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A model of account access control and lifecycle management

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A model of account access control and lifecycle
management

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Chapter 1

Introduction

This document introduces an RDF-based model describing the access control and lifecycle management policies of service providers. It is based upon the model structure proposed in my M.Sc. thesis [4]. This model is centered around a service provider's view of systems, and the agreements that they may reach with either individual users or virtual organizations, representing aggregations of users.

This document is structured as follows. First of all, the modelling languages and tools used in the creation of the model are introduced. Secondly, a high-level overview of the model will be presented, and the composition of the following chapters will be discussed.

1.1 Languages and Tools

For the model in question, the decision was made to use the Resource Description Framework (RDF) [2] and OWL Web Ontology Language [3] to encode it. RDF is a standardized language for modelling metadata, supported by the W3 Consortium. To RDF, OWL adds a standard waying of representing classes, relationships between classes, and cardinality constraints. Thus, using OWL and RDF as a basis allows tools to be developed which are able to perform automated reasoning based upon the defined parameters of the model.

A way of expressing the data required in the model also needed to be developed. The XML schema datatype specification [5] defines several basic datatypes which are used in the model, but additional datatypes also needed to be defined. As XML schema permits additional datatypes to be defined, new datatypes were defined in this language as needed. These new datatypes are described in Chapters 3 and 4.

Tools have been developed which facilitate the development and exploration of OWL-based models. Protege [1], a ontology editor developed at Stanford, was used to aid in the construction of the model. It also allows the relationships between classes to be visualized.

1.2 Structure

The model has at the top level a base class, and is from there broken down into a number of subclasses. The base class, *BaseElement*, defines information common to all elements, including details about modification times and details regarding the class of individuals to who data should be disclosed. This model defines a way in which the properties and relationships between resources may be viewed, through a relatively simple resource model whose parent class is the *Resource* class. It also defines a model of credentials via the *Credential* class. From this model users may deduce a set of credentials required to authenticate in some particular role. Standard username and password tokens as well as X.509 credentials and proxy credentials are supported. In addition, as virtual organizations are a key component of the model, users may be required to present attributes signed by an recognized virtual organizations as part of the authentication and authorization process. The credential model is used to regulate who can create accounts in an *AccountSet*, or access an existing *Account*, thereby gaining the privileges of any *AccountSet* to which the *Account* belongs.

The *Account* does not directly define the resources which a user can access and the duration for which access is available. This is accomplished in the model through an *AccessPolicy* class, connecting accounts with resources, and a *TimeSpec* class whose subclasses allow the duration for which access is available to be described in a flexible manner. The model also allows information to be stored regarding a service provider's access revocation policies. It includes classes to describe the creation of an archival copy of the account data as well as allowing file ownership to be changes and the files potentially migrated to a new location on the system.

This report is broken into several chapters. Following this introduction, Chapter 2 presents the structure of the model in RDF format. Then Chapter 3 contains the XML schema specification of datatypes created for the model. A more-detailed, easier-to-read description of the enumerations introduced is then found in Chapter 4.

Chapter 2

RDF Schema

```
<?xml version="1.0"?>

<!DOCTYPE rdf:RDF [
  <!ENTITY owl "http://www.w3.org/2002/07/owl#" >
  <!ENTITY owl11 "http://www.w3.org/2006/12/owl11#" >
  <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >
  <!ENTITY owl11xml "http://www.w3.org/2006/12/owl11-xml#" >
  <!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >
  <!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >
  <!ENTITY wsa "http://schemas.xmlsoap.org/ws/2004/08/addressing" >
  <!ENTITY lifecycle "http://grid.ucalgary.ca/lifecycle#" >
  <!ENTITY lifecycledt "http://grid.ucalgary.ca/lifecycle/datatypes#" >
]>

<rdf:RDF xmlns="http://grid.ucalgary.ca/lifecycle#"
  xml:base="http://grid.ucalgary.ca/lifecycle"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:owl11="http://www.w3.org/2006/12/owl11#"
  xmlns:owl11xml="http://www.w3.org/2006/12/owl11-xml#"
  xmlns:wsa="http://schemas.xmlsoap.org/ws/2004/08/addressing#"
  xmlns:lifecycle="http://grid.ucalgary.ca/lifecycle#"
  xmlns:lifecycledt="http://grid.ucalgary.ca/lifecycle/datatypes#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <owl:Ontology rdf:about="">
    <rdfs:label rdf:datatype="&xsd:string"
      >Account Access Control and Lifecycle Management Schema</rdfs:label>
    <rdfs:comment rdf:datatype="&xsd:string">This model is a translation of
```

the model as presented in chapter 5 of my thesis into RDF form. Users are referred to that chapter and the accompanying figures for documentation.

```
</rdfs:comment>  
<owl:versionInfo rdf:datatype="&xsd:string">1.0.0</owl:versionInfo>  
</owl:Ontology>
```

```
<!--  
////////////////////////////////////  
//  
// Object Properties  
//  
////////////////////////////////////  
-->
```

```
<!-- http://grid.ucalgary.ca/lifecycle#accessCredentials -->
```

```
<owl:ObjectProperty rdf:about="#accessCredentials">  
  <rdfs:range rdf:resource="#Credential"/>  
  <rdfs:domain rdf:resource="#UploadedCredential"/>  
  <rdfs:domain rdf:resource="#ManualRenewal"/>  
  <rdfs:domain rdf:resource="#Account"/>  
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#accessPolicy -->
```

```
<owl:ObjectProperty rdf:about="#accessPolicy">  
  <rdfs:range rdf:resource="#AccessPolicy"/>  
  <rdfs:domain rdf:resource="#Account"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#accessPolicyFor -->
```

```
<owl:ObjectProperty rdf:about="#accessPolicyFor">  
  <rdfs:domain rdf:resource="#AccessPolicy"/>  
  <rdfs:range rdf:resource="#Resource"/>  
</owl:ObjectProperty>
```

```

</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#accountTemplate -->

<owl:ObjectProperty rdf:about="#accountTemplate">
  <rdfs:range rdf:resource="#Account"/>
  <rdfs:domain rdf:resource="#AccountSet"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#actionOnExpiry -->

<owl:ObjectProperty rdf:about="#actionOnExpiry">
  <rdfs:range rdf:resource="#RevocationAction"/>
  <rdfs:domain rdf:resource="#AccessPolicy"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#addedOffset -->

<owl:ObjectProperty rdf:about="#addedOffset">
  <rdfs:domain rdf:resource="#TimeSpec"/>
  <rdfs:range rdf:resource="#Offset"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#associatedWith -->

<owl:ObjectProperty rdf:about="#associatedWith">
  <rdfs:domain rdf:resource="#SingleTime"/>
  <rdfs:domain rdf:resource="#Statistic"/>
  <rdfs:range rdf:resource="#Resource"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#combinedCredentials -->

<owl:ObjectProperty rdf:about="#combinedCredentials">
  <rdfs:domain rdf:resource="#CredentialCombination"/>
  <rdfs:range rdf:resource="#Credential"/>

