TECHNICAL REPORT

ISO/IEC TR 20943-6

First edition
2013-11-01

Information technology — Procedures for achieving metadata registry content consistency —

Part 6: Framework for generating ontologies

Technologies de l'information — Procédures pour réaliser la consistance du contenu de l'enregistrement des métadonnées —

Partie 6: Cadre pour générer des ontologies

Reference number
ISO/IEC TR 20943-6:2013(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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

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

In exceptional circumstances, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

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

ISO/IEC TR 20943-6 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

ISO/IEC TR 20943 consists of the following parts, under the general title *Information technology — Procedures for achieving metadata registry content consistency*:

— *Part 1: Data elements*

— *Part 3: Value domains*

— *Part 5: Metadata mapping procedure*

— *Part 6: Framework for generating ontologies*

Introduction

An ontology is developed for the representation of knowledge and information. By definition, it is an explicit specification of a shared conceptualization for a domain, and describes relations between pairs of vocabulary concepts that can be used to support reasoning about the entities that the concepts describe. W3C developed Resource Description Framework (RDF)[6] and Web Ontology Language (OWL)[7] to identify the web resources and to represent the semantics and relations. ISO/IEC 13250[2] also is a standard for the representation and interchange of knowledge.

ISO/IEC 11179, Metadata registries (MDR) addresses the semantics of data, the representation of data, and the registration of the descriptions of that data. The ISO/IEC 11179 series provides a good introduction to metadata concepts, including a lot of insight into certain aspects of the granularity of metadata. The ISO/IEC 11179 series contributes knowledge integrity in a large scale. In brief, the ISO/IEC 11179 series supports semantic interoperability of data, because it provides a set of shared vocabulary for an application domain.

The ISO/IEC 11179 series provides a way to explicitly record shared vocabulary (metadata, semantics, or concepts) for use in describing the semantics for data within a domain. Domain specific ontologies could be generated by reusing the metadata in the registry. It allows an ontology consisting of common concepts to be built and facilitates usage of the ISO/IEC 11179 series.

The goal of this part of ISO/IEC TR 20943 is to provide a framework for generating ontologies based on the ISO/IEC 11179 series. The objectives of this part of ISO/IEC TR 20943 are to promote the following:

a) the generation of ontologies consisting of well-defined concepts (i.e. well-known concepts, generalized common concepts, and sharable concepts, which are accepted by general users as well as domain experts);

b) support of easy and clear understanding of concepts across the same or similar application domains;

c) formalized ontology generation;

d) support of easy definition (building or generation) of ontology through reuse of metadata in a registry;

e) the enhancement of interoperability between ontologies;

f) the facilitation of use of ISO/IEC 11179 series.

Information technology — Procedures for achieving metadata registry content consistency —

Part 6: Framework for generating ontologies

1 Scope

This part of ISO/IEC TR 20943 covers the framework for generating ontologies based on ISO/IEC 11179-3, and provides the procedure and mapping model for generating ontologies.

This part of ISO/IEC TR 20943 describes a method to generate ontologies for a context using concepts in ISO/IEC 11179-3. Most ontologies are basically composed of classes (concepts), properties, relations between classes, and instances (objects or individuals). This part considers the generation of ontology consisting of a subset of ontology components required for defining ontologies at the conceptual level which is called "FGO_Ontology". This part uses the prefix "FGO_" to avoid confusion from homonym and to clearly identify each term. For example, "Property" is specified in ISO/IEC 11179-3 as well as in this part, but the meaning is slightly different. This part defines FGO_Class, FGO_Property, and FGO_Relation to distinguish between components of FGO_Ontology and components of ISO/IEC 11179-3.

This part of ISO/IEC TR 20943 specifies the method to generate ontologies using registered concepts in ISO/IEC 11179-3 Concepts metamodel region and Data description metamodel region. This part of ISO/IEC TR 20943 specifies a procedure and method for generating ontologies due to an application domain reusing concepts registered in a metadata registry.

