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Geographic information — Conceptual schema language

Information géographique — Schéma de language conceptuel

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In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

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IISO/TS 19103 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

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Introduction

This Technical Specification of the ISO geographic information standards is concerned with the adoption and use of a conceptual schema language (CSL) for developing computer-interpretable models, or schemas, of geographic information. Standardization of geographic information requires the use of a formal CSL to specify unambiguous schemas that can serve as a basis for data interchange and the definition of interoperable services. An important goal of the ISO geographic information standards is to create a framework in which data interchange and service interoperability can be realized across multiple implementation environments. The adoption and consistent use of a CSL to specify geographic information is of fundamental importance in achieving this goal.

There are two aspects to this Technical Specification. First, a CSL must be selected that meets the requirements for rigorous representation of geographic information. This Technical Specification identifies the combination of the Unified Modeling Language (UML) static structure diagram with its associated Object Constraint Language (OCL) and a set of basic type definitions as the conceptual schema language for specification of geographic information. Secondly, this Technical Specification provides guidelines on how UML should be used to create geographic information and service models that are a basis for achieving the goal of interoperability.

One goal of the ISO geographic information standards using UML models is that they will provide a basis for mapping to encoding schemas as defined in ISO 19118, as well as a basis for creating implementation specifications for implementation profiles for various environments.

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Geographic information — Conceptual schema language

1 Scope

This Technical Specification provides rules and guidelines for the use of a conceptual schema language within the ISO geographic information standards. The chosen conceptual schema language is the Unified Modeling Language (UML).

This Technical Specification provides a profile of the Unified Modeling Language (UML) for use with geographic information. In addition, it provides guidelines on how UML should be used to create standardized geographic information and service models.

2 Conformance

Any conceptual schema written for a specification, including a profile or functional standard, that claims conformance with this Technical Specification shall pass all of the requirements described in the abstract test suite in Annex A. Non-UML schemas shall be considered conformant if there is a well-defined mapping from a model in the source language into an equivalent model in UML and that this model in UML is conformant.

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3 Normative references

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The following referenced documents are indispensable for the application 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 19101:2002, *Geographic Information — Reference model*

ISO/IEC 19501:2005, *Information technology — Open Distributed Processing — Unified Modeling Language (UML) Version 1.4.2*

4 Terms, definitions and abbreviations

4.1 ISO/TS 19103 terms

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

4.1.1
application
manipulation and processing of data in support of user requirements

[ISO 19101]

4.1.2
application schema
conceptual schema for data required by one or more **applications**

[ISO 19101]

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4.1.3
conceptual model
model that defines concepts of a universe of discourse

[ISO 19101]

4.1.4
conceptual schema
formal description of a **conceptual model**

[ISO 19101]

4.1.5
data type
specification of a **value domain** with **operations** allowed on **values** in this **domain**

EXAMPLE Integer, Real, Boolean, String, Date and SG Point (conversion of data into a series of codes).

NOTE Data types include primitive predefined types and user-definable types.

4.1.6
domain
well-defined set

NOTE Domains are used to define the domain set and range set of attributes, operators and functions.

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4.1.7
feature
abstraction of real world phenomena

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[ISO 19101]

NOTE 1 A feature may occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

NOTE 2 In UML [8] a feature is a property, such as operation or attribute, which is encapsulated as part of a list within a classifier, such as interface, class or data type.

4.1.8
feature association
relationship that links instances of one **feature** type with instances of the same or a different **feature** type

[ISO 19109]

NOTE 1 A feature association may occur as a type or an instance. Feature association type or feature association instance is used when only one is meant.

NOTE 2 Feature associations include aggregation of features.

4.1.9
feature attribute
characteristic of a **feature**

[ISO 19101]

NOTE 1 A feature attribute has a name, a data type, and a value domain associated to it. A feature attribute for a feature instance also has an attribute value taken from the value domain.

NOTE 2 A feature attribute may occur as a type or an instance. Feature attribute type or feature attribute instance should be used when only one is meant.

