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Category: Proposed Recommendation
Usage Record Working Group

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Usage Record -- XML Format

Status of This Memo

This memo provides information to the Grid community in the area of usage records and accounting. Distribution is unlimited.

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Abstract

This document describes a common format with which to exchange basic accounting and usage data over the grid. This record format is intended to facilitate the sharing of usage information among grid sites, particularly in the area of job accounting. The usage record is represented in an XML format. This document does not address how these records should be used, nor does it attempt to dictate the format in which the accounting records are stored at a local site, rather it is simply meant to be a common exchange format. Furthermore, nothing is said regarding the communications mechanisms employed to exchange the records, i.e. transport layer, framing, authentication, integrity, etc.

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1. Introduction

In order for resources to be shared, sites must be able to exchange basic accounting and usage data in a common format. This document describes an XML-based format for usage records. The record format is intended to be specific enough to facilitate information sharing among grid sites, yet general enough that the usage data can be used for a variety of purposes - traditional usage accounting, charging, service usage monitoring, performance tuning, etc.

1.1 Encoding

1.1.1 XML Structure

This specification uses XML Schema documents conforming to the W3C XML Schema Specification [XML_Schema] and normative text to describe the syntax and semantics of XML encoded usage records.

1.1.2 Transport

This specification defines the structure of information that may be represented in a compliant XML document. No requirements are placed on the encoding of this document for a particular transport. Therefore, instance documents may be represented in ASCII or Unicode text. Further, we envision that many of the systems using this data definition will be OGSA compliant systems and therefore preferences to the http/ https protocols may occur. However, a usage record may be communicated via any lower level transport that is acceptable to the using parties.

1.2 Extensibility

The XML formats for representing Usage Records have been designed with consideration given to extensibility for implementation specific requirements. However, the use of extensions may reduce interoperability and therefore the introduction of extensions SHOULD be carefully considered.

2. Conventions Used in this Document

2.1 Key Words

The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in this specification are to be interpreted as described in IETF RFC 2119 [RFC2119]:

> *“they MUST only be used where it is actually required for interoperation or to limit behavior which has potential for causing harm (e.g. limiting retransmission)”*

These key words are thus capitalized when used to unambiguously specify requirements over features and behavior that affect interoperability and security of implementations.

2.2 Schema listings

```
Listings from the Usage Record Schema appear like this
```

In case of disagreement between the schema file and this specification, the schema file takes precedence.

2.3 *XML Conventions*

2.3.1 Element names

1. Element names SHALL be in UCC convention (example: <UpperCamelCaseElement/>.
2. Capitalization of element names in external specifications SHALL remain consistent with the initial specification. (example: ds:KeyInfo).
3. Acronyms SHOULD be avoided.
4. Underscores (_), periods (.) and dashes(-) MUST NOT be used.
5. Element names MUST comply with all XML Schema specific naming rules.

2.3.2 Attribute names

Attribute names SHALL be in LCC convention (example: <UpperCamelCaseElement lowerCamelCaseAttribute=”attributevalue”/>.

1. Attribute names SHALL be in LCC convention (example: <UpperCamelCaseElement lowerCamelCaseAttribute=”attributevalue”/>)
2. Capitalization of attribute names in external specifications SHALL remain consistent with the initial specification.
3. Acronyms SHOULD be avoided.
4. Underscores (_), periods (.) and dashes(-) MUST NOT be used.
5. Attribute names MUST comply with all XML Schema specific naming rules.

2.3.3 Enumerated attribute values

1. Attributes of type enumeration SHALL have values in LCC convention (example: <UpperCamelCaseElement enumAttribute=”valueOne”/>).
2. Capitalization of enumerated attribute values in external specifications SHALL remain consistent with the initial specification.

2.3.4 Empty and whitespace only values

This specification places the following restrictions on string values:

1. All string values that do not require whitespace characters other than the space character should be defined as the **token** type. This type does not permit leading or trailing spaces, two or more adjacent spaces, or any other whitespace character. Refer to the XML Schema specification for additional details on this type[XML_SCHEMA].
2. Identity constraints SHOULD use the schema identity constraint mechanisms rather than ID, IDREF or IDREFS definitions. Thus, any element that may be used as an identifier SHOULD use a datatype that strictly controls whitespace, such as token, NCName or QName.

   a. If a key identity constraint is declared for a particular element or attribute, then it MUST be present for each member of the participating nodeset. Additional information on the identity constraint can be found in [XML_SCHEMA].

3. No element declared in the UsageRecord schema specifies the xsd:nillable attribute. Therefore, empty element content means a string of zero length. Any schema extension that declares an element as nillable MUST not equate the nil string and a zero-length string. An instance document must use the *xsi:nil* attribute to set the value to nil <MyNillableElement xsi:nil=”true”/> whereas a zero-length string is represented by an empty element <MyElement/>.

2.3.5 Time values

2.3.5.1 Discrete time values

All time values that represent a discrete instance in time MUST be declared as the primitive XML Schema type **dateTime**. Values are represented with a character string corresponding to the date and time components specified in ISO 8601 [ISO8601]. According to [XML_SCHEMA], implementations must handle fractional seconds to six digits, and MUST round additional digits. This specification places several additional semantic constraints on time values contained in conforming instance documents:

1. Although the **dateTime** datatype permits negative values (to identify times B.C.E), semantically, compliant documents MUST not contain such values.
2. Both the date and time components of **dateTime** MUST be present.
3. All points in time MUST indicate a specific time zone to permit a total ordering on across all represented time values as well as comparisons between times. The suffix ‘Z’ represents Coordinated Universal Time.”

2.3.5.2 Interval time values

All time values that represent an interval of time MUST be declared as the primitive XML Schema type **duration**. A character string as specified in ISO 8601 represents values. Each numeral representing year, month, day, hour, minute or second is combined with a terminator to create a component of the duration. Each component may be omitted. This specification places additional semantic constraints on time durations within conforming instance documents:

1. Negative durations MUST not be present.
2. The smallest granularity component of duration MUST be used when representing time duration. For example, one month is not comparable to 30 days and thus duration should include the day component if resource usage is typically measured in increments of one day. To avoid these inherent comparison and conversion difficulties, only resources that are typically measured in month and year intervals should use that component of duration.

2.3.6 Comparing Usage Record Values

Two UsageRecord elements that carry identical values for the recordId attribute of the RecordIdentity element (see § 6.1.1) MUST be considered identical. It is left to the application producing or consuming UsageRecord instances to enforce this constraint. Further, it is also left to each site to ensure that the possibility of producing recordId values identical to the values used as recordId values of a different site is minimized. Although two UsageRecords with different recordId values MAY carry identical usage information, they are not considered identical instances. It is left to the application producing or consuming Usage Record instances to specify how this situation will be addressed.

2.3.7 Encoding within KeyInfo elements

[XML_DSIG] identifies several rules for encoding distinguished names within its X509IssuerSerial, X509SubjectName and KeyName child elements. These encoding rules are found at the end of §4.4.4 of the specification.

