

GLUE Schema Specification
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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://infnforge.cnaf.infn.it/glueinfomodel/index.php/Spec/V12>

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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 document presents a description of core Grid resources at the conceptual level by defining an information model, that is an abstraction of 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

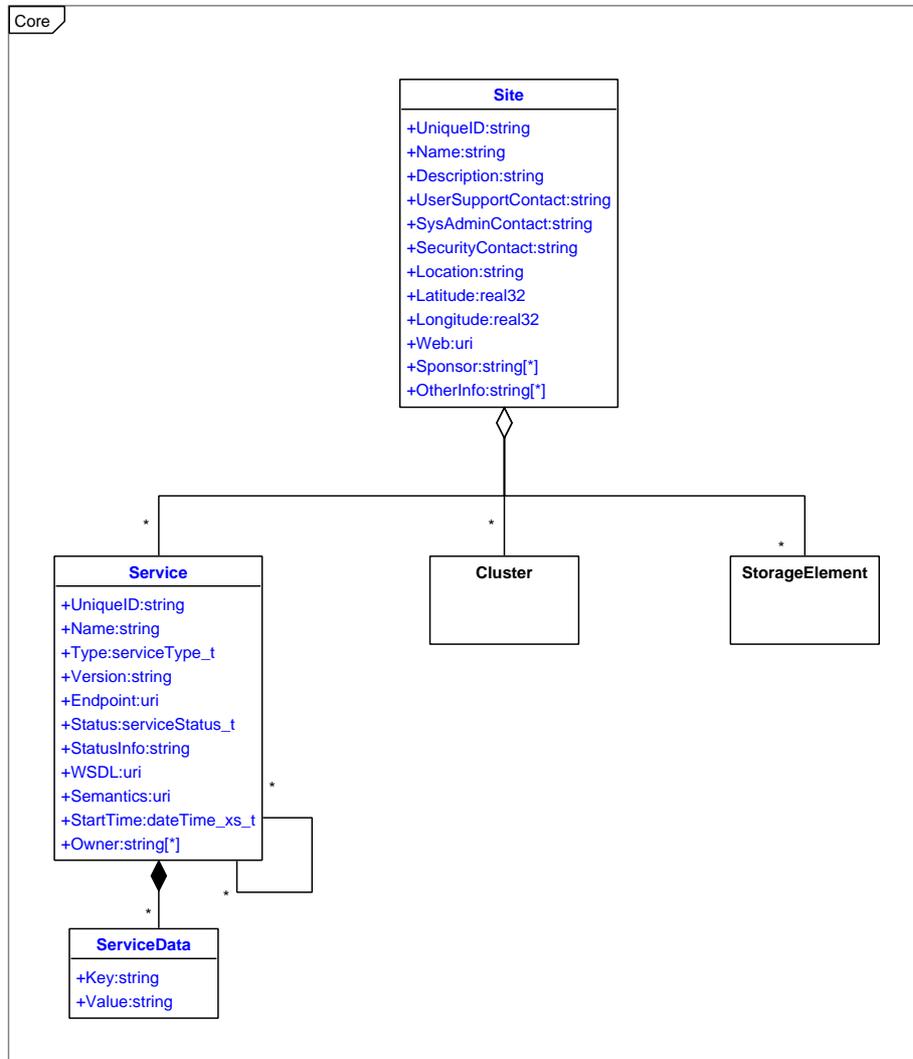
The UML class diagrams describing the information model have attributes in three different colors: black for attributes that are unmodified (U) with respect to the previous specification, blue for attributes are new (N), and red with smaller font for attributes that are deprecated (D). Attributes marked 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 syntay, 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].

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.



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Figure 1: Core (red=deprecated, blue=new, black=unmodified)

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)
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° to 90° 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° to 180° 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)
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)	
Property	Type	Mult.	Unit	Description
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

3 Computing Resources

In this section, we present a model for abstracting at the Grid level computing resources that are managed by different local resource managers. The Computing Element (CE) is a core concept of this model. It aims at describing the computing service that is offered to group of users or Virtual Organizations (VO).

Typically, computing resources are contributed to the Grid as set of machines locally managed by systems such 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 be associated to a set of policies. Moreover, they offer scheduling functionalities to manage the fair share of the resources against the set of requests.

The full set of features and policies for a given resource manager is typically much too large and complex to be represented in a reasonably compact schema. Further, 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 (i.e., 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 group of users can perceive a different state for a CE than the general one. 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.