```



```

</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#containedCredentials -->

<owl:ObjectProperty rdf:about="#containedCredentials">
  <rdfs:domain rdf:resource="#UploadedCredential"/>
  <rdfs:range rdf:resource="#Credential"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#controlledByApplication -->

<owl:ObjectProperty rdf:about="#controlledByApplication">
  <rdfs:range rdf:resource="#ApplicationResource"/>
  <rdfs:domain rdf:resource="#PolicyClassResource"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#controlledByService -->

<owl:ObjectProperty rdf:about="#controlledByService">
  <rdfs:domain rdf:resource="#PolicyClassResource"/>
  <rdfs:range rdf:resource="#ServiceResource"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#controls -->

<owl:ObjectProperty rdf:about="#controls">
  <rdfs:range rdf:resource="#Resource"/>
  <rdfs:domain rdf:resource="#PolicyClassResource"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#creationCredentials -->

<owl:ObjectProperty rdf:about="#creationCredentials">
  <rdfs:domain rdf:resource="#AccountSet"/>
  <rdfs:range rdf:resource="#Credential"/>
</owl:ObjectProperty>

```

```

<!-- http://grid.ucalgary.ca/lifecycle#credentialsUsedToCopy -->

<owl:ObjectProperty rdf:about="#credentialsUsedToCopy">
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:range rdf:resource="#Credential"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#disclosureCredentials -->

<owl:ObjectProperty rdf:about="#disclosureCredentials">
  <rdfs:range rdf:resource="#Credential"/>
  <rdfs:domain rdf:resource="#BaseElement"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#durAssociatedWith -->

<owl:ObjectProperty rdf:about="#durAssociatedWith">
  <rdfs:domain rdf:resource="#SingleOffset"/>
  <rdfs:range rdf:resource="#Resource"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#durSearchIn -->

<owl:ObjectProperty rdf:about="#durSearchIn">
  <rdfs:domain rdf:resource="#SingleOffset"/>
  <rdfs:range rdf:resource="#StatisticsContainer"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#endOf -->

<owl:ObjectProperty rdf:about="#endOf">
  <rdfs:range rdf:resource="#Account"/>
  <rdfs:domain rdf:resource="#EndOfAccount"/>
  <rdfs:range rdf:resource="#AccountSet"/>
</owl:ObjectProperty>

```

```

<!-- http://grid.ualgary.ca/lifecycle#filesInvolved -->

<owl:ObjectProperty rdf:about="#filesInvolved">
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:domain rdf:resource="#OwnershipChangeRevocationAction"/>
  <rdfs:range rdf:resource="#FileSet"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#filesystem -->

<owl:ObjectProperty rdf:about="#filesystem">
  <rdfs:range rdf:resource="#StorageResource"/>
  <rdfs:domain rdf:resource="#StorageMountPoint"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#gracePeriod -->

<owl:ObjectProperty rdf:about="#gracePeriod">
  <rdfs:domain rdf:resource="#TimeSpec"/>
  <rdfs:range rdf:resource="#TimeSpec"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#hardExpirationTime -->

<owl:ObjectProperty rdf:about="#hardExpirationTime">
  <rdfs:range rdf:resource="#TimeSpec"/>
  <rdfs:domain rdf:resource="#AccessPolicy"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#hasApplications -->

<owl:ObjectProperty rdf:about="#hasApplications">
  <rdfs:range rdf:resource="#ApplicationResource"/>
  <rdfs:domain rdf:resource="#HostLoginResource"/>
</owl:ObjectProperty>

```

```

<!-- http://grid.ualgary.ca/lifecycle#hasStatistic -->

<owl:ObjectProperty rdf:about="#hasStatistic">
  <rdfs:domain rdf:resource="#StatisticsContainer"/>
  <rdfs:range rdf:resource="#Statistic"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#issuedBy -->

<owl:ObjectProperty rdf:about="#issuedBy">
  <rdfs:domain rdf:resource="#VOAttribute"/>
  <rdfs:range rdf:resource="#VirtualOrganization"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#members -->

<owl:ObjectProperty rdf:about="#members">
  <rdfs:domain rdf:resource="#FederationOfVirtualOrganizations"/>
  <rdfs:range rdf:resource="#VirtualOrganization"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#mountedOn -->

<owl:ObjectProperty rdf:about="#mountedOn">
  <rdfs:domain rdf:resource="#StorageMountPoint"/>
  <rdfs:range rdf:resource="#HostLoginResource"/>
</owl:ObjectProperty>

<!-- http://grid.ualgary.ca/lifecycle#multAssociatedWith -->

<owl:ObjectProperty rdf:about="#multAssociatedWith">
  <rdfs:range rdf:resource="#Resource"/>
  <rdfs:domain rdf:resource="#SingleOffset"/>
</owl:ObjectProperty>

```

```

<!-- http://grid.ucalgary.ca/lifecycle#multSearchIn -->

<owl:ObjectProperty rdf:about="#multSearchIn">
  <rdfs:range rdf:resource="#StatisticsContainer"/>
  <rdfs:domain rdf:resource="#SingleOffset"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#offsetInvolved -->

<owl:ObjectProperty rdf:about="#offsetInvolved">
  <rdfs:domain rdf:resource="#OffsetCombination"/>
  <rdfs:range rdf:resource="#Offset"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#ownerCredentials -->

<owl:ObjectProperty rdf:about="#ownerCredentials">
  <rdfs:range rdf:resource="#Credential"/>
  <rdfs:domain rdf:resource="#Account"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#partOf -->

<owl:ObjectProperty rdf:about="#partOf">
  <rdfs:range rdf:resource="#AccountSet"/>
  <rdfs:domain rdf:resource="#Account"/>
</owl:ObjectProperty>

<!-- http://grid.ucalgary.ca/lifecycle#renewability -->

<owl:ObjectProperty rdf:about="#renewability">
  <rdfs:domain rdf:resource="#AccessPolicy"/>
  <rdfs:range rdf:resource="#Renewable"/>
</owl:ObjectProperty>

