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Network Service Interface Topology Representation

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Abstract

This document describes a normative extension to the Network Markup Language base schema version 1 which allows the description of service plane objects required for the Network Service Interface Connection Service.

Contents

1 Introduction

The NSI Connection Service requires topology descriptions to do pathfinding. In order to do that some representation of the topology is required. Once represented, some form of topology distribution is also needed. This document describes an extension of the Network Markup Language[GFD.206] to support the NSI Connection Service[NSI-CONNECTION] and NSI Topology Service[NSI-TOPO-SERV].

Section 3 describes the NSI topology representation extension of the Network Markup Language base schema version 1. Only section 3 and 4, and appendices B and A are normative and considered part of the recommendation.

1.1 Scope and Context

The NSI topology representation is an extension of the Network Markup Language version 1. The NSI topology covers concepts relevant for supporting the Connection Service, which are outside of the scope of NML.

The scope of this topology representation extension is limited to what the Connection Service requires. The NSI framework exists to provide users with an interface for inter-domain network requests. The topology service and representation have been defined to support the inter-domain communication between the different NSI actors. Creating and using inter-domain network connections happens in five steps:

1. *transport* The fundamental requirement for inter-domain communication is a connection on the transport plane between different domains.
2. *coordination* The agents of two neighboring domains must be able to coordinate their actions regarding the use of the transport plane connection.
3. *topology* To identify and use the connection on the transport plane, information and identifiers of this connection are required in topology descriptions.
4. *dissemination* The knowledge about the topology must be shared and disseminated between the actors, so that the reachability is known throughout the whole network.
5. *reservation* Actors with knowledge of this connection can communicate their requirements and create reservations for the connection.

This document contains terminology which together with the identifier specification in [GFD.202] can support the coordination phase. The identifiers and descriptions are then formalized in topology descriptions, for which a schema is defined in this document. The dissemination

phase is explicitly out of scope of this document, see also [NSI-TOPO-SERV]. The reservation phase is where the NSI interactions occur, see also [GFD.173].

The NSI topology representation is defined based on the concepts defined in the NSI Framework document[GFD.173], NSI Connection Service version 2[NSI-CONNECTION], the NSI Topology Service[NSI-TOPO-SERV] and the Network Markup Language base schema version 1[GFD.206].

1.2 Notational Conventions

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

The graphical representation of the relation definitions are to be interpreted as described in [GFD.206].

Names of classes are capitalised and written in italics (e.g. the *Node* class). Names of relations are written in camel case and in italics (e.g. the *hasNode* relation).

2 NSI Topology Schema

The NSI topology schema describes the components required for the NSI Connection Service which are not part of the NML Base schema. Below is an introduction to common NSI terminology related to topology.

2.1 Service Termination Point Definition

A prerequisite for an Service Termination Point (STP) is the existence of a physical connection into a Network. This pre-existing capability (typically made up of a physical port on a Network) can be advertized to an Network Service Agent (NSA). Note that the choice about which resources to advertize is subject to local policy. Once advertized, these capabilities may be used by the path-finding function of the NSA.

STPs are advertized as 'capabilities' to the NSA, i.e. they are not instantiated resources, but rather capabilities available for use in creating a Network Service. For example, this would include advertizing that a VLAN id 30 is available for use. When the NSA wishes to instantiate VLAN 30, this is signaled to the NRM and the VLAN 30 instance is created. Both STP capabilities and STP instances are represented in the NSI Service Plane with STP identifiers.

2.2 Service Termination Point Identifiers

A source or destination of a connection request in the NSI Connection Service is identified by the Topology identifier and two unidirectional *Ports* or *PortGroups*. The Topology identifier must be globally unique, and the Port or PortGroup identifiers must at least be locally unique such that combining them with a Topology identifiers yields a globally unique combination.

A recommended way of constructing such an identifier is by using the `urn:ogf:network` namespace[GFD.202], for example `urn:ogf:network:example.net:2013:A1`. This identifier has three components: the prefix, `urn:ogf:network` which describes that it is a network identifier, the authoring namespace, `example.net:2013` which is the DNS name and a (at least) year to make a globally unique prefix[1], and the local component, `A1` defined by the originating network.