There are three extra attributes in both the CE and VOView entities introduced in this revision, namely `ApplicationDir`, `DataDir` and `DefaultSE`, which are intended to support common usage in both LCG and Grid3. The first two are used for VO-specific areas mounted on all WNs which are used for application software and temporary data files respectively. The third is to specify a default SE 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 being 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).

Details of machines that offer the execution environment to jobs are described at a fine-grain level by the `SubCluster` entity. This provides also a summary description of homogeneous set of hosts. In this schema revision, the set of attributes that are used for the summary description have been isolated 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 `Cluster` can be considered as a set of `SubClusters`. A `SubCluster` refers to a disjointed set of hosts.

The following paragraphs are a suggestion for the syntax of the `AccessControlPolicyBase.Rule` and the `VOView.AccessControlBaseRule` attributes and for their use to represent or discover the authentication and authorization policies of a CE.

Each user accessing the site presents a proxy certificate that contains the user identity. For VOMS-enabled proxies, there will be also a Fully Qualified Attribute Name (FQAN) that is included in extended certificates and contains information about the VO/group and/or user role. The FQAN, like all the `AccessControlBaseRule` (or `AccessControlPolicyBase.Rule`) in the GLUE Schema, is a string where a series of identifier are separated by the `'/'` (slash) character. Each identifier is a string where `'/'` and `“*”` should not be used. Normally, an FQAN identifies a group of users within a VO and the different levels separated by

'/' increase the granularity of the selection, starting from the VO itself. Case in these strings is important and comparison is case sensitive. An example is `/myVO/mygroup/mysubgroup/myrole`.

The syntax `vo:VONAME` currently used for the `AccessControlBase.Rule` (LCG project) should be considered equivalent to `/voname`. A string with less level in the hierarchy includes each subgroup (e.g., `/cms/production/group1` is included in `/cms/production`). The union of the user space covered by the strings in the `AccessControlPolicyBase.Rule` should cover all the possible FQAN of every user able to authenticate to the CE. The '*' character could be used to identify any string within that level and allows more compact rule-sets. Each user allowed to use a CE will find at least one matching rule in the `AccessControlPolicyBase.Rule`. The matching FQAN-Rule is done through string comparison. A FQAN from a proxy matches any rule that is fully included in it (the `/voname` and all subgroups have to be in the FQAN in that exact order, that is the FQAN has to start with the string of the rule). A user coming with a proxy will be associated with the rule that provides the longest overlap.

The following rules are suggested to find whether a user is allowed to use a CE and to understand when some `VOView` attributes should be considered instead of the general ones. (1) You will have to find all the matching rules (ordered according to their overlap with the FQAN); if there is no matching rule (or the rule is '/', the default one), the user is likely not to be allowed to use the CE. (2) You will select the attributes in the `VOView` corresponding to the associated rule (these will describe the policy and the view of the resources the user should expect). (3) If some attribute is missing, that will be searched in the `VOView` of the next matching rule, up to the summary Computing Element attributes. A shortcut to find only if the user is authorized to use the CE consists in checking `AccessControlPolicyBase.Rule` instead of all the matching rules.

Each CE administrator should use `VOViews` to provide accounting and/or policies for subgroup of users and identify these groups using the `AccessControlBase` rules of that `VOView`. The `AccessControlPolicyBase` entity associated with the CE will also be used to list users allowed to access the CE. A rule already listed in the `AccessControlBase` of a `VOView` should be repeated here even if is redundant (for backward compatibility).

Example 1 shows an example of a rule set and how to find the attributes that apply to 2 incoming users.

```
(1) user1 membership:      /atlas/production/dc2
    user2 membership:      /atlas/production

CE.AccessControlBase.Rule: /atlas
CE.AccessControlBase.Rule: /alice
CE.AccessControlBase.Rule: /cms
CE.State.FreeJobSlots: 100

CE.VOView.LocalID:        ATLAS.production.dc2.view
CE.VOView.AccessControlBaseRule: /atlas/production/dc2
CE.VOView.FreeJobSlots: 30

CE.VOView.LocalID:        CMS.view
CE.VOView.AccessControlBaseRule: /cms
CE.VOView.FreeJobSlots: 30
```

