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Draft Q.ws-xml

**Guidelines for defining Web-services for managed objects and management interfaces****Summary**

This document defines a set of guidelines for managed object modelling and management interface for Web-service based network management. It specifies how service-oriented Web service interfaces are to be defined. It covers the suitable application scenario of Web-services in network management interfaces, generic accessing methods of XML based managed objects, information modelling in Web-service WSDL and XML Schema. Some WSDL definitions and XML Schema are provided defining some basic and data types, exceptions, notification constructs. This draft Recommendation and draft ITU-T Recommendation Q.ws-xml together compose a framework for Web-service based network management interfaces with a wide range of applications.

**Keywords**

Web Service (WS), Web Services Description Language (WSDL), eXtensible Markup Language (XML), XML Schema, Distributed Processing, Managed Objects, Network Management Interfaces.

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## 1 Scope

The network management architecture defined in [ITU-T M.3010] introduces the use of multiple management protocols. So far, the GDMO/CMIP and CORBA GIOP/IIOP are possible choices at the application layer. Based on the management interface specification methodology defined in [ITU-T M.3020], more technology-based paradigm can be introduced into network management interface, and Web-Service/XML is now an additional paradigm for network management.

This Recommendation, together with [ITU-T Q.ws-xml], sets out to define a framework for defining how interfaces supported by management systems and network elements should be modelled using Web-Service/XML schema. It is the scope of this Recommendation to provide the following guidelines or instructions:

- Service-oriented WSDL-based interface design approach;
- Suitable and unsuitable application scenarios for Web-service in network management interfaces;
- Generic accessing methods for managed objects;
- Inheritance of managed objects and interfaces;
- Information modelling guidelines for Web-service based interface;
- Style conventions for Web-service WSDL and XML schema specifications.

## 2 References

The following ITU-T Recommendations and other references contain provisions, which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Q.ws-xml] ITU-T Recommendation Q.ws-xml (20XX), *Web-Service based management services*.

[ITU-T M.3010] Recommendation ITU-T M.3010 (2000), *Principles for a telecommunications management network*.

[W3C] W3C Recommendation XXXX(20XX), *Title*

2007-08-28 *Semantic Annotations for WSDL and XML Schema*

2007-06-26 *Web Services Description Language (WSDL) Version 2.0 Part 0: Primer Recommendation*

2007-06-26 *Web Services Description Language (WSDL) Version 2.0 Part 2: Adjuncts Recommendation*

2007-06-26 *Web Services Description Language (WSDL) Version 2.0 Part 1: Core Language*

### 3 Definitions

#### 3.1 Terms defined elsewhere:

This Recommendation uses the following terms defined elsewhere:

**3.1.1 manager** [ITU-T M.3020]

**3.1.2 agent** [ITU-T M.3020]

**3.1.3 managed object class** [ITU-T X.701]

**3.1.4 notification** [ITU-T X.703]

#### 3.2 Terms defined in this Recommendation

This Recommendation does not define any new terms.

### 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CORBA Common Object Request and Broker Architecture

DCOM Distribute Component Object Model

EMS Element Management System

LAN Local Area Network

MOO Multiple Object Operation

NMS Network Management System

OS Operating System

SOAP Simple Object Access Protocol

W3C World Wide Web Consortium

WS Web Services

WSDL Web Services Description Language

XML eXtensible Markup Language

XSD XML Schema Definition

**Editor's Note : To be extended.**

### 5 Conventions

**Editor's Note : To be updated.**

A few conventions are followed in this Recommendation to make the reader aware of the purpose of the text. While most of the Recommendation is normative, paragraphs succinctly stating mandatory requirements to be met by a management system (managing and/or managed) are preceded by a boldface "R" enclosed in parentheses, followed by a short name indicating the subject of the requirement, and a number. For example:

**(R) EXAMPLE-1** An example mandatory requirement.

Requirements that may be optionally implemented by a management system are preceded by an "O" instead of an "R". For example:

**(O) EXAMPLE-2** An example optional requirement.

The requirement statements are used to create compliance and conformance profiles.

Examples of WSDL and XML are included in this Recommendation and normative WSDL and XML specifying the data types, base classes and other service-oriented modelling constructs of the framework, is included in Annex A. The IDL is written in a 9-point courier typeface:

```
// Example XML schema
void setAdditionalInfo(
    in globaldefs::NamingAttributes_T objectName,
    inout globaldefs::NVSList_T additionalInfo)
    raises (globaldefs::ProcessingFailureException);
```

Annex A of this Recommendation contains source code that implementers will want to extract and compile. It is normative and should be used by developers implementing systems that conform to this Recommendation.

