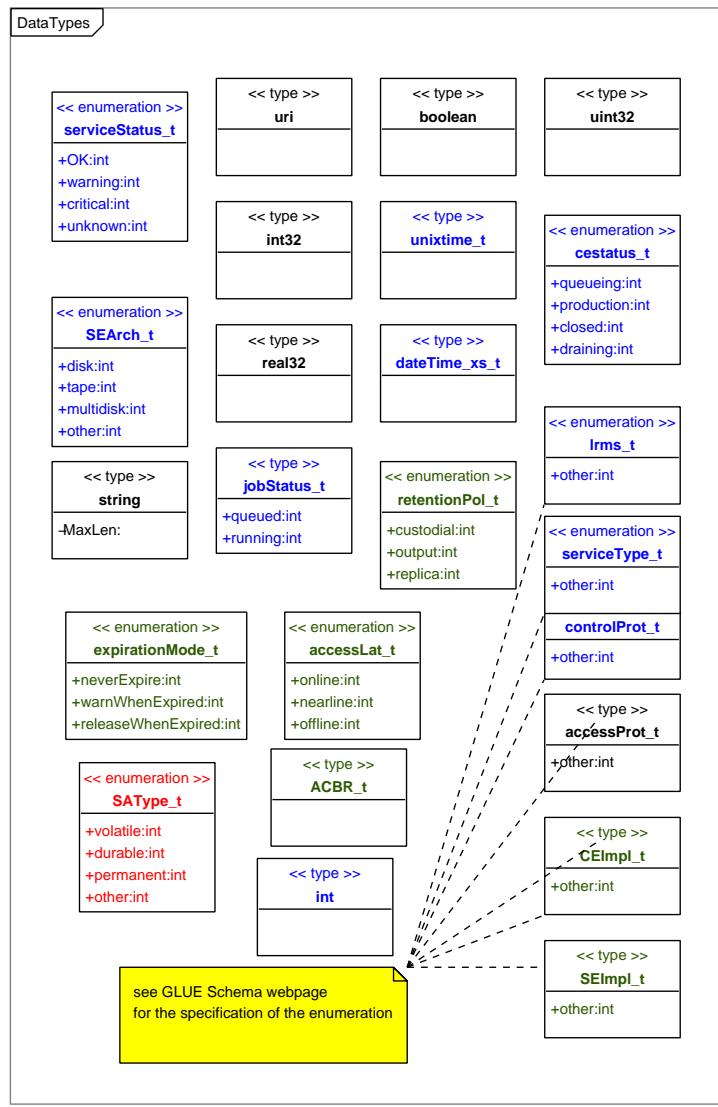


Figure 6: Datatypes (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

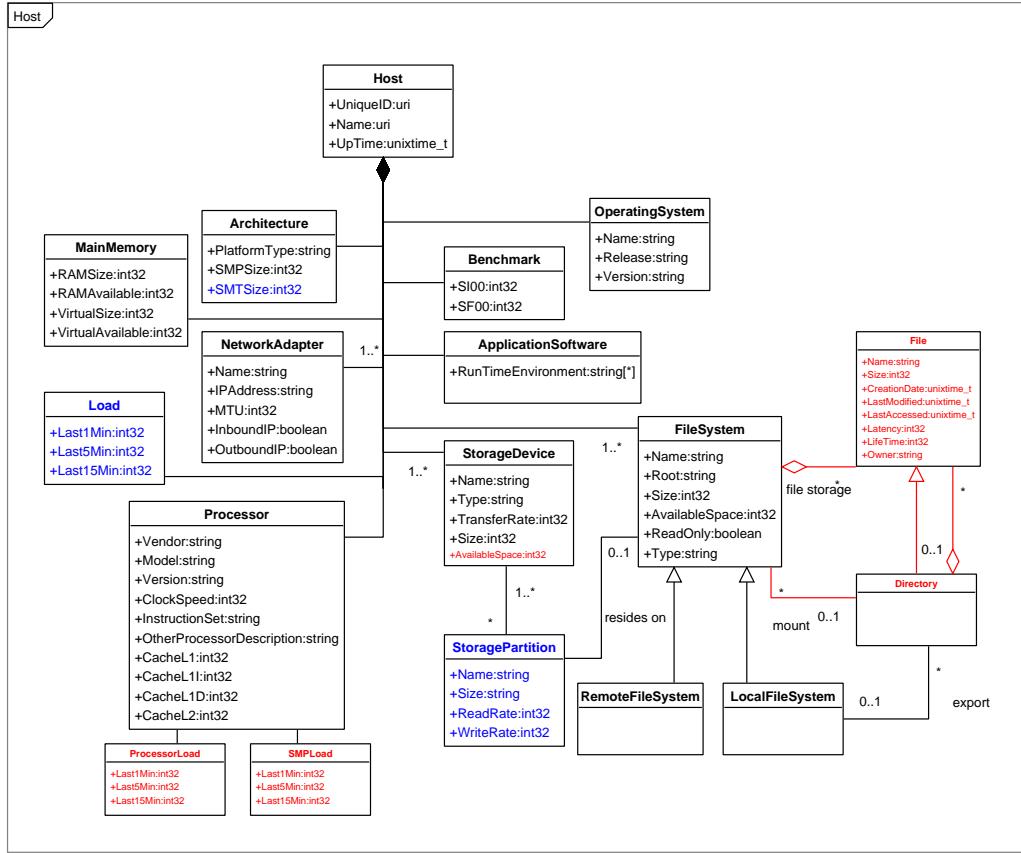


Figure 7: Host (black=unmodified, red=deprecated, blue=new in 1.2, green=new in 1.3)

## C Host

This section provides the modeling of a generic host entity. This entity has been decoupled from the generic CE/Cluster/SubCluster hierarchy as the former is mainly used for functional monitoring while the latter is used mainly for matchmaking.

Entity	Inherits from	Description		
Host		An elementary computing system		
Property	Type	Mult.	Unit	Description
UniqueID	string	1		Unique ID of the host (U)
Name	string	1		Name of the host (U)
UpTime	int32	1	s	UpTime since last OS boot (N)
Association Endpoint (Entity.Property)		Mult.		Description
Architecture		1		The host has an architecture
MainMemory		1		The host has a main memory
NetworkAdapter		1..*		The host has one or more network adapters
Load		1		The host has load status
Processor		1		The host has processors
OperatingSystem		1		The host has an operating system
Benchmark		1		The host has benchmark information
ApplicationSoftware		1		The host has application software installed
FileSystem.Name		1..*		The host has one or more file systems
StorageDevice.Name		1..*		The host has one or more storage devices
StoragePartition.Name		1..*		The host has one or more storage partitions

Entity	Inherits from	Description		
Architecture		Information about the host architecture		
Property	Type	Mult.	Unit	Description
PlatformType	string	1		Platform type of the host (N)
SMPSize	int32	1		number of physical CPUs in the host (N)
SMTSize	int32	1		number of logical CPUs in the host. If the CPUs support the Simultaneous Multi Threading (a.k.a., Hyper-Threading) technology and this is enabled, the logical CPUs have to be advertised (N)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		Architecture information for an host

