Reference number of working document: ISO/IEC JTC 1/SC 32 N XXXX

ISO/IEC JTC 1/SC 32 WG2 N 1660

Date: 2012-06-07

Reference number of document: ISO/IEC DTR 20943-6

Committee identification: ISO/IEC JTC 1/SC 32/WG 2

Secretariat: US

Information technology — Procedures for achieving metadata registry content consistency — Part 6: Framework for generating ontologies

Document type: Technical Report
Document subtype:
Document stage: (50) Approval (DTR)
Document language: E

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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.

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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/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 2: XML structured data

Part 3: Value domains

Part 4: Overview

Part 5: Semantic metadata mapping procedure

Part 6: Framework for generating ontologies (this part)

Introduction

An ontology is developed for the representation of knowledge and information. As the definition, An ontology is an explicit specification of conceptualization and shared vocabulary to model a domain. W3C developed Resource Description Framework (RDF) and Web Ontology Language (OWL) to identify the web resources and to represent the semantics and relations. ISO/IEC 13250 Topic Map 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. MDR provides a good introduction to metadata concepts, including a lot of insight into certain aspects of the granularity of metadata. MDR contributes knowledge integrity in a large scale. In brief, MDR supports semantic interoperability of data, because it provides a set of shared vocabulary for an application domain.

MDR provides shared and common vocabulary (metadata, semantics, or concepts) sets and an ontology is a set of semantics for a domain. Ontologies could be generated by reusing metadata in a registry. It allows ontology consisting of common concepts to be built and facilitates usage of MDR.

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

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 MDR.

Information technology — Procedures for achieving metadata registry content consistency —

Part 6:
Framework for generating ontologies

1 Scope

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

This part of ISO/IEC 20943 describes on the method to generate ontologies for an application domain using concepts in MDR. Most ontologies are basically composed of classes (concepts), properties, relations between classes, and instances (objects or individuals). This part considers the generation of generic ontology consisting of concepts, properties, and relations. 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 as well as in this part, but their meaning is slightly different each other. This part defines FGO_Class, FGO_Property, and FGO_Relation to distinguish between components of generic ontology and components of ISO/IEC 11179.

The note after the definition of "ontology" says "This part of ISO/IEC 20943 considers that an ontology consists of three components (class, property, and relation) used for describing most ontologies regardless of ontology description languages", yet it seems to preclude ontologies that are not framed in the class-property-relation paradigm. The limitation should be made clearer, and a rationale should be provided for this limitation.
Provide rationale for using only the class-property-relation model, or provide a more general description.

ISO/IEC 11179-3 specifies the packages such as Basic package, Identification, Designation and Definition package, Registration package, Concepts package, and Data description package. In the Concepts metamodel region, ontologies are registered as a concept system. However, this part of ISO/IEC 20943 specifies the generation method of ontologies using registered metadata in Concepts metamodel region and Data description metamodel region. Besides, ISO/IEC 11179-3 just describes examples of ontology registration. This part of ISO/IEC 20943 specifies a procedure and method for generating ontologies due to an application domain reusing ontologies registered in Metadata Registry.

This part of ISO/IEC 20943 includes the specification for definition of generic ontology which is not a specific ontology description language, such as Resource Description Framework (RDF), RDF Schema (RDFS), Web Ontology Language (OWL), Topic Map, Knowledge Interchange Format (KIF).

2 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/IEC 11179-1:2004, Information technology — Metadata registries (MDR) — Part 1: Framework for the specification and standardization of data elements

ISO/IEC 11179-3:2012, Information technology — Metadata registries (MDR) — Part 3: Registry metamodel and basic attributes

ISO/IEC 19763-3:2010, Information technology — Metamodel Framework for Interoperability (MFI) — Part 3: Metamodel for ontology registration

3 Terms, definitions, and abbreviated terms

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

3.1 Terms defined in ISO/IEC 11179-1

3.1.1
conceptual domain
concept that expresses its description or valid instance meanings.

[ISO/IEC 11179-1:2004, 3.2.4]

3.1.2
data element concept
concept that can be represented in the form of a data element, described independently of any particular representation.

[ISO/IEC 11179-1:2004, 3.3.9]

3.1.3
definition
representation of a concept by a descriptive statement which serves to differentiate it from related concepts.

[ISO/IEC 11179-1:2004, 3.2.8]

3.1.4
designation
representation of a concept by a sign which denotes it.

