1 NSI Topology Service

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 some requirements for the NSI Topology Service, suggests a short-term implementation and a strategy for better long-term support.

In the first section we describe what is necessary for the topology to support, what kind of elements should be in there. In the next section we describe the distribution requirements, some possible solutions and a recommended solution for the short-term and also for the longer term

1.1 Representation of Network Topologies

In order to use the NSI, some form of topology representation is required. An introduction to this representation and the issues involved in creating network representations for the NSI is described below. A diagram that provides some generic insight into NSI Topology is provided in figure 1.

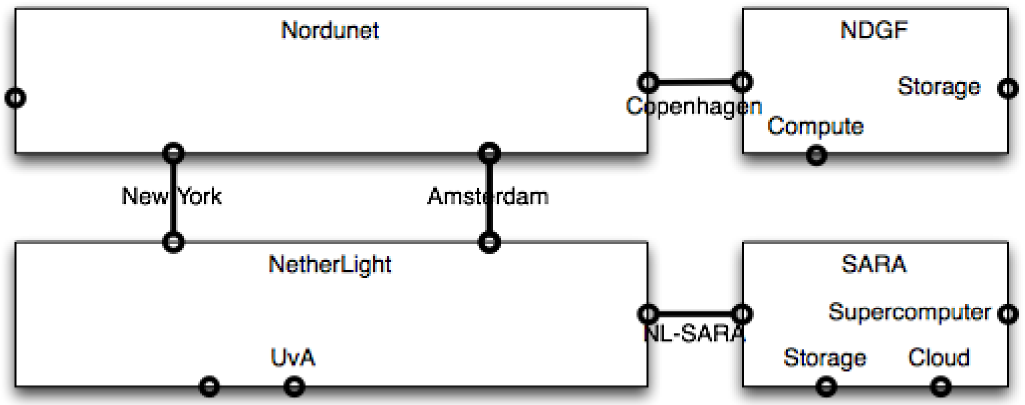

Figure 1: Abstract view of an example NSI Topology

1.1.1 Introduction to concept of STPs

The basic network topology for the Network Service Interface (NSI) consists of networks, points and connections. The NSI can be used to request a connection between two different points, which is then implemented using the connection(s) between those points. Since each of the points in the network topology can terminate a network service, they are called Service Termination Points (STPs). The figure above contains several of these, for example the Storage point at

SARA, another example is the connection point between the network on the edge of the SARA network which connects to the Netherlight network.

1.1.2 Identifying STPs in a request

The STPs in the Network Topology generally have two different roles:

Endpoints within the network –points which are of interest to users, used as source and destination points

One Part of a Service Demarcation Point (SDP) –meaning connections to other networks, used as transit points

For the NSI network service, knowledge of the connections between networks is necessary to enable pathfinding. It is not strictly necessary to know all of the user endpoints in a network, as long as it is known in which network the endpoint is. It is assumed that once the network is reached, the endpoint within the network can be reached as well.

To allow for pathfinding it is necessary that the Topology Service can identify the Networks, and the connections between those Networks, the SDPs. It is not necessary to distribute all of the endpoints within the network, which makes the distribution process much simpler.

This means that a request to NSI must contain the source and destination network, as well as the connection points within those respective networks.

1.1.3 Explicit routing using STPs

In a regular request only the source and destination STPs and their networks are specified. The selected path between those STPs is left to the NSA managing the request. In NSI v2.0 it is also possible to steer the requested path into a specific direction by defining intermediate STPs that the path must touch.

Instead of a normal request with just a source and destination STP, the explicitly routed request will contain a path element which contains an indication of the path that should be taken through the NSI Network.

If the Path object contains a description of the complete path end-to-end then this is simply a question of availability. However, problems can arise if the path object only contains a single "explicit route object"(ERO) that it must touch. With the current NSI implementation and its bi-directional model, there is no way to know from which way to cross that ERO. The proposal is to use uni-directional path elements, to avoid ambiguity in the path direction (the uni-directionality of the ERO implicitly defines the direction).

