

# Topology and Orchestration Specification for Cloud Applications Version 1.0

## Committee Specification 01

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### Specification URIs

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#### Additional artifacts:

This prose specification is one component of a Work Product which also includes:

- XML schema: <http://docs.oasis-open.org/tosca/TOSCA/v1.0/cs01/schemas/>

#### Declared XML namespace:

- <http://docs.oasis-open.org/tosca/ns/2011/12>

#### 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. 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.

**Status:**

This document was last revised or approved by the OASIS Topology and Orchestration Specification for Cloud Applications (TOSCA) TC on the above date. The level of approval is also listed above. Check the "Latest version" location noted above for possible later revisions of this document.

Technical Committee members should send comments on this specification to the Technical Committee's email list. Others should send comments to the Technical Committee by using the "Send A Comment" button on the Technical Committee's web page at <http://www.oasis-open.org/committees/tosca/>.

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# 1 Introduction

Cloud computing can become more valuable if the semi-automatic creation and management of application layer services can be ported across alternative cloud implementation environments so that the services remain interoperable. This core TOSCA specification provides a language to describe service components and their relationships using a *service topology*, and it provides for describing the management procedures that create or modify services using *orchestration processes*. The combination of topology and orchestration in a *Service Template* describes what is needed to be preserved across deployments in different environments to enable interoperable deployment of cloud services and their management throughout the complete lifecycle (e.g. scaling, patching, monitoring, etc.) when the applications are ported over alternative cloud environments.

---

## 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:

- XML Schema 1.0

### 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 **Error! Reference source not found.**, i.e. uses upper camel-case notation for XML element names and lower camel-case notation for XML attribute names.

### 2.3 Normative References

- |                     |   |
|---------------------|---|
| [RFC2119]           | S. Bradner, <i>Key words for use in RFCs to Indicate Requirement Levels</i> ,<br><a href="http://www.ietf.org/rfc/rfc2119.txt">http://www.ietf.org/rfc/rfc2119.txt</a> , IETF RFC 2119, March 1997. |
| [RFC 2396]          | Uniform Resource Identifiers (URI): Generic Syntax, RFC 2396, available via<br><a href="http://www.faqs.org/rfcs/rfc2396.html">http://www.faqs.org/rfcs/rfc2396.html</a>                            |
| [XML Base]          | XML Base (Second Edition), W3C Recommendation,<br><a href="http://www.w3.org/TR/xmlbase/">http://www.w3.org/TR/xmlbase/</a>   |
| [XML Infoset]       | XML Information Set, W3C Recommendation, <a href="http://www.w3.org/TR/2001/REC-xml-infoset-20011024/">http://www.w3.org/TR/2001/REC-xml-infoset-20011024/</a>                                      |
| [XML Namespaces]    | Namespaces in XML 1.0 (Second Edition), W3C Recommendation,<br><a href="http://www.w3.org/TR/REC-xml-names/">http://www.w3.org/TR/REC-xml-names/</a>  |
| [XML Schema Part 1] | XML Schema Part 1: Structures, W3C Recommendation, October 2004,<br><a href="http://www.w3.org/TR/xmlschema-1/">http://www.w3.org/TR/xmlschema-1/</a>   |
| [XML Schema Part 2] | XML Schema Part 2: Datatypes, W3C Recommendation, October 2004,<br><a href="http://www.w3.org/TR/xmlschema-2/">http://www.w3.org/TR/xmlschema-2/</a>  |
| [XMLSpec]           | XML Specification, W3C Recommendation, February 1998,<br><a href="http://www.w3.org/TR/1998/REC-xml-19980210">http://www.w3.org/TR/1998/REC-xml-19980210</a>  |

### 2.4 Non-Normative References

- |            |  |
|------------|--|
| [BPEL 2.0] | <i>Web Services Business Process Execution Language Version 2.0</i> . OASIS Standard. 11 April 2007. <a href="http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.html">http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.html</a> . |
| [BPMN 2.0] | OMG Business Process Model and Notation (BPMN) Version 2.0,<br><a href="http://www.omg.org/spec/BPMN/2.0/">http://www.omg.org/spec/BPMN/2.0/</a>   |
| [OVF]      | Open Virtualization Format Specification Version 1.1.0,<br><a href="http://www.dmtf.org/standards/published_documents/DSP0243_1.1.0.pdf">http://www.dmtf.org/standards/published_documents/DSP0243_1.1.0.pdf</a>                   |



**[XPATH 1.0]** XML Path Language (XPath) Version 1.0, W3C Recommendation, November 1999, <http://www.w3.org/TR/1999/REC-xpath-19991116>

**[UNCEFACT XMLNDR]** UN/CEFACT XML Naming and Design Rules Technical Specification, Version 3.0, <http://www.unece.org/fileadmin/DAM/cefact/xml/UNCEFACT+XML+NDR+V3p0.pdf>

## 2.5 Typographical Conventions

This specification uses the following conventions inside tables describing the resource data model:

- Resource names, and any other name that is usable as a type (i.e., names of embedded structures as well as atomic types such as "integer", "string"), are in *italic*.
- Attribute names are in regular font.

In addition, this specification uses the following syntax to define the serialization of resources:

- Values in *italics* indicate data types instead of literal values.
- Characters are appended to items to indicate cardinality:
  - "?" (0 or 1)
  - "\*" (0 or more)
  - "+" (1 or more)
- Vertical bars, "|", denote choice. For example, "a|b" means a choice between "a" and "b".
- Parentheses, "(" and ")", are used to indicate the scope of the operators "?", "\*", "+" and "|".
- Ellipses (i.e., "...") indicate points of extensibility. Note that the lack of an ellipses does not mean no extensibility point exists, rather it is just not explicitly called out - usually for the sake of brevity.

## 2.6 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.

Prefix	Namespace
tosca	<a href="http://docs.oasis-open.org/tosca/ns/2011/12">http://docs.oasis-open.org/tosca/ns/2011/12</a>
xs	<a href="http://www.w3.org/2001/XMLSchema">http://www.w3.org/2001/XMLSchema</a>

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.

## 2.7 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.

## 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.

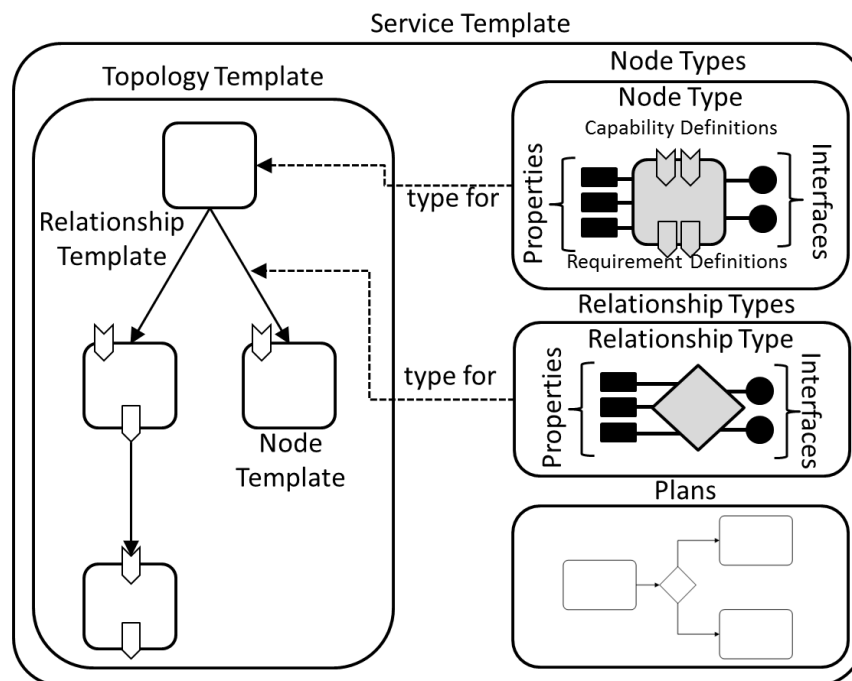


Figure 1: Structural Elements of a Service Template and their Relations

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 address, and an operation for shutting down an instance of this application server. A constraint in the Node Template can specify a range of IP addresses available when making a concrete application server available.

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 operations defined by the Node Types specified in the *type* attribute of the Node Templates, respectively), operations of Interfaces of Relationship Templates (or operations defined by the Relationship Types specified in the *type* attribute of the Relationship Templates, respectively), 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 Use Cases

The specification supports at least the following major use cases.

### 3.2.1 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.

### 3.2.2 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.

### 3.2.3 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.

### 3.2.4 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.

## 3.3 Service Templates and Artifacts

An artifact represents the content needed 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 needed 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 can have an implementation artifact that is a WAR file. The node type this REST operation is associated with can 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 needed 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).

### 3.4 Requirements and Capabilities

TOSCA allows for expressing *requirements* and *capabilities* of components of a service. This can be done, for example, to express that one component depends on (requires) a feature provided by another component, or to express that a component has certain requirements against the hosting environment such as for the allocation of certain resources or the enablement of a specific mode of operation.

Requirements and capabilities are modeled by annotating Node Types with *Requirement Definitions* and *Capability Definitions* of certain types. *Requirement Types* and *Capability Types* are defined as reusable entities so that those definitions can be used in the context of several Node Types. For example, a Requirement Type “DatabaseConnectionRequirement” might be defined to describe the requirement of a client for a database connection. This Requirement Type can then be reused for all kinds of Node Types that represent, for example, application with the need for a database connection.

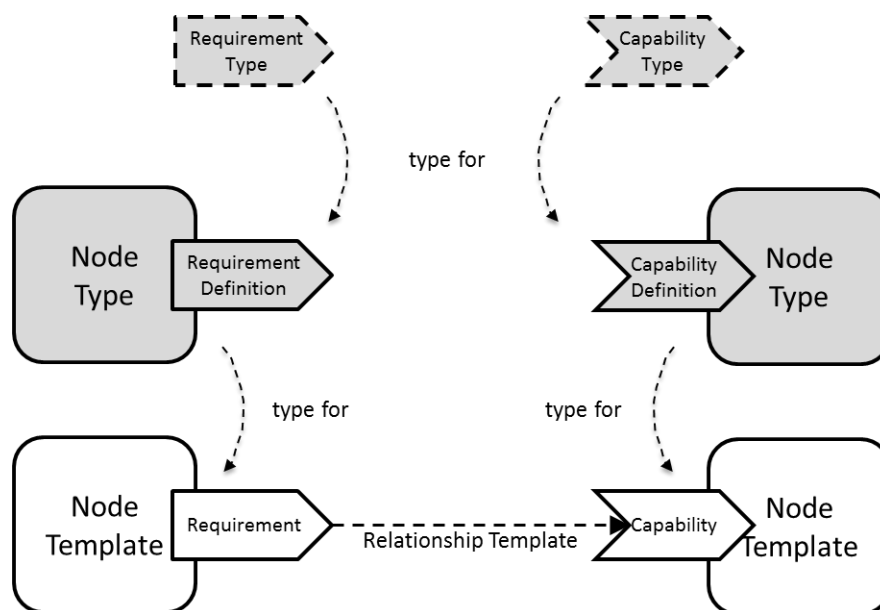


Figure 2: Requirements and Capabilities



Node Templates which have corresponding Node Types with Requirement Definitions or Capability Definitions will include representations of the respective *Requirements* and *Capabilities* with content specific to the respective Node Template. For example, while Requirement Types just represent Requirement metadata, the Requirement represented in a Node Template can provide concrete values for properties defined in the Requirement Type. In addition, Requirements and Capabilities of Node Templates in a Topology Template can optionally be connected via Relationship Templates to indicate that a specific requirement of one node is fulfilled by a specific capability provided by another node.

Requirements can be matched in two ways as briefly indicated above: (1) requirements of a Node Template can be matched by capabilities of another Node Template in the same Service Template by connecting the respective requirement-capability-pairs via Relationship Templates; (2) requirements of a Node Template can be matched by the general hosting environment (or the TOSCA container), for example by allocating needed resources for a Node Template during instantiation.

### 3.5 Composition of Service Templates

Service Templates can be based on and built on-top of other Service Templates based on the concept of Requirements and Capabilities introduced in the previous section. For example, a Service Template for a business application that is hosted on an application server tier might focus on defining the structure and manageability behavior of the application itself. The structure of the application server tier hosting the application can be provided in a separate Service Template built by another vendor specialized in deploying and managing application servers. This approach enables separation of concerns and re-use of common infrastructure templates.

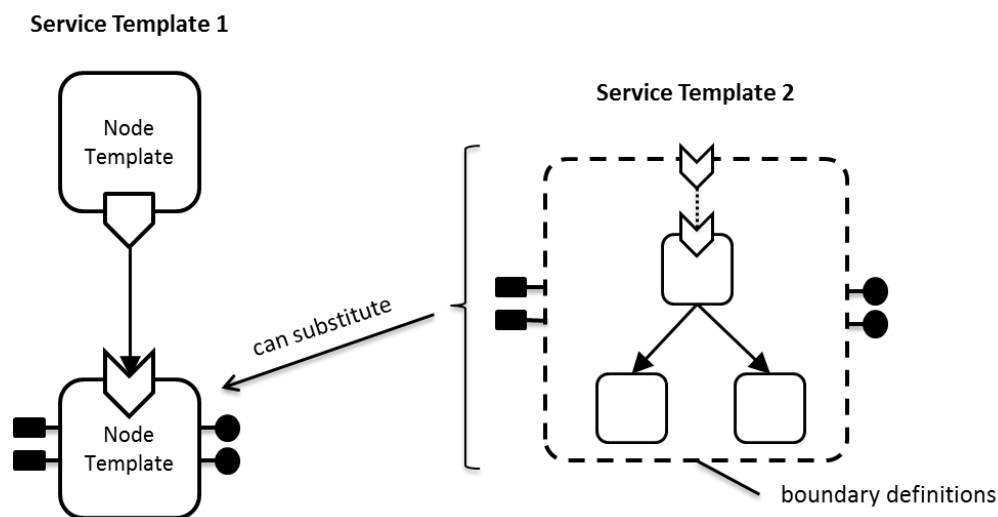


Figure 3: Service Template Composition

From the point of view of a Service Template (e.g. the business application Service Template from the example above) that uses another Service Template, the other Service Template (e.g. the application server tier) “looks” like just a Node Template. During deployment, however, this Node Template can be substituted by the second Service Template if it exposes the same boundaries (i.e. properties, capabilities, etc.) as the Node Template. Thus, a substitution with any Service Template that has the same *boundary definitions* as a certain Node Template in one Service Template becomes possible, allowing for a flexible composition of different Service Templates. This concept also allows for providing substitutable alternatives in the form of Service Templates. For example, a Service Template for a single node application server tier and a Service Template for a clustered application server tier might exist, and the appropriate option can be selected per deployment.

### 3.6 Policies in TOSCA

Non-functional behavior or quality-of-services are defined in TOSCA by means of policies. A Policy can express such diverse things like monitoring behavior, payment conditions, scalability, or continuous availability, for example.

A Node Template can be associated with a set of Policies collectively expressing the non-functional behavior or quality-of-services that each instance of the Node Template will expose. Each Policy specifies the actual properties of the non-functional behavior, like the concrete payment information (payment period, currency, amount etc) about the individual instances of the Node Template.

These properties are defined by a Policy Type. Policy Types might be defined in hierarchies to properly reflect the structure of non-functional behavior or quality-of-services in particular domains. Furthermore, a Policy Type might be associated with a set of Node Types the non-functional behavior or quality-of-service it describes.

Policy Templates provide actual values of properties of the types defined by Policy Types. For example, a Policy Template for monthly payments for US customers will set the “payment period” property to “monthly” and the “currency” property to “US\$”, leaving the “amount” property open. The “amount” property will be set when the corresponding Policy Template is used for a Policy within a Node Template. Thus, a Policy Template defines the invariant properties of a Policy, while the Policy sets the variant properties resulting from the actual usage of a Policy Template in a Node Template.

### 3.7 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 have to be available in that environment. This means that beside the service template of the cloud application, the deployment artifacts and implementation artifacts have to 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).

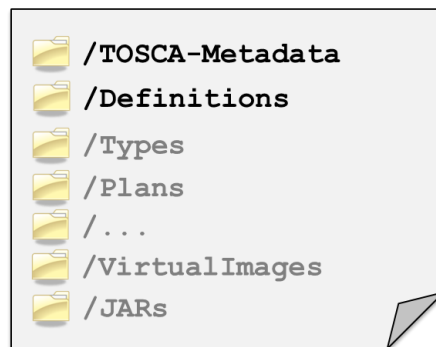


Figure 4: Structure of the CSAR

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.



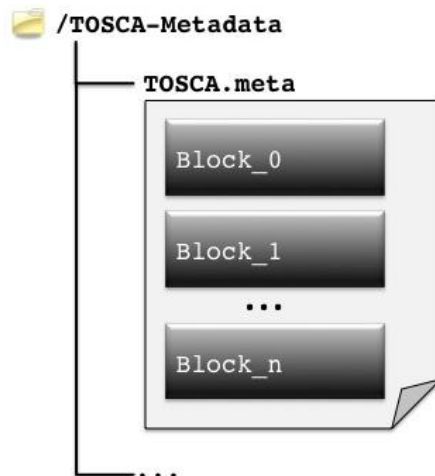


Figure 5: Structure of the TOSCA Meta File

The first block of the TOSCA meta file (Block\_0 in Figure 5) 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.

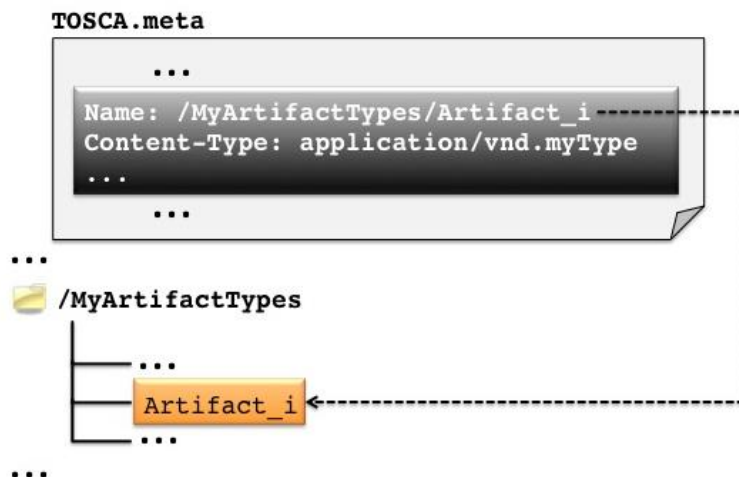


Figure 6: Providing Metadata for Artifacts

## 4 The TOSCA Definitions Document

All elements needed to define a TOSCA Service Template – such as Node Type definitions, Relationship Type definitions, etc. – as well as Service Templates themselves are provided in TOSCA *Definitions* documents. This section explains the overall structure of a TOSCA Definitions document, the extension mechanism, and import features. Later sections describe in detail Service Templates, Node Types, Node Type Implementations, Relationship Types, Relationship Type Implementations, Requirement Types, Capability Types, Artifact Types, Artifact Templates, Policy Types and Policy Templates.

### 4.1 XML Syntax

The following pseudo schema defines the XML syntax of a Definitions document:

```
01 <Definitions id="xs:ID"
02     name="xs:string"?
03     targetNamespace="xs:anyURI">
04
05     <Extensions>
06         <Extension namespace="xs:anyURI"
07             mustUnderstand="yes|no"?/> +
08     </Extensions> ?
09
10     <Import namespace="xs:anyURI"?
11         location="xs:anyURI"?
12         importType="xs:anyURI"/> *
13
14     <Types>
15         <xs:schema .../> *
16     </Types> ?
17
18     (
19         <ServiceTemplate> ... </ServiceTemplate>
20     |
21         <NodeType> ... </NodeType>
22     |
23         <NodeTypeImplementation> ... </NodeTypeImplementation>
24     |
25         <RelationshipType> ... </RelationshipType>
26     |
27         <RelationshipTypeImplementation> ... </RelationshipTypeImplementation>
28     |
29         <RequirementType> ... </RequirementType>
30     |
31         <CapabilityType> ... </CapabilityType>
32     |
33         <ArtifactType> ... </ArtifactType>
34     |
35         <ArtifactTemplate> ... </ArtifactTemplate>
36     |
37         <PolicyType> ... </PolicyType>
38     |
39         <PolicyTemplate> ... </PolicyTemplate>
40     ) +
41
42 </Definitions>
```

## 4.2 Properties

The `Definitions` element has the following properties:

- `id`: This attribute specifies the identifier of the Definitions document which MUST be unique within the target namespace.
- `name`: This OPTIONAL attribute specifies a descriptive name of the Definitions document.
- `targetNamespace`: The value of this attribute specifies the target namespace for the Definitions document. All elements defined within the Definitions document will be added to this namespace unless they override this attribute by means of their own `targetNamespace` attributes.
- `Extensions`: This OPTIONAL element specifies namespaces of TOSCA extension attributes and extension elements. If present, the `Extensions` element MUST include at least one `Extension` element.

The `Extension` element has the following properties:

- `namespace`: This attribute specifies the namespace of TOSCA extension attributes and extension elements.
- `mustUnderstand`: This OPTIONAL attribute specifies 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 mandatory extensions, then the Definitions document MUST be rejected. Optional extensions MAY be ignored. It is not necessary to declare optional extensions.  
The same extension URI MAY 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 TOSCA Definitions, XML Schema definitions, or WSDL definitions. Any number of `Import` elements MAY appear as children of the `Definitions` element.

The `Import` element has the following properties:

- `namespace`: This OPTIONAL attribute specifies an absolute URI that identifies the imported definitions. 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`.
- `location`: This OPTIONAL 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]. 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.

- `importType`: This REQUIRED 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 Definitions document MUST define or import all Node Types, Node Type Implementations, Relationship Types, Relationship Type Implementations, Requirement Type, Capability Types, Artifact Types, Policy Types, WSDL definitions, and XML Schema documents it uses. In order to support the use of definitions from namespaces spanning multiple documents, a Definitions document MAY include more than one import declaration for the same `namespace` and `importType`. Where a Definitions document 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 Definitions document MUST be rejected if the imported documents contain conflicting definitions of a component used by the importing Definitions document.

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 Definitions document, then a document (or namespace) that defines that item MUST be directly imported by the Definitions document. 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 Definitions document. Such definitions are provided within one or more separate Schema definitions (usually `xs:schema` elements). The `Types` element defines XML definitions within a Definitions document without having to define these XML definitions in separate files and importing 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 `Definitions` 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.

- `ServiceTemplate`: This element specifies a complete Service Template for a cloud application. A Service Template contains a definition of the Topology Template of the cloud application, as well as any number of Plans. Within the Service Template, any type definitions (e.g. Node Types, Relationship Types, etc.) defined in the same Definitions document or in imported Definitions document can be used.
- `NodeType`: This element specifies a type of Node that can be referenced as a type for Node Templates of a Service Template.
- `NodeTypeImplementation`: This element specifies the implementation of the manageability behavior of a type of Node that can be referenced as a type for Node Templates of a Service Template.
- `RelationshipType`: This element specifies a type of Relationship that can be referenced as a type for Relationship Templates of a Service Template.

- **RelationshipTypeImplementation**: This element specifies the implementation of the manageability behavior of a type of Relationship that can be referenced as a type for Relationship Templates of a Service Template.
- **RequirementType**: This element specifies a type of Requirement that can be exposed by Node Types used in a Service Template.
- **CapabilityType**: This element specifies a type of Capability that can be exposed by Node Types used in a Service Template.
- **ArtifactType**: This element specifies a type of artifact used within a Service Template. Artifact Types might be, for example, application modules such as .war files or .ear files, operating system packages like RPMs, or virtual machine images like .ova files.
- **ArtifactTemplate**: This element specifies a template describing an artifact referenced by parts of a Service Template. For example, the installable artifact for an application server node might be defined as an artifact template.
- **PolicyType**: This element specifies a type of Policy that can be associated to Node Templates defined within a Service Template. For example, a scaling policy for nodes in a web server tier might be defined as a Policy Type, which specifies the attributes the scaling policy can have.
- **PolicyTemplate**: This element specifies a template of a Policy that can be associated to Node Templates defined within a Service Template. Other than a Policy Type, a Policy Template can define concrete values for a policy according to the set of attributes specified by the Policy Type the Policy Template refers to.

A TOSCA Definitions document MUST define at least one of the elements `ServiceTemplate`, `NodeType`, `NodeTypeImplementation`, `RelationshipType`, `RelationshipTypeImplementation`, `RequirementType`, `CapabilityType`, `ArtifactType`, `ArtifactTemplate`, `PolicyType`, or `PolicyTemplate`, but it can define any number of those elements in an arbitrary order.

This technique supports a modular definition of Service Templates. For example, one Definitions document can contain only Node Type and Relationship Type definitions that can then be imported into another Definitions document that only defines a Service Template using those Node Types and Relationship Types. Similarly, Node Type Properties can be defined in separate XML Schema Definitions that are imported and referenced when defining a Node Type.

All TOSCA elements MAY use the `documentation` element 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:

```
01 <documentation source="xs:anyURI"? xml:lang="xs:language"?>
02   ...
03 </documentation>
```

Example of use of a `documentation` element:

```
01 <Definitions id="MyDefinitions" name="My Definitions" ...>
02
03   <documentation xml:lang="EN">
04     This is a simple example of the usage of the documentation
05     element nested under a Definitions element. It could be used,
06     for example, to describe the purpose of the Definitions document
07     or to give an overview of elements contained within the Definitions
08     document.
09   </documentation>
10
11 </Definitions>
```

## 527 4.3 Example

528 The following Definitions document defines two Node Types, "Application" and "ApplicationServer", as  
529 well as one Relationship Type "ApplicationHostedOnApplicationServer". The properties definitions for the  
530 two Node Types are specified in a separate XML schema definition file which is imported into the  
531 Definitions document by means of the `Import` element.

```
532 01 <Definitions id="MyDefinitions" name="My Definitions"  
533 02   targetNamespace="http://www.example.com/MyDefinitions"  
534 03   xmlns:my="http://www.example.com/MyDefinitions">  
535 04  
536 05   <Import importType="http://www.w3.org/2001/XMLSchema"  
537 06     namespace="http://www.example.com/MyDefinitions">  
538 07  
539 08   <NodeType name="Application">  
540 09     <PropertiesDefinition element="my:ApplicationProperties"/>  
541 10   </NodeType>  
542 11  
543 12   <NodeType name="ApplicationServer">  
544 13     <PropertiesDefinition element="my:ApplicationServerProperties"/>  
545 14   </NodeType>  
546 15  
547 16   <RelationshipType name="ApplicationHostedOnApplicationServer">  
548 17     <ValidSource typeRef="my:Application"/>  
549 18     <ValidTarget typeRef="my:ApplicationServer"/>  
550 19   </RelationshipTemplate>  
551 20  
552 21 </Definitions>
```

---

## 5 Service Templates

This chapter specifies how *Service Templates* are defined. A Service Template describes the structure of a cloud application by means of a Topology Template, and it defines the manageability behavior of the cloud application in the form of Plans.