This part of ISO/IEC TR 20943 does not include a way to describe in a specific ontology description language, such as Resource Description Framework (RDF), RDF Schema (RDFS), Web Ontology Language (OWL), Topic Map, and Knowledge Interchange Format (KIF).

2 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/IEC 11179-3:2013, *Information technology — Metadata registries (MDR) — Part 3: Registry metamodel and basic attributes*

3 Terms and definitions

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

3.1 Terms defined in ISO/IEC 11179-3

3.1.1
class
description of a set of objects that share the same attributes, operations, methods, relationships, and semantics

Note 1 to entry: This definition is from ISO/IEC 19505-2:2012, 7.3.7.

3.1.2
concept
unit of knowledge created by a unique combination of characteristics

[SOURCE: ISO/IEC 11179-3:2013, 3.2.18]

3.1.3
concept system
set of *concepts* (3.1.2) structured according to the *relations* (3.1.15) among them

[SOURCE: ISO/IEC 11179-3:2013, 3.2.19]

3.1.4
conceptual domain
CD
concept (3.1.2) that expresses its description or valid instance meanings

[SOURCE: ISO/IEC 11179-3:2013, 3.2.21]

3.1.5
data element concept
concept (3.1.2) that is an association of a *property* (3.1.14) with an *object class* (3.1.12)

[SOURCE: ISO/IEC 11179-3:2013, 3.2.29]

3.1.6
datatype
set of distinct values, characterized by properties of those values and by operations on those values

[SOURCE: ISO/IEC 11404:2007, 3.12]

3.1.7
definition
representation of a *concept* (3.1.2) by a descriptive statement which serves to differentiate it from related concepts

[SOURCE: ISO 1087-1:2000, 3.3.1]

3.1.8
designation
representation of a *concept* (3.1.2) by a sign which denotes it

[SOURCE: ISO 1087-1:2000, 3.4.1]

3.1.9
link
member of a *relation* (3.1.15)

[SOURCE: ISO/IEC 11179-3:2013, 3.2.69]

3.1.10
metadata
data that defines and describes other data

[SOURCE: ISO/IEC 11179-3:2013, 3.2.74]

3.1.11
metadata registry
MDR
information system for registering *metadata* (3.1.10)

[SOURCE: ISO/IEC 11179-3:2013, 3.2.78]

3.1.12
object class
set of ideas, abstractions, or things in the real world that are identified with explicit boundaries and meaning and whose properties and behaviour follow the same rules

[SOURCE: ISO/IEC 11179-3:2013, 3.2.88]

3.1.13
package
grouping of *metadata* (3.1.10) objects that provides a namespace for the grouped objects, and allows them to be referenced as a group

[SOURCE: ISO/IEC 11179-3:2013, 3.1.13]

3.1.14
property
quality common to all members of an *object class* (3.1.12)

[SOURCE: ISO/IEC 11179-3:2013, 3.2.100]

3.1.15
relation
sense in which *concepts* (3.1.2) may be connected via constituent roles

[SOURCE: ISO/IEC 11179-3:2013, 3.2.117]

3.1.16
relation role
role that a *concept* (3.1.2) plays in a *relation* (3.1.15)

[SOURCE: ISO/IEC 11179-3:2013, 3.2.118]

3.2 Terms defined in ISO/IEC 19763-3

3.2.1
ontology
specification of concrete or abstract things, and the relationships among them, in a prescribed domain of knowledge

[SOURCE: ISO/IEC 19763-3:2010, 3.1.1.1]

Note 1 to entry: An **ontology** is formal and explicit specification of a shared conceptualisation. (See Bibliography [4])

3.3 Terms defined in this part of ISO/IEC TR 20943

3.3.1
FGO_Class
class that refers to a general concept or a set of individual concepts

Note 1 to entry: An FGO_Class is the same with the definition of class in RDF Schema.