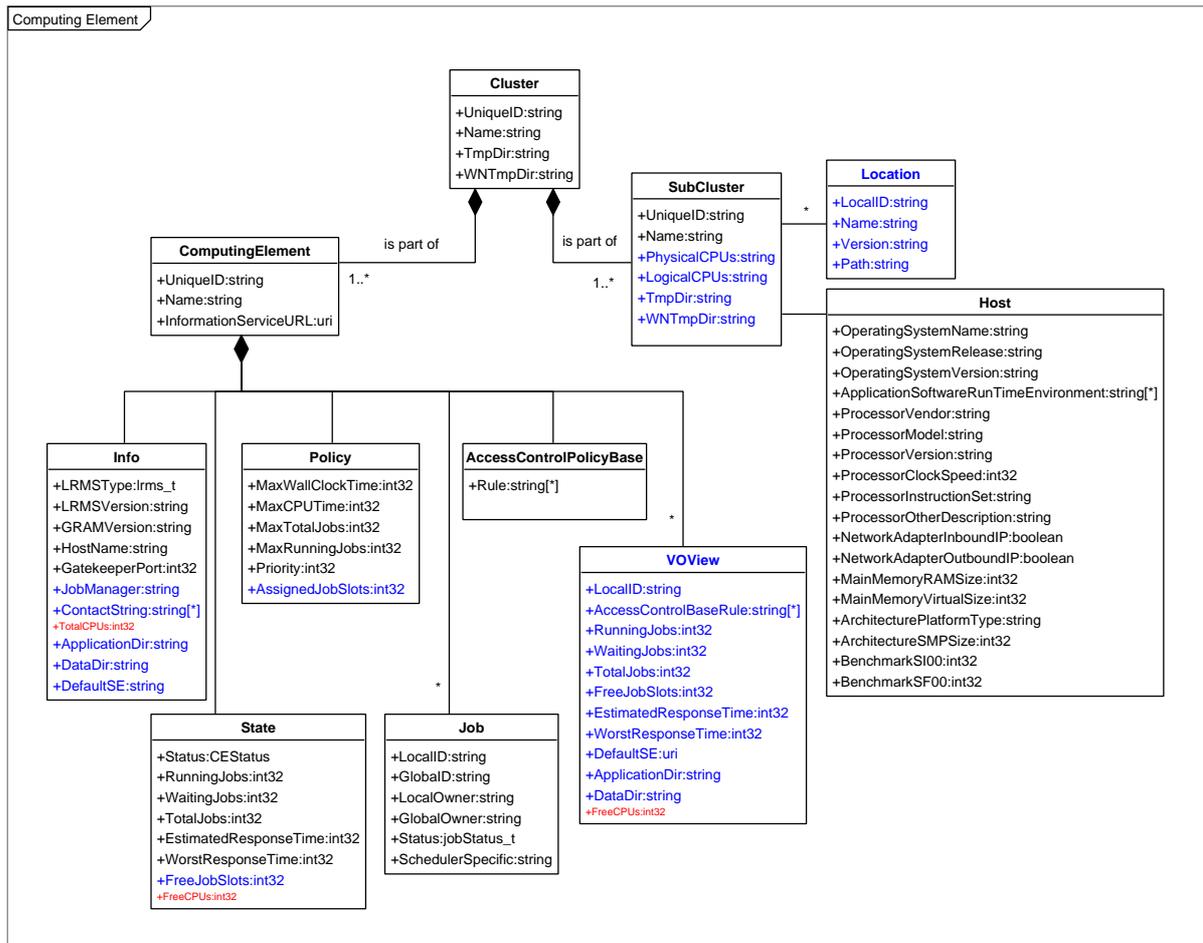
The user1 will consider 30 free job slots, while the user2 will consider 100 free job slots. As user2 refers to the general section of the Computing Elements, slots can be shared among other VO's/groups.

Like all the attributes in the schema, `AccessControl` rules are a description of the Grid, specifically the CE. 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 of other softwares on the CE). For this reason users should not take it as a guarantee of the described policies (e.g. a user may not have access even if it is listed

in ComputingElementAccessControlPolicyBase.Rule or vice-versa) and system administrators should expect requests violating the posted limits and enforce them through other mechanisms (e.g., unlisted users sending requests).

3.1 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 groups (AccessControlPolicyBase), accounting information about special groups of users and special policies (VOViews) and job running on it (Jobs). The next tables describe all these Entities.



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Figure 2: Computing Element (red=deprecated, blue=new, black=unmodified)

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)
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)
Association Endpoint (Entity.Property)		Mult.		Description
Info		1		A Computing Element has general information
State		1		A Computing Element has state information
Policy		1		A Computing Element has policy information
AccessControlBase.Rule		1		A Computing Element has authorization policies
Job.LocalID		*		A Computing Element is managing this jobs
VOView.LocalID		*		A Computing Element provides partitioned views of resources on a VO basis

