Course: Intelligent Systems

Unit 3: Ontology Engineering

Ontologies

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Course 2022 – 2023

Technical University of Madrid

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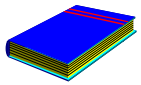
- Ontology Definitions
- Ontology Modelling
- Ontological Commitments
- Ontology Reuse
- Some Relevant Ontologies

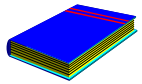
Definitions of Ontologies (I)

1. "An ontology defines the basic terms and relations comprising the vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary"



Neches, R.; Fikes, R.; Finin, T.; Gruber, T.; Patil, R.; Senator, T.; Swartout, W.R. *Enabling Technology for Knowledge Sharing.* AI Magazine. Winter 1991. 36-56.

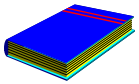
2. "An ontology is an explicit specification of a conceptualization"



Gruber, T. *A translation Approach to portable ontology specifications.* Knowledge Acquisition. Vol. 5. 1993. 199-220.

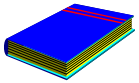
Definitions of Ontologies (II)

3. An ontology is a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base.



B. Swartout; R. Patil; k. Knight; T. Russ. *Toward Distributed Use of Large-Scale Ontologies* Ontological Engineering. AAAI-97 Spring Symposium Series. 1997. 138-148.

4. An ontology provides the means for describing explicitly the conceptualization behind the knowledge represented in a knowledge base.



A. Bernaras;I. Laresgoiti; J. Correra. *Building and Reusing Ontologies for Electrical Network Applications* ECAI96. 12th European conference on Artificial Intelligence. Ed. John Wiley & Sons, Ltd. 298-302.

Definitions of Ontologies (III)

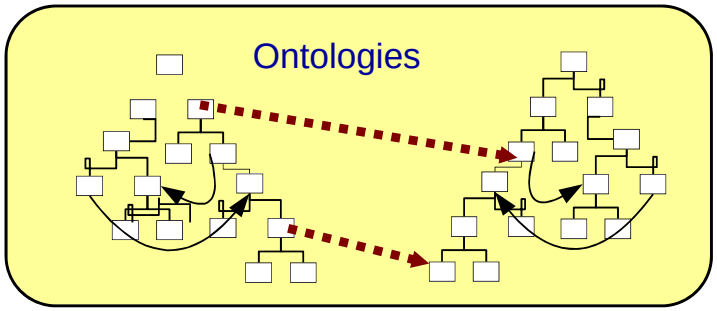
5. "An ontology is a formal, explicit specification of a shared conceptualization"

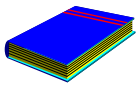
Machine-readable

Concepts, properties relations, functions, constraints, axioms, are explicitly defined

Consensual Knowledge

Abstract model and simplified view of some phenomenon in the world that we want to represent





Studer, Benjamins, Fensel. Knowledge Engineering: Principles and Methods. *Data and Knowledge Engineering*. 25 (1998) 161-197

Definitions of Ontologies (IV)

- Ontologies are **formalized vocabularies of terms**
  - covering a specific domain
  - shared by a community of users
- Ontologies provides a set of explicit assumptions regarding the **intended meaning of the terms**
  - Almost always including concepts and their classifications
  - Almost always including properties between concepts
- Ontologies are expressed in OWL or RDF(S), both based on RDF

Definitions of Ontologies (V)

Lightweight Ontologies:

- Include concepts with properties and taxonomies
- Do not include axioms and constraints

Heavyweight Ontologies:

- Include all the components
- Excellent!! If they have a lot of axioms

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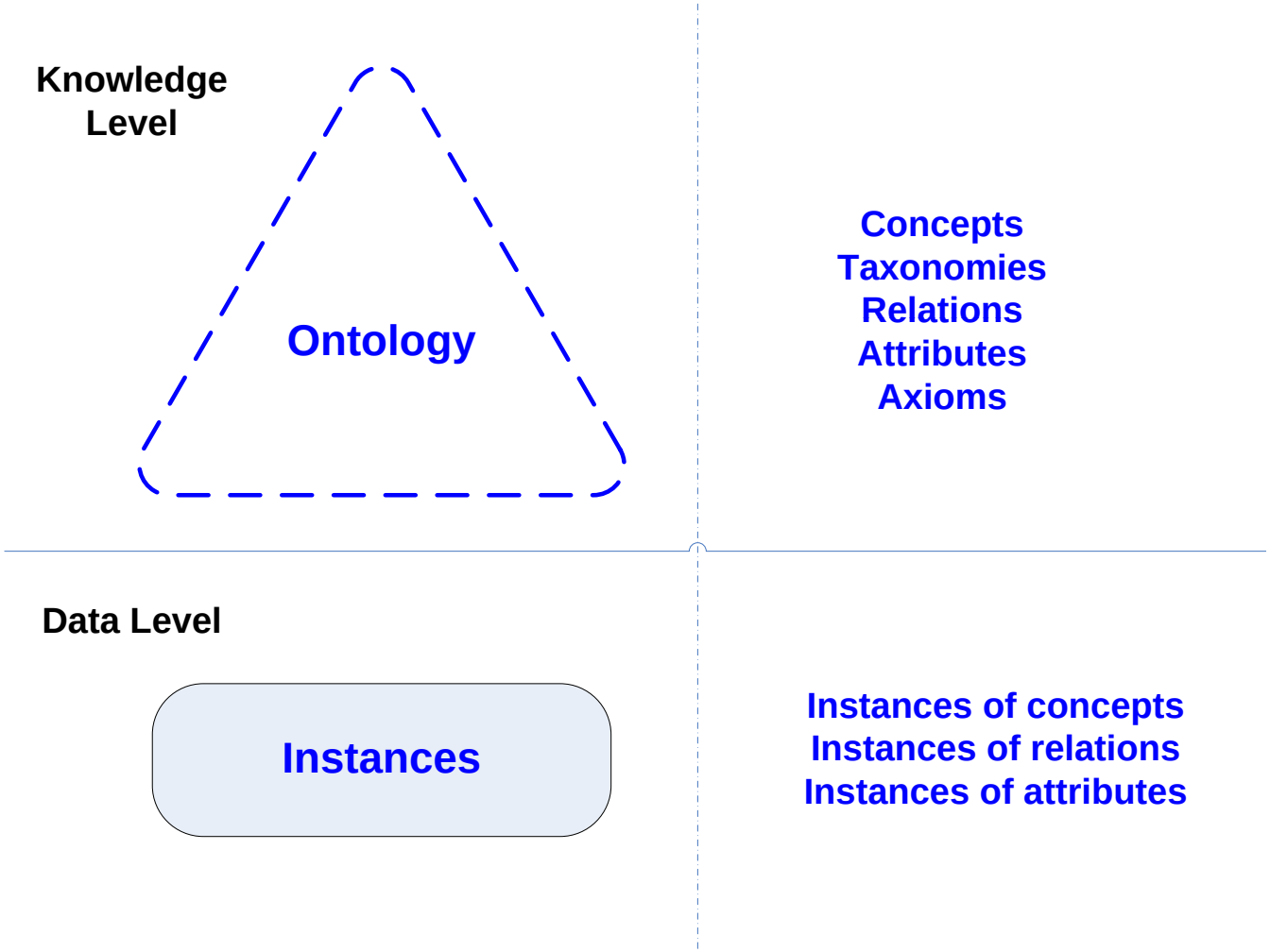
- Ontology Modelling
- Types of Ontologies
- Ontological Commitments
- Ontology Reuse
- Some Relevant Ontologies

Knowledge and Data Level

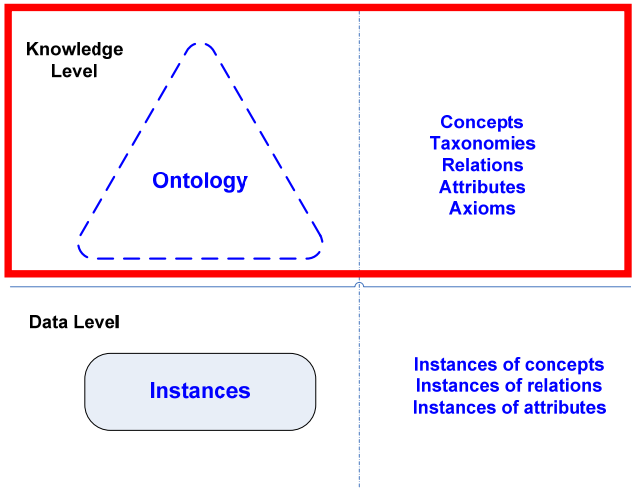


Ontologies: Main Components

- **Concepts** organized in taxonomies
  - Examples:
    - Literary work
    - The epics and essays are literary works
- **Atributes** of concepts
  - Example: A literary work has a name and an ISBN
- **Relationships** between concepts
  - Example: Authors write literary works
- **Axioms**: propositions that are always true

Gruber, T. A translation Approach to portable ontology specifications. Knowledge Acquisition. Vol. 5. 1993. 199-220.

Ontologies: Main Components. Example

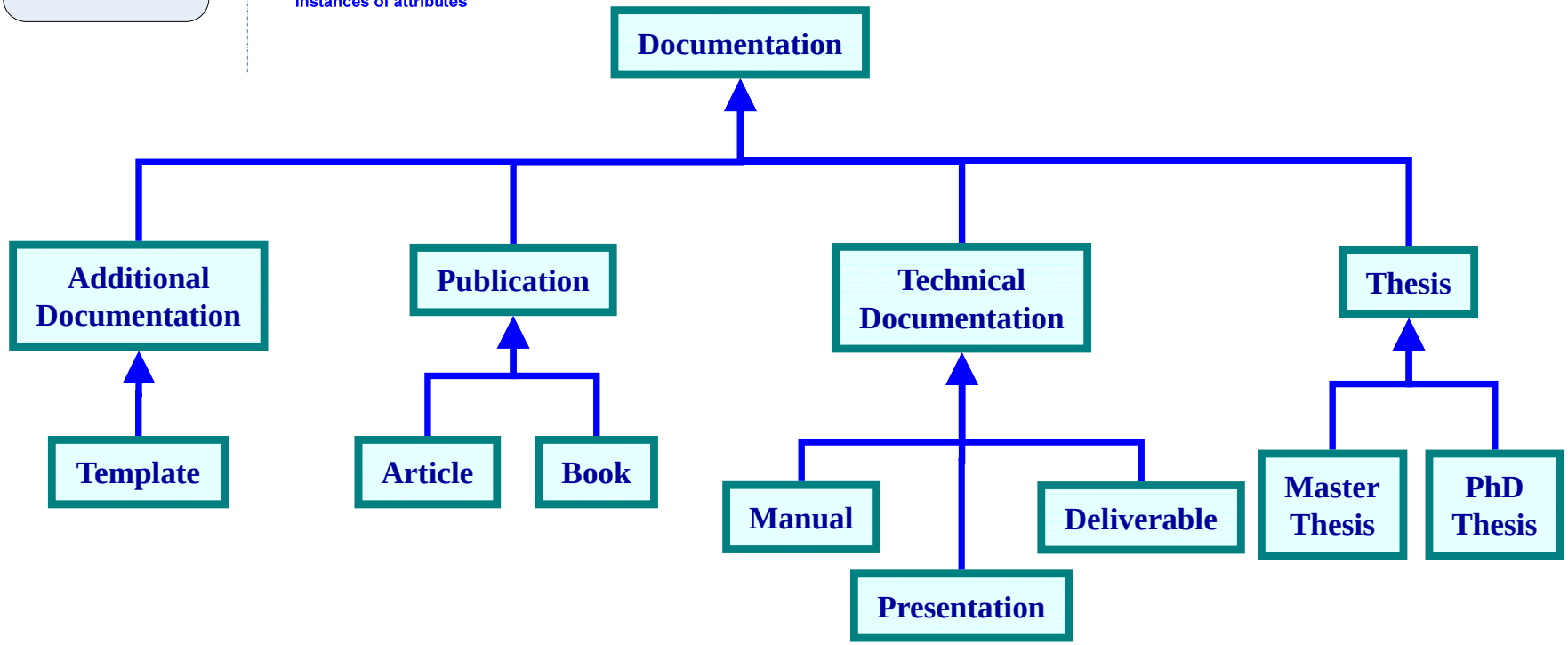


Concepts:

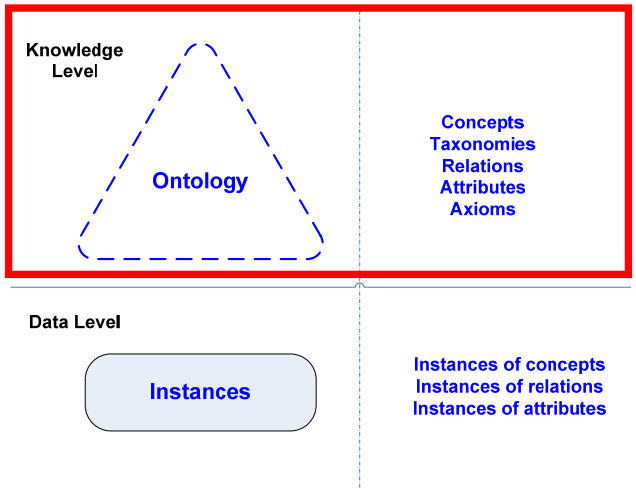
Documentation, Thesis, Book, Template, etc.

