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IRIS: An Address Registry (areg) Type  
for the Internet Registry Information Service

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

This document describes an IRIS registry schema for IP address and Autonomous System Number information. The schema extends the necessary query and result operations of IRIS to provide the functional information service needs for syntaxes and results used by Internet Protocol address registries.

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## 1. Introduction

An Internet address registry stores information about:

- o address ranges
- o autonomous system number ranges
- o associated contacts and organizations
- o name servers

This information is interrelated, and Internet address registries store this information and the information's interrelationships in a manner befitting the needs of each Internet address registry and its constituents. This document specifies a method for accessing and retrieving this information in a common XML format.

This document describes an IRIS namespace for Internet address registries using an XML Schema [8] derived from and using the IRIS [2] schema. This schema and registry type are provided to demonstrate the extensibility of the IRIS framework beyond the use of domains, a criteria defined in CRISP [4].

The schema given in this document is specified using the Extensible Markup Language (XML) 1.0 as described in XML [5], XML Schema notation as described in XML\_SD [7] and XML\_SS [8], and XML Namespaces as described in XML\_NS [6].

Examples of client/server XML exchanges with this registry type are available in Appendix B.

## 2. Document Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [1].

## 3. Schema Description

IRIS requires the derivation of both query and result elements by a registry schema. Descriptions for these follow.

The descriptions contained within this section refer to XML elements and attributes and their relation to the exchange of data within the protocol. These descriptions also contain specifications outside the scope of the formal XML syntax. Therefore, this section will use terms defined by RFC 2119 [1] to describe the specification outside

the scope of the formal XML syntax. While reading this section, please reference Section 5 for needed details on the formal XML syntax.

### 3.1. Query Derivatives

#### 3.1.1. <findContacts> Query

<findContacts> searches for contacts given search constraints.

The allowable search fields are handled by one of the elements in the "contactSearchGroup" (see Section 3.1.9) or the element <organizationId>. The <organizationId> element constrains the query based on the organization ID (handle) associated with contacts. This element is an "exactMatchParameter" (see Section 3.1.11).

This query also provides optional <language> elements containing language tags. Clients MAY use these elements to give a hint about the natural language(s) of the affected element. Servers MAY use this information in processing the query, such as tailoring normalization routines to aid in more effective searches.

The client SHOULD pass the names unchanged to the server, and the implementation of the server decides if the search is case sensitive or not.

#### 3.1.2. <findOrganizations>

<findOrganizations> searches for organizations given search constraints.

The allowable search fields are handled by one of the elements in the "commonSearchGroup" (see Section 3.1.10) or the element <organizationName>. This element is an "exactOrPartialMatchParameter" (see Section 3.1.11).

This query also provides optional <language> elements containing language tags. Clients MAY use these elements to give a hint about the natural language(s) of the affected element. Servers MAY use this information in processing the query, such as tailoring normalization routines to aid in more effective searches.

The client SHOULD pass the names unchanged to the server, and the implementation of the server decides if the search is case sensitive or not.

### 3.1.3. <findAutonomousSystemsByName> and <findNetworksByName>

The <findAutonomousSystemsByName> and <findNetworksByName> elements allow searches by name of autonomous systems and networks, respectively. Both have the same format.

The child element <name> is an "exactOrPartialMatchParameter" (see Section 3.1.11).

This query also provides optional <language> elements containing language tags. Clients MAY use these elements to give a hint about the natural language(s) of the affected element. Servers MAY use this information in processing the query, such as tailoring normalization routines to aid in more effective searches.

The client SHOULD pass the names unchanged to the server, and the implementation of the server decides if the search is case sensitive or not.

### 3.1.4. <findNetworksByAddress>

The <findNetworksByAddress> element is a query for a network given a related IP address or IP address range. It has the following child elements:

- o <ipv4Address> - has a child <start> element containing the starting IPv4 address of the network and an optional child of <end> containing the ending IPv4 address of the network. Clients MUST convert any short-form notation to the fully-qualified notation.
- o <ipv6Address> - same as <ipv4Address>, but the child addresses contain IPv6 addresses. Clients MUST convert any short-form notation to the fully-qualified notation.
- o <specificity> - determines the network specificity for the search (see Section 4). Valid values are "exact-match", "all-less-specific", "one-level-less-specific", "all-more-specific", and "one-level-more-specific". This element may have the optional attribute 'allowEquivalences'. When it is set to "true", the result set should include networks with equivalent starting and ending addresses. The default value for 'allowEquivalences' is "false".

The results from this query MUST be either <ipv4Network> or <ipv6Network> results. More than one network result MAY be returned.

### 3.1.5. <findNetworksByHandle>

The <findNetworksByHandle> element is a query for a network given a the handle of a related network. It has the following child elements:

- o <networkHandle> - specifies the network handle.
- o <specificity> - determines the network specificity for the search (see Section 4). Valid values are "all-less-specifics", "one-level-less-specifics", "all-more-specifics", and "one-level-more-specifics".

The results from this query MUST be either <ipv4Network> or <ipv6Network> results. More than one network result MAY be returned.

This query could be used to discover the parentage relationships between networks that have the same starting and ending addresses.

The client SHOULD pass handles unchanged to the server, and the implementation of the server decides if the search is case sensitive or not.

### 3.1.6. <findASByNumber>

The <findASByNumber> element allows a search for autonomous systems given an autonomous system number (ASN) range. It has the following child elements:

- o <asNumberStart> - specifies the start of the ASN range.
- o <asNumberEnd> - specifies the end of the ASN range.
- o <specificity> - determines the range specificity for the search (see Section 4). Valid values are "exact-match", "all-less-specific", "one-level-less-specific", "all-more-specific", and "one-level-more-specific". This element may have the optional attribute 'allowEquivalences'. When it is set to "true", the result set should include ranges with equivalent starting and ending numbers. The default value for 'allowEquivalences' is "false".

The results from this query MUST be <autonomousSystem> results. More than one result MAY be returned.

### 3.1.7. <findByContact>

The <findByContact> element allows a search for autonomous systems, IP networks, and organizations on fields associated with that entity's contact. The optional search element <returnedResultType> MUST restrict the results to autonomous systems, IPv4 networks, IPv6 networks, or organizations using the values 'returnASs', 'returnIPv4Networks', 'returnIPv6Networks', and 'returnOrganizations', respectively.

The allowable search fields are handled with either the <contactHandle> element or one of the elements in the "contactSearchGroup" (see Section 3.1.9). The <contactHandle> element allows for the entities to be selected based on the contact having the specified contact handle, and it is an "exactMatchParameter" type (see Section 3.1.11). The client SHOULD pass these search fields unchanged to the server, and the implementation of the server decides if the search is case sensitive or not.

The query MAY also be constrained further using the optional <role> element. The contents of this element signify the role the contact has with the entity. The allowable values for this element are "adminContact", "nocContact", "techContact", "abuseContact", and "otherContact".