[ISO/IEC 11179-1:2004, 3.2.9]

3.1.5
metadata
data that defines and describes other data.

[ISO/IEC 11179-1:2004, 3.2.16]

3.1.6
metadata registry
MDR
information system for registering metadata.

[ISO/IEC 11179-1:2004, 3.2.19]

3.1.7
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.

[ISO/IEC 11179-1:2004, 3.3.22]

3.1.8
property
characteristic common to all members of an object class.

[ISO/IEC 11179-1:2004, 3.3.29]

3.2 Terms defined in ISO/IEC 11179-3

3.2.1
class
<metamodel> description of a set of objects that share the same attributes (3.1.4), operations, methods, relationships, and semantics.

[ISO/IEC 11179-3:2012, 3.1.5]

3.2.2
concept
Unit of knowledge created by a unique combination of characteristics.

[ISO/IEC 11179-3:2012, 3.2.18]

3.2.3
concept system
set of concepts structured according to the relations among them.

[ISO/IEC 11179-3:2012, 3.2.19]

3.2.4
link
member of a relation.

[ISO/IEC 11179-3:2012, 3.2.69]

3.2.5
package
grouping of metadata objects that provides a namespace for the grouped objects, and allows them to be referenced as a group

[ISO/IEC 11179-3:2012, 3.1.13]

3.2.6
relation
sense in which concepts may be connected via constituent roles.

[ISO/IEC 11179-3:2012, 3.2.117]

3.2.7
relation role
role that a concept plays in a relation.

[ISO/IEC 11179-3:2012, 3.2.118]

3.3 Terms defined in ISO/IEC 19763-3

3.3.1
ontology
specification of concrete or abstract things, and the relationships among them, in a prescribed domain of knowledge.

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

Editor's NOTE "formal, explicit specification of a shared conceptualisation" in "Gruber, Thomas R. Gruber, *A translation approach to portable ontology specifications*, Knowledge Acquisition, vol. 5, no. 2, pp. 199–220, June 1993."

3.4 Definitions of this part of 20943

3.4.1
datatype
type of values which the property can have.

3.4.2
domain
set of subject of triple ontology for relation or property as a predicate.

3.4.3
FGO_Class
component of generic ontology, and a collection of sets which can be unambiguously defined by a property that all its members share.

3.4.4
FGO_Domain
component of generic ontology, and a mechanism used to isolate ontologies from one another so that they do not affect each other.

3.4.5
FGO_Property
component of generic ontology, and an objects in an ontology can be described by relating them to other things, typically aspects or parts.

3.4.6
FGO_Relation
component of generic ontology, and relationships between objects in an ontology specify how objects are related to other objects.

3.4.7
generic ontology
ontology consisting of basic ontology components required for defining ontologies at the conceptual level.

NOTE This part of ISO/IEC 20943 considers that a generic ontology consists of three main components (class, property, and relation) used for describing most ontologies regardless of ontology description languages.

Editor's NOTE "An ontology renders shared vocabulary and taxonomy which models a domain with the definition of objects and/or concepts and their properties and relations," in "F. Arvidsson and A. Flycht-Eriksson, Ontologies I, Retrieved 26 November 2008.

3.4.8
range
a set of object of triple ontology for relation or property as a predicate.

3.5 Abbreviated terms

3.5.1
KIF
Knowledge Interchange Format

3.5.2
OWL
Web Ontology Language

3.5.3
RDF
Resource Description Framework

3.5.4
RDFS
RDF Schema

4 Overview

4.1 General

This part of ISO/IEC 20943 prescribes a framework based on ISO/IEC 11179-3. This part of ISO/IEC 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 the generic ontology. This mapping model is used to generate ontologies according to the procedure (see Subclause 4.3).

The procedure involves processes for generating the generic ontologies using the classes in a metadata registry. The procedure is composed of four processes (see Subclause 4.4).