2.3.8 Extension Framework

The xsi:type attribute is used in instance documents to indicate which derived type we are using in an instance document. Therefore, if custom resources definitions are derived from any of the extensibility elements, then the instance documents using that content model must identify the derived type within the appropriate element declaration. See §8 for additional information on the extension points defined within this specification.

2.4 Schema Organization and Namespaces

The usage record structures are defined in a schema [URWG-XSD] associated with the following namespace. When referenced in this document, this namespace is associated with the prefix urwg.

http://www.gridforum.org/2003/ur-wg

The digital signature components are defined in a schema [XML_SIG] associated with the following namespace: This schema is imported into the URWG schema to directly use its definitions. When referenced in this document, this namespace is associated with the prefix ds.

http://www.w3.org/2000/09/xmldsig#

All simple data types referenced in this document are built into the W3C XML Schema Datatypes specification. When referenced in this document, this namespace is associated with the prefix xsd.

http://www.w3.org/2001/XMLSchema

The XMLSchema-instance namespace defines several attributes that are used in element definitions. When referenced in this document, this namespace is associated with the prefix xsi.

http://www.w3.org/2001/XMLSchema-instance

2.4.1 Schema Header and Namespace Declarations

The following schema fragment defines the XML namespaces and other header information:

```
<xsd:schema
       attributeFormDefault="qualified"
       elementFormDefault="qualified"
       targetNamespace="http://www.gridforum.org/2003/ur-wg"
       xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
       xmlns:urwg="http://www.gridforum.org/2003/ur-wg"
       xmlns:xsd="http://www.w3.org/2001/XMLSchema"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
       <xsd:annotation>
              <xsd:documentation xml:lang="en">Usage Record Working Group XML Schema
definition</xsd:documentation>
       </xsd:annotation>
       <xsd:import namespace="http://www.w3.org/2000/09/xmldsig#"
schemaLocation="http://www.w3.org/TR/xmldsig-core/xmldsig-core-schema.xsd"/>
…
</schema>
```

3. Global Element Definitions

The global definitions are those that may be used compliantly with this specification as root elements for an XML document or which may be used as extension points within or included within other XML Schema definitions. Although the elements that represent individual resources that are consumed are defined at a global level within the xml schema, semantically, a compliant instance document should only be rooted with one of the following elements or an element that derives from one of these elements. To facilitate extensibility, these elements participate in the substitution group mechanism from [XML_SCHEMA] according to the following abstract element definition :

```
<xsd:element abstract="true" name="Usage" type="urwg:UsageRecordType"/>
```

3.1 UsageRecord Element

The *UsageRecord* element encapsulates a single Usage Record. The UsageRecordType complex type dictates the particular structure of this element. All specific usage record elements should extend or restrict this element. Any structure that contains usage record information should reference the UsageRecord element so that extensions or restrictions of the element are automatically handled. This element should contain all the information that is generic to a usage record and addressed by this specification. Any extensions to or restrictions of the UsageRecord should not redefine this base structure.

```
<xsd:element name="UsageRecord" substitutionGroup="urwg:Usage" type="urwg:UsageRecordType"/>
```

3.2 JobUsageRecord Element

This element definition establishes the structure of job usage record as it derives from the generic UsageRecordType.

```
<xsd:element name="JobUsageRecord" substitutionGroup="urwg:Usage">
       <xsd:complexType>
              <xsd:complexContent>
                     <xsd:extension base="urwg:UsageRecordType"/>
              </xsd:complexContent>
       </xsd:complexType>
</xsd:element>
```

3.3 UsageRecords Element

This element definition allows a set of UsageRecords to be grouped together with a single common root element.

```
<xsd:element name="UsageRecords">
      <xsd:complexType>
            <xsd:sequence>
                  <xsd:element maxOccurs="unbounded" minOccurs="0" ref="urwg:Usage"/>
            </xsd:sequence>
      </xsd:complexType>
</xsd:element>
```

4. Global Attribute and Attribute Group Definitions

Global attributes, and attribute groups, are attributes that are common to many of the element definitions contained in this specification. A global definition of these maintains a standard semantic meaning within each context that they are used. By defining them globally, we ensure a standard definition for the appropriate information.

When referencing a global attribute, an element must specify whether the use of that attribute use is *required* or *optional* within its context. Each element must also identify the default attribute value to be assumed, if applicable, when the attribute is omitted from the instance document. Note that during XML Canonicalization, any attribute for which a default value is specified within the constraining schema will be inserted into the instance document with that default value by the canonicalizer if no value is supplied for that attribute.

When referencing a global attribute group, the characteristics of each member attribute are defined directly in the attribute group rather than in the context of a referring element.

4.1 Description

This attribute provides a mechanism for additional, optional information to be attached to a Usage Record element. The value of this attribute MAY provide clues to the semantic context to use while interpreting or examining the value of the owning element. As there are no constraints on the contents of this attribute, it is defined as a string rather than a token.

```
<xsd:attribute name="description" type="xsd:string" />
```

4.2 storageUnit

This attribute represents the unit of volume measure that should be applied to the value of its owning element. Each element that references this global attribute MUST define its use as required and identify the appropriate default value. The legal values for this attribute are listed below. Each value combines a prefix that identifies a multiplier and a suffix that identifies the base quantity. For example, the suffix -B represents volume in bytes and the prefix K- implies a kilo multiplier. Therefore, KB as the designated unit of measure value MUST be interpreted as kilobytes. Please refer to Appendix B for a listing of all valid values. When this attribute is used without a corresponding phaseUnit, no assumption may be made regarding the relationship between the usage represented by the referring element and the overall duration represented with the UsageRecord instance. Volume

SHOULD not be measured in terms of characters, words or blocks as these types of measurement are typically architecture specific and require additional information to be interpreted correctly. Any usage locally represented with such a unit MUST be converted into one of the legal units.

```
<xsd:attribute name="storageUnit">
       <xsd:simpleType>
              <xsd:restriction base="xsd:token">
                     <xsd:enumeration value="b"/>
                     <xsd:enumeration value="B"/>
                     <xsd:enumeration value="KB"/>
                     <xsd:enumeration value="MB"/>
                     <xsd:enumeration value="GB"/>
                     <xsd:enumeration value="TB"/>
                     <xsd:enumeration value="PB"/>
                     <xsd:enumeration value="EB"/>
                     <xsd:enumeration value="Kb"/>
                     <xsd:enumeration value="Mb"/>
                     <xsd:enumeration value="Gb"/>
                     <xsd:enumeration value="Tb"/>
                     <xsd:enumeration value="Pb"/>
                     <xsd:enumeration value="Eb"/>
              </xsd:restriction>
       </xsd:simpleType>
</xsd:attribute>
```

4.3 phaseUnit

This attribute represents the a duration of time that is relevant to the usage reported in the referring element. See § 2.3.5.2 for additional information on the use of duration.

```
<xsd:attribute name="phaseUnit" type="xsd:duration"/>
```

