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BSI Standards Publication

Geographic information — Ontology

Part 1: Framework

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National foreword

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Geographic information — Ontology —

Part 1: Framework

Information géographique — Ontologie —

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 19150-1 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

ISO/TS 19150 consists of the following parts, under the general title *Geographic information — Ontology*:

— *Part 1: Framework*

— *Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)*[1)]

The following parts are under development:

— *Part 3: Semantic operators*

— *Part 4: Service ontology*

— *Part 5: Domain ontology registry*

— *Part 6: Service ontology registry*

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Introduction

For more than two decades (since the World Wide Web was established) the web has been a network of data with proper syntax (structure) but without any meaning (semantics) to the machine. The Semantic Web has introduced the Web of data. The Semantic Web became an extension of the already existing web of data, by adding machine-processable data (with embedded semantics) as opposed to just documents. It can be seen as a tremendous worldwide open database that people can query from their own perspective, understanding, or abstraction of real world phenomena or events and get accurate, detailed, and appropriate answers. This approach involves reasoning capabilities based on ontologies. Following this path the notion of "Linked Data" has been introduced for data of various kinds, coming from different sources, to be connected together on the Web by the way of HTTP URIs. As a consequence, the Semantic Web and Linked Data bring new opportunities for the geographic information realm to lay out a new generation of standards in order to benefit from these in achieving semantic interoperability of geographic information.

Ontology consists of a formal representation of phenomena of a universe of discourse with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships. It supports the representation of concepts that supports the interpretation of data and reasoning to concur to semantic interoperability. Data from different disciplines including geographic information can be integrated and contribute to addressing from specific (e.g. oil spill) to global problems (e.g. climate change).

This Technical Specification defines a high level framework that structures the standards specifically addressing the semantics of geographic information through ontologies. The proposed other parts of the framework include:

ISO 19150-2, *Geographic information — Ontology — Part 2: Rules for developing ontologies in the Web Ontology Language (OWL),* defines rules and guidelines for the development of ontologies in OWL-DL, including a mapping between UML class diagram elements and OWL-DL and rules for describing application schemas in OWL-DL.

ISO 19150-3, *Geographic information — Ontology — Part 3: Semantic operators,* defines semantic proximity operators between concepts that complement geometric and temporal operators.

ISO 19150-4, *Geographic information — Ontology — Part 4: Service ontology,* identifies the framework for service ontology and defines the description of Web services for geographic information in an ontology language.

ISO 19150-5, *Geographic information — Ontology — Part 5: Domain ontology registry,* defines an international registry of geographic information domain ontologies and its maintenance.

ISO 19150-6, *Geographic information — Ontology — Part 6: Service ontology registry,* defines an international registry of geographic information service ontologies and its maintenance.

These parts are completed with the ISO/TC 211 Harmonized ontologies that consist of a set of OWL-DL ontologies that translate and complement the ISO/TC 211 Harmonized models developed in UML.

This Technical Specification is intended to be used primarily by standards developers in geographic information. It can also benefit information system analysts, program planners and developers of ISO geographic information standards. It will improve understanding of the basic principles of semantic interoperability and their consistent application to geographic information.

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Geographic information — Ontology —

Part 1: Framework

1 Scope

This Technical Specification defines the framework for semantic interoperability of geographic information. This framework defines a high level model of the components required to handle semantics in the ISO geographic information standards with the use of ontologies.

2 Conformance

Any documents claiming conformance with this Technical Specification shall pass the requirements described in the abstract test suite presented in Annex A.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TS 19103:2005, *Geographic information — Conceptual schema language*

ISO 19109:2005, *Geographic information — Rules for application schema*

ISO 19119:2005, *Geographic information — Services*

ISO 19135:2005, *Geographic information — Procedures for item registration*

4 Terms and definitions

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

4.1
application schema
conceptual schema (4.3) for *data* (4.4) required by one or more applications

[SOURCE: ISO 19101-1:—[2)], 4.1.2]

4.2
conceptual model
model that defines concepts of a universe of discourse

[SOURCE: ISO 19101-1:—[3)], 4.1.5]

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4.3
conceptual schema
formal description of a *conceptual model* (4.2)

[SOURCE: ISO 19101-1:—[4)], 4.1.6]

4.4
data
reinterpretable representation of *information* (4.7) in a formalized manner suitable for communication, interpretation, or processing

[SOURCE: ISO/IEC 2382-1:1993, 01.01.02]

4.5
feature
abstraction of real world phenomena

[SOURCE: ISO 19101-1:—[5)], 4.1.11]

4.6
framework
logical structure for classifying and organizing complex *information* (4.7)

[SOURCE: ISO/TS 27790:2009, 3.27]

4.7
information
knowledge (4.8) concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context has a particular meaning

[SOURCE: ISO 2382-1:1993, 01.01.01]

4.8
knowledge
cognizance which is based on reasoning

NOTE Adapted from ISO 5127:2001, 1.1.3.14.