Entity	Inherits from		Description	
Info	General information about a Computing Element			
Property	Type	Mult.	Unit	Description
LRMSType	lrms.t	1		Type of the underlying local resource management system (U)
LRMSVersion	string	1		Version of the local resource management system (U)
GRAMVersion	string	1		Version of Globus GRAM protocol (U)
HostName	string	1		Host name of the machine running this service (U)
GatekeeperPort	int32	1		Gatekeeper port (U)
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)
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 a given protocol (usually GRAM) (N)
TotalCPUs	int32	1		Number of CPUs available to the service (it does not necessarily represents the total available resources in the underlying system as more computing elements can share the same computing resources) (D)
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)
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 file the need further processing by local jobs or as staging area, specially if the Worker Node have no internet connectivity (N)
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)
Association Endpoint (Entity.Property)			Mult.	Description
ComputingElement.UniqueID			1	General information of a Computing Element

Entity	Inherits from			Description
State	Status description of a Computing Element			
Property	Type	Mult.	Unit	Description
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)
RunningJobs	int32	1		The number of jobs in running state (U)
WaitingJobs	int32	1		The number of jobs in waiting state (U)
TotalJobs	int32	1		the number of jobs in any state (U)
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)
WorstResponseTime	int32	1	s	Among the accepted jobs, the worst time from the job was accepted by the service to the start of its execution (U)
FreeJobSlots	int32	1		Number of free job slots (sometime 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)
FreeCPUs	int32	1		Number of free CPUs available to a scheduler (D, use FreeJobSlots instead)
Association Endpoint (Entity.Property)			Mult.	Description
ComputingElement.UniqueID			1	Status of a Computing Element

Entity	Inherits from			Description
Policy	Configuration policies associated to the Computing Element			
Property	Type	Mult.	Unit	Description
MaxWallTime	int32	1	min	The maximum amount of wall clock time allowed to each job by the execution environment. Once this time is expired the job will most likely be killed or removed from the queue. (U)
MaxCPUTime	int32	1	min	The maximum CPU time allowed to each job by the execution environment (U)
MaxTotalJobs	int32	1		The maximum allowed number of jobs in the CE (U)
MaxRunningJobs	int32	1		The maximum allowed number of jobs in running state in the CE (U)
Priority	int32	1		The priority given to jobs in this CE. The lower the number, the higher the priority (U)
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)
Association Endpoint (Entity.Property)			Mult.	Description
ComputingElement.UniqueID			1	Status of a Computing Element

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 being managed by a Computing Element

Entity	Inherits from			Description
Access Control Base				Set of rules defining the authorization policies to this Computing Element
Property	Type	Mult.	Unit	Description
Rule	string	*		An authorization rule (see the discussion at the beginning of the section for a proposed syntax and usage) (U)
Association Endpoint (Entity.Property)			Mult.	Description
ComputingElement.UniqueID			1	Set of authorizations for a Computing Element

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)
AccessControlBaseRule	string	*		Set of authorizations for the Computing Element specific to this view (see the discussion at the beginning of the section for a proposed syntax and usage) (N)
RunningJobs	int32	1		The number of jobs in running state on the CE for this VOview, that is the running jobs for the users selected by the AccessControlBaseRule). They can be considered also as the running jobs belonging to a specific VO (or VO subgroup) (N)
WaitingJobs	int32	1		The number of jobs in waiting state for this VOview (N)
TotalJobs	int32	1		The number of jobs in any state for this VOview (N)
FreeJobSlots	int32	1		Number of free job slots, i.e. number of single-processor jobs which could be started by users associated with this VOview if no other jobs are submitted and no jobs finish in the interim (N)
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 (N)
WorstResponseTime	int32	1	s	Among the accepted jobs, the worst time lapse between the job acceptance by the service and the start of its execution (N)
ApplicationDir	string	1		The path of the directory available for application installation. This directory must be available to programs using the normal file access primitives (open/read/write/close). The view provided by this directory on different hosts must be synchronized (N)
DataDir	string	1		The path of a shared directory available for application data (typically transient). This directory must be available to programs using the normal file access primitives (open/read/write/close). The view provided by this directory on different hosts must be synchronized (N)
DefaultSE	uri	1		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. This may be a SE close to the CE or a well connected VO default, e.g., gsiftp://myserver.local/data/rootdir/ (N)
FreeCPUs	int32	1		Number of free job slots, i.e., number of single-processor jobs which could be started if no other jobs are submitted and no jobs finish in the interim (D)
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 view provided by these directories on different hosts must be synchronized. For instance, 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 used technology. As regards `ApplicationDir`, the CE

may provide differentiated privileges, that allow read/write to VO's software managers and read-only access to other VO use (suggested extra feature).

