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Geographic information — XML schema implementation —

Part 1: Encoding rules

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

This first edition of ISO/TS 19139-1 cancels and replaces ISO/TS 19139:2007, which has been technically revised.

A list of all parts in the ISO 19139 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The importance of metadata describing digital geographic data is explained in detail in the text of ISO 19115-1, and other International Standards, e.g. ISO 19110, ISO 19119, ISO 19157. Those documents provide a structure for describing digital geographic data by defining metadata elements and establishing a common set of metadata terminology, definitions and extension procedures. These standards do not define encodings for those metadata.

To facilitate the standardization of implementations across the standards and in similar domain schemas, this document provides a definitive set of rules for encoding ISO metadata standards in Extensible Markup Language (XML). The resulting XML schemas are meant to enhance interoperability by providing a common specification for describing, validating and exchanging metadata. These rules are intended to be used in parallel to the rules in ISO 19136:2007, Annex E for encoding application schemas into XML/GML. The difference is that those rules are for data that represents features; these rules are for metadata about that data.

ISO 19118 describes the requirements for creating encoding rules based on UML schemas and the XML based encoding rules as well as introducing XML. This document uses the encoding rules defined in ISO 19118 and provides the specific details of their application with regards to deriving XML schema for the UML models for other metadata standards.

These rules were first used in creating ISO/TS 19115-3 as an XML encoding of ISO 19115-1, i.e. ISO/TS 19115-3 conforms to this document. They were also used to create ISO/TS 19157-2, an encoding of ISO 19157.

The standardization target of this document is XML implementations of metadata. This includes both other standards within the Geographic Information series and models developed by other organizations.

Geographic information — XML schema implementation —

Part 1:
Encoding rules

1 Scope

This document defines XML based encoding rules for conceptual schemas specifying types that describe geographic resources. The encoding rules support the UML profile as used in the UML models commonly used in the standards developed by ISO/TC 211. The encoding rules use XML schema for the output data structure schema.

The encoding rules described in this document are not applicable for encoding UML application schema for geographic features (see ISO 19136 for those rules).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19118, *Geographic information — Encoding*

W3C XMLName, Namespaces in XML. W3C Recommendation

W3C XMLSchema-1, XML Schema Part 1: Structures. W3C Recommendation

W3C XMLSchema-2, XML Schema Part 2: Datatypes. W3C Recommendation

W3C XML, Extensible Markup Language (XML) 1.0, W3C Recommendation

W3C XLink, XML Linking Language (XLink) Version 1.0. W3C Recommendation

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
namespace
collection of names, identified by a URI reference, which are used in XML documents as element names and attribute names

[SOURCE: W3C XML]

3.2
package
<UML> general purpose mechanism for organizing elements into groups

EXAMPLE Identification information, metadata entity set information, constraint information.

[SOURCE: ISO 19103:2015, 4.27 — modified: The EXAMPLE has been added.]

3.3
polymorphism
characteristic of being able to assign a different meaning or usage to something in different contexts, specifically, to allow an entity such as a variable, a function, or an object to have more than one form

Note 1 to entry: There are several different kinds of polymorphism.

[SOURCE: https://searchcio.techtarget.com/]

3.4
realization
<UML> specialized abstraction relationship between two sets of model elements, one representing a specification (the supplier) and the other representing an implementation of the latter (the client)

Note 1 to entry: Realization indicates inheritance of behaviour without inheritance of structure.

[SOURCE: ISO 19103:2015, 4.29]

4 Symbols and abbreviated terms

4.1 Abbreviated terms

UML Unified Modeling Language

URI Uniform Resource Identifier

XCT XML Class Type

XCPT XML Class Property Type

XCGE XML Class Global Element

XML Extensible Markup Language

XSD XML Schema Definition

4.2 Namespace abbreviations

Table 1 presents the external namespaces used in this document. The left column shows the common namespace prefix used to describe the elements in the namespace. The second column shows the English description of the namespace prefix. The third column is the URI of the actual namespace. These URIs do not correspond necessarily to the location of the schemas.

