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**Geographic information — Ontology —  
Part 2:  
Rules for developing ontologies in the  
Web Ontology Language (OWL)**

*Information géographique — Ontologie —*

*Partie 2: Règles pour le développement d'ontologies dans le langage  
d'ontologie Web (OWL)*

*ISO 19150-2:2015*  
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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.

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. [www.iso.org/directives](http://www.iso.org/directives)

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. [www.iso.org/patents](http://www.iso.org/patents)

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](http://Foreword - Supplementary information).

The Committee responsible for this document is ISO/TC 211, *Geographic information/Geomatics*.

ISO 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)*

*Semantic operators, Service ontology, Domain ontology registry and Service ontology registry* are planned to be covered in future Parts.

## Introduction

Fundamentally, ontology comes from philosophy and refers to the study of the nature of the world itself. The information technology and artificial intelligence communities borrowed this term of ontology for the explicit specification of a conceptualization.<sup>[2]</sup> Information technology and artificial intelligence consider that reality may be abstracted differently depending on the context from which “things” are perceived and, as such, recognize that multiple ontologies about the same part of reality may exist. In geographic information, ontology refers to 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.<sup>[1]</sup> An ontology can be formalized differently ranging from weak to strong semantics: taxonomy, thesaurus, conceptual model, logical theory.<sup>[2]</sup>

Ontology is a fundamental notion for semantic interoperability on the Semantic Web since it defines the meaning of data and describes it in a format that machines and applications can read. As such, an application using data also has access to their inherent semantics through the ontology associated with it. Therefore, ontologies can support integration of heterogeneous data captured by different communities by relating them based on their semantic similarity. The W3C has proposed the Web Ontology Language (OWL) family of knowledge representation languages for authoring ontologies characterised by formal semantics on the Web.<sup>[4,11]</sup>

Semantics is an important topic in the field of geographic information. The meaning of geographic information is essential for their discovery, sharing, integration, and use. Geographic information standards have recognized this fact in the standards on rules for application schema (ISO 19109) and the methodology for feature cataloguing (ISO 19110),<sup>[7]</sup> which are both based on the General Feature Model (GFM). Basically, semantics relates phenomena and signs used to represent them (i.e. data) by the way of concepts. Typically, concepts are maintained in repositories called ontologies.

The ISO geographic information standards have chosen the conceptual modelling language UML<sup>[10,12]</sup> for the formal representation of abstraction of the reality. Additionally as introduced in ISO/TS 19150-1:2012, there is a need to provide formal representation of abstraction of the reality in OWL to support the Semantic Web. Accordingly, this part of ISO 19150 defines rules to convert UML static views of geographic information and application schemas into OWL ontologies in order to benefit and support interoperability of geographic information over the Semantic Web. These rules are required for:

- ontology description completeness;
- consistency in the set of OWL ontologies for geographic information;
- consistency in conversion of UML diagrams to OWL ontologies; and
- cohesion and unity between UML models and ontologies.

These rules are based on but also extend the OMG's Ontology Definition Metamodel.<sup>[11]</sup> OWL ontologies are complementary to UML static views and serve different purposes.

# Geographic information — Ontology —

## Part 2:

## Rules for developing ontologies in the Web Ontology Language (OWL)

### 1 Scope

This part of ISO 19150 defines rules and guidelines for the development of ontologies to support better the interoperability of geographic information over the Semantic Web. The Web Ontology Language (OWL) is the language adopted for ontologies.

This part of ISO 19150 defines the conversion of the UML static view modeling elements used in the ISO geographic information standards into OWL. It further defines conversion rules for describing application schemas based on the General Feature Model defined in ISO 19109 into OWL.

This part of ISO 19150 does not define semantics operators, rules for service ontologies, and does not develop any ontology.

### 2 Conformance

Any application ontology or profile claiming conformance with this part of ISO 19150 shall pass the requirements described in the abstract test suite, presented in [Annex A](#).