4.2 Framework

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

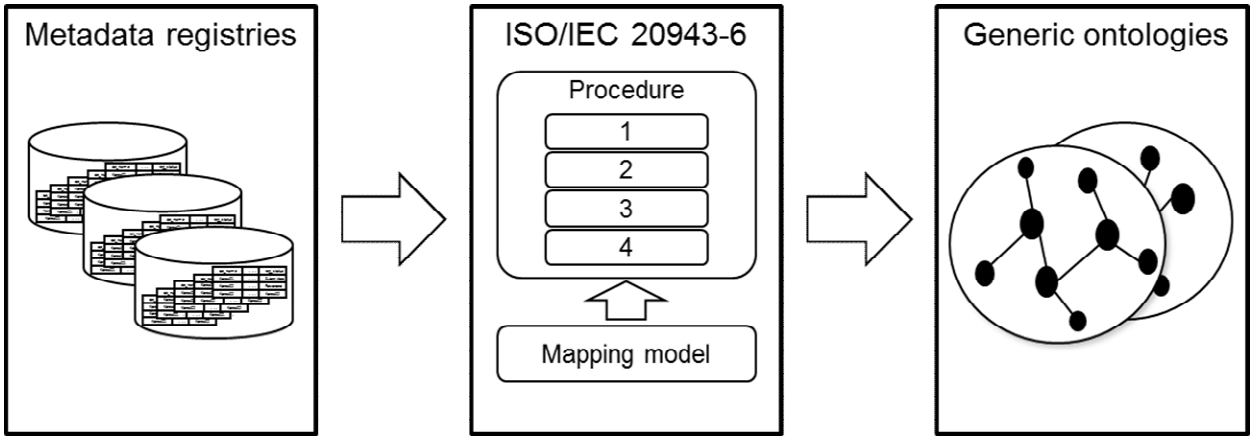

Figure 1 — Framework for generating ontologies

4.3 Mapping model

4.3.1 General

In order to generate the generic ontologies with common concepts in a registry, a mapping model should be defined. The mapping model has a role of mapping between the classes of metamodel specified in ISO/IEC

11179-3 and the components of the generic ontology. The classes of metamodel specified in ISO/IEC 11179-3 are included in Concepts package and Data description package for generating ontologies. The mapping model is used as a set of constraints for generating the generic ontologies. In other words, the mapping model determines valid candidates from a registry. The mapping model is basically based on classes in Concepts package (see Subclause 4.3.2) and classes in Data description package (see Subclause 4.3.3). The classes in Concepts package are mapped to FGO_Domains, FGO_Class, FGO_Relation or FGO_Property. The classes in Data description package are mapped to FGO_Class or FGO_Property. Therefore, two mapping models are complementarily used in progress of the procedure.

4.3.2 Mapping between classes in Concepts package and components of generic ontology

Figure 2 shows a mapping model between classes in Concepts package and components of generic ontology.

There are three classes used to define the mapping model in Concepts package. Concept System, Concept, and Relation Role in Concepts package are mapped to component of the generic ontology as follows:

— Concept System: mapped to FGO_Domain such an application domain of ontology;

— Concept: mapped to FGO_Class because the Concept is end of link. Concept inherits Relation, Relation Role in Concepts metamodel region, but this mapping model does not consider inheritance for Concept with Relation, Relation Role;

— Relation Role: mapped to FGO_Relation or FGO_Property. If a range of Relation is Concept, Relation Role is mapped to FGO_Relation of generic ontology, and Concept becomes FGO_Class as a range of FGO_Relation. If a range of Relation is a datatype, Relation Role is mapped to FGO_Property of generic ontology.

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

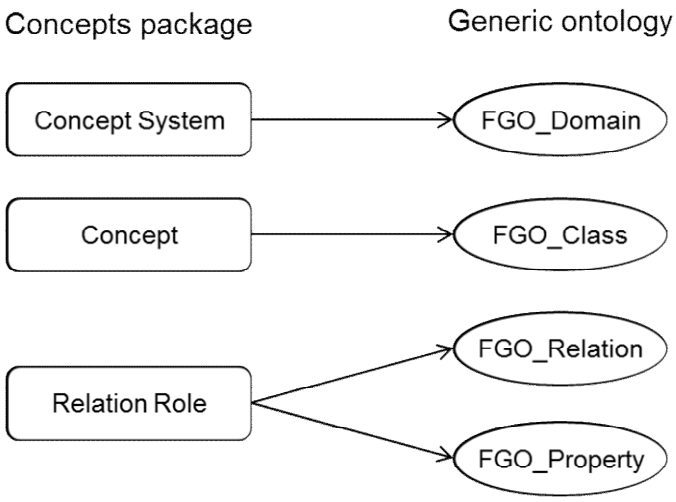

Figure 2 — Mapping model for Concepts package

4.3.3 Mapping between classes in Data description package and components of generic ontology

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

— Conceptual Domain: mapping to FGO_Class of generic ontology because Conceptual Domain has value meanings as an instance;

— Object Class: mapping to FGO_Class of generic ontology;