1.1.4 Requirements for Topology Descriptions

Taking the description above into account, and with the general idea of the Network Service Interface in mind, we come to the following requirements for the network topology description:

Scalable : An NSA does not need to be aware of all STPs in other networks;

Compact : A Topology description should be able to group individual data transport capabilities in one object rather than specifying each possible VLAN for example;

Abstract : The topology description should list the connections between domains, not how these connections are implemented;

Compatible : It should be possible to relate the NSI topology to other topologies, e.g. as used for monitoring. Preferably the NSI topology should be compatible with the NML topology;

Flexible : The topology description should support future extensions, e.g. different connection types (unidirectional, bidirectional, or multipoint connections), different levels of abstraction of the network (subtopologies), or multi-homing scenarios;

Unambiguous : The direction of an STP in an ERO should be unambiguous.

1.1.5 Proposal

To satisfy the unambiguity and flexibility requirements, we propose to describe STPs as two unidirectional Ports, since these have a single direction, there can be no misunderstanding. These unidirectional ports also easily allow point-to-multipoint requests.

To satisfy the compact requirement, we propose to allow PortGroups over Ports. A PortGroup groups together several Ports which have a single identifying attribute, for example a VLAN label.

To satisfy the scalability and flexibility requirement we propose to add the Topology ID as an added context for an STP in a request. This makes most of the global path through the network clear, without having specific knowledge about the internal endpoints. These can be handled by the NSAs responsible for those Topologies.

To satisfy the compatibility and flexibility requirements we propose to use full URIs for each component in a request. Globally unique identifiers make it possible to have delegated subtopologies without having to rewrite identifiers for example.

This means that a connection request for NSI should use the following tuple as source and destination:

(Topology ID, source PortGroup ID, sink PortGroup ID)

1.2 Topology Description Syntax

1.2.1 STP Identifiers

A source or destination of a connection reqest is identified by the Topology identifier and two unidirectional Ports or PortGroups. Each of these must be globally unique identifiers.

A recommended way of constructing such an identifier is by using the `urn:ogf:network` namespace, for example `urn:ogf:network:example.net:2012:A1`.

This identifer has three components: the prefix, urn:ogf:network which describes that it is a network identifier, the authoring namespace, example.net:2012 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.

1.2.2 STP Groups

Endpoints in a network often have a technology label associated with them, for example VLANs or wavelenghts. 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 [RFC3986], so for example:

`urn:ogf:network:example.net:2012: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:2012:A2`.

If no specific label or attribute is given to select an STP from an STP group, the NSA 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:2012: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.

1.2.3 DTOX Syntax

Version 1 of the NSI Connection Service specification left the topology definition out of scope. This has left a huge gap on the operational side, where implementers have had to cooperate to create a common file to represent the topologies of each of the domains, and how to share that data. The Distributed TOpology eXchange (DTOX) working group of GLIF jumped to the opportunity and quickly provided a topology format. This was heavily inspired by the NML work in progress, but also contained some additions specific to NSI. This has allowed us to gain some experience in required elements for a topology format, and the way it could be exchanged.

The current DTOX format contains the following elements:

STP Service Termination Point.

connectedTo relation to form an SDP with another STP

NSNetwork Network Service Network

[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.

hasSTP to define STP containment

locatedAt to define a location of a network

Location

lat, long define GPS coordinates

NSA Network Service Agent

managing to relate it to an NSNetwork

adminContact to describe contacts for the administrator

csProviderEndpoint to define the URL at which the NSA is reachable

The above format is simple, but has proven to be very effective. The STP elements are the most important ones which provide the identifiers and connectivity information necessary to do path calculations between domains.

The NSI topology representation will make use the NML topology representation as much as possible to build on standardized work in that group. This will be extended with some NSI specific terminology as shown in Figure 1.