Taxonomy:

- Article is subclass of Publication
- Master Thesis is subclass of Thesis



Ontologies: Main Components. Example

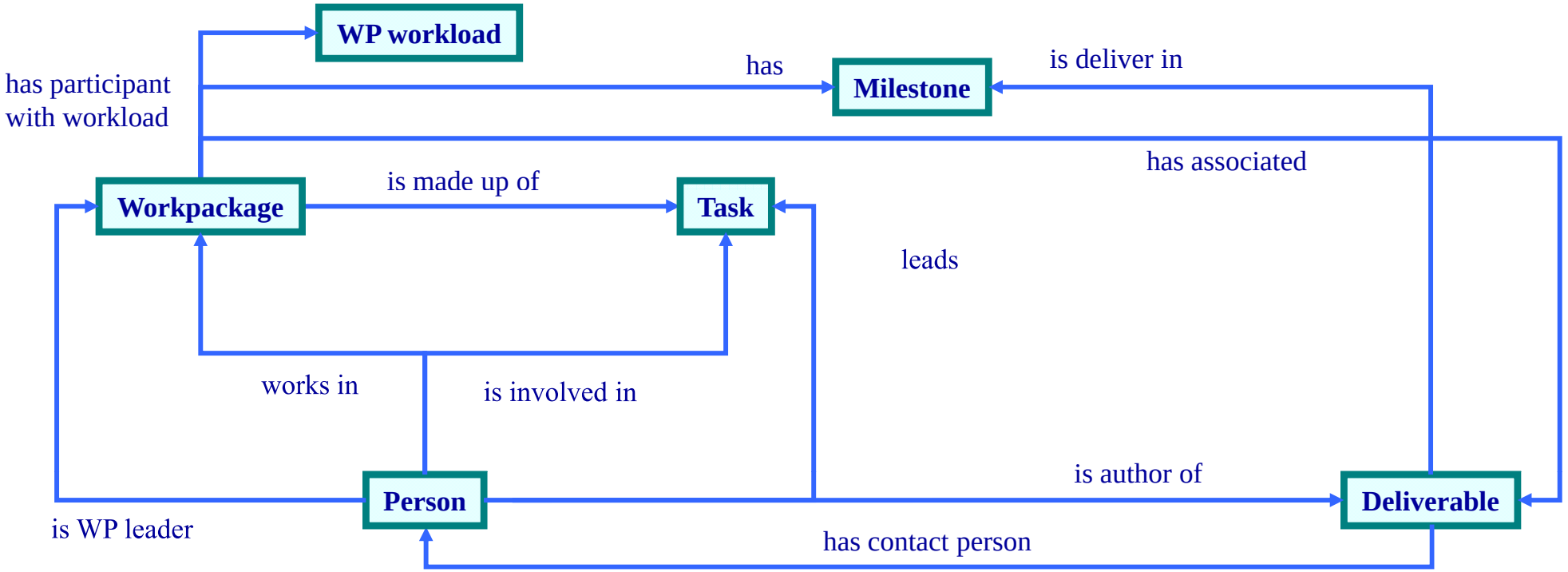


Attributes:

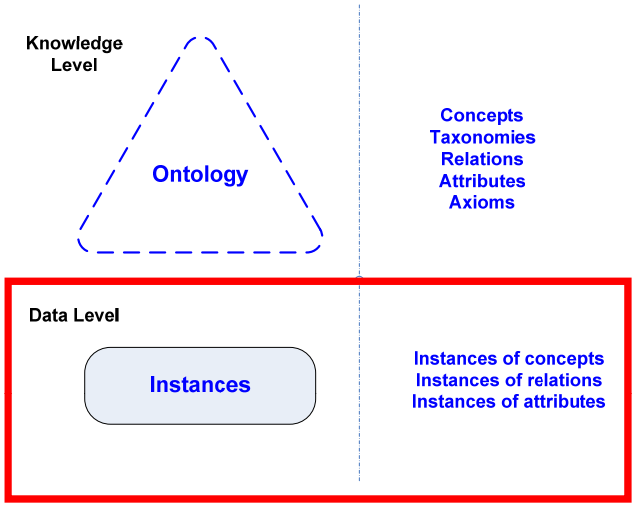
name, DNI, PageNumbers, etc.

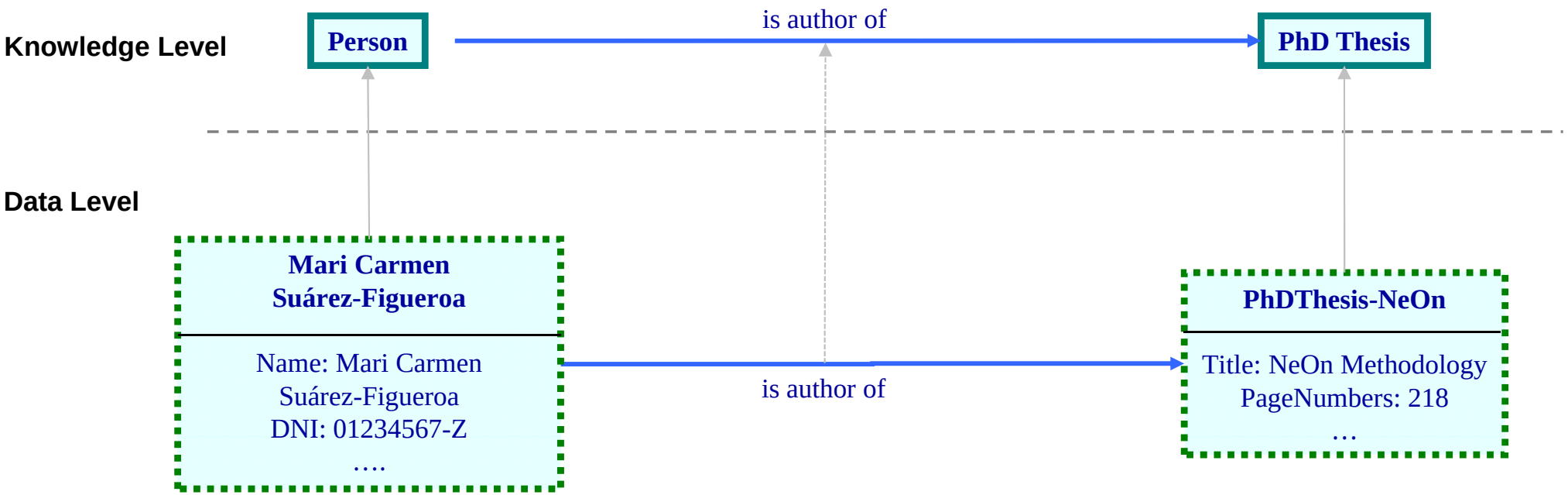
Relations:

leads, is author of, is deliver in, etc.



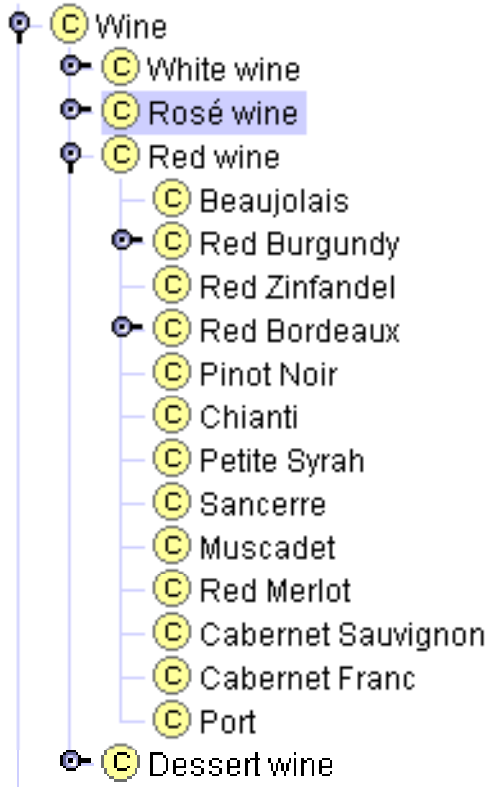
Ontologies: Main Components. Example





Ontologies

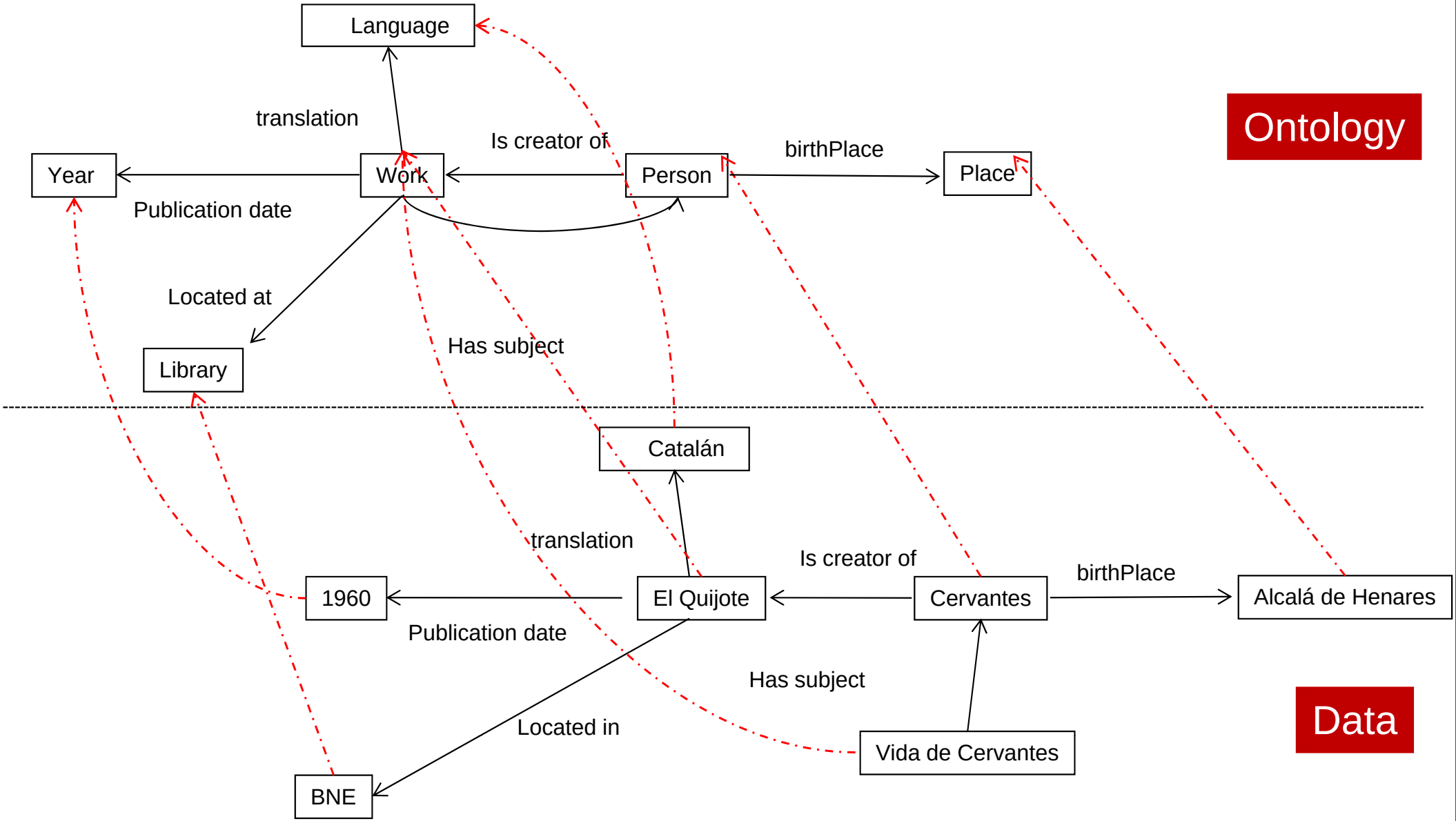
- An ontology
  - Provides terms in a particular domain
  - Includes
    - Concepts
    - Taxonomies
    - Properties
    - Relations



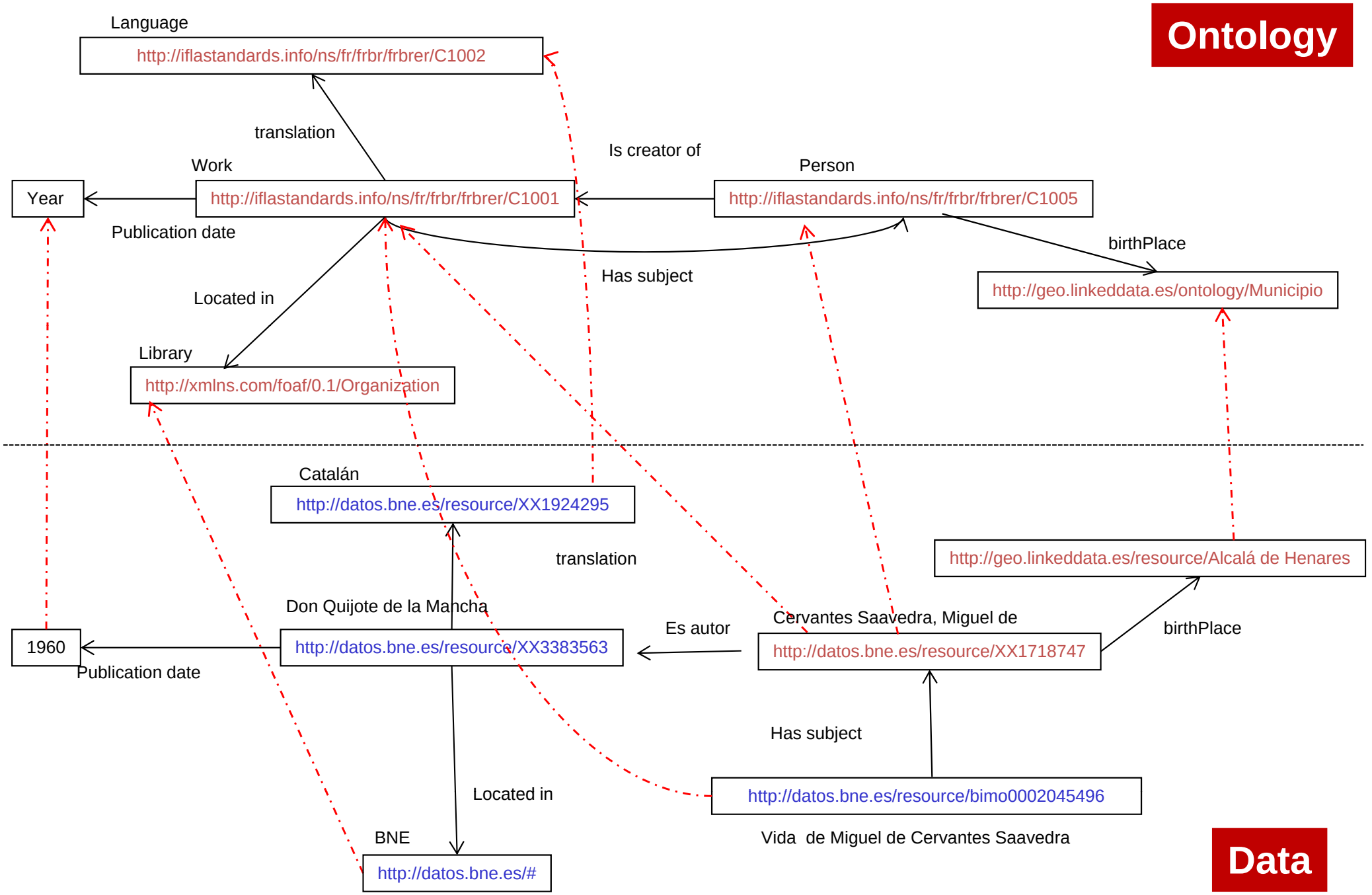
- Shared model in a particular domain

- Implemented in OWL or RDF(S)
- Editors: Protégé, NeOn Toolkit, Topbraid composer, etc.