3.3.2
FGO_Namespace
simple method for qualifying *concepts* (3.1.2)

3.3.3
FGO_Ontology
ontology (3.2.1) that consists of a set of components at the conceptual level

Note 1 to entry: In this part of ISO/IEC TR 20943, the components include **FGO_Namespaces**, **FGO_Classes**, **FGO_Properties**, and **FGO_Relations**.(see Bibliography [5])

3.3.4
FGO_Property
quality common to all members of an *FGO_Class* (3.3.1)

Note 1 to entry: An *FGO_Property* (3.3.4) is the same meaning with the definition of a *property* (3.1.14).

3.3.5
FGO_Relation
relationship between *FGO_Classes* (3.3.1)

3.3.6
mapping model
model for mapping between classes of ISO/IEC 11179-3 and components of an *FGO_Ontology* (3.3.3)

4 Abbreviated terms

FGO	Framework for Generating Ontologies
KIF	Knowledge Interchange Format
OWL	Web Ontology Language
RDF	Resource Description Framework
RDFS	RDF Schema

5 Overview

5.1 General

This part of ISO/IEC TR 20943 prescribes a framework based on ISO/IEC 11179-3. This part of ISO/IEC TR 20943 includes the procedure and mapping model for generating ontologies, as described below:

— The mapping model defines mapping relationships between the classes of metamodels specified in ISO/IEC 11179-3 and the components of an FGO_Ontology. This mapping model is used to generate ontologies according to the procedure (see 5.3).

— The procedure involves the processes for generating ontologies using the classes in a metadata registry. The procedure is composed of four processes (see 5.4).

5.2 Framework

Figure 1 shows the framework for generating ontologies. Registries built according to ISO/IEC 11179-3 manage various types of metadata including concepts. ISO/IEC TR 20943-6 refers to common concepts in the registries for generating ontologies. The common concepts are reused to generate ontologies through the mapping model and the procedure described in this part of ISO/IEC TR 20943.