Elements within a Service Template, such as Node Templates defined in the Topology Template, refer to other TOSCA element, such as Node Types that can be defined in the same Definitions document containing the Service Template, or that can be defined in separate, imported Definitions documents.

Service Templates can be defined for being directly used for the deployment and management of a cloud application, or they can be used for composition into larger Service Template (see section 3.5 for details).

### 5.1 XML Syntax

The following pseudo schema defines the XML syntax of a Service Template:

```
01 <ServiceTemplate id="xs:ID"
02     name="xs:string"?
03     targetNamespace="xs:anyURI"
04     substitutableNodeType="xs:QName"?>
05
06   <Tags>
07     <Tag name="xs:string" value="xs:string"/> +
08   </Tags> ?
09
10   <BoundaryDefinitions>
11     <Properties>
12       XML fragment
13     <PropertyMappings>
14       <PropertyMapping serviceTemplatePropertyRef="xs:string"
15         targetObjectRef="xs:IDREF"
16         targetPropertyRef="xs:string"/> +
17     </PropertyMappings> ?
18   </Properties> ?
19
20   <PropertyConstraints>
21     <PropertyConstraint property="xs:string"
22       constraintType="xs:anyURI"> +
23     constraint ?
24   </PropertyConstraint>
25 </PropertyConstraints> ?
26
27   <Requirements>
28     <Requirement name="xs:string"? ref="xs:IDREF"/> +
29   </Requirements> ?
30
31   <Capabilities>
32     <Capability name="xs:string"? ref="xs:IDREF"/> +
33   </Capabilities> ?
34
35   <Policies>
36     <Policy name="xs:string"? policyType="xs:QName"
37       policyRef="xs:QName"?>
38     policy specific content ?
39   </Policy> +
40 </Policies> ?
```

```

604 41
605 42     <Interfaces>
606 43         <Interface name="xs:NCName">
607 44             <Operation name="xs:NCName">
608 45                 (
609 46                     <NodeOperation nodeRef="xs:IDREF"
610 47                         interfaceName="xs:anyURI"
611 48                         operationName="xs:NCName"/>
612 49                 |
613 50                     <RelationshipOperation relationshipRef="xs:IDREF"
614 51                         interfaceName="xs:anyURI"
615 52                         operationName="xs:NCName"/>
616 53                 |
617 54                     <Plan planRef="xs:IDREF"/>
618 55                 )
619 56             </Operation> +
620 57         </Interface> +
621 58     </Interfaces> ?
622 59
623 60 </BoundaryDefinitions> ?
624 61
625 62 <TopologyTemplate>
626 63     (
627 64         <NodeTemplate id="xs:ID" name="xs:string"? type="xs:QName"
628 65             minInstances="xs:integer"?
629 66             maxInstances="xs:integer | xs:string"?>
630 67             <Properties>
631 68                 XML fragment
632 69             </Properties> ?
633 70
634 71             <PropertyConstraints>
635 72                 <PropertyConstraint property="xs:string"
636 73                     constraintType="xs:anyURI">
637 74                     constraint ?
638 75                 </PropertyConstraint> +
639 76             </PropertyConstraints> ?
640 77
641 78             <Requirements>
642 79                 <Requirement id="xs:ID" name="xs:string" type="xs:QName"> +
643 80                     <Properties>
644 81                         XML fragment
645 82                     <Properties> ?
646 83                     <PropertyConstraints>
647 84                         <PropertyConstraint property="xs:string"
648 85                             constraintType="xs:anyURI"> +
649 86                             constraint ?
650 87                         </PropertyConstraint>
651 88                     </PropertyConstraints> ?
652 89                 </Requirement>
653 90             </Requirements> ?
654 91
655 92             <Capabilities>
656 93                 <Capability id="xs:ID" name="xs:string" type="xs:QName"> +
657 94                     <Properties>
658 95                         XML fragment
659 96                     <Properties> ?
660 97                     <PropertyConstraints>
661 98                         <PropertyConstraint property="xs:string"

```



```

662 99                                     constraintType="xs:anyURI">
663 100                                     constraint ?
664 101                                     </PropertyConstraint> +
665 102                                     </PropertyConstraints> ?
666 103                                     </Capability>
667 104                                     </Capabilities> ?
668 105
669 106                                     <Policies>
670 107                                     <Policy name="xs:string"? policyType="xs:QName"
671 108                                         policyRef="xs:QName"?>
672 109                                         policy specific content ?
673 110                                     </Policy> +
674 111                                     </Policies> ?
675 112
676 113                                     <DeploymentArtifacts>
677 114                                     <DeploymentArtifact name="xs:string" artifactType="xs:QName"
678 115                                         artifactRef="xs:QName"?>
679 116                                         artifact specific content ?
680 117                                     </DeploymentArtifact> +
681 118                                     </DeploymentArtifacts> ?
682 119                                     </NodeTemplate>
683 120 |
684 121                                     <RelationshipTemplate id="xs:ID" name="xs:string"?
685 122                                         type="xs:QName">
686 123                                     <Properties>
687 124                                         XML fragment
688 125                                     </Properties> ?
689 126
690 127                                     <PropertyConstraints>
691 128                                     <PropertyConstraint property="xs:string"
692 129                                         constraintType="xs:anyURI">
693 130                                         constraint ?
694 131                                     </PropertyConstraint> +
695 132                                     </PropertyConstraints> ?
696 133
697 134                                     <SourceElement ref="xs:IDREF"/>
698 135                                     <TargetElement ref="xs:IDREF"/>
699 136
700 137                                     <RelationshipConstraints>
701 138                                     <RelationshipConstraint constraintType="xs:anyURI">
702 139                                         constraint ?
703 140                                     </RelationshipConstraint> +
704 141                                     </RelationshipConstraints> ?
705 142
706 143                                     </RelationshipTemplate>
707 144                                     ) +
708 145                                     </TopologyTemplate>
709 146
710 147                                     <Plans>
711 148                                     <Plan id="xs:ID"
712 149                                         name="xs:string"?
713 150                                         planType="xs:anyURI"
714 151                                         planLanguage="xs:anyURI">
715 152
716 153                                     <Precondition expressionLanguage="xs:anyURI">
717 154                                         condition
718 155                                     </Precondition> ?
719 156

```

```

720 157         <InputParameters>
721 158             <InputParameter name="xs:string" type="xs:string"
722 159                 required="yes|no"?/> +
723 160         </InputParameters> ?
724 161
725 162         <OutputParameters>
726 163             <OutputParameter name="xs:string" type="xs:string"
727 164                 required="yes|no"?/> +
728 165         </OutputParameters> ?
729 166
730 167         (
731 168             <PlanModel>
732 169                 actual plan
733 170             </PlanModel>
734 171             |
735 172             <PlanModelReference reference="xs:anyURI"/>
736 173         )
737 174
738 175         </Plan> +
739 176     </Plans> ?
740 177
741 178 </ServiceTemplate>

```

## 5.2 Properties

The `ServiceTemplate` element has the following properties:

- `id`: This attribute specifies the identifier of the Service Template which **MUST** be unique within the target namespace.
- `name`: This **OPTIONAL** attribute specifies a descriptive name of the Service Template.
- `targetNamespace`: The value of this **OPTIONAL** attribute specifies the target namespace for the Service Template. If not specified, the Service Template will be added to the namespace declared by the `targetNamespace` attribute of the enclosing `Definitions` element.
- `substitutableNodeType`: This **OPTIONAL** attribute specifies a Node Type that can be substituted by this Service Template. If another Service Template contains a Node Template of the specified Node Type (or any Node Type this Node Type is derived from), this Node Template can be substituted by an instance of this Service Template that then provides the functionality of the substituted node. See section 3.5 for more details.
- `Tags`: This **OPTIONAL** element allows the definition of any number of tags which can be used by the author to describe the Service Template. Each tag is defined by a separate, nested `Tag` element.

The `Tag` element has the following properties:

- `name`: This attribute specifies the name of the tag.
- `value`: This attribute specifies the value of the tag.

**Note:** The name/value pairs defined in tags have no normative interpretation.

- `BoundaryDefinitions`: This **OPTIONAL** element specifies the properties the Service Template exposes beyond its boundaries, i.e. properties that can be observed from outside the Service Template. The `BoundaryDefinitions` element has the following properties.
  - `Properties`: This **OPTIONAL** element specifies global properties of the Service Template in the form of an XML fragment contained in the body of the `Properties` element. Those properties **MAY** be mapped to properties of components within the

Service Template to make them visible to the outside.

The `Properties` element has the following properties:

- `PropertyMappings`: This OPTIONAL element specifies mappings of one or more of the Service Template's properties to properties of components within the Service Template (e.g. Node Templates, Relationship Templates, etc.). Each property mapping is defined by a separate, nested `PropertyMapping` element. The `PropertyMapping` element has the following properties:

- `serviceTemplatePropertyRef`: This attribute identifies a property of the Service Template by means of an XPath expression to be evaluated on the XML fragment defining the Service Template's properties.
- `targetObjectRef`: This attribute specifies the object that provides the property to which the respective Service Template property is mapped. The referenced target object MUST be one of Node Template, Requirement of a Node Template, Capability of a Node Template, or Relationship Template.
- `targetPropertyRef`: This attribute identifies a property of the target object by means of an XPath expression to be evaluated on the XML fragment defining the target object's properties.

Note: If a Service Template property is mapped to a property of a component within the Service Template, the XML schema type of the Service Template property and the mapped property MUST be compatible.

Note: If a Service Template property is mapped to a property of a component within the Service Template, reading the Service Template property corresponds to reading the mapped property, and writing the Service Template property corresponds to writing the mapped property.

- `PropertyConstraints`: This OPTIONAL element specifies constraints on one or more of the Service Template's properties. Each constraint is specified by means of a separate, nested `PropertyConstraint` element.

The `PropertyConstraint` element has the following properties:

- `property`: This attribute identifies a property by means of an XPath expression to be evaluated on the XML fragment defining the Service Template's properties.

Note: If the property affected by the property constraint is mapped to a property of a component within the Service Template, the property constraint SHOULD be compatible with any property constraint defined for the mapped property.

- `constraintType`: This attribute specifies the type of constraint by means of a URI, which defines both the semantic meaning of the constraint as well as the format of the content.

- The body of the `PropertyConstraint` element provides the actual constraint.

Note: The body MAY be empty in case the `constraintType` URI already specifies the constraint appropriately. For example, a "read-only" constraint could be expressed solely by the `constraintType` URI.

- `Requirements`: This OPTIONAL element specifies Requirements exposed by the Service Template. Those Requirements correspond to Requirements of Node Templates within the Service Template that are propagated beyond the boundaries of the Service Template. Each Requirement is defined by a separate, nested `Requirement` element.

The `Requirement` element has the following properties:

821                   ▪ `name`: This OPTIONAL attribute allows for specifying a name of the Requirement  
822                   other than that specified by the referenced Requirement of a Node Template.

823                   ▪ `ref`: This attribute references a `Requirement` element of a Node Template  
824                   within the Service Template.

825           ○ `Capabilities`: This OPTIONAL element specifies Capabilities exposed by the  
826           Service Template. Those Capabilities correspond to Capabilities of Node Templates  
827           within the Service Template that are propagated beyond the boundaries of the Service  
828           Template. Each Capability is defined by a separate, nested `Capability` element. The  
829           `Capability` element has the following properties:

830                   ▪ `name`: This OPTIONAL attribute allows for specifying a name of the Capability  
831                   other than that specified by the referenced Capability of a Node Template.

832                   ▪ `ref`: This attribute references a `Capability` element of a Node Template  
833                   within the Service Template.

834           ○ `Policies`: This OPTIONAL element specifies global policies of the Service Template  
835           related to a particular management aspect. All Policies defined within the `Policies`  
836           element MUST be enforced by a TOSCA implementation, i.e. Policies are AND-  
837           combined. Each policy is defined by a separate, nested `Policy` element.  
838           The `Policy` element has the following properties:

839                   ▪ `name`: This OPTIONAL attribute allows for the definition of a name for the Policy.  
840                   If specified, this name MUST be unique within the containing `Policies`  
841                   element.

842                   ▪ `policyType`: This attribute specifies the type of this Policy. The QName value  
843                   of this attribute SHOULD correspond to the QName of a `PolicyType` defined  
844                   in the same Definitions document or in an imported document.

845                   The `policyType` attribute specifies the artifact type specific content of the  
846                   `Policy` element body and indicates the type of Policy Template referenced by  
847                   the Policy via the `policyRef` attribute.

848                   ▪ `policyRef`: The QName value of this OPTIONAL attribute references a Policy  
849                   Template that is associated to the Service Template. This Policy Template can  
850                   be defined in the same TOSCA Definitions document, or it can be defined in a  
851                   separate document that is imported into the current Definitions document. The  
852                   type of Policy Template referenced by the `policyRef` attribute MUST be the  
853                   same type or a sub-type of the type specified in the `policyType` attribute.

854                   Note: if no Policy Template is referenced, the policy specific content of the  
855                   `Policy` element alone is assumed to represent sufficient policy specific  
856                   information in the context of the Service Template.

857                   Note: while Policy Templates provide invariant information about a non-functional  
858                   behavior (i.e. information that is context independent, such as the availability  
859                   class of an availability policy), the `Policy` element defined in a Service  
860                   Template can provide variant information (i.e. information that is context specific,  
861                   such as a specific heartbeat frequency for checking availability of a service) in  
862                   the policy specific body of the `Policy` element.

863           ○ `Interfaces`: This OPTIONAL element specifies the interfaces with operations that can  
864           be invoked on complete service instances created from the Service Template.  
865           The `Interfaces` element has the following properties:

866                   ▪ `Interface`: This element specifies one interfaces exposed by the Service  
867                   Template.  
868                   The `Interface` element has the following properties:

- `name`: This attribute specifies the name of the interfaces as either a URI or an NCName that MUST be unique in the scope of the Service Template's boundary definitions.
- `Operation`: This element specifies one exposed operation of an interface exposed by the Service Template.

An operation exposed by a Service Template maps to an internal component of the Service Template which actually provides the operation: it can be mapped to an operation provided by a Node Template (i.e. an operation defined by the Node Type specified in the `type` attribute of the Node Template), it can be mapped to an operation provided by a Relationship Template (i.e. an operation defined by the Relationship Type specified in the `type` attribute of the Relationship Template), or it can be mapped to a Plan of the Service Template.

When an exposed operation is invoked on a service instance created from the Service Template, the operation or Plan mapped to the exposed operation will actually be invoked.

The `Operation` element has the following properties:

- `name`: This attribute specifies the name of the operation, which MUST be unique within the containing interface.
- `NodeOperation`: This element specifies a reference to an operation of a Node Template. The `nodeRef` attribute of this element specifies a reference to the respective Node Template. The specific interface and operation to be mapped to the operation exposed by the Service Template are specified by means of the `interfaceName` and `operationName` attributes, respectively.

Note: An interface and operation with the specified names MUST be defined by the Node Type (or one of its super types) defined in the `type` attribute of the referenced Node Template.

- `RelationshipOperation`: This element specifies a reference to an operation of a Relationship Template. The `relationshipRef` attribute of this element specifies a reference to the respective Relationship Template. The specific interface and operation to be mapped to the operation exposed by the Service Template are specified by means of the `interfaceName` and `operationName` attributes, respectively.

Note: An interface and operation with the specified names MUST be defined by the Relationship Type (or one of its super types) defined in the `type` attribute of the referenced Relationship Template.

- `Plan`: This element specifies by means of its `planRef` attribute a reference to a Plan that provides the implementation of the operation exposed by the Service Template.

One of `NodeOperation`, `RelationshipOperation` or `Plan` MUST be specified within the `Operation` element.

- **TopologyTemplate**: This element specifies the overall structure of the cloud application defined by the Service Template, i.e. the components it consists of, and the relations between those components. The components of a service are referred to as *Node Templates*, the relations between the components are referred to as *Relationship Templates*.

The **TopologyTemplate** element has the following properties:

- **NodeTemplate**: This element specifies a kind of a component making up the cloud application.

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.
- **type**: 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 the **type** 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 Template with one having 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**.
- **Properties**: 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 **type** 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 **Properties** 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.

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.

- **Requirements:** This element contains a list of requirements for the Node Template, according to the list of requirement definitions of the Node Type specified in the `type` attribute of the Node Template. Each requirement is specified in a separate nested `Requirement` element.

The `Requirement` Element has the following properties:

- **id:** This attribute specifies the identifier of the Requirement. The identifier of the Requirement MUST be unique within the target namespace.
- **name:** This attribute specifies the name of the Requirement. The `name` and `type` of the Requirement MUST match the `name` and `type` of a Requirement Definition in the Node Type specified in the `type` attribute of the Node Template.
- **type:** The QName value of this attribute refers to the Requirement Type definition of the Requirement. This Requirement Type denotes the semantics and well as potential properties of the Requirement.
- **Properties:** This element specifies initial values for one or more of the Requirement Properties according to the Requirement Type providing the property definitions. Properties are provided in the form of an XML fragment. The same rules as outlined for the `Properties` element of the Node Template apply.
- **PropertyConstraints:** This element specifies constraints on the use of one or more of the Properties of the Requirement Type providing the property definitions for the Requirement. Each constraint is specified by means of a separate nested `PropertyConstraint` element. The same rules as outlined for the `PropertyConstraints` element of the Node Template apply.

- **Capabilities:** This element contains a list of capabilities for the Node Template, according to the list of capability definitions of the Node Type specified in the `type` attribute of the Node Template. Each capability is specified in a separate nested `Capability` element.

The `Capability` Element has the following properties:

- 1015
- 1016
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- 1061
- `id`: This attribute specifies the identifier of the Capability. The identifier of the Capability MUST be unique within the target namespace.
  - `name`: This attribute specifies the name of the Capability. The `name` and `type` of the Capability MUST match the `name` and `type` of a Capability Definition in the Node Type specified in the `type` attribute of the Node Template.
  - `type`: The QName value of this attribute refers to the Capability Type definition of the Capability. This Capability Type denotes the semantics and well as potential properties of the Capability.
  - `Properties`: This element specifies initial values for one or more of the Capability Properties according to the Capability Type providing the property definitions. Properties are provided in the form of an XML fragment. The same rules as outlined for the `Properties` element of the Node Template apply.
  - `PropertyConstraints`: This element specifies constraints on the use of one or more of the Properties of the Capability Type providing the property definitions for the Capability. Each constraint is specified by means of a separate nested `PropertyConstraint` element. The same rules as outlined for the `PropertyConstraints` element of the Node Template apply.
  - `Policies`: This OPTIONAL element specifies policies associated with the Node Template. All Policies defined within the `Policies` element MUST be enforced by a TOSCA implementation, i.e. Policies are AND-combined. Each policy is specified by means of a separate nested `Policy` element. The `Policy` element has the following properties:
    - `name`: This OPTIONAL attribute allows for the definition of a name for the Policy. If specified, this name MUST be unique within the containing `Policies` element.
    - `policyType`: This attribute specifies the type of this Policy. The QName value of this attribute SHOULD correspond to the QName of a `PolicyType` defined in the same Definitions document or in an imported document.

The `policyType` attribute specifies the artifact type specific content of the `Policy` element body and indicates the type of Policy Template referenced by the Policy via the `policyRef` attribute.

  - `policyRef`: The QName value of this OPTIONAL attribute references a Policy Template that is associated to the Node Template. This Policy Template can be defined in the same TOSCA Definitions document, or it can be defined in a separate document that is imported into the current Definitions document. The type of Policy Template referenced by the `policyRef` attribute MUST be the same type or a sub-type of the type specified in the `policyType` attribute.
- Note: if no Policy Template is referenced, the policy specific content of the `Policy` element alone is assumed to represent sufficient policy specific information in the context of the Node Template.



Note: while Policy Templates provide invariant information about a non-functional behavior (i.e. information that is context independent, such as the availability class of an availability policy), the `Policy` element defined in a Node Template can provide variant information (i.e. information that is context specific, such as a specific heartbeat frequency for checking availability of a component) in the policy specific body of the `Policy` element.

- `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 `DeploymentArtifact` element has the following properties:

- `name`: This attribute specifies the name of the artifact. Uniqueness of the name within the scope of the encompassing Node Template SHOULD be guaranteed by the definition.
- `artifactType`: This attribute specifies the type of this artifact. The `QName` value of this attribute SHOULD correspond to the `QName` of an `ArtifactType` defined in the same Definitions document or in an imported document.

The `artifactType` attribute specifies the artifact type specific content of the `DeploymentArtifact` element body and indicates the type of Artifact Template referenced by the Deployment Artifact via the `artifactRef` attribute.

- `artifactRef`: This OPTIONAL attribute contains a `QName` that identifies an Artifact Template to be used as deployment artifact. This Artifact Template can be defined in the same Definitions document or in a separate, imported document. The type of Artifact Template referenced by the `artifactRef` attribute MUST be the same type or a sub-type of the type specified in the `artifactType` attribute.

Note: if no Artifact Template is referenced, the artifact type specific content of the `DeploymentArtifact` element alone is assumed to represent the actual artifact. For example, the contents of a simple config file could be defined in place within the `DeploymentArtifact` element.

Note, that a deployment artifact specified with the Node Template under definition overrides any deployment artifact of the same `name` and the same `artifactType` (or any Artifact Type it is derived from) specified with the Node Type Implementation implementing the Node Type given as value of the `type` attribute of the Node Template under definition. Otherwise, the deployment artifacts of Node Type Implementations and the deployment artifacts defined with the Node Template are combined.

- `RelationshipTemplate`: This element specifies a kind of relationship between the components of the cloud application. For each specified Relationship Template the

source element and target element MUST be specified in the Topology Template.  
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.
- `type`: 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 `type` 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 Template with one having a specialized, derived Relationship Type has to be done at the latest during the instantiation time of the Relationship Template.

- `Properties`: 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. This instance document considers the inheritance structure deduced by the `DerivedFrom` property of the Relationship Type referenced by the `type` attribute of the Relationship Template.  
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 `Properties` 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.

The `PropertyConstraint` element has the following properties:

- `property`: The string value of this property is an XPath expression pointing to the property within the Relationship Type Properties document that is constrained within the context of the Relationship 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

1157 unique within a certain scope. The constraint type specific content of the  
1158 respective `PropertyConstraint` element could then define the  
1159 actual scope in which uniqueness has to be ensured in more detail.

- 1160 ▪ `SourceElement`: This element specifies the origin of the relationship  
1161 represented by the current Relationship Template.

1162 The `SourceElement` element has the following property:

- 1163 • `ref`: This attribute references by ID a Node Template or a Requirement  
1164 of a Node Template within the same Service Template document that is  
1165 the source of the Relationship Template.

1166  
1167 If the Relationship Type referenced by the `type` attribute defines a  
1168 constraint on the valid source of the relationship by means of its  
1169 `ValidSource` element, the `ref` attribute of `SourceElement` MUST  
1170 reference an object the type of which complies with the valid source  
1171 constraint of the respective Relationship Type.

1172  
1173 In the case where a Node Type is defined as valid source in the  
1174 Relationship Type definition, the `ref` attribute MUST reference a Node  
1175 Template of the corresponding Node Type (or of a sub-type).

1176  
1177 In the case where a Requirement Type is defined a valid source in the  
1178 Relationship Type definition, the `ref` attribute MUST reference a  
1179 Requirement of the corresponding Requirement Type within a Node  
1180 Template.

- 1181 ▪ `TargetElement`: This element specifies the target of the relationship  
1182 represented by the current Relationship Template.

1183 The `TargetElement` element has the following property:

- 1184 • `ref`: This attribute references by ID a Node Template or a Capability of  
1185 a Node Template within the same Service Template document that is the  
1186 target of the Relationship Template.

1187  
1188 If the Relationship Type referenced by the `type` attribute defines a  
1189 constraint on the valid source of the relationship by means of its  
1190 `ValidTarget` element, the `ref` attribute of `TargetElement` MUST  
1191 reference an object the type of which complies with the valid source  
1192 constraint of the respective Relationship Type.

1193  
1194 In case a Node Type is defined as valid target in the Relationship Type  
1195 definition, the `ref` attribute MUST reference a Node Template of the  
1196 corresponding Node Type (or of a sub-type).

1197  
1198 In case a Capability Type is defined a valid target in the Relationship  
1199 Type definition, the `ref` attribute MUST reference a Capability of the  
1200 corresponding Capability Type within a Node Template.

- 1201 ▪ `RelationshipConstraints`: This element specifies a list of constraints on  
1202 the use of the relationship in separate nested `RelationshipConstraint`  
1203 elements.

1204 The `RelationshipConstraint` element has the following properties:

- `constraintType`: This attribute specifies the type of relationship constraint by means of a URI. Depending on the type, the body of the `RelationshipConstraint` element might contain type specific content that further details the actual constraint.

- **Plans:** This element specifies the operational behavior of the service. A `Plan` contained in the `Plans` element can specify how to create, terminate or manage the service.

The `Plan` element has 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.

- <http://docs.oasis-open.org/tosca/ns/2011/12/PlanTypes/BuildPlan> - 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.

- o **planLanguage:** This attribute denotes the process modeling language (or metamodel) used to specify the plan. For example, “<http://www.omg.org/spec/BPMN/20100524/MODEL>” would specify that BPMN 2.0 has been used to model the plan.

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.

- **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.

- **InputParameters:** This OPTIONAL property contains a list of one or more input parameter definitions for the Plan, each defined in a nested, separate `InputParameter` element.

