Abstract:

The concept of a “service template” is used to specify the “topology” (or structure) and “orchestration” (or invocation of management behavior) of IT services (or simply “services” from here on). Typically, services are provisioned in an IT infrastructure and their management behavior must be orchestrated in accordance with constraints or policies from there on, for example in order to achieve service level objectives.

This specification introduces the formal description of Service Templates, including their structure, properties, and behavior.
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1 Introduction

IT services (or just services in what follows) are the main asset within IT environments in general, and in cloud environments in particular. The advent of cloud computing suggests the utility of standards that enable the (semi-) automatic creation and management of services (a.k.a. service automation). These standards describe a service and how to manage it independent of the supplier creating the service and independent of any particular cloud provider and the technology hosting the service. Making service topologies (i.e. the individual components of a service and their relations) and their orchestration plans (i.e. the management procedures to create and modify a service) interoperable elements, enables their exchange between different environments. This specification explains how to define services in a portable and interoperable manner in a Service Template document.
2 Language Design

The TOSCA language introduces a grammar for describing service templates by means of Topology Templates and plans. The focus is on design time aspects, i.e. the description of services to ensure their exchange. Runtime aspects are addressed by providing a container for specifying models of plans which support the management of instances of services.

The language provides an extension mechanism that can be used to extend the definitions with additional vendor-specific or domain-specific information.

2.1 Dependencies on Other Specifications

TOSCA utilizes the following specifications:

- WSDL 1.1
- XML Schema 1.0

and relates to:

- OVF 1.1

2.2 Notational Conventions

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 [RFC2119].

This specification follows XML naming and design rules as described in [UNCEFACT XMLNDR], i.e. uses upper camel-case notation for XML element names and lower camel-case notation for XML attribute names.

2.3 Normative References


2.4 Non-Normative References

2.5 Namespaces

This specification uses a number of namespace prefixes throughout; they are listed in Table 1. Note that the choice of any namespace prefix is arbitrary and not semantically significant (see [XML Namespaces]). Furthermore, the namespace http://docs.oasis-open.org/tosca/ns/2011/12 is assumed to be the default namespace, i.e. the corresponding namespace name ste is omitted in this specification to improve readability.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Namespace</th>
</tr>
</thead>
<tbody>
<tr>
<td>ste</td>
<td><a href="http://docs.oasis-open.org/tosca/ns/2011/12">http://docs.oasis-open.org/tosca/ns/2011/12</a></td>
</tr>
<tr>
<td>xs</td>
<td><a href="http://www.w3.org/2001/XMLSchema">http://www.w3.org/2001/XMLSchema</a></td>
</tr>
<tr>
<td>wsdl</td>
<td><a href="http://schemas.xmlsoap.org/wsdl/">http://schemas.xmlsoap.org/wsdl/</a></td>
</tr>
<tr>
<td>bpmn</td>
<td><a href="http://www.omg.org/bpmn/2.0">http://www.omg.org/bpmn/2.0</a></td>
</tr>
</tbody>
</table>

Table 1: Prefixes and namespaces used in this specification

All information items defined by TOSCA are identified by one of the XML namespace URIs above [XML Namespaces]. A normative XML Schema [XML Schema Part 1, XML Schema Part 2] document for TOSCA can be obtained by dereferencing one of the XML namespace URIs.

2.6 Language Extensibility

The TOSCA extensibility mechanism allows:
- Attributes from other namespaces to appear on any TOSCA element
- Elements from other namespaces to appear within TOSCA elements
- Extension attributes and extension elements MUST NOT contradict the semantics of any attribute or element from the TOSCA namespace

The specification differentiates between mandatory and optional extensions (the section below explains the syntax used to declare extensions). If a mandatory extension is used, a compliant implementation
MUST understand the extension. If an optional extension is used, a compliant implementation MAY ignore the extension.

2.7 Overall Language Structure

A Service Template is an XML document that consists of a Topology Template, Node Types, Relationship Types and Plans. This section explains the overall structure of a Service Template, the extension mechanism, and import features. Later sections describe in detail Topology Templates, Node Types, Relationship Types and Plans.

2.7.1 Syntax

```xml
<ServiceTemplate id="ID"
               name="string"?
               targetNamespace="anyURI">
    <Extensions>?</ Extensions>
    <Extension namespace="anyURI"
                 mustUnderstand="yes\|no"/>+</Extensions>
    <Import namespace="anyURI"?
             location="anyURI"?
             importType="anyURI"/>*
    <Types>?</ Types>
    <xs:schema .../>*
    <Topologies Template>
    ...</Topologies>
    |<TopologyTemplateReference reference="xs:QName">
    ...</TopologyTemplateReference>
    <NodeTypes>?
    ...</NodeTypes>
    <RelationshipTypes>?
    ...</RelationshipTypes>
    <Plans>?
    ...</Plans>
</ServiceTemplate>
```

2.7.2 Properties

The ServiceTemplate element has the following properties:

- **id**: This attribute specifies the identifier of the Service Template. The identifier of the Service Template MUST be unique within the target namespace.
Note: For elements defined in this specification, the value of the `id` attribute of an element is used as the local name part of the fully-qualified name (QName) of that element, by which it can be referenced from within another definition.

- **name**: This optional attribute specifies the name of the Service Template.

  Note: The `name` attribute for elements defined in this specification can generally be used as descriptive, human-readable name.

- **targetNamespace**: The value of this attribute is the namespace for the Service Template.

- **Extensions**: This element specifies namespaces of TOSCA extension attributes and extension elements. The element is optional. If present, the `Extensions` element MUST include at least one `Extension` element. The `Extension` element is used to specify a namespace of TOSCA extension attributes and extension elements, and indicates whether they are mandatory or optional.

  The attribute `mustUnderstand` is used to specify whether the extension must be understood by a compliant implementation. If the `mustUnderstand` attribute has value “yes” (which is the default value for this attribute) the extension is mandatory. Otherwise, the extension is optional. If a TOSCA implementation does not support one or more of the extensions with `mustUnderstand`=”yes”, then the Service Template MUST be rejected. Optional extensions MAY be ignored. It is not necessary to declare optional extensions.

  The same extension URI MUST be declared multiple times in the `Extensions` element. If an extension URI is identified as mandatory in one `Extension` element and optional in another, then the mandatory semantics have precedence and MUST be enforced. The extension declarations in an `Extensions` element MUST be treated as an unordered set.

- **Import**: This element declares a dependency on external Service Template, XML Schema definitions, or WSDL definitions. Any number of `Import` elements MAY appear as children of the `ServiceTemplate` element.

  The `namespace` attribute specifies an absolute URI that identifies the imported definitions. This attribute is optional. An `Import` element without a `namespace` attribute indicates that external definitions are in use, which are not namespace-qualified. If a `namespace` attribute is specified then the imported definitions MUST be in that namespace. If no namespace is specified then the imported definitions MUST NOT contain a `targetNamespace` specification. The namespace `http://www.w3.org/2001/XMLSchema` is imported implicitly. Note, however, that there is no implicit XML Namespace prefix defined for `http://www.w3.org/2001/XMLSchema`.

  The `location` attribute contains a URI indicating the location of a document that contains relevant definitions. The location URI MAY be a relative URI, following the usual rules for resolution of the URI base [XML Base, RFC 2396]. The `location` attribute is optional. An `Import` element without a `location` attribute indicates that external definitions are used but makes no statement about where those definitions might be found. The `location` attribute is a hint and a TOSCA compliant implementation is not obliged to retrieve the document being imported from the specified location.

  The mandatory `importType` attribute identifies the type of document being imported by providing an absolute URI that identifies the encoding language used in the document. The value of the `importType` attribute MUST be set to `http://docs.oasis-open.org/tosca/ns/2011/12` when importing Service Template documents, to `http://schemas.xmlsoap.org/wsdl/` when importing WSDL 1.1 documents, and to `http://www.w3.org/2001/XMLSchema` when importing an XSD document.

  According to these rules, it is permissible to have an `Import` element without `namespace` and `location` attributes, and only containing an `importType` attribute. Such an `Import`
element indicates that external definitions of the indicated type are in use that are not
namespace-qualified, and makes no statement about where those definitions might be found.

A Service Template MUST define or import all Topology Template, Node Types, Relationship
Types, Plans, WSDL definitions, and XML Schema documents it uses. In order to support the use
of definitions from namespaces spanning multiple documents, a Service Template MAY include
more than one import declaration for the same namespace and importType. Where a service
template has more than one import declaration for a given namespace and importType, each
declaration MUST include a different location value. Import elements are conceptually
unordered. A Service Template MUST be rejected if the imported documents contain conflicting
definitions of a component used by the importing Service Template.

Documents (or namespaces) imported by an imported document (or namespace) are not
transitively imported by a TOSCA compliant implementation. In particular, this means that if an
external item is used by an element enclosed in the Service Template, then a document (or
namespace) that defines that item MUST be directly imported by the Service Template. This
requirement does not limit the ability of the imported document itself to import other documents or
namespaces.

- **Types**: This element specifies XML definitions introduced within the Service Template
document. Such definitions are provided within one or more separate Schema Definitions (usually
xs:schema elements). The Types element defines XML definitions within a Service Template
file without having to define these XML definitions in separate files and import them. Note, that an
xs:schema element nested in the Types element MUST be a valid XML schema definition. In
case the targetNamespace attribute of a nested xs:schema element is not specified, all
definitions within this element become part of the target namespace of the encompassing
ServiceTemplate element.

Note: The specification supports the use of any type system nested in the Types element.
Nevertheless, only the support of xs:schema is REQUIRED from any compliant
implementation.

- **TopologyTemplate**: This element specifies in place the topological structure of an IT service
by means of a directed graph.

The main ingredients of a Topology Template are a set of Node Templates and Relationship
Templates. The Node Templates are the nodes of the directed graph. The Relationship
Templates are the directed edges between the nodes; each indicates the semantics of the
corresponding relationships.

- **TopologyTemplateReference**: This element references a Topology Template. Its
reference attribute specifies the QName of the definition available by reference in the
document under definition. The namespace of the referenced Topology Template MUST be
imported into the Service Template by means of an Import element.

Note that either zero or one Topology Template MUST occur in a Service Template, either
defined in place via a TopologyTemplate element or referenced via a
TopologyTemplateReference.

- **NodeTypes**: This element specifies the types of Node (Templates), i.e., their properties and
behavior.

- **RelationshipTypes**: This element specifies the types of relationships, i.e. the kind of links
between Node Templates within a Service Template, and their properties.

- **Plans**: This element specifies the operational behavior of the service. Each Plan contained in
the Plans element specifies how to create, terminate or manage the service.
A Service Template document can be intended to be instantiated into a service instance or it can be intended to be composed into other Service Templates. A Service Template document intended to be instantiated MUST contain either a TopologyTemplate or a TopologyTemplateReference, but not both. A Service Template document intended to be composed MUST include at least one of a NodeType, RelationshipTypes, or Plans element. This technique supports a modular definition of Service Templates. For example, one document can contain only Node Types that are referenced by a Service Template document that contains just a Topology Template and Plans. Similarly, Node Type Properties can be defined in separate XML Schema Definitions that are imported and referenced when defining a Node Type.

Example of the use of a type definition:

```xml
<Types>
  <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
             elementFormDefault="qualified"
             attributeFormDefault="unqualified">
    <xs:element name="ProjectProperties">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="Owner" type="xs:string"/>
          <xs:element name="ProjectName" type="xs:string"/>
          <xs:element name="AccountID" type="xs:string"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:schema>
</Types>
```

All TOSCA elements MAY use the element documentation to provide annotation for users. The content could be a plain text, HTML, and so on. The documentation element is optional and has the following syntax:

```xml
1 <documentation source="anyURI"? xml:lang="language"?>
2 ...
3 </documentation>
```

Example of use of a documentation:

```xml
<ServiceTemplate id="myService" name="My Service" ...>
  <documentation xml:lang="EN">
    This is a simple example of the usage of the documentation element as nested under a ServiceTemplate element.
  </documentation>
</ServiceTemplate>
```
3 Core Concepts and Usage Pattern

The main concepts behind TOSCA are described and some usage patterns of Service Templates are sketched.

3.1 Core Concepts

This specification defines a metamodel for defining IT services. This metamodel defines both the structure of a service as well as how to manage it. A Topology Template (also referred to as the topology model of a service) defines the structure of a service. Plans define the process models that are used to create and terminate a service as well as to manage a service during its whole lifetime. The major elements defining a service are depicted in Figure 1.

A Topology Template consists of a set of Node Templates and Relationship Templates that together define the topology model of a service as a (not necessarily connected) directed graph. A node in this graph is represented by a Node Template. A Node Template specifies the occurrence of a Node Type as a component of a service. A Node Type defines the properties of such a component (via Node Type Properties) and the operations (via Interfaces) available to manipulate the component. Node Types are defined separately for reuse purposes and a Node Template references a Node Type and adds usage constraints, such as how many times the component can occur.