## **6 Overview of Web-service technology and application scenarios in network management interfaces**

### **6.1 Characteristics of Web-Service technology**

Web Services provide a simplified mechanism to connect applications regardless of the technology or devices they use, or their location. They are based on industry standard protocols with universal vendor support that can leverage the internet for low cost communications, as well as other transport mechanisms. The loosely coupled messaging approach supports multiple connectivity and information sharing scenarios via services that are self describing and can be automatically discovered.

Unlike traditional distributed environments, Web services emphasize interoperability. Web services are independent of a particular programming language, whereas traditional environments tend to be bound to one language or another. Similarly, since they can be easily bound to different transport mechanisms, Web services offer more flexibility in the choice of these mechanisms. Furthermore, unlike traditional environments, Web services are often not bound to particular client or server frameworks. Overall, Web services are better suited to a loosely coupled, coarse-grained set of relationships. Relying on XML gives Web services an additional advantage, since XML makes it possible to use documents across heterogeneous environments.

Web-Service is a XML Schema based technology which has the following benefits in software applications.

#### 1) Good interoperability

Web service is universally interoperable because it uses platforms and language independent protocols such as SOAP. Web services technology provides a new level of interoperability between software applications. Many platform providers, software developers, and utility providers enable their software with SOAP, WSDL, and UDDI capabilities.

#### 2) Loosely coupled

Web Services are self-describing software modules which encapsulates discrete functionality. Web Services are accessible via standard Internet communication protocols like XML and SOAP. These Web Services can be developed in many implementation languages, and any other applications or Web Services can access these services. Therefore, Web Services are loosely coupled applications.

### 3) Broadly used

Web services are now broadly used in IT services industry, for example e-business, business-to-business applications. Now several stable platforms are already provided to support the development of Web service applications.

### 4) Software and data reusability

Web services support the component-based model in software development, which allows developers to reuse the building blocks created by others to assemble complex applications and extend them in new ways.

It is not only allowed to reuse source code but also data behind source code of reuse in Web services. Another kind of software reuse in Web services is to integrate these functions in several relevant applications and expose them via web service interfaces.

### 5) Easy for service composition

Web services allow the definition of increasingly complex applications by progressively aggregating components at higher levels of abstraction. A client invoking a composite service can itself be exposed as a web service. Combining the functionality of several web services can form a new web service, which is called service composition. Service composition can be either performed by composing elementary or composite services.

Web Services provide standardized way to expose and access the functionality of applications as services, and there are specialized languages (such as BPEL) for business process definition and execution.

### 6) Low cost

Currently, there are many tools, products, and technologies supporting Web service standards. This gives organizations a wide variety of choices, which help lower the cost in developing new applications and running environment and integration.

## **6.2 Suitable and unsuitable application scenarios of Web-service in network management**

### **(1) Suitable application scenarios in general**

Generally speaking, based on the characteristics of Web-services, it is suitable for the following application scenarios.

#### - Communication across firewall

As Web-Services use standard SOAP as the transferring protocol, it can easily pass firewalls or proxy servers which may be located between different related applications without difficult. It is usually more complex when using other communication middleware.

#### - Application Integration

It is known applications often need to run on programs in one kind of platform and obtain data from or send data to applications in some other platforms. Even in the same platform, a variety of software provided by different manufacturers often need to be integrated. Over Web-services, applications can expose functions and data to other applications to use in standard ways.

#### - B2B interface integration

Integration of cross-enterprise business transactions are usually called B2B integration. Through Web-services, enterprise can integrate critical business applications and then expose them to the

designated suppliers and customers, and the greatest benefit using web services to implement B2B integration is that it can easily achieve interoperability.

- Open interface supporting good changeability

Web services' interfaces are defined in Web Services Description Language (WSDL). The WSDL defines services as collections of network endpoints, or ports. The WSDL specification provides an XML format for documents for this purpose. The abstract definition of ports and messages are separated from their concrete use or instance, allowing the reuse of these definitions. In this way, WSDL describes the public open interface to the web service. Because of the separation of data definition and interfaces definition, client and server of web service applications can be developed separately and communicate through this open interface, and the change of interfaces will result in less impact on the development of web service applications.