```

```
<!-- http://grid.ualgary.ca/lifecycle#renewalPolicy -->
```

```
<owl:ObjectProperty rdf:about="#renewalPolicy">  
  <rdfs:range rdf:resource="#Renewable"/>  
  <rdfs:domain rdf:resource="#EndOfRenewalPolicy"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#searchIn -->
```

```
<owl:ObjectProperty rdf:about="#searchIn">  
  <rdfs:range rdf:resource="#StatisticsContainer"/>  
  <rdfs:domain rdf:resource="#SingleTime"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#signedBy -->
```

```
<owl:ObjectProperty rdf:about="#signedBy">  
  <rdfs:domain rdf:resource="#X509Certificate"/>  
  <rdfs:range rdf:resource="#CertificateAuthority"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#signingCertificate -->
```

```
<owl:ObjectProperty rdf:about="#signingCertificate">  
  <rdfs:domain rdf:resource="#VOMSVirtualOrganization"/>  
  <rdfs:range rdf:resource="#X509Certificate"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#softExpirationTime -->
```

```
<owl:ObjectProperty rdf:about="#softExpirationTime">  
  <rdfs:domain rdf:resource="#AccessPolicy"/>  
  <rdfs:range rdf:resource="#TimeSpec"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#startTime -->
```

```
<owl:ObjectProperty rdf:about="#startTime">  
  <rdfs:domain rdf:resource="#AccessPolicy"/>  
  <rdfs:range rdf:resource="#TimeSpec"/>  
</owl:ObjectProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#timesInvolved -->
```

```
<owl:ObjectProperty rdf:about="#timesInvolved">  
  <rdfs:domain rdf:resource="#TimeCombination"/>  
  <rdfs:range rdf:resource="#TimeSpec"/>  
</owl:ObjectProperty>
```

```
<!--  
////////////////////////////////////  
//  
// Data properties  
//  
////////////////////////////////////  
-->
```

```
<!-- http://grid.ualgary.ca/lifecycle#DistinguishedName -->
```

```
<owl:DatatypeProperty rdf:about="#distinguishedName">  
  <rdfs:range rdf:resource="#lifecycledt;distinguishedNameType"/>  
  <rdfs:domain rdf:resource="#X509Certificate"/>  
</owl:DatatypeProperty>
```

```
<!-- http://grid.ualgary.ca/lifecycle#allocationStatus -->
```

```
<owl:DatatypeProperty rdf:about="#allocationStatus">  
  <rdfs:domain rdf:resource="#Account"/>  
  <rdfs:range rdf:resource="#lifecycledt;allocationStatusEnum"/>  
</owl:DatatypeProperty>
```

```

<!-- http://grid.ualgary.ca/lifecycle#certificateData -->

<owl:DatatypeProperty rdf:about="#certificateData">
  <rdfs:domain rdf:resource="#X509Certificate"/>
  <rdfs:range rdf:resource="&xsd;base64Binary"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#combineType -->

<owl:DatatypeProperty rdf:about="#combineType">
  <rdfs:domain rdf:resource="#CredentialCombination"/>
  <rdfs:range rdf:resource="&lifecycledt;credentialCombinationEnum"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#condSubjects -->

<owl:DatatypeProperty rdf:about="#condSubjects">
  <rdfs:domain rdf:resource="#CertificateAuthority"/>
  <rdfs:range rdf:resource="&lifecycledt;listOfDistinguishedNamesType"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#contactAddress -->

<owl:DatatypeProperty rdf:about="#contactAddress">
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:domain rdf:resource="#AccountSet"/>
  <rdfs:domain rdf:resource="#CertificateAuthority"/>
  <rdfs:domain rdf:resource="#VirtualOrganization"/>
  <rdfs:range rdf:resource="&xsd;anyURI"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#contactInfo -->

<owl:DatatypeProperty rdf:about="#contactInfo">
  <rdfs:domain rdf:resource="#CertificateAuthority"/>
  <rdfs:range rdf:resource="&xsd;string"/>
  <rdfs:domain rdf:resource="#AccountSet"/>

```



```
    <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
    <rdfs:domain rdf:resource="#VirtualOrganization"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#contactResolverService -->
```

```
<owl:DatatypeProperty rdf:about="#contactResolverService">
  <rdfs:domain rdf:resource="#VirtualOrganization"/>
  <rdfs:range rdf:resource="&wsa;endpointReference"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#currentAsOf -->
```

```
<owl:DatatypeProperty rdf:about="#currentAsOf">
  <rdfs:range rdf:resource="&xsd;dateTime"/>
  <rdfs:domain rdf:resource="#BaseElement"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#description -->
```

```
<owl:DatatypeProperty rdf:about="#description">
  <rdfs:domain rdf:resource="#VirtualOrganization"/>
  <rdfs:domain rdf:resource="#AccountSet"/>
  <rdfs:range rdf:resource="&xsd;string"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#disclosureLevel -->
```

```
<owl:DatatypeProperty rdf:about="#disclosureLevel">
  <rdfs:domain rdf:resource="#BaseElement"/>
  <rdfs:range rdf:resource="&lifecycle;disclosureLevelEnum"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#durOrderBy -->
```

```
<owl:DatatypeProperty rdf:about="#durOrderBy">
```

```

        <rdfs:domain rdf:resource="#SingleOffset"/>
        <rdfs:range rdf:resource="&lifecycledt;orderByEnum"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#durOrderDir -->

<owl:DatatypeProperty rdf:about="#durOrderDir">
    <rdfs:domain rdf:resource="#SingleOffset"/>
    <rdfs:range rdf:resource="&lifecycledt;orderDirEnum"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#durCalcType -->

<owl:DatatypeProperty rdf:about="#durCalcType">
    <rdfs:domain rdf:resource="#SingleOffset"/>
    <rdfs:range rdf:resource="&lifecycledt;calcEnum"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#durStatisticName -->

<owl:DatatypeProperty rdf:about="#durStatisticName">
    <rdfs:range rdf:resource="&xsd:string"/>
    <rdfs:domain rdf:resource="#SingleOffset"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#durValue -->

<owl:DatatypeProperty rdf:about="#durValue">
    <rdfs:domain rdf:resource="#DurationStatistic"/>
    <rdfs:domain rdf:resource="#SingleOffset"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#exceptionAction -->

<owl:DatatypeProperty rdf:about="#exceptionAction">
    <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>