For example, consider a service that consists of an application server, a process engine, and a process model. A Topology Template defining that service would include one Node Template of Node Type "application server", another Node Template of Node Type "process engine", and a third Node Template of Node Type "process model". The application server Node Type defines properties like the IP address of an instance of this type, an operation for installing the application server with the corresponding IP

![Service Template Diagram]

Figure 1: Structural Elements of a Service Template and their Relations
A Relationship Template specifies the occurrence of a relationship between nodes in a Topology Template. Each Relationship Template refers to a Relationship Type that defines the semantics and any properties of the relationship. Relationship Types are defined separately for reuse purposes. The Relationship Template indicates the elements it connects and the direction of the relationship by defining one source and one target element (in nested SourceElement and TargetElement elements). The Relationship Template also defines any constraints with the optional RelationshipConstraints element.

For example, a relationship can be established between the process engine Node Template and application server Node Template with the meaning "hosted by", and between the process model Node Template and process engine Node Template with meaning "deployed on".

A deployed service is an instance of a Service Template. More precisely, the instance is derived by instantiating the Topology Template of its Service Template, most often by running a special plan defined for the Service Template, often referred to as build plan. The build plan will provide actual values for the various properties of the various Node Templates and Relationship Templates of the Topology Template. These values can come from input passed in by users as triggered by human interactions defined within the build plan, by automated operations defined within the build plan (such as a directory lookup), or the templates can specify default values for some properties. The build plan will typically make use of operations of the Node Types of the Node Templates.

For example, the application server Node Template will be instantiated by installing an actual application server at a concrete IP address considering the specified range of IP addresses. Next, the process engine Node Template will be instantiated by installing a concrete process engine on that application server (as indicated by the "hosted by" relationship template). Finally, the process model Node Template will be instantiated by deploying the process model on that process engine (as indicated by the "deployed on" relationship template).

Plans defined in a Service Template describe the management aspects of service instances, especially their creation and termination. These plans are defined as process models, i.e. a workflow of one or more steps. Instead of providing another language for defining process models, the specification relies on existing languages like BPMN or BPEL. Relying on existing standards in this space facilitates portability and interoperability, but any language for defining process models can be used. The TOSCA metamodel provides containers to either refer to a process model (via Plan Model Reference) or to include the actual model in the plan (via Plan Model). A process model can contain tasks (using BPMN terminology) that refer to operations of Interfaces of Node Templates or any other interface (e.g. the invocation of an external service for licensing); in doing so, a plan can directly manipulate nodes of the topology of a service or interact with external systems.

### 3.2 Service Templates and Artifacts

An artifact represents the content required to realize a deployment such as an executable (e.g. a script, an executable program, an image), a configuration file or data file, or something that might be required so that another executable can run (e.g. a library). Artifacts can be of different types, for example EJBs or python scripts. The content of an artifact depends on its type. Typically, descriptive metadata will also be provided along with the artifact. This metadata might be needed to properly process the artifact, for example by describing the appropriate execution environment.

TOSCA distinguishes two kinds of artifacts: **implementation artifacts** and **deployment artifacts**. An implementation artifact represents the executable of an operation of a node type, and a deployment artifact represents the executable for materializing instances of a node. For example, a REST operation to store an image may have an implementation artifact that is a WAR file. The node type this REST operation is associated with may have the image itself as a deployment artifact.

The fundamental difference between implementation artifacts and deployment artifacts is twofold, namely

1. the point in time when the artifact is deployed, and
2. by what entity and to where the artifact is deployed.
The operations of a node type perform management actions on (instances of) the node type. The implementations of such operations can be provided as implementation artifacts. Thus, the implementation artifacts of the corresponding operations have to be deployed in the management environment before any management operation can be started. In other words, “a TOSCA supporting environment” (i.e. a so-called TOSCA container) must be able to process the set of implementation artifacts types required to execute those management operations. One such management operation could be the instantiation of a node type.

The instantiation of a node type can require providing deployment artifacts in the target managed environment. For this purpose, a TOSCA container supports a set of types of deployment artifacts that it can process. A service template that contains (implementation or deployment) artifacts of non-supported types cannot be processed by the container (resulting in an error during import).

3.3 Archive Format for Cloud Applications

In order to support in a certain environment the execution and management of the lifecycle of a cloud application, all corresponding artifacts must be available in that environment. This means that beside the service template of the cloud application, the deployment artifacts and implementation artifacts must be available in that environment. To ease the task of ensuring the availability of all of these, this specification defines a corresponding archive format called CSAR (Cloud Service ARchive).

![Figure 2: Structure of the CSAR](image)

A CSAR is a container file, i.e. it contains multiple files of possibly different file types. These files are typically organized in several subdirectories, each of which contains related files (and possibly other subdirectories etc). The organization into subdirectories and their content is specific for a particular cloud application. CSARs are zip files, typically compressed.

Each CSAR must contain a subdirectory called **TOSCA-Metadata**. This subdirectory must contain a so-called **TOSCA meta file**. This file is named **TOSCA** and has the file extension `.meta`. It represents metadata of the other files in the CSAR. This metadata is given in the format of name/value pairs. These name/value pairs are organized in blocks. Each block provides metadata of a certain artifact of the CSAR. An empty line separates the blocks in the TOSCA meta file.
The first block of the TOSCA meta file (Block_0 in Figure 3) provides metadata of the CSAR itself (e.g., its version, creator etc). Each other block begins with a name/value pair that points to an artifact within the CSAR by means of a pathname. The remaining name/value pairs in a block are the proper metadata of the pointed to artifact. For example, a corresponding name/value pair specifies the MIME-type of the artifact.

3.4 Use Cases

The specification supports at least the following major use cases.

3.4.1 Services as Marketable Entities

Standardizing Service Templates will support the creation of a market for hosted IT services. Especially, a standard for specifying Topology Templates (i.e., the set of components a service consists of as well as their mutual dependencies) enables interoperable definitions of the structure of services. Such a service topology model could be created by a service developer who understands the internals of a particular service. The Service Template could then be published in catalogs of one or more service providers for selection and use by potential customers. Each service provider would map the specified service topology to its available concrete infrastructure in order to support concrete instances of the service and adapt the management plans accordingly.
Making a concrete instance of a Topology Template can be done by running a corresponding Plan (so-called instantiating management plan, a.k.a. build plan). This build plan could be provided by the service developer who also creates the Service Template. The build plan can be adapted to the concrete environment of a particular service provider. Other management plans useful in various states of the whole lifecycle of a service could be specified as part of a Service Template. Similar to build plans such management plans can be adapted to the concrete environment of a particular service provider.

Thus, not only the structure of a service can be defined in an interoperable manner, but also its management plans. These Plans describe how instances of the specified service are created and managed. Defining a set of management plans for a service will significantly reduce the cost of hosting a service by providing reusable knowledge about best practices for managing each service. While the modeler of a service can include deep domain knowledge into a plan, the user of such a service can use a plan by simply “invoking” it. This hides the complexity of the underlying service behavior. This is very similar to the situation resulting in the specification of ITIL.

### 3.4.2 Portability of Service Templates

Standardizing Service Templates supports the portability of definitions of IT Services. Here, portability denotes the ability of one cloud provider to understand the structure and behavior of a Service Template created by another party, e.g. another cloud provider, enterprise IT department, or service developer.

Note that portability of a service does not imply portability of its encompassed components. Portability of a service means that its definition can be understood in an interoperable manner, i.e. the topology model and corresponding plans are understood by standard compliant vendors. Portability of the individual components themselves making up a particular service has to be ensured by other means – if it is important for the service.

### 3.4.3 Service Composition

Standardizing Service Templates facilitates composing a service from components even if those components are hosted by different providers, including the local IT department, or in different automation environments, often built with technology from different suppliers. For example, large organizations could use automation products from different suppliers for different data centers, e.g., because of geographic distribution of data centers or organizational independence of each location. A Service Template provides an abstraction that does not make assumptions about the hosting environments.

### 3.4.4 Relation to Virtual Images

A cloud provider can host a service based on virtualized middleware stacks. These middleware stacks might be represented by an image definition such as an OVF [OVF] package. If OVF is used, a node in a Service Template can correspond to a virtual system or a component (OVF’s “product”) running in a virtual system, as defined in an OVF package. If the OVF package defines a virtual system collection containing multiple virtual systems, a sub-tree of a Service Template could correspond to the OVF virtual system collection.

A Service Template provides a way to declare the association of Service Template elements to OVF package elements. Such an association expresses that the corresponding Service Template element can be instantiated by deploying the corresponding OVF package element. These associations are not limited to OVF packages. The associations could be to other package types or to external service interfaces. This flexibility allows a Service Template to be composed from various virtualization technologies, service interfaces, and proprietary technology.
4 Node Types

This chapter specifies how Node Types are defined. A Node Type is a reusable entity that defines the type of one or more Node Templates. As such, a Node Type defines the structure of observable properties via Node Type Properties, i.e. the names, data types and allowed values the properties defined in Node Templates using a Node Type or instances of such Node Templates can have.

A Node Type can inherit properties from another Node Type by means of the DerivedFrom element. Node Types might be declared as abstract, meaning that they cannot be instantiated. The purpose of such abstract Node Types is to provide common properties and behavior for re-use in specialized, derived Node Types. Node Types might also be declared as final, meaning that they cannot be derived by other Node Types.

The functions that can be performed on (an instance of) a corresponding Node Template are defined by the Interfaces of the Node Type. Finally, management Policies are defined for a Node Type.

4.1 Syntax

```xml
<NodeTypes>?
  <NodeType id="ID"
    name="string"?
    abstract="yes|no"?
    final="yes|no"?>
    <NodeTypeProperties element="QName"?
      type="QName"?/>
    <DerivedFrom nodeTypeRef="QName"/>
    <InstanceStates>?
      <InstanceState state="anyURI">+
      </InstanceState>
    </InstanceStates>
    <Interfaces>?
      <Interface name="NCName | anyURI">+
        <Operation name="NCName">
          <WSDL portType="QName"
            operation="NCName"/>
          <REST method="GET | PUT | POST | DELETE"
            abs_path="anyURI"?
            absoluteURI="anyURI"?
            requestBody="QName"?
            responseBody="QName"/>
          <Parameters>?
            <Parameter name="string" required="yes|no"/>
          </Parameters>
        </Operation>
      </Interface>
    </Interfaces>
  </NodeType>+</NodeTypes>
```
<REST>
    |</REST>
</ScriptOperation>

<InputParameters>?
    <InputParameter name="string"
        type="string"
        required="yes|no"/>+
</InputParameters>

<OutputParameters>?
    <OutputParameter name="string"
        type="string"
        required="yes|no"/>+
</OutputParameters>

</ScriptOperation>

</Operation>

<ImplementationArtifacts>?
    <ImplementationArtifact operationName="string"
        type="anyURI">+
</ImplementationArtifacts>

<RequiredContainerCapabilities>?
    <RequiredContainerCapability capability="anyURI"/>+
</RequiredContainerCapabilities>

artifact specific content

</ImplementationArtifact>

</ImplementationArtifacts>

</Interface>

</Interfaces>

</Policies>?
    <Policy name="string" type="anyURI">+
        policy specific content
    </Policy>
</Policies>

</DeploymentArtifacts>?
    <DeploymentArtifact name="string" type="anyURI">+
        artifact specific content
    </DeploymentArtifact>
</DeploymentArtifacts>

</DeploymentArtifacts>

</Interface>

</Interfaces>

</Policies>?
    <Policy name="string" type="anyURI">+
        policy specific content
    </Policy>
</Policies>

</DeploymentArtifacts>?
4.2 Properties

The `NodeType` element has the following properties:

- **id**: This attribute specifies the identifier of the Node Type. The identifier of the Node Type MUST be unique within the target namespace.

- **name**: This optional attribute specifies the name of the Node Type.

- **abstract**: This optional attribute specifies that no instances can be created from Node Templates that use this Node Type as their type.

  As a consequence, the corresponding abstract Node Type referenced by any Node Template has to be substituted by a Node Type derived from the abstract Node Type at the latest during the instantiation time of a Node Template.

  Note: an abstract Node Type MUST not be declared as final.

- **final**: This optional attribute specifies that no other Node Types MUST be derived from the specific Node Type.

  Note: a final Node Type MUST not be declared as abstract.

- **NodeTypeProperties**: This element specifies the structure of the observable properties of the Node Type, such as its configuration and state, by means of XML schema.

- **DerivedFrom**: This is an optional reference to another Node Type from which this Node Type derives. Conflicting definitions are resolved by the rule that local new definitions always override derived definitions. See section 4.3 Derivation Rules for details.

- **InstanceStates**: This optional element lists the set of states an instance of this Node Type can occupy at runtime.

- **Interfaces**: These are the definitions of functions that can be performed on (instances of) this Node Type.

- **Policies**: The nested list of elements provides information related to a particular management aspect like billing or monitoring.

- **DeploymentArtifacts**: This element specifies deployment artifacts relevant for the Node Type. A deployment artifact is an entity that – if specified – is needed for creating an instance of the corresponding Node Type. For example, a virtual image could be a deployment artifact of a JEE server.