## **(2) Unsuitable application scenarios in general**

As Web-Service is a loosely coupled technology mainly designed for application interoperability and integration in heterogeneous environment, it also has weak points, such as lower execution speed and less encoding efficiency compared to some other technologies (such as CORBA or DCOM). In certain use cases, it may not be the best choice to use Web-Service. For example,

- Single machine system
- Isomorphic LAN applications (applications interworking in a single LAN environment with the same platform and underlying middleware)
- Online interaction with large amount of data

## **(3) Considerations for Web-services application scenarios in network management**

Based on the above analysis, the following interfaces in network management domain are considered more suitable for Web-services application:

- B2B/C2B interface
- F interface, and
- high level OS-OS interface (service management layer or business management layer), etc

In the above cases, the benefit of Web-services, such as loosely coupled, inter-enterprise application integration, web-based access, good extensibility for new service applications, can be made good use of.

It may not be a good choice to use Web-Services on EMS-NE management interfaces, as they are usually provided by the same vendor, and may not be necessary as open interfaces.

For NMS-EMS management interfaces, Web-Services may be used, but it may not be the best choice for some cases. For example, CORBA is more encoding efficient and has higher execution speed in LAN environment.

## **7 Principles for service-oriented WSDL-based interface design**

Web-service is a service-oriented technology compared with the traditional CORBA/IDL and GDMO/CMIP management paradigm.

Only attributes are defined for managed entities, and the accessing methods for those entities are defined in operations in a service-oriented approach.

Editor's Note: to be extended.

## 8 Definition of a generic Managed Object using XML Schema

Editor's Note : to be extended.

### 8.1 Web Service role in management interface

To support the software objects representing manageable resources, a base class is defined for use in modelling network resources. Other MOCs (managed object class) in information models must be derived from the base class in order to operate within this framework. Some generic accessing methods and some other extended services are defined to provide interfaces to manage MOs.

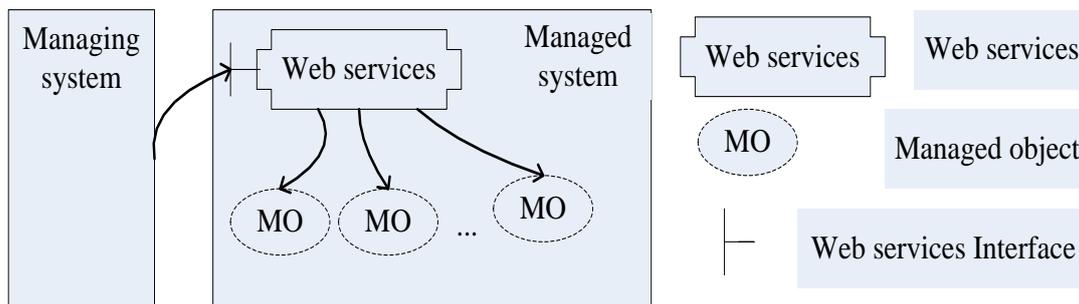


Figure 1 Web services role

Figure 1 shows how a managing system accesses a managed system that supports Web services interface. A Web services interface performs as an intermediate entity that enables a managing system to manage proper MOs in a managed system representing manageable resources.

### 8.2 Definition of managed objects using XML Schema

A MO is the OSI Management view of a resource that is subject to management, such as a connection, or an item of physical equipment. Thus, a MO is the abstraction of such a resource that represents its properties for the purpose of management. A MO may include attributes that provide information used to characterize itself and operations that represent its behaviors. The purpose of the framework is to provide a collection of capabilities to manage these MOs. MOs need some approaches to describe their properties and behaviors. A service-oriented MO is a managed entity that represents a manageable service resource in terms of shared state and behavior where state and behavior are separated through outsourcing of the behavior to an assigned so-called "managing entity" (e.g., a service and its interface) that takes a steward role with regard to the behaviors of its allocated managed entities. Since MO's state and behavior can be separated, state can be described by XML Schema and behavior by Web services' interface in WSDL. One important benefit of using XML document to store MO's state is that Web services uses XML Schema to describe the data type of its exchanged messages, and these XML-based MOs information can be exchanged without any modification.

#### 8.2.1 Definition of generic managed object class

Managed object class is the further abstraction of managed objects. All network resources have some common attributes and all MOCs shall inherit, either directly or indirectly, from a super class, namely ManagedObject. Using ManagedObject to define new MOCs will be easier and faster and

provide better maintenance. As mentioned above, all MOCs are described in XML Schema and the data type of ManagedObject is given in Table 1 and the attributes is found in Table 2.