The Model (**Ontology**) and the Data for Humans



The Model and the Data for Machines



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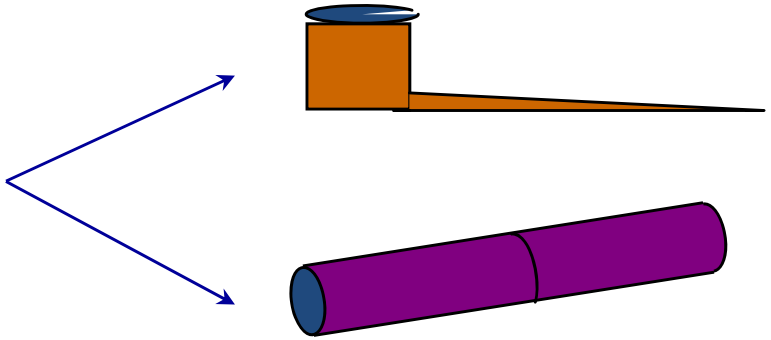
Ontological Commitments

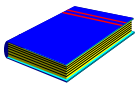
Agreements to use the vocabulary in a coherent and consistent manner (Gruber)

Connection between the ontology vocabulary and the meaning of the terms of such vocabulary

An agent commits (conforms) to an ontology if it "acts" consistently with the definitions

Example: What is a pipe?

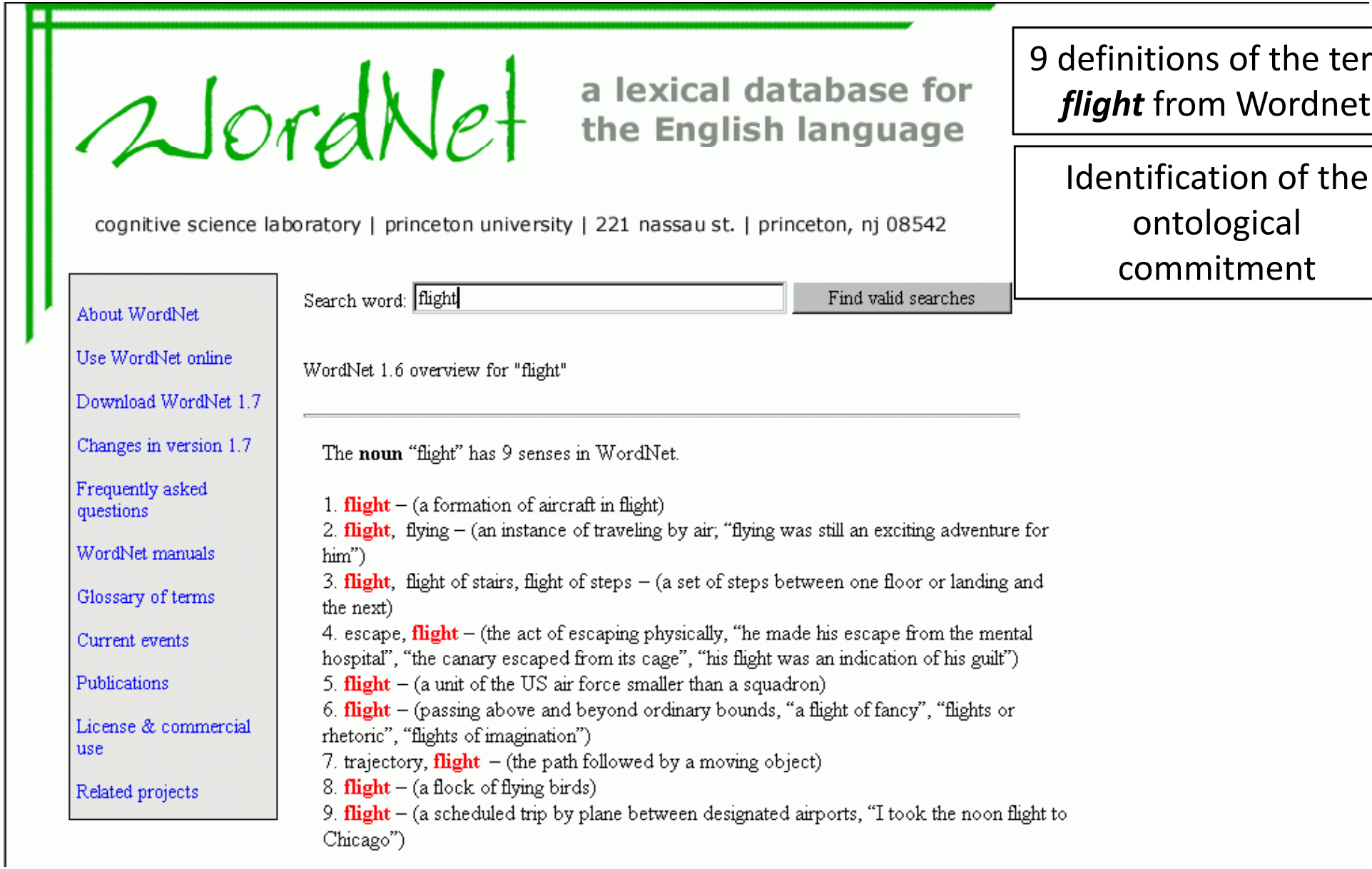




Gruber, T.; Olsen, G. *An Ontology for Engineering Mathematics.* Fourth International Conference on Principles of Knowledge Representation and Reasoning. Ed by Doyle and Torasso. Morgan Kaufmann. 1994. Also as KSL-94-18.

Guarino, N.; Carrara, M.; Giaretta, P. *Formalizing Ontological Commitments.* 12th National Conference on Artificial Intelligence. AAAI-94. 1994. 560-567

Ontological Commitments



9 definitions of the term ***flight*** from Wordnet

Identification of the ontological commitment

What is a Flight?

flight

A formation of aircraft in flight

A scheduled trip by plane between designated airports

Vuelo	Salida		Llegada	
Iberia IB 646	Santiago (SCQ), Santiago, España	06:30	Barajas (MAD), Madrid, España	07:35
Iberia IB 6741	Barajas (MAD), Madrid, España	12:10	Eldorado (BOG), Bogotá, Colombia	16:45
Aces VX 7290	Eldorado (BOG), Bogotá, Colombia	18:00	Rafael Nunez (CTG), Cartagena, Colombia	19:18
Iberia IB 646	Santiago (SCQ), Santiago, España	06:30	Barajas (MAD), Madrid, España	07:35
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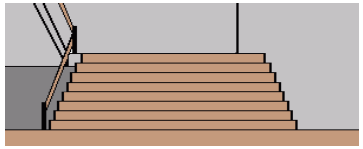
Aces VX 7290	Eldorado (BOG), Bogotá, Colombia	18:00	Rafael Nunez (CTG), Cartagena, Colombia	19:18

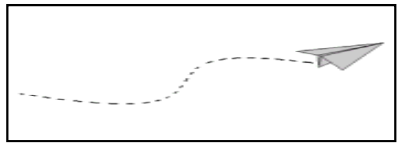
An instance of traveling by air

A flock of flying birds

A set or steps between one floor or landing for him

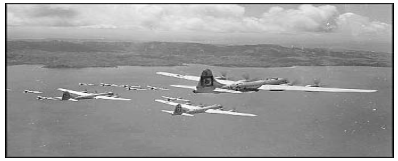


The path followed by a moving object



The act of escaping physically

A unit of the US air force smaller than a squadron



Passing above and beyond ordinary bounds

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Reuse: Motivation

- **Ontologies** play an important role for many knowledge-intensive applications
- To develop ontologies from scratch is a costly task, both in time and in resources
- Time and costs associated to ontology development can be reduced by **reusing knowledge resources**

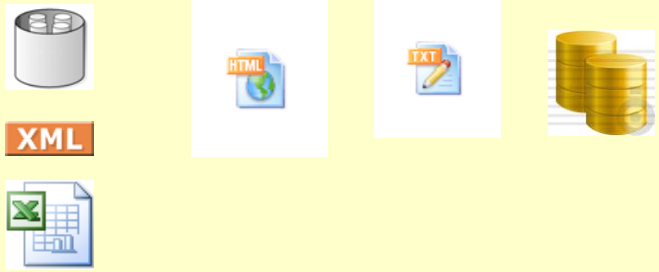
Reuse: Types

- In order to accelerate the development of ontologies, different types of knowledge resources can be reused
  - **Reuse of ontological resources**
    - Ontologies, modules, triples, and ontological design patterns
  - **Reuse of non ontological resources**
    - Glossaries, thesauri, taxonomies, etc.

Suárez-Figueroa, M. C., Aguado de Cea, G., Gómez-Pérez, A. (2013). Lights and shadows in creating a glossary about ontology engineering. *Terminology*, 19(2):202–236.