2.3 Service Termination Point Groups

Endpoints in a network often have a technology label associated with them, for example VLANs or wavelengths. Rather than describing each of these available labels as individual STPs, we introduce the *STP Group*, equivalent to an NML *PortGroup*.

An STP with a specific label can then be selected using the query component syntax as specified in [RFC 3986], so for example:

`urn:ogf:network:example.net:2013:A2?vlan=1781` is a way to phrase a request to an STP with VLAN 1781 part of the STP Group identified by `urn:ogf:network:example.net:2013:A2`.

If no specific label or attribute is given to select an STP from an STP group, the Network Service Agent for that network will select one from that STP group. The confirmation back to the requester will contain the fully specified STP selected for the request. An example for this kind of request is by specifying an STP which has VLAN labels, but not requesting a specific VLAN label. Continuing the example above, the STP `urn:ogf:network:example.net:2013:A2` has been specified to have a specific VLAN range available. A request with just that identifier as the destination will allow the pathfinder to select a VLAN on that specific endpoint, and return it to the user, using the query component.

[1] The date component in the identifier is optional but recommended. The DNS name is a temporary lease, which can change hands, so in order to guarantee uniqueness, the year component can be added.

2.3.1 Inter-Domain Topology

3 NSI Topology Representation

The NSI topology representation is defined as an extension to the NML topology representation. It builds as much as possible to build on standardized work in the NML group. An overview of the NSI concepts and the related representations are shown in table 1. The definitions of the new concepts are defined below.

The base namespace of the NSI Topology Extension schema is `http://schemas.ogf.org/nsi/2013/03/topology#`.

3.1 Classes

3.1.1 NSA

An *NSA* object represents a Network Service Agent which can accept Connection Service requests and manages a network.

NSA inherits from the NML *Network Object*

An *NSA* may have the following relations:

- *adminContact* to a vCard object describing contact details for its administrator
- *hasService* to a *Service* object describing a service the NSA provides

An *NSA* may have the following attributes:

- *id* to assign a persistent globally unique URI
- *name* to assign a human readable string

3.1.2 Service

The NSI framework contains many different services, the details of these can be described using a *Service* object. Further details of this object can be described using its attributes.

Service inherits from the NML *Network Object*

An *Service* may have the following attributes:

- *describedBy* to point to a WADL file
- *id* to assign a persistent globally unique URI

- *link* to define the URL endpoint
- *name* to assign a human readable string
- *type* to an NSI Service type

The values of the *type* attribute SHOULD be specified in a Grid Forum Documents (GFD), see also [DISCOVERY-SERVICE].

3.2 Relations

*Relation*s describe how different *Network Object*s relate to each other, typically to form a network topology description.

The *hasService* and *manages* relations are *implicit* relations. All other relations are *explicit*. The distinction between implicit and explicit relations may be used by a syntax to allow a more compact network description.

3.2.1 adminContact

adminContact is used to provide contact information about a *Network Object*. It relates a *Network Object* to a *vCard*.

Allowed relations are:

- *Network Object* —(*)— adminContact ▸ —(*)— *vCard*

Defined relations are:

- *NSA* —(*)— adminContact ▸ —(*)— *vCard*

hasService is used to relate a *Network Object* to an NSI service it provides, this service is described using a *Service* object.

Allowed relations are:

- *Network Object* —(*)— hasService ▸ —(*)— *Service*

Defined relations are:

- *NSA* —(*)— hasService ▸ —(*)— *Service*

3.2.2 manages

manages relates an *NSA* to a *Topology* to define that the *NSA* can take requests for that *Topology*.

Allowed relations are:

- *NSA* —(manages ▸, * — *)— *Network Object*

Defined relations are:

- *NSA* —(manages ▸, 1 — 1)— *Topology*

3.2.3 peersWith

The *peersWith* relation defines the control-plane connections between different *NSA*s.