```

```
    <rdfs:domain rdf:resource="#AutomaticRenewal"/>
    <rdfs:range rdf:resource="#lifecycledt;exceptionActionType"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#executablePath -->
```

```
<owl:DatatypeProperty rdf:about="#executablePath">
  <rdfs:range rdf:resource="#xsd:string"/>
  <rdfs:domain rdf:resource="#ApplicationResource"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#expectedOutput -->
```

```
<owl:DatatypeProperty rdf:about="#expectedOutput">
  <rdfs:domain rdf:resource="#AutomaticRenewal"/>
  <rdfs:range rdf:resource="#xsd:string"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#expiryDate -->
```

```
<owl:DatatypeProperty rdf:about="#expiryDate">
  <rdfs:domain rdf:resource="#X509Certificate"/>
  <rdfs:domain rdf:resource="#VOAttribute"/>
  <rdfs:range rdf:resource="#xsd:dateTime"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#fileServerAddress -->
```

```
<owl:DatatypeProperty rdf:about="#fileServerAddress">
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:range rdf:resource="#xsd:anyURI"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#groups -->
```

```
<owl:DatatypeProperty rdf:about="#groups">
```

```
    <rdfs:domain rdf:resource="#AccountSet"/>
    <rdfs:range rdf:resource="&lifecycledt;listOfStrings"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#inputParameters -->
```

```
<owl:DatatypeProperty rdf:about="#inputParameters">
  <rdfs:range rdf:resource="&xsd:string"/>
  <rdfs:domain rdf:resource="#ManualRenewal"/>
  <rdfs:domain rdf:resource="#AutomaticRenewal"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#interval -->
```

```
<owl:DatatypeProperty rdf:about="#interval">
  <rdfs:range rdf:resource="&xsd;duration"/>
  <rdfs:domain rdf:resource="#AutomaticRenewal"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#lastChecked -->
```

```
<owl:DatatypeProperty rdf:about="#lastChecked">
  <rdfs:range rdf:resource="&xsd;dateTime"/>
  <rdfs:domain rdf:resource="#AutomaticRenewal"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#lastModificationDate -->
```

```
<owl:DatatypeProperty rdf:about="#lastModificationDate">
  <rdfs:domain rdf:resource="#BaseElement"/>
  <rdfs:range rdf:resource="&xsd;dateTime"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#limitToMask -->
```

```
<owl:DatatypeProperty rdf:about="#limitToMask">
```

```

        <rdfs:domain rdf:resource="#FileSet"/>
        <rdfs:range rdf:resource="&lifecycledt;filePermissionsType"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#resultingMask -->

<owl:DatatypeProperty rdf:about="#resultingMask">
    <rdfs:domain rdf:resource="#FileSet"/>
    <rdfs:range rdf:resource="&lifecycledt;filePermissionsType"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#maxLifetime -->

<owl:DatatypeProperty rdf:about="#maxLifetime">
    <rdfs:domain rdf:resource="#Renewable"/>
    <rdfs:range rdf:resource="&xsd;dateTime"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#maxNumberOfRenewals -->

<owl:DatatypeProperty rdf:about="#maxNumberOfRenewals">
    <rdfs:range rdf:resource="&xsd;nonNegativeInteger"/>
    <rdfs:domain rdf:resource="#Renewable"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#multOrderBy -->

<owl:DatatypeProperty rdf:about="#multOrderBy">
    <rdfs:domain rdf:resource="#SingleOffset"/>
    <rdfs:range rdf:resource="&lifecycledt;orderByEnum"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#multOrderDir -->

<owl:DatatypeProperty rdf:about="#multOrderDir">
    <rdfs:domain rdf:resource="#SingleOffset"/>
    <rdfs:range rdf:resource="&lifecycledt;orderDirEnum"/>
</owl:DatatypeProperty>

```

```

<!-- http://grid.ualgary.ca/lifecycle#multCalcType -->

<owl:DatatypeProperty rdf:about="#multCalcType">
  <rdfs:domain rdf:resource="#SingleOffset"/>
  <rdfs:range rdf:resource="#lifecycledt;calcEnum"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#multStatisticName -->

<owl:DatatypeProperty rdf:about="#multStatisticName">
  <rdfs:domain rdf:resource="#SingleOffset"/>
  <rdfs:range rdf:resource="#xsd:string"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#multValue -->

<owl:DatatypeProperty rdf:about="#multValue">
  <rdfs:domain rdf:resource="#SingleOffset"/>
  <rdfs:range rdf:resource="#xsd:float"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#name -->

<owl:DatatypeProperty rdf:about="#name">
  <rdfs:range rdf:resource="#xsd:string"/>
  <rdfs:domain rdf:resource="#AccountSet"/>
  <rdfs:domain rdf:resource="#UsernameCredential"/>
  <rdfs:domain rdf:resource="#VirtualOrganization"/>
  <rdfs:domain rdf:resource="#ApplicationResource"/>
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:domain rdf:resource="#PolicyClassResource"/>
  <rdfs:domain rdf:resource="#CertificateAuthority"/>
  <rdfs:domain rdf:resource="#Account"/>
  <rdfs:domain rdf:resource="#VOAttribute"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#hostname -->

```

```

<owl:DatatypeProperty rdf:about="#hostname">
  <rdfs:range rdf:resource="&lifecycledt;hostnameType"/>
  <rdfs:domain rdf:resource="#HostLoginResource"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#negate -->

<owl:DatatypeProperty rdf:about="#negate">
  <rdfs:range rdf:resource="&xsd;boolean"/>
  <rdfs:domain rdf:resource="#VOAttribute"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#newAccountName -->

<owl:DatatypeProperty rdf:about="#newAccountName">
  <rdfs:range rdf:resource="&xsd;string"/>
  <rdfs:domain rdf:resource="#OwnershipChangeRevocationAction"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#newPathName -->

<owl:DatatypeProperty rdf:about="#newPathName">
  <rdfs:domain rdf:resource="#FileSet"/>
  <rdfs:range rdf:resource="&lifecycledt;pathnameType"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#numFailuresTolerated -->

<owl:DatatypeProperty rdf:about="#numFailuresTolerated">
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:domain rdf:resource="#AutomaticRenewal"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#numTimesRenewed -->

<owl:DatatypeProperty rdf:about="#numTimesRenewed">
  <rdfs:domain rdf:resource="#Renewable"/>