Reuse: Types and Benefits

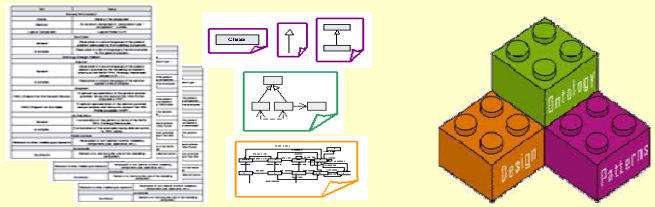
Non Ontological Resources



Ontologies

Flogic
RDF(S)
OWL

Ontology Design Patterns



Save Time

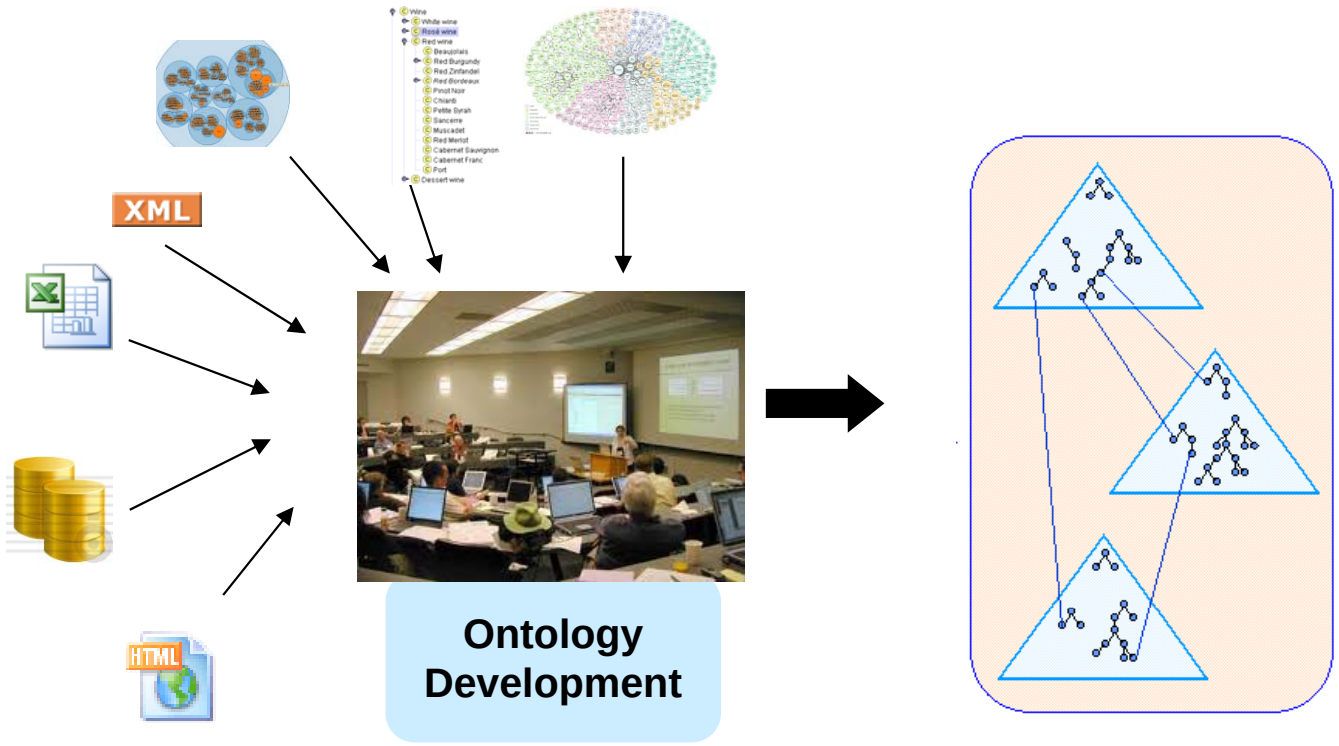
Reach Consensus

Save Resources

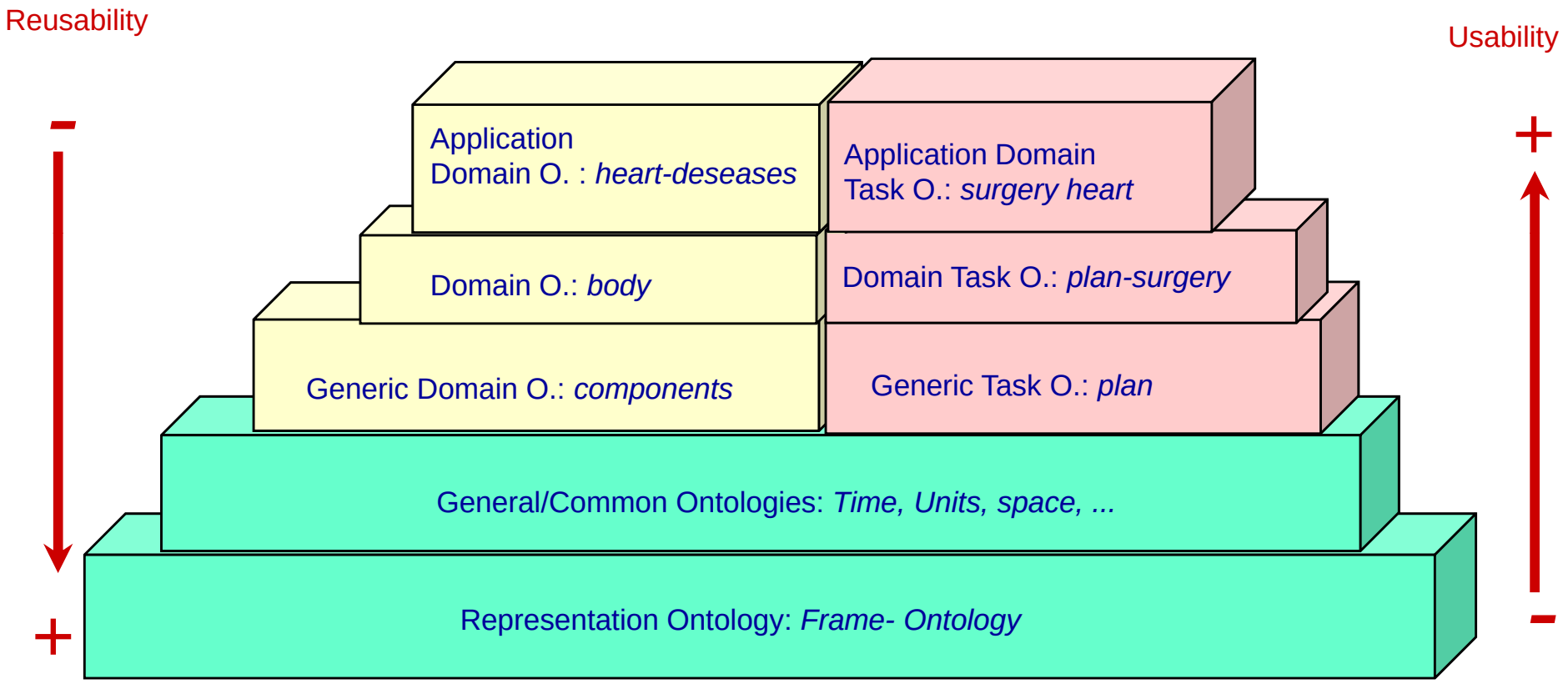
Promote Best Practices

Trends in Ontology Building

- Knowledge resource reuse
- Ontology and vocabulary building in a collaborative way
- Developing ontology and vocabulary networks



Modular Approach for Ontology Construction



Reuse: General Guidelines

- The **general schema** to reuse knowledge resources is mainly based on
  - To search knowledge resources
  - To analyze and compare knowledge resources
  - To select the most appropriate knowledge resources

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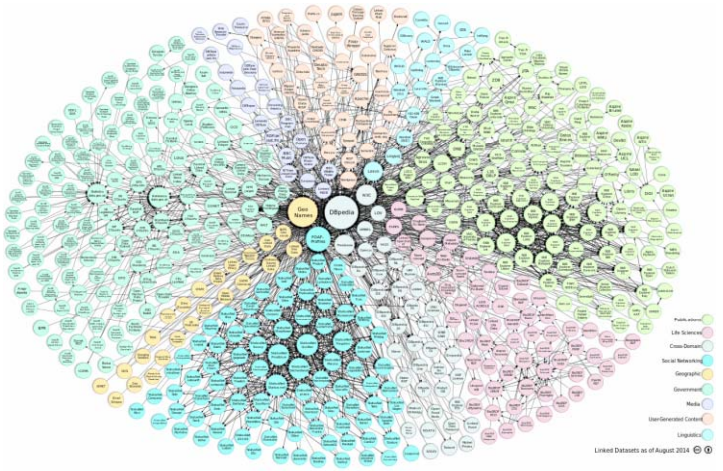
Linked Data (LD)

- Semantic Web technologies (RDF, OWL, SKOS, SPARQL, etc.) provides an environment where application can query **data**, draw inferences using **vocabularies**, etc.
- To make the Web of Data a reality,
  - it is important to have the **huge amount of data on the Web** available in a standard format, reachable and manageable by Semantic Web technologies
  - In addition, **relationships among data** should be made available
- The collection of interrelated datasets on the Web can also be referred to as **Linked Data**
  - **Knowledge Graphs**



Vocabularies used in LD

- Time, Mereology, Topology
- Persons and Organizations: FOAF, vCard, ORG
- Documents: DC, BIBO
- Geo: points, lineString and polygons
- Libraries: FRBR
- Statistics: Data Cube
- Measures: Sensor Network Ontology
- Other vocabularies: Provenance, VOID , DCAT, ODRL, etc.
- ….

FOAF: Friend Of A Friend

- RDF vocabulary to describe:
  - Persons
  - Groups
  - Documents

FOAF - Friend of a Friend vocabulary

Metadata:

Property	Value
is part of vocabulary space	All > City
Vocabulary URI	http://xmlns.com/foaf/0.1/
Prefix	foaf
Namespace URI	http://xmlns.com/foaf/0.1/
Last modified	2010-08-09
Creator	Dan Brickley, Libby Miller
Publisher	Dan Brickley
Class number	13
Property number	62
Homepage	http://www.foaf-project.org/
Represented by	format-foaf
Has review	(2011-03-11) Bernard Vatant: FOAF is the ancestor of all LOV vocabularies, and is everywhere in the Cloud. Wish it had more metadata such as last modification date.

http://www.foaf-project.org/

FOAF: The Vocabulary

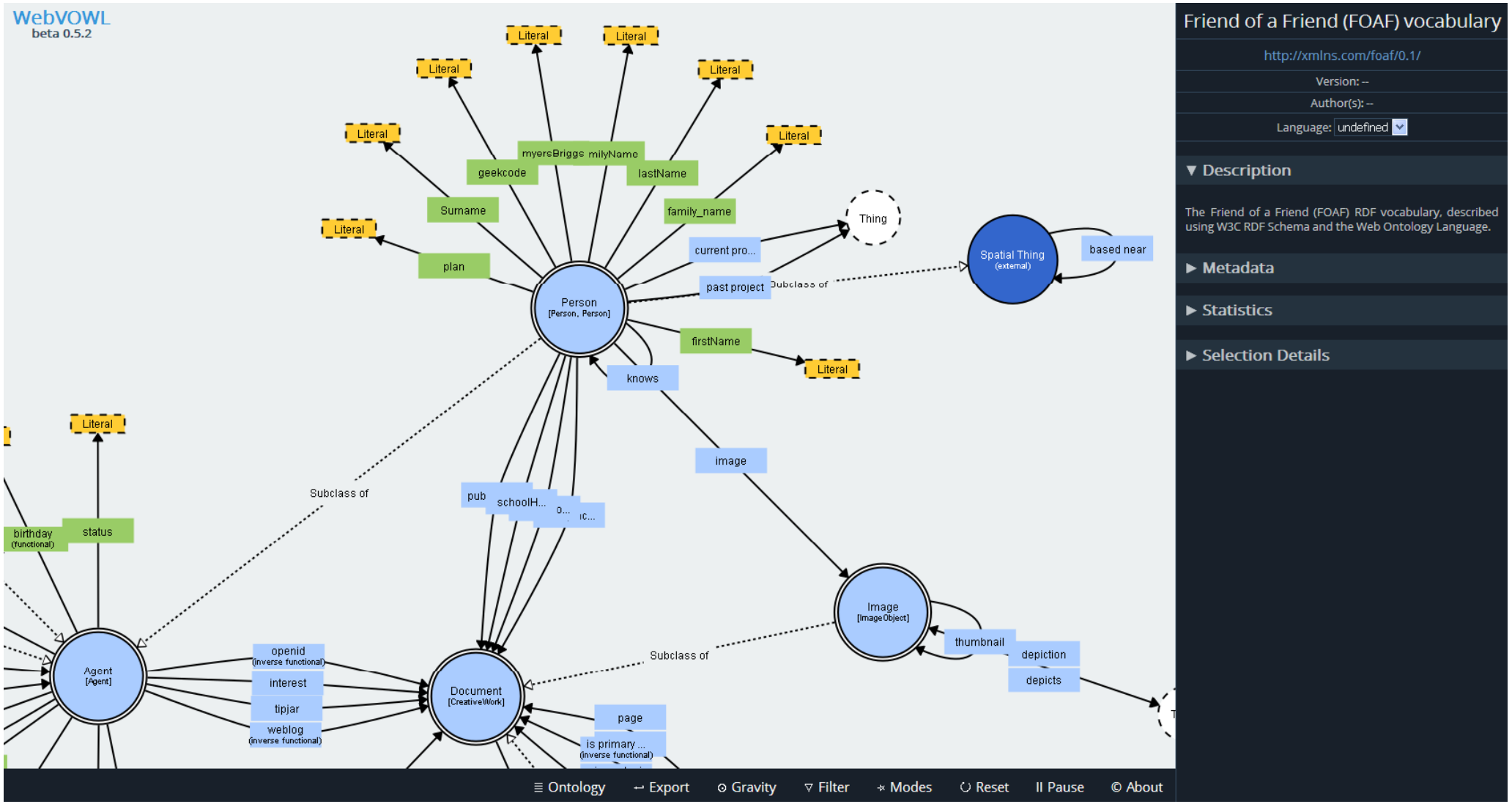
FOAF Core

- Agent
- Person
- name
- title
- img
- depiction (depicts)
- familyName
- givenName
- knows
- based_near
- age
- made (maker)
- primaryTopic (primaryTopicOf)
- Project
- Organization
- Group
- member
- Document
- Image

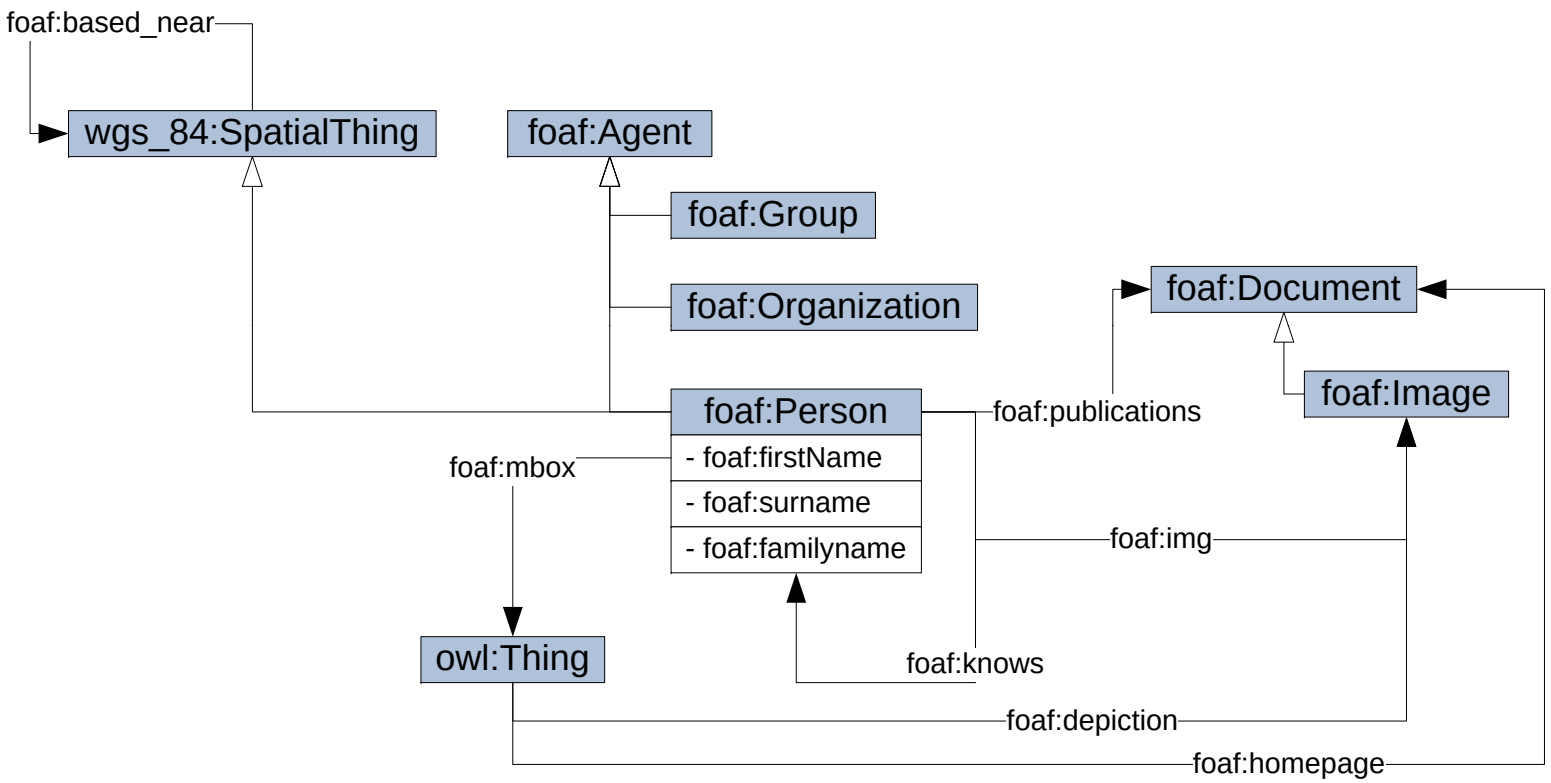
Social Web

- nick
- mbox
- homepage
- weblog
- openid
- jabberID
- mbox_sha1sum
- interest
- topic_interest
- topic (page)
- workplaceHomepage
- workInfoHomepage
- schoolHomepage
- publications
- currentProject
- pastProject
- account
- OnlineAccount
- accountName
- accountServiceHomepage
- PersonalProfileDocument
- tipjar
- sha1
- thumbnail
- logo

