



1. Ontologies

Asunción Gómez-Pérez

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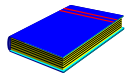
Table of Content

Ontologies

1. Reuse and Sharing
2. Definitions of Ontologies
3. Modeling of Ontologies
4. Type of Ontologies
5. Searching Ontologies

The knowledge Sharing Initiative

“Building new Knowledge Based Systems today usually entails constructing new knowledge bases from scratch. It could instead be done by **assembling reusable components**. System developers would then only need to worry about **creating the specialized knowledge and reasoners** new to the specific task of their systems. This new system would **interoperate with existing systems**, using them to perform some of its reasoning. In this way, **declarative knowledge, problem-solving techniques, and reasoning services could all be shared** between systems. This approach would facilitate building bigger and better systems cheaply. The infrastructure to support such sharing and reuse would lead to greater ubiquity of these systems, potentially transforming the knowledge industry ...”



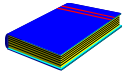
Neches, R.; Fikes, R.; Finin, T.; Gruber, T.; Patil, R.; Senator, T.; Swartout, W.R. *Enabling Technology for Knowledge Sharing*. *AI Magazine*. Winter 1991. 36-56.

Ontological Engineering

**It refers to the set of activities that concern
the ontology development process,
the ontology life cycle,
the methods and methodologies for building ontologies,
and the tool suites
and languages that support them.**

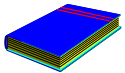
Definitions of Ontologies (I)

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.

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Travel Protégé 3.1 beta (file:/Users/natasha/Library/Mail%20Downloads/Travel.pprj, Protégé Files (.pont and .pins))

Classes Slots Forms Instances Queries

CLASS BROWSER

For Project: ● Travel

Class Hierarchy

- :THING
 - :SYSTEM-CLASS
 - Travel
 - Flight
 - American Airways Flight
 - AA7462
 - AA2010
 - AA0488
 - British Airways Flight
 - Iberia Flight
 - Ship
 - Train Travel
 - Location
 - European Location
 - African Location

Superclasses

- :THING

CLASS EDITOR

For Class: ● Travel (instance of :STANDARD-CLASS)

Name

Travel

Documentation

A journey from place to place

Constraints

◆ No Train from USA to Europe

Role

Concrete ●

Template Slots

Name	Cardinality	Type	Other Facets
arrival Date	required single	Instance of Date	
arrival Place	required single	Instance of Location	
company Name	multiple	String	
departure Date	required single	Instance of Date	
departure Place	required single	Instance of Location	
single Fare	single	Float	
NAME	required single	String	

Definitions of Ontologies (III)

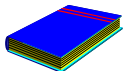
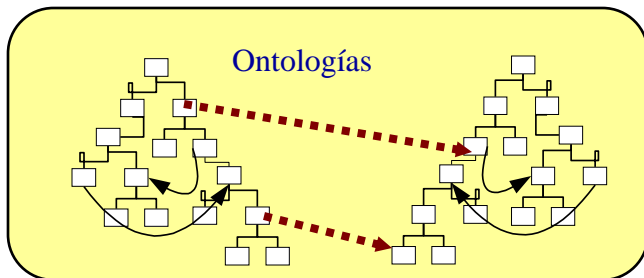
3. “An ontology is a formal, explicit specification of a **shared conceptualization**”

Machine-readable

Consensual
Knowledge

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

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)

Lightweight Ontologies :

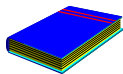
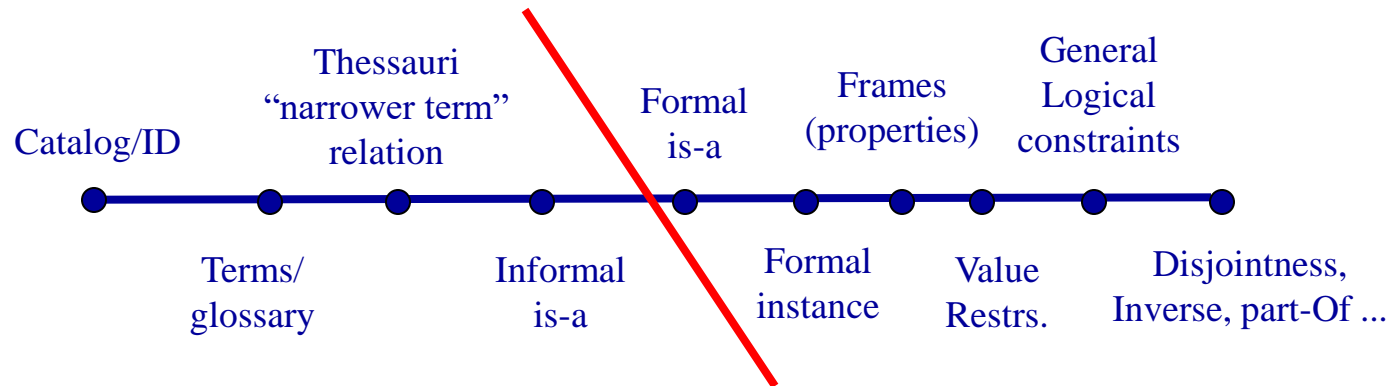
- Include Concepts with properties and Taxonomies
- Do not include Axioms and constraints.