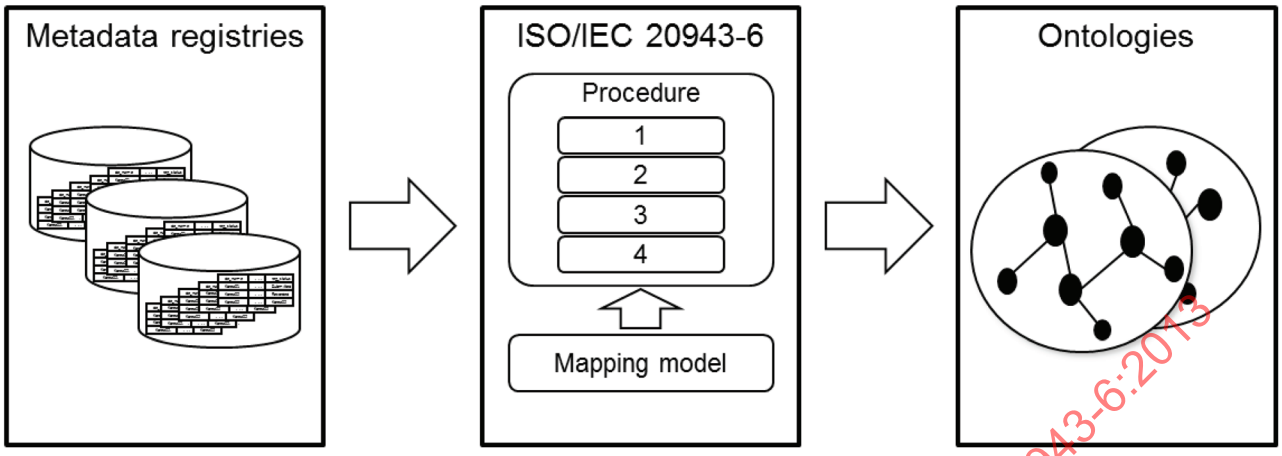

Figure 1 — Framework for generating ontologies

5.3 Mapping model

5.3.1 General

In order to generate ontologies with common concepts in a registry, a mapping model should be defined. The mapping model has a role of mapping between classes of the metamodel specified in ISO/IEC 11179-3 and the components of an FGO_Ontology. Especially, the classes of metamodel specified in ISO/IEC 11179-3 are included in Concepts package and Data description package. The mapping model is used as a set of constraints for generating ontologies. In other words, the mapping model determines valid candidates from a registry. The mapping model is based on classes in the Concepts package (see 5.3.2) and classes in the Data description package (see 5.3.3). The classes in the Concepts package are mapped to an FGO_Namespace, an FGO_Class, an FGO_Relation or an FGO_Property. The classes in the Data description package are mapped to an FGO_Class or an FGO_Property. Therefore, two mapping models are complementarily used in progress of the procedure.

5.3.2 Mapping between Concepts package and FGO_Ontology

Figure 2 shows a mapping model between the classes in Concepts package and the components of an FGO_Ontology.

There are three classes used to define the mapping model in Concepts package. A Concept System, a Concept, and a Relation Role in the Concepts package are mapped to the components of an FGO_Ontology as follows:

— Concept System: mapped to an FGO_Namespace such as the context of the ontology;

— Concept: mapped to an FGO_Class because a Concept is end of link. A Relation and a Relation Role are specializations of a Concept in the Concepts metamodel region, but this mapping model does not consider this;

— Relation Role: mapped to either an FGO_Relation or an FGO_Property. In case the range of a Relation Role is a Concept which is mapped to an FGO_Class and the Relation Role is mapped to an FGO_Relation. In case the range of the Relation Role is a datatype and the Relation Role is mapped to an FGO_Property. For example, the range of a Relation Role ":is-a" in Table A.5 is ":Person" which is mapped to an FGO_Class, and thus ":is-a" becomes an FGO_Relation. The mapping result is defined in Table A.8. The range of a Relation Role ":address" is a datatype "xsd:string", and thus ":address" becomes an FGO_Property.

Even though the Relation_Role is one of the subclasses of the Concept, it cannot be mapped the FGO_Class because the functional role of the Relation_Role is the same with relationships between ontology classes.

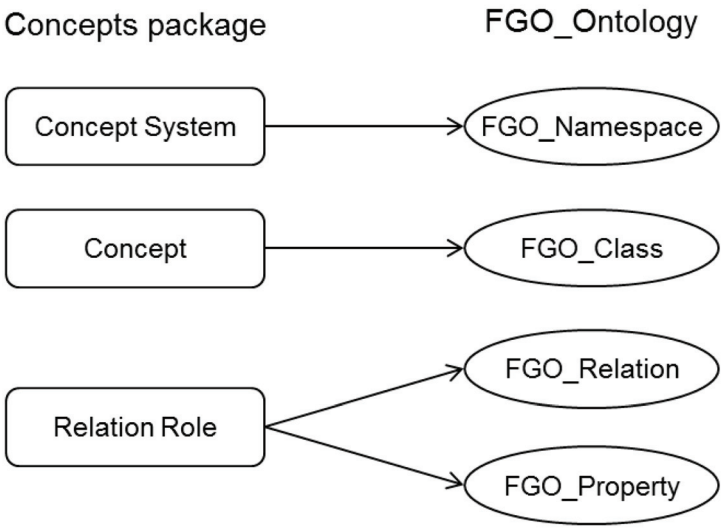

Figure 2 — Mapping model for Concepts package

5.3.3 Mapping between Data description package and FGO_Ontology

Figure 3 shows a mapping model between the classes in Data description package and the components of an FGO_Ontology. Four classes in the Data description package are associated to mapping model for generating ontologies. A Conceptual Domain, a Data Element Concept, an Object Class, and a Property in the Data description package are mapped to the components of an FGO_Ontology as follows:

— Conceptual Domain: mapping to an FGO_Class because a Conceptual Domain has value meanings as an instance;

— Object Class: mapping to an FGO_Class;

— Property: mapping to an FGO_Property;

— Data Element Concept: mapping to both of an FGO_Class and an FGO_Property. A Data Element Concept contains an Object Class and a Property in the Data description package. The contained Object Class and Property by a Data Element Concept are mapping to an FGO_Class and an FGO_Property respectively.