4.9
metadata
data (4.4) about data

[SOURCE: ISO 19115:2003, 4.5]

4.10
ontology
formal representation of phenomena of a universe of discourse with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships

[SOURCE: ISO 19101-1:—[6)], 4.1.24]

4.11
registry
information (4.7) system on which a register is maintained

[SOURCE: ISO 19135:2005, 4.1.13]

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4.12
schema
formal description of a model

[SOURCE: ISO 19101-1:—[7)], 4.1.32]

4.13
Semantic Web
Web of *data* (4.4) with meaning

[SOURCE: ISO 19101-1:—[8)], 4.1.33]

NOTE The association of meaning allows data and *information* (4.7) to be understood and processed by automated tools as well as by people.

4.14
universe of discourse
view of the real or hypothetical world that includes everything of interest

[SOURCE: ISO 19101-1:—[9)], 4.1.36]

4.15
Uniform Resource Identifier (URI)
unique identifier for a resource, structured in conformance with IETF RFC 2396

[SOURCE: ISO 19136:2007, 4.1.65]

4.16
Web service
service that is made available through the Web

[SOURCE: ISO 19101-1:—[10)], 4.1.39]

NOTE A Web service usually includes some combination of programming and data. It may also include human resources.

5 Symbols and abbreviated terms

For the purpose of this Technical Specification, the following symbols and abbreviated terms apply.

HTTP	Hypertext Transfer Protocol
LCCS	Land Cover Classification System
LADM	Land Administration Domain Model
ODM	Ontology Definition Metamodel
OMG	Object Management Group
OWL	Web Ontology Language
OWL-DL	OWL - Description Logic
OWL-S	Semantic Markup for Web Services

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PDF	Portable Document Format
RDF	Resource Description Framework
RDF-S	RDF Schema
RIF	Rule Interchange Format
SPARQL	Simple Protocol and RDF Query Language
UML	Unified Modelling Language
URI	Uniform Resource Identifier
W3C	World Wide Web Consortium
XML	eXtensible Markup Language
WSMO	Web Service Modelling Ontology

6 Ontology in geographic information

6.1 Introduction

Semantics has an essential role in the interoperability of geographic information. The background information to explain this is provided in Annex B. Ontology is a fundamental notion to support semantic interoperability of geographic information. Accordingly, this Technical Specification adheres to the information technology and artificial intelligence viewpoint for ontology. In agreement with this viewpoint and in the context of ISO geographic information standards, an ontology refers to a formal representation of phenomena with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships. An ontology can be used by software applications to support the sharing, reuse, and integration of geographic information with any other information sources within a domain of knowledge as well as between various domains of knowledge. It is represented by classes, relations, properties, attributes, and values. It constitutes a foundation to support reasoning, interpretation, and inference.

6.2 Values of ontologies

Ontology is a fundamental notion for semantic interoperability, for data available on the Semantic Web and as such for geographic information interoperability. The following values of ontology are recognized as important with respect to interoperability of geographic information:

— Interoperability across domains;

— Expose ISO geographic information standards to other communities that are not aware of the geographic information domain;

— Automatic machine reasoning and inference;

— From data description via information description to knowledge description;

— Focus on online access of information and knowledge (as opposed to offline access);

— Interrelate similar/different concepts (such as different keywords for similar concepts in metadata); and

— Associate (similar/different) concepts between domains.

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6.3 Issues of relevance

Considering the values of ontologies for interoperability of geographic information, the following issues become relevant for the ISO geographic information standards:

— Developing rules for writing application ontologies for OWL;

— Introducing ontologies as part of product specification applications;

— Developing content standards in ontologies using OWL [42] (application ontologies, domain ontologies, metalanguages);

— Introducing spatial operators as defined in ISO 19107 [19] and ISO 19125-1 [21] to the Semantic Web for spatial reasoning and inference, so that they can be used as part of Semantic Web languages (RDF [39], RDF-S [38], and OWL [42]);

— Defining semantic operators about the semantic similarity with respect to concepts, definition and use as part of Semantic Web languages (RDF [39], RDF-S [38], and OWL [42]);

— Translation of the ISO harmonized model from UML to OWL; and

— Defining Web services ontologies.

7 Framework

7.1 Overview of the framework

The framework of this Technical Specification (Figure 1) presents the structure of the packages that are introduced to address semantics of geographic information through ontologies. The chosen ontology language is OWL-DL. This choice is justified because of the level of expressivity and the reasoning capabilities it provides.

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