NSI Concept	*Representation*
STP	2x nml:Port / nml:BidirectionalPort
Connected To	nml:alias
NSNetwork	nml:Topology
Has STP	nml:hasPort
Located at	nml:locatedAt
Location	nml:Location
GPS co-ords	nml:lat, nml:long
NSA	nsi:NSA
Network managed by NSA	nsi:managedBy
Admin Contact	nsi:adminContact
Provider endpoint URL	nsi:csProviderEndpoint
Control-plane connections	nsi:peersWith

Figure 1 Relation of NSI and NML terminology

1.2.4 Topology Description Example

A simple example NSI Network topology description is provided below. This example describes only the NDGF network as depicted in Figure 1. The complete topology description for Figure 1 is available in Appendix A.

```
ndgf:NordicDataGridFacility a nml:Topology ;
        nml:version "2011112901" ;
        nml:name "NDGF" ;
        nml:locatedAt ndgf:location ;
        nml:hasOutboundPort ndgf:dk-ndgf-nordunet ;
        nml:hasInboundPort ndgf:nordunet-dk-ndgf ;
        nml:hasOutboundPort ndgf:ndgf-storage ;
        nml:hasInboundPort ndgf:storage-ndgf ;
        nsi:managedBy ndgf:nsa .
ndgf:location a nml:Location ;
        nml:lat "55.637"^^<http://www.w3.org/2001/XMLSchema#float> ;
        nml:long "12.641"^^<http://www.w3.org/2001/XMLSchema#float> .
ndgf:nsa a nsi:NSA ;
        nsi:csProviderEndpoint "http://nsa.ndgf.org/" .
ndgf:dk-ndgf-nordunet a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nordunet:dk-ndgf-nordunet .
ndgf:nordunet-dk-ndgf a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nordunet:nordunet-dk-ndgf .
ndgf:ndgf-storage a nml:PortGroup ;
        nmleth:vlans "1780-1783" .
ndgf:storage-ndgf a nml:PortGroup ;
        nmleth:vlans "1780-1783" .
```

The above example provides the minimal information to expose, a Topology, a Location, an NSA, two PortGroups for the connection with NorduNet, and finally two PortGroups describing the Storage endpoint in the network, all with VLAN ranges.

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

The NSA provides the management information for networks, how the NSI interface can be reached, and who actually maintain the NSA.

The Location element has also proven to be quite useful in allowing us to quickly create stunning visualizations using Google Earth.

1.2.5 Subtopologies

A topology can be further subdivided into subtopologies if required. If for example NORDUnet decides to split their USA and Scandinavian networks, we end up with a topology such as shown in figure 2.

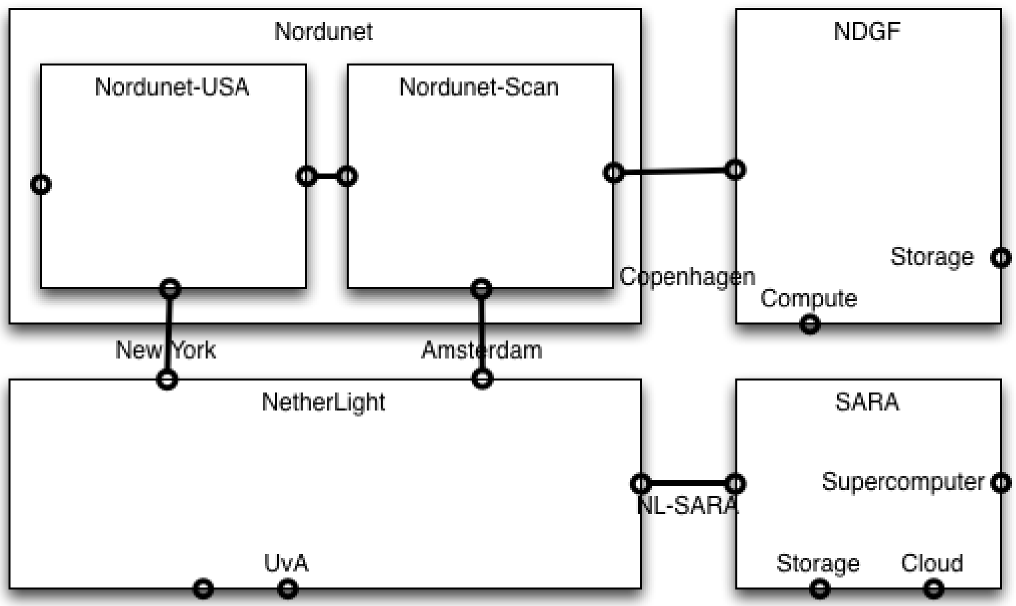

Figure 2: An example topology where Nordunet uses subtopologies

If described correctly, the other domains do not have to update their topologies or connections. NORDUnet just updates its version number, and makes a new topology file available with subtopologies. The description of the new NORDUnet topology is given at the end of Appendix A.

