# A model of account access control and lifecycle management

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January 16, 2008

# Contents

# 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 descripted 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>



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

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



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

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



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

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



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

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



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

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



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

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



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

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

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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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

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

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



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

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



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




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

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



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

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

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

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



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

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



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

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



<!-- http://grid.ucalgary.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.ucalgary.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="&lifecycledt;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.ucalgary.ca/lifecycle#multCalcType -->

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



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

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



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

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



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

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


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

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

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

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

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

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



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

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



<!-- http://grid.ucalgary.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 -->
```

```xml
<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>
```

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

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



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

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



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

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



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

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



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

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

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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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



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

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

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

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



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

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

```
</owl:Class>



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

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



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

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



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

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



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

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

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

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



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

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



<!-- http://grid.ucalgary.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.ucalgary.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 it 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 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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