Heavyweight Ontologies :

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

Types of Ontologies

Lassila and McGuinness Classification



Lassila O, McGuinness D. The Role of Frame-Based Representation on the Semantic Web. Technical Report. Knowledge Systems Laboratory. Stanford University. KSL-01-02. 2001.

Components

nouns

round object that is hit or thrown or kicked in games; "the ball travelled 90 mph on his serve"; "the mayor threw out the first ball"; "the ball rolled into the corner pocket"

- Hypernyms (... is kind of)
- Hyponyms (kinds of ...)
- Antonyms (opposites of ...)
- Meronyms (parts of ...)
- Holonyms (... is part of)
- Related Verbs
- Related Adjectives

a solid ball shot by a musket; "they had to carry a ball"

Verb

supported by the lexical reference system: nouns, verbs, and adjectives.

Thus, three different tabs are presented to you. A simple click opens a certain tab, and, meaning, each representing a certain **synset** of the search term. In order to find out which meaning or synset, please click on it. Two things happen:

The meaning gets marked (with red color) and so do the corresponding elements of the sphere, representing a specific synset, becomes marked red, and also all of the edges to synonyms (representing the synset). In addition, the 'meaning' opens its content and pointers associated with the selected part of speech. A click on one of these pointers, explore the broader domain of the selected synset.

SMART THESAURUS MUSIC supports the following lexical relationships:

- [1] Hypernym or broader term (... is a kind of)
- [2] Hyponym or narrower term (kinds of ...)
- [3] Antonym (opposites of ...)
- [4] Meronym (parts of ...)
- [5] Holonym (... is a part of)
- [6] Related verbs
- [7] Related Adjectives

Thesaurus

Id	Category Name	Parent
20000	Water area	1
21000	Environmental area	20000
22000	Fishing Statistical area	20000
24020	Jurisdiction area	20000
21001	Inland/marine	21000
21002	Ocean	21000
21003	North/South/Equatorial	21000
21004	Sub Ocean	21000
21005	Large Marine ecosystem	21000

diccionario de conversión DGN -> EDM.

FORMATO:

Tipo_dgn Entidad Tipo_istram Grupo Código_bcn Cerrado Trato

Tipo_dgn...NNSCCCGG Código_bcn...TTGGSS

NN : Nivel elemento TT : Tema

S : Estilo línea dgn GG : Grupo

CCC : Color línea dgn SS : Subgrupo

GG : Grosor línea dgn

Entidad Tipo_istram...???