The abstract test suite is organized in two conformance classes that address the following purposes:

- Conversion of a UML package from the ISO/TC 211 Harmonized Model to OWL (conformance class 19150-2owl-conf); and
- Formalization of an application schema in OWL (conformance class 19150-2app-conf).

### 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 19103:—<sup>1)</sup>, *Geographic information — Conceptual schema language*

ISO 19107:2003, *Geographic information — Spatial schema*

ISO 19108:2002, *Geographic information — Temporal schema*

ISO 19109:—<sup>2)</sup>, *Geographic information — Rules for application schema*

ISO 19112:2003, *Geographic information — Spatial referencing by geographic identifiers*

ISO 19115-1:2014, *Geographic information — Metadata — Part 1: Fundamentals*

ISO 19123:2005, *Geographic information — Schema for coverage geometry and functions*

1) To be published. (Revision of ISO/TS 19103:2005)

2) To be published. (Revision of ISO 19109:2005)

ISO 19156:2011, *Geographic information — Observations and measurements*

ISO 19157:2013, *Geographic information — Data quality*

W3C OWL 2, *OWL 2 Web Ontology Language: Structural Specification and Functional-Style Syntax* (W3C Recommendation 27 October 2009)

W3C OWL 2 RDF, *OWL 2 Web Ontology Language RDF-Based Semantics* (W3C Recommendation 27 October 2009)

W3C SKOS, *SKOS Simple Knowledge Organization System Reference* (W3C Recommendation 18 August 2009)

IETF RFC 5234, *Augmented BNF for Syntax Specifications: ABNF*

IETF RFC 3986, *Uniform Resource Identifier (URI): Generic Syntax*

## 4 Terms, definitions, abbreviations, and namespaces

### 4.1 Terms and definitions

#### 4.1.1

##### **aggregation**

<UML> special form of *association* (4.1.6) that specifies a whole-part relationship between the aggregate (whole) and a component part

Note 1 to entry: See *composition* (4.1.12).

[SOURCE: ISO 19103:—1], 4.1]

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#### 4.1.2

##### **annotation**

<OWL> additional information associated to ontologies, entities, and axioms

[SOURCE: OWL]

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#### 4.1.3

##### **annotation property**

<OWL> element used to provide a textual *annotation* (4.1.2) for an *ontology* (4.1.29), axiom, or an IRI

[SOURCE: OWL]

#### 4.1.4

##### **application ontology**

*ontology* (4.1.29) representing the concepts and relationships in an *application schema* (4.1.5)

#### 4.1.5

##### **application schema**

*conceptual schema* (4.1.14) for *data* (4.1.16) required by one or more applications

[SOURCE: ISO 19101-1:2014, 4.1.2]

#### 4.1.6

##### **association**

<UML> semantic relationship that can occur between typed instances

Note 1 to entry: A binary association is an association among exactly two classifiers (including the possibility of an association from a classifier to itself).

[SOURCE: OMG UML, Superstructure, version 2.4.1, 7.3.3]



**4.1.7****attribute**

<UML> feature within a classifier that describes a range of values that instances of the classifier may hold

[SOURCE: ISO 19103:—1), 4.5]

**4.1.8****cardinality**

<UML> number of elements in a set

Note 1 to entry: Contrast with *multiplicity* ([4.1.24](#)), which is the range of possible cardinalities a set may hold.

[SOURCE: ISO 19103:—1), 4.6]

**4.1.9****class**

<OWL> set of *individuals* ([4.1.20](#))

[SOURCE: OWL]

**4.1.10****class**

<UML> description of a set of objects that share the same *attributes* ([4.1.7](#)), *operations* ([4.1.30](#)), methods, relationships, and semantics

[SOURCE: ISO 19103:—1), 4.7]

**4.1.11****codelist**

value domain including a code for each permissible value

[SOURCE: ISO 19136:2007, 4.1.7]