3.2 Cluster

A cluster gives a representation of a set of physical resources (hosts or Worker Nodes or computers) behind a CE. A cluster may be dedicated to a CE (no other access to those hosts is possible) or shared either with other CEs or with local users bypassing the Grid and using directly a job queue or the computers.

A cluster is an heterogeneous set of resources (computers belonging to the same clusters may have different CPU, RAM and even different OS), while a subcluster, presented in the next section, is an homogeneous one.

Entity	Inherits from			Description
Cluster				Set of machines providing computing power managed by a local management system
Property	Type	Mult.	Unit	Description
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		Unique ID associated to the cluster (typically refers to the host name of the machine where the LRMS runs (U))
TmpDir	string	1		Name of the cluster. It does not need to be unique and can be used as a human-readable name (U)
WNTmpDir	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)
Association Endpoint (Entity.Property)			Mult.	Description
SubCluster.UniqueID			1..*	A cluster can be decomposed in one or more subclusters
ComputingElement.UniqueID			1..*	A cluster offers Computing Elements
Site.UniqueID			1	A cluster is part of a site (N)

3.3 SubCluster

The SubCluster entity provides details of the machines that offer execution environments to jobs. It refers to homogeneous set of hosts as regards the selected attributes. In this schema revision, the set of attributes that are used for the summary description have been isolated 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 Cluster can be considered as a set of SubClusters. A SubCluster refers to a disjointed set of hosts.

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 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 hyperthreading 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 directly these entries.
Property	Type	Mult.	Unit	Description
LocalID	string	1		A local identifier for the location (suggested value: concatenation of Name and Version attributes separated by the + character) (N)
Name	string	1		A name for this location (e.g., VDT_LOCATION) (N)
Version	string	1		Version, following the syntax adopted by that software (e.g., 1.3.6) (N)
Path	string	1		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 pointed 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) (N)
Association Endpoint (Entity.Property)			Mult.	Description
SubCluster.UniqueID			1	A location is associated to a subcluster

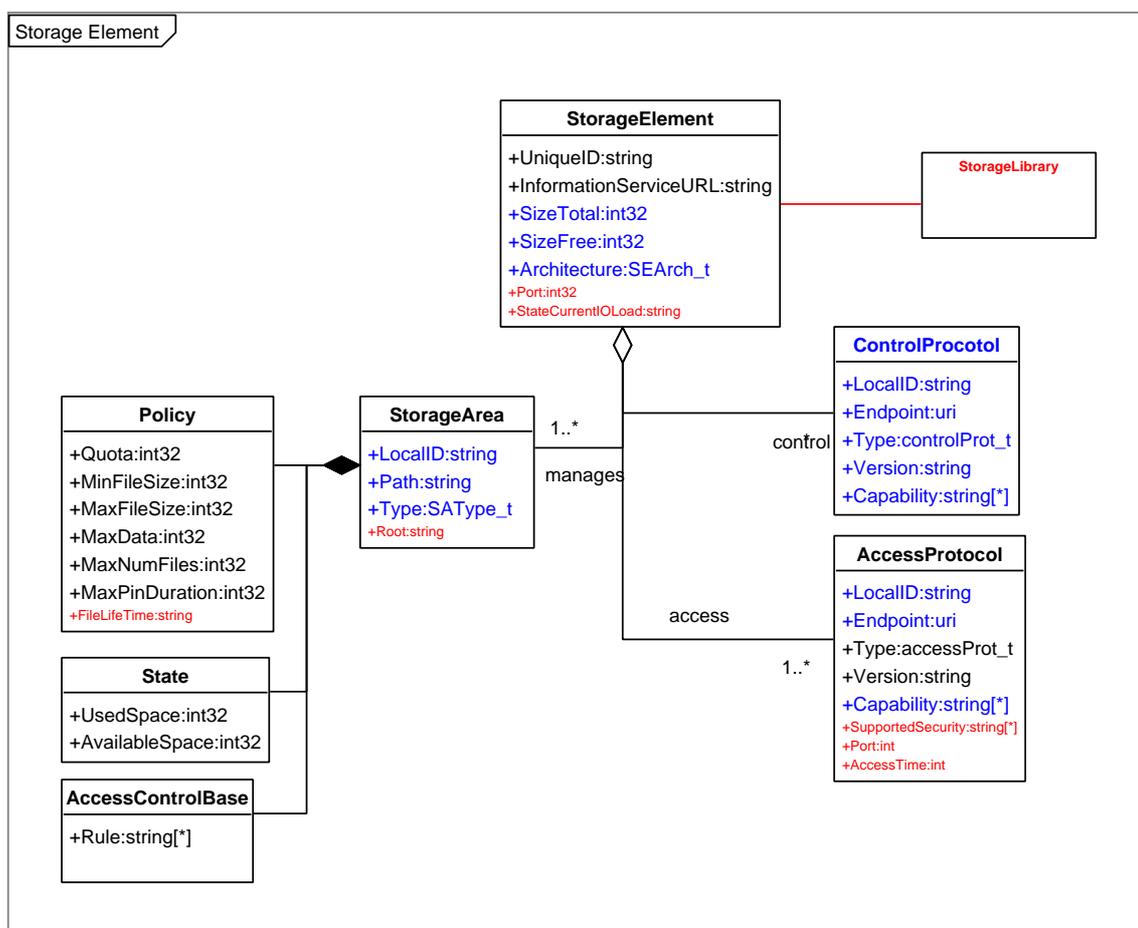
Entity	Inherits from			Description
Host	Summary description of the hosts part of the subcluster (N)			
Property	Type	Mult.	Unit	Description
OperatingSystemName	string	1		Name of the operating system (U)
OperatingSystemRelease	string	1		Release of the operating system (U)
OperatingSystemVersion	string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