The `NodeTypeProperties` element has one but not both of the following properties:

- The `element` attribute provides the QName of an XML element defining the structure of the Node Type Properties.

- The `type` attribute provides the QName of an XML (complex) type defining the structure of the Node Type Properties.

The `DerivedFrom` element has the following properties:

- **nodeTypeRef**: The QName specifies the Node Type from which this Node Type derives its definitions.
The `InstanceState` element has the following properties:

- `InstanceState`: specifies a potential state.

The `InstanceState` element has the following properties:

- `state`: a URI that represents a potential state.

The `Interface` element has the following properties:

- `name`: The name of the interface. This name is either a URI or it is an NCName that MUST be unique in the target namespace.
- `Operation`: This element defines an operation available to manage particular aspects of the Node Type. The `name` attribute of the `Operation` element defines the name of the operation and MUST be unique within the containing `Interface` of the Node Type.

Note that an interface of a Node Type typically defines one or more operations. However, interface definitions MAY also not contain any operation definition but just the definition of implementation artifacts. This allows for the definition of interfaces with just the description of operation signatures but not implementation artifacts in a Node Type. A derived Node Type can then provide the implementation artifacts for operations without having to redefine operation signatures provided by the Node Type derived from.

The `Operation` element has the following properties:

- `WSDL`: The operation is implemented by means of Web Service technology. The port type and operation of the Web Service are specified in the corresponding attributes of the `WSDL` element.
- `REST`: The operation is implemented as a REST API.
- `ScriptOperation`: The operation is implemented by scripts.

The `ImplementationArtifacts` element has the following properties:

- `ImplementationArtifact`: An implementation artifact of an operation. For example, a servlet might be an implementation artifact for a REST API.

Multiple implementation artifacts might be required for a single operation, e.g. in case a script operation is realized using different script languages in different environments.

The `WSDL` element has the following properties:

- `portType`: This is the QName of the port type that contains the definition of the operation defined as part of the interface. Note that the corresponding namespace MUST be imported.
- `operation`: This attribute specifies the name of an operation of the port type to become part of the interface.

The `REST` element has the following properties:

- `method`: The HTTP method to be used for building the REST request. If no method is explicitly specified, GET is assumed as default.
- `abs_path`: The absolute path of the URI that represents the target resource of the request.

Note, that the proper network location of the URI MUST be set as value of the Host header field of the request when using `abs_path` instead of `absoluteURI`.

- `absoluteURI`: The absolute URI of the resource.
Note, that either the `abs_path` or the `absoluteURI` MUST be specified.

- **requestBody**: The data passed in the body of the request message. The QName value of this attribute identifies the specification of the body, e.g. it refers to an XML Schema Definition document.

- **responseBody**: The data returned in the body of the response message. The QName value of this attribute identifies the specification of the body, e.g. it refers to an XML Schema Definition document.

- **Parameters**: This nested element describes a list of parameters as nested `Parameter` elements. Each `Parameter` has a `name` attribute and a `required` attribute that indicates whether the parameter is required or not. This list is the base for building the query string of the URI.

- **Headers**: This nested element describes a list of HTTP request headers as nested `Header` elements. Each `Header` has a `name` attribute and a `required` attribute that indicates whether the header is required or not. Only those headers SHOULD be listed that might be important for specifying the semantics of the request; otherwise, the HTTP client will set HTTP headers as usual.

The `ScriptOperation` element has the following properties:

- **InputParameters**: This optional property contains one or more nested `InputParameter` elements. Each such element specifies three attributes: the name of the parameter, its type, and whether it must be available as input (`required` attribute with a value of “yes”, which is the default) or not (value “no”). Note that the types of the parameters specified for an operation MUST comply with the type systems of the languages of implementations.

- **OutputParameters**: This optional property contains one or more nested `OutputParameter` elements. Each such element specifies three attributes: the name of the parameter, its type, and whether it must be available as output (`required` attribute with a value of “yes”, which is the default) or not (value “no”). Note that the types of the parameters specified for an operation MUST comply with the type systems of the languages of implementations.

The `ImplementationArtifact` element has the following properties:

- **operationName**: This optional attribute specifies the name of the operation that is implemented by the actual implementation artifact. If not specified, the implementation artifact is assumed to provide the implementation for all operations defined within the containing interface. For example, a `.WAR` file could provide the implementation for all REST operations of an interface.

- **type**: The type of the implementation artifact determines the specific content of the `ImplementationArtifact` element. For example, a script might be provided in place or by reference. A corresponding value of the `type` attribute indicates this.

- **RequiredContainerCapabilities**: An implementation of an operation might depend on certain capabilities of the environment it is executed in. For example, an implementation of an operation might use a particular interface for manipulating images, EJBs etc.

Each such dependency is explicitly declared by a separate `RequiredContainerCapability` element. The `capability` attribute of this element is a URI that denotes the corresponding requirement on the environment.

The `Policy` element has the following properties:
The type attribute specifies the kind of policy (e.g. management practice) supported by an instance of the Node Type containing this element. The name attribute defines the name of the policy. The name value MUST be unique within a given Node Type containing the current definition of the Policy.

Consider a hypothetical billing policy. In this example the type www.sample.com/BillingPractice could define a policy for billing usage of a service instance. The policy specific content can define the interface providing the operations to perform billing. Further content could specify the granularity of the base for payment, e.g. it could provide an enumeration with the possible values "service", "resource", and "labor". A value of "service" might specify that an instance of the corresponding node will be billed during its instance lifetime. A value of "resource" might specify that the resources consumed by an instance will be billed. A value of "labor" might specify that the use of a plan affecting a node instance will be billed.

The DeploymentArtifact element has the following properties:

- **name**: The attribute specifies the name of the artifact. Note, that uniqueness of the name within the scope of the encompassing Node Type SHOULD be guaranteed by the definition.
- **type**: The attribute specifies the type of the deployment artifact definition that is related to the Node Type, i.e. the attribute gives a hint how to interpret the body of the DeploymentArtifact element.

Note, that the combination of name and type SHOULD be unique within the scope of the Node Type.

- The body of this element contains the type-specific content.

For example, if the type attribute contains the value http://docs.oasis-open.org/tosca/ns/2011/12/deploymentArtifacts/ovfRef, the body will contain an XML fragment with a reference to an OVF package and a mapping between service template data and elements of the respective OVF envelope.

### 4.3 Derivation Rules

The following rules on combining definitions based on DerivedFrom apply:

- **Node Type Properties**: It is assumed that the XML element (or type) representing the Node Type Properties extends the XML element (or type) of the Node Type Properties of the Node Type referenced in the DerivedFrom element.

- **Instance States**: The set of instance states of the Node Type under definition consists of the set union of the instances states defined by the Nodes Type derived from and the instance states defined by the Node Type under definition. A set of instance states of the same name will be combined into a single instance state of the same name.

- **Interfaces**: The set of interfaces of the Node Type under definition consists of the set union of interfaces defined by the Node Type derived from and the interfaces defined by the Node Type under definition.

  Two interfaces of the same name will be combined into a single, derived interface with the same name. The set of operations of the derived interface consists of the set union of operations defined by both interfaces. If an operation defined by the Node Type under definition has the same name as an operation of the Node Type derived from, the former operation substitutes the latter one.

- **Implementation Artifacts**: The set of implementation artifacts of the Node Type under definition consists of the set union of implementation artifacts defined by the Node Type derived from and the implementation artifacts defined by the Node Type under definition.
If an implementation artifact defined by the Node Type under definition has the same operation name and type as an implementation artifact of the Node Type derived from, the former implementation artifact substitutes the latter one.

- Deployment Artifacts: The set of deployment artifacts of the Node Type under definition consists of the set union of the deployment artifacts defined by the Nodes Type derived from and the deployment artifacts defined by the Node Type under definition. A deployment artifact defined by the Node Type under definition substitutes a deployment artifact with the same name and type of the Node Type derived from.

- Policies: The set of policies of the Node Type under definition consists of the set union of the policies defined by the Nodes Type derived from and the policies defined by the Node Type under definition. A policy defined by the Node Type under definition substitutes a policy with the same name and type of the Node Type derived from.

### 4.4 Example

The following example defines the Node Type “Project”. It is defined in a Service Template “myService” within the target namespace “http://www.ibm.com/sample”. Thus, by importing the corresponding namespace in another Service Template, the Project Node Type is available for use in the other Service Template.

```xml
<ServiceTemplate id="myService" name="My Service" targetNamespace="http://www.ibm.com/sample">
  <NodeTypes>
    <NodeType id="Project" name="My Project">
      <documentation xml:lang="EN">
        A reusable definition of a node type supporting the creation of new projects.
      </documentation>
      <NodeTypeProperties element="ProjectProperties"/>
      <InstanceStates>
        <InstanceState state="www.example.com/active"/>
        <InstanceState state="www.example.com/onHalt"/>
      </InstanceStates>
      <Interfaces>
        <Interface name="ProjectInterface">
          <Operation name="CreateProject">
            <ScriptOperation>
              <InputParameters>
                <InputParameter name="ProjectName" type="string"/>
                <InputParameter name="Owner" type="string"/>
                <InputParameter name="AccountID" type="string"/>
              </InputParameters>
            </ScriptOperation>
          </Operation>
          <ImplementationArtifacts>
            <ImplementationArtifact operationName="CreateProject" type="http://www.example.com/ScriptArtifact/PhythonReference">
              <script>
                // Implementation code
              </script>
            </ImplementationArtifact>
          </ImplementationArtifacts>
        </Operation>
        <Operation>
          <ImplementationArtifacts>
            <ImplementationArtifact operationName="CreateProject" type="http://www.example.com/ScriptArtifact/PhythonReference">
              <script>
                // Implementation code
              </script>
            </ImplementationArtifact>
          </ImplementationArtifacts>
        </Operation>
      </Interfaces>
    </NodeType>
  </NodeTypes>
</ServiceTemplate>
```
The Node Type “Project” has three Node Type Properties defined as an XML element in the Types element definition of the Service Template document: Owner, ProjectName and AccountID which are all of type “string”. An instance of the Node Type “Project” could be “active” (more precise in state www.example.com/active) or “on hold” (more precise in state “www.example.com/onHold”). A single Interface is defined for this Node Type, and this Interface is defined by an Operation, i.e. its actual implementation is defined by the definition of the Operation. The Operation has the name CreateProject and two Input Parameters (exploiting the default value “yes” of the attribute required of the InputParameter element). The names of these two Input Parameters are ProjectName and AccountID, both of type “string”.

```xml
<scripts/phython/createProject.py
  </ImplementationArtifact>
  </ImplementationArtifacts>
  </Interface>
  </Interfaces>
  </NodeType>
  </NodeTypes>
  </ServiceTemplate>
```
5 Relationship Types

This chapter specifies how Relationship Types are defined. A Relationship Type is a reusable entity that
defines the type of one or more Relationship Templates between Node Templates. As such, a
Relationship Type can define the structure of observable properties via Relationship Type Properties. The
functions that can be performed on (an instance of) a corresponding Relationship Template are defined
by the Interfaces of the Relationship Type. Furthermore, a Relationship Type defines the potential states
an instance of it might reveal at runtime. A Relationship Type can inherit the definitions just listed from
another Relationship Type by means of the DerivedFrom element.

5.1 Syntax

```xml
<RelationshipTypes>
  <RelationshipType id="ID"
    name="string"?
    abstract="yes|no"?
    final="yes|no"?
    cascadingDeletion="yes|no">+
    <RelationshipTypeProperties element="QName"?
      type="QName"/>?
    <DerivedFrom relationshipTypeRef="QName"/>
  </RelationshipType>
  <InstanceStates>
    <InstanceState state="anyURI">+
  </InstanceStates>
  <SourceInterfaces>
    <Interface name="NCName | anyURI">+
  </SourceInterfaces>
  <TargetInterfaces>
  </TargetInterfaces>
  <ValidSource typeRef="QName"/>
  <ValidTarget typeRef="QName"/>
</RelationshipTypes>
```

5.2 Properties

The RelationshipType element has the following properties:

- **id**: This attribute specifies the identifier of the Relationship Type. The identifier of the
  Relationship Type MUST be unique within the target namespace.
- **name**: This optional attribute specifies the name of the Relationship Type.
- **abstract**: This optional attribute specifies that no instances can be created from Relationship Templates that use this Relationship Type as their type.
  
  As a consequence, the corresponding abstract Relationship Type referenced by any Relationship Template has to be substituted by a Relationship Type derived from the abstract Relationship Type at the latest during the instantiation time of a Relationship Template.

  Note: an abstract Relationship Type MUST not be declared as final.

- **final**: This optional attribute specifies that no other Relationship Types MUST be derived from the specific Relationship Type.
  
  Note: a final Relationship Type MUST not be declared as abstract.

- **cascadingDeletion**: If set to "yes" the target of an instance of a Relationship Template of this RelationshipType is automatically deleted when the source of the instance of the Relationship Template is deleted.