**4.1.12****composition**

<UML> *aggregation* ([4.1.1](#)) where the composite object (whole) has responsibility for the existence and storage of the composed objects (parts)

[SOURCE: ISO 19103:—1), 4.10]

**4.1.13****conceptual model**

model that defines concepts of a *universe of discourse* ([4.1.36](#))

[SOURCE: ISO 19101-1:2014, 4.1.5]

**4.1.14****conceptual schema**

formal description of a *conceptual model* ([4.1.13](#))

[SOURCE: ISO 19101-1:2014, 4.1.6]

**4.1.15****constraint**

<UML> condition or restriction expressed in natural language text or in a machine readable language for the purpose of declaring some of the semantics of an element

[SOURCE: ISO 19103:—1), 4.13]

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#### 4.1.16

##### **data**

reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing

[SOURCE: ISO/IEC 2382:2015, 2121272]

#### 4.1.17

##### **data property**

<OWL> semantic *association* (4.1.6) between an *individual* (4.1.20) and a typed *literal* (4.1.21)

Note 1 to entry: Data properties were sometimes referred to as ‘concrete properties’ in Description Logic.

[SOURCE: OWL]

#### 4.1.18

##### **datatype**

<OWL> entities that refer to a set of concrete *data* (4.1.16) values

EXAMPLE      xsd:string, xsd:integer, xsd:decimal

Note 1 to entry: Datatypes are distinct from *classes* (4.1.9) of *individuals* (4.1.20), the latter are denoted by URIs and may be used by reference.

[SOURCE: OWL]

#### 4.1.19

##### **generalization**

<UML> taxonomic relationship between a more general element and a more specific element of the same element type

Note 1 to entry: An instance of the more specific element can be used where the more general element is allowed.

[SOURCE: ISO 19103:—1], 4.18]

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#### 4.1.20

##### **individual**

instance of a *class* (4.1.9)

Note 1 to entry: It refers to a resource belonging to the extension of the class.

[SOURCE: Adapted from the OWL Web Ontology Language Guide]

#### 4.1.21

##### **literal value**

##### **literal**

constant, explicitly specified value

EXAMPLE      "1"^^xsd:integer, "abc"^^xsd:string

Note 1 to entry: This contrasts with a value that is determined by resolving a chain of substitution (e.g. a variable).

[SOURCE: ISO 19143:2010, 4.15]

#### 4.1.22

##### **localName**

reference to a local object directly accessible from a *namespace* (4.1.25)

[SOURCE: ISO 19103:—1], modified – Derived from 7.5.5.1]

**4.1.23****metadata**

information about a resource

[SOURCE: ISO 19115-1:2014, 4.10]

**4.1.24****multiplicity**

<UML> specification of the range of allowable cardinalities that a set may assume

[SOURCE: ISO 19103:—1), 4.24]

**4.1.25****namespace**

<general> domain in which names, expressed by character strings, can be mapped to objects

Note 1 to entry: The names can be subject to local *constraints* (4.1.15) enforced by the namespace.

[SOURCE: ISO 19103:—1), modified – Derived from 7.5.2.1]

**4.1.26****namespace**

<RDF> common URI prefix or stem used in identifiers for a set of related resources

Note 1 to entry: The RDF namespace is concatenated with the *localName* (4.1.22) to create the complete URI identifier for an RDF resource. Every RDF resource is identified by a URI. In contrast, an XML namespace URI scopes a local XML component name, but there is no rule for combining these into a single identifier string.

**4.1.27****namespace**

<XML> collection of names, identified by a URI reference, that are used in XML documents as element names and *attribute* (4.1.7) names

[SOURCE: ISO/TS 19139:2007, 4.1] <https://standards.iteh.ai/catalog/standards/sist/544f434-a3f3-40fe-a540-4a84da8b5cda/iso-19150-2-2015>

**4.1.28****object property**

<OWL> semantic *association* (4.1.6) between a pair of *individuals* (4.1.20)

Note 1 to entry: Object properties have sometimes been referred to as ‘abstract properties’ in Description Logic.