Allowed relations are:

- *NSA* —(peersWith ▸, * — *)— *NSA*

Defined relations are:

- *NSA* —(peersWith ▸, * — *)— *NSA*

3.3 Attributes

Attributes are properties of an object. The following attributes have been defined in section 3.1.

Attribute	**Class (section)**
describedBy	Service (3.1.2)
link	Service (3.1.2)
type	Service (3.1.2)

3.3.1 describedBy

describedBy defines that a *Service* is described by a WADL[WADL] or WSDL[WSDL] description located at the defined URL.

3.3.2 link

link defines the URL at which the webservice for the NSI service can be reached.

3.3.3 type

type defines the type of the *Service* using an identifier which SHOULD be defined in a GFD, see also [DISCOVERY-SERVICE].

4 Syntax

The NSI topology representation is an extension of the Network Markup Language base schema version 1. As such it has both an XML and an OWL representation, defined in appendix A and B respectively.

The XML syntax is the RECOMMENDED NSI topology syntax. An NSA MUST publish its topology in the XML syntax and MUST be able to parse the XML syntax, and MAY be able to parse the OWL syntax.

5 NSI Topology Description Example

A simple example NSI Network topology description is provided below in XML.

```
<?xml version="1.0" encoding="UTF-8"?>
<nsi:NSA xmlns:nml="http://schemas.ogf.org/nml/2013/05/base#"
              xmlns:nsi="http://schemas.ogf.org/nsi/2013/09/topology#"
              xmlns:vc="urn:ietf:params:xml:ns:vcard-4.0"
              id="urn:ogf:network:example.org:2013:nsa"
              version="2013-05-29T12:11:12">

    <nml:Location id="urn:ogf:network:example.com:2013:location">
      <nml:lat>55.637</nml:lat>
      <nml:long>12.641</nml:long>
    </nml:Location>


    <nsi:Service id="urn:ogf:network:example.com:2013:nsa-provserv">
        <nsi:link>http://nsa.example.com/provisioning</nsi:link>
        <nsi:describedBy>http://nsa.example.com/provisioning/wsdl</nsi:describedBy>
        <nsi:type>application/vnd.org.ogf.nsi.cs.v2+soap</nsi:type>
        <nsi:Relation type="http://schemas.ogf.org/nsi/2013/09/topology#providedBy">
            <nsi:NSA id="urn:ogf:network:example.com:2013:nsa"/>
        </nsi:Relation>
    </nsi:Service>

    <nsi:Service id="urn:ogf:network:example.com:2013:disc-serv">
        <nsi:link>http://nsa.example.com/discovery/services/discovery</nsi:link>
        <nsi:describedBy>http://nsa.example.com/discovery/wadl</nsi:describedBy>
        <nsi:type>application/vnd.org.ogf.nsi.discovery.v1+xml</nsi:type>
        <nsi:Relation type="http://schemas.ogf.org/nsi/2013/09/topology#providedBy">
            <nsi:NSA id="urn:ogf:network:example.com:2013:nsa"/>
        </nsi:Relation>
    </nsi:Service>

    <nml:Relation type="http://schemas.ogf.org/nsi/2013/09/topology#adminContact">
      <vc:vcard>
        <vc:fn><vc:text>Example Adminstrator</vc:text></vc:fn>
        <vc:n>
          <vc:surname>Administrator</vc:surname>
          <vc:given>Example</vc:given>
          <vc:suffix>ing. jr</vc:suffix>
          <vc:suffix>M.Sc.</vc:suffix>
```

```
40          </vc:n>
41          <vc:org>
42            <vc:parameters><vc:type><vc:text>work</vc:text></vc:type></vc:parameters>
43            <vc:text>Example.com Ltd.</vc:text>
44          </vc:org>
45          <vc:adr>
46            <vc:parameters>
47              <vc:type><vc:text>work</vc:text></vc:type>
48            </vc:parameters>
49            <vc:street>Imaginary Street 1</vc:street>
50            <vc:locality>Somewhere</vc:locality>
51            <vc:region>ST</vc:region>
52            <vc:code>123 ABC</vc:code>
53            <vc:country>Counrty</vc:country>
54          </vc:adr>
55          <vc:tel>
56            <vc:parameters>
57              <vc:type>
58                <vc:text>work</vc:text>
59                <vc:text>voice</vc:text>
60              </vc:type>
61            </vc:parameters>
62            <vc:uri>tel:+31-123-456-7892</vc:uri>
63          </vc:tel>
64          <vc:email>
65            <vc:parameters><vc:type><vc:text>work</vc:text></vc:type></vc:parameters>
66            <vc:text>bofh@example.com</vc:text>
67          </vc:email>
68          <vc:tz><vc:text>Europe/Amsterdam</vc:text></vc:tz>
69          <vc:geo>
70            <vc:parameters><vc:type><vc:text>work</vc:text></vc:type></vc:parameters>
71            <vc:uri>geo:52.357,4.953</vc:uri>
72          </vc:geo>
73        </vc:vcard>
74      </nml:Relation>
75
76      <nsi:Relation type="http://schemas.ogf.org/nsi/2013/09/topology#peersWith">
77          <nsi:NSA id="urn:ogf:network:example.org:2013:nsa"/>
78      </nsi:Relation>
79
80      <nml:Topology id="urn:ogf:network:example.org:2013:topology">
81          <nml:name>ExampleA Topology</nml:name>
82          <nml:Relation type="http://schemas.ogf.org/nml/2013/05/base#hasOutboundPort">
83              <nml:PortGroup id="urn:ogf:network:example.com:2013:eth0-out">
84                  <nml:LabelGroup labeltype="http://schemas.ogf.org/nml/2013/05/ethernet#vlan">1780-1783</
                        nml:LabelGroup>
85                  <nml:Relation type="http://schemas.ogf.org/nml/2013/05/base#isAlias">
86                      <nml:PortGroup id="urn:ogf:network:example.org:2013:eth0-in"/>
87                  </nml:Relation>
88              </nml:PortGroup>
89          </nml:Relation>
90
91          <nml:Relation type="http://schemas.ogf.org/nml/2013/05/base#hasInboundPort">
92              <nml:PortGroup id="urn:ogf:network:example.com:2013:eth0-in">
93                  <nml:LabelGroup labeltype="http://schemas.ogf.org/nml/2013/05/ethernet#vlan">1780-1783</
                        nml:LabelGroup>
94                  <nml:Relation type="http://schemas.ogf.org/nml/2013/05/base#isAlias">
95                      <nml:PortGroup id="urn:ogf:network:example.org:2013:eth0-out"/>
96                  </nml:Relation>
97              </nml:PortGroup>
```

```
        </nml:Relation>
    </nml:Topology>

</nsi:NSA>
```

