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Geografisk information – Modell för att beskriva rumsliga aspekter (ISO 19107:2003)

Geographic information – Spatial schema (ISO 19107:2003)

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Geographic information - Spatial schema (ISO 19107:2003)

Information géographique - Schéma spatial (ISO 19107:2003)

Geoinformation - Raumbezugsschema

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Foreword

The text of ISO 19107:2003 has been prepared by Technical Committee ISO/TC 211 "Geographic information/Geomatics" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 19107:2005 by Technical Committee CEN/TC 287 "Geographic Information", the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2005, and conflicting national standards shall be withdrawn at the latest by July 2005.

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Endorsement notice

The text of ISO 19107:2003 has been approved by CEN as EN ISO 19107:2005 without any modifications.

Introduction

This International Standard provides conceptual schemas for describing and manipulating the spatial characteristics of geographic features. Standardization in this area will be the cornerstone for other geographic information standards.

A feature is an abstraction of a real world phenomenon; it is a geographic feature if it is associated with a location relative to the Earth. Vector data consists of geometric and topological primitives used, separately or in combination, to construct objects that express the spatial characteristics of geographic features. Raster data is based on the division of the extent covered into small units according to a tessellation of the space and the assignment to each unit of an attribute value. This International Standard deals only with vector data.

In the model defined in this International Standard, spatial characteristics are described by one or more spatial attributes whose value is given by a geometric object (GM_Object) or a topological object (TP_Object). Geometry provides the means for the quantitative description, by means of coordinates and mathematical functions, of the spatial characteristics of features, including dimension, position, size, shape, and orientation. The mathematical functions used for describing the geometry of an object depend on the type of coordinate reference system used to define the spatial position. Geometry is the only aspect of geographic information that changes when the information is transformed from one geodetic reference system or coordinate system to another.

Topology deals with the characteristics of geometric figures that remain invariant if the space is deformed elastically and continuously — for example, when geographic data is transformed from one coordinate system to another. Within the context of geographic information, topology is commonly used to describe the connectivity of an n-dimensional graph, a property that is invariant under continuous transformation of the graph. Computational topology provides information about the connectivity of geometric primitives that can be derived from the underlying geometry.

Spatial operators are functions and procedures that use, query, create, modify, or delete spatial objects. This International Standard defines the taxonomy of these operators in order to create a standard for their definition and implementation. The goals are to:

a) Define spatial operators unambiguously, so that diverse implementations can be assured to yield comparable results within known limitations of accuracy and resolution.

b) Use these definitions to define a set of standard operations that will form the basis of compliant systems, and, thus act as a test-bed for implementers and a benchmark set for validation of compliance.

c) Define an operator algebra that will allow combinations of the base operators to be used predictably in the query and manipulation of geographic data.

Standardized conceptual schemas for spatial characteristics will increase the ability to share geographic information among applications. These schemas will be used by geographic information system and software developers and users of geographic information to provide consistently understandable spatial data structures.

Geographic information — Spatial schema

1 Scope

This International Standard specifies conceptual schemas for describing the spatial characteristics of geographic features, and a set of spatial operations consistent with these schemas. It treats vector geometry and topology up to three dimensions. It defines standard spatial operations for use in access, query, management, processing, and data exchange of geographic information for spatial (geometric and topological) objects of up to three topological dimensions embedded in coordinate spaces of up to three axes.

2 Conformance

2.1 Overview

Clauses 6 and 7 of this International Standard use the Unified Modeling Language (UML) to present conceptual schemas for describing the spatial characteristics of geographic features. These schemas define conceptual classes that shall be used in application schemas, profiles and implementation specifications. The document concerns ONLY externally visible interfaces and places no restriction on the underlying implementations other than what is needed to satisfy the interface specifications in the actual situation such as:

— Interfaces to software services using techniques such as COM or CORBA

— Interfaces to databases using techniques such as SQL

— Data interchange using encoding as defined in ISO 19118.