- **RelationshipTypeProperties**: This element specifies the structure of the observable properties of the Relationship Type, such as its configuration and state, by means of XML schema.

- **DerivedFrom**: This is an optional reference to another Relationship Type from which this Relationship Type derives. Conflicting definitions are resolved by the rule that local new definitions always override derived definitions. See section 5.3 Derivation Rules for details.

- **InstanceStates**: This optional element lists the set of states an instance of this Node Type can occupy at runtime.

- **SourceInterfaces**: This optional element contains definitions of manageability interfaces that can be performed on the source of a relationship of this Relationship Type to actually establish the relationship between the source and the target in the deployed service. Those interface definitions are contained in nested Interface elements, the content of which is that described for Node Type interfaces (see section 4.2).

- **TargetInterfaces**: This optional element contains definitions of manageability interfaces that can be performed on the target of a relationship of this Relationship Type to actually establish the relationship between the source and the target in the deployed service. Those interface definitions are contained in nested Interface elements, the content of which is that described for Node Type interfaces (see section 4.2).

- **ValidSource**: This optional element specifies by means of its typeRef attribute the QName of a Node Type that is allowed as a valid origin for relationships defined using the Relationship Type under definition. Node Types derived from the specified Node Type MUST also be accepted as valid origin of relationships. If not specified, any Node Type is allowed to be the origin of the relationship.

- **ValidTarget**: This optional element specifies by means of its typeRef attribute the QName of a Node Type that is allowed as a valid target for relationships defined using the Relationship Type under definition. Node Types derived from the specified Node Type MUST also be accepted as valid target of relationships. If not specified, any Node Type is allowed to be the origin of the relationship.

The **RelationshipTypeProperties** element has the following properties:
891  • **element**: The QName value of this attribute refers to an XML element defining the structure of
892  the Relationship Type Properties.
893  • **type**: The QName value of this attribute refers to an XML (complex) type defining the structure
894  of the Relationship Type Properties.
895  Either the `element` attribute or the `type` attribute MUST be specified, but not both.
896  The `InstanceStates` element has the following properties:
897  • **InstanceState**: specifies a potential state.
898  The `InstanceState` element has the following properties:
899  • **state**: a URI that represents a potential state.

5.3 Derivation Rules

The following rules on combining definitions based on `DerivedFrom` apply:

- **Relationship Type Properties**: It is assumed that the XML element (or type) representing the
  Relationship Type properties of the Relationship Type under definition extends the XML element
  (or type) of the Relationship Type properties of the Relationship Type referenced in the
  `DerivedFrom` element.

- **Instance States**: The resulting set of instance states of the Relationship Type under definition
  consists of the set union of the instances states defined by the Relationship Type derived from
  and the instance states explicitly defined by the Relationship Type under definition. Instance
  states with the same state attribute will be combined into a single instance state of the same
  state.

- **Valid source and target**: A Node Type specified as a valid source or target, respectively, of the
  Relationship Type under definition MUST be of a subtype defined as valid source or target,
  respectively, of the Relationship Type derived from.

  If the Relationship Type derived from has no valid source or target defined, the Node Types of the
  `ValidSource` or `ValidTarget` elements of the Relationship Type under definition are not
  restricted.

  If the Relationship Type under definition has no source or target defined, only the Node Types
  defined as source or target of the Relationship Type derived from are valid origins or destinations
  of the Relationship Type under definition.

5.4 Example

The following example defines the Relationship Type “processDeployedOn”. The meaning of this
Relationship Type is that “a process is deployed on a hosting environment”. When the source of an
instance of a Relationship Template refering to this Relationship Type is deleted, its target is
automatically deleted as well. The Relationship Type has Relationship Type Properties defined in the
`Types` section of the same Service Template document as the “ProcessDeployedOnProperties” element.
The states an instance of this Relationship Type can be in are also listed.

```xml
<RelationshipTypes>
  <RelationshipType id="processDeployedOn"
    name="Process is deployed on"
    cascadingDeletion="yes">
    <RelationshipTypeProperties element="ProcessDeployedOnProperties"/>
  </RelationshipType>
</RelationshipTypes>
```
936 <InstanceStates>
937   <InstanceState state="www.example.com/successfullyDeployed"/>
938   <InstanceState state="www.example.com/failed"/>
939 </InstanceStates>
940 </RelationshipType>
941 </RelationshipTypes>
6 Topology Template

This chapter specifies how Topology Templates are defined. A Topology Template defines the overall structure of an IT service, i.e. the components it consists of, the relations between those components, as well as grouping of components. The components of a service are referred to as Node Templates, the relations between the components are referred to as Relationship Templates, and groupings are referred to as Group Templates.

6.1 Syntax

```xml
<TopologyTemplate id="ID"
    name="string"?/>

  (  
    <NodeTemplate id="ID"
        name="string"?
        nodeType="QName"
        minInstances="int"?
        maxInstances="int|string"?/>

    <PropertyDefaults>?
        XML fragment
    </PropertyDefaults>

    <PropertyConstraints>?
        <PropertyConstraint property="string"
            constraintType="anyURI">+
            constraint?
        </PropertyConstraint>

    <Policies>?
        <Policy name="string" type="anyURI">+
            policy specific content
        </Policy>

    <EnvironmentConstraints>?
        <EnvironmentConstraint constraintType="anyURI">+
            constraint type specific content?
        </EnvironmentConstraint>

    <DeploymentArtifacts>?
        <DeploymentArtifact name="string" type="anyURI">+
            artifact specific content
        </DeploymentArtifact>

    <ImplementationArtifacts>?
        <ImplementationArtifact operationName="string"
            type="anyURI">+
            <RequiredContainerCapabilities>?
```
<RequiredContainerCapability capability="anyURI"/>
</RequiredContainerCapabilities>

artifact specific content

<ImplementationArtifact>
</ImplementationArtifacts>

</NodeTemplate>

| <RelationshipTemplate id="ID"
  name="string"?
  relationshipType="QName">

  <SourceElement id="IDREF"/>

  ( <TargetElement id="IDREF"/>
  | <TargetElementReference id="QName"/>
  )

  <PropertyDefaults>?

    XML fragment

  </PropertyDefaults>

  <PropertyConstraints>?

    <PropertyConstraint property="string"
      constraintType="anyURI">+
      constraint? 
    </PropertyConstraint>

  </PropertyConstraints>

</RelationshipTemplate>

| <GroupTemplate id="ID"
  name="string"?
  minInstances="int"?
  maxInstances="int|string">

  ( <NodeTemplate ... />
  | <RelationshipTemplate ... />
  | <GroupTemplate ... >)

</GroupTemplate>

| <Policies>?

  <Policy name="string" type="anyURI">+

    policy specific content
6.2 Properties

The TopologyTemplate element has the following properties:

- **id**: This attribute specifies the identifier of the Topology Template. The identifier of the Topology Template MUST be unique within the target namespace.

- **name**: This optional attribute specifies the name of the Topology Template.

- **NodeTemplate**: This is a kind of a component making up the IT service.

- **RelationshipTemplate**: This is a kind of relationship between the components (nodes or groups) of the service.

- **GroupTemplate**: This is a grouping of node templates, relationship templates, or (nested) group templates within the Topology Templates to express a special association between the grouped elements.

A Topology Template can contain any number of Node Templates, Relationship Templates, or Group Templates (i.e. “elements”). For each specified Relationship Template (either defined as a direct child of the Topology Template or within a Group Template) the source element and target element MUST be specified in the Topology Template except for target elements that are referenced (via a target element reference).

The NodeTemplate element has the following properties:

- **id**: This attribute specifies the identifier of the Node Template. The identifier of the Node Template MUST be unique within the target namespace.

- **name**: This optional attribute specifies the name of the Node Template.

- **nodeType**: The QName value of this attribute refers to the Node Type providing the type of the Node Template.

  Note: If the Node Type referenced by nodeType attribute of a Node Template is declared as abstract, no instances of the specific Node Template can be created. Instead, a substitution of the Node Type with a specialized, derived Node Type has to be done at the latest during the instantiation time of the Node Template.

- **minInstances**: This integer attribute specifies the minimum number of instances to be created when instantiating the Node Template. The default value of this attribute is 1. The value of minInstances MUST NOT be less than 0.

- **maxInstances**: This attribute specifies the maximum number of instances that can be created when instantiating the Node Template. The default value of this attribute is 1. If the string is set to “unbounded”, an unbounded number of instances can be created. The value of maxInstances MUST be 1 or greater and MUST NOT be less than the value specified for minInstances.

- **PropertyDefaults**: Specifies initial values for one or more of the Node Type Properties of the Node Type providing the property definitions in the concrete context of the Node Template.
The initial values are specified by providing an instance document of the XML schema of the corresponding Node Type Properties. This instance document considers the inheritance structure deduced by the DerivedFrom property of the Node Type referenced by the nodeType attribute of the Node Template.

The instance document of the XML schema might not validate against the existence constraints of the corresponding schema: not all Node Type properties might have an initial value assigned, i.e. mandatory elements or attributes might be missing in the instance provided by the Property Defaults element. Once the defined Node Template has been instantiated, any XML representation of the Node Type properties MUST validate according to the associated XML schema definition.

- **PropertyConstraints**: Specifies constraints on the use of one or more of the Node Type Properties of the Node Type providing the property definitions for the Node Template.
  Each constraint is specified by means of a separate nested PropertyConstraint element. This element contains the actual encoding of the constraint.

- **Policies**: Specifies policies of the Node Template. Each policy is specified by means of a separate nested Policy element. This element contains the actual policy specific content of the policy.
  Note, that a policy specified in the Node Template overrides any policy of the same name and type that might be specified with the Node Type of this Node Template.

  Any policies of the Node Type that are not overridden are combined with the policies of the Node Template.

- **EnvironmentConstraints**: The nested EnvironmentConstraint elements of the Node Template under definition constrain the runtime environment for the corresponding component of a service. For example, constraints on network security settings of the hosting environment or requirements on the existence of certain resources might be defined within the environment constraints definition of a Node Template.

- **DeploymentArtifacts**: This element specifies the deployment artifacts relevant for the Node Template under definition.
  Its nested DeploymentArtifact elements specify details about individual deployment artifacts. The name attribute of a DeploymentArtifact element specifies the name of the artifact. Uniqueness of the name within the scope of the encompassing Node Template SHOULD be guaranteed by the definition. The type attribute of a DeploymentArtifact element specifies the type of the deployment artifact definition that is related to the Node Template, i.e. the attribute gives a hint how to interpret the body of the DeploymentArtifact element. The body of this element contains the type-specific content.
  For example, if the type attribute contains the value http://docs.oasis-open.org/tosca/ns/2011/12/deploymentArtifacts/ovfRef, the body will contain an XML fragment with a reference to an OVF package and a mapping between service template data and elements of the respective OVF envelope.

  Note, that a deployment artifact specified with the Node Template under definition overrides any deployment artifact of the same name and the same type specified with the Node Type given as value of the nodeType attribute of the Node Template under definition.

  Otherwise, the deployment artifacts of the Node Type given as value of the nodeType attribute of the Node Template under definition and the deployment artifacts defined with the Node Template are combined.
• ImplementationArtifact: An implementation of an operation. For example, a servlet
might be an implementation artifact for a REST API. Multiple implementation artifacts might be
required for a single operation, e.g. in case a script operation is realized using different script
languages in different environments.

The operationName attribute specifies the name of the operation that is implemented by the
implementation artifact under definition. The type attribute determines the specific content of the
ImplementationArtifact element. For example, a script might be provided in place or by
reference. A corresponding value of the type attribute indicates this.

The nested RequiredContainerCapabilities element specifies certain capabilities of
the environment an implementation of an operation might depend on. For example, an
implementation of an operation might use a particular interface for manipulating images, EJBs
etc. Each such dependency is explicitly declared by a separate
RequiredContainerCapability element. The capability attribute of this element is
a URI that denotes the corresponding requirement on the environment.

Note, that an implementation artifact specified with the Node Template under definition overrides
any implementation artifact with the same operationName and the same type specified with
the Node Type given as value of the nodeType attribute of the Node Template under definition.

Otherwise, the implementation artifacts of the Node Type given as value of the nodeType
attribute of the Node Template under definition and the implementation artifacts defined with the
Node Template are combined.

The PropertyConstraint element has the following properties:

• property: The string value of this property is an XPath expression pointing to the property
within the Node Type Properties document that is constrained within the context of the Node
Template. More than one constraint MUST NOT be defined for each property.

• constraintType: The constraint type is specified by means of a URI, which defines both the
semantic meaning of the constraint as well as the format of the content.

For example, a constraint type of http://www.example.com/PropertyConstraints/unique could
denote that the reference property of the node template under definition has to be unique within a
certain scope. The constraint type specific content of the respective PropertyConstraint
element could then define the actual scope in which uniqueness has to be ensured in more detail.

The Policy element has the following properties:

• type: This attribute specifies the kind of policy (e.g. management practice) supported by an
instance of the Node Type containing this element.