This query also provides optional <language> elements containing language tags. Clients MAY use these elements to give a hint about the natural language(s) of the affected element. Servers MAY use this information in processing the query, such as tailoring normalization routines to aid in more effective searches.

The results from this query MUST be <ipv4Network> results, <ipv6Network> results, <autonomousSystem> results, or <organization> results. More than one result MAY be returned, and the results MAY be of mixed types.

### 3.1.8. <findNetworksByNameServer>

The <findNetworksByNameServer> element allows a search for IP networks based on their associated name servers. The <nameServer> element contains the fully qualified domain name of the name server. The optional search element <returnedResultType> MUST restrict the results to IPv4 networks or IPv6 networks using the values 'returnIPv4Networks' and 'returnIPv6Networks', respectively.

The results from this query MUST be <ipv4Network> or <ipv6Network> results. More than one result MAY be returned, and the results MAY be of mixed types.

#### 3.1.9. Contact Search Group

Some of the queries above have similar query constraints for searching on contacts. This section describes those common parameters.

<commonName> allows the query to be constrained based on the common name of the contact. This constraint is an "exactOrPartialMatchParameter" (see Section 3.1.11).

This group also contains all the members of the "commonSearchGroup" (see Section 3.1.10).

#### 3.1.10. Common Search Group

Some of the queries above have similar query constraints for searching on contacts. This section describes those common parameters.

<eMail> constrains the query based on the e-mail address of the contact. This constraint is a "domainResource" type (see Section 3.1.11).

The <city>, <region>, <country>, and <postalCode> elements restrict the scope of the query based on the city, region, country, or postal code of the contact, respectively. These constraints are all "exactMatchParameter" types (see Section 3.1.11). The contents of <country> MUST be compliant with ISO 3166 [9] two-character country codes.

#### 3.1.11. Match Parameters

Some of the queries above have constraints that match strings using matching parameters. This section describes those matching parameters.

Elements of type "exactMatchParameter" will have one child element of <exactMatch>. The contents of this child element are to match exactly in the use of the constraint.

Elements of type "partialMatchParameter" will have either a <beginsWith> child element with an optional <endsWith> child element or an <endsWith> child element. The content of the <beginsWith>

element specifies the beginning character sequence for the constraint. The content of the <endsWith> element specifies the ending character sequence for the constraint.

Elements of type "exactOrPartialMatchParameter" can have either the child element allowed with the "exactMatchParameter" type or the child elements allowed with the "partialMatchParameter" type.

Elements of type "domainResource" can have either the child element allowed with the "exactMatchParameter" type or a child element of <inDomain>. This parameter type is meant to match email, SIP, Extensible Messaging and Presence Protocol (XMPP), and other types of "user@domain" addresses. When this parameter is specified with the <exactMatch> child element, the constraint is based on the whole email address. When this parameter is specified with the <inDomain> child element, the constraint is based on any email address within the domain given. The <inDomain> MUST only contain a valid domain name (i.e., no '@' symbol), and the matching SHOULD take place only on the domain given (i.e., no partial matches with respect to substrings or parent domains).

### 3.2. Result Derivatives

#### 3.2.1. <ipv4Network> and <ipv6Network> Results

The <ipv4Network> and <ipv6Network> share a common definition of 'ipNetworkType'. It has the following child elements:

- o <networkHandle> contains the registry-unique assigned handle for this network.
- o <name> contains a human-friendly name for the network.
- o <startAddress> contains the first IP address of the network.
- o <endAddress> contains the last IP address of the network.
- o <networkType> contains a string denoting the type of network.
- o <networkTypeInfo> is an entity reference to a definition of the values explained in a plain natural language. The referent MUST be a <simpleEntity> as defined by [2].
- o <nameServer> contains the domain name of a nameserver responsible for reverse-DNS mapping for this network.

- o <organization> contains an entity reference to the organization assigned this network. The referent MUST be an <organization> (Section 3.2.4) result.
- o One of the following:
  - \* <parent> contains an entity reference to the parent network of this network. The referent MUST be an <ipv4Network> (Section 3.2.1) result if this reference is a child of <ipv4Network>. The referent MUST be an <ipv6Network> (Section 3.2.1) result if this reference is a child of <ipv6Network>.
  - \* <noParent> signifies that this network has no parent network.
- o Contact references (see Section 3.2.5).
- o Common child elements (see Section 3.2.6).

### 3.2.2. <autonomousSystem> Result

The <autonomousSystem> element represents an assigned or allocated autonomous system number range. It has the following children:

- o <asHandle> contains a registry-unique assigned handle for this autonomous system number range.
- o <asNumberStart> contains an integer indicating the starting number for the autonomous system number range.
- o <asNumberEnd> contains an integer indicating the ending number for the autonomous system number range.
- o <name> contains a human-readable name for this autonomous system.
- o <organization> contains an entity reference to the organization assigned or allocated this autonomous system number range. The referent MUST be an <organization> (Section 3.2.4) result.
- o One of the following:
  - \* <parent> contains an entity reference to the parent autonomous system of this autonomous system. The referent MUST be an <autonomousSystem> (Section 3.2.2) result.
  - \* <noParent> signifies that this autonomous system has no parent autonomous system.

- o Contact references (see Section 3.2.5).
- o Common child elements (see Section 3.2.6).

### 3.2.3. <contact> Result

The <contact> element represents the registration of a point of contact. It has the following child elements:

- o <contactHandle> contains the registry-unique assigned handle for this contact.
- o <commonName> specifies the name of the contact.
- o <eMail> contains the email address for this contact.
- o <sip> contains the sip address for this contact.
- o <organization> contains an entity reference to the organization associated with this contact. The referent MUST be an <organization> (Section 3.2.4) result.
- o <postalAddress> contains information for reaching the contact via postal mail. It is composed of the following child elements:
  - \* <address> contains the address for this contact.
  - \* <city> contains the city where this contact is located.
  - \* <region> contains the national region where this contact is located.
  - \* <postalCode> contains the postal code where this contact is located.
  - \* <country> contains the country code where this contact is located. This MUST be compliant with ISO 3166 [9] two-character country codes.
- o <phone> contains child elements describing the phone number of the contact. The child elements are <number>, <extension>, and <type>.
- o Common child elements (see Section 3.2.6).

### 3.2.4. <organization> Result

The <organization> element represents an organization. It has the following child elements:

- o <name> contains the name of the organization.
- o <id> contains a registry-unique identifier for this organization.
- o <eMail> contains the email address for this organization.
- o <postalAddress> contains a information for reaching the organization via postal mail. It is composed of the following child elements:
  - \* <address> contains the address for this organization.
  - \* <city> contains the city where this organization is located.
  - \* <region> contains the national region where this organization is located.
  - \* <postalCode> contains the postal code where this organization is located.
  - \* <country> contains the country code where this organization is located. This MUST be compliant with ISO 3166 [9] two-character country codes.
- o <phone> contains child elements describing the phone number of the contact. The child elements are <number>, <extension>, and <type>.
- o Contact references (see Section 3.2.5).
- o Common child elements (see Section 3.2.6).