Table 1. Data type of super class ManagedObject

```

<schema xmlns="http://www.w3.org/2001/XMLSchema" xmlns:mo="..."
targetNamespace="..." ...>
...
<complexType name="ManagedObject">
  <sequence>
    <element name="objectClass" type="string"/>
    <element name="objectInstance" type="mo:DN"/>
    <element name="packages" type="mo:PackageList"/>
    <element name="creationSource" type="mo:SourceIndicator"/>
  </sequence>
</complexType>
</schema>
    
```

Table 2. Attributes of super class ManagedObject

Attribute name	Support Qualifier	Read Qualifier	Write Qualifier
objectClass	Mandatory	Mandatory	-
objectInstance	Mandatory	Mandatory	-
packages	Optional	Mandatory	-
creationSource	Optional	Mandatory	-

As shown in Table 2, ManagedObject is made up of four attributes including objectClass, objectInstance, packages and creationSource. An attribute has an associated value, which may have a simple or a complex structure. Here, the “attribute” of MO is different from the “attribute” in XML Schema specification, and it can be just mapped to the “element” in XML Schema. The attribute “objectClass” is used to identify the class type of this MO instance. The attribute “objectInstance” is used to uniquely identify a MO instance, and the data type is using DN (Distinguished Name) in a using a serialized string format as specified in (1). The attribute “packages” is a set of strings to indicate capacities the MO supports. The attribute “creationSource” indicates whether a MO is created by automatically in managed system, or by a managing system through a management operation, or unknown.

$$\begin{aligned}
 \text{DN(string)} ::= & \text{"<attribute\_name\_1>=} \\
 & \text{<attribute\_value\_1>,<attribute\_name\_2>} \\
 & \text{<attribute\_value\_2>},\dots,\text{<attribute\_name\_n>} \\
 & \text{<attribute\_value\_n>} \qquad (1)
 \end{aligned}$$

### 8.2.2 Inheritance of managed objects

One "MOC" shall be defined as a specialization of another "MOC" by utilizing inheritance such as all the rest of MOs must directly or indirectly inherit from ManagedObject. Specialization of a "MOC" implies that all attributes defined on the super class will be supported by the subclass too. As attributes of MOs are described in XML Schema, the inheritance can be achieved by "extension" of data types. For example, assume the Equipment MOC inherits directly from the base ManagedObject class, and Equipment can inherit all attributes from ManagedObject by extension and declare other attributes showed in Table 3, such as userLabel, for itself.

Table 3. Data type of Equipment by extension

```
<complexType name="Equipment">
  <complexContent>
    <extension base="mo:ManagedObject">
      <sequence>
        <element name="userLabel" type="string"/>
        ...
      </sequence>
    </extension>
  </complexContent>
</complexType>
```

Some MOs may need multiple inheritance, but XML Schema only supports single inheritance for data types and it is not suggested to use multiple inheritance. [12] proposed a method to support multiple inheritance by extending the syntax structure of XML Schema but it is uneasy to implement. If semantic of multiple inheritance is required, the derived MOC has to singly inherit from one of the superior MOC and attributes from the other superior class should be added by hand.

## 9 Accessing methods for managed objects

This clause describes a Web services-based network management framework and this framework shall provide a collection of methods to control network resources. These methods provide basic capabilities to manage MOs and so they are called generic accessing methods. Figure 2 gives the accessing procedure and the framework uses Web services technology to exchange information of MOs. Web services separates MOs' states and behaviours and exposes their behaviours through Web services interface. As Web service is a service-oriented technology, in this framework all MOs are designed to be accessed through a single interface, and the interface must know which MO is the actual target of an operation, and the unique identifier of the target MO should be provided in each accessing request. According to above requirements, some necessary generic accessing methods are given in table 1:

Table 1. Generic accessing methods

Operation name	Input parameter	Output parameter
getMOAttributes	- objectInstance : Name - attributeNameList : SEQUENCE OF String	- attributeNameAndValueList : SEQUENCE OF {attributeName, attributeType, attributeValue} - status : EEUMERATION
setMOAttributes	- objectInstance : DN - attributeNVMLList : SEQUENCE OF {attributeName, attributeType, attributeValue, modifyType}	- status
createMO	- objectclass - objectClassInstance - attributeNameAndValueList	- status
deleteMO	- objectInstance	- status
getPackages	- objectInstance	- packages : List of string - status

Where,

1) getMOAttributes() - to retrieve all, or any subset, of a MO's attribute values in one operation. It uses the DN as the first parameter to uniquely identify the MO and a list of attribute names to be queried. The return result is made up of attribute values and operation status. The attributeNameAndValueList is a list of triples including attributeName, attributeType and attributeValue. The attributeType indicates the original type of attributeValue and attribute values are returned through the "any" element of XML Schema for arbitrary type values. The status parameter indicates whether the operation is performed successfully or failed. As "any" is defined for the data type of the return attribute value, when receiving such an request from the client, the server will return the requested attributes into the output parameter attributeNameAndValueList, where the attributeValue field will be encoded from an variable element to a piece of XML text, which can be decoded by the client application with the help of the attributeType parameter.