4.4 intervallicVolume Attribute Group

This attribute group identifies the measurements that must accompany usage measured in two distinct dimensions. These dimension are the volume of resource consumed and the interval of time for which the resource was used. All attributes within this group are required. Therefore, any element that references this attribute group MUST provide values for each attribute.

```
<xsd:attributeGroup name="intervallicVolume">
       <xsd:attribute ref="urwg:storageUnit" use="required"/>
       <xsd:attribute ref="urwg:phaseUnit" use="required"/>
</xsd:attributeGroup>
```

4.5 metric

This attribute identifies the method of measurement used for quantifying the associated resource consumption if there are multiple methods by which measure resource usage. This attribute is intended to provide a standard mechanism for including information about the how the measurement is performed, regardless of the resource that is measured. Therefore, the definition of metric within the schema document does not predefine the actual value that may appear for this attribute, either globally for all elements or unique to a specific element containing the attribute. However, particular to each element definition in this specification document that may carry the metric attribute, a minimal set of values are defined that must be semantically supported as values for that specific resource type. As an example, §7.2.2 indicates that the following values must be recognized for the metric associated with disk usage: average, total, max. This minimal set does not disqualify other values, such as "average scratch", as prohibited. It only implies requires entities sharing usage information in the standard usage record format must independently establish an understanding of those additional values. For the standard definitions unique to each metric value for a particular resource element, please refer directly to the resource specifications in §6 and §7 of this document. The following rules MUST be followed when creating metric value definitions for any resource.

1. Any use of this attribute MUST not attempt to differentiate between requested and utilized quantities of resource usage within a single record, even if this differentiation is pertinent to the final assessed charge.
2. Each element that differentiates usage according to the metric MUST define attribute usage as required and identify the appropriate default value.
3. The use of *average* as a metric value MUST be defined by the arithmetic mean.
4. The use of *average-95* as a metric value MUST be defined by the 95th percentile calculation for average.
5. Each metric value definition must differentiate between per-node and across-node measurements, when both measurements are feasible.

```
<xsd:attribute name="metric" type="xsd:token" />
```

4.6 type

This attribute identifies the type of the resource being measure when quantifying the associated resource consumption. This attribute is intended to provide a standard mechanism for including information about the type of measurement used, regardless of the resource that is measured. Therefore, the definition of type within the schema document does not predefine the actual value that may appear for this attribute, either globally for all elements or unique to a specific element containing the attribute. However, particular to each element definition in this specification document that may carry the type attribute, a minimal set of values are defined that must be semantically supported as values for that specific resource type. As an example, §7.2.3 indicates that the following values must be recognized for the type associated with disk usage: scratch, temp. This minimal set does not disqualify other values, such as "high speed disk", as prohibited. It only implies requires entities sharing usage information in the standard usage record format must independently establish an understanding of those additional values. For the standard definitions unique to each type value for a particular resource element, please refer directly to the resource specifications in §6 and §7 of this document. Any use of this attribute MUST not attempt to differentiate between requested and utilized quantities of resource usage within a single record, even if this differentiation is pertinent to the final assessed charge.

```
<xsd:attribute name="type" type="xsd:token" />
```

4.7 unit

This attribute may be used to express a unit of measure that is not quantifiable in terms of volume, time or a combination of both. For example, this attribute may represent any of the following units of measure “number of requests”, “operations”, “requests”, “signals”, “faults”, “context switches”, "swaps", "page reclaims" or "messages." However, there are no specific values for this attribute identified within this specification that MUST be supported.

```
<xsd:attribute name="unit" type="xsd:token" />
```

5. Global Type Definitions

5.1 UsageRecordType Complex Type

This complex type definition establishes the structure of the generic usage record. The properties defined in version 1.0 of the Usage Record Natural Language Document form the basis for the definition of the UsageRecordType components.

There are two mandatory elements of the UsageRecordType. These elements are RecordIdentity and Status. This implies that each element of this type that appears in an instance document must contain these child elements. The descriptions for those specific elements (see §6.1 and §6.6) define the semantics for their unique content models.

5.1.1 Content Model

The elements contained in the UsageRecordType content model may appear in various orderings, so long as they adhere to the following rules:

1. All identity,job name, charge and status elements MUST appear before any specific resource elements.
2. All resources that are differentiated by metric MUST appear before other resources
3. If multiple CpuDuration elements appear, they MUST appear together in single group.
4. If multiple ProjectName elements appear, they MUST appear together in a single group.
5. If multiple Host elements appear, they MUST appear together in a single group.

If any elements represent resource usage via the extensibility framework appear, they MUST appear after the specifically defined resource elements.

```
<xsd:complexType name="UsageRecordType">
       <xsd:sequence>
              <xsd:element maxOccurs="1" minOccurs="1" ref="urwg:RecordIdentity"/>
              <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:JobIdentity"/>
              <xsd:element maxOccurs="unbounded" minOccurs="0" ref="urwg:UserIdentity"/>
              <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:JobName"/>
              <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:Charge"/>
              <xsd:element maxOccurs="1" minOccurs="1" ref="urwg:Status"/>
              <xsd:choice maxOccurs="unbounded" minOccurs="0">
                     <xsd:annotation>
                            <xsd:documentation>The elements grouped together in this choice may be
                            represented within a usage record multiple times. Each of these
appearances
                            must be differentiated by the metric and/or type associated with the
element. </xsd:documentation>
                     </xsd:annotation>
                     <xsd:element ref="urwg:Disk"/>
                     <xsd:element ref="urwg:Memory"/>
                     <xsd:element ref="urwg:Swap"/>
                     <xsd:element ref="urwg:Network"/>
                     <xsd:element ref="urwg:TimeDuration"/>
```

```
                    <xsd:element ref="urwg:TimeInstant"/>
                    <xsd:element ref="urwg:ServiceLevel"/>
             </xsd:choice>
             <xsd:choice maxOccurs="unbounded" minOccurs="0">
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:WallDuration"/>
                    <xsd:sequence maxOccurs="1" minOccurs="0">
                           <xsd:element maxOccurs="2" minOccurs="0" ref="urwg:CpuDuration"/>
                    </xsd:sequence>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:NodeCount"/>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:Processors"/>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:EndTime"/>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:StartTime"/>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:MachineName"/>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:SubmitHost"/>
                    <xsd:element maxOccurs="1" minOccurs="0" ref="urwg:Queue"/>
                    <xsd:sequence maxOccurs="1" minOccurs="0">
                           <xsd:element maxOccurs="unbounded" minOccurs="0"
ref="urwg:ProjectName"/>
                    </xsd:sequence>
                    <xsd:sequence maxOccurs="1" minOccurs="0">
                           <xsd:element maxOccurs="unbounded" minOccurs="0" ref="urwg:Host"/>
                    </xsd:sequence>
                    <xsd:sequence maxOccurs="1" minOccurs="0">
                           <xsd:choice maxOccurs="unbounded" minOccurs="0">
                                  <xsd:element ref="urwg:PhaseResource"/>
                                  <xsd:element ref="urwg:VolumeResource"/>
                                  <xsd:element ref="urwg:Resource" />
                                  <xsd:element ref="urwg:ConsumableResource" />
                           </xsd:choice>
                    </xsd:sequence>
             </xsd:choice>
      </xsd:sequence>
</xsd:complexType>
```