Few applications will require the full range of capabilities described by this conceptual schema. This clause, therefore, defines a set of conformance classes that will support applications whose requirements range from the minimum necessary to define data structures to full object implementation. This flexibility is controlled by a set of UML types that can be implemented in a variety of manners. Implementations that define full object functionality must implement all operations defined by the types of the chosen conformance class, as is common for UML designed object implementations. Implementations that choose to depend on external “free functions” for some or all operations, or forgo them altogether, need not support all operation, but shall always support a data type sufficient to record the state of each of the chosen UML type as defined by its member variables. Common names for “metaphorically identical” but technically different entities are acceptable. The UML model in this International Standard defines abstract types, application schemas define conceptual classes, various software systems define implementation classes or data structures, and the XML from the encoding standard (ISO 19118) defines entity tags. All of these reference the same information content. There is no difficulty in allowing the use of the same name to represent the same information content even though at a deeper level there are significant technical differences in the digital entities being implemented. This “allows” types defined in the UML model to be used directly in application schemas.

There are 39 conformance options for application schemas that define types for the instantiation of geometric or topological objects. They are differentiated on the basis of three criteria.

The first two criteria (complexity and dimensionality) determine the types defined in this schema that shall be implemented according to an application schema that conforms to a given conformance option. In defining the dimensionality of object types to be implemented, the application schema will be required to specify which of the interpolation types for curves or surfaces they wish to implement. Curve implementations, for those application schemas including 1-dimensional objects, shall always include a “linear” interpolation technique. Application schema including 1-dimensional objects should always include a mechanism to approximate any curve as a line string to allow for transfer of data into simpler schema where needed. Surface implementations, for those application schemas including 2-dimensional objects, shall always include a “planar” interpolation technique. Application schema should always include a mechanism to approximate any surface as collections of planar surface patches to allow for transfer of data into simpler schema where needed. Additional curve and surface interpolation mechanism are optional, but if implemented, they shall follow the definition included in this International Standard.

The third criterion (functional complexity) determines the member elements (attributes, association roles and operations) of those types that shall be implemented. The most limited of such schema would define only data types, and may be used in the transfer of data or the passing of operational parameters to service providers.

The first criterion is level of data complexity. Four levels are identified:

— Geometric primitives

— Geometric complexes

— Topological complexes

— Topological complexes with geometric realization

NOTE Schemas for what is commonly called “spaghetti” data use only unstructured collections of geometric primitives. If single definitions of each component of geometry are required, then geometric complexes are introduced into the schema. Primitives within the same geometric complex share only boundaries. If the schema requires explicit topological information then the geometric complex is expanded to include the structure of a topological complex. The types of object included in a complex are controlled by the dimension of that complex. What is commonly called “chain-node” topology is a 1-dimensional topological complex. What is commonly called “full topology” in a cartographic 2D environment is a 2-dimensional topological complex realized by geometric objects in a 2D coordinate system.

The second criterion is dimensionality. There are four levels for simple geometry:

— 0-dimensional objects

— 0- and 1-dimensional objects

— 0-, 1-, and 2-dimensional objects

— 0-, 1-, 2- and 3-dimensional objects

However, 0-dimensional complexes provide no useful information beyond that provided by 0-dimensional geometric primitives, so conformance classes are only defined for complexes of 1-, 2-, and 3-dimensions.

The third criterion is level of functional complexity. There are three levels.

— Data types only

— Simple operations

— Complete operations

Clause 8 of this International Standard defines three groups of Boolean operators that may be used to derive topological relations between geometric and topological objects. This International Standard defines four conformance classes for application schemas that implement these operators.

2.2 Conformance classes

To conform to this International Standard, an implementation shall satisfy the requirements of the Abstract test suite (ATS) in Annex A for a specified conformance class. Table 1 through Table 5 identify the clauses of the ATS that apply for each conformance class.

Table 1 — Conformance classes for geometric primitives

Dimension	Data Types	Simple Operations	Complete Operations
0	A.1.1.1	A.1.2.1	A.1.3.1
1	A.1.1.2	A.1.2.2	A.1.3.2
2	A.1.1.3	A.1.2.3	A.1.3.3
3	A.1.1.4	A.1.2.4	A.1.3.4

Table 2 — Conformance classes for geometric complexes

Dimension	Data Types	Simple Operations	Complete Operations
1	A.2.1.1	A.2.2.1	A.2.3.1
2	A.2.1.2	A.2.2.2	A.2.3.2
3	A.2.1.3	A.2.2.3	A.2.3.3