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4.1.10
feature operation
operation that every **instance** of a **feature** type may perform

[ISO 19110]

EXAMPLE 1 An operation upon a “dam” is to raise the dam. The result of this operation is to raise the level of water in a reservoir.

EXAMPLE 2 An operation by a “dam” might be to block vessels from navigating along a “watercourse”.

NOTE Feature operations provide a basis for feature type definition.

4.1.11
metadata
data about data

[ISO 19115]

4.1.12
metadata element
discrete unit of **metadata**

[ISO 19115]

NOTE 1 Metadata elements are unique within a metadata entity.

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NOTE 2 Equivalent to an attribute in UML terminology.

4.1.13
schema
formal description of a model

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[ISO 19101]

4.1.14
service
distinct part of the functionality that is provided by an entity through interfaces

[ISO/IEC TR 14252]

4.1.15
value domain
set of accepted values

EXAMPLE The range 3-28, all integers, any ASCII character, enumeration of all accepted values (green, blue, white).

4.2 UML terms

The following are UML terms that are adapted from ISO/IEC 19501.

4.2.1
actor
coherent set of roles that users of use cases play when interacting with these use cases

NOTE An actor may be considered to play a separate role with regard to each use case with which it communicates.

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4.2.2
aggregation
special form of **association** that specifies a whole-part **relationship** between the aggregate (whole) and a **component** part

NOTE See composition.

4.2.3
association
semantic **relationship** between two or more **classifiers** that specifies connections among their **instances**

NOTE A binary association is an association among exactly two classifiers (including the possibility of an association from a classifier to itself).

4.2.4
attribute
feature within a **classifier** that describes a range of **values** that **instances** of the **classifier** may hold

NOTE 1 An attribute is semantically equivalent to a composition association; however, the intent and usage is normally different.

NOTE 2 "Feature" used in this definition is the UML meaning of the term and is not meant as defined in 4.1 of this Technical Specification.

4.2.5
behaviour
observable effects of an **operation** or event, including its results

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4.2.6
cardinality
number of elements in a set

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NOTE Contrast: multiplicity.

4.2.7
class
description of a set of **objects** that share the same **attributes**, operations, **methods**, **relationships** and semantics

NOTE A class may use a set of interfaces to specify collections of operations it provides to its environment. See: interface.

4.2.8
classifier
mechanism that describes behavioural and structural **features**

NOTE Classifiers include interfaces, classes, datatypes, and components.

4.2.9
component
modular, deployable, and replaceable part of a system that encapsulates implementation and exposes a set of **interfaces**

NOTE A component represents a physical piece of implementation of a system, including software code (source, binary or executable) or equivalents such as scripts or command files.

4.2.10
composition
form of **aggregation** which requires that a part **instance** be included in at most one composite at a time, and that the composite **object** is responsible for the creation and destruction of the parts

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NOTE Parts with non-fixed multiplicity may be created after the composite itself, but once created they live and die with it (i.e. they share lifetimes). Such parts can also be explicitly removed before the death of the composite. Composition may be recursive. Synonym: composite aggregation.

4.2.11
constraint
semantic condition or restriction

NOTE Certain constraints are predefined in the UML, others may be user defined. Constraints are one of three extensibility mechanisms in UML. See: tagged value, stereotype.

4.2.12
dependency
relationship between two modeling elements, in which a change to one modeling element (the independent element) will affect the other modeling element (the dependent element)

4.2.13
generalization
taxonomic **relationship** between a more general element and a more specific element that is fully consistent with the more general element and contains additional information

NOTE An instance of the more specific element may be used where the more general element is allowed. See: inheritance.

4.2.14
inheritance
mechanism by which more specific elements incorporate structure and **behaviour** of more general elements related by **behaviour**

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NOTE See generalization.

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4.2.15
instance
entity that has unique identity, a set of **operations** can be applied to it, and state that stores the effects of the **operations**

NOTE See: object.