The equivalent topology is also represented using the OWL format below.

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF xmlns:nsi="http://schemas.ogf.org/nsi/2013/09/topology#"
         xmlns:nml="http://schemas.ogf.org/nml/2013/05/base#"
         xmlns:vc="http://www.w3.org/2006/vcard/ns#"
         xmlns:nmleth="http://schemas.ogf.org/nml/2013/05/ethernet#"
         xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

    <nsi:NSA rdf:about="urn:ogf:network:example.com:2013:nsa">
        <nsi:hasService rdf:resource="urn:ogf:network:example.com:2013:nsa-provserv"/>
        <nml:manages rdf:resource="urn:ogf:network:example.com:2013:topology"/>
        <nsi:hasService rdf:resource="urn:ogf:network:example.com:2013:nsa-discserv"/>
        <nsi:peersWith rdf:resource="urn:ogf:network:example.org:2013:nsa"/>
    </nsi:NSA>

    <nml:Location rdf:about="urn:ogf:network:example.com:2013:location">
        <nml:lat rdf:datatype="http://www.w3.org/2001/XMLSchema#float">52.357</nml:lat>
        <nml:long rdf:datatype="http://www.w3.org/2001/XMLSchema#float">4.953</nml:long>
    </nml:Location>

    <nsi:Service rdf:about="urn:ogf:network:example.com:2013:nsa-provserv">
        <nsi:link>http://nsa.example.com/provisioning</nsi:link>
        <nsi:describedBy>http://nsa.example.com/provisioning/wsdl</nsi:describedBy>
        <nsi:providedBy rdf:resource="urn:ogf:network:example.com:2013:nsa"/>
    </nsi:Service>

    <nsi:Service rdf:about="urn:ogf:network:example.com:2013:disc-serv">
        <nsi:link>https://nsa.example.com/discovery/services/discovery</nsi:link>
        <nsi:providedBy rdf:resource="urn:ogf:network:example.com:2013:nsa"/>
        <nsi:describedBy>http://nsa.example.com/discovery/wadl</nsi:describedBy>
    </nsi:Service>

    <nsi:adminContact>
        <vc:VCard rdf:about="urn:ogf:network:example.com:2013:admin">
            <vc:n>
                <vc:Name rdf:nodeID="ub1bL5C10">
                    <vc:surname>Administrator</vc:surname>
                    <vc:given>Example</vc:given>
                    <vc:suffix>ing. jr</vc:suffix>
                    <vc:suffix>M.Sc.</vc:suffix>
                </vc:Name>
            </vc:n>
            <vc:fn>Example Administrator</vc:fn>
            <vc:tel>
                <vc:Work rdf:nodeID="ub1bL13C10">
                    <rdf:type rdf:resource="http://www.w3.org/2006/vcard/ns#Voice"/>
                    <rdf:value>+31-123-456-7890</rdf:value>
                </vc:Work>
            </vc:tel>
            <vc:geo>
                <rdf:Description rdf:nodeID="ub1bL27C14">
                    <vc:longitude>4.953</vc:longitude>
```

```
52                      <vc:latitude>52.357</vc:latitude>
53                  </rdf:Description>
54              </vc:geo>
55              <vc:adr>
56                  <vc:Work rdf:nodeID="ub1bL20C10">
57                      <vc:country-name>Country</vc:country-name>
58                      <vc:postal-code>123 ABC</vc:postal-code>
59                      <vc:street-address>Imaginary Street 1</vc:street-address>
60                      <vc:locality>Somewhere</vc:locality>
61                  </vc:Work>
62              </vc:adr>
63              <vc:email>
64                  <vc:Work rdf:nodeID="ub1bL16C14">
65                      <rdf:value rdf:resource="mailto:bofh@example.com"/>
66                  </vc:Work>
67              </vc:email>
68          </vc:VCard>
69      </nsi:adminContact>
70