### 3.2.5. Contact References

The registry schema defined in Section 5 normalizes out a group of elements used to reference contacts. This group is used by many of the result types for this registry. The group has the following elements, each of which may appear as many times as needed. The referent of each MUST be <contact> (Section 3.2.3) results.

- o <adminContact>
- o <techContact>

- o <nocContact>
- o <abuseContact>
- o <otherContact>

### 3.2.6. Common Result Child Elements

The registry schema defined in Section 5 normalizes out a group of common elements that are used most among the result types. The group has the following elements:

- o <numberResourceRegistry> contains an entity reference to the number resource registry of record. The referent MUST be an <organization> (Section 3.2.4) result.
- o <registrationDate> contains the date of first registration.
- o <lastUpdatedDate> contains the date when the registration was last updated.
- o The <iris:seeAlso> element contains an entity reference specifying an entity that is indirectly associated with this result object. This element can be used for comments and remarks.

### 3.3. Support for <iris:lookupEntity>

The following types of entity classes are recognized by the <lookupEntity> query of IRIS for this registry:

- o ipv4-handle - a registry-unique identifier specifying an IPv4 network. Queries with these names will yield a <ipv4Network> result.
- o ipv6-handle - a registry-unique identifier specifying an IPv6 network. Queries with these names will yield a <ipv6Network> result.
- o as-handle - a registry-unique identifier specifying an autonomous system. It yields a result of <autonomousSystem>.
- o contact-handle - a registry-unique identifier of a contact. Yields a result of <contact>.
- o organization-id - a registry-unique identifier of an organization. Yields a result of <organization>.
- o The entity names of these entity classes are case insensitive.

#### 4. Terminology for Nesting of Networks

The following terms are defined for describing the nesting of IP networks.

- o **More specific:** Given two networks, A and B, A is more specific than B if network B includes all space of network A, and if network B is larger than network A.
- o **Less specific:** Opposite of more specific. The network B is less specific than network A if network A's space is completely included in network B and if network A is smaller than network B.
- o **Most specific:** Given a set of networks, the network or networks that are more specific than zero or more specific of the other networks in the set, and that are not less specific of any of the networks in the set.
- o **Least specific:** Given a set of networks, the network or networks that are not more specific to any of the other networks in the set.

Examples:

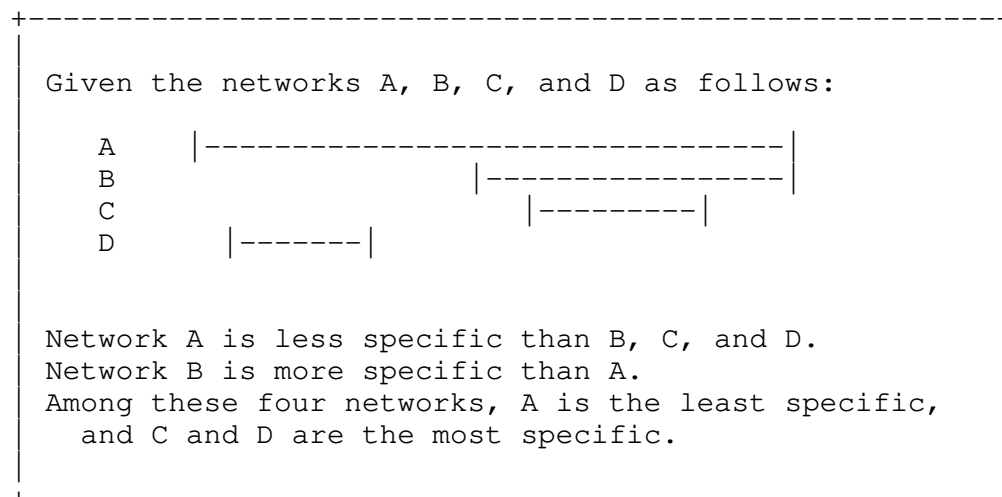


Figure 1: Nesting Example 1

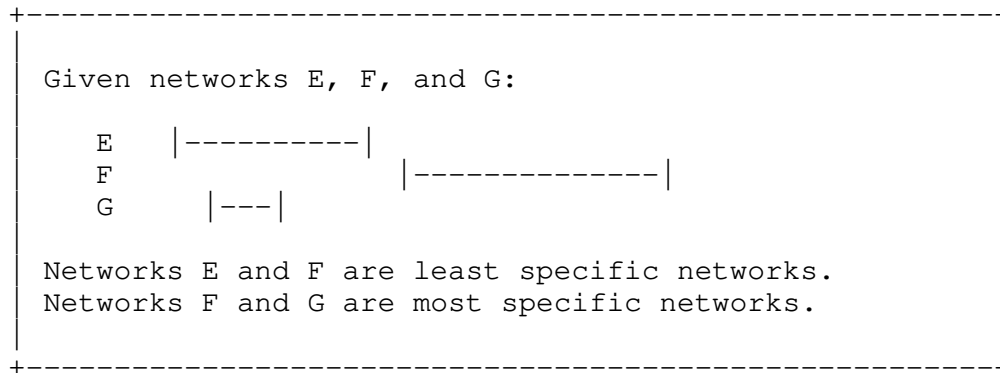


Figure 2: Nesting Example 2

The following definitions assume that there are no overlapping networks in the database. A network overlaps with another one when they encompass each other's space partially. Examples:

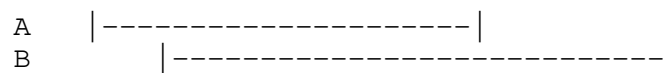


Figure 3: Nesting Example 3

Here, networks A and B are overlapping networks because network A encompasses network B's space partially, and network B encompasses network A's space partially.

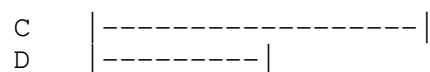


Figure 4: Nesting Example 4

Here, networks C and D are NOT overlapping networks because even if network D encompasses a part of network C's space, network C does not encompass network D's space partially (it encompasses network D completely).

The address directory can contain more than one network with the same range. They are said to be exact match networks.

The parent/child relationship in the internet address directory is unidirectional. That is, there might also be parent/child relationship with exact match networks, but a network cannot be a parent and a child of its exact match network at the same time.