Even though the Property is a subclass of the Concept, the Property cannot be mapped to the FGO_Class because the Property has the same functional role with attributes for describing objects.

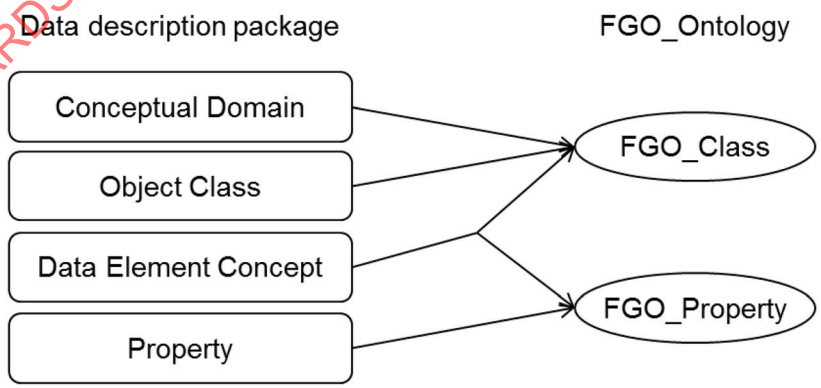

Figure 3 — Mapping model for Data description package

5.4 Procedure

5.4.1 General

Figure 4 shows the procedure for generating ontologies and the procedure consists of four processes as follows:

— Process-1 (Defining namespaces): Defining FGO_Namespaces by reusing Concept Systems in an MDR implementation;

— Process-2 (Defining classes): Defining FGO_Classes by reusing Object Classes and Conceptual Domains in an MDR implementation;

— Process-3 (Defining relations): Defining FGO_Relations for linking between FGO_Classes by reusing Relation Roles in an MDR implementation;

— Process-4 (Defining properties): Defining FGO_Properties for describing FGO_Classes by reusing Relation Roles and Data Elements in an MDR implementation.

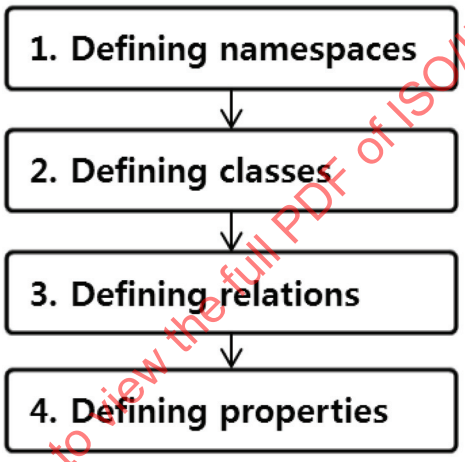

Figure 4 — Procedure for generating ontologies

5.4.2 Defining namespaces

This process defines FGO_Namespaces by selecting Concept Systems. An FGO_Namespace denotes a context or a namespace of an ontology to be generated. In the mapping model in Figure 3, a Concept System is mapped to an FGO_Namespace. Therefore, all Concept Systems in an MDR implementation are retrieved and displayed to a user. Then the user chooses a proper Concept System as a FGO Namespace.

For example, if a Concept system is “University” in an MDR implementation, then the FGO_Namespace is “University”. An appropriate Concept system is not available and a user can defines a new FGO_ Namespace. This process for defining FGO_Namespaces should be preceded by the other processes.

5.4.3 Defining classes

This process defines FGO_Classes. With the mapping model, the concepts in the Concepts package or the Data description package in ISO/IEC 11179-3 become FGO_Classes. The packages include various kinds of concepts, but only the Object Class and the Conceptual Domain are mapped to the FGO_Class. Therefore, this process retrieves all Object Classes and Conceptual Domains from an MDR implementation, and then a set of them is chosen as the FGO_Classes.