5.2 domainNameType Simple Type

This simple type definition establishes the structure of a Fully Qualified Domain Name in string format. Any valid value provided follows the format of a fully qualified domain name (FQDN) as defined by RFC 1034 [RFC1034]:

> *FQDNs can be up to 255 characters long and can contain alphabetic and numeric characters and the "-" and the "." characters.*

```
<xsd:simpleType name="domainNameType">
        <xsd:restriction base="xsd:string">
            <xsd:pattern value="([a-zA-Z0-9][a-zA-Z0-9'\-']*[a-zA-Z0-9]\.)*([a-zA-Z0-9][a-zA-Z0-
9'\-']*[a-zA-Z0-9])?"/>
            <xsd:maxLength value="255"/>
        </xsd:restriction>
</xsd:simpleType>
```

6. Usage Record Common Properties

The complete specifications for each element that MAY appear in the generic usage record element are presented below. A quick reference table summarizes these elements in Appendix A. Each of these elements MUST appear at most once within a UsageRecord. Thus, the usage details represented by these elements cannot be differentiated based on distinct metrics within each appearance of an element

6.1 RecordIdentity Element

This attribute group combines all the attribute information that may identify a particular a Usage Record or Usage Records element. However, no such identity constraint is defined directly within this schema. Each UsageRecord element MUST contain a child RecordIdentity element.

6.1.1 recordId Attribute

This attribute contains a token that may be referenced using the identity constraint mechanisms defined in XML Schema. It is used to identify a unique instance of a Usage Record. Attribute values must satisfy the following properties:

1. Any party that assigns a recordId MUST ensure that there is negligible probability that it, or any other party, will assign the same value to a different UsageRecord.
2. Each Usage Record may declare at most one identifier.

6.1.2 createTime Attribute

This attribute contains a dateTime that defines when this particular UsageRecord was created. This attribute MUST reflect the creation of the actual record and not when the consumption it reports occurred. See section § 2.3.5 for additional information about representing an instance in time.

6.1.3 ds:KeyInfo Element

KeyInfo is an optional element within the XML Digital Signature Specification [XML_DSIG] that "enables the recipients(s) to obtain the key needed to validate a signature." As each key ultimately correlates to a particular identified entity, this specification uses the KeyInfo fields to identify the entity that created a particular Usage Record. The following rules should be followed when populating the various sub-elements of this KeyInfo with identifying values:

1. The RetrievalMethod element MUST be present. The *Type* attribute of the element MUST contain the appropriate URI (see §4.4 of XML-DSIG for a complete list) to identify the type of identity in use. No other components of the RetrievalMethod element are required by this specification. The RetrievalMethod identified MUST correspond to the additional information represented within KeyInfo. Supported type URIs must include:
   a. http://www.w3.org/2000/09/xmldsig#DSAKeyValue
   b. http://www.w3.org/2000/09/xmldsig#RSAKeyValue
   c. http://www.w3.org/2000/09/xmldsig#X509Data
   d. http://www.w3.org/2000/09/xmldsig#rawX509Certificate
2. The following rules apply to the specific types KeyInfo data, according to the selected *RetrievalMethod Type*. Note that XML-Dsig allows multiple identifier types within a single *KeyInfo* element.
   a. *KeyName* contains one of a string identifier related to the key-pair, the distinguished name or the email address identifying the creator. If KeyName identifies a named key-pair, RetrievalMethod type MUST identify the type of keys contained within the key-pair.
   b. *KeyValue* contains the public key associated with the creator. If KeyValue is used, RetrievalMethod type MUST identify the type of the public key.

c. X509Data contains information from the X.509 certificate associated with the creator. RetrievalMethod type MUST reference http://www.w3.org/2000/09/xmldsig#X509Data. The relevant rules from [XML-Dsig], summarized below, must be followed when representing X509 information.
   i. At least one of *X509IssuerSerial, X509SubjectName, X509SKI or X509Certificate* must be present.
   ii. All elements from §2.c.i referring to a single certificate must be grouped within a single X509Data element.
   iii. All certificates appearing in an X509Data element MUST relate to the identity of the creator or be part of a certification chain terminating in a certificate that identifies the creator.

d. If *RetrievalMethod Type* is http://www.w3.org/2000/09/xmldsig#rawX509Certificate, the contents of KeyInfo MUST be a binary X509Certificate. No particular encoding is required by this specification.

3. No specific ordering must be imposed on the elements contained within KeyInfo.

See section § 2.3.7 for additional restrictions on value representation within a KeyInfo structure.

```
<xsd:element name="RecordIdentity">
	<xsd:complexType >
		<xsd:sequence maxOccurs="1" minOccurs="0">
			<xsd:element ref="ds:KeyInfo" />
		</xsd:sequence>
		<xsd:attribute name="recordId" type="xsd:token" use="required"/>
		<xsd:attribute name="createDate" type="xsd:dateTime" use="optional"/>
	</xsd:complexType>
</xsd:element>
```

6.2 JobIdentity

This element uniquely identifies the job associated with this usage. The scope representation of identity may be either local or global. An identifier of at least one scope MUST appear in the UsageRecord. Identifiers of both scopes MAY appear in a single UsageRecord. If both appear, there must be a semantic correlation between the presented local and global job identifiers. There is no upper bound on the number of job identifiers that MAY be associated with a single UsageRecord.

6.2.1 GlobalJobId

The value of this element represents a global identity for the job. No restrictions on the format of this value are required by this specification.

6.2.2 LocalJobId

The value of this element represents a local identity for the job. No restrictions on the format of this value are required by this specification. The value of this element MAY require additional information to be correctly interpreted.

6.2.3 ProcessId

If all processes associated with a job are tracked as part of usage, each individual process identifier MAY be reported with this element. Each individual process MUST be represented in a unique ProcessId element.

```
<xsd:element name="JobIdentity">
      <xsd:complexType>
            <xsd:sequence minOccurs="1">
                  <xsd:element name="GlobalJobId" type="xsd:string" minOccurs="0"/>
                  <xsd:element name="LocalJobId" type="xsd:string" minOccurs="0"/>
                  <xsd:sequence >
                        <xsd:element name="ProcessId" minOccurs="0" maxOccurs="unbounded"
type="xsd:string"/>
                  </xsd:sequence>
            </xsd:sequence>
      </xsd:complexType>
</xsd:element>
```

6.3 UserIdentity

This element uniquely identifies the user associated with this usage. The scope representation of identity may be either local or global. Identifiers of both scopes MAY appear in a single UsageRecord. If both appear, there must be a semantic correlation between the presented local and global user identifiers. There is no upper bound on the number of user identifiers that MAY be associated with a single UsageRecord.