— Property: mapping to FGO_Property of generic ontology;

— Data Element Concept: mapping to both of FGO_Class and FGO_Property of generic ontology. Data Element Concept contains Object Class and Property in Data description package. The contained Object Class and Property by Data Element Concept are mapping to FGO_Class and FGO_Property of generic ontology respectively;

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

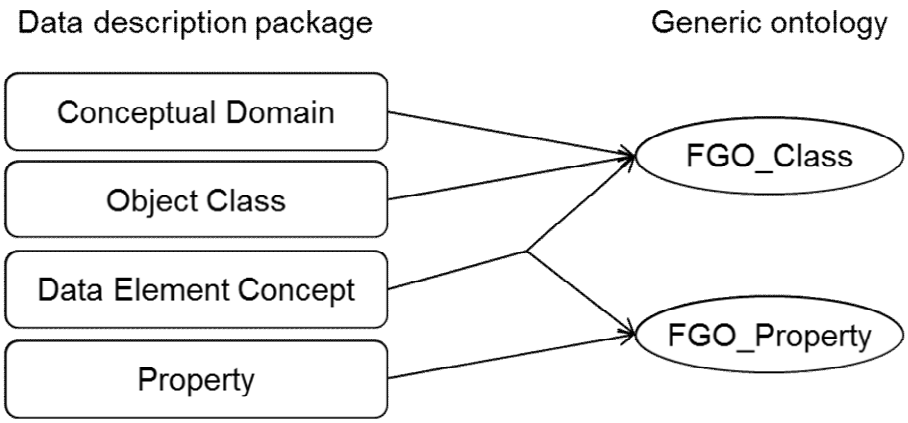

Figure 3 — Mapping model for Data description package

4.4 Procedure

4.4.1 General

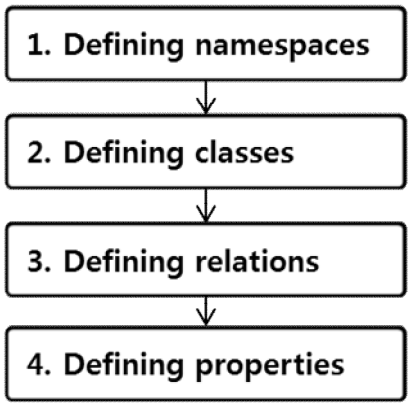

Figure 4 — Procedure for generation ontologies

Figure 4 show the procedure for generating ontologies, which has four processes as follows:

— Process-1: Defining namespaces

— Process-2: Defining classes

— Process-3: Defining relations

— Process-4: Defining properties

4.4.2 Defining namespaces

This process defines FGO_Domains by selecting Concept Systems. FGO_Domain is such an application domain or namespaces of generated ontologies and reduce heterogeneity.

4.4.3 Defining classes

This process defines FGO_Classes of generic ontology. With the mapping model, the classes in Concepts package or Data description package become FGO_Classes of generic ontology.

4.4.4 Defining relations

This process defines FGO_Relations of generic ontology between two FGO_Classes of generic ontology. FGO_Relation is defined by referring Links in Concepts package, and the process is (1) to select a Relation Role in Concepts package to define FGO_Relation of generic ontology, (2) to set a domain of FGO_Relation from defined FGO_Classes, and (3) to set a range of FGO_Relation from defined FGO_Classes.

4.4.5 Defining properties

This process defines FGO_Properties of FGO_Class of generic ontology. FGO_Property is defined by referring Links in Concepts package, and the process is (1) to select a Relation Role in Concepts package to define FGO_Property of generic ontology, (2) to set a domain of FGO_Property from FGO_Class, and (3) to set a range of FGO_Property from datatypes.

In addition, FGO_Property is also defined by referring Data Elements in Data description package, and the process is (1) to select a Property in Data description package to define FGO_Property of generic ontology, (2) to set a domain of FGO_Property from FGO_Class, and (3) to set a range of FGO_Property from datatypes.

Annex A
(Informative)

Mapping examples

Subclause 4.3 and Subclause 4.4 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 a domain University. The following tables (Table 1 to Table 6) represents University model in terms of Concepts package and Data description package of ISO/IEC 11179-3.