For example, in Table A.2, three Object Classes and one Conceptual Domain are retrieved and the set of candidates is {”:Person”, “:Professor”, “:Student”, “Country”}. A set of candidates can be chosen as the FGO_

Classes. If a proper FGO_Class is not available in the candidate set, then a new FGO_Class can be defined by users. This process should be preceded by the remaining process except the process "Defining namespaces".

5.4.4 Defining relations

This process defines FGO_Relations between two FGO_Classes. An FGO_Relation is defined by referring Links in the Concepts package in ISO/IEC 11179-3. This process consists of three subprocesses:

(1) Select a Relation Role in the Concepts package to define an FGO_Relation;

(2) Set a domain of the FGO_Relation from the defined FGO_Classes;

(3) Set a range of the FGO_Relation from the defined FGO_Classes.

For example, a Relation Role ":is-a" is selected as an FGO_Relation and the FGO_Class ":Professor" and the FGO_Class ":Person" are chosen as a domain and a range respectively.

5.4.5 Defining properties

This process defines FGO_Properties of the FGO_Classes. An FGO_Property is defined by referring the Links in the Concepts package, and the process is detailed as follows:

(1) Select a Relation Role in the Concepts package to define an FGO_Property;

(2) Set a domain of the FGO_Property from an FGO_Class;

(3) Set a range of an FGO_Property from datatypes.

For example, A Relation Role ":address" is chosen as an FGO_Property, and then an FGO_Class ":Person" and a datatype "string" as a domain and a range of the Relation Role ":address".

In addition, an FGO_Property is also defined by referring the Data Elements in the Data description package, and the process is composed of the following three subprocesses:

(1) Select a Property in the Data description package to define an FGO_Property;

(2) Set a domain of the FGO_Property from FGO_Class;

(3) Set a range of the FGO_Property from datatypes.

Annex A
(informative)

Mapping examples

Subclause 5.3 and Subclause 5.4 specify the mapping models and the procedure for generating ontologies. The mapping models are complementarily used in progress of the ontology generation procedure.

This Annex describes a mapping example using simple data in an application domain University. The following tables (Table A.1 to Table A.6) represent a University model in terms of the Concepts package and the Data description package of ISO/IEC 11179-3.

Table A.1 — University model – ISO/IEC 11179-3 Concept System

<Concept_System>			
name	notation	referencedConceptSystem	importedConceptSystem
University			

Table A.2 — University model – ISO/IEC 11179-3 Concepts

<Concept>		
name	source	subclass of <Concept>
:Person	University	Object_Class
:Professor	University	Object_Class
:Student	University	Object_Class
:Country	University	Conceptual_Domain
:teach_to	University	Relation_Role
:is-a	University	Relation_Role
:address	University	Relation_Role
:name	University	Property
:age	University	Property

Table A.3 — University model – ISO/IEC 11179-3 Binary Relations

<Binary_Relation>					
name	source	role	reflexivity	symmetry	transitivity
teach	University	:teach_to		asymmetry	intransitive
		:is_taught_by			
nationality	University	:has_nationality		asymmetry	intransitive
		inverse of:has_nationality			
is-a	University	:is-a		asymmetry	intransitive
		subclass			
address	University	:address		asymmetry	intransitive
		Inverse of:address			
relation-domain	University	:domain		asymmetry	intransitive
		domainof			
relation-range	University	:range		asymmetry	intransitive
		rangeof			

Table A.4 — University model – ISO/IEC 11179-3 Relation Roles

<Relation_Role>		
name	multiplicity	ordinal
:teach_to		
:is_taught_by		
:has_nationality		
inverse of:has_nationality		
:is-a	1	
instance		
:address		
Inverse of:address		
:domain		
domainof		
:range		
rangeof		