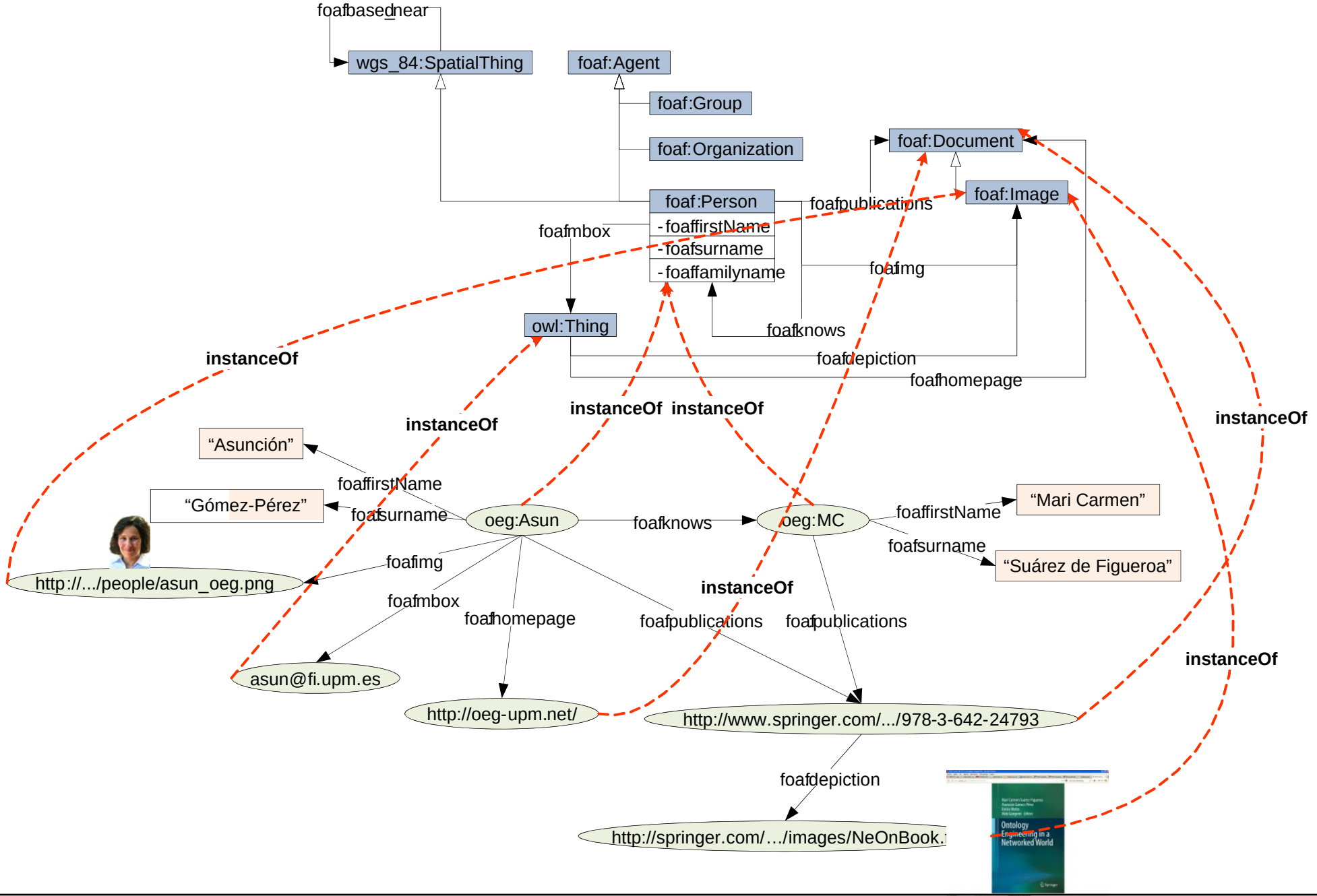
FOAF: The Vocabulary



FOAF: A Model Excerpt



FOAF: Model and Instances

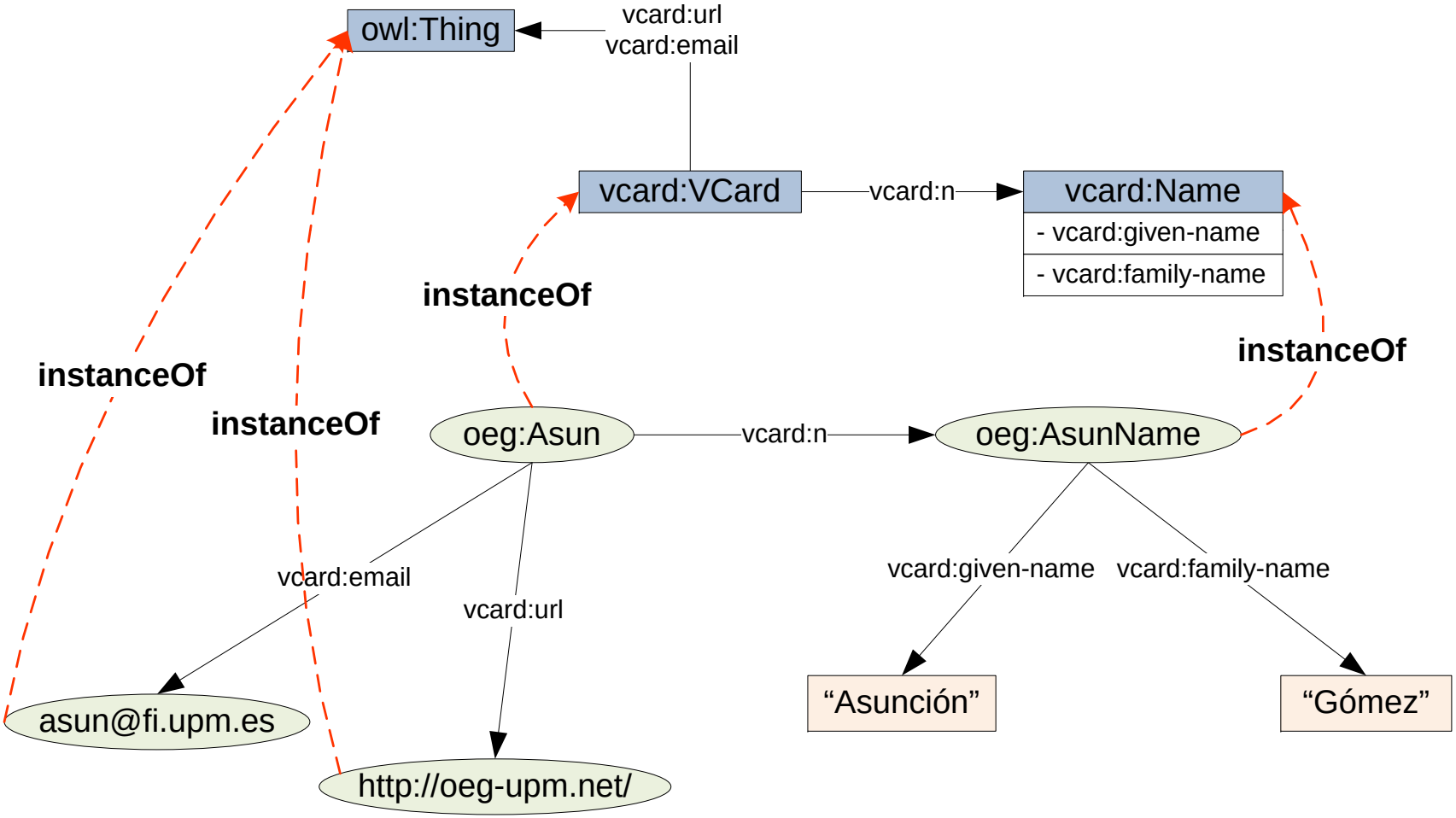


vCard: An Ontology for Visit Cards

- **vCard** automates the exchange of personal and organization information typically found on a traditional business card
- RDF Classes:
  - Vcard
  - Name
  - Address
  - Organisation
  - Location
  - Label
  - Tel
  - Email

http://www.w3.org/Submission/vcard-rdf/

An example of a vCard Instantiation

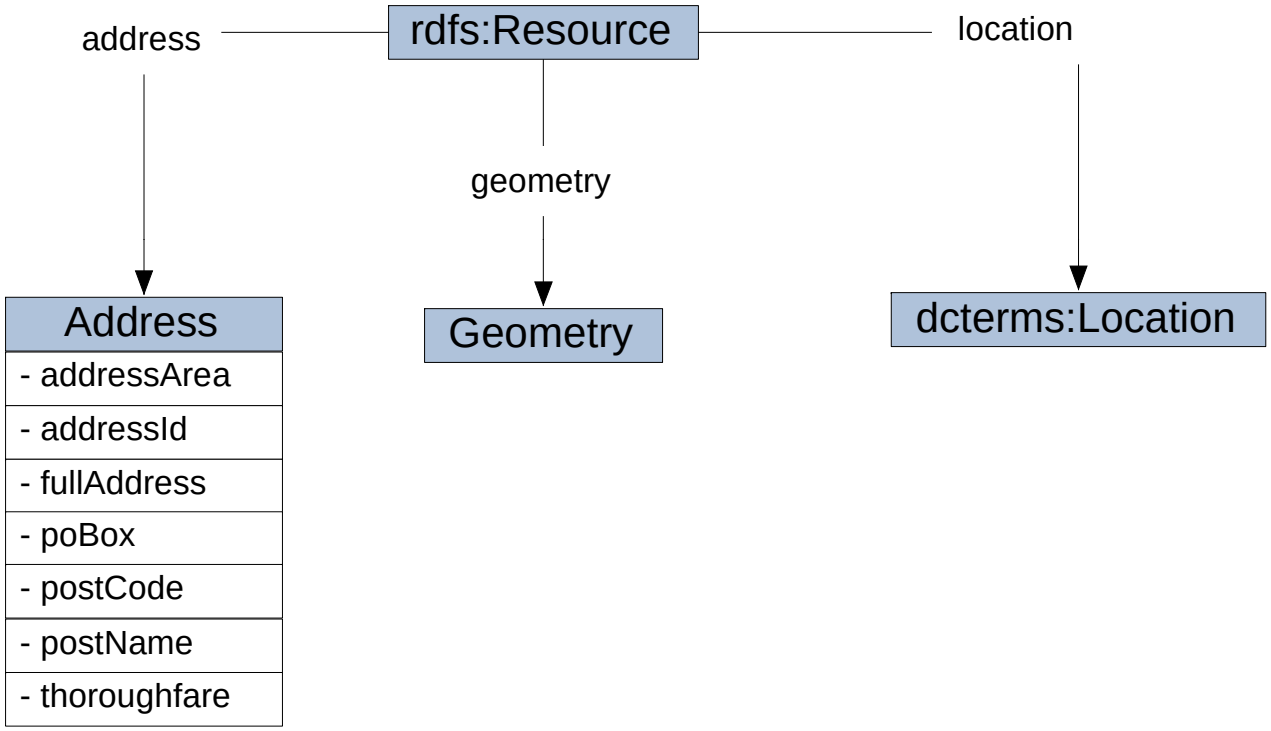


LOCN: ISA Programme Location Core Vocabulary

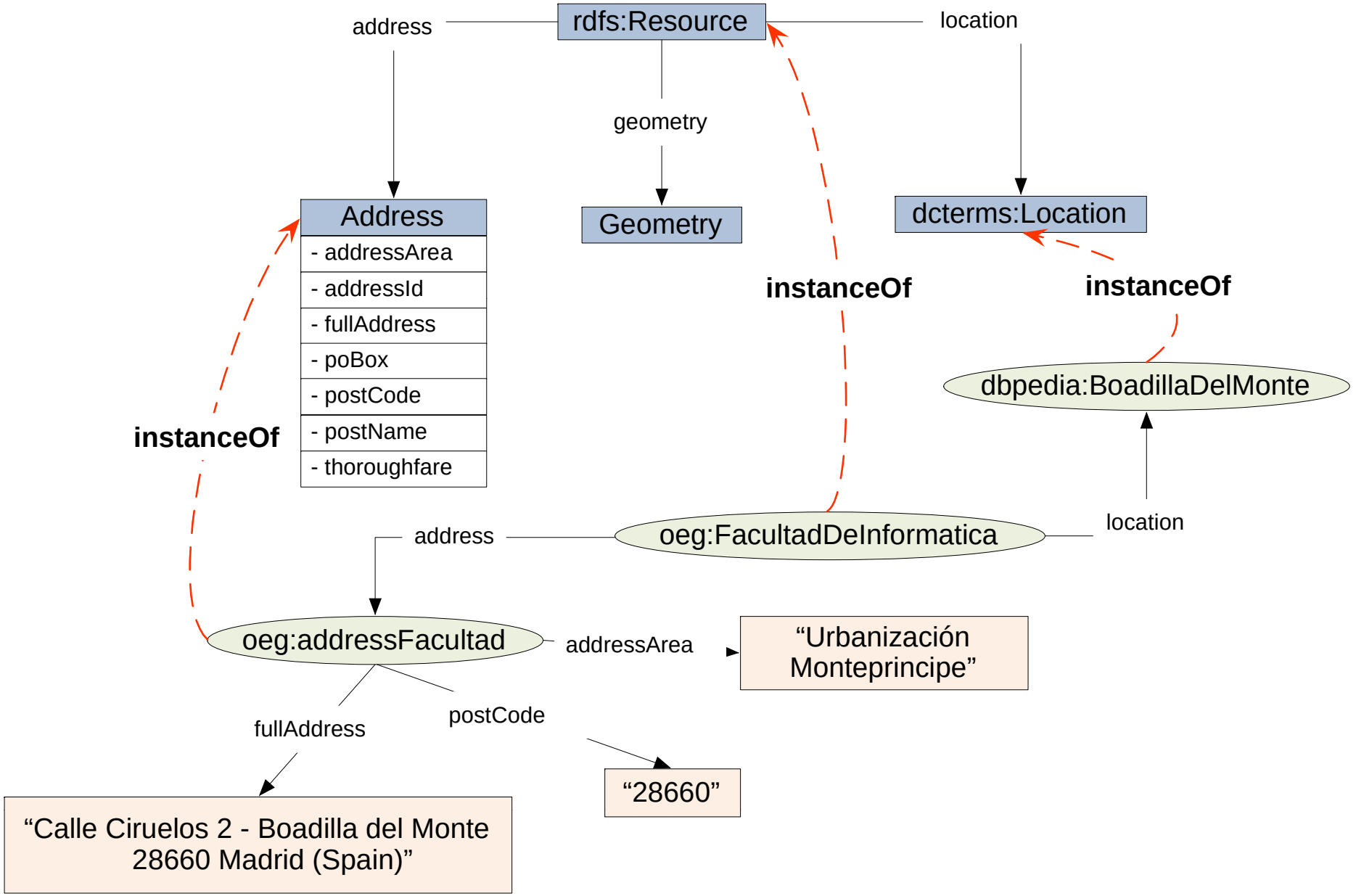
- **LOCN** provides a minimum set of classes and properties for describing any place in terms of its name, address or geometry.
- Main concepts described in LOCN are:
  - Address
  - Location
  - Geometry