```

```

        <rdfs:range rdf:resource="&xsd;nonNegativeInteger"/>
    </owl:DatatypeProperty>

    <!-- http://grid.ualgary.ca/lifecycle#numUnallocatedAccounts -->

    <owl:DatatypeProperty rdf:about="#numUnallocatedAccounts">
        <rdfs:range rdf:resource="&xsd;nonNegativeInteger"/>
        <rdfs:domain rdf:resource="#AccountSet"/>
    </owl:DatatypeProperty>

    <!-- http://grid.ualgary.ca/lifecycle#creationPriority -->

    <owl:DatatypeProperty rdf:about="#creationPriority">
        <rdfs:range rdf:resource="&xsd;int"/>
        <rdfs:domain rdf:resource="#AccountSet"/>
    </owl:DatatypeProperty>

    <!-- http://grid.ualgary.ca/lifecycle#accessPriority -->

    <owl:DatatypeProperty rdf:about="#accessPriority">
        <rdfs:range rdf:resource="&xsd;int"/>
        <rdfs:domain rdf:resource="#Account"/>
    </owl:DatatypeProperty>

    <!-- http://grid.ualgary.ca/lifecycle#numValue -->

    <owl:DatatypeProperty rdf:about="#numValue">
        <rdfs:domain rdf:resource="#NumberStatistic"/>
        <rdfs:range rdf:resource="&xsd;float"/>
    </owl:DatatypeProperty>

    <!-- http://grid.ualgary.ca/lifecycle#oldPathName -->

    <owl:DatatypeProperty rdf:about="#oldPathName">
        <rdfs:domain rdf:resource="#FileSet"/>
        <rdfs:range rdf:resource="&lifecycledt;pathnameType"/>
    </owl:DatatypeProperty>

    <!-- http://grid.ualgary.ca/lifecycle#orderBy -->

```



```
<owl:DatatypeProperty rdf:about="#orderBy">
  <rdfs:domain rdf:resource="#SingleTime"/>
  <rdfs:range rdf:resource="&lifecycledt;orderByEnum"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#orderDir -->
```

```
<owl:DatatypeProperty rdf:about="#orderDir">
  <rdfs:domain rdf:resource="#SingleTime"/>
  <rdfs:range rdf:resource="&lifecycledt;orderDirEnum"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#overrideAccountSet -->
```

```
<owl:DatatypeProperty rdf:about="#overrideAccountSet">
  <rdfs:domain rdf:resource="#Account"/>
  <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#password -->
```

```
<owl:DatatypeProperty rdf:about="#password">
  <rdfs:domain rdf:resource="#PasswordCredential"/>
  <rdfs:range rdf:resource="&xsd;string"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#path -->
```

```
<owl:DatatypeProperty rdf:about="#path">
  <rdfs:domain rdf:resource="#StorageMountPoint"/>
  <rdfs:range rdf:resource="&lifecycledt;pathnameType"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#properties -->
```

```
<owl:DatatypeProperty rdf:about="#properties">
  <rdfs:range rdf:resource="&xsd:string"/>
  <rdfs:domain rdf:resource="#ApplicationResource"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#quotaMB -->
```

```
<owl:DatatypeProperty rdf:about="#quotaMB">
  <rdfs:domain rdf:resource="#StorageResource"/>
  <rdfs:range rdf:resource="&xsd;nonNegativeInteger"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#recursive -->
```

```
<owl:DatatypeProperty rdf:about="#recursive">
  <rdfs:domain rdf:resource="#FileSet"/>
  <rdfs:range rdf:resource="&xsd:boolean"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#renewableAfterSoftLifetime -->
```

```
<owl:DatatypeProperty rdf:about="#renewableAfterSoftLifetime">
  <rdfs:domain rdf:resource="#Renewable"/>
  <rdfs:range rdf:resource="&xsd:boolean"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#renewableInGracePeriod -->
```

```
<owl:DatatypeProperty rdf:about="#renewableInGracePeriod">
  <rdfs:domain rdf:resource="#Renewable"/>
  <rdfs:range rdf:resource="&xsd:boolean"/>
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#renewalLength -->
```

```
<owl:DatatypeProperty rdf:about="#renewalLength">
```

```

        <rdfs:range rdf:resource="&xsd;duration"/>
        <rdfs:domain rdf:resource="#Renewable"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#serviceEPR -->

<owl:DatatypeProperty rdf:about="#serviceEPR">
    <rdfs:domain rdf:resource="#AutomaticRenewal"/>
    <rdfs:domain rdf:resource="#ManualRenewal"/>
    <rdfs:domain rdf:resource="#ServiceResource"/>
    <rdfs:domain rdf:resource="#UploadedCredential"/>
    <rdfs:range rdf:resource="&wsa;endPointReference"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#revocationServiceEPR -->

<owl:DatatypeProperty rdf:about="#revocationServiceEPR">
    <rdfs:domain rdf:resource="#AccessPolicy"/>
    <rdfs:range rdf:resource="&wsa;endPointReference"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#immediateRevocationSupported -->

<owl:DatatypeProperty rdf:about="#immediateRevocationSupported">
    <rdfs:domain rdf:resource="#AccessPolicy"/>
    <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#scheduledRevocationSupported -->

<owl:DatatypeProperty rdf:about="#scheduledRevocationSupported">
    <rdfs:domain rdf:resource="#AccessPolicy"/>
    <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>

<!-- http://grid.ucalgary.ca/lifecycle#revokeAfterIdleSupported -->

<owl:DatatypeProperty rdf:about="#revokeAfterIdleSupported">
    <rdfs:domain rdf:resource="#AccessPolicy"/>
    <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>

```

```

<!-- http://grid.ualgary.ca/lifecycle#requiresPassword -->

<owl:DatatypeProperty rdf:about="#requiresPassword">
  <rdfs:domain rdf:resource="#PasswordCredential"/>
  <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#resultingPermissions -->

<owl:DatatypeProperty rdf:about="#resultingPermissions">
  <rdfs:domain rdf:resource="#FileSet"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#retryInterval -->

<owl:DatatypeProperty rdf:about="#retryInterval">
  <rdfs:domain rdf:resource="#ArchiveCreationRevocationAction"/>
  <rdfs:range rdf:resource="&xsd;duration"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#revocationListURL -->

<owl:DatatypeProperty rdf:about="#revocationListURL">
  <rdfs:domain rdf:resource="#CertificateAuthority"/>
  <rdfs:range rdf:resource="&xsd;anyURI"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#calcType -->

<owl:DatatypeProperty rdf:about="#calcType">
  <rdfs:domain rdf:resource="#SingleTime"/>
  <rdfs:domain rdf:resource="#OffsetCombination"/>
  <rdfs:domain rdf:resource="#TimeCombination"/>
  <rdfs:range rdf:resource="&xsd;calcEnum"/>
</owl:DatatypeProperty>