4.2.16
interface
named set of **operations** that characterize the **behaviour** of an element

4.2.17
metamodel
model that defines the language for expressing a model

4.2.18
method
implementation of an **operation**

NOTE It specifies the algorithm or procedure associated with an operation.

4.2.19
multiplicity
specification of the range of allowable cardinalities that a set may assume

NOTE Multiplicity specifications may be given for roles within associations, parts within composites, repetitions and other purposes. Essentially a multiplicity is a (possibly infinite) subset of the non-negative integers. Contrast: cardinality.

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4.2.20
object
entity with a well-defined boundary and identity that encapsulates state and **behaviour**

NOTE State is represented by attributes and relationships, behaviour is represented by operations, methods and state machines. An object is an instance of a class. See: class, instance.

4.2.21
operation
service that can be requested from an **object** to affect **behaviour**

NOTE 1 An operation has a signature, which may restrict the actual parameters that are possible.

NOTE 2 Definition from UML Reference Manual: A specification of a transformation or query that an object may be called to execute.

NOTE 3 An operation has a name and a list of parameters. A method is a procedure that implements an operation. It has an algorithm or procedure description.

4.2.22
package
general purpose mechanism for organizing elements into groups

NOTE Packages may be nested within other packages. Both model elements and diagrams may appear in a package.

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4.2.23
refinement
relationship that represents a fuller **specification** of something that has already been specified at a certain level of detail

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NOTE For example, a design class is a refinement of an analysis class.

4.2.24
relationship
semantic connection among model elements

NOTE Kinds of relationships include association, generalization, metarelationship, flow and several kinds grouped under dependency.

4.2.25
specification
declarative description of what something is or does

NOTE Contrast: implementation.

4.2.26
stereotype
new type of modeling element that extends the semantics of the **metamodel**

NOTE Stereotypes must be based on certain existing types or classes in the metamodel. Stereotypes may extend the semantics, but not the structure of pre-existing types and classes. Certain stereotypes are predefined in the UML, others may be user defined. Stereotypes are one of three extensibility mechanisms in UML. The others are constraint and tagged value.

4.2.27
tagged value
explicit definition of a property as a name-**value** pair

NOTE In a tagged value, the name is referred as the tag. Certain tags are predefined in the UML; others may be user defined. Tagged values are one of three extensibility mechanisms in UML. The others are constraint and stereotype.

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4.2.28
type
stereotyped class that specifies a **domain** of **objects** together with the **operations** applicable to the **objects**, without defining the physical implementation of those **objects**

NOTE A type may have attributes and associations.

4.2.29
value
element of a type **domain**

NOTE 1 A value may consider a possible state of an object within a class or type (domain).

NOTE 2 A data value is an instance of a data type, a value without identity.

4.3 Abbreviations

API	Application Programming Interface
CASE	Computer Aided Software Engineering
CORBA	Common Object Request Broker Architecture
CSL	Conceptual schema language
CSMF	Conceptual Schema Modeling Facility
DCOM/OLE	Distributed Compound Object Model/Object Linking and Embedding
GFM	General Feature Model
OCL	Object Constraint Language
ODMG	Object Database Management Group
OMG	Object Management Group
ODP	Open Distributed Processing
ODBC	Open Database Connection
SRS	Spatial Reference System
UML	Unified Modeling Language
url	Uniform Resource Locator
XML	Extended Markup Language
XMI	XML Metamodel Interchange

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5 Organization

This Technical Specification contains a UML Profile which provides modeling guidelines for how to use UML for modeling compliant with the ISO geographic information standards.

The main technical content of this Technical Specification is found in Clause 6. An introduction to the general usage of UML is given in 6.1 and 6.2. The description of classes and attributes in 6.3 and 6.4 is based on general rules for UML. Data types described in 6.5 are developed for this Technical Specification, as standard UML does not prescribe the use of specific data types. More information on the necessary precision level of UML models required by this Technical Specification is provided in 6.6, 6.7 and 6.8. The conventions for defining optional attributes and associations are described in 6.9. Naming rules are described in 6.10.