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Figure 3: Storage Element (red=deprecated, blue=new, green=modified, black=unmodified)

4.1 Storage Element

Entity	Inherits from			Description
Storage Element	Service			Abstraction for a storage resource. Group of services, protocols and data sources.
Property	Type	Mult.	Unit	Description
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, multidisk, other (N)
SizeTotal	int32	1	GByte	the size of the storage capacity managed by this service (N)
SizeFree	int32	1	GByte	the size of the storage capacity that is free for new files for any VO/user. (N)
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)
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

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
StorageArea				Portion of storage extent to which a uniform set of policies applies
Property	Type	Mult.	Unit	Description
LocalID	string	1		Local Identifier of this area. It must be unique within the storage element. (N)
Root	string	1		The local directory that is the root of the area (D)
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. (N)
Association Endpoint (Entity.Property)			Mult.	Description
StorageElement.UniqueID			1	A Storage Area is part of a Storage Element

Entity	Inherits from		Description	
Policy			Policy related to a storage area	
Property	Type	Mult.	Unit	Description
Quota	int32	1	KByte	the quota assigned
MinFileSize	int32	1	Byte	minimum size for any single file (U)
MaxFileSize	int32	1	Byte	maximum size for any single file (U)
MaxData	int32	1	Byte	maximum amount of data that may be stored by one job (U)
MaxFileSize	int32	1	Byte	max number of files which may be stored by 1 job (U)
MaxPinDuration	int32	1	s	maximum time for a file to be pinned (U)
FileLifeTime	enum	1	s	Lifetime policy to be applied to the contained files (Permanent, Durable or Volatile) (D)
MaxNumFiles	int32	1	s	(U)
Association Endpoint (Entity.Property)			Mult.	Description
StorageArea.LocalID			1	A Policy is attached to a Storage Area

Entity	Inherits from		Description	
State			Status info of the storage area	
Property	Type	Mult.	Unit	Description
UsedSpace	int32	1	KByte	The used space (the guaranteed quota is taken first)
AvailableSpace	int32	1	KByte	The available space
Association Endpoint (Entity.Property)			Mult.	Description
StorageArea.LocalID			1	A Status is for a Storage Area

In the major schema revision, the unit of measure for UsedSpace and AvailableSpace are expected to be changed to GByte.

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
Access Protocol				Protocol available to access/transport files in/from storage areas
Property	Type	Mult.	Unit	Description
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)
Association Endpoint (Entity.Property)			Mult.	Description
StorageElement.UniqueID			1	Is part of a Storage Element