The `InputParameter` element has the following properties:

- 1250                   ▪   name: This attribute specifies the name of the input parameter, which MUST be
- 1251                   unique within the set of input parameters defined for the operation.
- 1252                   ▪   type: This attribute specifies the type of the input parameter.
- 1253                   ▪   required: This OPTIONAL attribute specifies whether or not the input
- 1254                   parameter is REQUIRED (required attribute with a value of “yes” – default) or
- 1255                   OPTIONAL (required attribute with a value of “no”).
- 1256           ○   OutputParameters: This OPTIONAL property contains a list of one or more output
- 1257           parameter definitions for the Plan, each defined in a nested, separate
- 1258           OutputParameter element.
- 1259           The OutputParameter element has the following properties:
- 1260                   ▪   name: This attribute specifies the name of the output parameter, which MUST be
- 1261                   unique within the set of output parameters defined for the operation.
- 1262                   ▪   type: This attribute specifies the type of the output parameter.
- 1263                   ▪   required: This OPTIONAL attribute specifies whether or not the output
- 1264                   parameter is REQUIRED (required attribute with a value of “yes” – default) or
- 1265                   OPTIONAL (required attribute with a value of “no”).
- 1266           ○   PlanModel: This property contains the actual model content.
- 1267           ○   PlanModelReference: This property points to the model content. Its reference
- 1268           attribute contains a URI of the model of the plan.
- 1269
- 1270           An instance of the Plan element MUST either contain the actual plan as instance of the
- 1271           PlanModel element, or point to the model via the PlanModelReference element.

## 1272 5.3 Example

1273 The following Service Template defines a Topology Template containing two Node Templates called  
 1274 “MyApplication” and “MyAppServer”. These Node Templates have the node types “Application” and  
 1275 “ApplicationServer”. The Node Template “MyApplication” is instantiated exactly once. Two of its Node  
 1276 Type Properties are initialized by a corresponding Properties element. The Node Template  
 1277 “MyAppServer” can be instantiated as many times as needed. The “MyApplication” Node Template is  
 1278 connected with the “MyAppServer” Node Template via the Relationship Template named  
 1279 “MyHostedRelationship”; the behavior and semantics of the Relationship Template is defined in the  
 1280 Relationship Type “HostedOn”, saying that “MyApplication” is hosted on “MyAppServer”. The Service  
 1281 Template further defines a Plan “UpdateApplication” for performing an update of the “MyApplication”  
 1282 application hosted on the application server. This Plan refers to a BPMN 2.0 process definition contained  
 1283 in a separate file.

```

1284 01 <ServiceTemplate id="MyService"
1285 02       name="My Service">
1286 03
1287 04   <TopologyTemplate>
1288 05
1289 06     <NodeTemplate id="MyApplication"
1290 07       name="My Application"
1291 08       type="my:Application">
1292 09       <Properties>
1293 10         <ApplicationProperties>
1294 11         <Owner>Frank</Owner>
1295 12         <InstanceName>Thomas' favorite application</InstanceName>
1296 13       </ApplicationProperties>
1297 14     </Properties>

```

```

1298 15     </NodeTemplate>
1299 16
1300 17     <NodeTemplate id="MyAppServer"
1301 18         name="My Application Server"
1302 19         type="my:ApplicationServer"
1303 20         minInstances="0"
1304 21         maxInstances="unbounded"/>
1305 22
1306 23     <RelationshipTemplate id="MyDeploymentRelationship"
1307 24         type="my:deployedOn">
1308 25         <SourceElement ref="MyApplication"/>
1309 26         <TargetElement ref="MyAppServer"/>
1310 27     </RelationshipTemplate>
1311 28
1312 29 </TopologyTemplate>
1313 30
1314 31 <Plans>
1315 32     <Plan id="UpdateApplication"
1316 33         planType="http://www.example.com/UpdatePlan"
1317 34         planLanguage="http://www.omg.org/spec/BPMN/20100524/MODEL">
1318 35         <PlanModelReference reference="plans:UpdateApp"/>
1319 36     </Plan>
1320 37 </Plans>
1321 38
1322 39 </ServiceTemplate>

```

---

## 6 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 a *Properties Definition*, 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.

A Node Type can declare to expose certain requirements and capabilities (see section 3.4) by means of *RequirementDefinition* elements or *CapabilityDefinition* elements, respectively.

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.

### 6.1 XML Syntax

The following pseudo schema defines the XML syntax of Node Types:

```
01 <NodeType name="xs:NCName" targetNamespace="xs:anyURI"?
02     abstract="yes|no"? final="yes|no"?>
03
04     <Tags>
05         <Tag name="xs:string" value="xs:string"/> +
06     </Tags> ?
07
08     <DerivedFrom typeRef="xs:QName"/> ?
09
10     <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
11
12     <RequirementDefinitions>
13         <RequirementDefinition name="xs:string"
14             requirementType="xs:QName"
15             lowerBound="xs:integer"?
16             upperBound="xs:integer | xs:string"?
17             <Constraints>
18                 <Constraint constraintType="xs:anyURI">
19                     constraint type specific content
20                 </Constraint> +
21             </Constraints> ?
22         </RequirementDefinition> +
23     </RequirementDefinitions> ?
24
25     <CapabilityDefinitions>
26         <CapabilityDefinition name="xs:string"
27             capabilityType="xs:QName"
28             lowerBound="xs:integer"?
29             upperBound="xs:integer | xs:string"?
30             <Constraints>
31                 <Constraint constraintType="xs:anyURI">
32                     constraint type specific content
33                 </Constraint> +
34             </Constraints> ?
```

```

1373 35     </CapabilityDefinition> +
1374 36 </CapabilityDefinitions>
1375 37
1376 38 <InstanceStates>
1377 39     <InstanceState state="xs:anyURI"> +
1378 40 </InstanceStates> ?
1379 41
1380 42 <Interfaces>
1381 43     <Interface name="xs:NCName | xs:anyURI">
1382 44         <Operation name="xs:NCName">
1383 45             <InputParameters>
1384 46                 <InputParameter name="xs:string" type="xs:string"
1385 47                     required="yes|no"?/> +
1386 48             </InputParameters> ?
1387 49             <OutputParameters>
1388 50                 <OutputParameter name="xs:string" type="xs:string"
1389 51                     required="yes|no"?/> +
1390 52             </OutputParameters> ?
1391 53         </Operation> +
1392 54     </Interface> +
1393 55 </Interfaces> ?
1394 56
1395 57 </NodeType>

```

## 6.2 Properties

The `NodeType` element has the following properties:

- **name:** This attribute specifies the name or identifier of the Node Type, which MUST be unique within the target namespace.
- **targetNamespace:** This OPTIONAL attribute specifies the target namespace to which the definition of the Node Type will be added. If not specified, the Node Type definition will be added to the target namespace of the enclosing Definitions document.
- **abstract:** This OPTIONAL attribute specifies that no instances can be created from Node Templates that use this Node Type as their type. If a Node Type includes a Requirement Definition or Capability Definition of an abstract Requirement Type or Capability Type, respectively, the Node Type MUST be declared as abstract as well.

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 other Node Types MUST NOT be derived from this Node Type.

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

- **Tags:** This OPTIONAL element allows the definition of any number of tags which can be used by the author to describe the Node Type. Each tag is defined by a separate, nested `Tag` element. The `Tag` element has the following properties:

- **name:** This attribute specifies the name of the tag.
- **value:** This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.



- 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 6.3 Derivation Rules for details.

The DerivedFrom element has the following properties:

  - typeRef: The QName specifies the Node Type from which this Node Type derives its definitions.
- PropertiesDefinition: This element specifies the structure of the observable properties of the Node Type, such as its configuration and state, by means of XML schema.

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

  - element: This attribute provides the QName of an XML element defining the structure of the Node Type Properties.
  - type: This attribute provides the QName of an XML (complex) type defining the structure of the Node Type Properties.
- RequirementDefinitions: This OPTIONAL element specifies the requirements that the Node Type exposes (see section 3.4 for details). Each requirement is defined in a nested RequirementDefinition element.

The RequirementDefinition element has the following properties:

  - name: This attribute specifies the name of the defined requirement and MUST be unique within the RequirementDefinitions of the current Node Type.

Note that one Node Type might define multiple requirements of the same Requirement Type, in which case each occurrence of a requirement definition is uniquely identified by its name. For example, a Node Type for an application might define two requirements for a database (i.e. of the same Requirement Type) where one could be named "customerDatabase" and the other one could be named "productsDatabase".
  - requirementType: This attribute identifies by QName the Requirement Type that is being defined by the current RequirementDefinition.
  - lowerBound: This OPTIONAL attribute specifies the lower boundary by which a requirement MUST be matched for Node Templates according to the current Node Type, or for instances created for those Node Templates. The default value for this attribute is one. A value of zero would indicate that matching of the requirement is optional.
  - upperBound: This OPTIONAL attribute specifies the upper boundary by which a requirement MUST be matched for Node Templates according to the current Node Type, or for instances created for those Node Templates. The default value for this attribute is one. A value of "unbounded" indicates that there is no upper boundary.

Constraints: This OPTIONAL element contains a list of Constraint elements that specify additional constraints on the requirement definition. For example, if a database is needed a constraint on supported SQL features might be expressed.

The nested Constraint element has the following properties:

    - constraintType: This attribute specifies the type of constraint. According to this type, the body of the Constraint element will contain type specific content.
- CapabilityDefinitions: This OPTIONAL element specifies the capabilities that the Node Type exposes (see section 3.4 for details). Each capability is defined in a nested CapabilityDefinition element.

The CapabilityDefinition element has the following properties:

  - name: This attribute specifies the name of the defined capability and MUST be unique within the CapabilityDefinitions of the current Node Type.

1473 Note that one Node Type might define multiple capabilities of the same Capability Type,  
 1474 in which case each occurrence of a capability definition is uniquely identified by its name.

- 1475 ○ `capabilityType`: This attribute identifies by QName the Capability Type of capability  
 1476 that is being defined by the current `CapabilityDefinition`.
- 1477 ○ `lowerBound`: This OPTIONAL attribute specifies the lower boundary of requiring nodes  
 1478 that the defined capability can serve. The default value for this attribute is one. A value of  
 1479 zero is invalid, since this would mean that the capability cannot actually satisfy any  
 1480 requiring nodes.
- 1481 ○ `upperBound`: This OPTIONAL attribute specifies the upper boundary of client  
 1482 requirements the defined capability can serve. The default value for this attribute is one.  
 1483 A value of "unbounded" indicates that there is no upper boundary.
- 1484 ○ `Constraints`: This OPTIONAL element contains a list of `Constraint` elements that  
 1485 specify additional constraints on the capability definition.  
 1486 The nested `Constraint` element has the following properties:
  - 1487 ▪ `constraintType`: This attribute specifies the type of constraint. According to  
 1488 this type, the body of the `Constraint` element will contain type specific  
 1489 content.
- 1490 • `InstanceStates`: This OPTIONAL element lists the set of states an instance of this Node  
 1491 Type can occupy. Those states are defined in nested `InstanceState` elements.  
 1492 The `InstanceState` element has the following nested properties:
  - 1493 ○ `state`: This attribute specifies a URI that identifies a potential state.
- 1494 • `Interfaces`: This element contains the definitions of the operations that can be performed on  
 1495 (instances of) this Node Type. Such operation definitions are given in the form of nested  
 1496 `Interface` elements.  
 1497 The `Interface` element has the following properties:
  - 1498 ○ `name`: The name of the interface. This name is either a URI or it is an NCName that  
 1499 MUST be unique in the scope of the Node Type being defined.
  - 1500 ○ `Operation`: This element defines an operation available to manage particular aspects  
 1501 of the Node Type.  
 1502  
 1503 The `Operation` element has the following properties:
    - 1504 ▪ `name`: This attribute defines the name of the operation and MUST be unique  
 1505 within the containing `Interface` of the Node Type.
    - 1506 ▪ `InputParameters`: This OPTIONAL property contains a list of one or more  
 1507 input parameter definitions, each defined in a nested, separate  
 1508 `InputParameter` element.  
 1509 The `InputParameter` element has the following properties:
      - 1510 • `name`: This attribute specifies the name of the input parameter, which  
 1511 MUST be unique within the set of input parameters defined for the  
 1512 operation.
      - 1513 • `type`: This attribute specifies the type of the input parameter.
      - 1514 • `required`: This OPTIONAL attribute specifies whether or not the input  
 1515 parameter is REQUIRED (`required` attribute with a value of "yes" –  
 1516 default) or OPTIONAL (`required` attribute with a value of "no").
    - 1517 ▪ `OutputParameters`: This OPTIONAL property contains a list of one or more  
 1518 output parameter definitions, each defined in a nested, separate  
 1519 `OutputParameter` element.  
 1520 The `OutputParameter` element has the following properties:

- `name`: This attribute specifies the name of the output parameter, which **MUST** be unique within the set of output parameters defined for the operation.
- `type`: This attribute specifies the type of the output parameter.
- `required`: This **OPTIONAL** attribute specifies whether or not the output parameter is **REQUIRED** (`required` attribute with a value of “yes” – default) or **OPTIONAL** (`required` attribute with a value of “no”).

## 6.3 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.
- **Requirements and capabilities**: The set of requirements or capabilities of the Node Type under definition consists of the set union of requirements or capabilities defined by the Node Type derived from and the requirements or capabilities defined by the Node Type under definition.  
  
In cases where the Node Type under definition defines a requirement or capability with a certain name where the Node Type derived from already contains a respective definition with the same name, the definition in the Node Type under definition overrides the definition of the Node Type derived from. In such a case, the requirement definition or capability definition, respectively, **MUST** reference a Requirement Type or Capability Type that is derived from the one in the corresponding requirement definition or capability definition of the Node Type derived from.
- **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. An operation defined by the Node Type under definition substitutes an operation with the same name of the Node Type derived from.

## 6.4 Example

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

```
01 <Definitions id="MyDefinitions" name="My Definitions"
02     targetNamespace="http://www.example.com/sample">
03
04   <NodeType name="Project">
05
06     <documentation xml:lang="EN">
07       A reusable definition of a node type supporting
08       the creation of new projects.
```

```

1567 09     </documentation>
1568 10
1569 11     <PropertiesDefinition element="ProjectProperties"/>
1570 12
1571 13     <InstanceStates>
1572 14         <InstanceState state="www.example.com/active"/>
1573 15         <InstanceState state="www.example.com/onHold"/>
1574 16     </InstanceStates>
1575 17
1576 18     <Interfaces>
1577 19         <Interface name="ProjectInterface">
1578 20             <Operation name="CreateProject">
1579 21                 <InputParameters>
1580 22                     <InputParamter name="ProjectName"
1581 23                         type="xs:string"/>
1582 24                     <InputParamter name="Owner"
1583 25                         type="xs:string"/>
1584 26                     <InputParamter name="AccountID"
1585 27                         type="xs:string"/>
1586 28                 </InputParameters>
1587 29             </Operation>
1588 30         </Interface>
1589 31     </Interfaces>
1590 32 </NodeType>
1591 33
1592 34 </Definitions>

```

1593 The Node Type "Project" has three Node Type Properties defined as an XML element in the `Types`  
1594 element definition of the Service Template document: `Owner`, `ProjectName` and `AccountID` which are all  
1595 of type `xs:string`. An instance of the Node Type "Project" could be "active" (more precise in state  
1596 `www.example.com/active`) or "on hold" (more precise in state `www.example.com/onHold`). A single  
1597 Interface is defined for this Node Type, and this Interface is defined by an Operation, i.e. its actual  
1598 implementation is defined by the definition of the Operation. The Operation has the name `CreateProject`  
1599 and three Input Parameters (exploiting the default value "yes" of the attribute `required` of the  
1600 `InputParameter` element). The names of these Input Parameters are `ProjectName`, `Owner` and  
1601 `AccountID`, all of type `xs:string`.

## 7 Node Type Implementations

This chapter specifies how *Node Type Implementations* are defined. A Node Type Implementation represents the executable code that implements a specific Node Type. It provides a collection of executables implementing the interface operations of a Node Type (aka implementation artifacts) and the executables needed to materialize instances of Node Templates referring to a particular Node Type (aka deployment artifacts). The respective executables are defined as separate Artifact Templates and are referenced from the implementation artifacts and deployment artifacts of a Node Type Implementation.

While Artifact Templates provide invariant information about an artifact – i.e. information that is context independent like the file name of the artifact – implementation or deployment artifacts can provide variant (or context specific) information, such as authentication data or deployment paths for a specific environment.

Node Type Implementations can specify hints for a TOSCA container that enable proper selection of an implementation that fits into a particular environment by means of Required Container Features definitions.

### 7.1 XML Syntax

The following pseudo schema defines the XML syntax of Node Type Implementations:

```
01 <NodeTypeImplementation name="xs:NCName" targetNamespace="xs:anyURI"?
02     nodeType="xs:QName"
03     abstract="yes|no"?
04     final="yes|no"?>
05
06   <Tags>
07     <Tag name="xs:string" value="xs:string"/> +
08   </Tags> ?
09
10   <DerivedFrom nodeTypeImplementationRef="xs:QName"/> ?
11
12   <RequiredContainerFeatures>
13     <RequiredContainerFeature feature="xs:anyURI"/> +
14   </RequiredContainerFeatures> ?
15
16   <ImplementationArtifacts>
17     <ImplementationArtifact interfaceName="xs:NCName | xs:anyURI"?
18       operationName="xs:NCName"?
19       artifactType="xs:QName"
20       artifactRef="xs:QName"?>
21       artifact specific content ?
22     <ImplementationArtifact> +
23   </ImplementationArtifacts> ?
24
25   <DeploymentArtifacts>
26     <DeploymentArtifact name="xs:string" artifactType="xs:QName"
27       artifactRef="xs:QName"?>
28       artifact specific content ?
29     <DeploymentArtifact> +
30   </DeploymentArtifacts> ?
31
32 </NodeTypeImplementation>
```

## 7.2 Properties

The `NodeTypeImplementation` element has the following properties:

- `name`: This attribute specifies the name or identifier of the Node Type Implementation, which **MUST** be unique within the target namespace.
- `targetNamespace`: This **OPTIONAL** attribute specifies the target namespace to which the definition of the Node Type Implementation will be added. If not specified, the Node Type Implementation will be added to the target namespace of the enclosing Definitions document.
- `nodeType`: The QName value of this attribute specifies the Node Type implemented by this Node Type Implementation.
- `abstract`: This **OPTIONAL** attribute specifies that this Node Type Implementation cannot be used directly as an implementation for the Node Type specified in the `nodeType` attribute.

For example, a Node Type implementer might decide to deliver only part of the implementation of a specific Node Type (i.e. for only some operations) for re-use purposes and require the implementation for specific operations to be delivered in a more concrete, derived Node Type Implementation.

Note: an abstract Node Type Implementation **MUST NOT** be declared as final.

- `final`: This **OPTIONAL** attribute specifies that other Node Type Implementations **MUST NOT** be derived from this Node Type Implementation.

Note: a final Node Type Implementation **MUST NOT** be declared as abstract.

- `Tags`: This **OPTIONAL** element allows the definition of any number of tags which can be used by the author to describe the Node Type Implementation. Each tag is defined by a separate, nested `Tag` element.

The `Tag` element has the following properties:

- `name`: This attribute specifies the name of the tag.
- `value`: This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.

- `DerivedFrom`: This is an **OPTIONAL** reference to another Node Type Implementation from which this Node Type Implementation derives. See section 7.3 Derivation Rules **Error! Reference source not found.** for details.

The `DerivedFrom` element has the following properties:

- `nodeTypeImplementationRef`: The QName specifies the Node Type Implementation from which this Node Type Implementation derives.

- `RequiredContainerFeatures`: An implementation of a Node Type might depend on certain features of the environment it is executed in, such as specific (potentially proprietary) APIs of the TOSCA container. For example, an implementation to deploy a virtual machine based on an image could require access to some API provided by a public cloud, while another implementation could require an API of a vendor-specific virtual image library. Thus, the contents of the `RequiredContainerFeatures` element provide “hints” to the TOSCA container allowing it to select the appropriate Node Type Implementation if multiple alternatives are provided.

Each such dependency is defined by a separate `RequiredContainerFeature` element.

The `RequiredContainerFeature` element has the following properties:

- `feature`: The value of this attribute is a URI that denotes the corresponding needed feature of the environment.

- `ImplementationArtifacts`: This element specifies a set of implementation artifacts for interfaces or operations of a Node Type.

The `ImplementationArtifacts` element has the following properties:

- `ImplementationArtifact`: This element specifies one implementation artifact of an interface or an operation.

Note: Multiple implementation artifacts might be needed to implement a Node Type according to the attributes defined below. An implementation artifact MAY serve as implementation for all interfaces and all operations defined for the Node Type, it MAY serve as implementation for one interface (and all its operations), or it MAY serve as implementation for only one specific operation.

The `ImplementationArtifact` element has the following properties:

- `name`: This attribute specifies the name of the artifact, which SHOULD be unique within the scope of the encompassing Node Type Implementation.
- `interfaceName`: This OPTIONAL attribute specifies the name of the interface that is implemented by the actual implementation artifact. If not specified, the implementation artifact is assumed to provide the implementation for all interfaces defined by the Node Type referred to by the `nodeType` attribute of the containing `NodeTypeImplementation`.
- `operationName`: This OPTIONAL attribute specifies the name of the operation that is implemented by the actual implementation artifact. If specified, the `interfaceName` MUST be specified and the specified `operationName` MUST refer to an operation of the specified interface. If not specified, the implementation artifact is assumed to provide the implementation for all operations defined within the specified interface.
- `artifactType`: This attribute specifies the type of this artifact. The QName value of this attribute SHOULD correspond to the QName of an `ArtifactType` defined in the same Definitions document or in an imported document.

The `artifactType` attribute specifies the artifact type specific content of the `ImplementationArtifact` element body and indicates the type of Artifact Template referenced by the Implementation Artifact via the `artifactRef` attribute.

- `artifactRef`: This OPTIONAL attribute contains a QName that identifies an Artifact Template to be used as implementation artifact. This Artifact Template can be defined in the same Definitions document or in a separate, imported document.  
The type of Artifact Template referenced by the `artifactRef` attribute MUST be the same type or a sub-type of the type specified in the `artifactType` attribute.

Note: if no Artifact Template is referenced, the artifact type specific content of the `ImplementationArtifact` element alone is assumed to represent the actual artifact. For example, a simple script could be defined in place within the `ImplementationArtifact` element.

- `DeploymentArtifacts`: This element specifies a set of deployment artifacts relevant for materializing instances of nodes of the Node Type being implemented.

The `DeploymentArtifacts` element has the following properties:

- `DeploymentArtifact`: This element specifies one deployment artifact.

Note: Multiple deployment artifacts MAY be defined in a Node Type Implementation. One reason could be that multiple artifacts (maybe of different types) are needed to materialize a node as a whole. Another reason could be that alternative artifacts are provided for use in different contexts (e.g. different installables of a software for use in different operating systems).

The `DeploymentArtifact` element has the following properties:

- `name`: This attribute specifies the name of the artifact, which SHOULD be unique within the scope of the encompassing Node Type Implementation.
- `artifactType`: This attribute specifies the type of this artifact. The QName value of this attribute SHOULD correspond to the QName of an `ArtifactType` defined in the same Definitions document or in an imported document.

The `artifactType` attribute specifies the artifact type specific content of the `DeploymentArtifact` element body and indicates the type of Artifact Template referenced by the Deployment Artifact via the `artifactRef` attribute.

- `artifactRef`: This OPTIONAL attribute contains a QName that identifies an Artifact Template to be used as deployment artifact. This Artifact Template can be defined in the same Definitions document or in a separate, imported document.  
The type of Artifact Template referenced by the `artifactRef` attribute MUST be the same type or a sub-type of the type specified in the `artifactType` attribute.

Note: if no Artifact Template is referenced, the artifact type specific content of the `DeploymentArtifact` element alone is assumed to represent the actual artifact. For example, the contents of a simple config file could be defined in place within the `DeploymentArtifact` element.

## 7.3 Derivation Rules

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

- **Implementation Artifacts:** The set of implementation artifacts of a Node Type Implementation consists of the set union of implementation artifacts defined by the Node Type Implementation itself and the implementation artifacts defined by any Node Type Implementation the Node Type Implementation is derived from.  
An implementation artifact defined by a Node Type Implementation overrides an implementation artifact having the same interface name and operation name of a Node Type Implementation the Node Type Implementation is derived from.  
If an implementation artifact defined in a Node Type Implementation specifies only an interface name, it substitutes implementation artifacts having the same interface name (with or without an operation name defined) of any Node Type Implementation the Node Type Implementation is derived from. In this case, the implementation of a complete interface of a Node Type is overridden.  
If an implementation artifact defined in a Node Type Implementation neither defines an interface name nor an operation name, it overrides all implementation artifacts of any Node Type Implementation the Node Type Implementation is derived from. In this case, the complete implementation of a Node Type is overridden.



- Deployment Artifacts: The set of deployment artifacts of a Node Type Implementation consists of the set union of the deployment artifacts defined by the Nodes Type Implementation itself and the deployment artifacts defined by any Node Type Implementation the Node Type Implementation is derived from. A deployment artifact defined by a Node Type Implementation overrides a deployment artifact with the same name and type (or any type it is derived from) of any Node Type Implementation the Node Type Implementation is derived from.

## 7.4 Example

The following example defines the Node Type Implementation “MyDBMSImplementation”. This is an implementation of a Node Type “DBMS”.

```

01 <Definitions id="MyImpls" name="My Implementations"
02   targetNamespace="http://www.example.com/SampleImplementations"
03   xmlns:bn="http://www.example.com/BaseNodeTypes"
04   xmlns:ba="http://www.example.com/BaseArtifactTypes"
05   xmlns:sa="http://www.example.com/SampleArtifacts">
06
07   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
08     namespace="http://www.example.com/BaseArtifactTypes"/>
09
10   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
11     namespace="http://www.example.com/BaseNodeTypes"/>
12
13   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
14     namespace="http://www.example.com/SampleArtifacts"/>
15
16   <NodeTypeImplementation name="MyDBMSImplementation"
17     nodeType="bn:DBMS">
18
19     <ImplementationArtifacts>
20       <ImplementationArtifact interfaceName="MgmtInterface"
21         artifactType="ba:WARFile"
22         artifactRef="sa:MyMgmtWebApp">
23       </ImplementationArtifact>
24     </ImplementationArtifacts>
25
26     <DeploymentArtifacts>
27       <DeploymentArtifact name="MyDBMS"
28         artifactType="ba:ZipFile"
29         artifactRef="sa:MyInstallable">
30       </DeploymentArtifact>
31     </DeploymentArtifacts>
32
33   </NodeTypeImplementation>
34
35 </Definitions>

```

The Node Type Implementation contains the “MyDBMSManagement” implementation artifact, which is an artifact for the “MgmtInterface” Interface that has been defined for the “DBMS” base Node Type. The type of this artifact is a “WARFile” that has been defined as base Artifact Type. The implementation artifact refers to the “MyMgmtWebApp” Artifact Template that has been defined before.