6.3.1 LocalUserId

The value of this element represents a local identity for the user. No restrictions on the format of this value are required by this specification. For example, this may report the local uid under which the job executed.

6.3.2 ds:KeyInfo

The contents of this element represent theglobal identity for the user associated with this usage. Similarly to the RecordIdentity element, rules for binding data elements to this structure assist the interpretation of data contained. The following rules should be followed when populating the various sub-elements of this KeyInfo with identifying values:

1. The RetrievalMethod element MUST be present. The *Type* attribute of the element MUST contain the appropriate URI (see section § 4.4 of XML-DSIG for a complete list) to identify the type of identity in use. No other components of the RetrievalMethod element are required by this specification. The RetrievalMethod identified MUST correspond to the additional information represented within KeyInfo. Supported type URIs must include:
    a. http://www.w3.org/2000/09/xmldsig#DSAKeyValue
    b. http://www.w3.org/2000/09/xmldsig#RSAKeyValue
    c. http://www.w3.org/2000/09/xmldsig#X509Data
    d. http://www.w3.org/2000/09/xmldsig#rawX509Certificate
2. The following rules apply to the specific types KeyInfo data, according to the selected *RetrievalMethod Type*. Note that XML-Dsig allows multiple identifier types within a single *KeyInfo* element.

e. *KeyName* contains one of a string identifier related to the key-pair, the distinguished name or the email address identifying the creator. If KeyName identifies a named key-pair, RetrievalMethod type MUST identify the type of keys contained within the key-pair.

f. *KeyValue* contains the public key associated with the creator. If KeyValue is used, RetrievalMethod type MUST identify the type of the public key.

g. X509Data contains information from the X.509 certificate associated with the creator. RetrievalMethod type MUST reference http://www.w3.org/2000/09/xmldsig#X509Data. The relevant rules from [XML-Dsig], summarized below, must be followed when representing X509 information.

   i. At least one of *X509IssuerSerial, X509SubjectName, X509SKI or X509Certificate* must be present.

   ii. All elements from §2.c.i referring to a single certificate must be grouped within a single X509Data element.

   iii. All certificates appearing in an X509Data element MUST relate to the identity of the creator or be part of a certification chain terminating in a certificate that identifies the creator.

h. If *RetrievalMethod Type* is http://www.w3.org/2000/09/xmldsig#rawX509Certificate, the contents of KeyInfo MUST be a binary X509Certificate. No particular encoding is required by this specification.

3. No specific ordering must be imposed on the elements contained within KeyInfo.

See section § 2.3.7 for additional restrictions on value representation within a KeyInfo structure.

```
<xsd:element name="UserIdentity">
       <xsd:complexType>
              <xsd:sequence>
                   <xsd:element maxOccurs="1" minOccurs="0" name="LocalUserId" type="xsd:string"/>
                   <xsd:element maxOccurs="1" minOccurs="0" ref="ds:KeyInfo"/>
              </xsd:sequence>
       </xsd:complexType>
</xsd:element>
```

6.4 *JobName*

This element specifies the name of the job or application that generated this usage. There is no requirement that this element contain a unique identifier for a job. For unique identification of a job, the JobIdentity (see § 6.2) MUST be used.

6.4.1 description

This optional attribute provides additional information about job name.

```
<xsd:element name="JobName">
       <xsd:complexType>
              <xsd:simpleContent>
                     <xsd:extension base="xsd:string">
                            <xsd:attribute ref="urwg:description" use="optional"/>
                     </xsd:extension>
              </xsd:simpleContent>
       </xsd:complexType>
```

```
</xsd:element>
```

6.5 *Charge*

This element specifies the total charge, in the generating system's allocation unit, associated with the usage represented by this structure. The charge MAY be reported without any additional information regarding the usage that generated this charge. However, the value reported MAY include premiums or discounts assessed on the actual usage represented within this record. Therefore, the reported charge may not be directly reconstructed from the specific usage reported.

6.5.1 description

This optional attribute may provide information about the meaning associated with the reported charge.

6.5.2 unit

This attribute specifies the unit of measurement in which the charge for usage is reported. There are no values that must be supported by implementations.

6.5.3 formula

This attribute provides information about the charge calculation applied to this particular usage. Given that a particular charge formula may be complex, this attribute MAY contain only a description of the formula applied. Each implementation MAY specify semantic value that can be interpreted from the value contained in this attribute.

```
<xsd:element name="Charge">
      <xsd:complexType>
            <xsd:simpleContent>
                  <xsd:extension base="xsd:float">
                        <xsd:attribute ref="urwg:description" use="optional"/>
                        <xsd:attribute ref="urwg:unit" use="optional"/>
                        <xsd:attribute name="formula" type="xsd:string" use="optional"/>
                  </xsd:extension>
            </xsd:simpleContent>
      </xsd:complexType>
</xsd:element>
```

6.6 *Status*

This element specifies a completion status associated with the usage as a string. If no value is reported for this element, no inference regarding the current job status may be made. The value for this element SHOULD report any completion status for a job. For example, this may represent the exit status of an interactive running process or the exit status from the batch queuing system's accounting record. Any resource usage reported in this record SHOULD be assumed as consumed regardless of the value, or lack thereof, specified for status. There is no defined semantic meaning attached to any particular value that may appear, other than the following pre-defined values. Compliant implementations MUST support the following values for status, and other values at their discretion.

1. aborted – A policy or human intervention caused the job to cease execution
2. completed – The execution completed
3. failed – Execution halted without external intervention
4. held – Execution is held at the time this usage record was generated

5. queued – Execution was queued at the time this usage record was generated
6. started – Execution started at the time this usage record was generated
7. suspended – Execution was suspended at the time this usage record was generated

6.6.1 description

This optional attribute may provide information about the meaning associated with the reported status.

```
<xsd:element name="Status">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:token">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
    </xsd:element>
```

6.7 WallDuration

This element specifies the wall clock time that elapsed.

6.7.1 description

This optional attribute provides additional information about the walltime reported

```
<xsd:element name="WallDuration">
       <xsd:complexType>
             <xsd:simpleContent>
                    <xsd:extension base="xsd:duration">
                           <xsd:attribute ref="urwg:description" use="optional"/>
                    </xsd:extension>
             </xsd:simpleContent>
       </xsd:complexType>
</xsd:element>
```

6.8 CpuDuration

This element specifies the CPU time used, summed over all processes associated with this usage.