Table 1 — External namespaces used by this document

Namespace prefix	English description of the namespace	URI of the actual namespace
gml	Geography Markup Language	http://www.opengis.net/gml/3.2
xlink	XML Linking Language (XLink)	http://www.w3.org/1999/xlink
xs	W3C XML base schemas	http://www.w3.org/2001/XMLSchema

4.3 UML model stereotypes

4.3.1 Overview of UML model stereotypes

A UML stereotype is an extension mechanism for existing UML concepts. In addition to the stereotypes already defined for describing geographic resources, this document defines stereotypes necessary for a rules-based encoding into XML schema.

The elements of the UML diagrams depicted in Clause 7 can carry stereotypes specifying an XML implementation. Those stereotypes, listed in the following subclauses, are carried by classes representing XML elements or XML types, UML attributes, UML links (realizations or dependencies) and UML packages.

4.3.2 Stereotypes of classes

In this document the following Stereotypes of classes are used:

a) <<xs:choice>>: The class represents an implementation type encoded as an XML choice block. Each property of the class is implemented as an element of the choice.

b) <<xs:complexType>>: The class represents an implementation type encoded as an XML complex type.

c) <<xs:simpleType>>: The class represents an implementation type encoded as an XML simple type.

d) <<xs:simpleContent>>: The class represents an implementation type encoded as an XML complex type with simple content.

4.3.3 Stereotypes of attributes

In this document the following Stereotypes of attributes are used:

a) <<xs:attribute>>: The property is encoded as an XML attribute.

b) <<xs:attributeGroup>>: The property is encoded as an XML attributeGroup.

c) <<xs:element>>: The property is encoded as an XML element with a name and a type (<xs:element name=”propertyName” type=”propertyType”/>).

4.3.4 Stereotypes of links

In this document, the following Stereotypes of links are used:

a) <<XCT>>: (carried by realization relationships) The XCT of the abstract concept to implement is substituted by the specified external implementation.

b) <<XCGE>>: (carried by realization relationships) The XCGE of the abstract concept to implement is substituted by the specified external implementation.

c) <<XCPT>>: (carried by realization relationships) The XCPT of the abstract concept to implement is substituted by the specified external implementation.

d) <<implement>>: (carried by dependency relationships) The source represents an XML schema implementing the abstract concepts defined in the target.

e) <<include>>: (carried by dependency relationships) The source and the target represent XML schemas. The source includes (<xs:include … />) the target.

f) <<import>>: (carried by dependency relationships) The source and the target represent sets of XML objects grouped within the same namespace. The source imports (<xs:import … />) the target.

4.3.5 Stereotypes of packages

In this document, the following Stereotypes of packages are used:

a) <<xmlSchema>>: The package represents an XML schema.

b) <<xmlNamespace>>: The package represents a set of XML objects grouped within the same namespace.

5 Conformance

The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance, are specified in ISO 19105. An XML schema implementation of geographic resources conforms to this document if it passes the test modules defined in Annex A.

6 Requirements for encoding

6.1 Overview of requirements

Geographic resources are generally specified in other standards and specifications, e.g. metadata according to ISO 19115-1 and feature catalogues according to ISO 19110. Geographic resources are represented as conceptual schemas comprising a set of UML packages containing one or more UML classes. These conceptual schemas provide an encoding-independent view of the related geographic resources.

XML offers many alternatives for structuring information for exchange. Clause 7, in conformance with ISO 19118, defines XML schema encoding rules more specifically applicable to the conceptual schemas of geographic resources.

Even within the reduced limitations of ISO 19118 and the encoding rules defined in this document, there are still choices for the creation of specific XML schemas.

This document provides the foundation needed to establish consistent XML schema implementations of geographic resources, in the form of a set of standardized encoding rules to be applied to the conceptual schemas of geographic resources to create standard XML schema.

The details of XML namespaces are not included in this document. A *namespace* is a collection of names that can be used in XML documents as element or attribute names. The namespace identifier is used to identify the names with a specific schema. A namespace identifier is a URI. A URI is often cumbersome for reading, writing and including in human discussion, so this document will refer to common namespace prefixes when identifying the contents of a namespace.