[SOURCE: OWL]

**4.1.29****ontology**

formal representation of phenomena of a *universe of discourse* (4.1.36) with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships

[SOURCE: ISO 19101-1:2014, 4.1.26]

**4.1.30****operation**

<UML> behavioural <UML> feature of a classifier that specifies the name, type, parameters, and *constraints* (4.1.15) for invoking an associated behaviour

[SOURCE: ISO 19103:—1), 4.26]

**4.1.31****package**

<UML> general purpose mechanism for organizing elements into groups

Note 1 to entry: A package provides a *namespace* (4.1.27) for the grouped elements.

[SOURCE: ISO 19103:—1), 4.27]

#### 4.1.32

##### **property restriction**

<OWL> special kind of *class* (4.1.9) description through the definition of *constraints* (4.1.15) on values and cardinalities

[SOURCE: OWL]

#### 4.1.33

##### **qualified cardinality**

<OWL> *cardinality* (4.1.8) restriction that applies to *literals* (4.1.21) or *individuals* (4.1.20) that are connected by a *data property* (4.1.17) or an *object property* (4.1.28) and are instance of the qualifying range [*datatype* (4.1.18) or *class* (4.1.9)]

[SOURCE: OWL]

#### 4.1.34

##### **source document**

document that contains the original definition of a resource

#### 4.1.35

##### **stereotype**

<UML> extension of an existing metaclass that enables the use of platform or domain specific terminology or notation in place of, or in addition to, the ones used for the extended metaclass

[SOURCE: ISO 19103:—1), 4.33]

#### 4.1.36

##### **universe of discourse**

view of the real or hypothetical world that includes everything of interest

[SOURCE: ISO 19101-1:2014, 4.1.38]  
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#### 4.1.37

##### **unqualified cardinality**

<OWL> *cardinality* (4.1.7) restriction that applies to all *literals* (4.1.21) or *individuals* (4.1.20) that are connected by a *data property* (4.1.17) or an *object property* (4.1.28)

[SOURCE: OWL]

## 4.2 Abbreviations

|      |  |
|------|--|
| DL   | Description Logic                        |
| IRI  | Internationalized Resource Identifier    |
| MOF  | MetaObject Facility                      |
| OMG  | Object Management Group                  |
| OWL  | Web Ontology Language (version 2)        |
| RDF  | Resource Description Framework           |
| RDFS | RDF Schema                               |
| SKOS | Simplified Knowledge Organization System |
| UML  | Unified Modeling Language                |

|     |                               |
|-----|-------------------------------|
| URI | Universal Resource Identifier |
| XML | eXtensible Markup Language    |
| XSD | XML Schema Definition         |