Table 1 — University model – ISO/IEC 11179 Concept System

<Concept_System>			
	notation	**referencedConceptSystem**	**importedConceptSystem**
University			

Table 2 — University model – ISO/IEC 11179 Concepts

<Concept> *(excluding Relations and Relation_Roles)*		
	source	**inherited_class**
: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 3 — University model – ISO/IEC 11179 Binary Relations

<Binary_Relation>					
	source	**role**	**reflexivity**	**symmetry**	**transitivity**
teach	University	:teach_to :is_taught_by		asymmetry	intransitive
nationality	University	:has_nationality inverse of :has_nationality		asymmetry	intransitive
is-a	University	:is-a subclass		asymmetry	intransitive

address	University	:address		asymmetry	intransitive
		Inverse of :address			
relation-domain	University	:domain		asymmetry	intransitive
		domainof			
relation-range	University	:range		asymmetry	intransitive
		rangeof			

Table 4 — University model – ISO/IEC 11179 Relation Roles

<Relation_Role>		
	multiplicity	**ordinal**
:teach_to		
:is_taught_by		
:has_nationality		
inverse of :has_nationality		
:is-a	1	
instance		
:address		
Inverse of :address		

Table 5 — University model – ISO/IEC 11179 Links

<Link>			
assertor	**relation**	**link_end**	
		end_role	**end**
University	is-a	instance	:Student
		:is-a	:Person
University	is-a	instance	:Professor
		:is-a	:Person
University	relation-domain	domainof	:has_nationality
		:domain	:Person
University	relatioin-range	rangeof	:has_nationality
		:range	:Country
University	relation-domain	domainof	:address
		:domain	:Person
University	relatioin-range	rangeof	:address
		:range	xsd:string
University	relation-domain	domainof	:teach_to
		:domain	:Professor
University	relatioin-range	rangeof	:teach_to

		:range	:Student

Table 6 — University model – ISO/IEC 11179 Data Elements

<Data Element>		
Data Element Concept		**Value Domain**
Object Class	**Property**	
:Person	:name	String
:Person	:age	Integer

Using the procedure and mapping model above, a generic ontology can be generated as follows:

Table 7 — University ontology – Generic Ontology FGO_Classes

FGO_Domain	FGO_Class
University	:Person
University	:Professor
University	:Student
University	:Country

Table 8 — University ontology – Generic Ontology FGO_Relations

FGO_Domain	FGO_Class (domain)	FGO_Relation	FGO_Class (range)
University	:Professor	:is-a	:Person
University	:Student	:is-a	:Person
University	:Person	:has_nationality	:Country
University	:Professor	:teach_to	:Student

Table 9 — University ontology – Generic Ontology FGO_Properties

FGO_Domain	FGO_Class	FGO_Property	datatype
University	:Person	:address	String
University	:Person	:name	String
University	:Person	:age	Integer

Figure 5 graphically depicts the generated ontology by reusing University model.

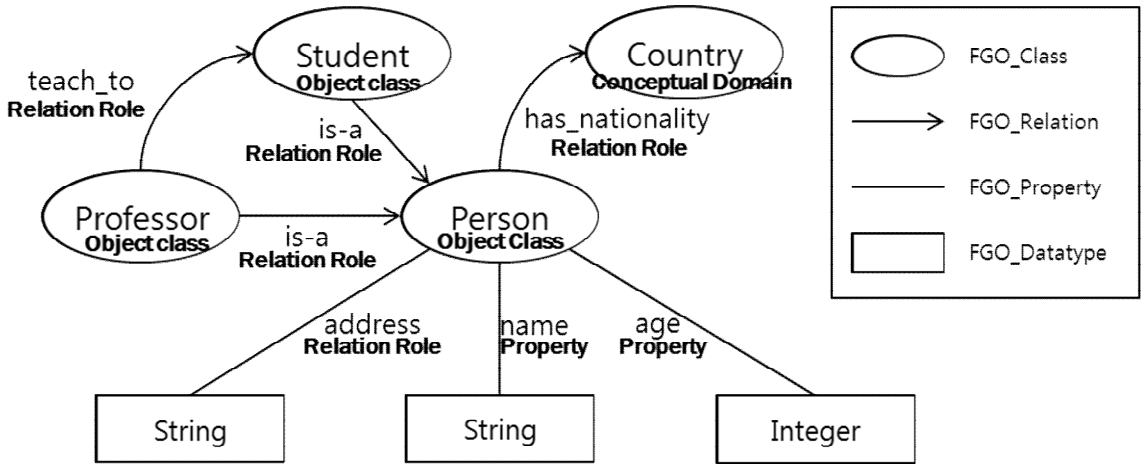

Figure 5 — A graphical representation of the University ontology