6.8.1 description

This optional attribute provides additional information about the cpu time reported

6.8.2 usageType

This optional attribute specifies whether the cpuTime reported is user or system cpu time. The recognized values for this attribute are:

- user
- system

This element appears at most once with a particular value of usageType

```
<xsd:element name="CpuDuration">
       <xsd:complexType>
```

```
              <xsd:simpleContent>
                     <xsd:extension base="xsd:duration">
                            <xsd:attribute ref="urwg:description" use="optional"/>
                            <xsd:attribute name="usageType">
                                   <xsd:simpleType>
                                          <xsd:restriction base="xsd:token">
                                                 <xsd:enumeration value="user"/>
                                                 <xsd:enumeration value="system"/>
                                          </xsd:restriction>
                                   </xsd:simpleType>
                            </xsd:attribute>
                     </xsd:extension>
              </xsd:simpleContent>
       </xsd:complexType>
</xsd:element>
```

6.9 EndTime

This element specifies the time at which usage ended. The end time may depend upon the queue system, file staging etc. If no EndTime value is reported, no assumption about the completion status of the job may be inferred. Only the Status (see § 6.6) may provide specific information regarding completion status.

6.9.1 description

This optional attribute provides additional information about end time reported.

```
<xsd:element name="EndTime">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:dateTime">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

6.10 StartTime

This element specifies the time at which usage started. The end time may depend upon the queue system, file staging etc.

6.10.1 description

This optional attribute provides additional information about end time reported.

```
<xsd:element name="StartTime">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:dateTime">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

6.11 MachineName

This element specifies the name of the machine on which a job ran.

6.11.1 description

This optional attribute provides additional information about machine.

```
<xsd:element name="MachineName">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="urwg:domainNameType">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

6.12 Host

This element specifies the name of the host on which a job ran.

6.12.1 description

This optional attribute provides additional information about host.

6.12.2 primary

This attribute indicates whether this host acted as the primary host for the execution that incurred this usage. This attribute contains a Boolean value which MUST be true if this host was the primary host. The default value for this attribute is false.

```
<xsd:element name="Host">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="urwg:domainNameType">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                    <xsd:attribute default="false" name="primary" type="xsd:boolean"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

6.13 SubmitHost

This element specifies the name of the host from which a job was submitted.

6.13.1 description

This optional attribute provides additional information about host.

```
<xsd:element name="SubmitHost">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="urwg:domainNameType">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

6.14 Queue

This element specifies the name of the queue from which the job executed or was submitted.

6.14.1 description

This optional attribute provides additional information about host.

```
<xsd:element name="Queue">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:string">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

6.15 ProjectName

This element specifies the name/identifier of the project or charge group associated with this usage.

6.15.1 description

This optional attribute provides additional information about project, for example a human readable project name.

```
<xsd:element name="ProjectName">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:string">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
</xsd:element>
```

7. Usage Record Properties differentiated by metric or type

These element definitions represent usage that may appear multiple times within a single UsageRecord if usage is measured with several distinct metrics or several types of the usage are included. If there are multiple appearances of a particular element, they MUST carry a unique combination of values for the metric and type attributes. The minimal set of supported values for metric and type is indicated within each element definition. Each element that can be differentiated by a metric is defined within a single choice structure. Please refer to the XML Schema documentation for details on the characteristics of the choice structure.

7.1 Network

This element specifies the network usage rate of transfer

7.1.1 description

This optional attribute may provide information about the type of network usage reported.

7.1.2 metric

This attribute specifies the metric for the reported network usage. The values that MUST be supported for this attribute are:

1. average – the average flow rate over the entire usage window
2. total – rate of transfer in the specified unit
3. min – minimum flow rate in the specified
4. max – flow rate in the specified unit

The default value for this attribute is total.

```
<xsd:element name="Network">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:positiveInteger">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                    <xsd:attributeGroup ref="urwg:intervallicVolume"/>
                   <xsd:attribute default="total" ref="urwg:metric" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
    </xsd:element>
```

7.2 Disk

This element specifies the disk storage for this usage.

7.2.1 description

This optional attribute may provide information about the type of disk usage reported. For example, it may be scratch space, network storage, etc.

7.2.2 metric

This attribute specifies the metric for the reported disk usage. The values that MUST be supported for this attribute are:

1. average
2. total
3. min
4. max

The default value for this attribute is total.

7.2.3 type

This attribute specifies the type of the reported disk usage. The values that MUST be supported for this attribute are:

1. scratch
2. temp

```
        <xsd:element name="Disk">
                <xsd:complexType>
                        <xsd:simpleContent>
                                <xsd:extension base="xsd:positiveInteger">
                                        <xsd:attribute ref="urwg:description" use="optional"/>
                                        <xsd:attributeGroup ref="urwg:intervallicVolume"/>
                                        <xsd:attribute default="total" ref="urwg:metric"
use="optional"/>
                                        <xsd:attribute ref="urwg:type" use="optional"/>
                                </xsd:extension>
                        </xsd:simpleContent>
                </xsd:complexType>
        </xsd:element>
```

7.3 Memory

This element specifies the memory usage.

7.3.1 description

This optional attribute may provide information about the type of memory usage reported. For example, it may be virtual memory, paged memory, shared memory, dedicated memory, etc

7.3.2 metric

This attribute specifies the metric for the reported memory usage. The values that MUST be supported for this attribute are:

1. average
2. total
3. max
4. min

The default value for this attribute is total.

7.3.3 type

This attribute specifies the type of the reported memory usage. The values that MUST be supported for this attribute are:

1. shared
2. physical
3. dedicated

```
        <xsd:element name="Memory">
                <xsd:complexType>
                        <xsd:simpleContent>
                                <xsd:extension base="xsd:positiveInteger">
                                        <xsd:attribute ref="urwg:description" use="optional"/>
```

```
                                  <xsd:attributeGroup ref="urwg:intervallicVolume"/>
                                  <xsd:attribute default="total" ref="urwg:metric"
use="optional"/>
                                  <xsd:attribute ref="urwg:type" use="optional"/>
                           </xsd:extension>
                    </xsd:simpleContent>
              </xsd:complexType>
       </xsd:element>
```

7.4 *Swap*

This element specifies the swap usage.

7.4.1 description

This optional attribute may provide information about the type of swap usage reported.

7.4.2 metric

This attribute specifies the metric for the reported swap usage. The values that MUST be supported for this attribute are:

1. average
2. total
3. max
4. min

The default value for this attribute is total.

7.4.3 type

This attribute specifies the type of the reported swap usage. There are no values that MUST be supported for this attribute.

```
       <xsd:element name="Swap">
              <xsd:complexType>
                    <xsd:simpleContent>
                           <xsd:extension base="xsd:positiveInteger">
                                  <xsd:attribute ref="urwg:description" use="optional"/>
                                  <xsd:attributeGroup ref="urwg:intervallicVolume"/>
                                  <xsd:attribute default="total" ref="urwg:metric"
use="optional"/>
                                  <xsd:attribute ref="urwg:type" use="optional"/>
                           </xsd:extension>
                    </xsd:simpleContent>
              </xsd:complexType>
</xsd:element>
```

7.5 *NodeCount*

This element specifies the number of nodes used. The definition of a node may depend upon architecture.