The following are nested matching searches:

- (1) all less specifics search: Given a range, find all the networks that contain that range (i.e., all less specifics and exact matches). These networks are the networks that fulfill the following condition:

$(\text{start}(\text{network}) \leq \text{start}(\text{search})) \text{ AND } (\text{end}(\text{network}) \geq \text{end}(\text{search}))$

- (2) one-level less specifics search: Given a range, find only the most specific network that contains that range (could be multiple networks, but usually single). This is the set of networks from (1), with the provision that no network in the return set is contained by any other network in the set. If there are exact match networks in the set from (1), they both must appear in the result set. The result set may contain a network that is exact match to the query range, if the search allows exact matches.

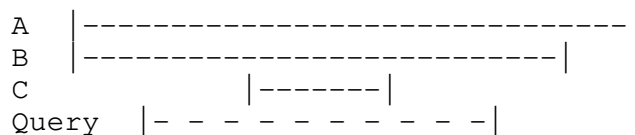


Figure 5: Nesting Example 5

In the above case, the query must return B.

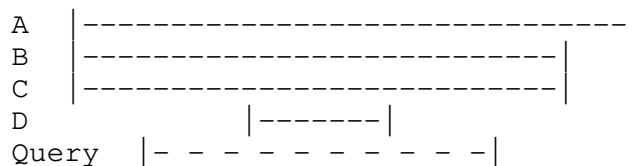


Figure 6: Nesting Example 6

Here, the query must return B and C (they are exact matches of each other).

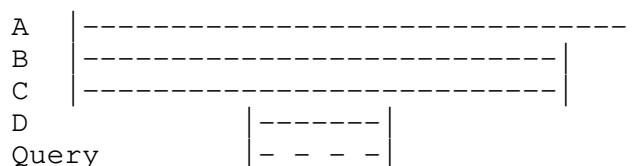


Figure 7: Nesting Example 7

Here, the query must return B and C (they are exact matches of each other). D must not be in the result set, as it is exact match to the query if the search specifies that exact matches of query range should not appear in the result set.

In Figure 7, if the search specifies that exact matches to the query range are allowed in the result set, then only D must be returned.

- (3) all more specifics search: Given a range, find all the networks that are fully within that range. The search contains a flag that specifies if an exact match to the query range should appear in the result set or not. Thus, the result set may or may not contain the exact match to the query range, as instructed by the search.

`(start(network) >= start(search)) AND (end(network) <= end(search))`

- (4) one-level more specifics search: Given a range, find only the least specific networks that are fully within that range. This is the set of networks from (3), with the provision that no network in the return set contains any other network in the return set.

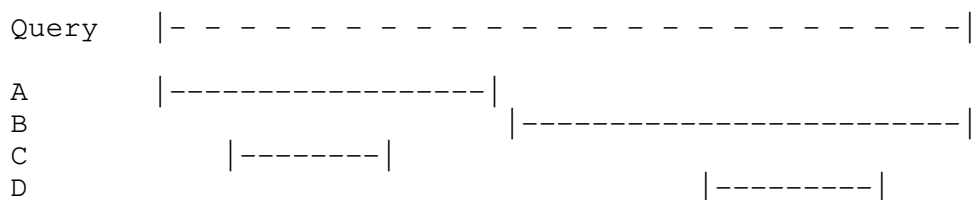


Figure 8: Nesting Example 8

- (5) exact match search: Given a range, find the networks that begin and end on the same IP addresses as the range. That is, the networks that fulfill the following condition:

`(start(network) = start(search)) AND (end(network) = end(search))`

- (6) Given a range, find the exact match network if it exists, and if it does not, perform the (2) search.

The following are parent-child relationship searches:

- (7) Given a network handle, find the network that is the direct (one level up) parent of the network with the given handle.

- (8) Given a network handle, find the network or networks that are direct (one level down) children of the network with the handle given.

## 5. Formal XML Syntax

This IP address registry is specified in the XML Schema notation. The formal syntax presented here is a complete schema representation suitable for automated validation of an XML instance when combined with the formal schema syntax of IRIS.

```
<?xml version="1.0"?>
<schema xmlns="http://www.w3.org/2001/XMLSchema"
  xmlns:areg="urn:ietf:params:xml:ns:areg1"
  xmlns:iris="urn:ietf:params:xml:ns:iris1"
  targetNamespace="urn:ietf:params:xml:ns:areg1"
  elementFormDefault="qualified" >

  <import namespace="urn:ietf:params:xml:ns:iris1" />

  <annotation>
    <documentation> IP address registry schema derived from IRIS
      schema </documentation>
  </annotation>

  <!-- ===== -->
  <!-- -->
  <!-- Query Types -->
  <!-- -->

  <!-- ===== -->
  <!-- -->
  <!-- Find Autonomous Systems By Name -->
  <!-- Find Networks By Name -->
  <!-- -->

  <complexType name="findByNameType" >
    <complexContent>
      <extension base="iris:queryType">
        <sequence>
          <element name="name"
            type="areg:exactOrPartialMatchParameter" />
          <element name="language" type="language" minOccurs="0"
            maxOccurs="unbounded"/>
        </sequence>
      </extension>
    </complexContent>
```

```

</complexType>

<element name="findNetworksByName" type="areg:findByNameType"
  substitutionGroup="iris:query" />
<element name="findAutonomousSystemsByName"
  type="areg:findByNameType"
  substitutionGroup="iris:query" />

<!-- -->
<!-- Address/Address Range type for -->
<!-- Find Network -->
<!-- -->

<complexType name="addressRangeType">
  <sequence>
    <element name="start" type="token" />
    <element name="end" type="token" minOccurs="0" maxOccurs="1" />
  </sequence>
</complexType>

<!-- -->
<!-- Find Networks By Address -->
<!-- -->

<complexType name="findNetworksByAddressType" >
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <choice>
          <element name="ipv4Address" type="areg:addressRangeType" />
          <element name="ipv6Address" type="areg:addressRangeType" />
        </choice>
        <element name="specificity">
          <complexType>
            <simpleContent>
              <extension base="areg:specificityType" >
                <attribute name="allowEquivalences" type="boolean"
                  default="false" />
              </extension>
            </simpleContent>
          </complexType>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>

```

```

<element name="findNetworksByAddress"
  type="areg:findNetworksByAddressType"
  substitutionGroup="iris:query" />

<!--                                     -->
<!-- Find AS By Number                 -->
<!--                                     -->

<complexType name="findASByNumberType" >
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <element name="asNumberStart" type="token" />
        <element name="asNumberEnd" type="token" minOccurs="0"
          maxOccurs="1" />
        <element name="specificity">
          <complexType>
            <simpleContent>
              <extension base="areg:specificityType" >
                <attribute name="allowEquivalences" type="boolean"
                  default="false" />
              </extension>
            </simpleContent>
          </complexType>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<element name="findASByNumber" type="areg:findASByNumberType"
  substitutionGroup="iris:query" />

<!--                                     -->
<!-- Specificity Type                 -->
<!--                                     -->

<simpleType name="specificityType">
  <restriction base="string">
    <enumeration value="exact-match" />
    <enumeration value="all-less-specific" />
    <enumeration value="one-level-less-specific" />
    <enumeration value="all-more-specific" />
    <enumeration value="one-level-more-specific" />
  </restriction>
</simpleType>

<!--                                     -->