104 : polilínea

203 : célula se convierte a símbolo

-1 : célula se explota en sus componentes

304 : rótulo

Grupo

0 : sin determinar

1 : carreteras

2 : hidrografía

3 : conducciones

4 : administrativo

En textos el grupo corresponde a la fuente Microstática

Cerrado en líneas en textos

1 : perimetral n : altura

0 : entidad lineal abierta

-1 : cultivo perimetral

-2 : cultivo línea abierta

Trato

I : Intocable A : Altimetría N : No tratar T : Textos Asociados

S : Textos Suelos C : Cultivo F : Solo salida ! : Tratar Normas

TTGGSS

02000900	104	1	0	090101	1	!	I	Marco de hoja
02300902	104	2	0	100200	0	!	I	Base Geodésica de M
06003900	104	3	0	025102	0	!	I	Acantilado
06006900	104	4	0	025302	0	!	I	Costa rocosa no ac
06009900	104	5	2	037402	1	!	I	Playa fluvial de gu
06012900	104	6	0	025501	1	!	I	Lavas. Contorno
06015900	104	7	0	058303	0	!	I	Dique de hormigón >
06018900	104	8	0	058304	0	!	I	Dique de hormigón <
07013400	104	9	0	058302	0	!	I	Dique de tierra
07016400	104	10	0	055401	1	!	I	vertedero. Contorno
11003003	104	11	1	062202	0	!	I	Autopista. Enlace
11012000	104	12	0	056091	1	!	I	Patio. Contorno
13003300	104	13	1	060101	0	!	I	Autopista. Eje
13303300	104	14	1	060131	0	!	I	Autopista en Contru
14002401	104	15	1	066901	1	!	I	Puesto de S.O.S.
14003301	104	16	1	067901	1	!	I	Peaje
15003003	104	17	1	062204	0	!	I	Autovia. Enlace
15003004	104	18	1	060701	0	!	I	Autovia

Informal is-a

Thesaurus

Formal is-a

Formal instance

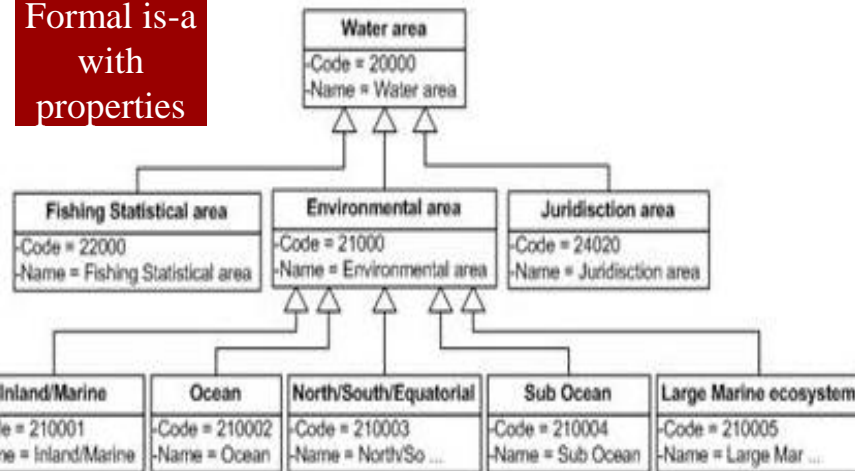
Frames (properties)

Value
Restrs.

General
Logical
constraints

Disjointness,
Inverse, part-Of ...

Formal is-a
with
properties



(define-relation connects (?edge ?source ?target))

"This relation links a source and a target by an edge. The source and destination are considered as spatial points. The relation has the following properties: symmetry and irreflexivity."

:def (and (SpatialPoint ?source)

(SpatialPoint ?target)

(Edge ?edge))

:axiom-def

((=> (connects ?edge ?source ?target)

(connects ?edge ?target ?source)) ;symmetry

(=> (connects ?edge ?source ?target)

(not (or (part-of ?source ?target) ;irreflexivity
(part-of ?target ?source))))))

General
Logical
constraints

(define-class Travel (?travel)

"A journey from place to place"

:axiom-def

(and (Superclass-Of Travel Flight)

(Template-Facet-Value Cardinality
arrivalDate Travel 1)

(Template-Facet-Value Cardinality
departureDate Travel 1)

(Template-Facet-Value Maximum-Cardinality
singleFare Travel 1))

:def

(and (arrivalDate ?travel Date)

(departureDate ?travel Date)

(singleFare ?travel Number)

(companyName ?travel String)))

Value
Restrs.

(define-class AmericanAirlinesFlight (?X)

:def (Flight ?X)

:axiom-def

(Disjoint-Decomposition AmericanAirlinesFlight
(Setof AA7462 AA2010 AA0488)))

(define-class Location (?X)

:axiom-def

(Partition Location

(Setof EuropeanLocation NorthAmericanLocation
SouthAmericanLocation AsianLocation
AfricanLocation AustralianLocation
AntarcticLocation)))

Disjointness

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Components of an Ontology

Concepts are organized in **taxonomies**

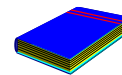
Relations $R: C_1 \times C_2 \times \dots \times C_{n-1} \times C_n$