Before presenting the details of the encoding, it is important to understand why certain encoding rules are used. Gaining an understanding of the rules will make clear the capabilities, limitations and best-practice use. Some of the major goals considered when developing this encoding rule were interoperability with other ISO 19100 series specifications, predictability, extensibility and usability. Additional details of these goals are described in 6.2 to 6.6.

6.2 Rule-based

This document defines a rule-based encoding built from UML models, e.g. those in the ISO 19100 series of International Standards, as required by ISO 19118. Using a rule-based method achieves three important goals:

— first, the resulting XML schemas are based directly on the conceptual models and therefore increase the chance for interoperability;

— second, the resulting schema is predictable since any class, attribute, association, etc. is encoded just as all other UML elements of the same type are encoded;

— third, XML schemas using these rules can be generated in an automated or semi-automated fashion.

6.3 Quality

XML schema quality in the context of this document implies that all elements of the conceptual model are consistently implemented and that a user can directly create and/or understand the content of an XML instance document using the conceptual schema of the corresponding geographic resource. Additionally, an implementer can determine the XML schema implementation of a geographic resource by knowing its conceptual schema and the encoding rules.

Another aspect to quality is completeness. This document enables encoding the entire conceptual schema of a geographic resource without regard to usage or application.

6.4 Web implementations

One of the goals stated in 6.1 is usability. Usability, as it pertains to the design of geographic resources, focuses on their exchange with the understanding that this will often happen in a web-based environment. While there is no restraint against creating instance documents that never transfer across a network, there are many aspects to the design that are intended to aid Internet and web-like transfer of geographic resources.

6.5 Use of external XML implementations

Another design principle that aids interoperability and usability is the re-use of existing XML schemas. If an XML schema standard already exists that encodes a part of the ISO 19100 series pertaining to geographic metadata, then it is advantageous to incorporate that XML schema standard. If the external XML schema is directly used, then interoperability is enhanced. It is also likely that software already exists that can process instance documents that conform to the external XML. Furthermore, if the external schema is well designed, it might be more efficient than XML schema generated from a series of encoding rules and this might help achieve the goal of usability.

While using an implementation that already exists has some important advantages, it is recommended that the external XML schemas should not violate the primary design principles defined herein. See 7.3.8 for details and examples.

6.6 Polymorphism

The term polymorphism is formally defined in 3.3. In general terms, polymorphism means the ability to assume different forms, i.e. to implement properties using their data type or any of its derived classes. Polymorphism allows implementers to extend the more general format of *properties* within their namespaces while still providing usable and understandable instance documents for users outside of their organization. Polymorphism primarily derives from the property type encodings described in 7.3.

7 Encoding rules

7.1 Overview of encoding rules

General rules for transforming UML to XML schema are described below and are in accordance with the rules defined in ISO 19118. In some cases, ISO 19118 allows for multiple methods of transforming UML to XML schema, and the rules defined here serve to clarify which method is to be used to conform with this document. Background on classes and how they are the building blocks for encoding all data exchange (and in this case metadata exchange) is purposefully absent from this document since ISO 19118 covers this in detail. This document is based on the encoding rules in ISO 19118 and a familiarity with that document will greatly enhance comprehension of the topics described throughout Clause 7.

NOTE The way the encoding rules are described doesn't prevent adopting best practices in generating XML schemas.

7.2 Default encoding

7.2.1 XML class type (XCT)

7.2.1.1 Overview of XML class type (XCT)

The class is the fundamental modelling concept in UML (ISO 19118), so the fundamental encoding rules focus on the encoding of a UML class and build from there. A class is made up of one or more properties. It is important to recall from ISO 19118 that a property can represent an attribute, association, aggregation or composition (ISO 19118). For example, in Figure 1, the *Class1* class has three properties: *attr1*, *attr2* and *role1*. For the sake of encoding into XML schema it is important to understand that there is no distinction between properties that are UML attributes, associations, aggregations or compositions.