Entity	Inherits from	Description		
MainMemory		Information about the main memory of the host		
Property	Type	Mult.	Unit	Description
RAMSize	int32	1	MByte	The amount of RAM (N)
RAMAvailable	int32	1	MByte	The amount of free RAM (N)
VirtualSize	int32	1	MByte	The amount of Virtual Memory (RAM+Swap) (N)
VirtualAvailable	int32	1	MByte	The amount of free Virtual Memory (N)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		Main memory information for an host

Entity	Inherits from	Description		
NetworkAdapter		Information about the network adapters of the host		
Property	Type	Mult.	Unit	Description
Name	string	1		The network adapter name (U)
IPAddress	string	1		Assigned IP address (U)
MTU	int32	1	byte	The Maximum Transmission Unit (MTU) size for the LAN to which the network card is attached (U)
OutboundIP	boolean	1		permission for outbound connectivity (U)
InboundIP	boolean	1		permission for inbound connectivity (U)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1..*		A network adapter is part of an host

Entity	Inherits from	Description		
Processor		Information about the processor of the host		
Property	Type	Mult.	Unit	Description
Vendor	string	1		Name of the processor vendor (U)
Model	string	1		Processor model as defined by the vendor (U)
Version	string	1		Processor version (U)
ClockSpeed	int32	1	MHz	The clock speed (U)
InstructionSet	string	1		Processor instruction set (U)
OtherProcessorDescription	string	1		Other processor description, to be used for extra information not covered by the schema (U)
CacheL1L	int32	1	KByte	first-level unified cache size of the processor (U)
CacheL1I	int32	1	KByte	first-level instruction cache size of the processor (U)
CacheL1D	int32	1	KByte	first-level data cache size of the processor (U)
CacheL2	int32	1	KByte	second-level unified cache size of the processor (U)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The processor is part of an host