### 4.3 Namespaces

|                 |   |
|-----------------|---|
| dc              | Dublin Core <a href="http://purl.org/dc/elements/1.1/">http://purl.org/dc/elements/1.1/</a> <sup>[5]</sup>  |
| dct             | Dublin Core <a href="http://purl.org/dc/terms/">http://purl.org/dc/terms/</a>   |
| owl             | Web Ontology Language <a href="http://www.w3.org/2002/07/owl#">http://www.w3.org/2002/07/owl#</a>   |
| rdf             | Resource Description Framework <a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#">http://www.w3.org/1999/02/22-rdf-syntax-ns#</a>  |
| rdfs            | RDF Schema <a href="http://www.w3.org/2000/01/rdf-schema#">http://www.w3.org/2000/01/rdf-schema#</a>  |
| skos            | Simple Knowledge Organization System <a href="http://www.w3.org/2004/02/skos/core#">http://www.w3.org/2004/02/skos/core#</a>  |
| 19150-2owl      | Requirements class for conversion of a UML package from the ISO/TC 211 Harmonized Model to OWL <a href="http://standards.iso.org/iso/19150-2/req/owl">http://standards.iso.org/iso/19150-2/req/owl</a>    |
| 19150-2owl-conf | Conformance class for conversion of a UML package from the ISO/TC 211 Harmonized Model to OWL <a href="http://standards.iso.org/iso/19150-2/conf/owl">http://standards.iso.org/iso/19150-2/conf/owl</a>   |
| 19150-2app      | Requirements class for formalization of an application schema in OWL <a href="http://standards.iso.org/iso/19150-2/req/applicationSchema">http://standards.iso.org/iso/19150-2/req/applicationSchema</a>  |
| 19150-2app-conf | Conformance class for formalization of an application schema in OWL <a href="http://standards.iso.org/iso/19150-2/conf/applicationSchema">http://standards.iso.org/iso/19150-2/conf/applicationSchema</a> |
| iso19150-2      | Base ontology elements required for formalization of UML models and application schemas in OWL <a href="http://def.isotc211.org/iso19150-2/2012/base#">http://def.isotc211.org/iso19150-2/2012/base#</a>  |
| exPk            | Generic prefix for examples for UML and conceptual schema language rules <a href="http://def.isotc211.org/example/aPackage#">http://def.isotc211.org/example/aPackage#</a>                                |
| exPkCode        | Generic prefix for examples of code-lists for UML and conceptual schema language rules <a href="http://def.isotc211.org/example/aPackage/code/">http://def.isotc211.org/example/aPackage/code/</a>        |
| myapp           | Dummy prefix for examples, representing an application schema namespace   |
| xsd             | XML Schema Definition <a href="http://www.w3.org/2001/XMLSchema#">http://www.w3.org/2001/XMLSchema#</a>   |
| gfm             | ontology describing the General Feature Model (ISO 19109:— <sup>2)</sup> )  |

## 5 Namespace

A namespace is a collection of names identified by a URI reference.<sup>[13]</sup> The definition of namespaces shall follow the rules for URI definition as documented in [Annex B](#). In RDF applications (including OWL) every resource, including definitions and datatypes as well as individuals, is identified by an IRI.

**NOTE** The prefix that references a namespace within an ontology in OWL is identified in the namespace declaration as part of the ontology header element (see [6.3](#)).

## 6 Rules for mapping ISO geographic information UML models to OWL ontologies

### 6.1 General

As introduced in ISO/TS 19150-1:2012, Clause 6 defines the conversion of UML static view modeling elements that are used in the ISO geographic information standards into OWL. These elements are name, package, class, stereotype, enumeration, code list, attribute, multiplicity, generalization/inheritance, association, aggregation, composition, and constraints.

ISO 19103:—<sup>1</sup>) defines the profile of UML used in conceptual modelling in ISO geographic information standards. Among others, three important aspects of the UML profile are:

- a) every navigable association-end must have a role-name (ISO 19103:—<sup>1</sup>), [6.8.2](#));
- b) class stereotypes «CodeList» and «Union» indicate a special behaviour different to normal classes (ISO 19103:—<sup>1</sup>), [6.10](#));
- c) a set of primitive datatypes are provided.

Item a) means that the UML models under consideration map easily to the RDF model where all properties have semantic names. This allows for a more streamlined mapping from UML to OWL than, for example, the generic approach taken by OMG, which supports all the options implied by the MOF and UML meta model.

Item b) means that different UML-OWL transformation rules are required for classes with these stereotypes compared with standard classes. There are also standard stereotypes provided by UML, such as «enumeration».

Item c) requires that mappings from the UML classes representing datatypes to specific constructs using RDF, RDFS, OWL and the XSD datatypes accessible to OWL be defined.

The conversion rules are limited to OWL 2 RL, meaning that OWL RL shall be used for the definitions of the rules (see W3C OWL 2 and W3C OWL 2 RFD).

NOTE OWL2 RL profile corresponds approximately with OWL version 1 DL profile. This profile ensures a level of computability which is generally considered desirable for rigorous ontologies.