• name: This attribute defines the name of the policy. The name MUST be unique within a given
Node Type containing the Policy element.

The EnvironmentConstraint element has the following properties:

• constraintType: The constraint type is specified by means of a URI, which defines both the
semantic meaning of the constraint as well as the format of the contraint content.

The RelationshipTemplate element has the following properties:

• id: This attribute specifies the identifier of the Relationship Template. The identifier of the
Relationship Template MUST be unique within the target namespace.
- **name**: This optional attribute specifies the name of the Relationship Template.

- **relationshipType**: The QName value of this property refers to the Relationship Type providing the type of the Relationship Template.

  Note: If the Relationship Type referenced by the relationshipType attribute of a Relationship Template is declared as abstract, no instances of the specific Relationship Template can be created. Instead, a substitution of the Relationship Type with a specialized, derived Relationship Type has to be done at the latest during the instantiation time of the Relationship Template.

- **SourceElement**: The id attribute of this element references a Node Template or Group Template within the same Service Template document that is the source of the Relationship Template.

  If the Relationship Type referenced by the relationshipType attribute defines a constraint on the valid source of the relationship by means of its ValidSource element, the id attribute of SourceElement MUST reference a Node Template the type of which complies with the valid source constraint of the respective Relationship Type.

- **TargetElement**: The id attribute of this element references a Node Template or Group Template within the same Service Template document that is the target of the Relationship Template.

  If the Relationship Type referenced by the relationshipType attribute defines a constraint on the valid target of the relationship by means of its ValidTarget element, the id attribute of TargetElement MUST reference a Node Template the type of which complies with the valid target constraint of the respective Relationship Type.

- **TargetElementReference**: The id attribute of this element refers by QName to an imported Node Template or Group Template that is the target of the Relationship Template. The referenced Node Template or Group Template will typically be the root node or root group of the corresponding Topology Template. In some cases a non-root Node Template or non-root Group Template might be referenced to support access to particular resources from a larger service, for example.

  If the Relationship Type referenced by the relationshipType attribute defines a constraint on the valid target of the relationship by means of its ValidTarget element, the id attribute of TargetElementReference MUST reference a Node Template the type of which complies with the valid target constraint of the respective Relationship Type.

  Either TargetElement or TargetElementReference MUST be specified but not both.

- **PropertyDefaults**: Specifies initial values for one or more of the Relationship Type properties of the Relationship Type providing the property definitions in the concrete context of the Relationship Template.

  The initial values are specified by providing an instance document of the XML schema of the corresponding Relationship Type properties.

  The instance document of the XML schema might not validate against the existence constraints of the corresponding schema: not all Relationship Type properties might have an initial value assigned, i.e. mandatory elements or attributes might be missing in the instance provided by the Property Defaults element. Once the defined Relationship Template has been instantiated, any
XML representation of the Relationship Type properties MUST validate according to the associated XML schema definition.

- **PropertyConstraints**: Specifies constraints on the use of one or more of the Relationship Type properties of the Relationship Type providing the property definitions for the Relationship Template.
  
  Each constraint is specified by means of a separate nested `PropertyConstraint` element. This element contains the actual encoding of the constraint.

- **RelationshipConstraints**: Specifies constraints on the use of the relationship.
  
  Each constraint is specified by means of a separate nested `RelationshipConstraint` element. This element can contain the actual encoding of the constraint, or its `constraintType` attribute already denotes the constraint itself. The constraint type is specified by means of a URI, which defines both the semantic meaning of the constraint as well as the format of any content.

The `GroupTemplate` element has the following properties:

- **id**: This attribute specifies the identifier of the Group Template. The identifier of the Group Template MUST be unique within the target namespace.

- **name**: This optional attribute specifies the name of the Group Template.

- **minInstances**: This integer attribute specifies the minimum number of instances to be created when instantiating the Group Template. The default value of this attribute is 1. The value of `minInstances` MUST NOT be less than 0.

- **maxInstances**: This attribute specifies the maximum number of instances that can be created when instantiating the Group Template. The default value of this attribute is 1. If the string is set to "unbounded", an unbounded number of instances can be created. The value of `maxInstances` MUST be 1 or greater and MUST NOT be less than the value specified for `minInstances`.

- **NodeTemplate**: This is a node template contained within, or grouped by the Group Template.

- **RelationshipTemplate**: This is a relationship template contained within, or grouped by the Group.

- **GroupTemplate**: This is a Group Template of a nested group contained within, or grouped by the Group Template.

- **Policies**: Specifies policies of the Group Template. Each policy is specified by means of a separate nested `Policy` element. This element contains the actual policy specific content of the policy.

### 6.3 Example

The following Service Template defines a Topology Template in-place. The corresponding Topology Template contains two Node Templates called “MyApplication” and “MyAppServer”. These Node Templates have the node types “Application” and “ApplicationServer”, respectively, the definitions of which are imported by the `Import` element. The Node Template “MyApplication” is instantiated exactly once. Two of its Node Type Properties are initialized by a corresponding `PropertyDefaults` element. The Node Template “MyAppServer” can be instantiated as many times as needed. The “MyApplication” Node Template is connected with the “MyAppServer” Node Template via the Relationship Template named “MyDeploymentRelationship”; the behavior and semantics of the Relationship Template is defined in the Relationship Type “deployedOn” in the same Service Template document, saying that “MyApplication” is deployed on “MyAppServer”. When instantiating the “SampleApplication” Topology
Template, instances of “MyApplication” and “MyAppServer” are related by means of corresponding instances of “MyDeploymentRelationship”.

```xml
<ServiceTemplate id="myService"
  name="My Service"
  targetNamespace="http://www.ibm.com/sample"
  xmlns:abc="http://www.ibm.com/sample">
  <Import namespace="http://www.ibm.com/sample"
    importType="http://docs.oasis-open.org/tosca/ns/2011/12"/>

  <TopologyTemplate id="SampleApplication">
    <NodeTemplate id="MyApplication"
      name="My Application"
      nodeType="abc:Application">
      <PropertyDefaults>
        <ApplicationProperties>
          <Owner>Frank</Owner>
          <InstanceName>Thomas’ favorite application</InstanceName>
        </ApplicationProperties>
      </PropertyDefaults>
    </NodeTemplate/>

    <NodeTemplate id="MyAppServer"
      name="My Application Server"
      nodeType="abc:ApplicationServer"
      minInstances="0"
      maxInstances="unbounded"/>

    <RelationshipTemplate id="MyDeploymentRelationship"
      relationshipType="deployedOn">
      <SourceElement id="MyApplication"/>
      <TargetElement id="MyAppServer"/>
    </RelationshipTemplate>
  </TopologyTemplate>
</ServiceTemplate>
```
7 Plans

The operational management behavior of a Service Template is invoked by means of orchestration plans, or more simply, Plans. Plans consist of individual steps (aka tasks or activities) to be performed and the definition of the potential order of these steps. The execution of a step can be performed by one of the functions offered via the interfaces of a Node Template, by invoking operations of a Service Template API, or by invoking other operations being required in the context of a specific service. Plans are classified by a type, and the following two plan types are defined as part of the TOSCA specification. Build plans specify how instances of their associated Service Templates are made, and termination plans specify how an instance of a Service Template is removed from the environment. Other plan types for managing existing service instances throughout their life time are termed modification plans, and it is expected that such plan types will be defined subsequently by authors of service templates and domain expert groups.

7.1 Syntax

```xml
<Plans>
  <Plan id="ID"
    name="string"?
    planType="anyURI"
    languageUsed="anyURI">
    <PreCondition expressionLanguage="anyURI">?
      condition
    </PreCondition>
    ( <PlanModel>
      actual plan
    </PlanModel>
    |<PlanModelReference reference="anyURI"/>
  )
</Plan>
</Plans>
```

7.2 Properties

The Plans element contains one or more Plan elements which have the following properties:

- **id**: This attribute specifies the identifier of the Plan. The identifier of the Plan MUST be unique within the target namespace.

- **name**: This optional attribute specifies the name of the Plan.

- **planType**: The value of the attribute specifies the type of the plan as an indication on what the effect of executing the plan on a service will have. The plan type is specified by means of a URI, allowing for an extensibility mechanism for authors of service templates to define new plan types over time.

The following plan types are defined as part of the TOSCA specification.
This URI defines the build plan plan type for plans used to initially create a new instance of a service from a Service Template.

- http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/TerminationPlan - This URI defines the termination plan plan type for plans used to terminate the existence of a service instance.

Note that all other plan types for managing service instances throughout their life time will be considered and referred to as modification plans in general.

- languageUsed: This attribute denotes the process modeling language (or metamodel) used to specify the plan. For example, "http://www.omg.org/spec/BPMN/2.0/" would specify that BPMN 2.0 has been used to model the plan.

- PreCondition: This optional element specifies a condition that needs to be satisfied in order for the plan to be executed. The expressionLanguage attribute of this element specifies the expression language the nested condition is provided in.

  Typically, the precondition will be an expression in the instance state attribute of some of the node templates or relationship templates of the topology template. It will be evaluated based on the actual values of the corresponding attributes at the time the plan is requested to be executed.
  
  Note, that any other kind of pre-condition is allowed.

- PlanModel: This property contains the actual model content.

- PlanModelReference: This property points to the model content. Its reference attribute contains a URI of the model of the plan.

An instance of the Plan element MUST either contain the actual plan as instance of the PlanModel element, or point to the model via the PlanModelReference element.

### 7.3 Use of Process Modeling Languages

TOSCA does not specify a separate metamodel for defining plans. Instead, it is assumed that a process modelling language (a.k.a. metamodel) like BPEL [BPEL 2.0] or BPMN [BPMN 2.0] is used to define plans. The specification favours the use of BPMN for modeling plans.

### 7.4 Example

The following defines two Plans, one Plan for creating a new instance of the “SampleApplication” Topology Template (the plan is named “DeployApplication”), and one Plan for removing instances of “SampleApplication”. The Plan “DeployApplication” is a build plan specified in BPMN; the process model is immediately included in the Plan Model (note that the BPMN model is incomplete but used to show the mechanism of the PlanModel element). The Plan can only run when the PreCondition “Run only if funding is available” is satisfied. The Plan “RemoveApplication” is a termination plan specified in BPEL; the corresponding BPEL definition is defined elsewhere and only referenced by the PlanModelReference element.

```xml
<Plans>
  <Plan id="DeployApplication"
    name="Sample Application Build Plan"
    planType="http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/BuildPlan"
    languageUsed="http://www.omg.org/spec/BPMN/2.0/">
    <PreCondition expressionLanguage="www.example.com/text">?
      Run only if funding is available
  </Plan>
  <Plan id="RemoveApplication"
    name="Sample Application Termination Plan"
    planType="http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/TerminationPlan"
    languageUsed="http://www.omg.org/spec/BPEL/2.0/">
    <PreCondition expressionLanguage="www.example.com/text">?
      Remove only if sufficient funds are available
  </Plan>
</Plans>
```
</PreCondition>

<PlanModel>
  <Process name="DeployNewApplication" id="p1">
    <Documentation>This process deploys a new instance of the sample application.</Documentation>
    <Task id="t1" name="CreateAccount"/>
    <Task id="t2" name="AcquireNetworkAddresses"
      isSequential="false"
      loopDataInput="t2Input.LoopCounter"/>
    <Documentation>Assumption: t2 gets data of type "input" as input and this data has a field names "LoopCounter" that contains the actual multiplicity of the task.</Documentation>
    <Task id="t3" name="DeployApplicationServer"
      isSequential="false"
      loopDataInput="t3Input.LoopCounter"/>
    <Task id="t4" name="DeployApplication"
      isSequential="false"
      loopDataInput="t4Input.LoopCounter"/>
    <SequenceFlow id="s1" targetRef="t2" sourceRef="t1"/>
    <SequenceFlow id="s2" targetRef="t3" sourceRef="t2"/>
    <SequenceFlow id="s3" targetRef="t4" sourceRef="t3"/>
  </Process>
</PlanModel>

<Plan id="RemoveApplication"
  planType="http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/TerminationPlan"
  languageUsed="http://docs.oasis-open.org/wsbpel/2.0/process/executable">
  <PlanModelReference reference="prj:RemoveApp"/>
</Plan>
</Plans>
8 Cloud Service Archive (CSAR)

This section defines the metadata of a cloud service archive as well as its overall structure.

8.1 Overall Structure of a CSAR

A CSAR is a zip file containing at least two directories, the TOSCA-Metadata directory and the Service-Template directory. Beyond that, other directories may be contained in a CSAR, i.e. the creator of a CSAR has all freedom to define the content of a CSAR and the structuring of this content as appropriate for the cloud application.

The TOSCA-Metadata directory contains metadata describing the other content of the CSAR. This metadata is referred to as TOSCA meta file. This file is named TOSCA and has the file extension .meta.