1.3 Distribution of NSI Topology

Some form of Topology distribution is required in order for an inter-domain NSI network to function. In NSI 1.0 this process was performed out-of-band, mostly through e-mail. For NSI 2.0 we take the opportunity to define an NSI Topology Service for NSI topology exchange, which can support the NSI Connection Service.

1.3.1 Transport and Service plane relationship

The NSI Connection Service is implemented on Network Service Agents (NSAs), which together form a network and tree-like structure. This graph represents how reservation requests would propagate through the network, but not necessarily reflects the transport-plane. One NSA may be an aggregation point for other NSAs, not visible from the outside.

The messaging between the NSAs will happen on the service plane, which is completely separate from the transport plane.

1.3.2 Elements of a Topology Exchange Mechanism

There are three main elements of topology exchange:

Bootstrapping Topology Exchange To start the initial Network Service the NSAs must be able to find each other, in order to communicate details about the network. So some form of bootstrapping is required, with initial synchronization between domains on both the service plane and the transport plane, i.e. the NSAs of both domains must be able to contact each other, and the details of transport plane connections between them have to be synchronized as well.

Initiating a transport plane connection between two networks is not a frequent occurrence, and a longer process, involving out-of-band (for NSI) contact. Part of that process can be that the networks also communicate the access details for the NSAs, thus forming an NSA relationship.

Expanding the Topology Exchange Once the neighboring (on the control-plane) NSAs have exchanged details, they can also distribute details about the rest of the network, both the control plane details and connectivity, but also some transport details.

Update Mechanism The transport network is not static, and links are added or removed from time to time. An update mechanism is thus required to inform other NSAs about these kinds of events.

1.3.3 Topology Exchange Implementations

The above mechanisms can be implemented in five different ways:

Centralized Manual Distribution An initial attempt at topology distribution in the Automated GOLE demonstration was through a central maintainer. This maintainer collected all topology information from the networks involved, gathered all the topology data and sent out a topology file through e-mail. The network maintainers would than download the attachment and insert it into their provisioning system. Updates to the topology were all handled through the central maintainer, distributed through e-mail.

While this system worked initially, it soon ran into scaling problems. This system also does not allow to have a good way of doing automatic updates or insertion.

Version Controlled Distribution The Automated GOLE demonstration has transitioned into a different distribution mechanism using a Git source code repository, available on GitHub. This mechanism also still has a central maintainer, this also allows networks to manipulate their own topology information. The distribution mechanism is either directly from the GitHub website, or through the git version control system itself. The git system has the added advantage that it is a distributed version control system, so it is not required to download directly from GitHub.

Bootstrapping and updating all happens through the git system itself.

PerfSonar Lookup Service The PerfSonar monitoring system suite also contains a service for looking up information. This service uses a "home Lookup Service"(hLS) where metadata of information is registered, which is then uploaded into the "global Lookup Service"(gLS) (this can be cloud of services).

The retrieval of information happens by first querying the gLS, then the relevant hLS, followed by the service where the actual information is stored.

Since topology information would be stored locally, no update mechanism is necessary, except for location changes of the services itself. However, this method of storing and lookup does require full connectivity between all NSAs to provide and retrieve information, which may not be possible.

A soon to be released (target Dec 2012) updated PS Lookup service will incorporate subscription capabilities, which allow an hLS to push information to a remote hLS and have it cached locally there. By adapting the new Lookup service to store topology, and selectively managing the subscription of data, full connectivity between NSAs would not be necessary to disseminate global topology.

HTTP Distribution A common way of distributing information is using the HTTP protocol. The topology files would include links to topology description files, which would allow other domains to directly fetch the topology description.

However, as with the Lookup Service, this requires direct access between NSAs which may not be possible.

A Peer-to-Peer Distribution Protocol Another method is to define a new protocol for NSI topology distribution. As explained above the protocol would only require a small set of primitives, and would work directly between peering NSAs.