Entity	Inherits from	Description		
ProcessorLoad		Information about the load of the machine (D)		
Property	Type	Mult.	Unit	Description
Last1Min	int32	1		The average number of process ready to run during the last 1 minute (the value is times 100 to be meaningfully represented as an integer) (D)
Last5Min	int32	1		The average number of process ready to run during the last 5 minutes (the value is times 100 to be meaningfully represented as an integer) (D)
Last15Min	int32	1		The average number of process ready to run during the last 15 minutes (the value is times 100 to be meaningfully represented as an integer) (D)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The load of the host

Entity	Inherits from	Description		
SMPLoad		Information about the load of a processor (D)		
Property	Type	Mult.	Unit	Description
Last1Min	int32	1		The average number of process ready to run during the last 1 minute (the value is times 100 to be meaningfully represented as an integer) (D)
Last5Min	int32	1		The average number of process ready to run during the last 5 minutes (the value is times 100 to be meaningfully represented as an integer) (D)
Last15Min	int32	1		The average number of process ready to run during the last 15 minutes (the value is times 100 to be meaningfully represented as an integer) (D)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The processor is part of an host

Entity	Inherits from	Description		
Load		Information about the load of the host		
Property	Type	Mult.	Unit	Description
Last1Min	int32	1		average of the sum of the run queue length and the number of jobs currently running on the CPUs in the last minute (the value is times 100 to be meaningfully represented as an integer) (N)
Last5Min	int32	1		average of the sum of the run queue length and the number of jobs currently running on the CPUs in the last 5 minutes (the value is times 100 to be meaningfully represented as an integer) (N)
Last15Min	int32	1		average of the sum of the run queue length and the number of jobs currently running on the CPUs in the last 15 minutes (the value is times 100 to be meaningfully represented as an integer) (N)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The load of the host

Entity	Inherits from	Description		
Benchmark		Mult.	Unit	Information about benchmark for the host
Property	Type	1		Description
SI00	int32	1		SpecInt2000 (U)
SF00	int32	1		SpecFloat2000 (U)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The benchmarks of the host

Entity	Inherits from	Description		
OperatingSystem		Mult.	Unit	Information about the operating system of the host
Property	Type	1		Description
Name	string	1		Name of the operating system (U)
Release	string	1		Release of the operating system (U)
Version	string	1		Version of the operating system (U)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The operating system information of the host

Entity	Inherits from	Description		
ApplicationSoftware		Mult.	Unit	Information about the application software available in the host
Property	Type	1		Description
RunTimeEnvironment	string	*		environment variable associated to an installed software package (U)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The runtime environment information of the host

Entity	Inherits from	Description		
StorageDevice		Mult.	Unit	Information about a storage device in the host
Property	Type	1		Description
Name	string	1		Name of the storage device
Type	string	1		Type of storage device (U)
Size	int32	1	MByte	Size of the storage device (U)
TransferRate	int32	1		Maximum transfer rate for the device (U)
AvailableSpace	int32	1	MByte	Space available (D)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The storage device of the host
StoragePartition.Name		*		The storage device can hosts zero or more storage partitions

Entity	Inherits from	Description		
StoragePartition		Mult.	Unit	Information about a storage partition in the storage device
Property	Type	1		Description
Name	string	1		Name of the storage partition (N)
Size	int32	1	Mbytes	Size (N)
ReadRate	int32	1	Mbytes	Number of megabytes write per second (N)
WriteRate	int32	1	Mbytes	Number of megabytes read per second (N)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The storage partition is part of the host
StorageDevice.Name		1..*		The storage partition can span one or more storage devices
FileSystem.Name		0..1		The Storage Partition can be associated to a file system