The Node Type Implementation further contains the “MyDBMS” deployment artifact, which is a software installable used for instantiating the “DBMS” Node Type. This software installable is a “ZipFile” that has been separately defined as the “MyInstallable” Artifact Template before.

## 8 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 a *Properties Definition*, i.e. the names, data types and allowed values the properties defined in Relationship Templates using a Relationship Type or instances of such Relationship Templates can have.

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

### 8.1 XML Syntax

The following pseudo schema defines the XML syntax of Relationship Types:

```
01 <RelationshipType name="xs:NCName"
02     targetNamespace="xs:anyURI"?
03     abstract="yes|no"?
04     final="yes|no"?> +
05
06   <Tags>
07     <Tag name="xs:string" value="xs:string"/> +
08   </Tags> ?
09
10   <DerivedFrom typeRef="xs:QName"/> ?
11
12   <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
13
14   <InstanceStates>
15     <InstanceState state="xs:anyURI"> +
16   </InstanceStates> ?
17
18   <SourceInterfaces>
19     <Interface name="xs:NCName | xs:anyURI">
20       ...
21     </Interface> +
22   </SourceInterfaces> ?
23
24   <TargetInterfaces>
25     <Interface name="xs:NCName | xs:anyURI">
26       ...
27     </Interface> +
28   </TargetInterfaces> ?
29
30   <ValidSource typeRef="xs:QName"/> ?
31
32   <ValidTarget typeRef="xs:QName"/> ?
33
34 </RelationshipType>
```

## 8.2 Properties

The `RelationshipType` element has the following properties:

- `name`: This attribute specifies the name or identifier of the Relationship Type, which MUST be unique within the target namespace.
- `targetNamespace`: This OPTIONAL attribute specifies the target namespace to which the definition of the Relationship Type will be added. If not specified, the Relationship Type definition will be added to the target namespace of the enclosing Definitions document.
- `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 other Relationship Types MUST NOT be derived from this Relationship Type.

Note: a final Relationship Type MUST NOT be declared as abstract.

- `Tags`: This OPTIONAL element allows the definition of any number of tags which can be used by the author to describe the Relationship Type. Each tag is defined by a separate, nested `Tag` element.

The `Tag` element has the following properties:

- `name`: This attribute specifies the name of the tag.
- `value`: This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.

- `DerivedFrom`: This is an OPTIONAL reference to another Relationship Type from which this Relationship Type is derived. Conflicting definitions are resolved by the rule that local new definitions always override derived definitions. See section 8.3 Derivation Rules for details.

The `DerivedFrom` element has the following properties:

- `typeRef`: The QName specifies the Relationship Type from which this Relationship Type derives its definitions.

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

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

- `element`: This attribute provides the QName of an XML element defining the structure of the Relationship Type Properties.
- `type`: This attribute provides the QName of an XML (complex) type defining the structure of the Relationship Type Properties.

- `InstanceStates`: This OPTIONAL element lists the set of states an instance of this Relationship Type can occupy at runtime. Those states are defined in nested `InstanceState` elements.

The `InstanceState` element has the following nested properties:

- `state`: This attribute specifies a URI that identifies a potential state.

- `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 6.2).

- `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 6.2).

- `ValidSource`: This OPTIONAL element specifies the type of object that is allowed as a valid origin for relationships defined using the Relationship Type under definition. If not specified, any Node Type is allowed to be the origin of the relationship.

The `ValidSource` element has the following properties:

- `typeRef`: This attribute specifies the QName of a Node Type or Requirement Type that is allowed as a valid source for relationships defined using the Relationship Type under definition. Node Types or Requirements Types derived from the specified Node Type or Requirement Type, respectively, MUST also be accepted as valid relationship source.

Note: If `ValidSource` specifies a Node Type, the `ValidTarget` element (if present) of the Relationship Type under definition MUST also specify a Node Type.

If `ValidSource` specifies a Requirement Type, the `ValidTarget` element (if present) of the Relationship Type under definition MUST specify a Capability Type. This Capability Type MUST match the requirement defined in `ValidSource`, i.e. it MUST be of the type (or a sub-type of) the capability specified in the `requiredCapabilityType` attribute of the respective `RequirementType` definition.

- `ValidTarget`: This OPTIONAL element specifies the type of object that is allowed as a valid target for relationships defined using the Relationship Type under definition. If not specified, any Node Type is allowed to be the origin of the relationship.

The `ValidTarget` element has the following properties:

- `typeRef`: This attribute specifies the QName of a Node Type or Capability Type that is allowed as a valid target for relationships defined using the Relationship Type under definition. Node Types or Capability Types derived from the specified Node Type or Capability Type, respectively, MUST also be accepted as valid targets of relationships.

Note: If `ValidTarget` specifies a Node Type, the `ValidSource` element (if present) of the Relationship Type under definition MUST also specify a Node Type.

If `ValidTarget` specifies a Capability Type, the `ValidSource` element (if present) of the Relationship Type under definition MUST specify a Requirement Type. This Requirement Type MUST declare it requires the capability defined in `ValidTarget`, i.e. it MUST declare the type (or a super-type of) the capability in the `requiredCapabilityType` attribute of the respective `RequirementType` definition.

## 8.3 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

- 1996 and the instance states explicitly defined by the Relationship Type under definition. Instance  
 1997 states with the same state attribute will be combined into a single instance state of the same  
 1998 state.
- 1999 • Valid source and target: An object specified as a valid source or target, respectively, of the  
 2000 Relationship Type under definition MUST be of a subtype defined as valid source or target,  
 2001 respectively, of the Relationship Type derived from.  
 2002
  - 2003 If the Relationship Type derived from has no valid source or target defined, the types of object  
 2004 being defined in the `ValidSource` or `ValidTarget` elements of the Relationship Type  
 2005 under definition are not restricted.  
 2006
  - 2007 If the Relationship Type under definition has no source or target defined, only the types of objects  
 2008 defined as source or target of the Relationship Type derived from are valid origins or destinations  
 2009 of the Relationship Type under definition.
  - 2010 • Interfaces: The set of interfaces (both source and target interfaces) of the Relationship Type  
 2011 under definition consists of the set union of interfaces defined by the Relationship Type derived  
 2012 from and the interfaces defined by the Relationship Type under definition.  
 2013 Two interfaces of the same name will be combined into a single, derived interface with the same  
 2014 name. The set of operations of the derived interface consists of the set union of operations  
 2015 defined by both interfaces. An operation defined by the Relationship Type under definition  
 2016 substitutes an operation with the same name of the Relationship Type derived from.

## 2017 8.4 Example

2018 The following example defines the Relationship Type “processDeployedOn”. The meaning of this  
 2019 Relationship Type is that “a process is deployed on a hosting environment”. When the source of an  
 2020 instance of a Relationship Template referring to this Relationship Type is deleted, its target is  
 2021 automatically deleted as well. The Relationship Type has Relationship Type Properties defined in the  
 2022 `Types` section of the same Definitions document as the “ProcessDeployedOnProperties” element. The  
 2023 states an instance of this Relationship Type can be in are also listed.

```

2024 01 <RelationshipType name="processDeployedOn">
2025 02
2026 03   <RelationshipTypeProperties element="ProcessDeployedOnProperties"/>
2027 04
2028 05   <InstanceStates>
2029 06     <InstanceState state="www.example.com/successfullyDeployed"/>
2030 07     <InstanceState state="www.example.com/failed"/>
2031 08   </InstanceStates>
2032 09
2033 10 </RelationshipType>
  
```

## 9 Relationship Type Implementations

This chapter specifies how *Relationship Type Implementations* are defined. A Relationship Type Implementation represents the runnable code that implements a specific Relationship Type. It provides a collection of executables implementing the interface operations of a Relationship Type (aka implementation artifacts). The particular executables are defined as separate Artifact Templates and are referenced from the implementation artifacts of a Relationship Type Implementation.

While Artifact Templates provide invariant information about an artifact – i.e. information that is context independent like the file name of the artifact – implementation artifacts can provide variant (or context specific) information, e.g. authentication data for a specific environment.

Relationship Type Implementations can specify hints for a TOSCA container that enable proper selection of an implementation that fits into a particular environment by means of Required Container Features definitions.

Note that there MAY be Relationship Types that do not define any interface operations, i.e. that also do not require any implementation artifacts. In such cases, no Relationship Type Implementation is needed but the respective Relationship Types can be used by a TOSCA implementation as is.

### 9.1 XML Syntax

The following pseudo schema defines the XML syntax of Relationship Type Implementations:

```
01 <RelationshipTypeImplementation name="xs:NCName"
02     targetNamespace="xs:anyURI"?
03     relationshipType="xs:QName"
04     abstract="yes|no"?
05     final="yes|no"?>
06
07   <Tags>
08     <Tag name="xs:string" value="xs:string" /> +
09   </Tags> ?
10
11   <DerivedFrom relationshipTypeImplementationRef="xs:QName" /> ?
12
13   <RequiredContainerFeatures>
14     <RequiredContainerFeature feature="xs:anyURI" /> +
15   </RequiredContainerFeatures> ?
16
17   <ImplementationArtifacts>
18     <ImplementationArtifact interfaceName="xs:NCName | xs:anyURI"?
19       operationName="xs:NCName"?
20       artifactType="xs:QName"
21       artifactRef="xs:QName"?>
22       artifact specific content ?
23     <ImplementationArtifact> +
24   </ImplementationArtifacts> ?
25
26 </RelationshipTypeImplementation>
```

### 9.2 Properties

The RelationshipTypeImplementation element has the following properties:

- **name:** This attribute specifies the name or identifier of the Relationship Type Implementation, which **MUST** be unique within the target namespace.

- `targetNamespace`: This OPTIONAL attribute specifies the target namespace to which the definition of the Relationship Type Implementation will be added. If not specified, the Relationship Type Implementation will be added to the target namespace of the enclosing Definitions document.
- `relationshipType`: The QName value of this attribute specifies the Relationship Type implemented by this Relationship Type Implementation.
- `abstract`: This OPTIONAL attribute specifies that this Relationship Type Implementation cannot be used directly as an implementation for the Relationship Type specified in the `relationshipType` attribute.

For example, a Relationship Type implementer might decide to deliver only part of the implementation of a specific Relationship Type (i.e. for only some operations) for re-use purposes and require the implementation for specific operations to be delivered in a more concrete, derived Relationship Type Implementation.

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

- `final`: This OPTIONAL attribute specifies that other Relationship Type Implementations MUST NOT be derived from this Relationship Type Implementation.

Note: a final Relationship Type Implementation MUST NOT be declared as abstract.

- `Tags`: This OPTIONAL element allows the definition of any number of tags which can be used by the author to describe the Relationship Type Implementation. Each tag is defined by a separate, nested `Tag` element.

The `Tag` element has the following properties:

- `name`: This attribute specifies the name of the tag.
- `value`: This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.

- `DerivedFrom`: This is an OPTIONAL reference to another Relationship Type Implementation from which this Relationship Type Implementation derives. See section 9.3 Derivation Rules or details.

The `DerivedFrom` element has the following properties:

- `relationshipTypeImplementationRef`: The QName specifies the Relationship Type Implementation from which this Relationship Type Implementation derives.

- `RequiredContainerFeatures`: An implementation of a Relationship Type might depend on certain features of the environment it is executed in, such as specific (potentially proprietary) APIs of the TOSCA container.

Thus, the contents of the `RequiredContainerFeatures` element provide “hints” to the TOSCA container allowing it to select the appropriate Relationship Type Implementation if multiple alternatives are provided.

Each such dependency is defined by a separate `RequiredContainerFeature` element.

The `RequiredContainerFeature` element has the following properties:

- `feature`: The value of this attribute is a URI that denotes the corresponding needed feature of the environment.

- `ImplementationArtifacts`: This element specifies a set of implementation artifacts for interfaces or operations of a Relationship Type.

The `ImplementationArtifacts` element has the following properties:

- `ImplementationArtifact`: This element specifies one implementation artifact of an interface or an operation.



Note: Multiple implementation artifacts might be needed to implement a Relationship Type according to the attributes defined below. An implementation artifact MAY serve as implementation for all interfaces and all operations defined for the Relationship Type, it MAY serve as implementation for one interface (and all its operations), or it MAY serve as implementation for only one specific operation.

The `ImplementationArtifact` element has the following properties:

- `name`: This attribute specifies the name of the artifact, which SHOULD be unique within the scope of the encompassing Node Type Implementation.
- `interfaceName`: This OPTIONAL attribute specifies the name of the interface that is implemented by the actual implementation artifact. If not specified, the implementation artifact is assumed to provide the implementation for all interfaces defined by the Relationship Type referred to by the `relationshipType` attribute of the containing `RelationshipTypeImplementation`.

Note that the referenced interface can be defined in either the `SourceInterfaces` element or the `TargetInterfaces` element of the Relationship Type implemented by this Relationship Type Implementation.

- `operationName`: This OPTIONAL attribute specifies the name of the operation that is implemented by the actual implementation artifact. If specified, the `interfaceName` MUST be specified and the specified `operationName` MUST refer to an operation of the specified interface. If not specified, the implementation artifact is assumed to provide the implementation for all operations defined within the specified interface.
- `artifactType`: This attribute specifies the type of this artifact. The QName value of this attribute SHOULD correspond to the QName of an `ArtifactType` defined in the same Definitions document or in an imported document.

The `artifactType` attribute specifies the artifact type specific content of the `ImplementationArtifact` element body and indicates the type of Artifact Template referenced by the Implementation Artifact via the `artifactRef` attribute.

- `artifactRef`: This OPTIONAL attribute contains a QName that identifies an Artifact Template to be used as implementation artifact. This Artifact Template can be defined in the same Definitions document or in a separate, imported document.  
The type of Artifact Template referenced by the `artifactRef` attribute MUST be the same type or a sub-type of the type specified in the `artifactType` attribute.

Note: if no Artifact Template is referenced, the artifact type specific content of the `ImplementationArtifact` element alone is assumed to represent the actual artifact. For example, a simple script could be defined in place within the `ImplementationArtifact` element.

## 9.3 Derivation Rules

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

- Implementation Artifacts: The set of implementation artifacts of a Relationship Type Implementation consists of the set union of implementation artifacts defined by the Relationship



2181 Type Implementation itself and the implementation artifacts defined by any Relationship Type  
 2182 Implementation the Relationship Type Implementation is derived from.  
 2183 An implementation artifact defined by a Node Type Implementation overrides an implementation  
 2184 artifact having the same interface name and operation name of a Relationship Type  
 2185 Implementation the Relationship Type Implementation is derived from.  
 2186 If an implementation artifact defined in a Relationship Type Implementation specifies only an  
 2187 interface name, it substitutes implementation artifacts having the same interface name (with or  
 2188 without an operation name defined) of any Relationship Type Implementation the Relationship  
 2189 Type Implementation is derived from. In this case, the implementation of a complete interface of a  
 2190 Relationship Type is overridden.  
 2191 If an implementation artifact defined in a Relationship Type Implementation neither defines an  
 2192 interface name nor an operation name, it overrides all implementation artifacts of any  
 2193 Relationship Type Implementation the Relationship Type Implementation is derived from. In this  
 2194 case, the complete implementation of a Relationship Type is overridden.

## 2195 9.4 Example

2196 The following example defines the Node Type Implementation “MyDBMSImplementation”. This is an  
 2197 implementation of a Node Type “DBMS”.

```

2198 01 <Definitions id="MyImpls" name="My Implementations"
2199 02   targetNamespace="http://www.example.com/SampleImplementations"
2200 03   xmlns:bn="http://www.example.com/BaseRelationshipTypes"
2201 04   xmlns:ba="http://www.example.com/BaseArtifactTypes"
2202 05   xmlns:sa="http://www.example.com/SampleArtifacts">
2203 06
2204 07   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
2205 08           namespace="http://www.example.com/BaseArtifactTypes"/>
2206 09
2207 10   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
2208 11           namespace="http://www.example.com/BaseRelationshipTypes"/>
2209 12
2210 13   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
2211 14           namespace="http://www.example.com/SampleArtifacts"/>
2212 15
2213 16   <RelationshipTypeImplementation name="MyDBConnectImplementation"
2214 17                                   relationshipType="bn:DBConnection">
2215 18
2216 19     <ImplementationArtifacts>
2217 20       <ImplementationArtifact interfaceName="ConnectionInterface"
2218 21                               operationName="connectTo"
2219 22                               artifactType="ba:ScriptArtifact"
2220 23                               artifactRef="sa:MyConnectScript">
2221 24       <ImplementationArtifact>
2222 25     </ImplementationArtifacts>
2223 26
2224 27   </RelationshipTypeImplementation>
2225 28
2226 29 </Definitions>

```

2227 The Relationship Type Implementation contains the “MyDBConnectionImpl” implementation artifact,  
 2228 which is an artifact for the “ConnectionInterface” interface that has been defined for the “DBConnection”  
 2229 base Relationship Type. The type of this artifact is a “ScriptArtifact” that has been defined as base Artifact  
 2230 Type. The implementation artifact refers to the “MyConnectScript” Artifact Template that has been defined  
 2231 before.

## 10 Requirement Types

This chapter specifies how *Requirement Types* are defined. A Requirement Type is a reusable entity that describes a kind of requirement that a Node Type can declare to expose. For example, a Requirement Type for a database connection can be defined and various Node Types (e.g. a Node Type for an application) can declare to expose (or “to have”) a requirement for a database connection.

A Requirement Type defines the structure of observable properties via a *Properties Definition*, i.e. the names, data types and allowed values the properties defined in *Requirements* of Node Templates of a Node Type can have in cases where the Node Type defines a requirement of the respective Requirement Type.

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

### 10.1 XML Syntax

The following pseudo schema defines the XML syntax of Requirement Types:

```
01 <RequirementType name="xs:NCName"
02     targetNamespace="xs:anyURI"?
03     abstract="yes|no"?
04     final="yes|no"?
05     requiredCapabilityType="xs:QName"?>
06
07   <Tags>
08     <Tag name="xs:string" value="xs:string"/> +
09   </Tags> ?
10
11   <DerivedFrom typeRef="xs:QName"/> ?
12
13   <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
14
15 </RequirementType>
```

### 10.2 Properties

The *RequirementType* element has the following properties:

- **name:** This attribute specifies the name or identifier of the Requirement Type, which **MUST** be unique within the target namespace.
- **targetNamespace:** This **OPTIONAL** attribute specifies the target namespace to which the definition of the Requirement Type will be added. If not specified, the Requirement Type definition will be added to the target namespace of the enclosing Definitions document.
- **abstract:** This **OPTIONAL** attribute specifies that no instances can be created from Node Templates of a Node Type that defines a requirement of this Requirement Type.

As a consequence, a Node Type with a Requirement Definition of an abstract Requirement Type **MUST** be declared as abstract as well and a derived Node Type that defines a requirement of a type derived from the abstract Requirement Type has to be defined. For example, an abstract Node Type “Application” might be defined having a requirement of the abstract type “Container”. A derived Node Type “Web Application” can then be defined with a more concrete requirement of type “Web Application Container” which can then be used for defining Node Templates that can

be instantiated during the creation of a service according to a Service Template.

Note: an abstract Requirement Type MUST NOT be declared as final.

- **final**: This OPTIONAL attribute specifies that other Requirement Types MUST NOT be derived from this Requirement Type.

Note: a final Requirement Type MUST NOT be declared as abstract.

- **requiredCapabilityType**: This OPTIONAL attribute specifies the type of capability needed to match the defined Requirement Type. The QName value of this attribute refers to the QName of a **CapabilityType** element defined in the same Definitions document or in a separate, imported document.

Note: The following basic match-making for Requirements and Capabilities MUST be supported by each TOSCA implementation. Each Requirement is defined by a Requirement Definition, which in turn refers to a Requirement Type that specifies the needed Capability Type by means of its **requiredCapabilityType** attribute. The value of this attribute is used for basic type-based match-making: a Capability matches a Requirement if the Requirement's Requirement Type has a **requiredCapabilityType** value that corresponds to the Capability Type of the Capability or one of its super-types.

Any domain-specific match-making semantics (e.g. based on constraints or properties) has to be defined in the cause of specifying the corresponding Requirement Types and Capability Types.

- **Tags**: This OPTIONAL element allows the definition of any number of tags which can be used by the author to describe the Requirement Type. Each tag is defined by a separate, nested **Tag** element.

The **Tag** element has the following properties:

- **name**: This attribute specifies the name of the tag.
- **value**: This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.

- **DerivedFrom**: This is an OPTIONAL reference to another Requirement Type from which this Requirement Type derives. See section 10.3 Derivation Rules for details.

The **DerivedFrom** element has the following properties:

- **typeRef**: The QName specifies the Requirement Type from which this Requirement Type derives its definitions and semantics.

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

The **PropertiesDefinition** element has one but not both of the following properties:

- **element**: This attribute provides the QName of an XML element defining the structure of the Requirement Type Properties.
- **type**: This attribute provides the QName of an XML (complex) type defining the structure of the Requirement Type Properties.

## 10.3 Derivation Rules

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

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

## 10.4 Example

The following example defines the Requirement Type “DatabaseClientEndpoint” that expresses the requirement of a client for a database connection. It is defined in a Definitions document “MyRequirements” within the target namespace “http://www.example.com/SampleRequirements”. Thus, by importing the corresponding namespace into another Definitions document, the “DatabaseClientEndpoint” Requirement Type is available for use in the other document.

```
01 <Definitions id="MyRequirements" name="My Requirements"
02   targetNamespace="http://www.example.com/SampleRequirements"
03   xmlns:br="http://www.example.com/BaseRequirementTypes"
04   xmlns:mrp="http://www.example.com/SampleRequirementProperties">
05
06   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
07     namespace="http://www.example.com/BaseRequirementTypes"/>
08
09   <Import importType="http://www.w3.org/2001/XMLSchema"
10     namespace="http://www.example.com/SampleRequirementProperties"/>
11
12   <RequirementType name="DatabaseClientEndpoint">
13     <DerivedFrom typeRef="br:ClientEndpoint"/>
14     <PropertiesDefinition
15       element="mrp:DatabaseClientEndpointProperties"/>
16   </RequirementType>
17
18 </Definitions>
```

The Requirement Type “DatabaseClientEndpoint” defined in the example above is derived from another generic “ClientEndpoint” Requirement Type defined in a separate file by means of the `DerivedFrom` element. The definitions in that separate Definitions file are imported by means of the first `Import` element and the namespace of those imported definitions is assigned the prefix “br” in the current file.

The “DatabaseClientEndpoint” Requirement Type defines a set of properties through an XML schema element definition “DatabaseClientEndpointProperties”. For example, those properties might include the definition of a port number to be used for client connections. The XML schema definition is stored in a separate XSD file that is imported by means of the second `Import` element. The namespace of the XML schema definitions is assigned the prefix “mrp” in the current file.

---

## 11 Capability Types

This chapter specifies how *Capability Types* are defined. A Capability Type is a reusable entity that describes a kind of capability that a Node Type can declare to expose. For example, a Capability Type for a database server endpoint can be defined and various Node Types (e.g. a Node Type for a database) can declare to expose (or to “provide”) the capability of serving as a database server endpoint.

A Capability Type defines the structure of observable properties via a *Properties Definition*, i.e. the names, data types and allowed values the properties defined in *Capabilities* of Node Templates of a Node Type can have in cases where the Node Type defines a capability of the respective Capability Type.

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

### 11.1 XML Syntax

The following pseudo schema defines the XML syntax of Capability Types:

```
01 <CapabilityType name="xs:NCName"
02     targetNamespace="xs:anyURI"?
03     abstract="yes|no"?
04     final="yes|no"?>
05
06   <Tags>
07     <Tag name="xs:string" value="xs:string"/> +
08   </Tags> ?
09
10   <DerivedFrom typeRef="xs:QName"/> ?
11
12   <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
13
14 </CapabilityType>
```

### 11.2 Properties

The *CapabilityType* element has the following properties:

- **name:** This attribute specifies the name or identifier of the Capability Type, which **MUST** be unique within the target namespace.
- **targetNamespace:** This **OPTIONAL** attribute specifies the target namespace to which the definition of the Capability Type will be added. If not specified, the Capability Type definition will be added to the target namespace of the enclosing Definitions document.
- **abstract:** This **OPTIONAL** attribute specifies that no instances can be created from Node Templates of a Node Type that defines a capability of this Capability Type.

As a consequence, a Node Type with a Capability Definition of an abstract Capability Type **MUST** be declared as abstract as well and a derived Node Type that defines a capability of a type derived from the abstract Capability Type has to be defined. For example, an abstract Node Type “Server” might be defined having a capability of the abstract type “Container”. A derived Node Type “Web Server” can then be defined with a more concrete capability of type “Web Application Container” which can then be used for defining Node Templates that can be instantiated during the creation of a service according to a Service Template.

Note: an abstract Capability Type MUST NOT be declared as final.

- **final**: This OPTIONAL attribute specifies that other Capability Types MUST NOT be derived from this Capability Type.

Note: a final Capability Type MUST NOT be declared as abstract.

- **Tags**: This OPTIONAL element allows the definition of any number of tags which can be used by the author to describe the Capability Type. Each tag is defined by a separate, nested Tag element.

The Tag element has the following properties:

- **name**: This attribute specifies the name of the tag.
- **value**: This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.

- **DerivedFrom**: This is an OPTIONAL reference to another Capability Type from which this Capability Type derives. See section 11.3 Derivation Rules for details.

The DerivedFrom element has the following properties:

- **typeRef**: The QName specifies the Capability Type from which this Capability Type derives its definitions and semantics.

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

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

- **element**: This attribute provides the QName of an XML element defining the structure of the Capability Type Properties.
- **type**: This attribute provides the QName of an XML (complex) type defining the structure of the Capability Type Properties.