2) setMOAttributes() - to modify attribute values of a MO in existence. Besides using objectInstance to indicate the target MO whose values are to be modified, the operation also use a list of quadruples including attributeName, attributeType, attributeValue, and modifyType to set MO attributes. The first three attributes are the same as above. The modifyType indicates how to set corresponding MO attribute values. It is an enumeration type consisting of "REPLACE", "ADDValues", "REMOVEValues" and "SETToDefault". "REPLACE" means the attribute value(s) specified shall be used to replace the current values(s) of the attribute. "ADDValues" means the attribute values(s) specified shall be added to the current value(s) of the attribute. "REMOVEValues" means the attribute value(s) specified shall be removed from the current values(s). "SETToDefault" means the attribute shall be set to its default value. The modifyType is optional, and if it is not specified, the "REPLACE" shall be assumed.

3) createMO() - to create a MO in the managed system. It must specify the created MO's class and name. The attributeNameAndValueList parameter is used to provide attribute values, but it can be omitted, and if it is omitted the attributes are set to default values.

4) deleteMO() - to release any resources associated with the MO and to delete it. It uses DN to identify the target MO and then return the operation status. If the target MO cannot be removed or any of its contained MO cannot be removed, the operation will return OperationFailed status.

5) getPackages() - to return the capabilities of the target MO (a group of attributes and/or operations). An MO instance may or may not support all the capability groups defined in an MOC, and this operation is used by the client to get the actually supported capacities of the MO instance.

List and tabular structures are used extensively to provide a compact and efficient representation of potentially complex data that is to be conveyed as a single unit. At the same time, it also brings in some problems such as difficulty of data validation and comprehension. For Web services is service-oriented and service inheritance will brake up its loose coupling, it is not recommended. In order to keep data consistency of MOs, it can be considered using singleton design pattern.

All the methods mentioned above just operate on one MO. With potentially millions of entities to manage, there is a need for the framework to support operations on multiple objects with a single method invocation or perhaps a small number of invocations. The Multiple-Object Operation (MOO) Service provides this capability, which can be found in Recommendation [ITU-T Q.ws-xml].

## **10 Inheritance of managed objects and interface operations**

### **10.1 Attributes inheritance of managed objects**

One "Managed Object Class" may be defined as a specialization of another "Managed Object Class" by utilizing inheritance. Specialization of a "Managed Object Class" implies that all methods and attributes defined on the super class will also be supported by the subclass. In case of service-Oriented interfaces based on web services, only attributes of managed object classes are supported. Operations inheritance introduced will lead to weaken these characteristics such as good interoperability and loosely couple.

While attributes of managed objects are described with XML Schema, it can be followed the part 4.2 Deriving Types by Extension in XML Schema Part 0: Primer Second Edition to create attributes inheritance. Since attributes data types of base managed objects are defined in complex type in XML Schema, Subclass can extend the base managed objects data type by the value of *base* attribute on the *extension* element in XML Schema.

When a complex type is derived by extension, its effective content model is the content model of the base type plus the content model specified in the type derivation. Furthermore, the two content models are treated as two children of a sequential group. In the case of UKAddress, the content model of UKAddress is the content model of Address plus the declarations for a postcode element and an exportCode attribute.

```
<complexType name="Address">
```

```
<sequence>  
  <element name="name" type="string"/>  
  <element name="street" type="string"/>  
  <element name="city" type="string"/>  
</sequence>  
</complexType>  
<complexType name="USAddress">  
  <complexContent>  
    <extension base="ipo:Address">  
      <sequence>  
        <element name="state" type="ipo:USState"/>  
        <element name="zip" type="positiveInteger"/>  
      </sequence>  
    </extension>  
  </complexContent>  
</complexType>
```

USAddress equals to the following:

```
<sequence>  
  <element name="name" type="string"/>  
  <element name="street" type="string"/>  
  <element name="city" type="string"/>  
  <element name="state" type="ipo:USState"/>  
  <element name="zip" type="positiveInteger"/>  
</sequence>  
</complexType>
```

The above approach can be use for element inheritance, which supporting the semantics for Managed Object attribute inheritance..

## 10.2 Inheritance of interface operation

Editor's Note : To be extended.

## 11 Information modelling guidelines for Web-service based interfaces

Editor's Note : To be extended.