```

```

<!-- http://grid.ualgary.ca/lifecycle#serverAddress -->

<owl:DatatypeProperty rdf:about="#serverAddress">
  <rdfs:range rdf:resource="&xsd:anyURI"/>
  <rdfs:domain rdf:resource="#VOMSVirtualOrganization"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#services -->

<owl:DatatypeProperty rdf:about="#services">
  <rdfs:domain rdf:resource="#HostLoginResource"/>
  <rdfs:range rdf:resource="&lifecycledt;listOfServicesType"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#statisticName -->

<owl:DatatypeProperty rdf:about="#statisticName">
  <rdfs:domain rdf:resource="#SingleTime"/>
  <rdfs:range rdf:resource="&xsd:string"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#supportsCreation -->

<owl:DatatypeProperty rdf:about="#supportsCreation">
  <rdfs:domain rdf:resource="#AccountSet"/>
  <rdfs:range rdf:resource="&xsd:boolean"/>
</owl:DatatypeProperty>

<!-- http://grid.ualgary.ca/lifecycle#timeValue -->

<owl:DatatypeProperty rdf:about="#timeValue">
  <rdfs:domain rdf:resource="#TimeStatistic"/>
  <rdfs:domain rdf:resource="#SingleTime"/>
  <rdfs:range rdf:resource="&xsd:dateTime"/>
</owl:DatatypeProperty>

```

```
<!-- http://grid.ucalgary.ca/lifecycle#updateInterval -->
```

```
<owl:DatatypeProperty rdf:about="#updateInterval">  
  <rdfs:domain rdf:resource="#BaseElement"/>  
  <rdfs:range rdf:resource="&xsd;duration"/>  
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#value -->
```

```
<owl:DatatypeProperty rdf:about="#value">  
  <rdfs:domain rdf:resource="#VOAttribute"/>  
  <rdfs:range rdf:resource="&xsd;anyType"/>  
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#version -->
```

```
<owl:DatatypeProperty rdf:about="#version">  
  <rdfs:range rdf:resource="&xsd;string"/>  
  <rdfs:domain rdf:resource="#ApplicationResource"/>  
</owl:DatatypeProperty>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#waitFor -->
```

```
<owl:DatatypeProperty rdf:about="#waitFor">  
  <rdfs:domain rdf:resource="#EndOfAccount"/>  
  <rdfs:range rdf:resource="&lifecycledt;waitForEnum"/>  
</owl:DatatypeProperty>
```

```
<!--  
////////////////////////////////////  
//  
// Classes  
//  
////////////////////////////////////  
-->
```

```

<!-- http://grid.ualgary.ca/lifecycle#AccessPolicy -->

<owl:Class rdf:about="#AccessPolicy">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#RevocationAction"/>
  <owl:disjointWith rdf:resource="#TimeSpec"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
  <owl:disjointWith rdf:resource="#Credential"/>
  <owl:disjointWith rdf:resource="#FileSet"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Offset"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#Account -->

<owl:Class rdf:about="#Account">
  <rdfs:subClassOf rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#AccountSet"/>
  <owl:disjointWith rdf:resource="#VirtualOrganization"/>
  <owl:disjointWith rdf:resource="#Resource"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#AccountSet -->

<owl:Class rdf:about="#AccountSet">
  <rdfs:subClassOf rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Resource"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#ApplicationResource -->

<owl:Class rdf:about="#ApplicationResource">
  <rdfs:subClassOf rdf:resource="#Resource"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#ArchiveCreationRevocationAction -->

```

```

<owl:Class rdf:about="#ArchiveCreationRevocationAction">
  <rdfs:subClassOf rdf:resource="#RevocationAction"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#AutomaticRenewal -->

<owl:Class rdf:about="#AutomaticRenewal">
  <rdfs:subClassOf rdf:resource="#Renewable"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#BaseElement -->

<owl:Class rdf:about="#BaseElement"/>

<!-- http://grid.ucalgary.ca/lifecycle#CertificateAuthority -->

<owl:Class rdf:about="#CertificateAuthority">
  <rdfs:subClassOf rdf:resource="#X509Certificate"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#Credential -->

<owl:Class rdf:about="#Credential">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
  <owl:disjointWith rdf:resource="#TimeSpec"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Offset"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#CredentialCombination -->

<owl:Class rdf:about="#CredentialCombination">
  <rdfs:subClassOf rdf:resource="#Credential"/>
</owl:Class>

```



```

<!-- http://grid.ucalgary.ca/lifecycle#DurationStatistic -->

<owl:Class rdf:about="#DurationStatistic">
  <rdfs:subClassOf rdf:resource="#Statistic"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#EndOfAccount -->

<owl:Class rdf:about="#EndOfAccount">
  <rdfs:subClassOf rdf:resource="#TimeSpec"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#EndOfRenewalPolicy -->

<owl:Class rdf:about="#EndOfRenewalPolicy">
  <rdfs:subClassOf rdf:resource="#TimeSpec"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#EndOfTime -->

<owl:Class rdf:about="#EndOfTime">
  <rdfs:subClassOf rdf:resource="#TimeSpec"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#FederationOfVirtualOrganizations -->

<owl:Class rdf:about="#FederationOfVirtualOrganizations">
  <rdfs:subClassOf rdf:resource="#VirtualOrganization"/>
</owl:Class>

<!-- http://grid.ucalgary.ca/lifecycle#FileSet -->

<owl:Class rdf:about="#FileSet">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>