Subclass-of: Concept 1 x Concept2
Connected to: Component1 x Component2

Functions $F: C_1 \times C_2 \times \dots \times C_{n-1} \rightarrow C_n$

Mother-of: Person \rightarrow Women
Price of a used car: Model x Year x Kilometers \rightarrow Price

Instances **Elements**

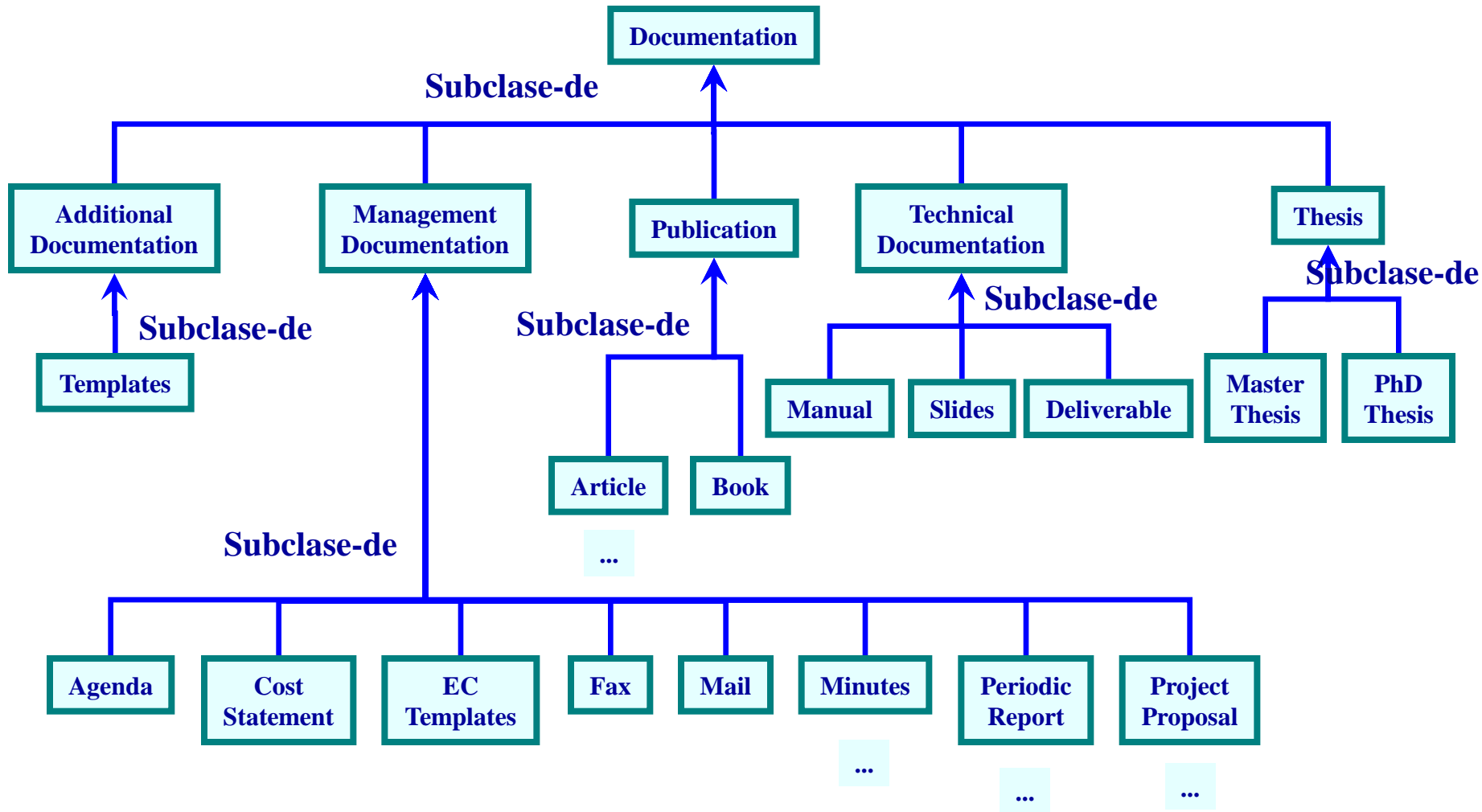


Gruber, T. A translation Approach to portable
ontology specifications. **Knowledge Acquisition.**

Axioms **Sentences which are always true**

Vol. 5. 1993. 199-220.