- 11.1 namespace**
- 11.2 element**
- 11.3 attribute**
- 11.4 request**
- 11.5 response**
- 11.6 notification**

## **12 Style Idioms for Web-service WSDL and XML schema specifications**

**Editor's Note:** The following mainly come from the ATIS draft IIF-WT-083R4.

### **12.1 Data Model using XML Schema**

XML allows arbitrary data definitions using ad-hoc tags. The XML document becomes practical for use when it is constrained by a well defined structure. XML Schema provides a means to define rules, semantics and structure for XML documents. A schema provides programmatic validation of a structured XML document. An XML Schema is defined using a XML format in a file with a ".xsd" extension.

#### **Schema specification version**

The namespace for XML Schema 1.1 <http://www.w3.org/2001/XMLSchema> is same as XML Schema for 1.0 document and the namespace for XML instance document remains <http://www.w3.org/2001/XMLSchema-instance>. This allows schema developers to develop XML schema 1.0 documents without worrying about updating namespace when adding 1.1 features. XML Schema 1.1 introduces a new namespace for version control (<http://www.w3.org/2007/XMLSchemaversioning>).

An XML document conforming to a 1.0 schema can be validated using a 1.1 schema validator, but an XML document conforming to a 1.1 schema will likely not validate using a 1.0 schema validator.

Schema developers will have to use appropriate discretion when deciding to use version 1.1 constructs in XML schema definitions.

### **12.2 XML Schema Design Considerations**

#### **12.2.1 Developing a single schema or a collection of related schemas**

The schema definition language allows constructs to import schema from other documents. When developing a set of related schemas, namespace considerations become important in how the resulting

XML instance document references other schemas.

- Reference using `<xsd:import>`: The import element allows references to schema components from schema documents with different target namespaces. This is the most common schema design approach and is also referred to as heterogeneous namespace design.

- Reference using `<xsd:include>`: The include element adds the schema components from other schema documents that have the same target namespace (or no specified target namespace) to the containing schema. The include element thus allows you to add all the components of an included schema to the containing schema. This gives rise to two different design approaches:
  - o Homogeneous namespace design approach: In this design approach all related schemas being developed are assigned the same target namespace.
  - o Chameleon namespace design approach: In chameleon namespace design approach, there is one or more supporting schema defined with no target namespace, the main schema includes the supporting schema(s). The supporting schema(s) take the namespace of the main schema.

The homogeneous or the chameleon design approach allows ability to redefine a type, group and attribute group definitions defined in a supporting schema. Type redefinition affects the elements in the including schema as well as those in the included schema. Thus redefined types can interact with derived types and generate conflicts.

### **12.2.2 Schema design patterns**

There are following four structural design patterns commonly mentioned related to XML schema design:

- Russian Doll: The Russian Doll design provides a single global element in the schema file. All child elements are defined within this single element definition hierarchy. The design does not promote element reusability and requires definition of element in a single schema file.
- Salami Slice: In this design approach, multiple root elements are defined but no complexType is defined. The design supports reusability of individual elements.
- Garden of Eden: A schema design approach in which all elements and types are exposed globally, complex types are defined through reference to reusable global elements. The characteristic of this design pattern is that there are many possible root elements.
- Venetian Blinds: A schema design approach in which types are created first from which elements are built. The simpleTypes and complexTypes are created so as to maximize reuse. The characteristic of this design approach is that there is a single root element.

### **12.2.3 Designing for resiliency**

When developing a schema one of the goals is to make it resilient to changes and provide flexibility that anticipates future needs of the schema users. This section discusses some of the mechanisms that are available for providing flexibility and extensibility in an XML schema model.

#### **12.2.3.1 Using wildcards**

The W3C schema allows constructs such as `<xsd:any>` and `<xsd:anyAttribute>` to allow instance document to contain XML data not directly constrained by the content model of the defining XML Schema. This allows extensibility mechanism with some degree of control that can be specified using “namespace” and “processContents” attributes [See XML Schema Premier and W3C XML Schema Part 1]. The namespace attribute, for example, can be used to constrain the XML data to a set of predefined namespaces thus providing some data validation that can be performed on these extended XML data within an instance document. The “processContents” attribute controls how this extended XML data is validated by the XML validator.

The `<xsd:any>` wildcard can allow vendors to develop vendor specific functionalities not defined in the defining Schema. A careful use of `<xsd:any>` and `<xsd:anyAttribute>` can help build a schema

content model more resilient to change and less prone to schema churn. However on a note of caution, with `<xsd:any>` it is possible to inadvertently allow creation of non-deterministic content models which can cause issues with some XML parsers. A schema developer will have to be consider this constraint when deciding to use `<xsd:any>`.