71      <nml:Topology rdf:about="urn:ogf:network:example.com:2013:topology">
72          <nml:locatedAt rdf:resource="urn:ogf:network:example.com:2013:Location"/>
73          <nml:name>ExampleA Topology</nml:name>
74          <nml:version>2013-05-29T12:11:12</nml:version>
75          <nml:hasInboundPort>
76              <nml:PortGroup rdf:about="urn:ogf:network:example.com:2013:eth0-in">
77                  <nml:isAlias rdf:resource="urn:ogf:network:example.org:2013:if0-out"/>
78                  <nmleth:vlans>1780-1783</nmleth:vlans>
79              </nml:PortGroup>
80          </nml:hasInboundPort>
81          <nml:hasOutboundPort>
82              <nml:PortGroup rdf:about="urn:ogf:network:example.com:2013:eth0-out">
83                  <nmleth:vlans>1780-1783</nmleth:vlans>
84                  <nml:isAlias rdf:resource="urn:ogf:network:example.org:2013:if0-in"/>
85              </nml:PortGroup>
86          </nml:hasOutboundPort>
87      </nml:Topology>
88  </rdf:RDF>
```

The above example provides a minimal description to expose, an *NSA*, a *Location*, two *Service*s, and a *Topology*, with two *PortGroups* for the connection with example.org domain.

The *NSA* element is the main description point of the network. Through the *Service*s elements it describes how the NSI different services can be reached, the peering with other domains, as well as the *Topology* that is managed by the *NSA*.

The *Topology* element is used to hide internal connectivity, and a full-mesh connectivity is assumed. By adding more NML topology information, it is possible to include more detailed descriptions of the internal network.

The *Location* element has also proven to be quite useful in allowing us to quickly create stunning visualizations using digital maps.

6 Security Considerations

There are important security concerns associated with the generation and distribution of network topology information. For example, ISPs frequently consider network topologies to be proprietary. We do not address these concerns in this document, but implementers are encouraged to consider the security implications of generating and distributing network topology information.

Implementers should be aware that the NML descriptions and their NSI extensions do not provide any guarantee regarding their integrity nor their authenticity. The NML documents also can not provide this for the identifiers contained in the documents. Implementers should use external means of verifying the authenticity of identifiers contained in the documents.

7 Contributors

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NSI Concept	*Representation*
STP Local ID	2x `nml:Port` / `nml:BidirectionalPort`
Connected To	`nml:isAlias`
NSNetwork	`nml:Topology`
Has STP	`nml:hasPort`
Located at	`nml:locatedAt`
Location	`nml:Location`
GPS coords	`nml:lat`, `nml:long`
NSA	`nsi:NSA`
NSA manages NSNetwork	`nsi:manages`
Admin Contact	`nsi:adminContact`
NSI Services	`nsi:Service`
Control-plane connections	`nsi:peersWith`

Table 1: Relation of NSI and NML terminology

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[NDL] Jeroen van der Ham A Semantic Model for Complex Computer Networks - The Network Description Language PhD Thesis, University of Amsterdam, April 2010 URL https://staff.science.uva.nl/~vdham/research/publications/vdham-phdthesis.pdf

A XML Schema

This section describes the normative schema of XML documents using the XML Schema language.