## 11.3 Derivation Rules

The following rules on combining definitions based on DerivedFrom apply:

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

## 11.4 Example

The following example defines the Capability Type “DatabaseServerEndpoint” that expresses the capability of a component to serve database connections. It is defined in a Definitions document “MyCapabilities” within the target namespace “http://www.example.com/SampleCapabilities”. Thus, by importing the corresponding namespace into another Definitions document, the “DatabaseServerEndpoint” Capability Type is available for use in the other document.

```
01 <Definitions id="MyCapabilities" name="My Capabilities"
02   targetNamespace="http://www.example.com/SampleCapabilities"
03   xmlns:bc="http://www.example.com/BaseCapabilityTypes"
04   xmlns:mcp="http://www.example.com/SampleCapabilityProperties">
05
06   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
07     namespace="http://www.example.com/BaseCapabilityTypes"/>
08
09   <Import importType="http://www.w3.org/2001/XMLSchema"
10     namespace="http://www.example.com/SampleCapabilityProperties"/>
```

```
2451 11
2452 12 <CapabilityType name="DatabaseServerEndpoint">
2453 13 <DerivedFrom typeRef="bc:ServerEndpoint"/>
2454 14 <PropertiesDefinition
2455 15 element="mcp:DatabaseServerEndpointProperties"/>
2456 16 </CapabilityType>
2457 17
2458 18 </Definitions>
```

2459 The Capability Type “DatabaseServerEndpoint” defined in the example above is derived from another  
2460 generic “ServerEndpoint” Capability Type defined in a separate file by means of the `DerivedFrom`  
2461 element. The definitions in that separate Definitions file are imported by means of the first `Import`  
2462 element and the namespace of those imported definitions is assigned the prefix “bc” in the current file.

2463 The “DatabaseServerEndpoint” Capability Type defines a set of properties through an XML schema  
2464 element definition “DatabaseServerEndpointProperties”. For example, those properties might include the  
2465 definition of a port number where the server listens for client connections, or credentials to be used by  
2466 clients. The XML schema definition is stored in a separate XSD file that is imported by means of the  
2467 second `Import` element. The namespace of the XML schema definitions is assigned the prefix “mcp”  
2468 in the current file.



## 12 Artifact Types

This chapter specifies how *Artifact Types* are defined. An Artifact Type is a reusable entity that defines the type of one or more Artifact Templates which in turn serve as deployment artifacts for Node Templates or implementation artifacts for Node Type and Relationship Type interface operations. For example, an Artifact Type “WAR File” might be defined for describing web application archive files. Based on this Artifact Type, one or more Artifact Templates representing concrete WAR files can be defined and referenced as deployment or implementation artifacts.

An Artifact Type can define the structure of observable properties via a *Properties Definition*, i.e. the names, data types and allowed values the properties defined in Artifact Templates using an Artifact Type or instances of such Artifact Templates can have. Note that properties defined by an Artifact Type are assumed to be invariant across the contexts in which corresponding artifacts are used – as opposed to properties that can vary depending on the context. As an example of such an invariant property, an Artifact Type for a WAR file could define a “signature” property that can hold a hash for validating the actual artifact proper. In contrast, the path where the web application contained in the WAR file gets deployed can vary for each place where the WAR file is used.

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

### 12.1 XML Syntax

The following pseudo schema defines the XML syntax of Artifact Types:

```
01 <ArtifactType name="xs:NCName"
02             targetNamespace="xs:anyURI"?
03             abstract="yes|no"?
04             final="yes|no"?>
05
06   <Tags>
07     <Tag name="xs:string" value="xs:string"/> +
08   </Tags> ?
09
10   <DerivedFrom typeRef="xs:QName"/> ?
11
12   <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
13
14 </ArtifactType>
```

### 12.2 Properties

The *ArtifactType* element has the following properties:

- **name:** This attribute specifies the name or identifier of the Artifact Type, which **MUST** be unique within the target namespace.
- **targetNamespace:** This **OPTIONAL** attribute specifies the target namespace to which the definition of the Artifact Type will be added. If not specified, the Artifact Type definition will be added to the target namespace of the enclosing Definitions document.
- **abstract:** This **OPTIONAL** attribute specifies that no instances can be created from Artifact Templates of that abstract Artifact Type, i.e. the respective artifacts cannot be used directly as deployment or implementation artifact in any context.



As a consequence, an Artifact Template of an abstract Artifact Type MUST be replaced by an artifact of a derived Artifact Type at the latest during deployment of the element that uses the artifact (i.e. a Node Template or Relationship Template).

Note: an abstract Artifact Type MUST NOT be declared as final.

- **final**: This OPTIONAL attribute specifies that other Artifact Types MUST NOT be derived from this Artifact Type.

Note: a final Artifact Type MUST NOT be declared as abstract.

- **Tags**: This OPTIONAL element allows the definition of any number of tags which can be used by the author to describe the Artifact Type. Each tag is defined by a separate, nested Tag element. The Tag element has the following properties:

- **name**: This attribute specifies the name of the tag.
- **value**: This attribute specifies the value of the tag.

Note: The name/value pairs defined in tags have no normative interpretation.

- **DerivedFrom**: This is an OPTIONAL reference to another Artifact Type from which this Artifact Type derives. See section 12.3 Derivation Rules for details.

The DerivedFrom element has the following properties:

- **typeRef**: The QName specifies the Artifact Type from which this Artifact Type derives its definitions and semantics.

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

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

- **element**: This attribute provides the QName of an XML element defining the structure of the Artifact Type Properties.
- **type**: This attribute provides the QName of an XML (complex) type defining the structure of the Artifact Type Properties.

## 12.3 Derivation Rules

The following rules on combining definitions based on DerivedFrom apply:

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

## 12.4 Example

The following example defines the Artifact Type “RMPackage” that can be used for describing RPM packages as deployable artifacts on various Linux distributions. It is defined in a Definitions document “MyArtifacts” within the target namespace “http://www.example.com/SampleArtifacts”. Thus, by importing the corresponding namespace into another Definitions document, the “RMPackage” Artifact Type is available for use in the other document.

```
01 <Definitions id="MyArtifacts" name="My Artifacts"
02   targetNamespace="http://www.example.com/SampleArtifacts"
03   xmlns:ba="http://www.example.com/BaseArtifactTypes"
04   xmlns:map="http://www.example.com/SampleArtifactProperties">
05
06   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
07     namespace="http://www.example.com/BaseArtifactTypes"/>
08
```

```
2563 09 <Import importType="http://www.w3.org/2001/XMLSchema"
2564 10     namespace="http://www.example.com/SampleArtifactProperties"/>
2565 11
2566 12 <ArtifactType name="RPMPackage">
2567 13     <DerivedFrom typeRef="ba:OSPackage"/>
2568 14     <PropertiesDefinition element="map:RPMPackageProperties"/>
2569 15 </ArtifactType>
2570 16
2571 17 </Definitions>
```

2572 The Artifact Type “RPMPackage” defined in the example above is derived from another generic  
2573 “OSPackage” Artifact Type defined in a separate file by means of the `DerivedFrom` element. The  
2574 definitions in that separate Definitions file are imported by means of the first `Import` element and the  
2575 namespace of those imported definitions is assigned the prefix “ba” in the current file.

2576 The “RPMPackage” Artifact Type defines a set of properties through an XML schema element definition  
2577 “RPMPackageProperties”. For example, those properties might include the definition of the name or  
2578 names of one or more RPM packages. The XML schema definition is stored in a separate XSD file that is  
2579 imported by means of the second `Import` element. The namespace of the XML schema definitions is  
2580 assigned the prefix “map” in the current file.

---

## 13 Artifact Templates

This chapter specifies how *Artifact Templates* are defined. An Artifact Template represents an artifact that can be referenced from other objects in a Service Template as a deployment artifact or implementation artifact. For example, from Node Types or Node Templates, an Artifact Template for some software installable could be referenced as a deployment artifact for materializing a specific software component. As another example, from within interface definitions of Node Types or Relationship Types, an Artifact Template for a WAR file could be referenced as implementation artifact for a REST operation.

An Artifact Template refers to a specific Artifact Type that defines the structure of observable properties (metadata) or the artifact. The Artifact Template then typically defines values for those properties inside the `Properties` element. Note that properties defined by an Artifact Type are assumed to be invariant across the contexts in which corresponding artifacts are used – as opposed to properties that can vary depending on the context.

Furthermore, an Artifact Template typically provides one or more references to the actual artifact itself that can be contained as a file in the CSAR (see section 3.7 and section 14) containing the overall Service Template or that can be available at a remote location such as an FTP server.

### 13.1 XML Syntax

The following pseudo schema defines the XML syntax of Artifact Templates:

```
01 <ArtifactTemplate id="xs:ID" name="xs:string"? type="xs:QName">
02
03   <Properties>
04     XML fragment
05   </Properties> ?
06
07   <PropertyConstraints>
08     <PropertyConstraint property="xs:string"
09                           constraintType="xs:anyURI"> +
10       constraint ?
11     </PropertyConstraint>
12   </PropertyConstraints> ?
13
14   <ArtifactReferences>
15     <ArtifactReference reference="xs:anyURI">
16       (
17         <Include pattern="xs:string"/>
18         |
19         <Exclude pattern="xs:string"/>
20       ) *
21     </ArtifactReference> +
22   </ArtifactReferences> ?
23
24 </ArtifactTemplate>
```

### 13.2 Properties

The `ArtifactTemplate` element has the following properties:

- `id`: This attribute specifies the identifier of the Artifact Template. The identifier of the Artifact Template **MUST** be unique within the target namespace.
- `name`: This **OPTIONAL** attribute specifies the name of the Artifact Template.

- `type`: The QName value of this attribute refers to the Artifact Type providing the type of the Artifact Template.

Note: If the Artifact Type referenced by the `type` attribute of an Artifact Template is declared as abstract, no instances of the specific Artifact Template can be created, i.e. the artifact cannot be used directly as deployment or implementation artifact. Instead, a substitution of the Artifact Template with one having a specialized, derived Artifact Type has to be done at the latest during the instantiation time of a Service Template.

- `Properties`: This OPTIONAL element specifies the invariant properties of the Artifact Template, i.e. those properties that will be commonly used across different contexts in which the Artifact Template is used.

The initial values are specified by providing an instance document of the XML schema of the corresponding Artifact Type Properties. This instance document considers the inheritance structure deduced by the `DerivedFrom` property of the Artifact Type referenced by the `type` attribute of the Artifact Template.

- `PropertyConstraints`: This OPTIONAL element specifies constraints on the use of one or more of the Artifact Type Properties of the Artifact Type providing the property definitions for the Artifact Template. Each constraint is specified by means of a separate nested `PropertyConstraint` element.

The `PropertyConstraint` element has the following properties:

- `property`: The string value of this property is an XPath expression pointing to the property within the Artifact Type Properties document that is constrained within the context of the Artifact 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 Artifact 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.

- `ArtifactReferences`: This OPTIONAL element contains one or more references to the actual artifact proper, each represented by a separate `ArtifactReference` element.

The `ArtifactReference` element has the following properties:

- `reference`: This attribute contains a URI pointing to an actual artifact. If this URI is a relative URI, it is interpreted relative to the root directory of the CSAR containing the Service Template (see also sections 3.7 and 14).
- `Include`: This OPTIONAL element can be used to define a pattern of files that are to be included in the artifact reference in case the reference points to a complete directory. The `Include` element has the following properties:
  - `pattern`: This attribute contains a pattern definition for files that are to be included in the overall artifact reference. For example, a pattern of `"*.py"` would include all python scripts contained in a directory.
- `Exclude`: This OPTIONAL element can be used to define a pattern of files that are to be excluded from the artifact reference in case the reference points to a complete directory.

The `Exclude` element has the following properties:

2676                   ▪ `pattern`: This attribute contains a pattern definition for files that are to be  
2677                   excluded in the overall artifact reference. For example, a pattern of `"*.sh"`  
2678                   would exclude all bash scripts contained in a directory.

### 2679 13.3 Example

2680 The following example defines the Artifact Template "MyInstallable" that points to a zip file containing  
2681 some software installable. It is defined in a Definitions document "MyArtifacts" within the target  
2682 namespace "http://www.example.com/SampleArtifacts". The Artifact Template can be used in the same  
2683 document, for example as a deployment artifact for some Node Template representing a software  
2684 component, or it can be used in other Definitions documents by importing the corresponding namespace  
2685 into another document.

```
2686 01 <Definitions id="MyArtifacts" name="My Artifacts"  
2687 02   targetNamespace="http://www.example.com/SampleArtifacts"  
2688 03   xmlns:ba="http://www.example.com/BaseArtifactTypes">  
2689 04  
2690 05   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"  
2691 06     namespace="http://www.example.com/BaseArtifactTypes"/>  
2692 07  
2693 08   <ArtifactTemplate id="MyInstallable"  
2694 09     name="My installable"  
2695 10     type="ba:ZipFile">  
2696 11     <ArtifactReferences>  
2697 12       <ArtifactReference reference="files/MyInstallable.zip"/>  
2698 13     </ArtifactReferences>  
2699 14   </ArtifactTemplate>  
2700 15  
2701 16 </Definitions>
```

2702 The Artifact Template "MyInstallable" defined in the example above is of type "ZipFile" that is specified in  
2703 the `type` attribute of the `ArtifactTemplate` element. This Artifact Type is defined in a separate file,  
2704 the definitions of which are imported by means of the `Import` element and the namespace of those  
2705 imported definitions is assigned the prefix "ba" in the current file.

2706 The "MyInstallable" Artifact Template provides a reference to a file "MyInstallable.zip" by means of the  
2707 `ArtifactReference` element. Since the URI provided in the `reference` attribute is a relative URI,  
2708 it is interpreted relative to the root directory of the CSAR containing the Service Template.

## 14 Policy Types

This chapter specifies how *Policy Types* are defined. A Policy Type is a reusable entity that describes a kind of non-functional behavior or a kind of quality-of-service (QoS) that a Node Type can declare to expose. For example, a Policy Type can be defined to express high availability for specific Node Types (e.g. a Node Type for an application server).

A Policy Type defines the structure of observable properties via a Properties Definition, i.e. the names, data types and allowed values the properties defined in a corresponding Policy Template can have.

A Policy Type can inherit properties from another Policy Type by means of the `DerivedFrom` element.

A Policy Type declares the set of Node Types it specifies non-functional behavior for via the `AppliesTo` element. Note that being “applicable to” does not enforce implementation: i.e. in case a Policy Type expressing high availability is associated with a “Webserver” Node Type, an instance of the Webserver is not necessarily highly available. Whether or not an instance of a Node Type to which a Policy Type is applicable will show the specified non-functional behavior, is determined by a Node Template of the corresponding Node Type.

### 14.1 XML Syntax

The following pseudo schema defines the XML syntax of Policy Types:

```
01 <PolicyType name="xs:NCName"
02     policyLanguage="xs:anyURI"?
03     abstract="yes|no"?
04     final="yes|no"?
05     targetNamespace="xs:anyURI"?>
06   <Tags>
07     <Tag name="xs:string" value="xs:string"/> +
08   </Tags> ?
09
10   <DerivedFrom typeRef="xs:QName"/> ?
11
12   <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
13
14   <AppliesTo>
15     <NodeTypeReference typeRef="xs:QName"/> +
16   </AppliesTo> ?
17
18   policy type specific content ?
19
20 </PolicyType>
```

### 14.2 Properties

The `PolicyType` element has the following properties:

- **name:** This attribute specifies the name or identifier of the Policy Type, which **MUST** be unique within the target namespace.
- **targetNamespace:** This **OPTIONAL** attribute specifies the target namespace to which the definition of the Policy Type will be added. If not specified, the Policy Type definition will be added to the target namespace of the enclosing Definitions document.
- **policyLanguage:** This **OPTIONAL** attribute specifies the language used to specify the details of the Policy Type. These details can be defined as policy type specific content of the `PolicyType` element.

- 2755 • **abstract**: This OPTIONAL attribute specifies that no instances can be created from Policy

2756 Templates of that abstract Policy Type, i.e. the respective policies cannot be used directly during

2757 the instantiation of a Service Template.

2758

2759 As a consequence, a Policy Template of an abstract Policy Type MUST be replaced by a policy

2760 of a derived Policy Type at the latest during deployment of the element that policy is attached to.
- 2761 • **final**: This OPTIONAL attribute specifies that other Policy Types MUST NOT be derived from

2762 this Policy Type.

2763

2764 Note: a final Policy Type MUST NOT be declared as abstract.
- 2765 • **Tags**: This OPTIONAL element allows the definition of any number of tags which can be used by

2766 the author to describe the Policy Type. Each tag is defined by a separate, nested `Tag` element.

2767 The `Tag` element has the following properties:

  - 2768 ○ **name**: This attribute specifies the name of the tag.
  - 2769 ○ **value**: This attribute specifies the value of the tag.

2770

2771 Note: The name/value pairs defined in tags have no normative interpretation.
- 2772 • **DerivedFrom**: This is an OPTIONAL reference to another Policy Type from which this Policy

2773 Type derives. See section 14.3 Derivation Rules for details.

2774 The `DerivedFrom` element has the following properties:

  - 2775 ○ **typeRef**: The QName specifies the Policy Type from which this Policy Type derives its
  - 2776 definitions from.
- 2777 • **PropertiesDefinition**: This element specifies the structure of the observable properties

2778 of the Policy Type by means of XML schema.

2779 The `PropertiesDefinition` element has one but not both of the following properties:

  - 2780 ○ **element**: This attribute provides the QName of an XML element defining the structure
  - 2781 of the Policy Type Properties.
  - 2782 ○ **type**: This attribute provides the QName of an XML (complex) type defining the
  - 2783 structure of the Policy Type Properties.
- 2784 • **AppliesTo**: This OPTIONAL element specifies the set of Node Types the Policy Type is

2785 applicable to, each defined as a separate, nested `NodeTypeReference` element.

2786 The `NodeTypeReference` element has the following property:

  - 2787 ○ **typeRef**: The attribute provides the QName of a Node Type to which the Policy Type
  - 2788 applies.

## 2789 14.3 Derivation Rules

2790 The following rules on combining definitions based on `DerivedFrom` apply:

- 2791 • **Properties Definitions**: It is assumed that the XML element (or type) representing the Policy Type

2792 Properties Definitions extends the XML element (or type) of the Policy Type Properties Definitions

2793 of the Policy Type referenced in the `DerivedFrom` element.
- 2794 • **Applies To**: The set of Node Types the Policy Type is applicable to consist of the set union of

2795 Node Types derived from and Node Types explicitly referenced by the Policy Type by means of

2796 its `AppliesTo` element.
- 2797 • **Policy Language**: A Policy Type MUST define the same policy language as the Policy Type it

2798 derives from. In case the Policy Type used as basis for derivation has no `policyLanguage`

2799 attribute defined, the deriving Policy Type can define any appropriate policy language.

## 14.4 Example

The following example defines two Policy Types, the “HighAvailability” Policy Type and the “ContinuousAvailability” Policy Type. They are defined in a Definitions document “MyPolicyTypes” within the target namespace “http://www.example.com/SamplePolicyTypes”. Thus, by importing the corresponding namespace into another Definitions document, both Policy Types are available for use in the other document.

```
01 <Definitions id="MyPolicyTypes" name="My Policy Types"
02   targetNamespace="http://www.example.com/SamplePolicyTypes"
03   xmlns:bnt="http://www.example.com/BaseNodeTypes">
04   xmlns:spp="http://www.example.com/SamplePolicyProperties">
05
06   <Import importType="http://www.w3.org/2001/XMLSchema"
07     namespace="http://www.example.com/SamplePolicyProperties"/>
08
09   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"
10     namespace="http://www.example.com/BaseNodeTypes"/>
11
12
13   <PolicyType name="HighAvailability">
14     <PropertiesDefinition element="spp:HAProperties"/>
15   </PolicyType>
16
17   <PolicyType name="ContinuousAvailability">
18     <DerivedFrom typeRef="HighAvailability"/>
19     <PropertiesDefinition element="spp:CAProperties"/>
20     <AppliesTo>
21       <NodeTypeReference typeRef="bnt:DBMS"/>
22     </AppliesTo>
23   </PolicyType>
24
25 </Definitions>
```

The Policy Type “HighAvailability” defined in the example above has the “HAProperties” properties that are defined in a separate namespace as an XML element. The same namespace contains the “CAProperties” element that defines the properties of the “ContinuousAvailability” Policy Type. This namespace is imported by means of the first `Import` element and the namespace of those imported definitions is assigned the prefix “spp” in the current file.

The “ContinuousAvailability” Policy Type is derived from the “HighAvailability” Policy Type. Furthermore, it is applicable to the “DBMS” Node Type. This Node Type is defined in a separate namespace, which is imported by means of the second `Import` element and the namespace of those imported definitions is assigned the prefix “bnt” in the current file.



---

## 15 Policy Templates

This chapter specifies how *Policy Templates* are defined. A Policy Template represents a particular non-functional behavior or quality-of-service that can be referenced by a Node Template. A Policy Template refers to a specific Policy Type that defines the structure of observable properties (metadata) of the non-functional behavior. The Policy Template then typically defines values for those properties inside the *Properties* element. Note that properties defined by a Policy Template are assumed to be invariant across the contexts in which corresponding behavior is exposed – as opposed to properties defined in Policies of Node Templates that may vary depending on the context.

### 15.1 XML Syntax

The following pseudo schema defines the XML syntax of Policy Templates:

```
01 <PolicyTemplate id="xs:ID" name="xs:string"? type="xs:QName">
02
03   <Properties>
04     XML fragment
05   </Properties> ?
06
07   <PropertyConstraints>
08     <PropertyConstraint property="xs:string"
09                           constraintType="xs:anyURI"> +
10       constraint ?
11     </PropertyConstraint>
12   </PropertyConstraints> ?
13
14   policy type specific content ?
15
16 </PolicyTemplate>
```

### 15.2 Properties

The *PolicyTemplate* element has the following properties:

- **id**: This attribute specifies the identifier of the Policy Template which **MUST** be unique within the target namespace.
- **name**: This **OPTIONAL** attribute specifies the name of the Policy Template.
- **type**: The QName value of this attribute refers to the Policy Type providing the type of the Policy Template.
- **Properties**: This **OPTIONAL** element specifies the invariant properties of the Policy Template, i.e. those properties that will be commonly used across different contexts in which the Policy Template is used.

The initial values are specified by providing an instance document of the XML schema of the corresponding Policy Type Properties. This instance document considers the inheritance structure deduced by the *DerivedFrom* property of the Policy Type referenced by the *type* attribute of the Policy Template.

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

The *PropertyConstraint* element has the following properties:

- 2886           ○ `property`: The string value of this property is an XPath expression pointing to the  
2887           property within the Policy Type Properties document that is constrained within the context  
2888           of the Policy Template. More than one constraint MUST NOT be defined for each  
2889           property.
- 2890           ○ `constraintType`: The constraint type is specified by means of a URI, which defines  
2891           both the semantic meaning of the constraint as well as the format of the content.

## 2892 15.3 Example

2893 The following example defines a Policy Template “MyHAPolicy”. It is defined in a Definitions document  
2894 “MyPolicies” within the target namespace “http://www.example.com/SamplePolicies”. The Policy  
2895 Template can be used in the same Definitions document, for example, as a Policy of some Node  
2896 Template, or it can be used in other document by importing the corresponding namespace into the other  
2897 document.

```
2898 01 <Definitions id="MyPolicies" name="My Policies"  
2899 02   targetNamespace="http://www.example.com/SamplePolicies"  
2900 03   xmlns:spt="http://www.example.com/SamplePolicyTypes">  
2901 04  
2902 05   <Import importType="http://docs.oasis-open.org/tosca/ns/2011/12"  
2903 06     namespace="http://www.example.com/SamplePolicyTypes"/>  
2904 07  
2905 08   <PolicyTemplate id="MyHAPolicy"  
2906 09     name="My High Availability Policy"  
2907 10     type="bpt:HighAvailability">  
2908 11     <Properties>  
2909 12       <HAProperties>  
2910 13         <AvailabilityClass>4</AvailabilityClass>  
2911 14         <HeartbeatFrequency measuredIn="msec">  
2912 15           250  
2913 16         </HeartbeatFrequency>  
2914 17       </HAProperties>  
2915 18     </Properties>  
2916 19   </PolicyTemplate>  
2917 20  
2918 21 </Definitions>
```

2919 The Policy Template “MyHAPolicy” defined in the example above is of type “HighAvailability” that is  
2920 specified in the `type` attribute of the `PolicyTemplate` element. This Policy Type is defined in a  
2921 separate file, the definitions of which are imported by means of the `Import` element and the namespace  
2922 of those imported definitions is assigned the prefix “spt” in the current file.

2923 The “MyHAPolicy” Policy Template provides values for the properties defined by the Properties Definition  
2924 of the “HighAvailability” Policy Type. The `AvailabilityClass` property is set to “4”. The value of the  
2925 `HeartbeatFrequency` is “250”, measured in “msec”.  
2926

---

## 16 Cloud Service Archive (CSAR)

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

### 16.1 Overall Structure of a CSAR

A CSAR is a zip file containing at least two directories, the *TOSCA-Metadata* directory and the *Definitions* 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 Definitions directory contains one or more TOSCA Definitions documents (file extension `.tosca`). These Definitions files typically contain definitions related to the cloud application of the CSAR. In addition, CSARs can contain just the definition of elements for re-use in other contexts. For example, a CSAR might be used to package a set of Node Types and Relationship Types with their respective implementations that can then be used by Service Templates provided in other CSARs. In cases where a complete cloud application is packaged in a CSAR, one of the Definitions documents in the Definitions directory MUST contain a Service Template definition that defines the structure and behavior of the cloud application.

### 16.2 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.

```
01 <name>: <value>
```

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:

```
01 TOSCA-Meta-File-Version: digit.digit
02 CSAR-Version: digit.digit
03 Created-By: string
04 Entry-Definitions: string ?
```

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-Definitions:** This OPTIONAL name/value pair references a TOSCA Definitions file from the Definitions directory of the CSAR that SHOULD be used as entry point for processing the contents of the CSAR.  
Note, that a CSAR may contain multiple Definitions files. One reason for this is completeness, e.g. a Service Template defined in one of the Definitions files could refer to Node Types defined in another Definitions file that might be included in the Definitions directory to avoid importing it from external locations. The `Entry-Definitions` name/value pair is a hint to allow optimized processing of the set of files in the Definitions directory.