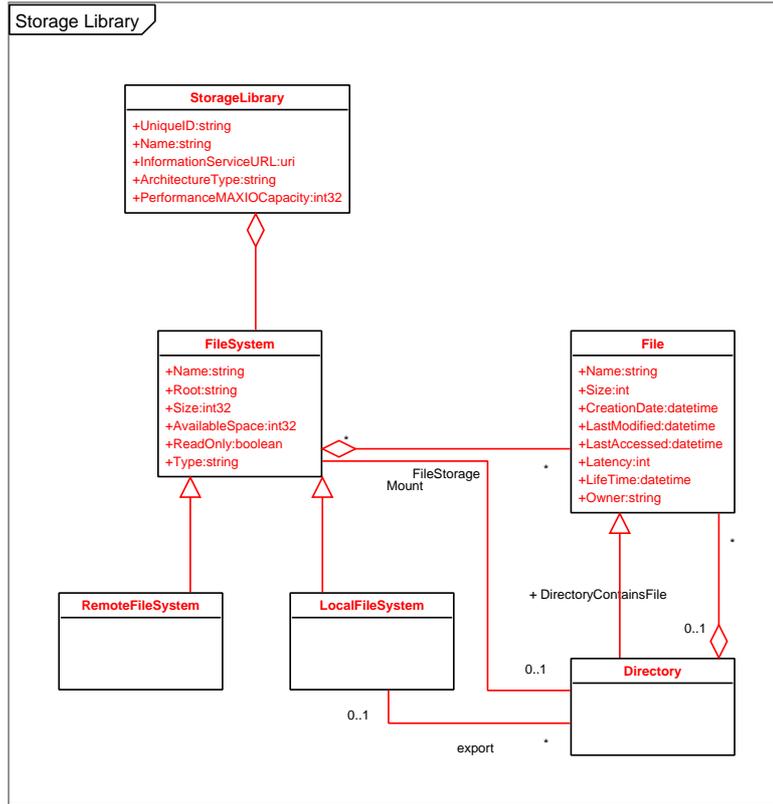
4.4 Control Protocol

The ControlProtocol is similar to the AccessProtocol, but orthogonal to it. Current protocols include `srn` 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)
Property	Type	Mult.	Unit	Description
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



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Figure 4: Storage Library (red=deprecated, blue=new, black=unmodified)

Entity	Inherits from			Description
StorageLibrary				The machine providing for the storage service (D)
Property	Type	Mult.	Unit	Description
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

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 rfiio 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. rfiio.

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.

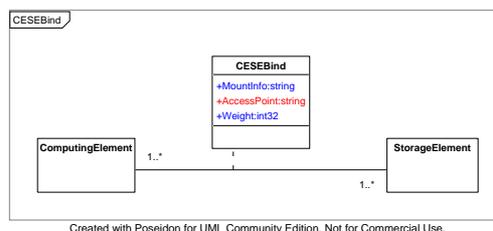


Figure 5: Computing Element/Storage Element Relationship (red=deprecated, blue=new, green=modified, black=unmodified)

Entity	Inherits from		Description	
Bind			Association Class between CE and SE describing preference	
Property	Type	Mult.	Unit	Description
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
28 Oct 04	1	Initial Draft published	Sergio Andreatozzi
17 Feb 05	2	Added more issues from both LCG and Grid3/OSG	LCG, Grid3/OSG
21 Feb 05	3	Added extensions based on the Grid3/OSG	Grid3/OSG
14 Mar 05	5	Added outcome from f2f meeting	
16 Mar 05	6	Added comments from Marco's first review	
6 Apr 05	7	Applied changes as decided in the 31 march phoneconf	
22 Jul 05	8	minor editorial changes	
24 Sep 05	9	included contributions from Marco, Steve and Stephen	
03 Dec 05	final	small editorial changes, added info about operating system, changed relationship from site-CE to site-Cluster	