Table 3 — Conformance classes for topological complexes

Dimension	Data Types	Simple Operations	Complete Operations
1	A.3.1.1	A.3.2.1	A.3.3.1
2	A.3.1.2	A.3.2.2	A.3.3.2
3	A.3.1.3	A.3.2.3	A.3.3.3

Table 4 — Conformance classes for topological complexes with geometric realizations

Dimension	Data Types	Simple Operations	Complete Operations
1	A.4.1.1	A.4.2.1	A.4.3.1
2	A.4.1.2	A.4.2.2	A.4.3.2
3	A.4.1.3	A.4.2.3	A.4.3.3

Table 5 — Conformance classes for Boolean operators

Set operators	A.5.1
Egenhofer operators	A.5.2
Full topological operators	A.5.3
All operators	A.5.4

3 Normative references

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 19109:—[1], *Geographic information — Rules for application schema*

ISO 19111:—[1], *Geographic information — Spatial referencing by coordinates*

ISO/IEC 11404:1996, *Information technology — Programming languages, their environments and system software interfaces — Language-independent datatypes*

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply. The terms are listed alphabetically in this clause. In Annex B they are organized by their conceptual relationships.

4.1
application
manipulation and processing of data in support of user requirements [ISO 19101]

4.2
application schema
conceptual schema for data required by one or more **applications** [ISO 19101]

4.3
bag
finite, unordered collection of related items (**objects** or values) that may be repeated

NOTE Logically, a bag is a set of pairs <item, count>.

4.4
boundary
set that represents the limit of an entity

NOTE **Boundary** is most commonly used in the context of geometry, where the set is a collection of points or a collection of objects that represent those points. In other arenas, the term is used metaphorically to describe the transition between an entity and the rest of its domain of discourse.

4.5
buffer
geometric object that contains all **direct positions** whose distance from a specified **geometric object** is less than or equal to a given distance

4.6
circular sequence
sequence which has no logical beginning and is therefore equivalent to any circular shift of itself; hence the last item in the sequence is considered to precede the first item in the sequence

4.7
class
description of a **set** of **objects** that share the same attributes, operations, methods, relationships, and semantics [ISO/TS 19103]

1) To be published.

NOTE A class may use a **set** of **interfaces** to specify collections of **operations** it provides to its environment. The term was first used in this way in the general theory of object oriented programming, and later adopted for use in this same sense in UML.

4.8
closure
union of the **interior** and **boundary** of a **topological** or **geometric object**

4.9
coboundary
set of **topological primitives** of higher topological dimension associated with a particular **topological object**, such that this **topological object** is in each of their **boundaries**

NOTE If a node is on the boundary of an edge, that edge is on the coboundary of that node. Any orientation parameter associated to one of these relations would also be associated to the other. So that if the node is the end node of the edge (defined as the end of the positive directed edge), then the positive orientation of the node (defined as the positive directed node) would have the edge on its coboundary, see Figure 35.

4.10
composite curve
sequence of **curves** such that each curve (except the first) starts at the end point of the previous curve in the **sequence**

NOTE A composite curve, as a set of **direct positions**, has all the properties of a curve.

4.11
composite solid
connected **set** of **solids** adjoining one another along shared **boundary surfaces**

NOTE A composite solid, as a set of **direct positions**, has all the properties of a solid.

4.12
composite surface
connected **set** of **surfaces** adjoining one another along shared **boundary curves**

NOTE A composite surface, as a set of **direct positions**, has all the properties of a surface.

4.13
computational geometry
manipulation of and calculations with geometric representations for the implementation of geometric **operations**

EXAMPLE Computational geometry operations include testing for geometric inclusion or intersection, the calculation of **convex hulls** or **buffer** zones, or the finding of shortest distances between **geometric objects**.

4.14
computational topology
topological concepts, structures and algebra that aid, enhance or define **operations** on **topological objects** usually performed in **computational geometry**

4.15
connected
property of a **geometric object** implying that any two **direct positions** on the object can be placed on a **curve** that remains totally within the object

NOTE A topological object is connected if and only if all its **geometric realizations** are connected. This is not included as a definition because it follows from a theorem of topology.

4.16
connected node
node that starts or ends one or more **edges**

4.17
convex hull
smallest **convex set** containing a given **geometric object** [Dictionary of Computing [7]]

NOTE "Smallest" is the set theoretic smallest, not an indication of a measurement. The definition can be rewritten as "the intersection of all convex sets that contain the geometric object".