Entity	Inherits from	Description		
FileSystem		Mult.	Unit	Information about a file system
Property	Type	1		Description
Name	string	1		Name of the file partition (U)
Root	int32	1		path name or other information defining the root of the file system (U)
Size	int32	1	Mbyte	Size of the file system (U)
AvailableSpace	int32	1	Mbyte	Available space in the file system (U)
ReadOnly	boolean	1		Read-only or read-write capabilities (U)
Type	string	1		Type of file system (U)
Association Endpoint (Entity.Property)		Mult.		Description
Host.UniqueID		1		The storage partition of the host
StoragePartition.Name		1		The file system resides on a storage partition
Directory.Name		0..1		The file system can be mount to one directory
File.Name		*		The file system contains zero or more files

Entity	Inherits from	Description		
LocalFileSystem	FileSystem	Mult.	Unit	Information about a local file system (U)
Property	Type	1		Description
Association Endpoint (Entity.Property)		Mult.		Description
Directory.Name		*		The file system can exports zero or more directories

Entity	Inherits from	Description		
RemoteFileSystem	FileSystem	Mult.	Unit	Information about a remote file system (U)
Property	Type	1		Description
Association Endpoint (Entity.Property)		Mult.		Description

Entity	Inherits from	Description		
File		Mult.	Unit	Information about a file
Property	Type	1		Description
Name	string	1		Name of the file (D)
Size	int32	1	KByte	File size (D)
CreationDate	unixtime.t	1	s	File creation date and time (D)
LastModified	unixtime.t	1	s	Last modified date and time (D)
LastAccessed	unixtime.t	1	s	Last accessed date and time (D)
Latency	int32	1		Time taken to access file in seconds (D)
LifeTime	int32	1	s	Lifetime left for this file (-1 if never expires) (D)
Owner	string	1		File owner
Association Endpoint (Entity.Property)		Mult.		Description
Directory.Name		0..1		The file can be part of a directory
FileSystem.Name		*		The file is part of a file system

Entity	Inherits from		Description
Directory	File	Information about a directory (D)	
Property	Type	Mult.	Description
Association Endpoint (Entity.Property)		Mult.	
File.Name		*	The directory contains zero or more files (D)
LocalFileSystem.Name		0..1	The directory can be exported from the local file system (D)

## References

- [1] K. Czajkowski, S. Fitzgerald, I. Foster, and C. Kesselman. Grid Information Services for distributed resource sharing. In IEEE Press, editor, *Tenth IEEE International Symposium on High-Performance Distributed Computing (HPDC-10)*, Aug 2001.
- [2] GLUE Schema collaboration. The GLUE Schema homepage. <http://infnforge.cnaf.infn.it/glueinfomodel/>.
- [3] The Globus Alliance. Glue Schema page. <http://www.globus.org/mds/glueschemalink.html>.
- [4] LHC Computing Grid. LCG 2 Information Reference. [http://grid-deployment.web.cern.ch/grid-deployment//documentation/public/gis/InformationModel\\_/html/InformationModel\\_.index.html](http://grid-deployment.web.cern.ch/grid-deployment//documentation/public/gis/InformationModel_/html/InformationModel_.index.html).
- [5] M. Mambelli and the Grid2003 Project. Grid3 information directory schema, Sep 2003. [http://www.ivdgl.org/documents/document\\_server/show\\_docs.php?series=grid3&category=tech&id=765](http://www.ivdgl.org/documents/document_server/show_docs.php?series=grid3&category=tech&id=765).
- [6] S. Burke, L. Field, M. Litmaath, D. Smith, J. Casey, J.P. Baud, and J. Templon. LCG Proposal for a Minor Upgrade to the GLUE Schema, Jan 2005. <http://infnforge.cnaf.infn.it/docman/view.php/9/72/GLUE%20proposal%20final.doc>.
- [7] B. Kónya. The NorduGrid/ARC Information System - technical description and reference manual. [http://cvs.nordugrid.org/cgi-bin/cvsweb/~checkout~/nordugrid/doc/informationsystem/arc\\_infosys.pdf?content-type=application/pdf](http://cvs.nordugrid.org/cgi-bin/cvsweb/~checkout~/nordugrid/doc/informationsystem/arc_infosys.pdf?content-type=application/pdf).
- [8] GLUE schema, datatypes definition. <http://infnforge.cnaf.infn.it/glueinfomodel/index.php/Spec/V12>.
- [9] Linux Standard Base Specification. <http://www.linuxbase.org/>.
- [10] P.V. Biron and A. Malhotra. XML Schema Part 2: Datatypes Second Edition, 2004. W3C Recommendation 28 October 2004, <http://www.w3.org/TR/xmlschema2/#dateTime>.