```
<?xml version="1.0" encoding="UTF-8"?>


<!--

 File: nsi-ext.xsd - The NSI extension of NML
 Version: $Id$
 Purpose:

-->

<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
           targetNamespace="http://schemas.ogf.org/nsi/2013/09/topology#"
           xmlns:nsi="http://schemas.ogf.org/nsi/2013/09/topology#"
           xmlns:nml="http://schemas.ogf.org/nml/2013/05/base#"
           elementFormDefault="qualified">

  <xs:import schemaLocation="nmlbase.xsd"
             namespace="http://schemas.ogf.org/nml/2013/05/base#"/>

  <xs:complexType name="NSARelationType">
    <xs:choice>
      <xs:element ref="nsi:NSA" minOccurs="1" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="type" use="required">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:enumeration value="http://schemas.ogf.org/nsi/2013/09/topology#managedBy"/>
          <xs:enumeration value="http://schemas.ogf.org/nsi/2013/09/topology#peersWith"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
  </xs:complexType>


  <!-- address: rfc6351 xCard: vCard XML Representation -->
  <xs:element name="adminContact">
    <xs:complexType>
      <xs:sequence>
        <xs:any namespace="##other" processContents="lax" minOccurs="1" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>


  <xs:group name="BaseNSAContent">
    <xs:sequence>
      <xs:element name="Service" type="nsi:NsiServiceType" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="nsi:adminContact" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:group>

```