The Service-Template directory contains one or more Service Template files (file extension .ste). These Service Template files contain definitions related to the cloud application of the CSAR. One of these Service Template files is distinguished as entry Service Template, i.e. it contains the definition of the structure and behavior of the cloud application, while the other Service Template files contain definitions that are referenced by the entry Service Template.

8.2 TOSCA Meta File

The TOSCA meta file includes metadata that allows interpreting the various artifacts within the CSAR properly. The TOSCA.meta file is contained in the TOSCA-Metadata directory of the CSAR.

A TOSCA meta file consists of name/value pairs. The name-part of a name/value pair is followed by a colon, followed by a blank, followed by the value-part of the name/value pair. The name MUST not contain a colon. Values that represent binary data must be base64 encoded. Values that extend beyond one line can be spread over multiple lines if each subsequent line starts with at least one space. Such spaces are then collapsed when the value string is read.

Each name/value pair is in a separate line. A list of related name/value pairs, i.e. a list of consecutive name/value pairs describing a particular file in a CSAR, is called a block. Blocks are separated by an empty line. The first block, called block_0, is metadata about the CSAR itself. All other blocks represent metadata of files in the CSAR.

The structure of block_0 in the TOSCA meta file is as follows:

TOSCA-Meta-File-Version: digit.digit
CSAR-Version: digit.digit
Created-By: string
Entry-Service-Template: filename

The name/value pairs are as follows:

- TOSCA-Meta-File-Version: This is the version number of the TOSCA meta file format. The value must be "1.0" in the current version of the TOSCA specification.
- CSAR-Version: This is the version number of the CSAR specification. The value must be "1.0" in the current version of the TOSCA specification.
- Created-By: The person or vendor, respectively, who created the CSAR.
- Entry-Service-Template: The service template from the Service-Template directory of the CSAR that is the entry point for the overall cloud application.
Note, that a CSAR may contain multiple Service Template files. One reason for this is completeness, e.g. a Service Template containing Node Types referred to by the entry Service Template might be included in the Service-Template directory to avoid importing it from external locations.

The first line of a block (other than block_0) must be a name/value pair that has the name “Name” and the value of which is the path-name of the file described. The second line must be a name/value pair that has the name “Content-Type” describing the type of the file described; the format is that of a MIME type with type/subtype structure. The other name/value pairs that consecutively follow are file-type specific.

```plaintext
Name: <path-name_1>
Content-Type: type_1/subtype_1
<namell_1>: <value_11>
<namell_2>: <value_12>
...
<namell_n>: <value_1n>

Name: <path-name_k>
Content-Type: type_k/subtype_k
<namell_1>: <value_k1>
<namell_2>: <value_k2>
...
<namell_km>: <value_km>
```

The name/value pairs are as follows:

- **Name:** The pathname or pathname pattern of the file(s) or resources described within the actual CSAR.
  
  Note, that the file located at this location may basically contain a reference to an external file. Such a reference is given by a URI that is of one of the URL schemes “file”, “http”, or “https”.

- **Content-Type:** The type of the file described. This type is a MIME type complying with the type/subtype structure. Vendor defined subtypes should start as usual with the string “vnd.”.

Note that later directives override earlier directives. This allows for specifying global default directives that can be specialized by later directorives in the TOSCA meta file.

### 8.3 Example

Figure 5 depicts a sample Service Template of an application, named Payroll.ste. The application is a payroll application written in Java that must be deployed on a proper application server. The Service Template of the application defines the Node Template Payroll Application, the Node Template Application Server, as well as the Relationship Template deployed_on. The Payroll Application is associated with an EAR file (named Payroll.ear) which is provided as corresponding Deployment Artifact of the Payroll Application Node Template. An Amazon Machine Image (AMI) is the Deployment Artifact of the Application Server Node Template; this Deployment Artifact is a reference to the image in the Amazon EC2 environment. The Implementation Artifacts of some operations of the Node Templates are provided too; for example, the start operation of the Payroll Application is implemented by a Java API supported by the payrolladm.jar file, the installApp operation of the Application Server is realized by the Python script wsadmin.py, while the runInstances operation is a REST API available at Amazon for running instances of an AMI. Note, that the runInstances operation is not related to a particular implementation artifact because it is available as an Amazon Web Service (https://ec2.amazonaws.com/?Action=RunInstances); but the details of this REST API are specified with the operation of the Application Server Node Type.
The corresponding Node Types and Relationship Types have been defined in the PayrollTypes.ste document, which is imported by the Payroll Service Template. The following listing provides some of the details:

```xml
<ServiceTemplate id="Payroll"
    targetNamespace="http://www.example.com/ste"
    xmlns:pay="http://www.example.com/ste/Types">
    <Import namespace="http://www.example.com/ste/Types"
        location="http://www.example.com/ste/Types/PayrollTypes.ste"
        importType="http://docs.oasis-open.org/ns/tosca/2011/12/">
        <Types>
            ...
        </Types>
    </Import>

    <TopologyTemplate ID="PayrollTemplate">
        <NodeTemplate id="Payroll Application"
            nodeType="pay:ApplicationNodeType">
            ...
            <DeploymentArtifacts>
                <DeploymentArtifact name="PayrollEAR"
                    type="http://www.example.com/ns/tosca/2011/12/DeploymentArtifactTypes/CSARref">
                    EARs/Payroll.ear
                </DeploymentArtifact>
            </DeploymentArtifacts>

            <ImplementationArtifacts>
                <ImplementationArtifact operationName="start"
                    type="http://www.example.com/ns/tosca/2011/12/ImplementationArtifactTypes/CSARref">
                    JARs/payrolladm.jar
                </ImplementationArtifact>
            </ImplementationArtifacts>
        </NodeTemplate>
    </TopologyTemplate>
</ServiceTemplate>
```

Figure 5: Sample Service Template
The **Payroll Application** Node Template specifies the deployment artifact **PayrollEAR**. It is a reference to the CSAR containing the **Payroll.ste** file, which is indicated by the **/CSARref** type of the **DeploymentArtifact** element. The type specific content is a path expression in the directory structure of the CSAR: it points to the **Payroll.ear** file in the **EARS** directory of the CSAR (see Figure 6 for the structure of the corresponding CSAR).

The **Payroll Application** Node Template also contains an **ImplementationArtifact** element. This element contains information about the implementation of the **start** operation by pointing to the **payrolladm.jar** file in the **JARs** directory of the CSAR.

The **Application Server** Node Template has a **DeploymentArtifact** called **ApplicationServerImage** that is a reference to an AMI (Amazon Machine Image), indicated by an **/AMIref** type. It provides a Python script (the **wsadmin.py** file in the **Python** directory of the CSAR) as implementation of the **install** operation; the type of the implementation artifact is again a CSAR reference.

The corresponding CSAR has the following structure (see Figure 6): The **TOSCA.meta** file is contained in the **TOSCA-Metadata** directory. The **Payroll.ste** file itself is contained in the **ServiceTemplate** directory. Also, the **PayrollTypes.ste** file is in this directory. The content of the other directories has been sketched before.
The TOSCA.meta file is as follows:

```
TOSCA-Meta-Version: 1.0
CSAR-Version: 1.0
Created-By: Frank
Entry-Service-Template: /Service-Template/Payroll.ste

Name: Service-Template/Payroll.ste
Content-Type: application/vnd.oasis.service_template

Name: Service-Template/PayrollTypes.ste
Content-Type: application/vnd.oasis.service_template

Name: Plans/AddUser.bpmn
Content-Type: application/vnd.oasis.bpmn

Name: EARs/Payroll.ear
Content-Type: application/vnd.oasis.ear

Name: JARs/Payrolladm.jar
Content-Type: application/vnd.oasis.jar

Name: Python/wsadmin.py
Content-Type: application/vnd.oasis.py
```
9 Security Considerations

TOSCA does not mandate the use of any specific mechanism or technology for client authentication. However, a client MUST provide a principal or the principal MUST be obtainable by the infrastructure.
10 Conformance

This section is to be done.
Appendix A. Portability and Interoperability Considerations

This section illustrates the portability and interoperability aspects addressed by Service Templates:

Portability - The ability to take Service Templates created in one vendor's environment and use them in another vendor's environment.

Interoperability - The capability for multiple components (e.g. a task of a plan and the definition of a topology node) to interact using well-defined messages and protocols. This enables combining components from different vendors allowing seamless management of services.

Portability demands support of TOSCA elements.
Appendix B. Acknowledgements

The following individuals have participated in the creation of this specification and are gratefully acknowledged.

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Appendix C. Complete TOSCA Grammar