Once an NSA comes up, it contacts its neighbors to request the topology information that they know about, and subscribes to future topology updates. These updates are propogated in a peer-to-peer fashion through the whole network.

The end-result would be that all the NSAs have a global view of the topology, with only local interaction.

1.3.4 Summarizing Topology Distribution

Above we have described five different topology distribution mechanisms, from these five only the version controlled and peer-to-peer systems fit the requirements that the NSI has, others require too much manual operation, or require globally reachable NSAs. The peer-to-peer system would be the best solution with minimal interaction between systems, and no reliance on outside mechanisms. For practical reasons we believe the best solution right now is a version controlled distribution system, and in time evolve to a peer-to-peer distribution protocol.

Appendix A –Example Topology Description

Below is the complete topology description of Figure 1 written in NML using the Notation3 syntax.

```
@prefix nml:       <http://schemas.ogf.org/nml/2012/10/base#> .
@prefix nmleth:    <http://schemas.ogf.org/nml/ethernet/2012/10#> .
@prefix nsi:       <http://schemas.ogf.org/nsi/topology/2012/10#> .
@prefix ndgf:      <urn:ogf:network:ndgf.org:2012:> .
@prefix nordunet:  <urn:ogf:network:nordu.net:2012:> .
@prefix nl:        <urn:ogf:network:netherlight.net:2010:> .
@prefix sara:      <urn:ogf:network:sara.nl:2011:> .

ndgf:NordicDataGridFacility a nml:Topology ;
        nml:version "2011112901" ;
        nml:name "NDGF" ;
        nml:locatedAt ndgf:location ;
        nml:hasOutboundPort ndgf:dk-ndgf-nordunet ;
        nml:hasInboundPort ndgf:nordunet-dk-ndgf ;
        nml:hasOutboundPort ndgf:ndgf-storage ;
        nml:hasInboundPort ndgf:storage-ndgf ;
        nsi:managedBy ndgf:nsa .
ndgf:location a nml:Location ;
        nml:lat "55.637"^^<http://www.w3.org/2001/XMLSchema#float> ;
        nml:long "12.641"^^<http://www.w3.org/2001/XMLSchema#float> .
ndgf:nsa a nsi:NSA ;
        nsi:csProviderEndpoint "http://nsa.ndgf.org/" .
ndgf:dk-ndgf-nordunet a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nordunet:dk-ndgf-nordunet .
ndgf:nordunet-dk-ndgf a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nordunet:nordunet-dk-ndgf .
ndgf:ndgf-storage a nml:PortGroup ;
        nmleth:vlans "1780-1783" .
ndgf:storage-ndgf a nml:PortGroup ;
        nmleth:vlans "1780-1783" .

nordunet:Nordunet a nml:Topology ;
        nml:version "2012061801" ;
        nml:name "Nordunet" ;
        nml:hasOutboundPort nordunet:nordunet-dk-ndgf ;
        nml:hasOutboundPort nordunet:nordunet-surfnet-NYC ;
        nml:hasOutboundPort nordunet:nordunet-surfnet-AMS ;
        nml:hasInboundPort nordunet:dk-ndgf-nordunet ;
        nml:hasInboundPort nordunet:surfnet-NYC-nordunet ;
        nml:hasInboundPort nordunet:surfnet-AMS-nordunet .
nordunet:nordunet-dk-ndgf a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias ndgf:nordunet-dk-ndgf .
nordunet:dk-ndgf-nordunet a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias ndgf:dk-ndgf-nordunet .
nordunet:nordunet-surfnet-AMS a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nl:nordunet-surfnet-AMS .
nordunet:nordunet-surfnet-NYC a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nl:nordunet-surfnet-NYC .
nordunet:surfnet-AMS-nordunet a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nl:surfnet-AMS-nordunet .
nordunet:surfnet-NYC-nordunet a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nl:surfnet-NYC-nordunet .

nl:NetherLight a nml:Topology ;
        nml:version "2011062101" ;
        nml:name "NetherLight" ;
        nml:hasOutboundPort nl:surfnet-NYC-nordunet ;
        nml:hasOutboundPort nl:surfnet-AMS-nordunet ;
        nml:hasOutboundPort nl:surfnet-SARA ;
        nml:hasInboundPort nl:nordunet-surfnet-NYC ;
        nml:hasInboundPort nl:nordunet-surfnet-AMS ;
        nml:hasInboundPort nl:SARA-surfnet .
nl:nordunet-surfnet-AMS a nml:PortGroup ;
        nmleth:vlans "1780-1783" ;
        nml:alias nordunet:nordunet-surfnet-AMS .
```

```
  nl:nordunet-surfnet-NYC a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias nordunet:nordunet-surfnet-NYC .
  nl:SARA-surfnet a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias sara:SARA-surfnet .
  nl:surfnet-AMS-nordunet a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias nordunet:surfnet-AMS-nordunet .
  nl:surfnet-NYC-nordunet a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias nordunet:surfnet-NYC-nordunet .
  nl:surfnet-SARA a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias sara:surfnet-SARA .


  sara:SARA a nml:Topology ;
          nml:version "2010072401" ;
          nml:name "SARA" ;
          nml:hasOutboundPort sara:SARA-surfnet ;
          nml:hasInboundPort sara:surfnet-SARA .
  sara:SARA-surfnet a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias nl:SARA-surfnet .
  sara:surfnet-SARA a nml:PortGroup ;
          nmleth:vlans "1780-1783" ;
          nml:alias nl:surfnet-SARA .
```