```

```
<owl:disjointWith rdf:resource="#X509Certificate"/>
<owl:disjointWith rdf:resource="#RevocationAction"/>
<owl:disjointWith rdf:resource="#TimeSpec"/>
<owl:disjointWith rdf:resource="#StatisticsContainer"/>
<owl:disjointWith rdf:resource="#Offset"/>
<owl:disjointWith rdf:resource="#Credential"/>
</owl:Class>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#HostLoginResource -->
```

```
<owl:Class rdf:about="#HostLoginResource">
  <rdfs:subClassOf rdf:resource="#Resource"/>
</owl:Class>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#ManualRenewal -->
```

```
<owl:Class rdf:about="#ManualRenewal">
  <rdfs:subClassOf rdf:resource="#Renewable"/>
</owl:Class>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#NumberStatistic -->
```

```
<owl:Class rdf:about="#NumberStatistic">
  <rdfs:subClassOf rdf:resource="#Statistic"/>
</owl:Class>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#Offset -->
```

```
<owl:Class rdf:about="#Offset">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
</owl:Class>
```

```
<!-- http://grid.ucalgary.ca/lifecycle#OffsetCombination -->
```

```

<owl:Class rdf:about="#OffsetCombination">
  <rdfs:subClassOf rdf:resource="#Offset"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#OwnershipChangeRevocationAction -->

<owl:Class rdf:about="#OwnershipChangeRevocationAction">
  <rdfs:subClassOf rdf:resource="#ArchiveCreationRevocationAction"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#PasswordCredential -->

<owl:Class rdf:about="#PasswordCredential">
  <rdfs:subClassOf rdf:resource="#Credential"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#PolicyClassResource -->

<owl:Class rdf:about="#PolicyClassResource">
  <rdfs:subClassOf rdf:resource="#Resource"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#Renewable -->

<owl:Class rdf:about="#Renewable">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#TimeSpec"/>
  <owl:disjointWith rdf:resource="#Statistic"/>
  <owl:disjointWith rdf:resource="#RevocationAction"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Credential"/>
  <owl:disjointWith rdf:resource="#AccessPolicy"/>
  <owl:disjointWith rdf:resource="#Offset"/>
  <owl:disjointWith rdf:resource="#StorageMountPoint"/>
  <owl:disjointWith rdf:resource="#FileSet"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
</owl:Class>

```

```

<!-- http://grid.ualgary.ca/lifecycle#Resource -->

<owl:Class rdf:about="#Resource">
  <rdfs:subClassOf rdf:resource="#StatisticsContainer"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#RevocationAction -->

<owl:Class rdf:about="#RevocationAction">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#TimeSpec"/>
  <owl:disjointWith rdf:resource="#Offset"/>
  <owl:disjointWith rdf:resource="#Credential"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#ServiceResource -->

<owl:Class rdf:about="#ServiceResource">
  <rdfs:subClassOf rdf:resource="#Resource"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#SingleOffset -->

<owl:Class rdf:about="#SingleOffset">
  <rdfs:subClassOf rdf:resource="#Offset"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#SingleTime -->

<owl:Class rdf:about="#SingleTime">
  <rdfs:subClassOf rdf:resource="#TimeSpec"/>
</owl:Class>

```

```

<!-- http://grid.ualgary.ca/lifecycle#Statistic -->

<owl:Class rdf:about="#Statistic">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#Offset"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#FileSet"/>
  <owl:disjointWith rdf:resource="#Credential"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
  <owl:disjointWith rdf:resource="#AccessPolicy"/>
  <owl:disjointWith rdf:resource="#RevocationAction"/>
  <owl:disjointWith rdf:resource="#StorageMountPoint"/>
  <owl:disjointWith rdf:resource="#TimeSpec"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#StatisticsContainer -->

<owl:Class rdf:about="#StatisticsContainer">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#StorageMountPoint -->

<owl:Class rdf:about="#StorageMountPoint">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#RevocationAction"/>
  <owl:disjointWith rdf:resource="#TimeSpec"/>
  <owl:disjointWith rdf:resource="#Offset"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Credential"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
  <owl:disjointWith rdf:resource="#FileSet"/>
  <owl:disjointWith rdf:resource="#AccessPolicy"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#StorageResource -->

<owl:Class rdf:about="#StorageResource">
  <rdfs:subClassOf rdf:resource="#Resource"/>

```

```

</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#TimeCombination -->
<owl:Class rdf:about="#TimeCombination">
  <rdfs:subClassOf rdf:resource="#TimeSpec"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#TimeSpec -->
<owl:Class rdf:about="#TimeSpec">
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#X509Certificate"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Offset"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#TimeStatistic -->
<owl:Class rdf:about="#TimeStatistic">
  <rdfs:subClassOf rdf:resource="#Statistic"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#UploadedCredential -->
<owl:Class rdf:about="#UploadedCredential">
  <rdfs:subClassOf rdf:resource="#Credential"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#UsernameCredential -->
<owl:Class rdf:about="#UsernameCredential">
  <rdfs:subClassOf rdf:resource="#Credential"/>
</owl:Class>

```

```

<!-- http://grid.ualgary.ca/lifecycle#VOAttribute -->

<owl:Class rdf:about="#VOAttribute">
  <rdfs:subClassOf rdf:resource="#Credential"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#VOMSVirtualOrganization -->

<owl:Class rdf:about="#VOMSVirtualOrganization">
  <rdfs:subClassOf rdf:resource="#VirtualOrganization"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#VirtualOrganization -->

<owl:Class rdf:about="#VirtualOrganization">
  <rdfs:subClassOf rdf:resource="#StatisticsContainer"/>
  <owl:disjointWith rdf:resource="#Resource"/>
  <owl:disjointWith rdf:resource="#AccountSet"/>
</owl:Class>

<!-- http://grid.ualgary.ca/lifecycle#X509Certificate -->

<owl:Class rdf:about="#X509Certificate">
  <rdfs:subClassOf rdf:resource="#Credential"/>
  <rdfs:subClassOf rdf:resource="#BaseElement"/>
  <owl:disjointWith rdf:resource="#StatisticsContainer"/>
</owl:Class>

<!--
////////////////////////////////////
//
// Individuals
//
////////////////////////////////////
-->

```

```
<!-- http://grid.ucalgary.ca/lifecycle#OwnerCredentials -->  
<Credential rdf:about="#OwnerCredentials"/>  
</rdf:RDF>
```