Documentation Taxonomy



Modelling disjoint knowledge



class-Partition: a set of disjoint classes

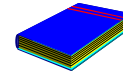
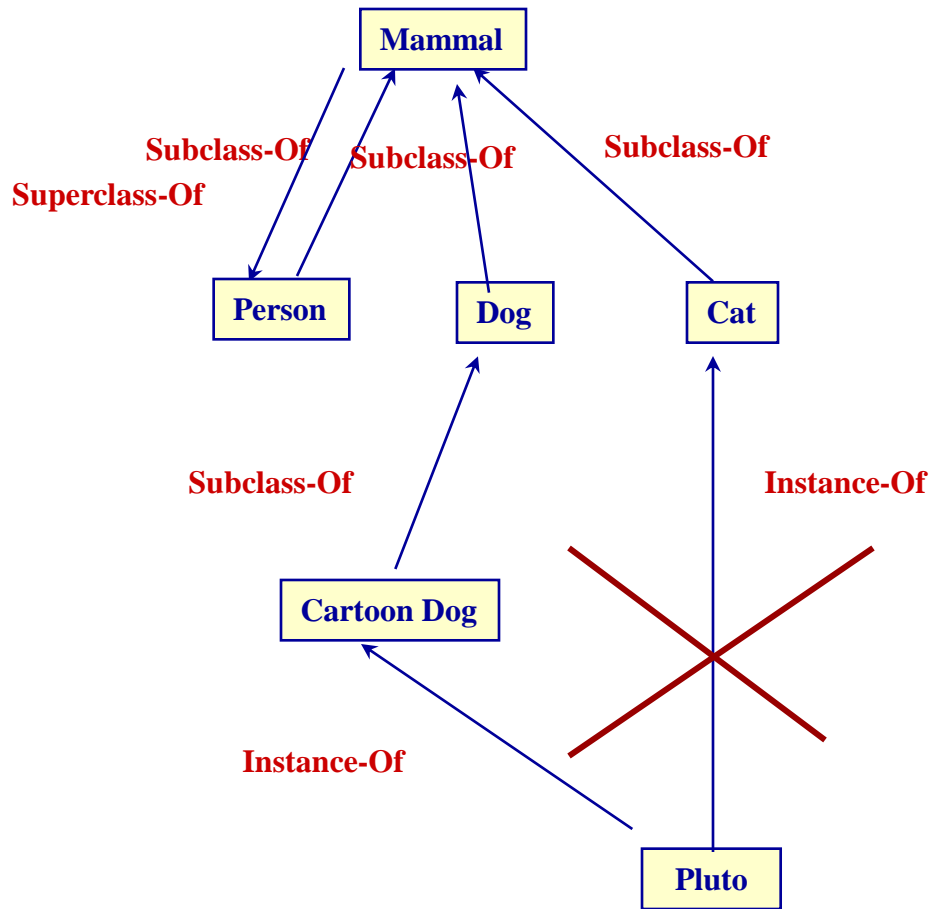


Disjoint: Defines the set of classes in the partition as subclasses of the parent class.
This classification does not necessarily to be complete.



Exhaustive-Disjoint: Defines the set of classes in the partition as subclasses of the parent class.
This classification is complete.

Why disjoint knowledge is important (I)



A. Gómez-Pérez. *Evaluation of Ontologies*.
International Journal of Intelligent Systems.
Vol. 16, Nº3. March 2001. PP391-410