4.18
convex set
geometric set in which any **direct position** on the straight-line segment joining any two **direct positions** in the geometric set is also contained in the **geometric set** [Dictionary of Computing [7]]

NOTE Convex sets are "simply connected", meaning that they have no interior holes, and can normally be considered topologically isomorphic to a Euclidean ball of the appropriate dimension. So the surface of a sphere can be considered to be geodesically convex.

4.19
coordinate
one of a **sequence** of N-numbers designating the position of a **point** in N-dimensional space [ISO 19111]

NOTE In a **coordinate reference system**, the numbers must be qualified by units.

4.20
coordinate dimension
number of measurements or axes needed to describe a position in a **coordinate system**

4.21
coordinate reference system
coordinate system that is related to the real world by a datum [ISO 19111]

4.22
coordinate system
set of mathematical rules for specifying how **coordinates** are to be assigned to **points** [ISO 19111]

4.23
curve
1-dimensional **geometric primitive**, representing the continuous image of a line

NOTE The **boundary** of a **curve** is the **set** of **points** at either end of the **curve**. If the curve is a cycle, the two ends are identical, and the curve (if topologically closed) is considered to not have a boundary. The first **point** is called the **start point**, and the last is the **end point**. Connectivity of the curve is guaranteed by the "continuous image of a line" clause. A topological theorem states that a continuous image of a connected set is connected.

4.24
curve segment
1-dimensional **geometric object** used to represent a continuous component of a **curve** using homogeneous interpolation and definition methods

NOTE The **geometric set** represented by a single curve segment is equivalent to a **curve**.

4.25
cycle
⟨geometry⟩ **spatial object** without a **boundary**

NOTE Cycles are used to describe boundary components (see **shell**, **ring**). A cycle has no boundary because it closes on itself, but it is bounded (i.e., it does not have infinite extent). A circle or a sphere, for example, has no boundary, but is bounded.

4.26
direct position
position described by a single set of **coordinates** within a **coordinate reference system**

4.27
directed edge
directed topological object that represents an association between an **edge** and one of its orientations

NOTE A directed edge that is in agreement with the orientation of the edge has a + orientation, otherwise, it has the opposite (–) orientation. Directed edge is used in **topology** to distinguish the right side (–) from the left side (+) of the same edge and the **start node** (–) and **end node** (+) of the same edge and in **computational topology** to represent these concepts.

4.28
directed face
directed topological object that represents an association between a **face** and one of its orientations

NOTE The orientation of the **directed edges** that compose the exterior **boundary** of a directed face will appear positive from the direction of this vector; the orientation of a directed face that bounds a **topological solid** will point away from the **topological solid**. Adjacent solids would use different orientations for their shared boundary, consistent with the same sort of association between adjacent faces and their shared edges. Directed faces are used in the **coboundary** relation to maintain the spatial association between **face** and **edge**.

4.29
directed node
directed topological object that represents an association between a **node** and one of its orientations

NOTE Directed nodes are used in the **coboundary** relation to maintain the spatial association between **edge** and **node**. The orientation of a node is with respect to an edge, "+" for end node, "–" for start node. This is consistent with the vector notion of "result = end - start".

4.30
directed solid
directed topological object that represents an association between a **topological solid** and one of its orientations

NOTE Directed solids are used in the **coboundary** relation to maintain the spatial association between **face** and **topological solid**. The orientation of a solid is with respect to a face, "+" if the upNormal is outward, "–" if inward. This is consistent with the concept of "up = outward" for a surface bounding a solid.

4.31
directed topological object
topological object that represents a logical association between a **topological primitive** and one of its orientations

4.32
domain
well-defined **set** [ISO/TS 19103]

NOTE Domains are used to define the domain and range of operators and **functions**.

4.33
edge
1-dimensional **topological primitive**

NOTE The **geometric realization** of an edge is a **curve**. The **boundary** of an edge is the **set** of one or two **nodes** associated to the edge within a **topological complex**.

4.34
edge-node graph
graph embedded within a **topological complex** composed of all of the **edges** and **connected nodes** within that **complex**

NOTE The **edge-node graph** is a subcomplex of the complex within which it is embedded.