```

```
<!-- Find By Contact                                -->
<!--                                                -->

<complexType name="findByContactType">
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <choice>
          <group ref="areg:contactSearchGroup" />
          <element name="contactHandle"
            type="areg:exactMatchParameter" />
        </choice>
        <element name="returnedResultType" minOccurs="0"
          maxOccurs="1" >
          <simpleType>
            <restriction base="string" >
              <enumeration value="returnASs" />
              <enumeration value="returnIPv4Networks" />
              <enumeration value="returnIPv6Networks" />
              <enumeration value="returnOrganizations" />
            </restriction>
          </simpleType>
        </element>
        <element name="role" minOccurs="0" maxOccurs="1" >
          <simpleType>
            <restriction base="string" >
              <enumeration value="adminContact" />
              <enumeration value="techContact" />
              <enumeration value="nocContact" />
              <enumeration value="abuseContact" />
              <enumeration value="otherContact" />
            </restriction>
          </simpleType>
        </element>
        <element name="language" type="language" minOccurs="0"
          maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<element name="findByContact" type="areg:findByContactType"
  substitutionGroup="iris:query" />

<!--                                                -->
<!-- Find Networks By Handle                        -->
<!--                                                -->
```

```

<complexType name="findNetworksByHandleType" >
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <element name="networkHandle" type="token" />
        <element name="specificity"
          type="areg:specificitySubsetType" />
      </sequence>
    </extension>
  </complexContent>
</complexType>

<element name="findNetworksByHandle"
  type="areg:findNetworksByHandleType"
  substitutionGroup="iris:query" />

<!-- -->
<!-- Specificity Subtype -->
<!-- -->

<simpleType name="specificitySubsetType">
  <restriction base="string">
    <enumeration value="all-less-specific" />
    <enumeration value="one-level-less-specific" />
    <enumeration value="all-more-specific" />
    <enumeration value="one-level-more-specific" />
  </restriction>
</simpleType>

<!-- -->
<!-- Find Contacts -->
<!-- -->

<complexType name="findContactsType">
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <choice>
          <group ref="areg:contactSearchGroup" />
          <element name="organizationId"
            type="areg:exactMatchParameter" />
        </choice>
        <element name="language" type="language" minOccurs="0"
          maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

```

```
<element name="findContacts" type="areg:findContactsType"
  substitutionGroup="iris:query" />

<!-- -->
<!-- Find Organizations -->
<!-- -->

<complexType name="findOrganizationsType">
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <choice>
          <element name="organizationName"
            type="areg:exactOrPartialMatchParameter" />
          <group ref="areg:commonSearchGroup" />
        </choice>
        <element name="language" type="language" minOccurs="0"
          maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<element name="findOrganizations" type="areg:findOrganizationsType"
  substitutionGroup="iris:query" />

<!-- -->
<!-- Find Networks by Name Server -->
<!-- -->

<complexType name="findNetworksByNameServerType">
  <complexContent>
    <extension base="iris:queryType">
      <sequence>
        <element name="nameServer" type="normalizedString" />
        <element name="returnedResultType" minOccurs="0"
          maxOccurs="1" >
          <simpleType>
            <restriction base="string" >
              <enumeration value="returnIPv4Networks" />
              <enumeration value="returnIPv6Networks" />
            </restriction>
          </simpleType>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
```

```
<element name="findNetworksByNameServer"
  type="areg:findNetworksByNameServerType"
  substitutionGroup="iris:query" />

<!--                                     -->
<!-- Contact Search Group             -->
<!--                                     -->

<group name="contactSearchGroup">
  <choice>
    <element name="commonName"
      type="areg:exactOrPartialMatchParameter" />
    <group ref="areg:commonSearchGroup" />
  </choice>
</group>

<!--                                     -->
<!-- Common Search Group              -->
<!--                                     -->

<group name="commonSearchGroup">
  <choice>
    <element name="eMail" type="areg:domainResourceParameter" />
    <element name="city" type="areg:exactMatchParameter" />
    <element name="region" type="areg:exactMatchParameter" />
    <element name="country" type="areg:exactMatchParameter" />
    <element name="postalCode" type="areg:exactMatchParameter" />
  </choice>
</group>

<!--                                     -->
<!-- Parameters for Search Groups     -->
<!--                                     -->

<complexType name="exactOrPartialMatchParameter">
  <choice>
    <group ref="areg:partialMatchGroup" />
    <group ref="areg:exactMatchGroup" />
  </choice>
</complexType>

<complexType name="exactMatchParameter">
  <group ref="areg:exactMatchGroup" />
</complexType>

<complexType name="partialMatchParameter">
  <sequence>
    <group ref="areg:partialMatchGroup" />
  </sequence>
</complexType>
```

```

    </sequence>
  </complexType>

  <complexType name="domainResourceParameter" >
    <choice>
      <group ref="areg:exactMatchGroup" />
      <element name="inDomain" type="token" />
    </choice>
  </complexType>

  <group name="partialMatchGroup">
    <choice>
      <sequence>
        <element name="beginsWith">
          <simpleType>
            <restriction base="token">
              <minLength value="1"/>
            </restriction>
          </simpleType>
        </element>
        <element minOccurs="0" ref="areg:endsWith"/>
      </sequence>
      <element ref="areg:endsWith" />
    </choice>
  </group>

  <element name="endsWith">
    <simpleType>
      <restriction base="token">
        <minLength value="1"/>
      </restriction>
    </simpleType>
  </element>

  <group name="exactMatchGroup">
    <sequence>
      <element name="exactMatch" type="normalizedString" />
    </sequence>
  </group>

  <!-- ===== -->
  <!-- -->
  <!-- Result Types -->
  <!-- -->
  <!-- ===== -->

  <!-- -->
  <!-- IPv4 and IPv6 Network Results -->