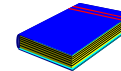
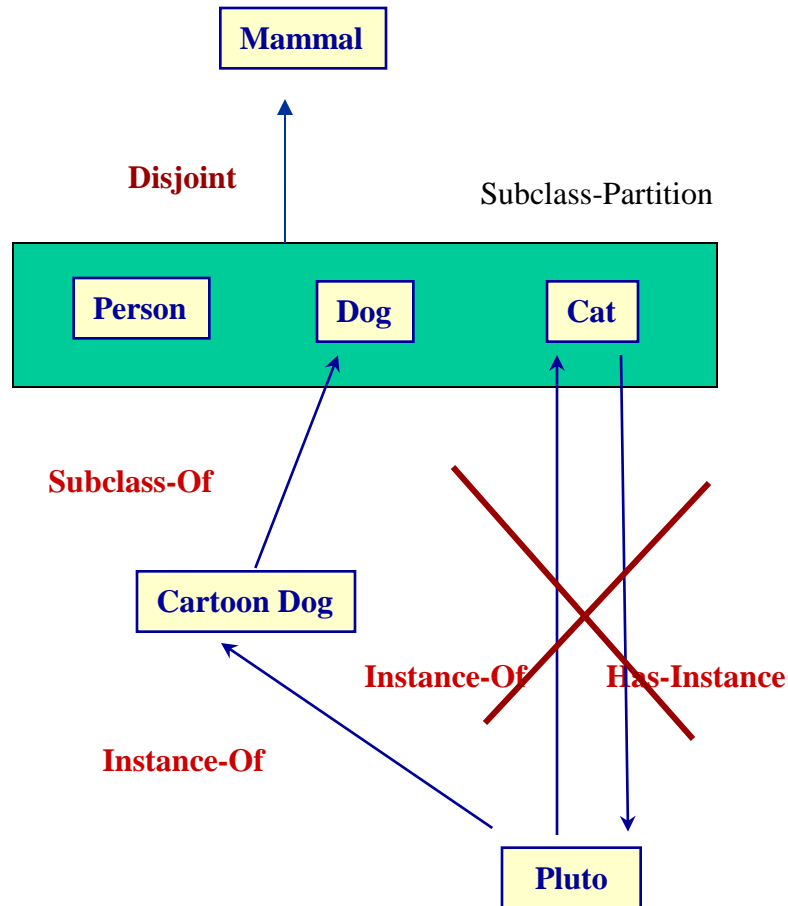


Pluto could be an instance of cat and dog



Semantic Error

Why disjoint knowledge is important (II)

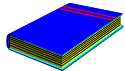
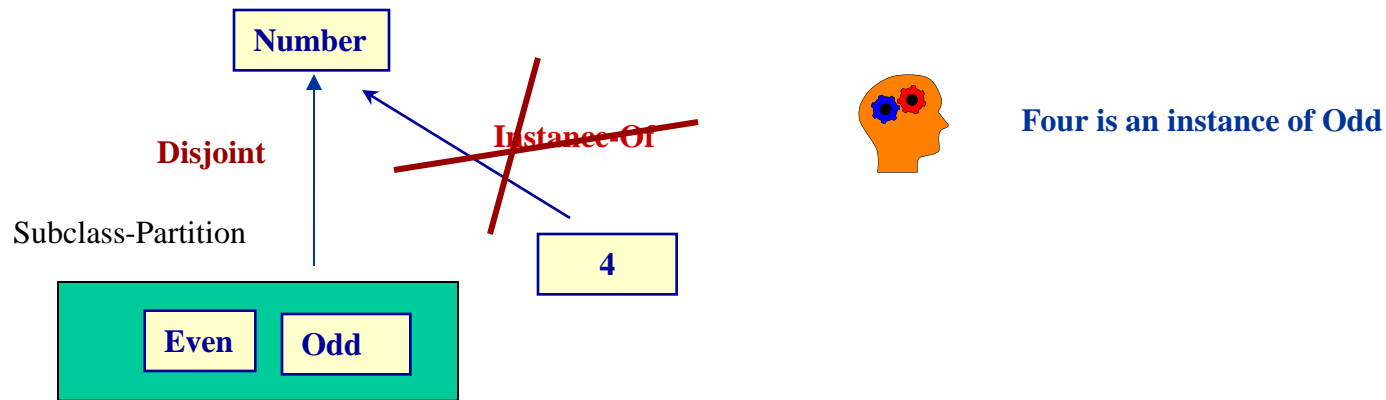


A. Gómez-Pérez. *Evaluation of Ontologies*.
International Journal of Intelligent Systems.
Vol. 16, Nº3. March 2001. PP391-410



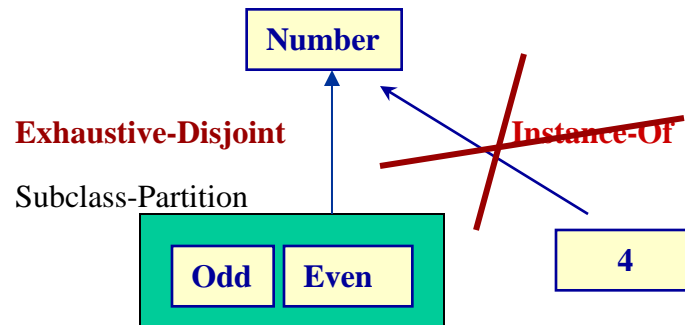
Pluto can not be simultaneously a class of **Cat** and **Dog** because they are disjoint