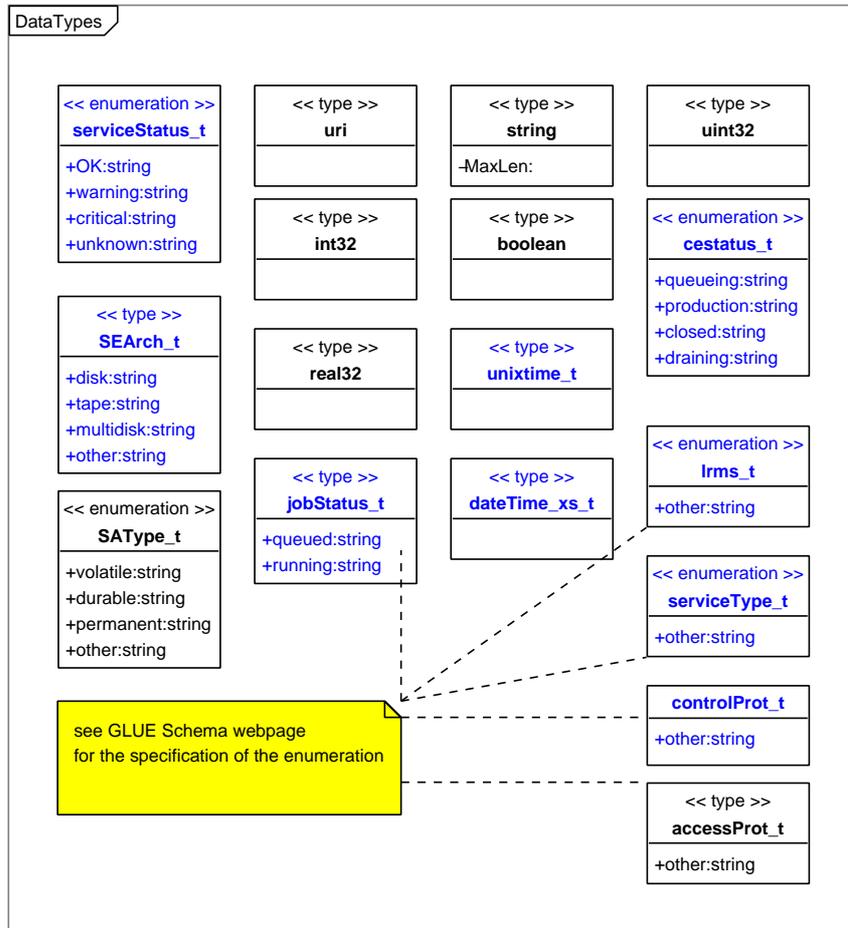
A Description of the template

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.



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Figure 6: Datatypes

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.

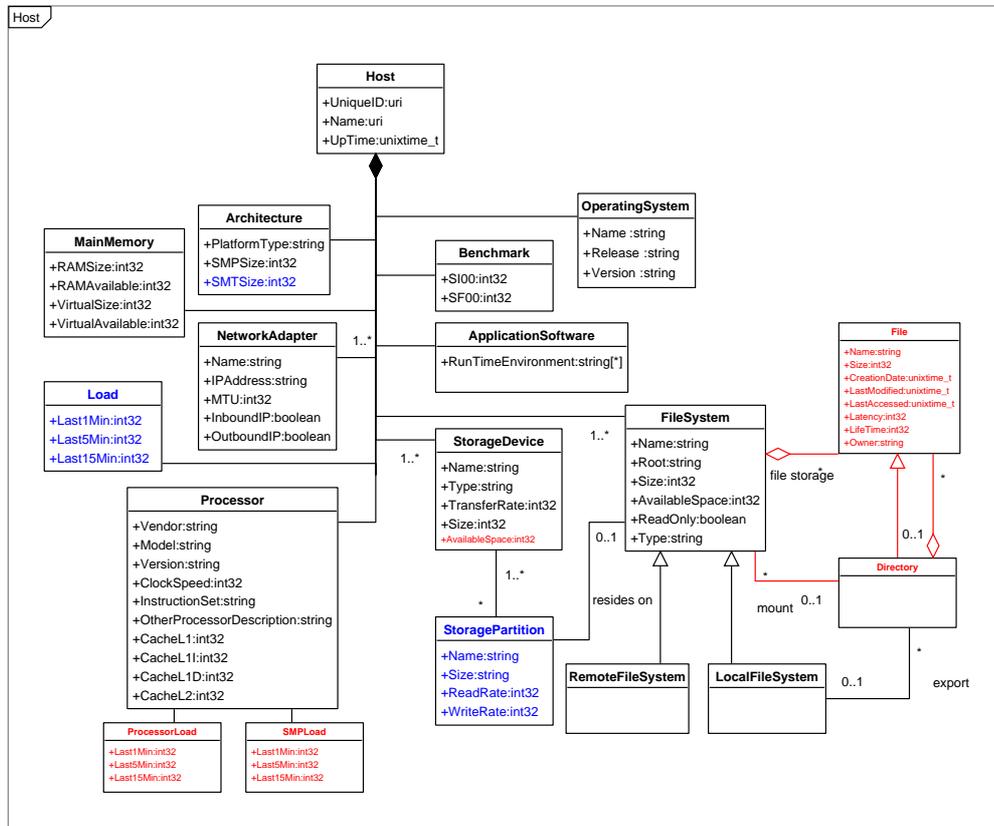


Figure 7: Host (red=deprecated, blue=new, black=unmodified)

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)
CacheL1	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				Information about benchmark for the host
Property	Type	Mult.	Unit	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				Information about the operating system of the host
Property	Type	Mult.	Unit	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				Information about the application software available in the host
Property	Type	Mult.	Unit	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				Information about a storage device in the host
Property	Type	Mult.	Unit	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				Information about a storage partition in the storage device
Property	Type	Mult.	Unit	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				Information about a file system
Property	Type	Mult.	Unit	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			Information about a local file system (U)
Property	Type	Mult.	Unit	Description
Association Endpoint (Entity.Property)			Mult.	Description
Directory.Name			*	The file system can exports zero or more directories

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

Entity	Inherits from			Description
File				Information about a file
Property	Type	Mult.	Unit	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.	Unit	Description
Association Endpoint (Entity.Property)			Mult.	Description
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)

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