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.

```
01 Name: <path-name_1>
02 Content-Type: type_1/subtype_1
03 <name_11>: <value_11>
04 <name_12>: <value_12>
05 ...
06 <name_1n>: <value_1n>
07
08 ...
09
10 Name: <path-name_k>
11 Content-Type: type_k/subtype_k
12 <name_k1>: <value_k1>
13 <name_k2>: <value_k2>
14 ...
15 <name_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.

## 16.3 Example

Figure 7 depicts a sample Definitions file named `Payroll.tosca` containing a Service Template of an application. 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.

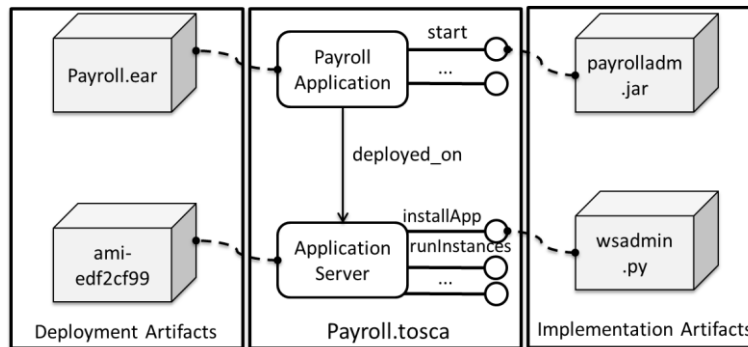


Figure 7: Sample Service Template

The corresponding Node Types and Relationship Types have been defined in the PayrollTypes.tosca document, which is imported by the Definitions document containing the Payroll Service Template. The following listing provides some of the details:

```
01 <Definitions id="PayrollDefinitions"
02     targetNamespace="http://www.example.com/ste"
03     xmlns:pay="http://www.example.com/ste/Types">
04
05     <Import namespace="http://www.example.com/ste/Types"
06           location="http://www.example.com/ste/Types/PayrollTypes.tosca"
07           importType=" http://docs.oasis-open.org/tosca/ns/2011/12"/>
08
09     <Types>
10         ...
11     </Types>
12
13     <ServiceTemplate id="Payroll" name="Payroll Service Template">
14
15         <TopologyTemplate ID="PayrollTemplate">
16
17             <NodeTemplate id="Payroll Application"
18                           type="pay:ApplicationNodeType">
19                 ...
20
21             <DeploymentArtifacts>
22                 <DeploymentArtifact name="PayrollEAR"
23                                   type="http://www.example.com/
24                                         ns/tosca/2011/12/
25                                         DeploymentArtifactTypes/CSARref">
26
27                     EARs/Payroll.ear
28                 </DeploymentArtifact>
29             </DeploymentArtifacts>
30
31             </NodeTemplate>
32
33             <NodeTemplate id="Application Server"
34                           type="pay:ApplicationServerNodeType">
```

```

3062 34      ...
3063 35
3064 36      <DeploymentArtifacts>
3065 37          <DeploymentArtifact name="ApplicationServerImage"
3066 38              type="http://www.example.com/
3067 39                  ns/tosca/2011/12/
3068 40                      DeploymentArtifactTypes/AMIref">
3069 41              ami-edf2cf99
3070 42          </DeploymentArtifact>
3071 43      </DeploymentArtifacts>
3072 44
3073 45  </NodeTemplate>
3074 46
3075 47      <RelationshipTemplate id="deployed_on"
3076 48          type="pay:deployed_on">
3077 49          <SourceElement ref="Payroll Application"/>
3078 50          <TargetElement ref="Application Server"/>
3079 51      </RelationshipTemplate>
3080 52
3081 53  </TopologyTemplate>
3082 54
3083 55 </ServiceTemplate>
3084 56
3085 57 </Definitions>

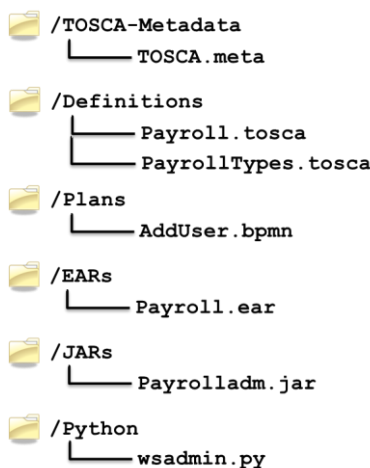
```

3086

3087 The Payroll Application Node Template specifies the deployment artifact PayrollEAR. It is a  
 3088 reference to the CSAR containing the Payroll.ste file, which is indicated by the .../CSARref type  
 3089 of the DeploymentArtifact element. The type specific content is a path expression in the directory  
 3090 structure of the CSAR: it points to the Payroll.ear file in the EARs directory of the CSAR (see Figure  
 3091 8 for the structure of the corresponding CSAR).

3092 The Application Server Node Template has a DeploymentArtifact called  
 3093 ApplicationServerImage that is a reference to an AMI (Amazon Machine Image), indicated by an  
 3094 .../AMIref type.

3095 The corresponding CSAR has the following structure (see Figure 8): The TOSCA.meta file is contained  
 3096 in the TOSCA-Metadata directory. The Payroll.ste file itself is contained in the Service-  
 3097 Template directory. Also, the PayrollTypes.ste file is in this directory. The content of the other  
 3098 directories has been sketched before.



3099

3100 Figure 8: Structure of CSAR Sample

3101 The TOSCA.meta file is as follows:

```
3102 01 TOSCA-Meta-Version: 1.0
3103 02 CSAR-Version: 1.0
3104 03 Created-By: Frank
3105 04
3106 05 Name: Service-Template/Payroll.tosca
3107 06 Content-Type: application/vnd.oasis.tosca.definitions
3108 07
3109 08 Name: Service-Template/PayrollTypes.ste
3110 09 Content-Type: application/vnd.oasis.tosca.definitions
3111 10
3112 11 Name: Plans/AddUser.bpmn
3113 12 Content-Type: application/vnd.oasis.bpmn
3114 13
3115 14 Name: EARs/Payroll.ear
3116 15 Content-Type: application/vnd.oasis.ear
3117 16
3118 17 Name: JARs/Payrolladm.jar
3119 18 Content-Type: application/vnd.oasis.jar
3120 19
3121 20 Name: Python/wsadmin.py
3122 21 Content-Type: application/vnd.oasis.py
```

3123

---

3124 **17 Security Considerations**

3125 TOSCA does not mandate the use of any specific mechanism or technology for client authentication.  
3126 However, a client **MUST** provide a principal or the principal **MUST** be obtainable by the infrastructure.



---

## 18 Conformance

3127

3128 A TOSCA Definitions document conforms to this specification if it conforms to the TOSCA schema and  
3129 follows the syntax and semantics defined in the normative portions of this specification. The TOSCA  
3130 schema takes precedence over the TOSCA grammar (pseudo schema as defined in section 2.5), which  
3131 in turn takes precedence over normative text, which in turn takes precedence over examples.

3132 An implementation conforms to this specification if it can process a conformant TOSCA Definitions  
3133 document according to the rules described in chapters 4 through 16 of this specification.

3134 This specification allows extensions. Each implementation SHALL fully support all required functionality of  
3135 the specification exactly as specified. The use of extensions SHALL NOT contradict nor cause the non-  
3136 conformance of functionality defined in the specification.

---

## 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.

### Participants:

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Afkham Azeez	WSO2
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Bryan Haynie	VCE
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Chandrasekhar Sundaresh	CA Technologies
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Colin Hopkinson	3M HIS
Dale Moberg	Axway Software
Debojyoti Dutta	Cisco Systems
Dee Schur	OASIS
Denis Nothern	CenturyLink
Denis Weerasiri	WSO2
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Dhiraj Pathak	PricewaterhouseCoopers LLP:
Diane Mueller	ActiveState Software, Inc.
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Gerd Breiter	IBM
James Thomason	Gale Technologies
Jan Ignatius	Nokia Siemens Networks GmbH & Co. KG
Jie Zhu	Huawei Technologies Co., Ltd.
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Thilina Buddhika	WSO2
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wayne adams	EMC
Wenbo Zhu	Google Inc.
Xiaonan Song	Primeton Technologies, Inc.
YanJiong WANG	Primeton Technologies, Inc.
Zhexuan Song	Huawei Technologies Co., Ltd.

## 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.

```
01 <Definitions id="xs:ID"
02     name="xs:string"?
03     targetNamespace="xs:anyURI">
04
05     <Extensions>
06         <Extension namespace="xs:anyURI"
07             mustUnderstand="yes|no"?/> +
08     </Extensions> ?
09
10     <Import namespace="xs:anyURI"?
11         location="xs:anyURI"?
12         importType="xs:anyURI"/> *
13
14     <Types>
15         <xs:schema .../> *
16     </Types> ?
17
18     (
19         <ServiceTemplate id="xs:ID"
20             name="xs:string"?
21             targetNamespace="xs:anyURI"
22             substitutableNodeType="xs:QName"?>
23
24             <Tags>
25                 <Tag name="xs:string" value="xs:string"/> +
26             </Tags> ?
27
28             <BoundaryDefinitions>
29                 <Properties>
30                     XML fragment
31                 <PropertyMappings>
32                     <PropertyMapping serviceTemplatePropertyRef="xs:string"
33                         targetObjectRef="xs:IDREF"
34                         targetPropertyRef="xs:IDREF"/> +
35                 </PropertyMappings/> ?
36             </Properties> ?
37
38             <PropertyConstraints>
39                 <PropertyConstraint property="xs:string"
40                     constraintType="xs:anyURI"> +
41                     constraint ?
42                 </PropertyConstraint>
43             </PropertyConstraints> ?
44
45             <Requirements>
46                 <Requirement name="xs:string" ref="xs:IDREF"/> +
47             </Requirements> ?
48
49             <Capabilities>
50                 <Capability name="xs:string" ref="xs:IDREF"/> +
51             </Capabilities> ?
```

```

3205 52
3206 53     <Policies>
3207 54         <Policy name="xs:string"? policyType="xs:QName"
3208 55             policyRef="xs:QName"?>
3209 56             policy specific content ?
3210 57         </Policy> +
3211 58     </Policies> ?
3212 59
3213 60     <Interfaces>
3214 61         <Interface name="xs:NCName">
3215 62             <Operation name="xs:NCName">
3216 63                 (
3217 64                     <NodeOperation nodeRef="xs:IDREF"
3218 65                         interfaceName="xs:anyURI"
3219 66                         operationName="xs:NCName"/>
3220 67                 |
3221 68                 <RelationshipOperation relationshipRef="xs:IDREF"
3222 69                     interfaceName="xs:anyURI"
3223 70                     operationName="xs:NCName"/>
3224 71                 |
3225 72                 <Plan planRef="xs:IDREF"/>
3226 73                 )
3227 74             </Operation> +
3228 75         </Interface> +
3229 76     </Interfaces> ?
3230 77
3231 78 </BoundaryDefinitions> ?
3232 79
3233 80 <TopologyTemplate>
3234 81     (
3235 82         <NodeTemplate id="xs:ID" name="xs:string"? type="xs:QName"
3236 83             minInstances="xs:integer"?
3237 84             maxInstances="xs:integer | xs:string"?>
3238 85             <Properties>
3239 86                 XML fragment
3240 87             </Properties> ?
3241 88
3242 89             <PropertyConstraints>
3243 90                 <PropertyConstraint property="xs:string"
3244 91                     constraintType="xs:anyURI">
3245 92                     constraint ?
3246 93                 </PropertyConstraint> +
3247 94             </PropertyConstraints> ?
3248 95
3249 96             <Requirements>
3250 97                 <Requirement id="xs:ID" name="xs:string" type="xs:QName"> +
3251 98                     <Properties>
3252 99                         XML fragment
3253 100                     <Properties> ?
3254 101                     <PropertyConstraints>
3255 102                         <PropertyConstraint property="xs:string"
3256 103                             constraintType="xs:anyURI"> +
3257 104                             constraint ?
3258 105                         </PropertyConstraint>
3259 106                     </PropertyConstraints> ?
3260 107                 </Requirement>
3261 108             </Requirements> ?
3262 109

```

```

3263 110         <Capabilities>
3264 111             <Capability id="xs:ID" name="xs:string"
3265 112                 type="xs:QName"> +
3266 113                 <Properties>
3267 114                     XML fragment
3268 115                 <Properties> ?
3269 116                 <PropertyConstraints>
3270 117                     <PropertyConstraint property="xs:string"
3271 118                         constraintType="xs:anyURI">
3272 119                         constraint ?
3273 120                     </PropertyConstraint> +
3274 121                 </PropertyConstraints> ?
3275 122             </Capability>
3276 123         </Capabilities> ?
3277 124
3278 125         <Policies>
3279 126             <Policy name="xs:string"? policyType="xs:QName"
3280 127                 policyRef="xs:QName"?>
3281 128                 policy specific content ?
3282 129             </Policy> +
3283 130         </Policies> ?
3284 131
3285 132         <DeploymentArtifacts>
3286 133             <DeploymentArtifact name="xs:string"
3287 134                 artifactType="xs:QName"
3288 135                 artifactRef="xs:QName"?>
3289 136                 artifact specific content ?
3290 137             </DeploymentArtifact> +
3291 138         </DeploymentArtifacts> ?
3292 139     </NodeTemplate>
3293 140 |
3294 141     <RelationshipTemplate id="xs:ID" name="xs:string"?
3295 142         type="xs:QName">
3296 143         <Properties>
3297 144             XML fragment
3298 145         </Properties> ?
3299 146
3300 147         <PropertyConstraints>
3301 148             <PropertyConstraint property="xs:string"
3302 149                 constraintType="xs:anyURI">
3303 150                 constraint ?
3304 151             </PropertyConstraint> +
3305 152         </PropertyConstraints> ?
3306 153
3307 154         <SourceElement ref="xs:IDREF"/>
3308 155         <TargetElement ref="xs:IDREF"/>
3309 156
3310 157         <RelationshipConstraints>
3311 158             <RelationshipConstraint constraintType="xs:anyURI">
3312 159                 constraint ?
3313 160             </RelationshipConstraint> +
3314 161         </RelationshipConstraints> ?
3315 162
3316 163     </RelationshipTemplate>
3317 164 ) +
3318 165 </TopologyTemplate>
3319 166
3320 167 <Plans>

```

```

3321 168      <Plan id="xs:ID"
3322 169          name="xs:string"?
3323 170          planType="xs:anyURI"
3324 171          planLanguage="xs:anyURI">
3325 172
3326 173          <Precondition expressionLanguage="xs:anyURI">
3327 174              condition
3328 175          </Precondition> ?
3329 176
3330 177          <InputParameters>
3331 178              <InputParameter name="xs:string" type="xs:string"
3332 179                  required="yes|no"?/> +
3333 180          </InputParameters> ?
3334 181
3335 182          <OutputParameters>
3336 183              <OutputParameter name="xs:string" type="xs:string"
3337 184                  required="yes|no"?/> +
3338 185          </OutputParameters> ?
3339 186
3340 187          (
3341 188              <PlanModel>
3342 189                  actual plan
3343 190              </PlanModel>
3344 191              |
3345 192              <PlanModelReference reference="xs:anyURI"/>
3346 193          )
3347 194
3348 195      </Plan> +
3349 196  </Plans> ?
3350 197
3351 198 </ServiceTemplate>
3352 199 |
3353 200 <NodeType name="xs:NCName" targetNamespace="xs:anyURI"?
3354 201     abstract="yes|no"? final="yes|no"?>
3355 202
3356 203     <DerivedFrom typeRef="xs:QName"/> ?
3357 204
3358 205     <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
3359 206
3360 207     <RequirementDefinitions>
3361 208         <RequirementDefinition name="xs:string"
3362 209             requirementType="xs:QName"
3363 210             lowerBound="xs:integer"?
3364 211             upperBound="xs:integer | xs:string"?>
3365 212             <Constraints>
3366 213                 <Constraint constraintType="xs:anyURI">
3367 214                     constraint type specific content
3368 215                 </Constraint> +
3369 216             </Constraints> ?
3370 217         </RequirementDefinition> +
3371 218     </RequirementDefinitions> ?
3372 219
3373 220     <CapabilityDefinitions>
3374 221         <CapabilityDefinition name="xs:string"
3375 222             capabilityType="xs:QName"
3376 223             lowerBound="xs:integer"?
3377 224             upperBound="xs:integer | xs:string"?>
3378 225             <Constraints>

```



```

3379 226         <Constraint constraintType="xs:anyURI">
3380 227             constraint type specific content
3381 228         </Constraint> +
3382 229     </Constraints> ?
3383 230     </CapabilityDefinition> +
3384 231 </CapabilityDefinitions>
3385 232
3386 233 <InstanceStates>
3387 234     <InstanceState state="xs:anyURI"> +
3388 235 </InstanceState> ?
3389 236
3390 237 <Interfaces>
3391 238     <Interface name="xs:NCName | xs:anyURI">
3392 239         <Operation name="xs:NCName">
3393 240             <InputParameters>
3394 241                 <InputParameter name="xs:string" type="xs:string"
3395 242                     required="yes|no"?/> +
3396 243             </InputParameters> ?
3397 244             <OutputParameters>
3398 245                 <OutputParameter name="xs:string" type="xs:string"
3399 246                     required="yes|no"?/> +
3400 247             </OutputParameters> ?
3401 248         </Operation> +
3402 249     </Interface> +
3403 250 </Interfaces> ?
3404 251
3405 252 </NodeType>
3406 253 |
3407 254 <NodeTypeImplementation name="xs:NCName"
3408 255     targetNamespace="xs:anyURI"?
3409 256     nodeType="xs:QName"
3410 257     abstract="yes|no"?
3411 258     final="yes|no"?>
3412 259
3413 260     <DerivedFrom nodeTypeImplementationRef="xs:QName"/> ?
3414 261
3415 262     <RequiredContainerFeatures>
3416 263         <RequiredContainerFeature feature="xs:anyURI"/> +
3417 264     </RequiredContainerFeatures> ?
3418 265
3419 266     <ImplementationArtifacts>
3420 267         <ImplementationArtifact interfaceName="xs:NCName | xs:anyURI"?
3421 268             operationName="xs:NCName"?
3422 269             artifactType="xs:QName"
3423 270             artifactRef="xs:QName"?>
3424 271             artifact specific content ?
3425 272         </ImplementationArtifact> +
3426 273     </ImplementationArtifacts> ?
3427 274
3428 275     <DeploymentArtifacts>
3429 276         <DeploymentArtifact name="xs:string" artifactType="xs:QName"
3430 277             artifactRef="xs:QName"?>
3431 278             artifact specific content ?
3432 279         </DeploymentArtifact> +
3433 280     </DeploymentArtifacts> ?
3434 281
3435 282 </NodeTypeImplementation>
3436 283 |

```

```

3437 284     <RelationshipType name="xs:NCName"
3438 285         targetNamespace="xs:anyURI"?
3439 286         abstract="yes|no"?
3440 287         final="yes|no"?> +
3441 288
3442 289     <DerivedFrom typeRef="xs:QName"/> ?
3443 290
3444 291     <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
3445 292
3446 293     <InstanceStates>
3447 294         <InstanceState state="xs:anyURI"> +
3448 295     </InstanceStates> ?
3449 296
3450 297     <SourceInterfaces>
3451 298         <Interface name="xs:NCName | xs:anyURI">
3452 299             <Operation name="xs:NCName">
3453 300                 <InputParameters>
3454 301                     <InputParameter name="xs:string" type="xs:string"
3455 302                         required="yes|no"?/> +
3456 303                 </InputParameters> ?
3457 304                 <OutputParameters>
3458 305                     <OutputParameter name="xs:string" type="xs:string"
3459 306                         required="yes|no"?/> +
3460 307                 </OutputParameters> ?
3461 308             </Operation> +
3462 309         </Interface> +
3463 310     </SourceInterfaces> ?
3464 311
3465 312     <TargetInterfaces>
3466 313         <Interface name="xs:NCName | xs:anyURI">
3467 314             <Operation name="xs:NCName">
3468 315                 <InputParameters>
3469 316                     <InputParameter name="xs:string" type="xs:string"
3470 317                         required="yes|no"?/> +
3471 318                 </InputParameters> ?
3472 319                 <OutputParameters>
3473 320                     <OutputParameter name="xs:string" type="xs:string"
3474 321                         required="yes|no"?/> +
3475 322                 </OutputParameters> ?
3476 323             </Operation> +
3477 324         </Interface> +
3478 325     </TargetInterfaces> ?
3479 326
3480 327     <ValidSource typeRef="xs:QName"/> ?
3481 328
3482 329     <ValidTarget typeRef="xs:QName"/> ?
3483 330
3484 331 </RelationshipType>
3485 332 |
3486 333 <RelationshipTypeImplementation name="xs:NCName"
3487 334     targetNamespace="xs:anyURI"?
3488 335     relationshipType="xs:QName"
3489 336     abstract="yes|no"?
3490 337     final="yes|no"?>
3491 338
3492 339     <DerivedFrom relationshipTypeImplementationRef="xs:QName"/> ?
3493 340
3494 341     <RequiredContainerFeatures>

```

```

3495 342         <RequiredContainerFeature feature="xs:anyURI"/> +
3496 343     </RequiredContainerFeatures> ?
3497 344
3498 345     <ImplementationArtifacts>
3499 346         <ImplementationArtifact interfaceName="xs:NCName | xs:anyURI"?
3500 347             operationName="xs:NCName"?
3501 348             artifactType="xs:QName"
3502 349             artifactRef="xs:QName"?>
3503 350             artifact specific content ?
3504 351         <ImplementationArtifact> +
3505 352     </ImplementationArtifacts> ?
3506 353
3507 354 </RelationshipTypeImplementation>
3508 355 |
3509 356     <RequirementType name="xs:NCName"
3510 357         targetNamespace="xs:anyURI"?
3511 358         abstract="yes|no"?
3512 359         final="yes|no"?
3513 360         requiredCapabilityType="xs:QName"?>
3514 361
3515 362     <DerivedFrom typeRef="xs:QName"/> ?
3516 363
3517 364     <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
3518 365
3519 366 </RequirementType>
3520 367 |
3521 368     <CapabilityType name="xs:NCName"
3522 369         targetNamespace="xs:anyURI"?
3523 370         abstract="yes|no"?
3524 371         final="yes|no"?>
3525 372
3526 373     <DerivedFrom typeRef="xs:QName"/> ?
3527 374
3528 375     <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
3529 376
3530 377 </CapabilityType>
3531 378 |
3532 379     <ArtifactType name="xs:NCName"
3533 380         targetNamespace="xs:anyURI"?
3534 381         abstract="yes|no"?
3535 382         final="yes|no"?>
3536 383
3537 384     <DerivedFrom typeRef="xs:QName"/> ?
3538 385
3539 386     <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
3540 387
3541 388 </ArtifactType>
3542 389 |
3543 390     <ArtifactTemplate id="xs:ID" name="xs:string"? type="xs:QName">
3544 391
3545 392         <Properties>
3546 393             XML fragment
3547 394         </Properties> ?
3548 395
3549 396         <PropertyConstraints>
3550 397             <PropertyConstraint property="xs:string"
3551 398                 constraintType="xs:anyURI"> +
3552 399                 constraint ?

```

```

3553 400         </PropertyConstraint>
3554 401     </PropertyConstraints> ?
3555 402
3556 403     <ArtifactReferences>
3557 404         <ArtifactReference reference="xs:anyURI">
3558 405             (
3559 406                 <Include pattern="xs:string"/>
3560 407                 |
3561 408                 <Exclude pattern="xs:string"/>
3562 409             ) *
3563 410         </ArtifactReference> +
3564 411     </ArtifactReferences> ?
3565 412
3566 413 </ArtifactTemplate>
3567 414 |
3568 415     <PolicyType name="xs:NCName"
3569 416                 policyLanguage="xs:anyURI"?
3570 417                 abstract="yes|no"?
3571 418                 final="yes|no"?
3572 419                 targetNamespace="xs:anyURI"?>
3573 420         <Tags>
3574 421             <Tag name="xs:string" value="xs:string"/> +
3575 422         </Tags> ?
3576 423
3577 424         <DerivedFrom typeRef="xs:QName"/> ?
3578 425
3579 426         <PropertiesDefinition element="xs:QName"? type="xs:QName"?/> ?
3580 427
3581 428         <AppliesTo>
3582 429             <NodeTypeReference typeRef="xs:QName"/> +
3583 430         </AppliesTo> ?
3584 431
3585 432         policy type specific content ?
3586 433
3587 434 </PolicyType>
3588 435 |
3589 436     <PolicyTemplate id="xs:ID" name="xs:string"? type="xs:QName">
3590 437
3591 438         <Properties>
3592 439             XML fragment
3593 440         </Properties> ?
3594 441
3595 442         <PropertyConstraints>
3596 443             <PropertyConstraint property="xs:string"
3597 444                                 constraintType="xs:anyURI"> +
3598 445                 constraint ?
3599 446             </PropertyConstraint>
3600 447         </PropertyConstraints> ?
3601 448
3602 449         policy type specific content ?
3603 450
3604 451     </PolicyTemplate>
3605 452 ) +
3606 453
3607 454 </Definitions>

```

---

## Appendix D. TOSCA Schema

### TOSCA-v1.0.xsd:

```
01 <?xml version="1.0" encoding="UTF-8"?>
02 <xs:schema targetNamespace="http://docs.oasis-open.org/tosca/ns/2011/12"
03   elementFormDefault="qualified" attributeFormDefault="unqualified"
04   xmlns="http://docs.oasis-open.org/tosca/ns/2011/12"
05   xmlns:xs="http://www.w3.org/2001/XMLSchema">
06
07   <xs:import namespace="http://www.w3.org/XML/1998/namespace"
08     schemaLocation="http://www.w3.org/2001/xml.xsd"/>
09
10   <xs:element name="documentation" type="tDocumentation"/>
11   <xs:complexType name="tDocumentation" mixed="true">
12     <xs:sequence>
13       <xs:any processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
14     </xs:sequence>
15     <xs:attribute name="source" type="xs:anyURI"/>
16     <xs:attribute ref="xml:lang"/>
17   </xs:complexType>
18
19   <xs:complexType name="tExtensibleElements">
20     <xs:sequence>
21       <xs:element ref="documentation" minOccurs="0" maxOccurs="unbounded"/>
22       <xs:any namespace="##other" processContents="lax" minOccurs="0"
23         maxOccurs="unbounded"/>
24     </xs:sequence>
25     <xs:anyAttribute namespace="##other" processContents="lax"/>
26   </xs:complexType>
27
28   <xs:complexType name="tImport">
29     <xs:complexContent>
30       <xs:extension base="tExtensibleElements">
31         <xs:attribute name="namespace" type="xs:anyURI"/>
32         <xs:attribute name="location" type="xs:anyURI"/>
33         <xs:attribute name="importType" type="importedURI" use="required"/>
34       </xs:extension>
35     </xs:complexContent>
36   </xs:complexType>
37
38   <xs:element name="Definitions">
39     <xs:complexType>
40       <xs:complexContent>
41         <xs:extension base="tDefinitions"/>
42       </xs:complexContent>
43     </xs:complexType>
44   </xs:element>
45   <xs:complexType name="tDefinitions">
46     <xs:complexContent>
47       <xs:extension base="tExtensibleElements">
48         <xs:sequence>
49           <xs:element name="Extensions" minOccurs="0">
50             <xs:complexType>
51               <xs:sequence>
52                 <xs:element name="Extension" type="tExtension"
```

```

3662 53         maxOccurs="unbounded"/>
3663 54     </xs:sequence>
3664 55 </xs:complexType>
3665 56 </xs:element>
3666 57 <xs:element name="Import" type="tImport" minOccurs="0"
3667 58     maxOccurs="unbounded"/>
3668 59 <xs:element name="Types" minOccurs="0">
3669 60     <xs:complexType>
3670 61         <xs:sequence>
3671 62             <xs:any namespace="##other" processContents="lax" minOccurs="0"
3672 63                 maxOccurs="unbounded"/>
3673 64         </xs:sequence>
3674 65     </xs:complexType>
3675 66 </xs:element>
3676 67 <xs:choice maxOccurs="unbounded">
3677 68     <xs:element name="ServiceTemplate" type="tServiceTemplate"/>
3678 69     <xs:element name="NodeType" type="tNodeType"/>
3679 70     <xs:element name="NodeTypeImplementation"
3680 71         type="tNodeTypeImplementation"/>
3681 72     <xs:element name="RelationshipType" type="tRelationshipType"/>
3682 73     <xs:element name="RelationshipTypeImplementation"
3683 74         type="tRelationshipTypeImplementation"/>
3684 75     <xs:element name="RequirementType" type="tRequirementType"/>
3685 76     <xs:element name="CapabilityType" type="tCapabilityType"/>
3686 77     <xs:element name="ArtifactType" type="tArtifactType"/>
3687 78     <xs:element name="ArtifactTemplate" type="tArtifactTemplate"/>
3688 79     <xs:element name="PolicyType" type="tPolicyType"/>
3689 80     <xs:element name="PolicyTemplate" type="tPolicyTemplate"/>
3690 81 </xs:choice>
3691 82 </xs:sequence>
3692 83 <xs:attribute name="id" type="xs:ID" use="required"/>
3693 84 <xs:attribute name="name" type="xs:string" use="optional"/>
3694 85 <xs:attribute name="targetNamespace" type="xs:anyURI" use="required"/>
3695 86 </xs:extension>
3696 87 </xs:complexContent>
3697 88 </xs:complexType>
3698 89
3699 90 <xs:complexType name="tServiceTemplate">
3700 91     <xs:complexContent>
3701 92         <xs:extension base="tExtensibleElements">
3702 93             <xs:sequence>
3703 94                 <xs:element name="Tags" type="tTags" minOccurs="0"/>
3704 95                 <xs:element name="BoundaryDefinitions" type="tBoundaryDefinitions"
3705 96                     minOccurs="0"/>
3706 97                 <xs:element name="TopologyTemplate" type="tTopologyTemplate"/>
3707 98                 <xs:element name="Plans" type="tPlans" minOccurs="0"/>
3708 99             </xs:sequence>
3709 100             <xs:attribute name="id" type="xs:ID" use="required"/>
3710 101             <xs:attribute name="name" type="xs:string" use="optional"/>
3711 102             <xs:attribute name="targetNamespace" type="xs:anyURI"/>
3712 103             <xs:attribute name="substitutableNodeType" type="xs:QName"
3713 104                 use="optional"/>
3714 105         </xs:extension>
3715 106     </xs:complexContent>
3716 107 </xs:complexType>
3717 108
3718 109 <xs:complexType name="tTags">
3719 110     <xs:sequence>

```

```

3720 111     <xs:element name="Tag" type="tTag" maxOccurs="unbounded"/>
3721 112     </xs:sequence>
3722 113 </xs:complexType>
3723 114
3724 115 <xs:complexType name="tTag">
3725 116     <xs:attribute name="name" type="xs:string" use="required"/>
3726 117     <xs:attribute name="value" type="xs:string" use="required"/>
3727 118 </xs:complexType>
3728 119
3729 120 <xs:complexType name="tBoundaryDefinitions">
3730 121     <xs:sequence>
3731 122         <xs:element name="Properties" minOccurs="0">
3732 123             <xs:complexType>
3733 124                 <xs:sequence>
3734 125                     <xs:any namespace="##other"/>
3735 126                     <xs:element name="PropertyMappings" minOccurs="0">
3736 127                         <xs:complexType>
3737 128                             <xs:sequence>
3738 129                                 <xs:element name="PropertyMapping" type="tPropertyMapping"
3739 130                                     maxOccurs="unbounded"/>
3740 131                             </xs:sequence>
3741 132                         </xs:complexType>
3742 133                     </xs:element>
3743 134                 </xs:sequence>
3744 135             </xs:complexType>
3745 136         </xs:element>
3746 137         <xs:element name="PropertyConstraints" minOccurs="0">
3747 138             <xs:complexType>
3748 139                 <xs:sequence>
3749 140                     <xs:element name="PropertyConstraint" type="tPropertyConstraint"
3750 141                         maxOccurs="unbounded"/>
3751 142                 </xs:sequence>
3752 143             </xs:complexType>
3753 144         </xs:element>
3754 145         <xs:element name="Requirements" minOccurs="0">
3755 146             <xs:complexType>
3756 147                 <xs:sequence>
3757 148                     <xs:element name="Requirement" type="tRequirementRef"
3758 149                         maxOccurs="unbounded"/>
3759 150                 </xs:sequence>
3760 151             </xs:complexType>
3761 152         </xs:element>
3762 153         <xs:element name="Capabilities" minOccurs="0">
3763 154             <xs:complexType>
3764 155                 <xs:sequence>
3765 156                     <xs:element name="Capability" type="tCapabilityRef"
3766 157                         maxOccurs="unbounded"/>
3767 158                 </xs:sequence>
3768 159             </xs:complexType>
3769 160         </xs:element>
3770 161         <xs:element name="Policies" minOccurs="0">
3771 162             <xs:complexType>
3772 163                 <xs:sequence>
3773 164                     <xs:element name="Policy" type="tPolicy" maxOccurs="unbounded"/>
3774 165                 </xs:sequence>
3775 166             </xs:complexType>
3776 167         </xs:element>
3777 168         <xs:element name="Interfaces" minOccurs="0">

```

```

3778 169     <xs:complexType>
3779 170     <xs:sequence>
3780 171     <xs:element name="Interface" type="tExportedInterface"
3781 172         maxOccurs="unbounded"/>
3782 173     </xs:sequence>
3783 174     </xs:complexType>
3784 175 </xs:element>
3785 176 </xs:sequence>
3786 177 </xs:complexType>
3787 178
3788 179 <xs:complexType name="tPropertyMapping">
3789 180 <xs:attribute name="serviceTemplatePropertyRef" type="xs:string"
3790 181     use="required"/>
3791 182 <xs:attribute name="targetObjectRef" type="xs:IDREF" use="required"/>
3792 183 <xs:attribute name="targetPropertyRef" type="xs:string"
3793 184     use="required"/>
3794 185 </xs:complexType>
3795 186
3796 187 <xs:complexType name="tRequirementRef">
3797 188 <xs:attribute name="name" type="xs:string" use="optional"/>
3798 189 <xs:attribute name="ref" type="xs:IDREF" use="required"/>
3799 190 </xs:complexType>
3800 191
3801 192 <xs:complexType name="tCapabilityRef">
3802 193 <xs:attribute name="name" type="xs:string" use="optional"/>
3803 194 <xs:attribute name="ref" type="xs:IDREF" use="required"/>
3804 195 </xs:complexType>
3805 196
3806 197 <xs:complexType name="tEntityType" abstract="true">
3807 198 <xs:complexContent>
3808 199 <xs:extension base="tExtensibleElements">
3809 200 <xs:sequence>
3810 201 <xs:element name="Tags" type="tTags" minOccurs="0"/>
3811 202 <xs:element name="DerivedFrom" minOccurs="0">
3812 203 <xs:complexType>
3813 204 <xs:attribute name="typeRef" type="xs:QName" use="required"/>
3814 205 </xs:complexType>
3815 206 </xs:element>
3816 207 <xs:element name="PropertiesDefinition" minOccurs="0">
3817 208 <xs:complexType>
3818 209 <xs:attribute name="element" type="xs:QName"/>
3819 210 <xs:attribute name="type" type="xs:QName"/>
3820 211 </xs:complexType>
3821 212 </xs:element>
3822 213 </xs:sequence>
3823 214 <xs:attribute name="name" type="xs:NCName" use="required"/>
3824 215 <xs:attribute name="abstract" type="tBoolean" default="no"/>
3825 216 <xs:attribute name="final" type="tBoolean" default="no"/>
3826 217 <xs:attribute name="targetNamespace" type="xs:anyURI"
3827 218     use="optional"/>
3828 219 </xs:extension>
3829 220 </xs:complexContent>
3830 221 </xs:complexType>
3831 222
3832 223 <xs:complexType name="tEntityTypeTemplate" abstract="true">
3833 224 <xs:complexContent>
3834 225 <xs:extension base="tExtensibleElements">
3835 226 <xs:sequence>

```



```

3836 227     <xs:element name="Properties" minOccurs="0">
3837 228         <xs:complexType>
3838 229             <xs:sequence>
3839 230                 <xs:any namespace="##other" processContents="lax"/>
3840 231             </xs:sequence>
3841 232         </xs:complexType>
3842 233     </xs:element>
3843 234     <xs:element name="PropertyConstraints" minOccurs="0">
3844 235         <xs:complexType>
3845 236             <xs:sequence>
3846 237                 <xs:element name="PropertyConstraint"
3847 238                     type="tPropertyConstraint" maxOccurs="unbounded"/>
3848 239             </xs:sequence>
3849 240         </xs:complexType>
3850 241     </xs:element>
3851 242 </xs:sequence>
3852 243     <xs:attribute name="id" type="xs:ID" use="required"/>
3853 244     <xs:attribute name="type" type="xs:QName" use="required"/>
3854 245 </xs:extension>
3855 246 </xs:complexContent>
3856 247 </xs:complexType>
3857 248
3858 249 <xs:complexType name="tNodeTemplate">
3859 250     <xs:complexContent>
3860 251         <xs:extension base="tEntityTemplate">
3861 252             <xs:sequence>
3862 253                 <xs:element name="Requirements" minOccurs="0">
3863 254                     <xs:complexType>
3864 255                         <xs:sequence>
3865 256                             <xs:element name="Requirement" type="tRequirement"
3866 257                                 maxOccurs="unbounded"/>
3867 258                         </xs:sequence>
3868 259                     </xs:complexType>
3869 260                 </xs:element>
3870 261                 <xs:element name="Capabilities" minOccurs="0">
3871 262                     <xs:complexType>
3872 263                         <xs:sequence>
3873 264                             <xs:element name="Capability" type="tCapability"
3874 265                                 maxOccurs="unbounded"/>
3875 266                         </xs:sequence>
3876 267                     </xs:complexType>
3877 268                 </xs:element>
3878 269                 <xs:element name="Policies" minOccurs="0">
3879 270                     <xs:complexType>
3880 271                         <xs:sequence>
3881 272                             <xs:element name="Policy" type="tPolicy"
3882 273                                 maxOccurs="unbounded"/>
3883 274                         </xs:sequence>
3884 275                     </xs:complexType>
3885 276                 </xs:element>
3886 277                 <xs:element name="DeploymentArtifacts" type="tDeploymentArtifacts"
3887 278                     minOccurs="0"/>
3888 279             </xs:sequence>
3889 280             <xs:attribute name="name" type="xs:string" use="optional"/>
3890 281             <xs:attribute name="minInstances" type="xs:int" use="optional"
3891 282                 default="1"/>
3892 283             <xs:attribute name="maxInstances" use="optional" default="1">
3893 284                 <xs:simpleType>

```

```

3894 285     <xs:union>
3895 286     <xs:simpleType>
3896 287         <xs:restriction base="xs:nonNegativeInteger">
3897 288             <xs:pattern value="([1-9]+[0-9]*)"/>
3898 289         </xs:restriction>
3899 290     </xs:simpleType>
3900 291     <xs:simpleType>
3901 292         <xs:restriction base="xs:string">
3902 293             <xs:enumeration value="unbounded"/>
3903 294         </xs:restriction>
3904 295     </xs:simpleType>
3905 296 </xs:union>
3906 297 </xs:simpleType>
3907 298 </xs:attribute>
3908 299 </xs:extension>
3909 300 </xs:complexContent>
3910 301 </xs:complexType>
3911 302
3912 303 <xs:complexType name="tTopologyTemplate">
3913 304     <xs:complexContent>
3914 305         <xs:extension base="tExtensibleElements">
3915 306             <xs:choice maxOccurs="unbounded">
3916 307                 <xs:element name="NodeTemplate" type="tNodeTemplate"/>
3917 308                 <xs:element name="RelationshipTemplate"
3918 309                     type="tRelationshipTemplate"/>
3919 310             </xs:choice>
3920 311         </xs:extension>
3921 312     </xs:complexContent>
3922 313 </xs:complexType>
3923 314
3924 315 <xs:complexType name="tRelationshipType">
3925 316     <xs:complexContent>
3926 317         <xs:extension base="tEntityType">
3927 318             <xs:sequence>
3928 319                 <xs:element name="InstanceStates"
3929 320                     type="tTopologyElementInstanceStates" minOccurs="0"/>
3930 321                 <xs:element name="SourceInterfaces" minOccurs="0">
3931 322                     <xs:complexType>
3932 323                         <xs:sequence>
3933 324                             <xs:element name="Interface" type="tInterface"
3934 325                                 maxOccurs="unbounded"/>
3935 326                         </xs:sequence>
3936 327                     </xs:complexType>
3937 328                 </xs:element>
3938 329                 <xs:element name="TargetInterfaces" minOccurs="0">
3939 330                     <xs:complexType>
3940 331                         <xs:sequence>
3941 332                             <xs:element name="Interface" type="tInterface"
3942 333                                 maxOccurs="unbounded"/>
3943 334                         </xs:sequence>
3944 335                     </xs:complexType>
3945 336                 </xs:element>
3946 337                 <xs:element name="ValidSource" minOccurs="0">
3947 338                     <xs:complexType>
3948 339                         <xs:attribute name="typeRef" type="xs:QName" use="required"/>
3949 340                     </xs:complexType>
3950 341                 </xs:element>
3951 342                 <xs:element name="ValidTarget" minOccurs="0">

```

```

3952 343         <xs:complexType>
3953 344         <xs:attribute name="typeRef" type="xs:QName" use="required"/>
3954 345     </xs:complexType>
3955 346 </xs:element>
3956 347 </xs:sequence>
3957 348 </xs:extension>
3958 349 </xs:complexContent>
3959 350 </xs:complexType>
3960 351
3961 352 <xs:complexType name="tRelationshipTypeImplementation">
3962 353     <xs:complexContent>
3963 354         <xs:extension base="tExtensibleElements">
3964 355             <xs:sequence>
3965 356                 <xs:element name="Tags" type="tTags" minOccurs="0"/>
3966 357                 <xs:element name="DerivedFrom" minOccurs="0">
3967 358                     <xs:complexType>
3968 359                         <xs:attribute name="relationshipTypeImplementationRef"
3969 360                             type="xs:QName" use="required"/>
3970 361                     </xs:complexType>
3971 362                 </xs:element>
3972 363                 <xs:element name="RequiredContainerFeatures"
3973 364                     type="tRequiredContainerFeatures" minOccurs="0"/>
3974 365                 <xs:element name="ImplementationArtifacts"
3975 366                     type="tImplementationArtifacts" minOccurs="0"/>
3976 367             </xs:sequence>
3977 368             <xs:attribute name="name" type="xs:NCName" use="required"/>
3978 369             <xs:attribute name="targetNamespace" type="xs:anyURI"
3979 370                 use="optional"/>
3980 371             <xs:attribute name="relationshipType" type="xs:QName"
3981 372                 use="required"/>
3982 373             <xs:attribute name="abstract" type="tBoolean" use="optional"
3983 374                 default="no"/>
3984 375             <xs:attribute name="final" type="tBoolean" use="optional"
3985 376                 default="no"/>
3986 377         </xs:extension>
3987 378     </xs:complexContent>
3988 379 </xs:complexType>
3989 380
3990 381 <xs:complexType name="tRelationshipTemplate">
3991 382     <xs:complexContent>
3992 383         <xs:extension base="tEntityTemplate">
3993 384             <xs:sequence>
3994 385                 <xs:element name="SourceElement">
3995 386                     <xs:complexType>
3996 387                         <xs:attribute name="ref" type="xs:IDREF" use="required"/>
3997 388                     </xs:complexType>
3998 389                 </xs:element>
3999 390                 <xs:element name="TargetElement">
4000 391                     <xs:complexType>
4001 392                         <xs:attribute name="ref" type="xs:IDREF" use="required"/>
4002 393                     </xs:complexType>
4003 394                 </xs:element>
4004 395                 <xs:element name="RelationshipConstraints" minOccurs="0">
4005 396                     <xs:complexType>
4006 397                         <xs:sequence>
4007 398                             <xs:element name="RelationshipConstraint"
4008 399                                 maxOccurs="unbounded">
4009 400                                 <xs:complexType>

```

```

4010 401      <xs:sequence>
4011 402      <xs:any namespace="##other" processContents="lax"
4012 403      minOccurs="0"/>
4013 404      </xs:sequence>
4014 405      <xs:attribute name="constraintType" type="xs:anyURI"
4015 406      use="required"/>
4016 407      </xs:complexType>
4017 408      </xs:element>
4018 409      </xs:sequence>
4019 410      </xs:complexType>
4020 411      </xs:element>
4021 412      </xs:sequence>
4022 413      <xs:attribute name="name" type="xs:string" use="optional"/>
4023 414      </xs:extension>
4024 415      </xs:complexContent>
4025 416  </xs:complexType>
4026 417
4027 418  <xs:complexType name="tNodeType">
4028 419      <xs:complexContent>
4029 420      <xs:extension base="tEntityType">
4030 421      <xs:sequence>
4031 422      <xs:element name="RequirementDefinitions" minOccurs="0">
4032 423      <xs:complexType>
4033 424      <xs:sequence>
4034 425      <xs:element name="RequirementDefinition"
4035 426      type="tRequirementDefinition" maxOccurs="unbounded"/>
4036 427      </xs:sequence>
4037 428      </xs:complexType>
4038 429      </xs:element>
4039 430      <xs:element name="CapabilityDefinitions" minOccurs="0">
4040 431      <xs:complexType>
4041 432      <xs:sequence>
4042 433      <xs:element name="CapabilityDefinition"
4043 434      type="tCapabilityDefinition" maxOccurs="unbounded"/>
4044 435      </xs:sequence>
4045 436      </xs:complexType>
4046 437      </xs:element>
4047 438      <xs:element name="InstanceStates"
4048 439      type="tTopologyElementInstanceStates" minOccurs="0"/>
4049 440      <xs:element name="Interfaces" minOccurs="0">
4050 441      <xs:complexType>
4051 442      <xs:sequence>
4052 443      <xs:element name="Interface" type="tInterface"
4053 444      maxOccurs="unbounded"/>
4054 445      </xs:sequence>
4055 446      </xs:complexType>
4056 447      </xs:element>
4057 448      </xs:sequence>
4058 449      </xs:extension>
4059 450      </xs:complexContent>
4060 451  </xs:complexType>
4061 452
4062 453  <xs:complexType name="tNodeTypeImplementation">
4063 454      <xs:complexContent>
4064 455      <xs:extension base="tExtensibleElements">
4065 456      <xs:sequence>
4066 457      <xs:element name="Tags" type="tTags" minOccurs="0"/>
4067 458      <xs:element name="DerivedFrom" minOccurs="0">

```

```

4068 459      <xs:complexType>
4069 460      <xs:attribute name="nodeTypeImplementationRef" type="xs:QName"
4070 461          use="required"/>
4071 462      </xs:complexType>
4072 463  </xs:element>
4073 464  <xs:element name="RequiredContainerFeatures"
4074 465      type="tRequiredContainerFeatures" minOccurs="0"/>
4075 466  <xs:element name="ImplementationArtifacts"
4076 467      type="tImplementationArtifacts" minOccurs="0"/>
4077 468  <xs:element name="DeploymentArtifacts" type="tDeploymentArtifacts"
4078 469      minOccurs="0"/>
4079 470  </xs:sequence>
4080 471  <xs:attribute name="name" type="xs:NCName" use="required"/>
4081 472  <xs:attribute name="targetNamespace" type="xs:anyURI"
4082 473      use="optional"/>
4083 474  <xs:attribute name="nodeType" type="xs:QName" use="required"/>
4084 475  <xs:attribute name="abstract" type="tBoolean" use="optional"
4085 476      default="no"/>
4086 477  <xs:attribute name="final" type="tBoolean" use="optional"
4087 478      default="no"/>
4088 479  </xs:extension>
4089 480  </xs:complexContent>
4090 481 </xs:complexType>
4091 482
4092 483 <xs:complexType name="tRequirementType">
4093 484   <xs:complexContent>
4094 485     <xs:extension base="tEntityType">
4095 486       <xs:attribute name="requiredCapabilityType" type="xs:QName"
4096 487         use="optional"/>
4097 488     </xs:extension>
4098 489   </xs:complexContent>
4099 490 </xs:complexType>
4100 491
4101 492 <xs:complexType name="tRequirementDefinition">
4102 493   <xs:complexContent>
4103 494     <xs:extension base="tExtensibleElements">
4104 495       <xs:sequence>
4105 496         <xs:element name="Constraints" minOccurs="0">
4106 497           <xs:complexType>
4107 498             <xs:sequence>
4108 499               <xs:element name="Constraint" type="tConstraint"
4109 500                 maxOccurs="unbounded"/>
4110 501             </xs:sequence>
4111 502           </xs:complexType>
4112 503         </xs:element>
4113 504       </xs:sequence>
4114 505       <xs:attribute name="name" type="xs:string" use="required"/>
4115 506       <xs:attribute name="requirementType" type="xs:QName"
4116 507         use="required"/>
4117 508       <xs:attribute name="lowerBound" type="xs:int" use="optional"
4118 509         default="1"/>
4119 510       <xs:attribute name="upperBound" use="optional" default="1">
4120 511         <xs:simpleType>
4121 512           <xs:union>
4122 513             <xs:simpleType>
4123 514               <xs:restriction base="xs:nonNegativeInteger">
4124 515                 <xs:pattern value="([1-9]+[0-9]*)"/>
4125 516             </xs:restriction>

```

```

4126 517         </xs:simpleType>
4127 518         <xs:simpleType>
4128 519             <xs:restriction base="xs:string">
4129 520                 <xs:enumeration value="unbounded"/>
4130 521             </xs:restriction>
4131 522         </xs:simpleType>
4132 523     </xs:union>
4133 524 </xs:simpleType>
4134 525 </xs:attribute>
4135 526 </xs:extension>
4136 527 </xs:complexContent>
4137 528 </xs:complexType>
4138 529
4139 530 <xs:complexType name="tRequirement">
4140 531     <xs:complexContent>
4141 532         <xs:extension base="tEntityTemplate">
4142 533             <xs:attribute name="name" type="xs:string" use="required"/>
4143 534         </xs:extension>
4144 535     </xs:complexContent>
4145 536 </xs:complexType>
4146 537
4147 538 <xs:complexType name="tCapabilityType">
4148 539     <xs:complexContent>
4149 540         <xs:extension base="tEntityType"/>
4150 541     </xs:complexContent>
4151 542 </xs:complexType>
4152 543
4153 544 <xs:complexType name="tCapabilityDefinition">
4154 545     <xs:complexContent>
4155 546         <xs:extension base="tExtensibleElements">
4156 547             <xs:sequence>
4157 548                 <xs:element name="Constraints" minOccurs="0">
4158 549                     <xs:complexType>
4159 550                         <xs:sequence>
4160 551                             <xs:element name="Constraint" type="tConstraint"
4161 552                                 maxOccurs="unbounded"/>
4162 553                         </xs:sequence>
4163 554                     </xs:complexType>
4164 555                 </xs:element>
4165 556             </xs:sequence>
4166 557             <xs:attribute name="name" type="xs:string" use="required"/>
4167 558             <xs:attribute name="capabilityType" type="xs:QName"
4168 559                 use="required"/>
4169 560             <xs:attribute name="lowerBound" type="xs:int" use="optional"
4170 561                 default="1"/>
4171 562             <xs:attribute name="upperBound" use="optional" default="1">
4172 563                 <xs:simpleType>
4173 564                     <xs:union>
4174 565                         <xs:simpleType>
4175 566                             <xs:restriction base="xs:nonNegativeInteger">
4176 567                                 <xs:pattern value="([1-9]+[0-9]*)"/>
4177 568                             </xs:restriction>
4178 569                         </xs:simpleType>
4179 570                         <xs:simpleType>
4180 571                             <xs:restriction base="xs:string">
4181 572                                 <xs:enumeration value="unbounded"/>
4182 573                             </xs:restriction>
4183 574                         </xs:simpleType>