Chapter 3

XML Schema-based Custom Datatypes

```
<?xml version="1.0"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  targetNamespace="http://grid.ucalgary.ca/lifecycle/datatypes"
  xmlns="http://grid.ucalgary.ca/lifecycle/datatypes"
  elementFormDefault="qualified">

  <!-- Custom datatypes for the access control and lifecycle management model
    at http://grid.ucalgary.ca/lifecycle

    These types were created according the documentation at
    http://www.w3.org/TR/xmlschema-2/
    and also by following the examples in the GRC datatype schema
  -->

  <!-- Disclosure policy list. Used to indicate the class of requesters to
    which information shall be released. The first four values indicate
    an increasingly restrictive release policy, and the last value is used
    to indicate that a separate list of credentials defines the parties to
    whom the data will be released. -->
  <xsd:simpleType name="disclosureLevelEnum">
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="all"/>
      <xsd:enumeration value="VO"/>
      <xsd:enumeration value="user"/>
      <xsd:enumeration value="private"/>
      <xsd:enumeration value="credentials"/>
    </xsd:restriction>
  </xsd:simpleType>
```

```

<!-- Hostnames are formed of clusters of non-whitespace characters separated
      by periods-->
<xsd:simpleType name="hostnameType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="(\S+\.)*\S+"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- Paths are formed by concatenating names separated by '/' characters. To
      maintain compatibility with Windows-based systems the pathname may be
      prefixed by a lowercase drive letter and colon -->
<xsd:simpleType name="pathnameType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="(\p{Ll}:)?/([~/]+/?)*/>
  </xsd:restriction>
</xsd:simpleType>

<!-- A service types consists of a port number followed by a service type
      e.g. "22,ssh" or "80,http"
-->
<xsd:simpleType name="serviceType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="\d+,\S+"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- A list of instances of serviceType -->
<xsd:element name="listOfServicesType">
  <xsd:simpleType>
    <xsd:list itemType="serviceType"/>
  </xsd:simpleType>
</xsd:element>

<!-- The format of X.509 distinguished names
      is similar to the format of strings allowed
      by the following regular expression
      /([^=/>+=[^=/>+)*
-->
<xsd:simpleType name="distinguishedNameType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="/([^=/>+=[^=/>+)*"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- A list of instances of distinguishedNameType -->

```

```

<xsd:element name="listOfDistinguishedNamesType">
  <xsd:simpleType>
    <xsd:list itemType="distinguishedNameType"/>
  </xsd:simpleType>
</xsd:element>

<!-- The credentialCombinationEnum indicates the ways in which a list of
      credentials may be combined -->
<xsd:simpleType name="credentialCombinationEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="and"/>
  <xsd:enumeration value="any"/>
  <xsd:enumeration value="not"/>
</xsd:restriction>
</xsd:simpleType>

<!-- The credentialCombinationEnum indicates the ways in which a list of
      credentials may be combined -->
<xsd:simpleType name="allocationStatusEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="allocated"/>
  <xsd:enumeration value="unallocated"/>
  <xsd:enumeration value="flagged"/>
</xsd:restriction>
</xsd:simpleType>

<!-- The waitForEnum indicates whether to wait for all the accounts in an
      EndOfAccount class to expire, or if the expiry of one is sufficient
      to trigger this -->
<xsd:simpleType name="waitForEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="any"/>
  <xsd:enumeration value="all"/>
</xsd:restriction>
</xsd:simpleType>

<!-- The orderDirEnum specifies whether values should be listed
      in ascending or descending order -->
<xsd:simpleType name="orderDirEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="asc"/>
  <xsd:enumeration value="desc"/>
</xsd:restriction>
</xsd:simpleType>

<!-- The orderByEnum selects whether to sort by timestamp

```

```

        or by value -->
<xsd:simpleType name="orderByEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="timestamp"/>
  <xsd:enumeration value="value"/>
</xsd:restriction>
</xsd:simpleType>

<!-- The calcEnum type is used to determine what sort of calculation
      should be done on a list of values -->
<xsd:simpleType name="calcEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="min"/>
  <xsd:enumeration value="max"/>
  <xsd:enumeration value="median"/>
  <xsd:enumeration value="avg"/>
  <xsd:enumeration value="first"/>
</xsd:restriction>
</xsd:simpleType>

<!-- Basic exception handling
      - notify = alert account holder
      - flag   = note error condition, wait for sysadmin intervention
      - ignore = proceed as if no error occurred -->
<xsd:simpleType name="basicExceptionActionEnum">
<xsd:restriction base="xsd:string">
  <xsd:enumeration value="notify"/>
  <xsd:enumeration value="flag"/>
  <xsd:enumeration value="ignore"/>
</xsd:restriction>
</xsd:simpleType>

<!-- A list of instances of basicExceptionActionEnum -->
<xsd:element name="exceptionActionType">
  <xsd:simpleType>
    <xsd:list itemType="basicExceptionActionEnum"/>
  </xsd:simpleType>
</xsd:element>

<!-- File permissions. Basic user-group-other numerical
      values as works with the chmod command -->
<xsd:simpleType name="filePermissionsType">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="[0-7][0-7][0-7]"/>
  </xsd:restriction>
</xsd:simpleType>

```

```
<!-- A list of strings. Used in the model for storing group names -->
<xsd:simpleType name="listOfStrings">
  <xsd:list itemType="xsd:string"/>
</xsd:simpleType>
</xsd:schema>
```

Chapter 4

Enumerations Used in the Model

This chapter contains a list, in alphabetical order, of enumerations specified in the model introduced in this thesis. More details about the datatypes used in the model may be found examining the datatype specification in XML schema format in Appendix 3.

Table 4.1: allocationStatusEnum

Value	Description
allocated	A user is mapped to the account
unallocated	No user is mapped to the account
flagged	The account is in an error state, requiring system administrator intervention

Table 4.2: calcEnum

Value	Description
min	Minimum
max	Maximum
median	Median
avg	Average
first	First

Table 4.3: credentialCombinationEnum

Value	Description
and	All credentials in the list must be presented
any	Any of the credentials in the list must be presented
not	If credentials in the list are presented then access will be denied

Table 4.4: disclosureEnum

Value	Description
all	Release information to anonymous users
VO	Release information to members of the virtual organization involved
user	Release information to the users of the accounts involved
private	Do not release information
credentials	Release information to users holding the separately-specified credentials

Table 4.5: exceptionActionEnum. exceptionActionType is a set of these values

Value	Description
notify	Notify the owner of the account (if possible)
flag	Flag the account as being in an error state and await intervention by a system administrator
ignore	Ignore the error and continue

Table 4.6: orderByEnum

Value	Description
timestamp	Sort by timestamp value
value	Sort according to data value

Table 4.7: orderDirEnum

Value	Description
asc	Sort in ascending order
desc	Sort in descending order

Table 4.8: waitForEnum

Value	Description
any	Wait for any of the monitored accounts to expire
all	Wait for all of the monitored accounts to expire

Appendix A

Bibliography

Bibliography

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