```

```

<!--                                -->

<complexType name="ipNetworkType">
  <complexContent>
    <extension base="iris:resultType">
      <sequence>
        <element name="networkHandle" type="token"
          minOccurs="0" maxOccurs="1" />
        <element name="name" minOccurs="0" maxOccurs="1"
          type="normalizedString" />
        <element name="startAddress" type="token" />
        <element name="endAddress" type="token" />
        <sequence minOccurs="0" maxOccurs="1">
          <element name="networkType" type="normalizedString"
            minOccurs="1" maxOccurs="1" />
          <element name="networkTypeInfo" type="iris:entityType"
            minOccurs="0" maxOccurs="1" />
        </sequence>
        <element name="nameServer" type="normalizedString"
          minOccurs="0" maxOccurs="unbounded" />
        <element name="organization" type="iris:entityType"
          minOccurs="0" maxOccurs="1" />
        <choice minOccurs="0" maxOccurs="1" >
          <element name="parent" type="iris:entityType" />
          <element name="noParent">
            <element>
          </element>
        </choice>
        <group ref="areg:contactGroup" />
        <group ref="areg:commonGroup" />
      </sequence>
    </extension>
  </complexContent>
</complexType>

<element name="ipv4Network" type="areg:ipNetworkType"
  substitutionGroup="iris:result" />

<element name="ipv6Network" type="areg:ipNetworkType"
  substitutionGroup="iris:result" />

<!--                                -->
<!-- Autonomous System              -->
<!--                                -->

<complexType name="autonomousSystemType">
  <complexContent>
    <extension base="iris:resultType">
      <sequence>

```

```

    <element name="asHandle" type="token"
      minOccurs="0" maxOccurs="1" />
    <element name="asNumberStart" type="integer" minOccurs="0"
      maxOccurs="1" />
    <element name="asNumberEnd" type="integer" minOccurs="0"
      maxOccurs="1" />
    <element name="name" type="normalizedString" minOccurs="0"
      maxOccurs="1" />
    <element name="organization" type="iris:entityType"
      minOccurs="0" maxOccurs="1" />
    <choice minOccurs="0" maxOccurs="1">
      <element name="parent" type="iris:entityType" />
      <element name="noParent" />
    </choice>
    <group ref="areg:contactGroup" />
    <group ref="areg:commonGroup" />
  </sequence>
</extension>
</complexContent>
</complexType>

<element name="autonomousSystem" type="areg:autonomousSystemType"
  substitutionGroup="iris:result" />

<!-- -->
<!-- Contact -->
<!-- -->

<complexType name="contactType">
  <complexContent>
    <extension base="iris:resultType">
      <sequence>
        <element name="contactHandle" type="token"
          minOccurs="0" maxOccurs="1" />
        <element name="commonName" type="normalizedString"
          minOccurs="0" maxOccurs="1" />
        <element name="eMail" type="normalizedString" minOccurs="0"
          maxOccurs="unbounded" />
        <element name="sip" type="normalizedString" minOccurs="0"
          maxOccurs="unbounded" />
        <element name="organization" type="iris:entityType"
          minOccurs="0" maxOccurs="unbounded" />
        <element name="postalAddress" minOccurs="0"
          maxOccurs="unbounded">
          <complexType>
            <sequence>
              <element name="address" type="string" minOccurs="0"
                maxOccurs="1" />

```

```

        <element name="city" type="string" minOccurs="0"
          maxOccurs="1" />
        <element name="region" type="string" minOccurs="0"
          maxOccurs="1" />
        <element name="postalCode" type="normalizedString"
          minOccurs="0" maxOccurs="1" />
        <element name="country" type="token" minOccurs="0"
          maxOccurs="1" />
      </sequence>
    </complexType>
  </element>
  <element name="phone" minOccurs="0" maxOccurs="unbounded" >
    <complexType>
      <sequence>
        <element name="number" type="normalizedString" />
        <element name="extension" type="normalizedString"
          minOccurs="0" maxOccurs="unbounded" />
        <element name="type" type="normalizedString"
          minOccurs="0" maxOccurs="1" />
      </sequence>
    </complexType>
  </element>
  <group ref="areg:commonGroup" />
</sequence>
</extension>
</complexContent>
</complexType>

<element name="contact" type="areg:contactType"
  substitutionGroup="iris:result" />

<!-- -->
<!-- Organization -->
<!-- -->

<complexType name="organizationType">
  <complexContent>
    <extension base="iris:resultType">
      <sequence>
        <element name="name" type="normalizedString"
          minOccurs="0" maxOccurs="1" />
        <element name="eMail" type="normalizedString" minOccurs="0"
          maxOccurs="unbounded" />
        <element name="id" type="token" />
        <element name="postalAddress" minOccurs="0"
          maxOccurs="unbounded">
          <complexType>
            <sequence>

```

```

        <element name="address" type="string" minOccurs="0"
          maxOccurs="1" />
        <element name="city" type="string" minOccurs="0"
          maxOccurs="1" />
        <element name="region" type="string" minOccurs="0"
          maxOccurs="1" />
        <element name="postalCode" type="normalizedString"
          minOccurs="0" maxOccurs="1" />
        <element name="country" type="token" minOccurs="0"
          maxOccurs="1" />
      </sequence>
    </complexType>
  </element>
  <element name="phone" minOccurs="0" maxOccurs="unbounded" >
    <complexType>
      <sequence>
        <element name="number" type="normalizedString" />
        <element name="extension" type="normalizedString"
          minOccurs="0" maxOccurs="unbounded" />
        <element name="type" type="normalizedString"
          minOccurs="0" maxOccurs="1" />
      </sequence>
    </complexType>
  </element>
  <group ref="areg:contactGroup" />
  <group ref="areg:commonGroup" />
</sequence>
</extension>
</complexContent>
</complexType>

<element name="organization" type="areg:organizationType"
  substitutionGroup="iris:result" />

<!-- -->
<!-- Contact Group -->
<!-- -->

<group name="contactGroup">
  <sequence>
    <element name="adminContact" type="iris:entityType"
      minOccurs="0" maxOccurs="unbounded" />
    <element name="techContact" type="iris:entityType"
      minOccurs="0" maxOccurs="unbounded" />
    <element name="nocContact" type="iris:entityType" minOccurs="0"
      maxOccurs="unbounded" />
    <element name="abuseContact" type="iris:entityType"
      minOccurs="0" maxOccurs="unbounded" />
  </sequence>
</group>

```

```
<element name="otherContact" type="iris:entityType"
  minOccurs="0" maxOccurs="unbounded" />
</sequence>
</group>

<!--                                     -->
<!-- Common Group                       -->
<!--                                     -->

<group name="commonGroup">
  <sequence>
    <element name="numberResourceRegistry" type="iris:entityType"
      minOccurs="0" maxOccurs="1" />
    <element name="registrationDate" type="dateTime" minOccurs="0"
      maxOccurs="1" />
    <element name="lastUpdatedDate" type="dateTime" minOccurs="0"
      maxOccurs="1" />
    <element ref="iris:seeAlso" minOccurs="0" maxOccurs="unbounded"
      />
  </sequence>
</group>
</schema>
```

Figure 9

## 6. BEEP Transport Compliance

IRIS allows several extensions of the core capabilities. This section outlines those extensions allowable by IRIS-BEEP [3].

### 6.1. Message Pattern

This registry type uses the default message pattern as described in IRIS-BEEP [3].

### 6.2. Server Authentication

This registry type uses the default server authentication method as described in IRIS-BEEP [3].