7.5.1 description

This optional attribute provides additional information about the node count reported, for example it may report architecture (cluster vs. smp) associated with this usage record.

```
<xsd:element name="NodeCount">
        <xsd:complexType>
            <xsd:simpleContent>
                <xsd:extension base="xsd:positiveInteger">
                    <xsd:attribute ref="urwg:description" use="optional"/>
                           <xsd:attribute default="total" ref="urwg:metric" use="optional"/>
                </xsd:extension>
            </xsd:simpleContent>
        </xsd:complexType>
    </xsd:element>
```

7.5.2 metric

This attribute specifies the metric for the reported disk usage. The values that MUST be supported for this attribute are:

1. average
2. total
3. min
4. max

7.6 Processors

This element specifies the number of processors used. A processor definition may depend on machine architecture

7.6.1 description

This optional attribute provides additional information about number of processor reported, for example it may report machine architecture associated with this usage record.

```
<xsd:element name="Processors">
       <xsd:complexType>
             <xsd:simpleContent>
                    <xsd:extension base="xsd:positiveInteger">
                           <xsd:attribute ref="urwg:description" use="optional"/>
                           <xsd:attribute ref="urwg:metric" use="optional"/>
                           <xsd:attribute name="consumptionRate" type="xsd:float" use="optional"/>
                    </xsd:extension>
             </xsd:simpleContent>
       </xsd:complexType>
</xsd:element>
```

7.6.2 metric

This attribute specifies the metric for the reported processor usage. The values that MUST be supported for this attribute are:

1. average
2. total
3. min
4. max

7.6.3 consumptionRate

This attribute specifies the consumption rate for the reported processor usage. The consumption rate is a scaling factor that indicates the average percentage of utilization. It intends to facilitate the application of fair charging when accounting for multiplexed jobs. For example, we might have <Processors consumptionrate="0.67">2</Processors>. This says that of the two processors, they were only about 2/3rds utilized on average across the duration of the job. Presumably, the user will only be charged (2 * per_processor_charge_rate * 0.67 * wall_clock_duration_of_job).

7.7 TimeDuration

This element specifies the any additional measure of time duration that is relevant to the reported usage.

7.7.1 description

This optional attribute may provide information about the type of duration being reported. For example, it may be connection time within a multi-tasking queue.

7.7.2 type

This attribute specifies the metric for the reported time duration associated with this usage. The values that MUST be supported for this attribute are:

1. submit
2. connect
3. dedicated

There is no default value for this attribute. The metric attribute MUST be present within the element.

```
<xsd:element name="TimeDuration">
       <xsd:complexType>
              <xsd:simpleContent>
                     <xsd:extension base="xsd:duration">
                            <xsd:attribute ref="urwg:type" use="required"/>
                     </xsd:extension>
              </xsd:simpleContent>
       </xsd:complexType>
</xsd:element>
```

7.8 TimeInstant

This element specifies the any additionally identified discrete time that is relevant to the usage reported

7.8.1 description

This optional attribute may provide information about the type of time being reported. For example, it may report the submit time, rather than start time, of the job.

7.8.2 type

This attribute specifies the type for the reported time instant associated with the usage. The values that MUST be supported for this attribute are:

1. submit

There is no default value for this attribute. The type attribute MUST be present within the element.

```
<xsd:element name="TimeInstant">
       <xsd:complexType>
              <xsd:simpleContent>
                     <xsd:extension base="xsd:dateTime">
                            <xsd:attribute ref="urwg:type" use="required"/>
                     </xsd:extension>
              </xsd:simpleContent>
       </xsd:complexType>
</xsd:element>
```

7.9 ServiceLevel

This element identifies the service level, or quality of service, associated with this resource consumption. Each installation may support several service levels. The values reported are installation specific and will affect charging. For example, service level may represent a combination of priority, expansion and roles associated with the reported usage.

```
<xsd:element name="ServiceLevel">
       <xsd:complexType>
              <xsd:simpleContent>
                     <xsd:extension base="xsd:token">
                            <xsd:attribute ref="urwg:type" use="required"/>
                     </xsd:extension>
              </xsd:simpleContent>
       </xsd:complexType>
</xsd:element>
```

7.9.1 type

This attribute specifies the type for the reported service level associated with the usage. The values that MUST be supported for this attribute are:

1. defined policy

There is no default value for this attribute.

8. Extension Framework

These element definitions represent a mechanism for sites to exchange data that does not correspond to one of the common properties (for example, perhaps grid telescope power). There specific types of extension elements that are defined for use – or further extension – are detailed in the following sub-sections. A site may choose to extend these basic resource element definitions with additional attributes or child elements. However, the site must define the new semantics of additionally imposed structure.

8.1 Type Definitions

Standard type definitions allow sites to define elements that are explicitly typed by these definitions or to extend or restrict the generic type definitions as appropriate to the data needed for their resource usage records.

8.1.1 ResourceType

This type definition provides a mechanism to represent the consumption of an additional resource within the usage record. For example, the quote identifier, the executable or application name may be reported with this element.

8.1.1.1 description

This optional attribute provides additional information about the resource reported. Although its usage is optional, the value of this attribute can be used to distinguish between multiple resources that are included in a single usage record. For example, it may indicate which resource element contains the quote identifier and another contains the name of the executable used when both are reported within a single usage record. Therefore, if multiple resources elements are included in a single usage record, this attribute SHOULD be present.

```
<xsd:complexType name="ResourceType">
      <xsd:simpleContent>
            <xsd:extension base="xsd:string">
                  <xsd:attribute ref="urwg:description" use="optional"/>
            </xsd:extension>
      </xsd:simpleContent>
</xsd:complexType>
```

8.1.2 ConsumableResourceType

This type definition provides a mechanism to represent the consumption of an additional resource within the usage record that is measured. For example, this resource element may report a standard support charge allocated to usage or the number of priority processes created to execute a job.

8.1.2.1 description

This optional attribute provides additional information about the resource reported. Although its usage is optional, the value of this attribute can be used to distinguish between multiple resources that are included in a single usage record. Therefore, when multiple resources elements are included in a single usage record, this attribute SHOULD be present.

8.1.2.2 unit

This attribute specifies the unit of measurement in which the consumed resource for this usage is reported. There are no values that must be supported by implementations.

```
<xsd:complexType name="ConsumableResourceType">
      <xsd:simpleContent>
            <xsd:extension base="xsd:float">
                  <xsd:attribute name="units" type="xsd:string" use="optional"/>
                  <xsd:attribute ref="urwg:description" use="optional"/>
            </xsd:extension>
      </xsd:simpleContent>
```

```
</xsd:complexType>
```

8.2 *Element Definitions*

Global element definitions allow sites to use these global element definitions directly rather than defining particular typed elements.