Note: The following is a pseudo EBNF grammar notation meant for documentation purposes only. The grammar is not intended for machine processing.

```
<ServiceTemplate id="ID"
    name="string"?
    targetNamespace="anyURI">
  <Extensions>?</
    <Extension namespace="anyURI"
      mustUnderstand="yes|no"/>+</Extensions>
  <Import namespace="anyURI"?
    location="anyURI"?
    importType="anyURI"/>*
  <Types>?</
    <xs:schema .../>*
</Types>
(1
  <TopologyTemplateReference reference="QName"/>
  |
  <TopologyTemplate id="ID"
    name="string"?>
  )
  (25
  <NodeTemplate id="ID"
    name="string"?
    nodeType="QName"
    minOccurs="int"?
    maxInstances="int|string"?)
  <PropertyDefaults>?
    XML fragment
</PropertyDefaults>
  <PropertyConstraints>?
    <PropertyConstraint property="string"
      constraintType="anyURI">+</n
  <EnvironmentConstraints>?
    <EnvironmentConstraint constraintType="anyURI">+
</EnvironmentConstraints>
  <Policies>?
    <Policy name="string" type="anyURI">+
      policy specific content
</Policy>
</Policies>
  <EnvironmentConstraints>?
    <EnvironmentConstraint constraintType="anyURI">+
</EnvironmentConstraints>
</ServiceTemplate>
constraint type specific content?
</EnvironmentConstraint>
</EnvironmentConstraints>

<DeploymentArtifacts>?
  <DeploymentArtifact name="string" type="anyURI">+
    artifact specific content
  </DeploymentArtifact>
</DeploymentArtifacts>

<ImplementationArtifacts>?
  <ImplementationArtifact operationName="string"
    type="anyURI">+
    <RequiredContainerCapabilities>?
      <RequiredContainerCapability capability="anyURI"/>+
    </RequiredContainerCapabilities>
    artifact specific content
  </ImplementationArtifact>
</ImplementationArtifacts>

</NodeTemplate> | 

<RelationshipTemplate id="ID"
  name="string"?
  relationshipType="QName">+
  <SourceElement id="IDREF"/>
  ( <TargetElement id="IDREF"/>
    | <TargetElementReference id="QName"/>
  )
</PropertyDefaults>?
  XML fragment
</PropertyDefaults>

<PropertyConstraints>?
  <PropertyConstraint property="string"
    constraintType="anyURI">+
    constraint?
  </PropertyConstraint>
</PropertyConstraints>

<RelationshipConstraints>?
  <RelationshipConstraint constraintType="anyURI">+
    constraint?
  </RelationshipConstraint>
</RelationshipConstraints>

</RelationshipTemplate> | 

<GroupTemplate id="ID"
  name="string"?
<NodeTemplate ... />
| <RelationshipTemplate ... />
| <GroupTemplate ... />
)+
<Policies>?
  <Policy name="string" type="anyURI">+
    policy specific content
  </Policy>
</Policies>
</GroupTemplate>
)+
</TopologyTemplate>
<NodeTypes>?
  <NodeType id="ID" name="string"?
    abstract="yes|no"?
    final="yes|no"?>+
    <NodeTypeProperties element="QName"?
      type="QName"/>?
    <DerivedFrom nodeTypeRef="QName"/>?
  </NodeType>
  +
  <InstanceStates>?
    <InstanceState state="anyURI">+
    </InstanceState>
  </InstanceStates>
  +
  <Interfaces>?
    <Interface name="NCName | anyURI">+
    <Operation name="NCName">*
      (<WSDL portType="QName"
        operation="NCName"/>
      | <REST method="GET | PUT | POST | DELETE"
        abs_path="anyURI"?
        absoluteURI="anyURI"?
        requestBody="QName"?
        responseBody="QName"?>
    </Parameters>?
      <Parameter name="string" required="yes|no"/>+
    </Parameters>
168     <Headers>?
169         <Header name="string" required="yes|no"/>
170     </Headers>
171 </REST>
172     <ScriptOperation>
173     <InputParameters>?
174         <InputParameter name="string"
175             type="string"
176             required="yes|no"/>
177     </InputParameters>
178     <OutputParameters>?
179         <OutputParameter name="string"
180             type="string"
181             required="yes|no"/>
182     </OutputParameters>
183 </ScriptOperation>
184 }
185 } "artifact specific content"
186 </Operation>
187 <ImplementationArtifacts>?
188 <ImplementationArtifact operationName="string"
189     type="anyURI"/>
190 <RequiredContainerCapabilities>?
191 <RequiredContainerCapability capability="anyURI"/>
192 </RequiredContainerCapabilities>
193 artifact specific content
194 <ImplementationArtifact>
195 </ImplementationArtifacts>
196 </Interface>
197 </Interfaces>
198 <DeploymentArtifacts>?
199 <DeploymentArtifact name="string" type="anyURI">artifact specific content
200 </DeploymentArtifact>
201 </DeploymentArtifacts>
202 <Policies>?
<Policy name="string" type="anyURI">+
    policy specific content
</Policy>
</Policies>
</NodeType>
</NodeTypes>
</RelationshipTypes>
<RelationshipType id="ID"
    name="string"?
    abstract="yes|no"?
    final="yes|no"?
    cascadingDeletion="yes|no"??+<RelationshipTypeProperties element="QName"?
    type="QName"?/>
<InstanceState state="anyURI">+
</InstanceState>
</SourceInterfaces>
</TargetInterfaces>
<ValidSource typeRef="QName"/>
<ValidTarget typeRef="QName"/>
</RelationshipType>
</RelationshipTypes>
<Plans>
    <Plan id="ID"
        name="string"?
        planType="anyURI"
        languageUsed="anyURI">+
        <PreCondition expressionLanguage="anyURI">?
            condition
        </PreCondition>
    </Plan>
</Plans>
<PlanModel>
  ...
</PlanModel>

<PlanModelReference reference="anyURI"/>

</Plan>
Appendix D. TOSCA Schema

TOSCA-v1.0.xsd:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="http://docs.oasis-open.org/tosca/ns/2011/12"
   elementFormDefault="qualified" attributeFormDefault="unqualified"
   xmlns="http://docs.oasis-open.org/tosca/ns/2011/12"
   xmlns:xs="http://www.w3.org/2001/XMLSchema">
               schemaLocation="http://www.w3.org/2001/xml.xsd"/>
    <xs:element name="documentation" type="tDocumentation"/>
    <xs:complexType name="tDocumentation" mixed="true">
      <xs:sequence>
        <xs:any processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="source" type="xs:anyURI"/>
      <xs:attribute ref="xml:lang"/>
    </xs:complexType>
    <xs:complexType name="tExtensibleElements">
      <xs:sequence>
        <xs:element ref="documentation" minOccurs="0" maxOccurs="unbounded"/>
        <xs:any namespace="##other" processContents="lax" minOccurs="0"
                 maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:anyAttribute namespace="##other" processContents="lax"/>
    </xs:complexType>
    <xs:complexType name="tImport">
      <xs:complexContent>
        <xs:extension base="tExtensibleElements">
          <xs:attribute name="namespace" type="xs:anyURI"/>
          <xs:attribute name="location" type="xs:anyURI"/>
          <xs:attribute name="importType" type="importedURI" use="required"/>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <xs:element name="ServiceTemplate">
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="tServiceTemplate"/>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <xs:complexType name="tServiceTemplate">
      <xs:complexContent>
        <xs:extension base="tExtensibleElements">
          <xs:sequence>
            <xs:element name="Import" type="tImport" minOccurs="0"
                       maxOccurs="unbounded"/>
            <xs:element name="Types" minOccurs="0">
          </xs:element>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
  </xs:schema>
```
<xs:complexType>
  <xs:sequence>
    <xs:element name="Extensions" minOccurs="0">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="Extension" type="tExtension"
            maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="TopologyTemplateReference">
      <xs:complexType>
        <xs:attribute name="reference" type="xs:QName"/>
      </xs:complexType>
    </xs:element>
    <xs:element name="TopologyTemplate" type="tTopologyTemplate"/>
    <xs:choice minOccurs="0">
      <xs:element name="NodeTypes" type="tNodeTypes" minOccurs="0"/>
      <xs:element name="RelationshipTypes" type="tRelationshipTypes"
        minOccurs="0"/>
      <xs:element name="Plans" type="tPlans" minOccurs="0"/>
      <xs:extension name="Properties" type="tProperties" minOccurs="0"/>
    </xs:choice>
    <xs:element name="DeploymentArtifact">
      <xs:complexType name="tDeploymentArtifact">
        <xs:complexContent>
          <xs:extension base="tExtensibleElements">
            <xs:sequence>
              <xs:element name="PropertyDefaults" minOccurs="0">
                <xs:complexType>
                  <xs:sequence>
                    <xs:any namespace="#other" processContents="lax"/>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
              <xs:element name="PropertyConstraints" minOccurs="0">
                <xs:complexType>
                  <xs:sequence>
                    <xs:any namespace="#other" processContents="lax"/>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
            </xs:sequence>
          </xs:extension>
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      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
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  <xs:element name="PropertyConstraint" type="tPropertyConstraint" maxOccurs="unbounded"/>
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<xs:element name="Policies" minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="Policy" type="tPolicy" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
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<xs:element name="EnvironmentConstraints" minOccurs="0">
  <xs:complexType>
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      <xs:element name="EnvironmentConstraint" type="tEnvironmentConstraint" maxOccurs="unbounded"/>
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  </xs:complexType>
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<xs:attribute name="id" type="xs:ID" use="required"/>
<xs:attribute name="name" type="xs:string" use="optional"/>
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<xs:attribute name="minInstances" type="xs:int" use="optional" default="1"/>
<xs:attribute name="maxInstances" use="optional" default="1">
  <xs:simpleType>
    <xs:union>
      <xs:simpleType>
        <xs:restriction base="xs:nonNegativeInteger">
          <xs:pattern value="([1-9]+[0-9]*)"/>
        </xs:restriction>
      </xs:simpleType>
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:enumeration value="unbounded"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:union>
  </xs:simpleType>
</xs:attribute>
169   </xs:simpleType>
170   </xs:attribute>
171   </xs:extension>
172   </xs:complexContent>
173   </xs:complexType>
174
175   <xs:complexType name="tPropertyConstraint">
176     <xs:sequence>
177       <xs:any namespace="##other" processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
178     </xs:sequence>
179     <xs:attribute name="property" type="xs:string" use="required"/>
180     <xs:attribute name="constraintType" type="xs:anyURI" use="required"/>
181   </xs:complexType>
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183   <xs:element name="TopologyTemplate" type="tTopologyTemplate"/>
184   <xs:complexType name="tTopologyTemplate">
185     <xs:complexContent>
186       <xs:extension base="tTopologyElementCollection"/>
187     </xs:complexContent>
188   </xs:complexType>
189
190   <xs:element name="GroupTemplate" type="tGroupTemplate"/>
191   <xs:complexType name="tGroupTemplate">
192     <xs:complexContent>
193       <xs:extension base="tTopologyElementCollection"/>
194     </xs:complexContent>
195   </xs:complexType>
196
197   <xs:element name="Policies" minOccurs="0">
198     <xs:complexType>
199       <xs:sequence>
200         <xs:element name="Policy" type="tPolicy" minOccurs="0" maxOccurs="unbounded"/>
201       </xs:sequence>
202     </xs:complexType>
203   </xs:element>
204
205   <xs:sequence>
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207     <xs:attribute name="maxInstances" type="xs:int" use="optional" minOccurs="0" maxOccurs="1" default="1"/>
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210   <xs:complexType name="tPolicy">
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212       <xs:sequence>
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215       </xs:sequence>
216     </xs:complexType>
217   </xs:complexType>
218
219   <xs:complexType name="tTopologyElementCollection">
220     <xs:complexContent>
221       <xs:extension base="tPolicy"/>
222     </xs:complexContent>
223   </xs:complexType>
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      <xs:element name="RelationshipTemplate" type="tRelationshipTemplate"/>
      <xs:element name="GroupTemplate" type="tGroupTemplate"/>
    </xs:choice>
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    <xs:attribute name="targetNamespace" type="xs:anyURI"/>
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    <xs:element name="RelationshipType" type="tRelationshipType" maxOccurs="unbounded"/>
  </xs:sequence>
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<xs:element name="RelationshipType" type="tRelationshipType"/>
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  <xs:complexContent>
    <xs:extension base="tExtensibleElements">
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            <xs:attribute name="type" type="xs:QName"/>
          </xs:complexType>
        </xs:element>
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            <xs:attribute name="relationshipTypeRef" type="xs:QName" use="required"/>
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        <xs:element name="SourceInterfaces" minOccurs="0">
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            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="TargetInterfaces" minOccurs="0">
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            <xs:sequence>
              <xs:element name="Interface" type="tInterface" maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="InstanceStates" type="tTopologyElementInstanceStates" minOccurs="0"/>
        <xs:element name="SourceInterfaces" minOccurs="0">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="Interface" type="tInterface" maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="TargetInterfaces" minOccurs="0">
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            <xs:sequence>
              <xs:element name="Interface" type="tInterface" maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="InstanceStates" type="tTopologyElementInstanceStates" minOccurs="0"/>
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    </xs:extension>
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<xs:element name="ValidSource" minOccurs="0">
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</xs:element>

<xs:element name="ValidTarget" minOccurs="0">
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    <xs:attribute name="typeRef" type="xs:QName" use="required"/>
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<xs:complexType name="tRelationshipTemplate">
  <xs:complexContent>
    <xs:extension base="tExtensibleElements">
      <xs:sequence>
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        </xs:element>
        <xs:choice>
          <xs:element name="TargetElement">
            <xs:complexType>
              <xs:attribute name="id" type="xs:IDREF" use="required"/>
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          </xs:element>
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              <xs:attribute name="id" type="xs:QName" use="required"/>
            </xs:complexType>
          </xs:element>
        </xs:choice>
        <xs:element name="PropertyDefaults" minOccurs="0">
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            <xs:sequence>
              <xs:any namespace="##other" processContents="lax"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="PropertyConstraints" minOccurs="0">
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            <xs:sequence>
              <xs:element name="PropertyConstraint" type="tPropertyConstraint" maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
343  </xs:complexType>
344  </xs:element>
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346  <xs:complexType>
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348      <xs:element name="RelationshipConstraint" maxOccurs="unbounded">
349        <xs:complexType>
350          <xs:sequence>
351            <xs:any namespace="#other" processContents="lax" minOccurs="0"/>
352          </xs:sequence>
353          <xs:attribute name="constraintType" type="xs:anyURI" use="required"/>
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355      </xs:element>
356    </xs:sequence>
357    </xs:complexType>
358  </xs:element>
359  </xs:complexType>
360  </xs:element>
361  </xs:element>
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363  <xs:attribute name="name" type="xs:string" use="optional"/>
364  <xs:attribute name="relationshipType" type="xs:QName" use="required"/>
365  </xs:extension>
366  </xs:complexContent>
367  </xs:complexType>
368  </xs:element>
369  <xs:element name="NodeTypes" type="tNodeTypes"/>
370  <xs:complexType name="tNodeTypes">
371    <xs:sequence>
372      <xs:element name="NodeType" type="tNodeType" maxOccurs="unbounded">
373        <xs:attribute name="targetNamespace" type="xs:anyURI"/>
374      </xs:element>
375    </xs:sequence>
376    <xs:attribute name="targetNamespace" type="xs:anyURI"/>
377  </xs:complexType>
378  <xs:element name="NodeType" type="tNodeType"/>
379  <xs:complexType name="tNodeType">
380    <xs:complexContent>
381      <xs:extension base="tExtensibleElements">
382        <xs:sequence>
383          <xs:element name="NodeTypeProperties" minOccurs="0">
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385              <xs:attribute name="element" type="xs:QName"/>
386              <xs:attribute name="type" type="xs:QName"/>
387            </xs:complexType>
388          </xs:element>
389        </xs:sequence>
390        <xs:attribute name="DerivedFrom" minOccurs="0">
391          <xs:complexType>
392            <xs:attribute name="nodeTypeRef" type="xs:QName" use="required"/>
393          </xs:complexType>
394        </xs:attribute>
395        <xs:attribute name="InstanceStates" type="tTopologyElementInstanceStates" minOccurs="0"/>
396        <xs:element name="Interfaces" minOccurs="0">
397          <xs:complexType>
398            <xs:attribute name="Interfaces" minOccurs="0"/>
399          </xs:complexType>
400          <xs:sequence>
<xs:complexType name="tInterface">
    <xs:sequence>
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        <xs:element name="Policies" minOccurs="0">
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                <xs:sequence>
                    <xs:element name="Policy" type="tPolicy" maxOccurs="unbounded"/>
                </xs:sequence>
            </xs:complexType>
        </xs:element>
        <xs:element name="DeploymentArtifacts" minOccurs="0">
            <xs:complexType>
                <xs:sequence>
                    <xs:element name="DeploymentArtifact" type="tDeploymentArtifact" maxOccurs="unbounded"/>
                </xs:sequence>
            </xs:complexType>
        </xs:element>
    </xs:sequence>
</xs:complexType>
<xs:element name="tPolicy">
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="tExtensibleElements">
        <xs:attribute name="id" type="xs:ID" use="required"/>
        <xs:attribute name="name" type="xs:string" use="optional"/>
        <xs:attribute name="planType" type="xs:anyURI" use="required"/>
        <xs:attribute name="languageUsed" type="xs:anyURI" use="required"/>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>