http://www.w3.org/ns/locn#

LOCN: The Vocabulary



LOCN: Model and Instances

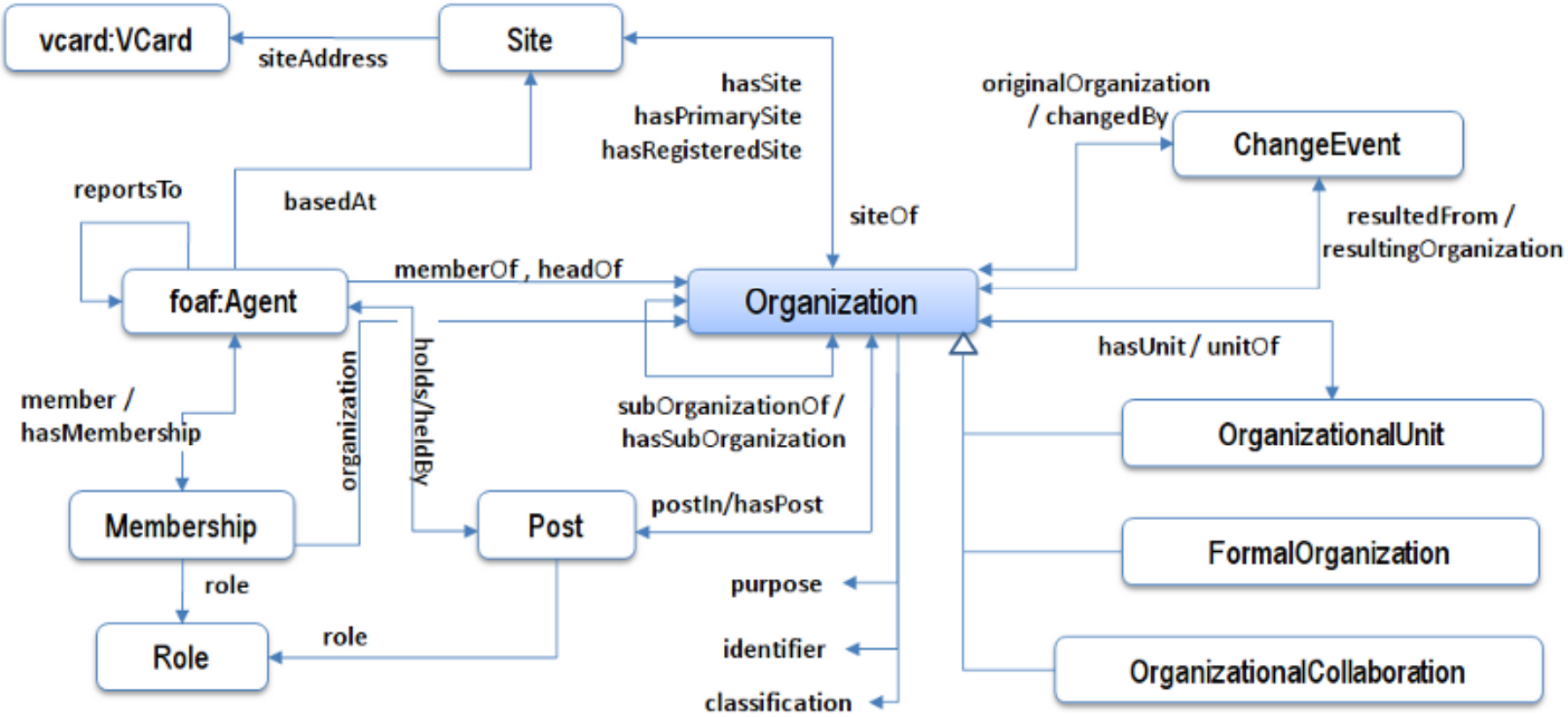


ORG: An Organization Ontology (W3C)

- ORG is a core ontology for organizational structures
  - **organizational structure**
    - notion of an organization
    - decomposition into sub-organizations and units
    - purpose and classification of organizations
  - **reporting structure**
    - membership and reporting structure within an organization
    - roles, posts, and the relationship between people and organizations
  - **location information**
    - sites or buildings, locations within sites
  - **organizational history (merger, renaming)**
- It supports linked data publishing of organizational information across a number of domains

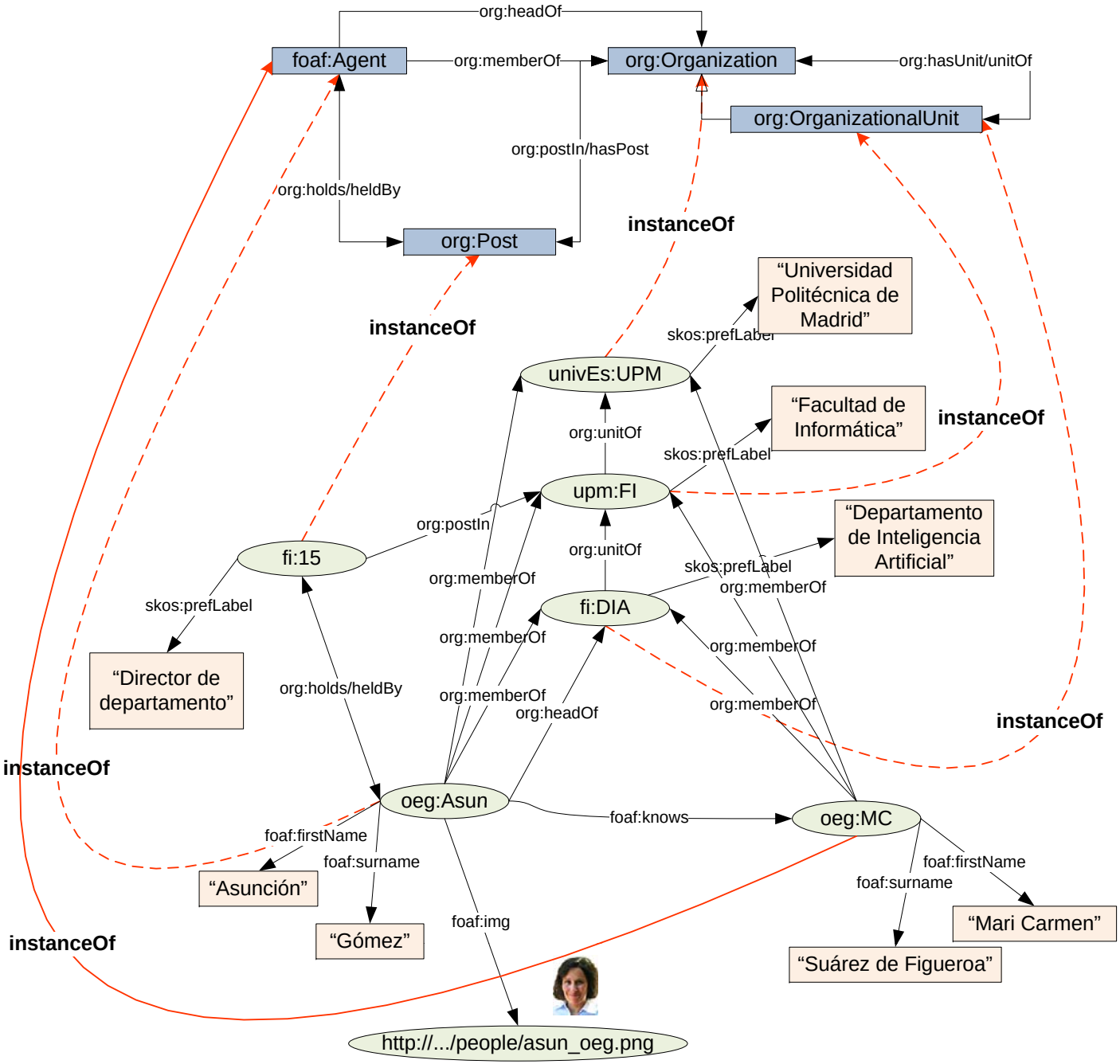
http://www.w3.org/TR/vocab-org/

ORG: An Organization Ontology



http://www.w3.org/TR/vocab-org/

ORG: Model and Instances



DC: Dublin Core

- **Dublin Core** is a vocabulary to describe resources by means of simple and general metadata (DC terms)
- A subset of 15 elements (DC elements) has been ratified as IETF RFC 5013, ANSI/NISO Standard Z39.85-2007, and ISO Standard 15836:2009
- To be used together with other specialized vocabularies to meet particular implementation requirements

Dublin Core® Metadata Initiative
Making it easier to find information.

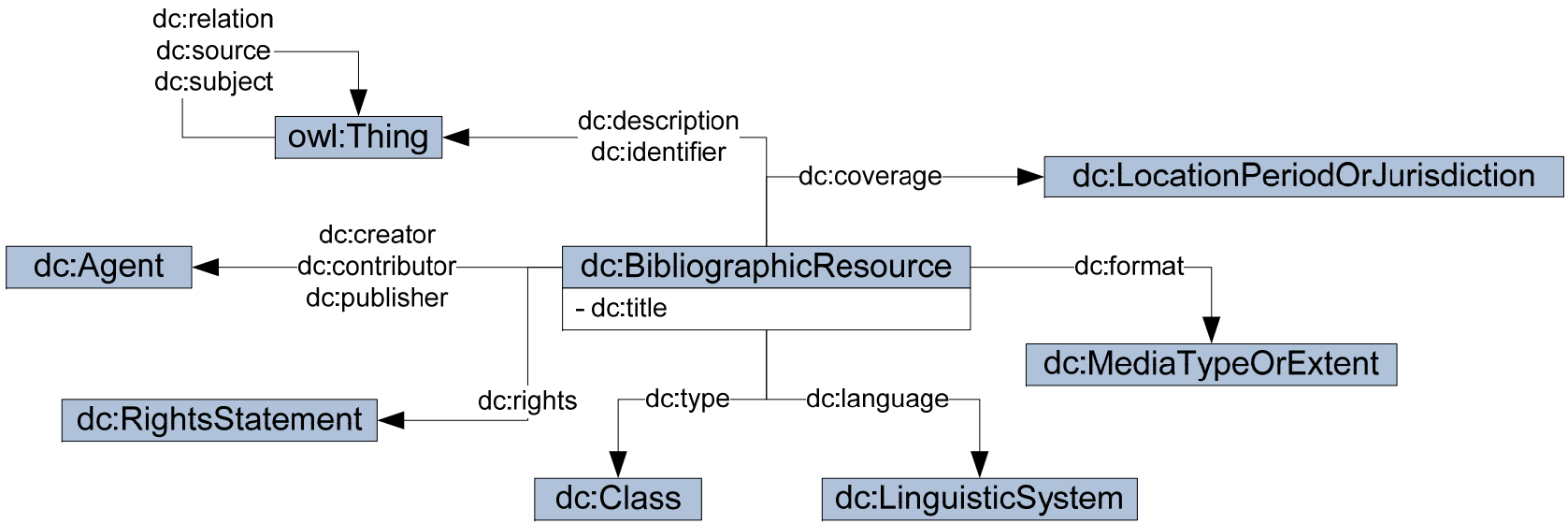
http://dublincore.org/documents/2012/06/14/dcmi-terms/?v=terms