[Clause 6](#) uses Augmented Backus Naur Form notation (see IETF RFC 5234), which is summarized in [Annex C](#).

This part of ISO 19150 requires the use of standard HTTP URIs to identify resources in geographic information for the purpose of ontologies. The URI structures are defined in [Annex B](#).

This part of ISO 19150 requires an ontology that defines additional annotation properties, properties and classes to support the representation of ISO geographic information UML models into OWL ontologies. This ontology and its namespace are documented in [Annex D](#).

The requirements for representing a UML package from a standard in the series of ISO geographic information standards in OWL comprise a single requirements class ([Table 1](#)), identified as <http://standards.iso.org/iso/19150-2/req/2owl> and abbreviated as 19150-2owl.

**Table 1 — Requirements class for representing a UML package from a standard in the series of ISO geographic information standards in OWL**

| Requirements class   |  |
|--|--|
| 19150-2package = <a href="http://standards.iso.org/iso/19150-2/req/package">http://standards.iso.org/iso/19150-2/req/package</a> |  |
| Target type  | Ontology   |
| Dependency   | <a href="http://www.w3.org/TR/owl2-syntax/">http://www.w3.org/TR/owl2-syntax/</a> (OWL)  |
| Dependency   | <a href="http://tools.ietf.org/html/rfc3986">http://tools.ietf.org/html/rfc3986</a> (URI Syntax)                                   |
| Dependency   | <a href="http://standards.iso.org/iso/19103/ed-2/en/">http://standards.iso.org/iso/19103/ed-2/en/</a> (Conceptual schema language) |

Table 1 (continued)

| Requirements class   |  |
|--|--|
| 19150-2package = <a href="http://standards.iso.org/iso/19150-2/req/package">http://standards.iso.org/iso/19150-2/req/package</a> |  |
| Requirement  | 19150-2package:name                        |
| Requirement  | 19150-2package:ontologyName                |
| Requirement  | 19150-2package:rdNamespaces                |
| Requirement  | 19150-2package:className                   |
| Requirement  | 19150-2package:datatypeName                |
| Requirement  | 19150-2package:propertyName                |
| Requirement  | 19150-2package:codeName                    |
| Requirement  | 19150-2package:package                     |
| Requirement  | 19150-2package:class                       |
| Requirement  | 19150-2package:abstractClass               |
| Requirement  | 19150-2package:attribute-dataProperty      |
| Requirement  | 19150-2package:attribute-objectProperty    |
| Requirement  | 19150-2package:enumeration                 |
| Requirement  | 19150-2package:odelist                     |
| Requirement  | 19150-2package:odelistextension            |
| Requirement  | 19150-2package:union                       |
| Requirement  | 19150-2package:multiplicity                |
| Requirement  | 19150-2package:relationship-generalization |
| Requirement  | 19150-2package:relationship-association    |
| Requirement  | 19150-2package:relationship-aggregation    |
| Requirement  | 19150-2package:constraint                  |

## 6.2 Name

### 6.2.1 Scoping and namespaces

The first set of requirements deals with the construction of URIs used to identify ontology namespaces, classes, datatypes and properties, and is summarized in [Annex B](#).

UML sets a number of restrictions and conventions on element names. Key restrictions are that (a) each class shall have a unique name within the context of a package, and (b) each attribute and role has a unique name within the context of a class. Hence, a UML package provides the namespace for its classes, and a UML class provides the namespace for its attributes and association roles. Therefore, an attribute name *attributeName* that is used in a *ClassA* can also be used in a *ClassB* both having a specific semantics in the context of each class ([Figure 1](#)). The class is therefore a namespace for its attributes.

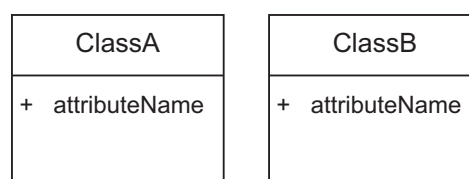


Figure 1 — UML class and attribute names