8.2.1 Resource

This optional element may provide information about a resource associated with the usage.

```
<xsd:element name="Resource" type="urwg:ResourceType"/>
```

Example:

```
<Resource urwg:description="quoteId">1435</Resource>
```

8.2.2 ConsumableResource

This optional element may provide information about a measured resource associated with the usage.

```
<xsd:element name="ConsumableResource" type="urwg:ConsumableResourceType"/>
```

Example:

```
<urwg:ConsumableResource urwg:description="mt process count"
urwg:units="processes">1919</urwg:ConsumableResource>
```

8.2.3 PhaseResource

This optional element extends the ConsumableResource element to report extended resource usage that measures resource usage with the phaseUnit attribute.

```
<xsd:element name="PhaseResource">
       <xsd:complexType>
              <xsd:complexContent>
                     <xsd:extension base="urwg:ConsumableResourceType">
                            <xsd:attribute ref="urwg:phaseUnit" use="optional"/>
                     </xsd:extension>
              </xsd:complexContent>
       </xsd:complexType>
</xsd:element>
```

8.2.4 VolumeResource

This optional element extends the ConsumableResource element to report extended resource usage that measures resource usage with the storageUnit attribute.

```
<xsd:element name="VolumeResource">
       <xsd:complexType>
              <xsd:complexContent>
                     <xsd:extension base="urwg:ConsumableResourceType">
                            <xsd:attribute ref="urwg:storageUnit" use="optional"/>
                     </xsd:extension>
              </xsd:complexContent>
       </xsd:complexType>
</xsd:element>
```

9. Example Usage Records

9.1 Sample Usage Record 1

```
<?xml version="1.0" encoding="UTF-8"?>
<JobUsageRecord xmlns="http://www.gridforum.org/2003/ur-wg"
        xmlns:urwg="http://www.gridforum.org/2003/ur-wg"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://www.gridforum.org/2003/ur-wg
file:/Users/bekah/Documents/GGF/URWG/urwg-schema.09.xsd">
        <RecordIdentity urwg:recordId="http://www.emsl.pnl.gov/mscf/colony/PBS.1234.0"
urwg:createTime="2003-08-13T18:56:56Z" />
        <JobIdentity>
                <LocalJobId>PBS.1234.0</LocalJobId>
        </JobIdentity>
        <UserIdentity>
                <LocalUserId>scottmo</LocalUserId>
        </UserIdentity>
        <Charge>2870</Charge>
        <Status>completed</Status>
        <Memory urwg:storageUnit="MB">1234</Memory>
        <ServiceLevel urwg:type="QOS">BottomFeeder</ServiceLevel>
        <Processors>4</Processors>
        <ProjectName>mscfops</ProjectName>
        <MachineName>Colony</MachineName>
        <WallDuration>PT1S</WallDuration>
        <StartTime>2003-08-13T17:34:50Z</StartTime>
        <EndTime>2003-08-13T18:37:38Z</EndTime>
        <NodeCount>2</NodeCount>
        <Queue>batch</Queue>
        <Resource urwg:description="quoteId">1435</Resource>
        <Resource urwg:description="application">NWChem</Resource>
        <Resource urwg:description="executable">nwchem_linux</Resource>
</JobUsageRecord>
```

9.2 Sample Usage Record 2

```
<?xml version="1.0" encoding="UTF-8"?>
<UsageRecord xmlns="http://www.gridforum.org/2003/ur-wg"
        xmlns:urwg="http://www.gridforum.org/2003/ur-wg"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.gridforum.org/2003/ur-wg
file:/Users/bekah/Documents/GGF/URWG/urwg-schema.09.02.xsd">
        <RecordIdentity urwg:createTime="2003-08-15T14:25:56Z"
urwg:recordId="urn:nasa:arc:usage:82125.lomax.nas.nasa.gov:0"/>
```

```
		<urwg:JobIdentity>
			<urwg:LocalJobId>82125.lomax.nas.nasa.gov</urwg:LocalJobId>
		</urwg:JobIdentity>
		<urwg:UserIdentity>
			<urwg:LocalUserId>foobar</urwg:LocalUserId>
		</urwg:UserIdentity>
		<Status urwg:description="pbs exit status">0</Status>
		<urwg:Memory urwg:metric="max" urwg:storageUnit="KB"
	urwg:type="virtual">1060991</urwg:Memory>
		<urwg:Processors urwg:metric="total">32</urwg:Processors>
		<urwg:EndTime>2003-06-16T08:24:32Z</urwg:EndTime>
		<urwg:ProjectName urwg:description="local charge
	group">g13563</urwg:ProjectName>
		<urwg:Host urwg:primary="true">lomax.nas.nasa.gov</urwg:Host>
		<urwg:Queue>lomax</urwg:Queue>
		<urwg:WallDuration>PT45M48S</urwg:WallDuration>
		<urwg:CpuDuration>PT15S</urwg:CpuDuration>
		<urwg:Resource urwg:description="pbs-jobname">m0.20a-7.0b0.0v</urwg:Resource>
	</UsageRecord>
```

10. Security Considerations

There are no explicit security considerations for these requirements.

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Appendix A

Table Column Interpretations

In the property tables, the columns are interpreted to have the following meanings:

Element Name: Name of the XML element (xsd:element)

Type: Data type defined by Sections 1 & 2 and the W3C XML Schema specification

Description: Brief description of the meaning of the property

Common Usage Record Properties

Simple (unstructured) usage record properties are enumerated in Table 1.

Table 1 Simple Usage Record Properties

Element Name	Type	Description
Charge	xsd:positiveInteger	Total charge for this usage
CPUDuration	xsd:positiveInteger	CPU Time used in seconds, summed over all processes in the job
Disk	xsd:positiveInteger	Disk storage for this usage
EndTime	xsd:dateTime	Date and time when usage ended
Host	xsd:token	Host on which the job ran
MachineName	xsd:token	Name of the machine or cluster on where usage was incurred
Memory	xsd:positiveInteger	Memory for this usage
Network	xsd:positiveInteger	Network usage rate of transfer
NodeCount	xsd:positiveInteger	Number of nodes used
Processors	xsd:positiveInteger	Number of processors used
ProjectName	xsd:token	Project or account name
Queue	xsd:token	Queue name
StartTime	xsd:dateTime	Date and time when usage started
Status	xsd:token	Completion Status
SubmitHost	xsd:token	The hostname from which request was submitted
Swap	xsd:positiveInteger	Swap for this usage
TimeDuration	xsd:duration	A specific interval relevant to this usage. Metric and type attributes provide additional information
TimeInstant	xsd:dateTime	A specific instant relevant to this usage. Metric and type attributes provide additional details.
WallDuration	xsd:positiveInteger	Wallclock duration of usage in seconds (sometimes referred to as WallClockTime)

Appendix B

Units of Measure for Volume

Abbreviation	Definition	Quanitty
b	bit	1 bit
B	byte	1 byte
KB	kilobyte	1000 bytes

MB	megabyte	1000 KB
GB	gigabyte	1000 MB
TB	terabyte	1000 GB
PB	petabyte	1000 TB
EB	exabyte	1000 PB
Kb	kilobit	1000 bits
Mb	megabit	1000 Kb
Gb	gigabit	1000 Mb
Tb	terabit	1000 Gb
Pb	petabit	1000 Tb
Eb	exabit	1000 Pb