An example of an updated topology for NorduNet with subtopologies. This new topology does not require any changes on the other network topologies.

```
nordunet:Nordunet a nml:Topology ;
        nml:version "2012080401" ;
        nml:name "Nordunet" ;
        nml:hasTopology nordunet:NordunetScandinavia ;
        nml:hasTopology nordunet:NordunetUSA .

nordunet:NordunetScandinavia a nml:Topology ;
        nml:version "2012080401" ;
        nml:name "Nordunet Scandinavia" ;
        nml:hasOutboundPort nordunet:nordunet-dk-ndgf ;
        nml:hasOutboundPort nordunet:nordunet-surfnet-AMS ;
        nml:hasOutboundPort nordunet:Scan-to-USA-trunk ;
        nml:hasInboundPort nordunet:dk-ndgf-nordunet ;
        nml:hasInboundPort nordunet:surfnet-AMS-nordunet ;
        nml:hasInboundPort nordunet:Scan-from-USA-trunk .
nordunet:dk-ndgf-nordunet a nml:PortGroup ;
        nml:alias ndgf:dk-ndgf-nordunet .
nordunet:nordunet-dk-ndgf a nml:PortGroup ;
        nml:alias ndgf:nordunet-dk-ndgf .
nordunet:nordunet-surfnet-AMS a nml:PortGroup ;
        nml:alias nl:nordunet-surfnet-AMS .
nordunet:Scan-from-USA-trunk a nml:PortGroup ;
        nml:alias nordunet:USA-to-Scan-trunk .
nordunet:Scan-to-USA-trunk a nml:PortGroup ;
        nml:alias nordunet:USA-from-Scan-trunk .
nordunet:surfnet-AMS-nordunet a nml:PortGroup ;
        nml:alias nl:surfnet-AMS-nordunet .

nordunet:NordunetUSA a nml:Topology ;
        nml:version "2012080401" ;
        nml:name "Nordunet USA" ;
        nml:hasOutboundPort nordunet:nordunet-surfnet-NYC ;
        nml:hasOutboundPort nordunet:USA-to-Scan-trunk ;
        nml:hasInboundPort nordunet:surfnet-NYC-nordunet ;
        nml:hasInboundPort nordunet:USA-from-Scan-trunk .
nordunet:nordunet-surfnet-NYC a nml:PortGroup ;
        nml:alias nl:nordunet-surfnet-NYC .
nordunet:surfnet-NYC-nordunet a nml:PortGroup ;
        nml:alias nl:surfnet-NYC-nordunet .
nordunet:USA-from-Scan-trunk a nml:PortGroup ;
        nml:alias nordunet:Scan-to-USA-trunk .
nordunet:USA-to-Scan-trunk a nml:PortGroup ;
        nml:alias nordunet:Scan-from-USA-trunk .
```