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```

4184 575         </xs:union>
4185 576         </xs:simpleType>
4186 577         </xs:attribute>
4187 578         </xs:extension>
4188 579         </xs:complexContent>
4189 580     </xs:complexType>
4190 581
4191 582     <xs:complexType name="tCapability">
4192 583         <xs:complexContent>
4193 584             <xs:extension base="tEntityType">
4194 585                 <xs:attribute name="name" type="xs:string" use="required"/>
4195 586             </xs:extension>
4196 587         </xs:complexContent>
4197 588     </xs:complexType>
4198 589
4199 590     <xs:complexType name="tArtifactType">
4200 591         <xs:complexContent>
4201 592             <xs:extension base="tEntityType"/>
4202 593         </xs:complexContent>
4203 594     </xs:complexType>
4204 595
4205 596     <xs:complexType name="tArtifactTemplate">
4206 597         <xs:complexContent>
4207 598             <xs:extension base="tEntityTemplate">
4208 599                 <xs:sequence>
4209 600                     <xs:element name="ArtifactReferences" minOccurs="0">
4210 601                         <xs:complexType>
4211 602                             <xs:sequence>
4212 603                                 <xs:element name="ArtifactReference" type="tArtifactReference"
4213 604                                     maxOccurs="unbounded"/>
4214 605                             </xs:sequence>
4215 606                         </xs:complexType>
4216 607                     </xs:element>
4217 608                 </xs:sequence>
4218 609                 <xs:attribute name="name" type="xs:string" use="optional"/>
4219 610             </xs:extension>
4220 611         </xs:complexContent>
4221 612     </xs:complexType>
4222 613
4223 614     <xs:complexType name="tDeploymentArtifacts">
4224 615         <xs:sequence>
4225 616             <xs:element name="DeploymentArtifact" type="tDeploymentArtifact"
4226 617                 maxOccurs="unbounded"/>
4227 618         </xs:sequence>
4228 619     </xs:complexType>
4229 620
4230 621     <xs:complexType name="tDeploymentArtifact">
4231 622         <xs:complexContent>
4232 623             <xs:extension base="tExtensibleElements">
4233 624                 <xs:attribute name="name" type="xs:string" use="required"/>
4234 625                 <xs:attribute name="artifactType" type="xs:QName" use="required"/>
4235 626                 <xs:attribute name="artifactRef" type="xs:QName" use="optional"/>
4236 627             </xs:extension>
4237 628         </xs:complexContent>
4238 629     </xs:complexType>
4239 630
4240 631     <xs:complexType name="tImplementationArtifacts">
4241 632         <xs:sequence>

```

```

4242 633     <xs:element name="ImplementationArtifact" maxOccurs="unbounded">
4243 634         <xs:complexType>
4244 635             <xs:complexContent>
4245 636                 <xs:extension base="tImplementationArtifact"/>
4246 637             </xs:complexContent>
4247 638         </xs:complexType>
4248 639     </xs:element>
4249 640 </xs:sequence>
4250 641 </xs:complexType>
4251 642
4252 643 <xs:complexType name="tImplementationArtifact">
4253 644     <xs:complexContent>
4254 645         <xs:extension base="tExtensibleElements">
4255 646             <xs:attribute name="interfaceName" type="xs:anyURI"
4256 647                 use="optional"/>
4257 648             <xs:attribute name="operationName" type="xs:NCName"
4258 649                 use="optional"/>
4259 650             <xs:attribute name="artifactType" type="xs:QName" use="required"/>
4260 651             <xs:attribute name="artifactRef" type="xs:QName" use="optional"/>
4261 652         </xs:extension>
4262 653     </xs:complexContent>
4263 654 </xs:complexType>
4264 655
4265 656 <xs:complexType name="tPlans">
4266 657     <xs:sequence>
4267 658         <xs:element name="Plan" type="tPlan" maxOccurs="unbounded"/>
4268 659     </xs:sequence>
4269 660     <xs:attribute name="targetNamespace" type="xs:anyURI"
4270 661         use="optional"/>
4271 662 </xs:complexType>
4272 663
4273 664 <xs:complexType name="tPlan">
4274 665     <xs:complexContent>
4275 666         <xs:extension base="tExtensibleElements">
4276 667             <xs:sequence>
4277 668                 <xs:element name="Precondition" type="tCondition" minOccurs="0"/>
4278 669                 <xs:element name="InputParameters" minOccurs="0">
4279 670                     <xs:complexType>
4280 671                         <xs:sequence>
4281 672                             <xs:element name="InputParameter" type="tParameter"
4282 673                                 maxOccurs="unbounded"/>
4283 674                         </xs:sequence>
4284 675                     </xs:complexType>
4285 676                 </xs:element>
4286 677                 <xs:element name="OutputParameters" minOccurs="0">
4287 678                     <xs:complexType>
4288 679                         <xs:sequence>
4289 680                             <xs:element name="OutputParameter" type="tParameter"
4290 681                                 maxOccurs="unbounded"/>
4291 682                         </xs:sequence>
4292 683                     </xs:complexType>
4293 684                 </xs:element>
4294 685             <xs:choice>
4295 686                 <xs:element name="PlanModel">
4296 687                     <xs:complexType>
4297 688                         <xs:sequence>
4298 689                             <xs:any namespace="##other" processContents="lax"/>
4299 690                         </xs:sequence>

```



```

4300 691         </xs:complexType>
4301 692     </xs:element>
4302 693     <xs:element name="PlanModelReference">
4303 694         <xs:complexType>
4304 695             <xs:attribute name="reference" type="xs:anyURI"
4305 696                 use="required"/>
4306 697         </xs:complexType>
4307 698     </xs:element>
4308 699 </xs:choice>
4309 700 </xs:sequence>
4310 701 <xs:attribute name="id" type="xs:ID" use="required"/>
4311 702 <xs:attribute name="name" type="xs:string" use="optional"/>
4312 703 <xs:attribute name="planType" type="xs:anyURI" use="required"/>
4313 704 <xs:attribute name="planLanguage" type="xs:anyURI" use="required"/>
4314 705 </xs:extension>
4315 706 </xs:complexContent>
4316 707 </xs:complexType>
4317 708
4318 709 <xs:complexType name="tPolicyType">
4319 710     <xs:complexContent>
4320 711         <xs:extension base="tEntityType">
4321 712             <xs:sequence>
4322 713                 <xs:element name="AppliesTo" type="tAppliesTo" minOccurs="0"/>
4323 714             </xs:sequence>
4324 715             <xs:attribute name="policyLanguage" type="xs:anyURI"
4325 716                 use="optional"/>
4326 717         </xs:extension>
4327 718     </xs:complexContent>
4328 719 </xs:complexType>
4329 720
4330 721 <xs:complexType name="tPolicyTemplate">
4331 722     <xs:complexContent>
4332 723         <xs:extension base="tEntityTemplate">
4333 724             <xs:attribute name="name" type="xs:string" use="optional"/>
4334 725         </xs:extension>
4335 726     </xs:complexContent>
4336 727 </xs:complexType>
4337 728
4338 729 <xs:complexType name="tAppliesTo">
4339 730     <xs:sequence>
4340 731         <xs:element name="NodeTypeReference" maxOccurs="unbounded">
4341 732             <xs:complexType>
4342 733                 <xs:attribute name="typeRef" type="xs:QName" use="required"/>
4343 734             </xs:complexType>
4344 735         </xs:element>
4345 736     </xs:sequence>
4346 737 </xs:complexType>
4347 738
4348 739 <xs:complexType name="tPolicy">
4349 740     <xs:complexContent>
4350 741         <xs:extension base="tExtensibleElements">
4351 742             <xs:attribute name="name" type="xs:string" use="optional"/>
4352 743             <xs:attribute name="policyType" type="xs:QName" use="required"/>
4353 744             <xs:attribute name="policyRef" type="xs:QName" use="optional"/>
4354 745         </xs:extension>
4355 746     </xs:complexContent>
4356 747 </xs:complexType>
4357 748

```

```

4358 749 <xs:complexType name="tConstraint">
4359 750 <xs:sequence>
4360 751 <xs:any namespace="##other" processContents="lax"/>
4361 752 </xs:sequence>
4362 753 <xs:attribute name="constraintType" type="xs:anyURI" use="required"/>
4363 754 </xs:complexType>
4364 755
4365 756 <xs:complexType name="tPropertyConstraint">
4366 757 <xs:complexContent>
4367 758 <xs:extension base="tConstraint">
4368 759 <xs:attribute name="property" type="xs:string" use="required"/>
4369 760 </xs:extension>
4370 761 </xs:complexContent>
4371 762 </xs:complexType>
4372 763
4373 764 <xs:complexType name="tExtensions">
4374 765 <xs:complexContent>
4375 766 <xs:extension base="tExtensibleElements">
4376 767 <xs:sequence>
4377 768 <xs:element name="Extension" type="tExtension"
4378 769 maxOccurs="unbounded"/>
4379 770 </xs:sequence>
4380 771 </xs:extension>
4381 772 </xs:complexContent>
4382 773 </xs:complexType>
4383 774
4384 775 <xs:complexType name="tExtension">
4385 776 <xs:complexContent>
4386 777 <xs:extension base="tExtensibleElements">
4387 778 <xs:attribute name="namespace" type="xs:anyURI" use="required"/>
4388 779 <xs:attribute name="mustUnderstand" type="tBoolean" use="optional"
4389 780 default="yes"/>
4390 781 </xs:extension>
4391 782 </xs:complexContent>
4392 783 </xs:complexType>
4393 784
4394 785 <xs:complexType name="tParameter">
4395 786 <xs:attribute name="name" type="xs:string" use="required"/>
4396 787 <xs:attribute name="type" type="xs:string" use="required"/>
4397 788 <xs:attribute name="required" type="tBoolean" use="optional"
4398 789 default="yes"/>
4399 790 </xs:complexType>
4400 791
4401 792 <xs:complexType name="tInterface">
4402 793 <xs:sequence>
4403 794 <xs:element name="Operation" type="tOperation"
4404 795 maxOccurs="unbounded"/>
4405 796 </xs:sequence>
4406 797 <xs:attribute name="name" type="xs:anyURI" use="required"/>
4407 798 </xs:complexType>
4408 799
4409 800 <xs:complexType name="tExportedInterface">
4410 801 <xs:sequence>
4411 802 <xs:element name="Operation" type="tExportedOperation"
4412 803 maxOccurs="unbounded"/>
4413 804 </xs:sequence>
4414 805 <xs:attribute name="name" type="xs:anyURI" use="required"/>
4415 806 </xs:complexType>

```

```

4416 807
4417 808 <xs:complexType name="tOperation">
4418 809   <xs:complexContent>
4419 810     <xs:extension base="tExtensibleElements">
4420 811       <xs:sequence>
4421 812         <xs:element name="InputParameters" minOccurs="0">
4422 813           <xs:complexType>
4423 814             <xs:sequence>
4424 815               <xs:element name="InputParameter" type="tParameter"
4425 816                 minOccurs="unbounded"/>
4426 817             </xs:sequence>
4427 818           </xs:complexType>
4428 819         </xs:element>
4429 820         <xs:element name="OutputParameters" minOccurs="0">
4430 821           <xs:complexType>
4431 822             <xs:sequence>
4432 823               <xs:element name="OutputParameter" type="tParameter"
4433 824                 minOccurs="unbounded"/>
4434 825             </xs:sequence>
4435 826           </xs:complexType>
4436 827         </xs:element>
4437 828       </xs:sequence>
4438 829       <xs:attribute name="name" type="xs:NCName" use="required"/>
4439 830     </xs:extension>
4440 831   </xs:complexContent>
4441 832 </xs:complexType>
4442 833
4443 834 <xs:complexType name="tExportedOperation">
4444 835   <xs:choice>
4445 836     <xs:element name="NodeOperation">
4446 837       <xs:complexType>
4447 838         <xs:attribute name="nodeRef" type="xs:IDREF" use="required"/>
4448 839         <xs:attribute name="interfaceName" type="xs:anyURI"
4449 840           use="required"/>
4450 841         <xs:attribute name="operationName" type="xs:NCName"
4451 842           use="required"/>
4452 843       </xs:complexType>
4453 844     </xs:element>
4454 845     <xs:element name="RelationshipOperation">
4455 846       <xs:complexType>
4456 847         <xs:attribute name="relationshipRef" type="xs:IDREF"
4457 848           use="required"/>
4458 849         <xs:attribute name="interfaceName" type="xs:anyURI"
4459 850           use="required"/>
4460 851         <xs:attribute name="operationName" type="xs:NCName"
4461 852           use="required"/>
4462 853       </xs:complexType>
4463 854     </xs:element>
4464 855     <xs:element name="Plan">
4465 856       <xs:complexType>
4466 857         <xs:attribute name="planRef" type="xs:IDREF" use="required"/>
4467 858       </xs:complexType>
4468 859     </xs:element>
4469 860   </xs:choice>
4470 861   <xs:attribute name="name" type="xs:NCName" use="required"/>
4471 862 </xs:complexType>
4472 863
4473 864 <xs:complexType name="tCondition">

```

```

4474 865     <xs:sequence>
4475 866     <xs:any processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
4476 867   </xs:sequence>
4477 868   <xs:attribute name="expressionLanguage" type="xs:anyURI"
4478 869     use="required"/>
4479 870 </xs:complexType>
4480 871
4481 872 <xs:complexType name="tTopologyElementInstanceStates">
4482 873   <xs:sequence>
4483 874     <xs:element name="InstanceState" maxOccurs="unbounded">
4484 875       <xs:complexType>
4485 876         <xs:attribute name="state" type="xs:anyURI" use="required"/>
4486 877       </xs:complexType>
4487 878     </xs:element>
4488 879   </xs:sequence>
4489 880 </xs:complexType>
4490 881
4491 882 <xs:complexType name="tArtifactReference">
4492 883   <xs:choice minOccurs="0" maxOccurs="unbounded">
4493 884     <xs:element name="Include">
4494 885       <xs:complexType>
4495 886         <xs:attribute name="pattern" type="xs:string" use="required"/>
4496 887       </xs:complexType>
4497 888     </xs:element>
4498 889     <xs:element name="Exclude">
4499 890       <xs:complexType>
4500 891         <xs:attribute name="pattern" type="xs:string" use="required"/>
4501 892       </xs:complexType>
4502 893     </xs:element>
4503 894   </xs:choice>
4504 895   <xs:attribute name="reference" type="xs:anyURI" use="required"/>
4505 896 </xs:complexType>
4506 897
4507 898 <xs:complexType name="tRequiredContainerFeatures">
4508 899   <xs:sequence>
4509 900     <xs:element name="RequiredContainerFeature"
4510 901       type="tRequiredContainerFeature" maxOccurs="unbounded"/>
4511 902   </xs:sequence>
4512 903 </xs:complexType>
4513 904
4514 905 <xs:complexType name="tRequiredContainerFeature">
4515 906   <xs:attribute name="feature" type="xs:anyURI" use="required"/>
4516 907 </xs:complexType>
4517 908
4518 909 <xs:simpleType name="tBoolean">
4519 910   <xs:restriction base="xs:string">
4520 911     <xs:enumeration value="yes"/>
4521 912     <xs:enumeration value="no"/>
4522 913   </xs:restriction>
4523 914 </xs:simpleType>
4524 915
4525 916 <xs:simpleType name="importedURI">
4526 917   <xs:restriction base="xs:anyURI"/>
4527 918 </xs:simpleType>
4528 919
4529 920 </xs:schema>

```

---

## Appendix E. Sample

This appendix contains the full sample used in this specification.

### E.1 Sample Service Topology Definition

```
01 <Definitions name="MyServiceTemplateDefinition"
02     targetNamespace="http://www.example.com/sample">
03     <Types>
04         <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
05             elementFormDefault="qualified"
06             attributeFormDefault="unqualified">
07             <xs:element name="ApplicationProperties">
08                 <xs:complexType>
09                     <xs:sequence>
10                         <xs:element name="Owner" type="xs:string"/>
11                         <xs:element name="InstanceName" type="xs:string"/>
12                         <xs:element name="AccountID" type="xs:string"/>
13                     </xs:sequence>
14                 </xs:complexType>
15             </xs:element>
16             <xs:element name="AppServerProperties">
17                 <xs:complexType>
18                     <xs:sequence>
19                         <element name="HostName" type="xs:string"/>
20                         <element name="IPAddress" type="xs:string"/>
21                         <element name="HeapSize" type="xs:positiveInteger"/>
22                         <element name="SoapPort" type="xs:positiveInteger"/>
23                     </xs:sequence>
24                 </xs:complexType>
25             </xs:element>
26         </xs:schema>
27     </Types>
28
29     <ServiceTemplate id="MyServiceTemplate">
30
31         <Tags>
32             <Tag name="author" value="someone@example.com"/>
33         </Tags>
34
35         <TopologyTemplate id="SampleApplication">
36
37             <NodeTemplate id="MyApplication"
38                 name="My Application"
39                 nodeType="abc:Application">
40                 <Properties>
41                     <ApplicationProperties>
42                         <Owner>Frank</Owner>
43                         <InstanceName>Thomas' favorite application</InstanceName>
44                     </ApplicationProperties>
45                 </Properties>
46             </NodeTemplate>
47
48             <NodeTemplate id="MyAppServer"
49                 name="My Application Server"
```

```

4582 50         nodeType="abc:ApplicationServer"
4583 51         minInstances="0"
4584 52         maxInstances="unbounded"/>
4585 53
4586 54     <RelationshipTemplate id="MyDeploymentRelationship"
4587 55         relationshipType="abc:deployedOn">
4588 56         <SourceElement id="MyApplication"/>
4589 57         <TargetElement id="MyAppServer"/>
4590 58     </RelationshipTemplate>
4591 59
4592 60 </TopologyTemplate>
4593 61
4594 62 <Plans>
4595 63     <Plan id="DeployApplication"
4596 64         name="Sample Application Build Plan"
4597 65         planType="http://docs.oasis-
4598 66             open.org/tosca/ns/2011/12/PlanTypes/BuildPlan"
4599 67         planLanguage="http://www.omg.org/spec/BPMN/20100524/MODEL">
4600 68
4601 69         <Precondition expressionLanguage="www.example.com/text"> ?
4602 70             Run only if funding is available
4603 71         </Precondition>
4604 72
4605 73         <PlanModel>
4606 74             <process name="DeployNewApplication" id="p1">
4607 75                 <documentation>This process deploys a new instance of the
4608 76                     sample application.
4609 77                 </documentation>
4610 78
4611 79                 <task id="t1" name="CreateAccount"/>
4612 80
4613 81                 <task id="t2" name="AcquireNetworkAddresses"
4614 82                     isSequential="false"
4615 83                     loopDataInput="t2Input.LoopCounter"/>
4616 84                 <documentation>Assumption: t2 gets data of type "input"
4617 85                     as input and this data has a field names "LoopCounter"
4618 86                     that contains the actual multiplicity of the task.
4619 87                 </documentation>
4620 88
4621 89                 <task id="t3" name="DeployApplicationServer"
4622 90                     isSequential="false"
4623 91                     loopDataInput="t3Input.LoopCounter"/>
4624 92
4625 93                 <task id="t4" name="DeployApplication"
4626 94                     isSequential="false"
4627 95                     loopDataInput="t4Input.LoopCounter"/>
4628 96
4629 97                 <sequenceFlow id="s1" targetRef="t2" sourceRef="t1"/>
4630 98                 <sequenceFlow id="s2" targetRef="t3" sourceRef="t2"/>
4631 99                 <sequenceFlow id="s3" targetRef="t4" sourceRef="t3"/>
4632 100             </process>
4633 101         </PlanModel>
4634 102     </Plan>
4635 103
4636 104     <Plan id="RemoveApplication"
4637 105         planType="http://docs.oasis-
4638 106             open.org/tosca/ns/2011/12/PlanTypes/TerminationPlan"
4639 107         planLanguage="http://docs.oasis-

```

```

4640 108         open.org/wsbpel/2.0/process/executable">
4641 109         <PlanModelReference reference="prj:RemoveApp"/>
4642 110     </Plan>
4643 111 </Plans>
4644 112
4645 113 </ServiceTemplate>
4646 114
4647 115 <NodeType name="Application">
4648 116     <documentation xml:lang="EN">
4649 117         A reusable definition of a node type representing an
4650 118         application that can be deployed on application servers.
4651 119     </documentation>
4652 120     <NodeTypeProperties element="ApplicationProperties"/>
4653 121     <InstanceStates>
4654 122         <InstanceState state="http://www.example.com/started"/>
4655 123         <InstanceState state="http://www.example.com/stopped"/>
4656 124     </InstanceStates>
4657 125     <Interfaces>
4658 126         <Interface name="DeploymentInterface">
4659 127             <Operation name="DeployApplication">
4660 128                 <InputParameters>
4661 129                     <InputParamter name="InstanceName"
4662 130                         type="xs:string"/>
4663 131                     <InputParamter name="AppServerHostname"
4664 132                         type="xs:string"/>
4665 133                     <InputParamter name="ContextRoot"
4666 134                         type="xs:string"/>
4667 135                 </InputParameters>
4668 136             </Operation>
4669 137         </Interface>
4670 138     </Interfaces>
4671 139 </NodeType>
4672 140
4673 141 <NodeType name="ApplicationServer"
4674 142     targetNamespace="http://www.example.com/sample">
4675 143     <NodeTypeProperties element="AppServerProperties"/>
4676 144     <Interfaces>
4677 145         <Interface name="MyAppServerInterface">
4678 146             <Operation name="AcquireNetworkAddress"/>
4679 147             <Operation name="DeployApplicationServer"/>
4680 148         </Interface>
4681 149     </Interfaces>
4682 150 </NodeType>
4683 151
4684 152 <RelationshipType name="deployedOn">
4685 153     <documentation xml:lang="EN">
4686 154         A reusable definition of relation that expresses deployment of
4687 155         an artifact on a hosting environment.
4688 156     </documentation>
4689 157 </RelationshipType>
4690 158
4691 159 </Definitions>

```

## Appendix F. Revision History

Revision	Date	Editor	Changes Made
wd-01	2012-01-26	Thomas Spatzier	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.
wd-02	2012-02-23	Thomas Spatzier	Changes for JIRA Issue TOSCA-6: Reviewed and adapted normative statement keywords according to RFC2119.
wd-03	2012-03-06	Arvind Srinivasan, Thomas Spatzier	Changes for JIRA Issue TOSCA-10: Marked all occurrences of keywords from the TOSCA language (element and attribute names) in Courier New font.
wd-04	2012-03-22	Thomas Spatzier	Changes for JIRA Issue TOSCA-4: Changed definition of <code>NodeType</code> <code>Interfaces</code> element; adapted text and examples
wd-05	2012-03-30	Thomas Spatzier	Changes for JIRA Issue TOSCA-5: Changed definition of <code>NodeTemplate</code> to include <code>ImplementationArtifact</code> element; adapted text Added Acknowledgements section in Appendix
wd-06	2012-05-03	Thomas Spatzier, Derek Palma	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
wd-07	2012-06-15	Thomas Spatzier	Changes for JIRA Issue TOSCA-20: Added <code>abstract</code> attribute to <code>NodeType</code> for sub-issue 2; Added <code>final</code> attribute to <code>NodeType</code> for sub-issue 4; Added explanatory text on Node Type properties for sub-issue 8
wd-08	2012-06-29	Thomas Spatzier, Derek Palma	Changes for JIRA Issue TOSCA-23: Added interfaces and introduced inheritance for <code>RelationshipType</code> ; based on wd-07 Added reference to XML element and attribute naming scheme used in this spec



wd-09	2012-07-16	Thomas Spatzier	Changes for JIRA Issue TOSCA-17: Specifies the format of a CSAR file; Explained CSAR concept in the corresponding section.
wd-10	2012-07-30	Thomas Spatzier, Derek Palma	Changes for JIRA Issue TOSCA-18 and related issues: Introduced concept of Requirements and Capabilities; Restructuring of some paragraphs to improve readability
wd-11	2012-08-25	Thomas Spatzier, Derek Palma	Changes for JIRA Issue TOSCA-13: Clarifying rewording of introduction Changes for JIRA Issue TOSCA-38: Add <code>substitutableNodeType</code> attribute and <code>BoundaryDefinitions</code> to Service Template to allow for Service Template composition. Changes for JIRA Issue TOSCA-41: Add Tags to Service Template as simple means for Service Template versioning; Changes for JIRA Issue TOSCA-47: Use <code>name</code> and <code>targetNamespace</code> for uniquely identifying TOSCA types; Changes for JIRA Issue TOSCA-48 (partly): implement notational conventions in pseudo schemas
wd-12	2012-09-29	Thomas Spatzier, Derek Palma	Editorial changes for TOSCA-10: Formatting corrections according to OASIS feedback Changes for JIRA Issue TOSCA-28,29: Added Node Type Implementation (with deployment artifacts and implementation artifacts) that points to a Node Type it realizes; added Relationship Type Implementation analogously for Relationship Types Changes for JIRA Issue TOSCA-38: Added <code>Interfaces</code> to <code>BoundaryDefinitions</code> . Changes for JIRA Issue TOSCA-52: Removal of <code>GroupTemplate</code> Changes for JIRA Issue TOSCA-54: Clarifying rewording in section 3.5 Changes for JIRA Issue TOSCA-56: Clarifying rewording in section 2.8.2 Changes for JIRA Issue TOSCA-58: Clarifying rewording in section 13 Updated roster as of 2012-09-29

wd-13	2012-10-26	Thomas Spatzier, Derek Palma	<p>Changes for JIRA Issue TOSCA-10: More fixes to formatting and references in document according to OASIS staff comments</p> <p>Changes for JIRA Issues TOSCA-36/37: Added <code>PolicyType</code> and <code>PolicyTemplate</code> elements to allow for reusable definitions of policies.</p> <p>Changes for JIRA Issue TOSCA-57: Restructure TOSCA schema to allow for better modular definitions and separation of concerns.</p> <p>Changes for JIRA Issue TOSCA-59: Rewording to clarify overriding of deployment artifacts of Node Templates.</p> <p>Some additional minor changes in wording.</p> <p>Changes for JIRA Issue TOSCA-63: clarifying rewording</p>
wd-14	2012-11-19	Thomas Spatzier	<p>Changes for JIRA Issue TOSCA-76: Add Entry-Definitions property for TOSCA.meta file.</p> <p>Multiple general editorial fixes: Typos, namespaces and MIME types used in examples</p> <p>Fixed schema problems in <code>tPolicyTemplate</code> and <code>tPolicyType</code></p> <p>Added text to Conformance section.</p>
wd-15	2013-02-26	Thomas Spatzier	<p>Changes for JIRA Issue TOSCA-79: Handle public review comments: fixes of typos and other non-material changes like inconsistencies between the specification document and the schema in this document and the TOSCA schema</p>