ISO 19118 also describes the need to use identifiers (ids) and domain unique identifiers (DUIDs) as identifiers in XML schema. There is a special XML schema type in baseTypes2014.xsd in the gco namespace, gco:AbstractObject_Type, which provides the necessary identifiers. It is mentioned here because it is part of the default XML Class type encoding.

7.2.1.2 XCT rule

As a worked example, the UML in Figure 1 is encoded in XML using the following requirements.

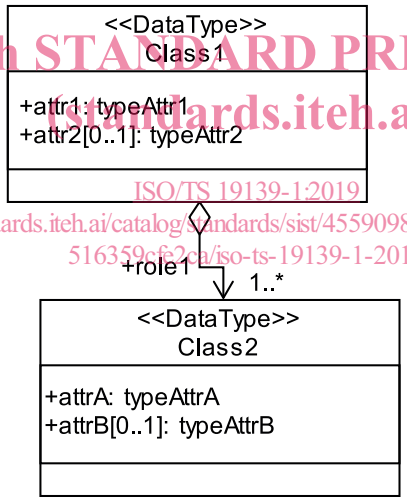

Figure 1 — Example

Requirement /req/default/XCT

A UML Class shall be encoded into XML schema as an XML complex type (xs:complexType) referred to as the XML Class Type (XCT).

Requirement /req/default/XCT-name

Each XCT shall have a name attribute whose value is the class name with the suffix _Type:

EXAMPLE 1 Step 1) of building the Class1 class shown in Figure 1 is:

```
<xs:complexType name="Class1_Type">
        (...)
</xs:complexType>
```

Requirement /req/default/XCT-complex-content

All UML Classes following the default encoding rules shall have complex content, and to provide this capability, the xs:complexType element contains an xs:complexContent element.

EXAMPLE 2 Step 2) of building the Class1 class shown in Figure 1 is:

```
<xs:complexType name="Class1_Type">
  <xs:complexContent>
       (...)
  </xs:complexContent>
</xs:complexType>
```

Requirement /req/default/XCT-extend-abstract

All UML Classes following the default encoding rules shall extend the gco:AbstractObject_Type which is done by adding an xs:extension element with the base attribute equal to gco:AbstractObject_Type.

EXAMPLE 3 Step 3) of building the Class1 class shown in Figure 1 is:

```
<xs:complexType name="Class1_Type">
  <xs:complexContent>
    <xs:extension base="gco:AbstractObject_Type">
       (...)
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

Requirement /req/default/XCT-sequence

All UML Classes following the default encoding rules shall have a sequence containing all the properties of the class. This is accomplished by adding an xs:sequence element, containing xs:element elements for each property of the class.

Requirement /req/default/XCT-properties

The attributes of the *xs:element* element shall be:

a) the *name* attribute, equal to the name of the property;

b) the *type* attribute, equal to the name of the XCPT corresponding to the UML class specified as the type of the property. Subclause 7.2.3 explains that by default this is the class name plus "_ PropertyType" and 7.3.8 defines the only exceptions to this XCPT naming convention. The name of the XCPT used as the value for this type attribute will also be properly prefixed with the appropriate namespace.

c) the *minOccurs* and *maxOccurs* attributes, with the values described in ISO 19118:2011, Table C.5. Additionally, if a property of the class happens to be an attribute that uses the 'set' or 'sequence' structure, then the *minOccurs* attribute shall be "0" for optional attributes and "1" for mandatory attributes and the *maxOccurs* is "unbounded".

EXAMPLE 4 Step 4) of building the Class1 class shown in Figure 1 is:

```
<xs:complexType name="Class1_Type">
  <xs:complexContent>
    <xs:extension base="gco:AbstractObject_Type">
      <xs:sequence>
        <xs:element name="attr1" type="ns1:typeAttr1_PropertyType"/>
        <xs:element name="attr2" type="ns1:typeAttr2_PropertyType" minOccurs="0" />
         <xs:element name="role1" type="ns1:Class2_PropertyType" minOccurs="1"
            maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```