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Annex A describes an abstract test suite for checking that UML models are made according to the rules of this Technical Specification.

An introduction to conceptual schema languages can be found in Annex B, and a set of modeling guidelines for both information modeling and service modeling can be found in Annex C. The general UML as defined in ISO/IEC 19501 is briefly described in Annex D.

6 The ISO/TS 19103 UML Profile

6.1 Introduction

This clause provides rules and guidelines on the use of UML within the field of geographic information. It defines specific aspects for the use of UML compliant with the ISO geographic information standards. It is based on general UML as defined in ISO/IEC 19501 (Annex D). Annex D follows the same structure as this clause, to make it easy to refer to the relevant standard UML concepts.

The subclauses are structured as follows:

— General usage of UML

— Classes

— Attributes

— Data types

— Operations

— Relationships and associations

— Stereotypes and tagged values

— Optional, conditional and mandatory attributes and associations

— Naming and name spaces

— Packages

— Notes

— Constraints

— Documentation of models

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6.2 General usage of UML

UML (The Unified Modeling Language) shall be used in a manner that is consistent with ISO/IEC 19501.

NOTE Books, such as “UML User Guide” [1] and “UML Reference Manual” [2] contain further information. The book “UML Distilled” [4] is a shorter introductory text.

All normative class models shall contain complete definitions of attributes, associations, operations and appropriate data type definitions. Other kinds of UML diagrams may also be used as normative models. It is the need for this completeness that makes it necessary to define this UML profile, as UML in general can be used on various levels of precision and completeness.

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6.3 Classes

A class according to this Technical Specification is normally viewed as a specification and not as an implementation. Attributes are considered abstract and do not have to be directly implemented (i.e. as fields in a record or instance variables in an object). This is not in conflict with the process of encoding as described in ISO 19118, as this describes an external representation that does not have to be equivalent to the internal representation.

For this reason, conceptual schemas adhering to this profile of UML shall stereotype all classifiers as <<Type>> unless they specifically intend to specify internal representation.

NOTE Classifiers specified as <<DataType>> (lacking identity) are not usually assumed to be types in UML, but may be assumed to be abstract for conceptual schemas adhering to this profile of UML unless the schema in which they are defined specifically states otherwise.

For each class defined according to this Technical Specification, the set of attributes defined with this class, together with the sets of attributes of classes that are reachable directly or indirectly via associations, shall be sufficient to fully support the implementation of each operation defined for this particular class.

Use of multiple inheritance is an issue in many implementation environments and can cause problems if handled improperly in those environments. For this reason, the use of multiple inheritance should be minimized or avoided unless it is a fundamental part of the semantics of the type hierarchy. If used, the schema adhering to this UML profile shall not require that the implementation classes realizing the standards specified types replicate the inheritance model of the types.

6.4 Attributes

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Attributes are used according to standard UML (see D.4).

6.5 Data types

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6.5.1 General considerations

The classes and templates (parameterized types) defined in this clause are those that are usually defined by the development environment's data definition language. Each of these types can be represented in a variety of logically equivalent forms. The ones presented here are not meant to restrict the usage of other equivalent forms native to the chosen development environment. ISO/IEC 11404 presents an equivalent definition for most of the types and templates presented here.

The basic data types have been grouped into three categories, as shown in Figure 1:

a) Primitive types: Fundamental types for representing values, examples are CharacterString, Integer, Boolean, Date, Time, etc.

b) Implementation and collection types: Types for implementation and representation structures, examples are Names and Records, and types for representing multiple occurrences of other types, examples are Set, Bag and Sequence.

c) Derived types: Measure types and units of measurement.

The basic types are defined as abstract types, class name in italic, and appropriate representations will be defined by implementation and encoding mappings for the various subtypes.

The repertoire of basic data types is described in 6.5.2 – 6.5.7.

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