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  <xs:sequence>
    <xs:any namespace="##other" processContents="lax"/>
  </xs:sequence>
  <xs:attribute name="constraintType" type="xs:anyURI" use="required"/>
</xs:complexType>

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  <xs:complexContent>
    <xs:extension base="tExtensibleElements">
      <xs:sequence>
        <xs:element name="Extension" type="tExtension" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
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<xs:complexType name="tExtension">
  <xs:complexContent>
    <xs:extension base="tExtensibleElements">
      <xs:attribute name="namespace" type="xs:anyURI" use="required"/>
      <xs:attribute name="mustUnderstand" type="tBoolean" use="optional" default="yes"/>
    </xs:extension>
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</xs:complexType>

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  <xs:attribute name="type" type="xs:string" use="required"/>
  <xs:attribute name="required" type="tBoolean" use="optional" default="yes"/>
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<xs:complexType name="tInterface">
  <xs:sequence>
    <xs:element name="Operation" type="tOperation" minOccurs="0"/>
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</xs:complexType>
<xs:element name="ImplementationArtifacts" minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="ImplementationArtifact" type="tImplementationArtifact" maxOccurs="unbounded"/>
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  <xs:attribute name="portType" type="xs:QName" use="required"/>
  <xs:attribute name="operation" type="xs:NCName" use="required"/>
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<xs:complexType name="tOperation">
  <xs:complexContent>
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        <xs:element name="REST" type="tREST"/>
        <xs:element name="ScriptOperation" type="tScriptOperation"/>
      </xs:choice>
      <xs:attribute name="name" type="xs:NCName" use="required"/>
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    <xs:element name="Parameters" minOccurs="0">
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            </xs:complexType>
          </xs:element>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="Headers" minOccurs="0">
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          <xs:element name="Header" maxOccurs="unbounded">
            <xs:complexType>
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              <xs:attribute name="required" type="tBoolean" use="optional" default="yes"/>
            </xs:complexType>
          </xs:element>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="tScriptOperation">
  <xs:sequence>
    <xs:element name="Header" maxOccurs="unbounded">
      <xs:complexType>
        <xs:attribute name="name" type="xs:string" use="required"/>
        <xs:attribute name="required" type="tBoolean" use="optional" default="yes"/>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
2560     </xs:element>
2561     </xs:sequence>
2562     <xs:attribute name="method" default="GET">
2563     
2564     <xs:restriction base="xs:string">
2565     <xs:enumeration value="GET"/>
2566     <xs:enumeration value="PUT"/>
2567     <xs:enumeration value="POST"/>
2568     <xs:enumeration value="DELETE"/>
2569     </xs:restriction>
2570     </xs:attribute>
2571     </xs:complexType>
2572     <xs:attribute name="abs_path" type="xs:anyURI" use="optional"/>
2573     <xs:attribute name="absoluteURI" type="xs:anyURI" use="optional"/>
2574     <xs:attribute name="requestBody" type="xs:QName" use="optional"/>
2575     <xs:attribute name="responseBody" type="xs:QName" use="optional"/>
2576     </xs:complexType>
2577     
2578     <xs:complexType name="tScriptOperation">
2579     
2580     <xs:element name="InputParameters" minOccurs="0">
2581     
2582     <xs:complexType>
2583     <xs:sequence>
2584     <xs:element name="InputParameter" type="tParameter" maxOccurs="unbounded"/>
2585     </xs:sequence>
2586     </xs:complexType>
2587     </xs:element>
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2592     <xs:element name="OutputParameter" type="tParameter" maxOccurs="unbounded"/>
2593     </xs:sequence>
2594     </xs:complexType>
2595     </xs:element>
2596     </xs:sequence>
2597     </xs:complexType>
2598     <xs:complexType name="tImplementationArtifact">
2599     
2600     <xs:extension base="tExtensibleElements">
2601     <xs:sequence>
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2604     <xs:complexType>
2605     <xs:sequence>
2606     <xs:element name="RequiredContainerCapability" maxOccurs="unbounded">
2607     <xs:complexType>
2608     <xs:attribute name="capability" type="xs:anyURI" use="required"/>
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2611     </xs:sequence>
2612     </xs:complexType>
2613     </xs:element>
2614     </xs:sequence>
2615     </xs:complexType>
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<xs:attribute name="type" type="xs:anyURI" use="required"/>
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</xs:complexType>
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<xs:sequence>
<xs:any processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:attribute name="expressionLanguage" type="xs:anyURI" use="required"/>
</xs:complexType>
</xs:complexType>
<xs:complexType name="tTopologyElementInstanceStates">
<xs:sequence>
<xs:element name="InstanceState" maxOccurs="unbounded">
<xs:complexType>
<xs:attribute name="state" type="xs:anyURI" use="required"/>
</xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:complexType>
<xs:simpleType name="tBoolean">
<xs:restriction base="xs:string">
<xs:enumeration value="yes"/>
<xs:enumeration value="no"/>
</xs:restriction>
</xs:simpleType>
<xs:simpleType name="importedURI">
<xs:restriction base="xs:anyURI"/>
</xs:simpleType>
</xs:schema>
Appendix E. Sample

This appendix contains the full sample used in this specification.

E.1 Sample Service Topology Definition

```xml
<ServiceTemplate name="myService"
    targetNamespace="http://www.ibm.com/sample">

    <Types>
        <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
            elementFormDefault="qualified"
            attributeFormDefault="unqualified">
            <xs:element name="ApplicationProperties">
                <xs:complexType>
                    <xs:sequence>
                        <xs:element name="Owner" type="xs:string"/>
                        <xs:element name="InstanceName" type="xs:string"/>
                        <xs:element name="AccountID" type="xs:string"/>
                    </xs:sequence>
                </xs:complexType>
            </xs:element>

            <xs:element name="AppServerProperties">
                <xs:complexType>
                    <xs:sequence>
                        <element name="HostName" type="string"/>
                        <element name="IPAddress" type="string"/>
                        <element name="HeapSize" type="positiveInteger"/>
                        <element name="SoapPort" type="positiveInteger"/>
                    </xs:sequence>
                </xs:complexType>
            </xs:element>
        </xs:schema>
    </Types>

    <TopologyTemplate id="SampleApplication">
        <NodeTemplate id="MyApplication"
            name="My Application"
            nodeType="abc:Application">
            <PropertyDefaults>
                <ApplicationProperties>
                    <Owner>Frank</Owner>
                    <InstanceName>Thomas’ favorite application</InstanceName>
                </ApplicationProperties>
            </PropertyDefaults>
        </NodeTemplate>

        <NodeTemplate id="MyAppServer"
            name="My Application Server"
            nodeType="abc:ApplicationServer"
            minInstances="0"
            maxInstances="unbounded">
            <RelationshipTemplate id="MyDeploymentRelationship">
```
relationshipsType="deployedOn">
  <SourceElement id="MyApplication"/>
  <TargetElement id="MyAppServer"/>
</RelationshipTemplate>
</TopologyTemplate>

<NodeTypes>
  <NodeType name="Application">
    <documentation xml:lang="EN">
      A reusable definition of a node type representing an
      application that can be deployed on application servers.
    </documentation>
    <NodeTypeProperties element="ApplicationProperties"/>
    <InstanceState state="http://www.example.com/started"/>
    <InstanceState state="http://www.example.com/stopped"/>
  </NodeType>
  <NodeType name="ApplicationServer" targetNamespace="http://www.ibm.com/sample">
    <NodeTypeProperties element="AppServerProperties"/>
    <Interfaces>
      <Interface name="DeploymentInterface">
        <Operation name="DeployApplication">
          <ScriptOperation>
            <InputParameters>
              <InputParameter name="InstanceName" type="string"/>
              <InputParameter name="AppServerHostname" type="string"/>
              <InputParameter name="ContextRoot" type="string"/>
            </InputParameters>
          </ScriptOperation>
        </Operation>
      </Interface>
    </Interfaces>
  </NodeType>
</NodeTypes>
</ImplementationArtifact>

<ImplementationArtifact operationName="DeployApplicationServer"
type="http://www.example.com/MyJeeArtifact/EarRef">
    artifacts/jee/AppServerManagement.ear
</ImplementationArtifact>
</ImplementationArtifacts>
</Interface>
</Interfaces>
</NodeType>
</NodeTypes>

<RelationshipTypes>
    <documentation xml:lang="EN">
        A reusable definition of relation that expresses deployment of
        an artifact on a hosting environment.
    </documentation>
    <RelationshipType name="deployedOn">
    </RelationshipType>
</RelationshipTypes>

<Plans>
    <Plan id="DeployApplication"
        name="Sample Application Build Plan"
        planType="http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/BuildPlan"
        languageUsed="http://www.omg.org/spec/BPMN/2.0/">
        <PreCondition expressionLanguage="www.example.com/text">?
            Run only if funding is available
        </PreCondition>

        <PlanModel>
            <process name="DeployNewApplication" id="p1">
                <documentation>This process deploys a new instance of the
                sample application.
            </documentation>

            <task id="t1" name="CreateAccount"/>

            <task id="t2" name="AcquireNetworkAddresses"
                isSequential="false"
                loopDataInput="t2Input.LoopCounter"/>
                <documentation>Assumption: t2 gets data of type "input"
                as input and this data has a field names "LoopCounter"
                that contains the actual multiplicity of the task.
            </documentation>

            <task id="t3" name="DeployApplicationServer"
                isSequential="false"
                loopDataInput="t3Input.LoopCounter"/>

            <task id="t4" name="DeployApplication"
                isSequential="false"
                loopDataInput="t4Input.LoopCounter"/>

            <sequenceFlow id="s1" targetRef="t2" sourceRef="t1"/>
            <sequenceFlow id="s2" targetRef="t3" sourceRef="t2"/>
            <sequenceFlow id="s3" targetRef="t4" sourceRef="t3"/>
        </sequenceFlow>
    </process>
</PlanModel>
</Plans>
<Plan id="RemoveApplication"
    planType="http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/TerminationPlan"
    languageUsed="http://docs.oasis-open.org/wsbpel/2.0/process/executable">
    <PlanModelReference reference="prj:RemoveApp"/>
</Plan>
</Plans>
</ServiceTemplate>
### Appendix F. Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Editor</th>
<th>Changes Made</th>
</tr>
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<tbody>
<tr>
<td>wd-01</td>
<td>2012-01-26</td>
<td>Thomas Spatzier</td>
<td>Changes for JIRA Issue TOSCA-1: Initial working draft based on input spec delivered to TOSCA TC. Copied all content from input spec and just changed namespace. Added line numbers to whole document.</td>
</tr>
<tr>
<td>wd-02</td>
<td>2012-02-23</td>
<td>Mike Edwards, Thomas Spatzier</td>
<td>Changes for JIRA Issue TOSCA-6: Reviewed and adapted normative statement keywords according to RFC2119.</td>
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<tr>
<td>wd-03</td>
<td>2012-03-06</td>
<td>Arvind Srinivasan, Mike Edwards, Thomas Spatzier</td>
<td>Changes for JIRA Issue TOSCA-10: Marked all occurrences of keywords from the TOSCA language (element and attribute names) in Courier New font.</td>
</tr>
<tr>
<td>wd-04</td>
<td>2012-03-22</td>
<td>Thomas Spatzier, Frank Leymann</td>
<td>Changes for JIRA Issue TOSCA-4: Changed definition of NodeType Interfaces element; adapted text and examples</td>
</tr>
<tr>
<td>wd-05</td>
<td>2012-03-30</td>
<td>Thomas Spatzier, Frank Leymann</td>
<td>Changes for JIRA Issue TOSCA-5: Changed definition of NodeTemplate to include ImplementationArtifact element; adapted text; Added Acknowledgements section in Appendix</td>
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<tr>
<td>wd-06</td>
<td>2012-05-03</td>
<td>Thomas Spatzier, Derek Palma</td>
<td>Changes for JIRA Issue TOSCA-15: Added clarifying section about artifacts (see section 3.2); Implemented editorial changes according to OASIS staff recommendations; updated Acknowledgements section</td>
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<tr>
<td>wd-07</td>
<td>2012-06-15</td>
<td>Thomas Spatzier, Frank Leymann</td>
<td>Changes for JIRA Issue TOSCA-20: Added abstract attribute to NodeType for sub-issue 2; Added final attribute to NodeType for sub-issue 4; Added explanatory text on Node Type properties for sub-issue 8</td>
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<tr>
<td>wd-08</td>
<td>2012-06-29</td>
<td>Thomas Spatzier, Derek Palma</td>
<td>Changes for JIRA Issue TOSCA-23: Added interfaces and introduced inheritance for RelationshipType; based on wd-07; Added reference to XML element and attribute naming scheme used in this spec</td>
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<tr>
<td>wd-09</td>
<td>2012-07-16</td>
<td>Frank Leyman, Thomas Spatzier, Tobias Kunze</td>
<td>Changes for JIRA Issue TOSCA-17: Specifies the format of a CSAR file; Explained CSAR concept in the corresponding section.</td>
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