```
53
54    <xs:complexType name="NSAType">
55      <xs:complexContent>
56        <xs:extension base="nml:NetworkObject">
57          <xs:sequence>
58            <xs:group ref="nsi:BaseNSAContent"/>
59            <xs:element name="Relation" type="nsi:NSARelationType" minOccurs="0" maxOccurs="unbounded"/>
60            <xs:element ref="nml:Topology" minOccurs="0" maxOccurs="unbounded"/>
61          </xs:sequence>
62        </xs:extension>
63      </xs:complexContent>
64    </xs:complexType>
65
66
67    <xs:element name="NSA" type="nsi:NSAType"/>
68
69
70    <xs:complexType name="NsiServiceRelationType">
71      <xs:choice>
72        <xs:element ref="nsi:NSA" minOccurs="1" maxOccurs="unbounded"/>
73      </xs:choice>
74      <xs:attribute name="type" use="required">
75        <xs:simpleType>
76          <xs:restriction base="xs:string">
77            <xs:enumeration value="http://schemas.ogf.org/nsi/2013/09/topology#providedBy"/>
78          </xs:restriction>
79        </xs:simpleType>
80      </xs:attribute>
81    </xs:complexType>
82
83
84    <xs:group name="BaseNsiServiceContent">
85      <xs:sequence>
86        <xs:element name="link" type="xs:anyURI" minOccurs="0" maxOccurs="1"/>
87        <xs:element name="describedBy" type="xs:anyURI" minOccurs="0" maxOccurs="1"/>
88        <xs:element name="type" type="xs:string" minOccurs="0" maxOccurs="1"/>
89      </xs:sequence>
90    </xs:group>
91
92
93    <xs:complexType name="NsiServiceType">
94      <xs:complexContent>
95        <xs:extension base="nml:NetworkObject">
96          <xs:sequence>
97            <xs:group ref="nsi:BaseNsiServiceContent"/>
98            <xs:element name="Relation" type="nsi:NsiServiceRelationType" minOccurs="0" maxOccurs="unbounded"/>
99          </xs:sequence>
100       </xs:extension>
101     </xs:complexContent>
102   </xs:complexType>
103
104
105   <xs:element name="Service" type="nsi:NsiServiceType"/>
106
107
108 </xs:schema>
```

B OWL Schema

This section describes the normative schema of the OWL syntax using the OWL ontology definition below.

```
<?xml version="1.0"?>
<rdf:RDF xmlns="http://schemas.ogf.org/nsi/2013/03/topology#"
     xml:base="http://schemas.ogf.org/nsi/2013/03/topology"
     xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
     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#"
     xmlns:nml="http://schemas.ogf.org/nml/2013/03/base#"
     xmlns:nsi="http://schemas.ogf.org/nsi/2013/03/topology#">

    <owl:Ontology rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#">
        <owl:imports rdf:resource="http://schemas.ogf.org/nml/2013/03/base#"/>
    </owl:Ontology>

    <!-- http://schemas.ogf.org/nsi/2013/03/topology#adminContact -->

    <owl:ObjectProperty rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#adminContact">
        <rdfs:domain rdf:resource="http://schemas.ogf.org/nml/2013/03/base#NetworkObject"/>
    </owl:ObjectProperty>

    <!-- http://schemas.ogf.org/nsi/2013/03/topology#manages -->

    <owl:ObjectProperty rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#manages">
        <rdfs:domain rdf:resource="http://schemas.ogf.org/nsi/2013/03/topology#NSA"/>
        <rdfs:range rdf:resource="http://schemas.ogf.org/nml/2013/03/base#NetworkObject"/>
    </owl:ObjectProperty>

    <!-- http://schemas.ogf.org/nsi/2013/03/topology#peersWith -->

    <owl:ObjectProperty rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#peersWith">
        <rdfs:domain rdf:resource="http://schemas.ogf.org/nsi/2013/03/topology#NSA"/>
        <rdfs:range rdf:resource="http://schemas.ogf.org/nsi/2013/03/topology#NSA"/>
    </owl:ObjectProperty>

    <!-- http://schemas.ogf.org/nsi/2013/03/topology#csProviderEndpoint -->

    <owl:DatatypeProperty rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#csProviderEndpoint">
        <rdfs:domain rdf:resource="http://schemas.ogf.org/nsi/2013/03/topology#NSA"/>
        <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#anyURI"/>
    </owl:DatatypeProperty>

    <!-- http://schemas.ogf.org/nsi/2013/03/topology#NSA -->

    <owl:Class rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#NSA">
        <rdfs:subClassOf rdf:resource="http://schemas.ogf.org/nml/2013/03/base#NetworkObject"/>
    </owl:Class>
    <owl:Class rdf:about="http://schemas.ogf.org/nsi/2013/03/topology#Service">
        <rdfs:subClassOf rdf:resource="http://schemas.ogf.org/nml/2013/03/base#Service"/>
    </owl:Class>
</rdf:RDF>
```