DC: The vocabulary

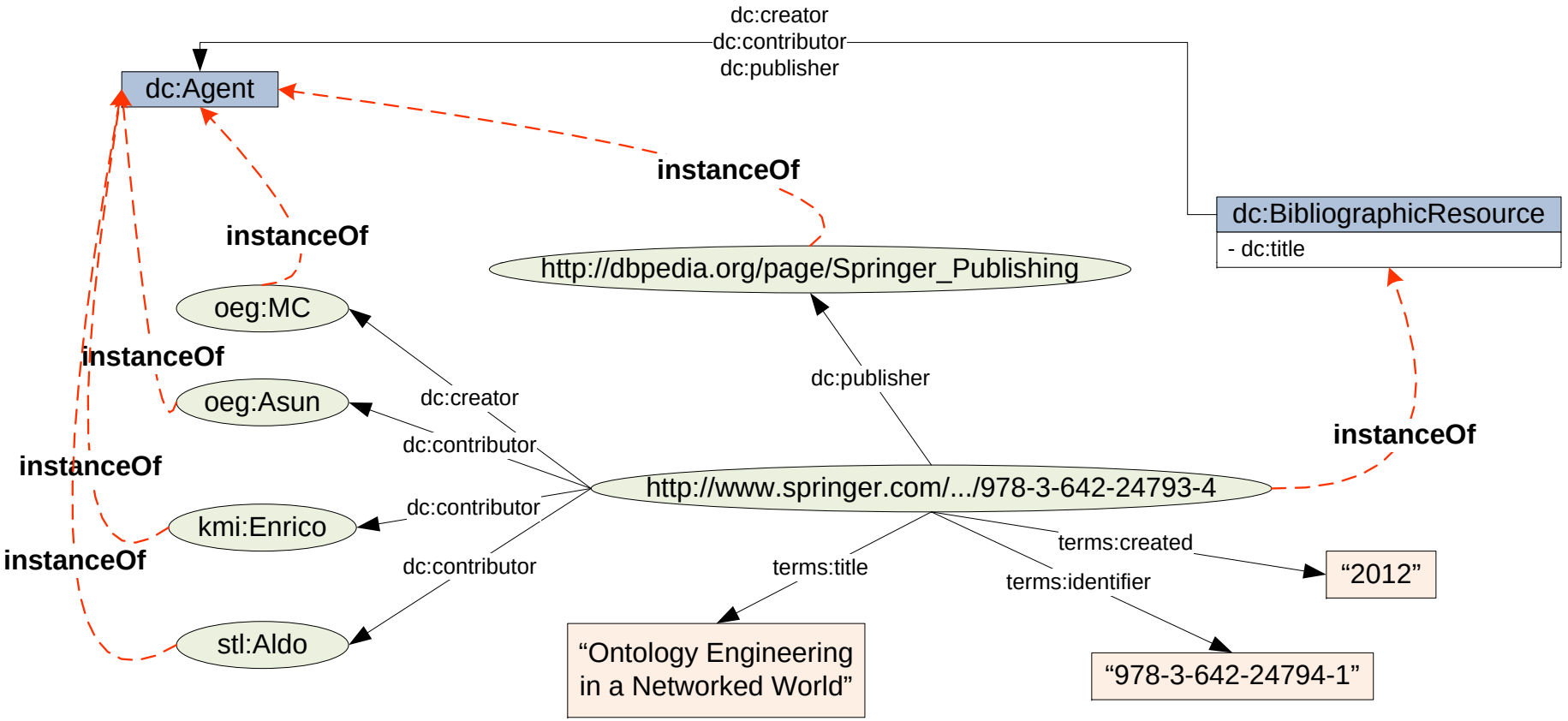
126 Elements

Properties in the */terms/* namespace	abstract , accessRights , accrualMethod , accrualPeriodicity , accrualPolicy , alternative , audience , available , bibliographicCitation , conformsTo , contributor , coverage , created , creator , date , dateAccepted , dateCopyrighted , dateSubmitted , description , educationLevel , extent , format , hasFormat , hasPart , hasVersion , identifier , instructionalMethod , isFormatOf , isPartOf , isReferencedBy , isReplacedBy , isRequiredBy , issued , isVersionOf , language , license , mediator , medium , modified , provenance , publisher , references , relation , replaces , requires , rights , rightsHolder , source , spatial , subject , tableOfContents , temporal , title , type , valid
Properties in the */elements/1.1/* namespace	contributor , coverage , creator , date , description , format , identifier , language , publisher , relation , rights , source , subject , title , type
Vocabulary Encoding Schemes	DCMIType , DDC , IMT , LCC , LCSH , MESH , NLM , TGN , UDC
Syntax Encoding Schemes	Box , ISO3166 , ISO639-2 , ISO639-3 , Period , Point , RFC1766 , RFC3066 , RFC4646 , RFC5646 , URI , W3CDTF
Classes	Agent , AgentClass , BibliographicResource , FileFormat , Frequency , Jurisdiction , LicenseDocument , LinguisticSystem , Location , LocationPeriodOrJurisdiction , MediaType , MediaTypeOrExtent , MethodOfAccrual , MethodOfInstruction , PeriodOfTime , PhysicalMedium , PhysicalResource , Policy , ProvenanceStatement , RightsStatement , SizeOrDuration , Standard
DCMI Type Vocabulary	Collection , Dataset , Event , Image , InteractiveResource , MovingImage , PhysicalObject , Service , Software , Sound , StillImage , Text
Terms related to the DCMI Abstract Model	memberOf , VocabularyEncodingScheme

DC: A Model Excerpt

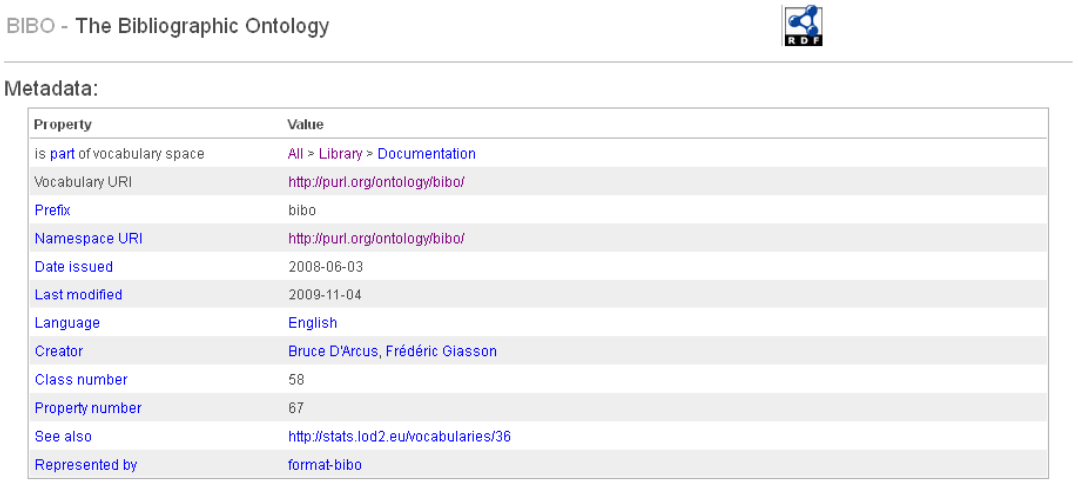


DC: Model and Instances



BIBO: The Bibliographic Ontology

- The **Bibliographic Ontology (BIBO)** describes bibliographic things on the Semantic Web in RDF
- BIBO can be used as
  - –a citation ontology,
  - –a document classification ontology, or
  - –a way to describe any kind of document in RDF



BIBO - The Bibliographic Ontology

Metadata:

Property	Value
is part of vocabulary space	All > Library > Documentation
Vocabulary URI	http://purl.org/ontology/bibo/
Prefix	bibo
Namespace URI	http://purl.org/ontology/bibo/
Date issued	2008-06-03
Last modified	2009-11-04
Language	English
Creator	Bruce D'Arcus, Frédéric Giasson
Class number	58
Property number	67
See also	http://stats.lod2.eu/vocabularies/36
Represented by	format-bibo