## 7. URI Resolution

### 7.1. Application Service Label

See Section 9 for the application service label registration.

### 7.2. Operational Considerations

Address registries do not have natural links to DNS. Using reverse DNS tree presents problems for IP address delegation (for example, delegations do not fall into byte boundaries, unlike reverse DNS), and DNS does not currently contain any information regarding autonomous system delegation.

Therefore, in order for the top-down resolution to operate properly, it is requested that the IAB instruct IANA to insert and maintain a NAPTR DNS resource record for `areg.iris.arpa`, as described in Section 9.

### 7.3. Top-Down Resolution

The top-down alternative resolution method MUST be identified as 'top' in IRIS URIs.

The process for this condition is as follows:

1. The IRIS [2] direct-resolution process is tried against `areg.iris.arpa`.
2. If the direct-resolution process yields no server for which a connection can be made, then a negative response is returned, and no further action is taken.

It is RECOMMENDED that IRIS clients issuing AREG1 requests use the 'top' resolution method when no resolution method has been explicitly given by a user. IRIS servers accepting AREG1 requests that seek information for which they are not authoritative SHOULD refer clients using the 'top' resolution method.

## 8. Internationalization Considerations

This document lays out no new considerations for internationalization beyond those specified in IRIS [2].

## 9. IANA Considerations

The following URN has been registered with IANA according to the IANA considerations defined in IRIS [2]:

```
urn:ietf:params:xml:ns:aregl
```

The following S-NAPTR application service label has been registered with IANA according to the IANA considerations defined in IRIS [2]:

AREG1

Under instructions from the IAB, the IANA will create a new second level domain under .arpa called iris (i.e., iris.arpa.). The contents of this new domain are to be under the control of the IAB. Under instructions from the IAB, the IANA will insert and maintain a NAPTR DNS resource record in the iris.arpa. domain for the name areg.iris.arpa. The initial contents for that record is:

```
areg.iris.arpa.
;;          order pref flags service                re replacement
IN NAPTR  100   10   ""      "AREG1:iris.xpc:iris.lwz" "" areg.nro.net
```

## 10. Security Considerations

This document lays out no new considerations for security precautions beyond those specified in IRIS [2].

## 11. References

### 11.1. Normative References

- [1] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [2] Newton, A. and M. Sanz, "IRIS: The Internet Registry Information Service (IRIS) Core Protocol", RFC 3981, January 2005.
- [3] Newton, A. and M. Sanz, "Using the Internet Registry Information Service (IRIS) over the Blocks Extensible Exchange Protocol (BEEP)", RFC 3983, January 2005.
- [4] Newton, A., "Cross Registry Internet Service Protocol (CRISP) Requirements", RFC 3707, February 2004.

### 11.2. Informative References

- [5] World Wide Web Consortium, "Extensible Markup Language (XML) 1.0", W3C XML, February 1998, <<http://www.w3.org/TR/1998/REC-xml-19980210>>.
- [6] World Wide Web Consortium, "Namespaces in XML", W3C XML Namespaces, January 1999, <<http://www.w3.org/TR/1999/REC-xml-names-19990114>>.
- [7] World Wide Web Consortium, "XML Schema Part 2: Datatypes", W3C XML Schema, October 2000, <<http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/>>.
- [8] World Wide Web Consortium, "XML Schema Part 1: Structures", W3C XML Schema, October 2000, <<http://www.w3.org/TR/2001/REC-xmlschema-1-20010502/>>.
- [9] International Organization for Standardization, "Codes for the representation of names of countries, 3rd edition", ISO Standard 3166, August 1988.

## Appendix A. Privacy Considerations

Internet address registries store contact details and other information that may be abused. The XML Schema defined in this document purposefully makes the inclusion of any data in a response an option that is dependent on the needs and policies of the Internet address registry serving the data.

Combined with the authentication mechanisms of an IRIS transfer protocol, Internet address registries may derive authorization policies to meet their needs without compromising general privacy policies. As an example, the constituents of an Internet address registry may create a policy whereby NOC contact email addresses are only to be available to members of the Internet address registry. To institute this policy, the XML elements for NOC contacts will never appear in a response to a user that has not been authenticated to be a member of the Internet address registry.

## Appendix B. Example Requests and Responses

The examples in this section use the string "C:" to denote data sent by a client to a server and the string "S:" to denote data sent by a server to a client.

### B.1. Example 1

The following is an example of entity lookup for the contact-handle of 'JN560-RIR1'.

```
C: <?xml version="1.0"?>
C: <request xmlns="urn:ietf:params:xml:ns:iris1"
C:   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
C:   xsi:schemaLocation="urn:ietf:params:xml:ns:iris1 iris.xsd" >
C:
C:   <searchSet>
C:
C:     <lookupEntity
C:       registryType="urn:ietf:params:xml:ns:areg1"
C:       entityClass="contact-handle"
C:       entityName="JN560-RIR1" />
C:
C:   </searchSet>
C:
C: </request>

S: <?xml version="1.0"?>
S: <iris:response
S:   xmlns:iris="urn:ietf:params:xml:ns:iris1"
```

```
S:  xmlns="urn:ietf:params:xml:ns:areg1"
S:  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
S:
S:  <iris:resultSet>
S:    <iris:answer>
S:
S:      <contact
S:        authority="rir.example.net"
S:        registryType="areg1"
S:        entityClass="contact-handle"
S:        entityName="JN560-RIR1">
S:
S:        <contactHandle>JN560-RIR1</contactHandle>
S:
S:        <commonName>Bob Smurd</commonName>
S:
S:        <organization
S:          iris:referentType="organization"
S:          authority="rir.example.net"
S:          registryType="areg1"
S:          entityClass="organization-id"
S:          entityName="ORGX">
S:            <iris:displayName
S:              language="en">
S:                Organization X, Inc.
S:            </iris:displayName>
S:          </organization>
S:
S:          <phone>
S:            <number>+1-703-555-5555</number>
S:            <type>office</type>
S:          </phone>
S:
S:        </contact>
S:
S:      </iris:answer>
S:    </iris:resultSet>
S:
S:  </iris:response>
```