### **12.2.3.2 Using substitutionGroup**

The content model of substitution group members is related to each other by type derivation. The replaceable element is called the head element and has to be defined in the schema's global scope. In essence, the substitutionGroup construct helps build a collection of elements that can be specified using a generic element.

The substitutionGroup construct can be helpful in following cases:

- Development of related class hierarchies: Creating class hierarchies can enable object oriented programming languages to take advantages of such inheritance.
- Customizing an external schema for a specific need: If an element in an imported schema is defined globally, it is possible to create a substitutionGroup for this element through construction of a derived type and allowing substitution of this derived type in a complex data structure.

Class hierarchies and substitutionGroup results in tight coupling between data structures and can lead to brittle and unmodifiable design. Constructs such as `<xsd:choice>` can be used instead to create composite content model. The composite design can lead to simplicity and a decoupled design.

## **12.3 Recommendations for Schema Developers**

### **12.3.1 XML Schema Design Recommendations**

The authoring committee should:

- Create shared schemas whenever feasible.

The author Shall:

- Use the following namespace format is to be used for ITU-T generated schemas:  
"http://www.itu.int/schemas/<ITU-T document number>/<data model identifier>/<Schema major version number>"
- Use only lowercase characters for namespace names.
- Couple the namespace to the Standard document which defines the Schema but not too tightly.
- It is possible that the document could change with little or no change to the Schema (e.g. updated references).

For this reason, the `<ITU-T document number>` does not include the document version number. Including the document version number would force a change in namespace with every document update. The `<Schema major version number>` allows the namespace to be changed when a significant incompatible change is made to the Schema. Never modify a published schema without an update to the parent standard document.

The author should:

Declare all Simple and Complex Types globally.

- Declare elements and attributes locally. One main element encapsulates all others.

- Ensure the Schema version attribute (Schema minor version number) is present and increments with any change to the Schema. The initial value is expected to be “0”.
- Ensure all schemas have at least 2 namespaces: the W3C XML Schema namespace and the namespace related to the companion Standard.
- Example Schema attributes for version 1.0 of the EAS schema

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

```
<schema
```

```
  xmlns="http://www.w3.org/2001/XMLSchema"
```

```
  targetNamespace="http://www.itu.int/schemas/0800012/eas/1"
```

```
  xmlns:eas="http://www.itu.int/schemas/0800012/eas/1"
```

```
  version="0">
```

```
.....
```

```
</schema>
```

- Provide a schema version number:
  - o Major version number: The last part of the schema namespace (an integer > 1).
  - o Minor version number: The Schema version attribute, version=“<schema minor version number>” (an integer >= 0).

### 12.3.2 XML Schema Coding Recommendations

The author *should* utilize the following guidelines for Type, Element, and Attribute TAG names:

- Utilize common industry or business names where possible to ensure consistency between industry or business documentation and schemas.
- Do not use abbreviations, make names descriptive.
- Do not use the same name twice in any one schema.
- Limit tag names to 20 bytes (not including prefix and ‘:’).
- Use Alpha-Numeric characters only.
- Avoid acronyms but if they are used, the capitalization remains.
- Avoid underscore, period and dash characters.
- Use only Alpha-Numeric characters to define Elements and Type names.
- Use UpperCamelCase e.g. “PersonName” for Elements.
- Use lowerCamelCase for defining simpleType names and UpperCamelCase for defining complexType names.
- Allow Attribute names to contain only Alpha-Numeric characters and to be in lowerCamelCase (the first word is lowercase, others uppercase) e.g., “minOccurs”.
- End Type names with “Type” (not separated with an underscore).
- Use singular names unless the concept itself is plural.
- Use names that only contain nouns, verbs and adjectives.

The author should consider element as the default model type and use the following guidelines:

- If the item can be considered an independent object, make it an element.
- If the item needs to be re-usable, make it a global type.
- If the item does not have any children and describes a characteristic of an element and is never multi-valued, make it an attribute.

The author should utilize the following general guidelines:

- Declare elements as optional unless absolutely required.
- Use minOccurs="0" instead of nillable="True".
- Use maxOccurs. If dimension is more than 1, define it. Otherwise use maxOccurs="unbounded".
- Create simpleTypes as much as possible.
- Create a global Type when the element is to be reusable. (Global Types are defined directly under the Schema element.)
- All Types are to be defined globally.
- Use elementFormDefault = "qualified".
- Use attributeFormDefault = "unqualified".
- Use UTF-8 character encoding: <?xml version="1.0" encoding="UTF-8"?>
- The <documentation> elements are to be used wherever re-use is likely and more clarity is desired. (The xsd:lang attribute is to be used to specify language.)
- Use annotations to describe all Types definitions; minimally include the Type name.
- Use only xsd:datetime element for date and time items.
- Use only <sequence> or <choice> where a compositor is required.
- The author should utilize the following guidelines when adding constraints:
  - When designing new schema, the new simple types are to be constrained and appropriate restrictions applied whenever possible.
  - Identify facets that constrain the range of values.
  - Choose the appropriate simple type. For example, when a number is required, use of nonNegativeInteger or positiveInteger simple type is preferred to integer if possible.
  - When defining string type, if possible use maxLength and patterns to provide additional restrictions. For example when defining a 15 digit international phone number, the pattern can be (ITU-T Recommendation E.164):

```
<xsd:restriction base="xsd:string">  
<xsd:pattern value="([1-9][0-9]{0,2})(-[1-9][0-9]{0,4})?(-[1-9][0-9]{0,13})(-[0-9]+)?"/>  
</xsd:restriction>
```
- When a simple type takes only a predefined set of values, use enumeration facet to restrict the legal values of the simple type.
- Use Union Types if the data types take two different set of values that can independently be constrained. For example, State Code or Zip Code. The author should utilize the following guidelines when using "id" attribute in the schema

- Use the “id” attribute of the schema to identify the schema. The “id” attribute is an optional attribute within the schema element. Defining an “id” can allow better debugging support for programmatic identification of XML elements references to schema. It is recommended that ITU-T Recommendations number be used for the “id” attribute.

### 12.3.3 XML Schema Constructs to Avoid

The author should use the following guidelines for XML Schema Constructs:

- Do not use <xsd:all> (use <sequence> or <choice>). The <xsd:sequence> and <xsd:choice> forces a fixed ordering of child elements in the instance document.
- Do not use processing instructions. Processing instructions don’t form part of the document but are passed to the application to perform application specific functions. Processing instructions don’t have to follow internal structure and as such have little use in schema definitions.
- Do not use notations. The notation element is used to describe format of non-XML data within XML document. They are not used in validation but are used to validate strings as members of NOTATION simple type. They can be used to pass processing instructions to applications.
- Do not use Abstract types. Use of abstract type allows extension and consequently possibility of vendor specific extensions of the abstract data type in derived schema. These can potentially cause interoperability issue and incompatibilities.
- Do not use DTD or XML style comments. The annotation and documentation elements provide construct for comments and information. The XML style comments are not useful for processing of an instance document.
- Do not use XML Groups or Group redefinition. The redefinition of a group can generate conflict between processing of redefined type and derived type instance data.
- Do not use Substitution Groups. The substitution group construct creates tight coupling and adds complexity, which can lead to brittle and unmodifiable design.
- Do not use default/fixed values. Including such attribute uses will tend to mislead readers of the schema document, because the attribute uses would have no effect.

## 12.4 Guidelines for schema extensions

It is understood that the schema authors cannot in advance anticipate all future needs of a schema. The author should utilize schema definition that provides flexibility and allow implementers to carry private or custom data. In general, schema authors should anticipate the need for supporting private data by including constructs to support inclusion of some data in a generic way (for example name-value pair).

However such inclusion might not suffice a more complex need, where for example validation, rules assertions and policies might be required.

The schema author should utilize one of two possible ways of extending support for private data in a schema:

1. Anticipate needs of extensions to specific portions of schema and allow users to add private openContent data.
2. Type Inheritance using <xsd:extension>.

Use of such extension is discouraged as this potentially will lead to interpretability issues. For example, if an implementer extends a standard schema using xsd:extension to add an implementer

specific elements and attributes, a resultant XML data might not parse correctly by other implementers who base their applications on the original standard schema.

The <xsd:extension> might also lead to backward compatibility issues.

### **13 Compliance and Conformance**

**Editor's Note : The following is to be completed.**

Compliance to the mandatory schema guidelines is required for approval of a schema definition by this Recommendation. The recommendation is expected to be followed unless there is a specific reason to do otherwise in a specific case. Review process of a schema definition proposal will apply both requirements and recommendation specified in this document.

## **Annex A**

### **Common WSDL and XML Schema definitions**

(This annex forms an integral part of this Recommendation)

In this annex, the common definitions of WSDL interfaces as well as some common XML Schema based data types are defined.

## Appendix I

**<To be modified >**

(This appendix does not form an integral part of this Recommendation)

<Body of appendix I>

## **Bibliography**

- [b-ITU-T Q.816] ITU-T Recommendation Q.816 (2001), *CORBA-based TMN Services*
- [b-ITU-T Q.816.2] ITU-T Recommendation Q.816.2 (2007), *Service-oriented CORBA-based TMN Services*
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