- bibliontology.com/
- http://purl.org/ontology/bibo/

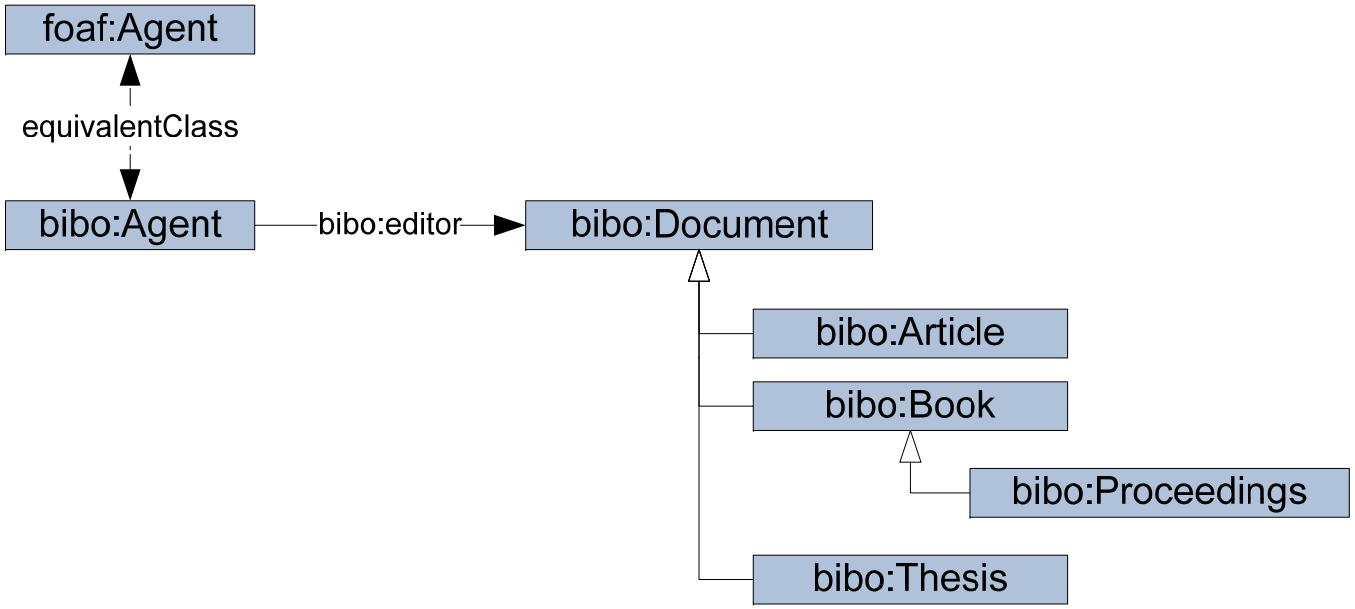
The Bibliographic Ontology

BIBO: The Vocabulary

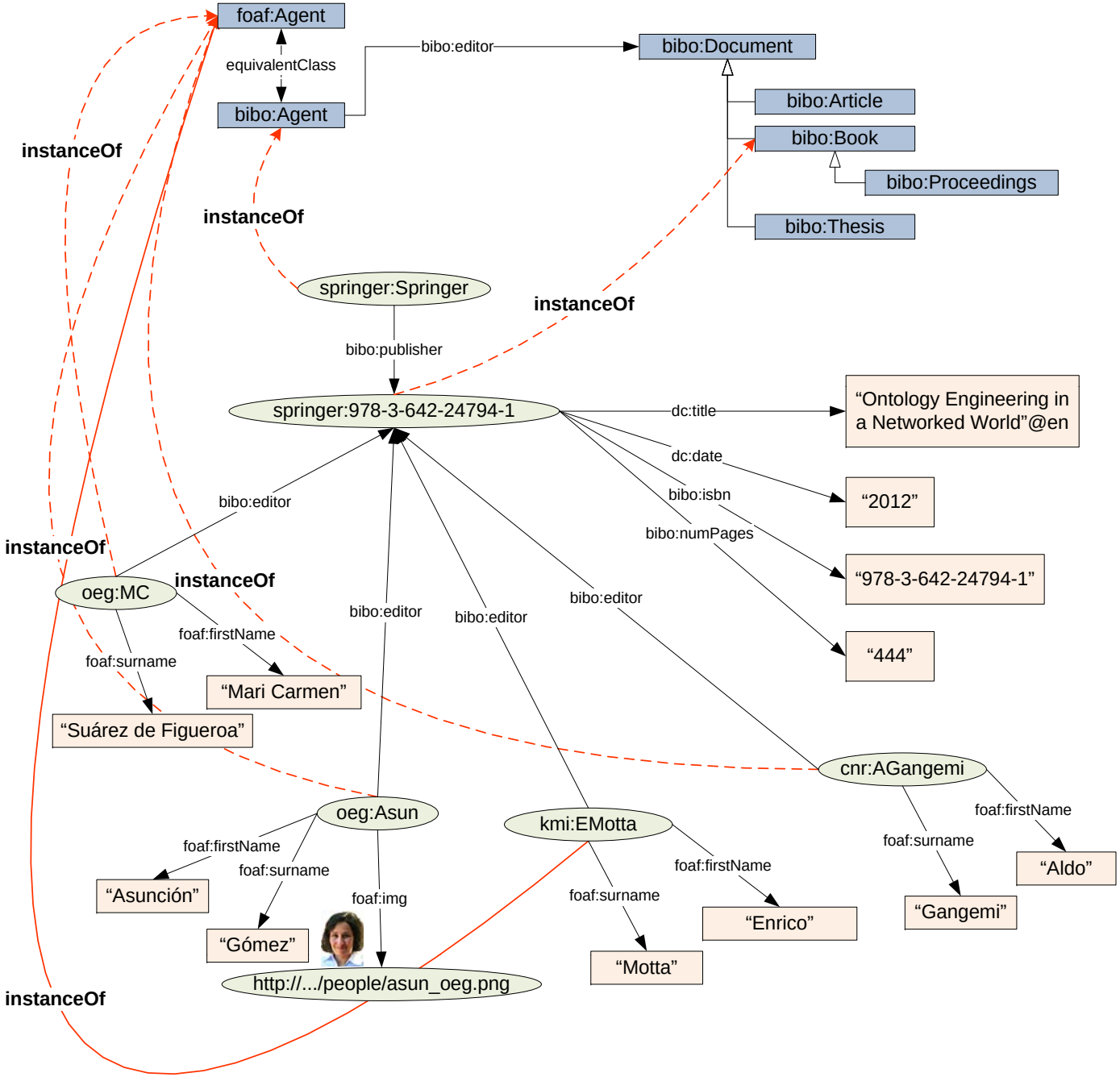
189 Elements

- owl:Thing
- bibo:abstract
- bibo:AcademicArticle
- bibo:affirmedBy
- bibo:annotates
- bibo:argued
- bibo:Article
- bibo:asin
- bibo:AudioDocument
- bibo:AudioVisualDocument
- bibo:authorList
- bibo:bdarcus
- bibo:Bill
- bibo:Book
- bibo:BookSection
- bibo:Brief
- bibo:chapter
- bibo:Chapter
- bibo:citedBy
- bibo:cites
- bibo:Code
- bibo:coden
- bibo:CollectedDocument
- bibo:Collection
- bibo:Conference
- bibo:content
- bibo:contributorList
- bibo:court
- bibo:CourtReporter
- bibo:degree
- bibo:degrees/ma
- bibo:degrees/ms
- bibo:degrees/phd
- bibo:director
- bibo:distributor
- bibo:Document
- bibo:DocumentPart
- bibo:DocumentStatus
- bibo:doi
- bibo:eanucc13
- bibo:EditedBook
- bibo:edition
- bibo:editor
- bibo:editorList
- bibo:eissn
- bibo:Email
- bibo:Event
- bibo:Excerpt
- bibo:fgiasson
- bibo:Film
- bibo:gtin14
- bibo:handle
- bibo:Hearing
- bibo:identifier
- bibo:Image
- bibo:Interview
- bibo:interviewee
- bibo:interviewer
- bibo:isbn
- bibo:isbn10
- bibo:isbn13
- bibo:issn
- bibo:Issue
- bibo:issue
- bibo:issuer
- bibo:Journal
- bibo:lccn
- bibo:LegalCaseDocument
- bibo:LegalDecision
- bibo:LegalDocument
- bibo:Legislation
- bibo:Letter
- bibo:locator
- bibo:Magazine
- bibo:Manual
- bibo:Manuscript
- bibo:Map
- bibo:MultiVolumeBook
- bibo:Newspaper
- bibo:Note
- bibo:number
- bibo:numPages
- bibo:numVolumes
- bibo:oclcnum
- bibo:organizer
- bibo:owner
- bibo:pageEnd
- bibo:pages
- bibo:pageStart
- bibo:Patent
- bibo:Performance
- bibo:performer
- bibo:Periodical
- bibo:PersonalCommunication
- bibo:PersonalCommunicationDocument
- bibo:pmid
- bibo:prefixName
- bibo:presentedAt
- bibo:presents
- bibo:Proceedings
- bibo:producer
- bibo:Quote
- bibo:recipient
- bibo:ReferenceSource
- bibo:Report
- bibo:reproducedIn
- bibo:reversedBy
- bibo:reviewOf
- bibo:section
- bibo:Series
- bibo:shortDescription
- bibo:shortTitle
- bibo:sici
- bibo:Slide
- bibo:Slideshow
- bibo:Standard
- bibo:status
- bibo:status/accepted
- bibo:status/draft
- bibo:status/forthcoming
- bibo:status/legal
- bibo:status/nonPeerReviewed
- bibo:status/peerReviewed
- bibo:status/published
- bibo:status/rejected
- bibo:status/unpublished
- bibo:Statute
- bibo:subsequentLegalDecision
- bibo:suffixName
- bibo:Thesis
- bibo:ThesisDegree
- bibo:transcriptOf
- bibo:translationOf
- bibo:translator
- bibo:upc
- bibo:uri
- bibo:volume
- bibo:Webpage
- bibo:Website
- bibo:Workshop
- dcterms:Agent
- dcterms:contributor
- dcterms:created
- dcterms:date
- dcterms:description
- dcterms:format
- dcterms:hasPart
- dcterms:isPartOf
- dcterms:isReferencedBy
- dcterms:issued
- dcterms:isVersionOf
- dcterms:language
- dcterms:publisher
- dcterms:relation
- dcterms:rights
- dcterms:subject
- dcterms:title
- event:agent
- event:Event
- event:place
- event:produced_in
- event:product
- event:sub_event
- event:time
- foaf:Agent
- foaf:based_near
- foaf:depiction
- foaf:Document
- foaf:family_name
- foaf:givenname
- foaf:homepage
- foaf:Image
- foaf:name
- foaf:Organization
- foaf:Person
- localityName
- prism:doi
- prism:edition
- prism:eIssn
- prism:endingPage
- prism:isbn
- prism:issn
- prism:number
- prism:volume
- prism:volumestartingPage
- rdf:List
- rdf:Seq
- rdf:value
- rdfs:Resource

BIBO: A Model Excerpt



BIBO: Model and Instances



Cartography Points: WGS84

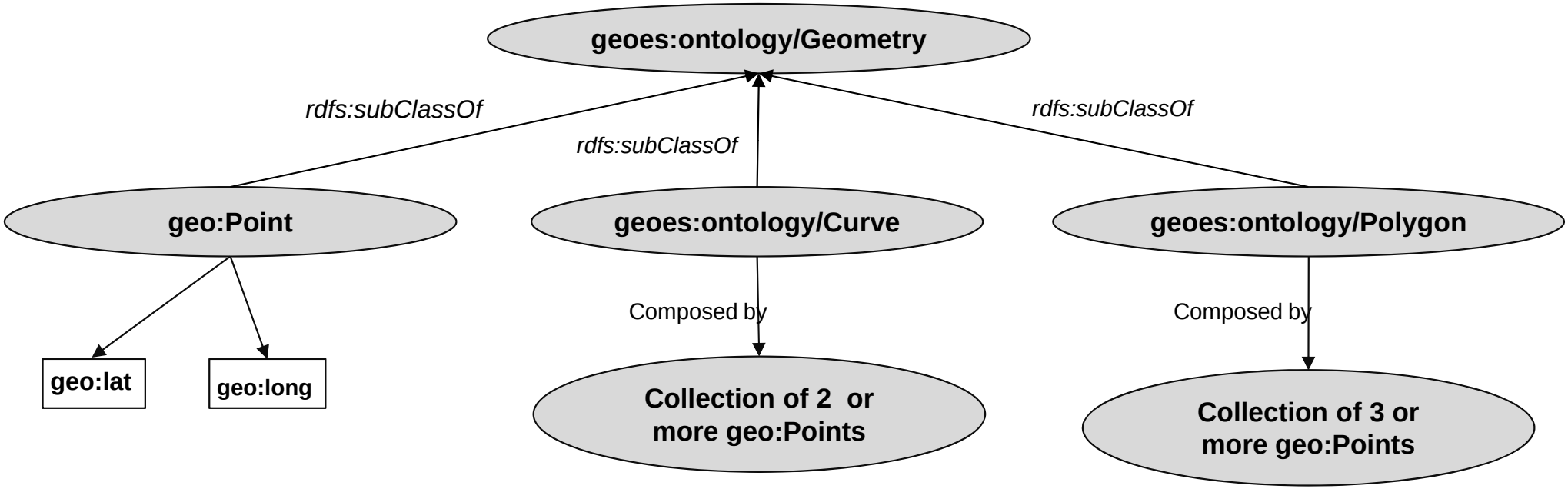
- Vocabulary for representing Points:
  - Latitude
  - Longitude
  - @en

- http://www.w3.org/2003/01/geo/

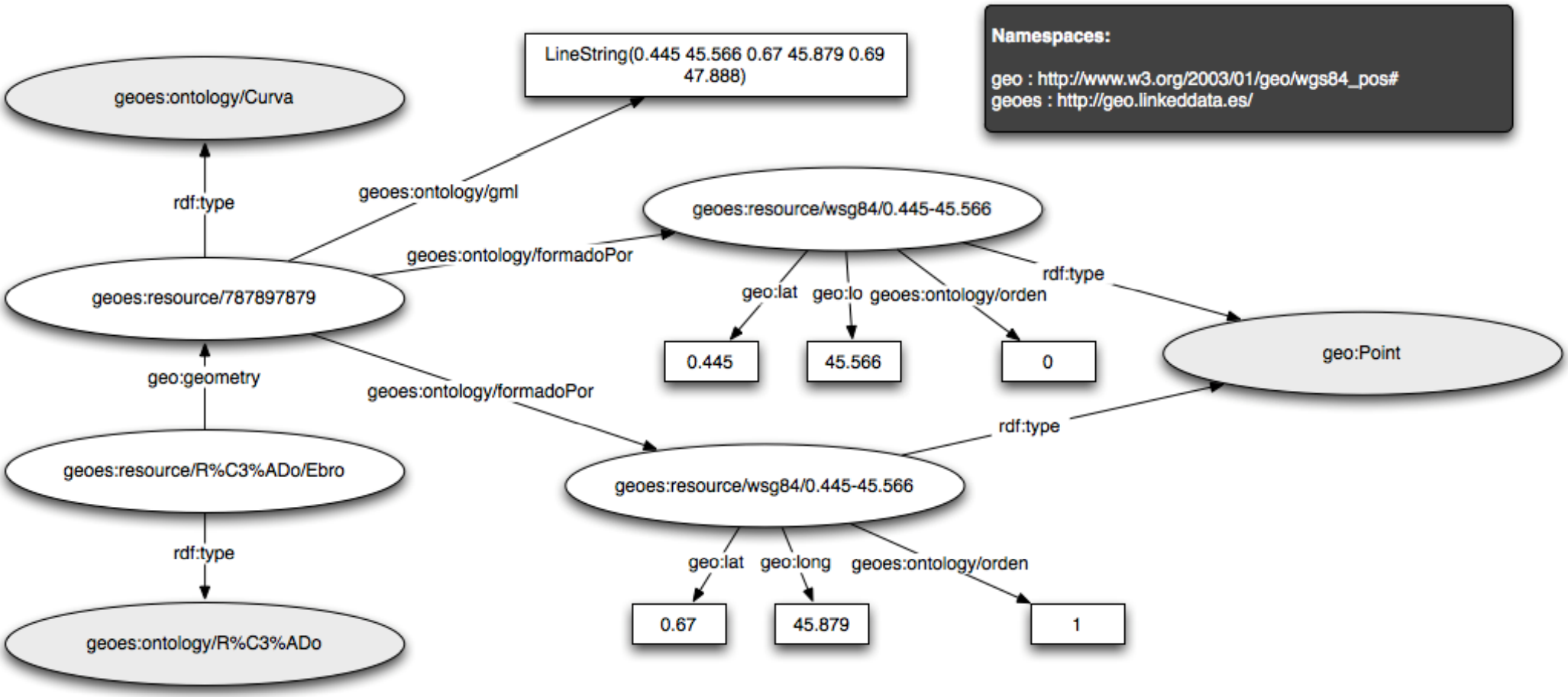
```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:geo="http://www.w3.org/2003/01/geo/wgs84_pos#">
<geo:Point>
    <geo:lat> 55.701</geo:lat>
    <geo:long>12.552</geo:long>
</geo:Point>
</rdf:RDF>
```

Geoes: Geometry Model

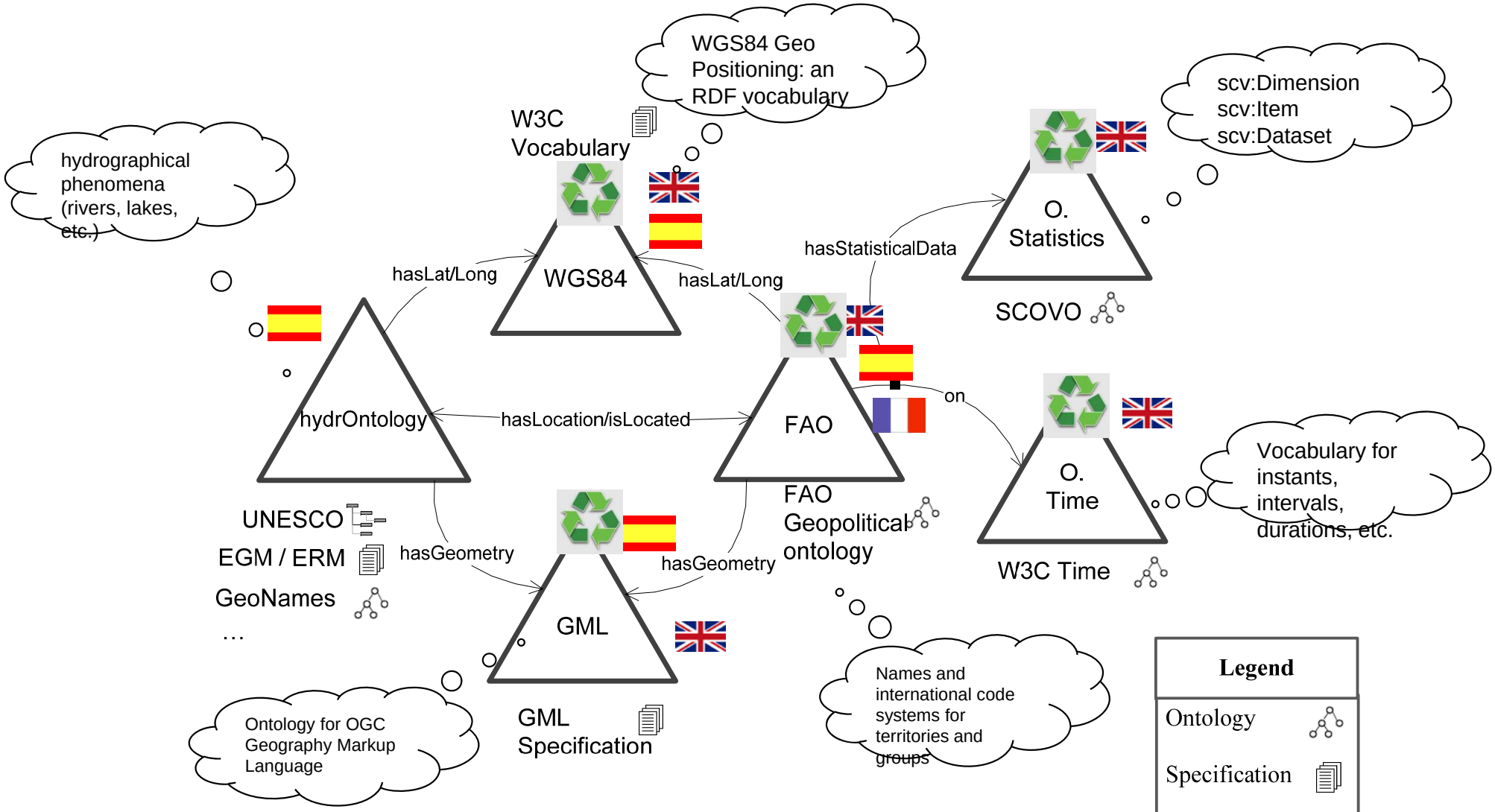
geoes: http://geo.linkeddata.es/
geo: http://www.w3.org/2003/01/geo/wgs84_pos#



Geoes: lineString



Example: Geolinked Data Ontologies



Following the INSPIRE
(INfrastructure for SPatial InfoRmation in Europe) recommendation.

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- Asunción Gómez-Pérez (OEG)
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Course: Intelligent Systems

Unit 3: Ontology Engineering

Ontologies

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Course 2022 – 2023

Technical University of Madrid