Figure 11: Example 1

## B.2. Example 2

The following example shows a query to find the IP networks containing a given address.

```
C: <?xml version="1.0"?>
C: <request xmlns="urn:ietf:params:xml:ns:iris1"
C:       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
C:
C:   <searchSet>
C:     <findNetworksByAddress
C:       xmlns="urn:ietf:params:xml:ns:areg1">
C:
C:       <ipv4Address>
C:         <start>192.0.2.134</start>
C:       </ipv4Address>
C:
C:       <specificity
C:         allowEquivalences="true"
C:         >one-level-less-specific</specificity>
C:
C:     </findNetworksByAddress>
C:   </searchSet>
C: </request>

S: <?xml version="1.0"?>
S: <iris:response xmlns:iris="urn:ietf:params:xml:ns:iris1"
S:   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
S:
S:   <iris:resultSet>
S:     <iris:answer>
S:       <areg:ipv4Network
S:         xmlns="urn:ietf:params:xml:ns:areg1"
S:         xmlns:areg="urn:ietf:params:xml:ns:areg1"
S:         xsi:schemaLocation="urn:ietf:params:xml:ns:areg1 areg.xsd"
S:         authority="rir.example.net" registryType="areg1"
S:         entityClass="ipv4-handle" entityName="NET-192-0-2-128-1" >
S:         <networkHandle>
S:           NET-192-0-2-128-1
S:         </networkHandle>
S:         <name>
S:           UU-192-0-2-D6
S:         </name>
S:         <startAddress>
S:           192.0.2.128
S:         </startAddress>
S:         <endAddress>
```

```
S:      192.0.2.255
S:    </endAddress>
S:    <networkType>reassigned</networkType>
S:    <organization
S:      iris:referentType="areg:organization"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="organization-id" entityName="ORGX">
S:        <iris:displayName language="en">
S:          Organization X, Inc.
S:        </iris:displayName>
S:      </organization>
S:    <parent
S:      iris:referentType="areg:ipv4Network"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="ipv4-handle" entityName="NET-192-0-2-0-1"/>
S:    <techContact
S:      iris:referentType="areg:contact"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="contact-handle" entityName="JN560-RIR1">
S:        <iris:displayName language="en">
S:          Smurd, Bob
S:        </iris:displayName>
S:      </techContact>
S:    <registrationDate>
S:      2002-11-18T00:00:00-00:00
S:    </registrationDate>
S:    <lastUpdatedDate>
S:      2002-11-18T00:00:00-00:00
S:    </lastUpdatedDate>
S:    <iris:seeAlso
S:      iris:referentType="ANY"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="local" entityName="portability-notice"/>
S:  </areg:ipv4Network>
S:  <areg:ipv4Network
S:    xmlns="urn:ietf:params:xml:ns:areg1"
S:    xmlns:areg="urn:ietf:params:xml:ns:areg1"
S:    xsi:schemaLocation="urn:ietf:params:xml:ns:areg1 areg.xsd"
S:    authority="rir.example.net" registryType="areg1"
S:    entityClass="ipv4-handle" entityName="NET-192-0-2-0-2" >
S:    <networkHandle>
S:      NET-192-0-2-0-2
S:    </networkHandle>
S:    <name>
S:      UU-192-0-2-0-D5
S:    </name>
S:    <startAddress>
S:      192.0.2.0
```

```

S:      </startAddress>
S:      <endAddress>
S:      192.0.2.255
S:      </endAddress>
S:      <networkType>direct allocation</networkType>
S:      <nameServer>auth03.ns.example.org</nameServer>
S:      <nameServer>auth00.ns.example.org</nameServer>
S:      <organization
S:      iris:referentType="areg:organization"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="organization-id" entityName="ORGY">
S:      <iris:displayName language="en">
S:      Organization Y, Inc.
S:      </iris:displayName>
S:      </organization>
S:      <parent
S:      iris:referentType="areg:ipv4Network"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="ipv4-handle" entityName="NET-192-0-2-0-1"/>
S:      <techContact
S:      iris:referentType="areg:contact"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="contact-handle" entityName="OA12-RIR1" />
S:      <registrationDate>
S:      2000-10-27T00:00:00-00:00
S:      </registrationDate>
S:      <lastUpdatedDate>
S:      2002-02-13T00:00:00-00:00
S:      </lastUpdatedDate>
S:      <iris:seeAlso
S:      iris:referentType="ANY"
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="local" entityName="portability-notice"/>
S:      </areg:ipv4Network>
S:      </iris:answer>
S:      <iris:additional>
S:      <iris:simpleEntity
S:      authority="rir.example.net" registryType="areg1"
S:      entityClass="local" entityName="portability-notice" >
S:      <iris:property name="portability" language="en">
S:      Addresses within this block are non-portable.
S:      </iris:property>

```

```

S:      </iris:simpleEntity>
S:      </iris:additional>
S:      </iris:resultSet>
S:
S: </iris:response>

```

Figure 12: Example 2

## Appendix C. Specificity Examples

This section includes examples to clarify specificity options for network and ASN searches.

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9

Contents of the DB

Figure 13: Specificity Example 1

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	-----	192.0.2.0 - 192.0.2.9

Exact match (1)

Result: C

Figure 14: Specificity Example 2

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	-----	192.0.2.0 - 192.0.2.12

Exact match (2)

Result: None

Figure 15: Specificity Example 3

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	-----	192.0.2.0 - 192.0.2.15

All more specifics, allowEquivalences = false

Result: C, F, & G (A is not included; exact match)

Figure 16: Specificity Example 4

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	-----	192.0.2.0 - 192.0.2.15

All more specifics, allowEquivalences = true

Result: A, C, F, & G (A is included; exact match)

Figure 17: Specificity Example 5

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- - - - -	192.0.2.0 - 192.0.2.15

One level more specifics, allowEquivalences = false

Result: C

Figure 18: Specificity Example 6

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- - - - -	192.0.2.0 - 192.0.2.15

One level more specifics, allowEquivalences = true

Result: A

Figure 19: Specificity Example 7

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- -	192.0.2.6 - 192.0.2.9

All less specifics, allowEquivalences = true

Result: A, C, & G (G is included; exact match)

Figure 20: Specificity Example 8

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- -	192.0.2.6 - 192.0.2.9

All less specifics, allowEquivalences = false

Result: A & C (G is not included; exact match)

Figure 21: Specificity Example 9

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- -	192.0.2.6 - 192.0.2.9

One level less specifics, allowEquivalences = true

Result: G (the exact match)

Figure 22: Specificity Example 10

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- -	192.0.2.6 - 192.0.2.9

One level less specifics, allowEquivalences = false

Result: C

Figure 23: Specificity Example 11

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	- - - - -	192.0.2.0 - 192.0.2.8

One level less specifics, allowEquivalences = false or true

Result: C

Figure 24: Specificity Example 12

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9
Query	= E	

Find parent (Query argument is a handle)

Result: D

Figure 25: Specificity Example 13

A	-----	192.0.2.0 - 192.0.2.15
B	-----	192.0.2.16 - 192.0.2.31
C	-----	192.0.2.0 - 192.0.2.9
D	-----	192.0.2.16 - 192.0.2.30
E	-----	192.0.2.16 - 192.0.2.30
F	-----	192.0.2.0 - 192.0.2.5
G	----	192.0.2.6 - 192.0.2.9

Query = D

Find child (Query argument is a handle)

Result: E

Figure 26: Specificity Example 14

#### Appendix D. Contributors

David Blacka and Tim Christensen made substantial contributions to this document.

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