Why disjoint knowledge is important (III)



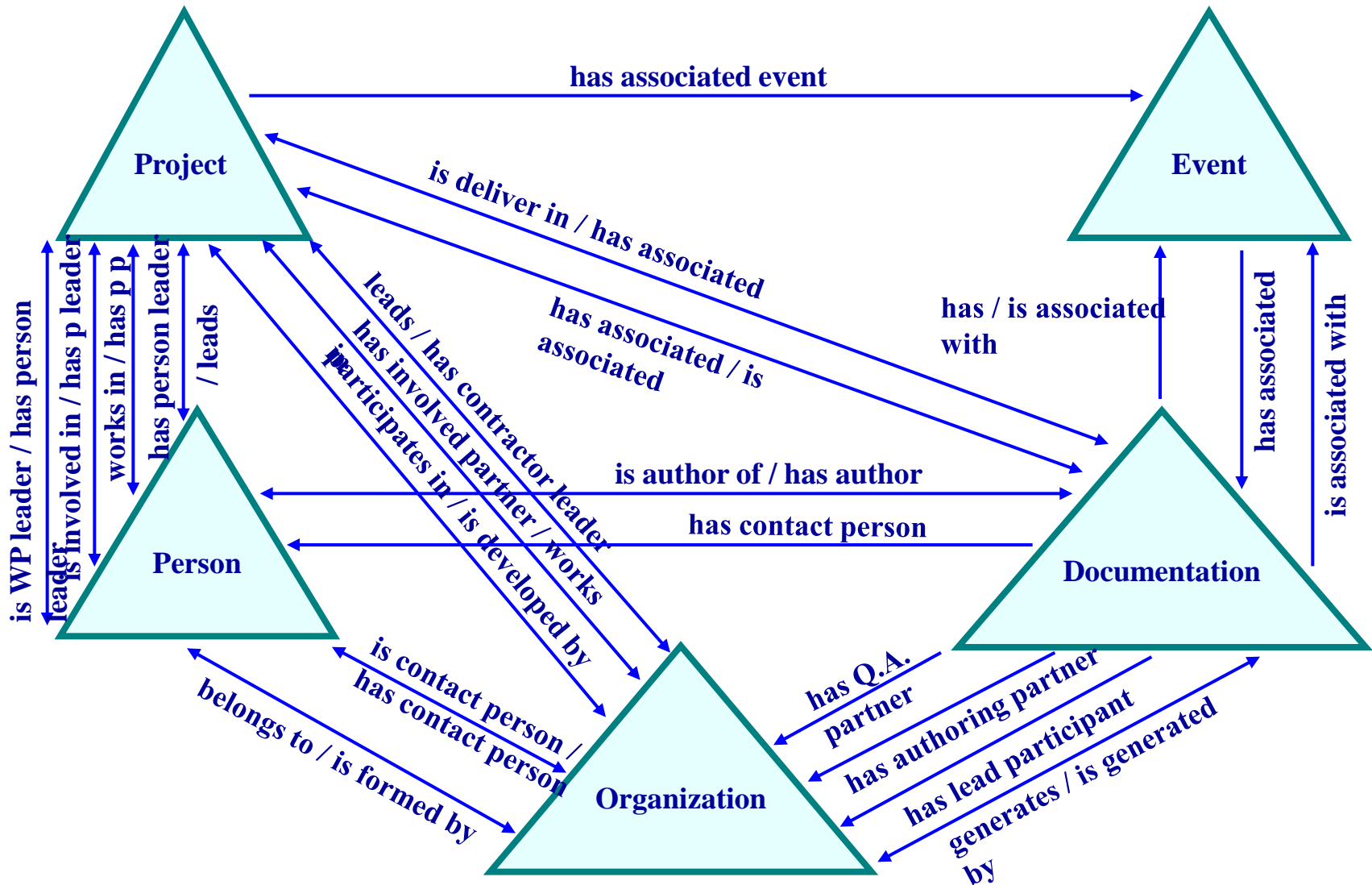
A. Gómez-Pérez. *Evaluation of Ontologies*. **International Journal of Intelligent Systems**. Vol. 16, N°3. March 2001. PP391-410

Why disjoint knowledge is important (IV)

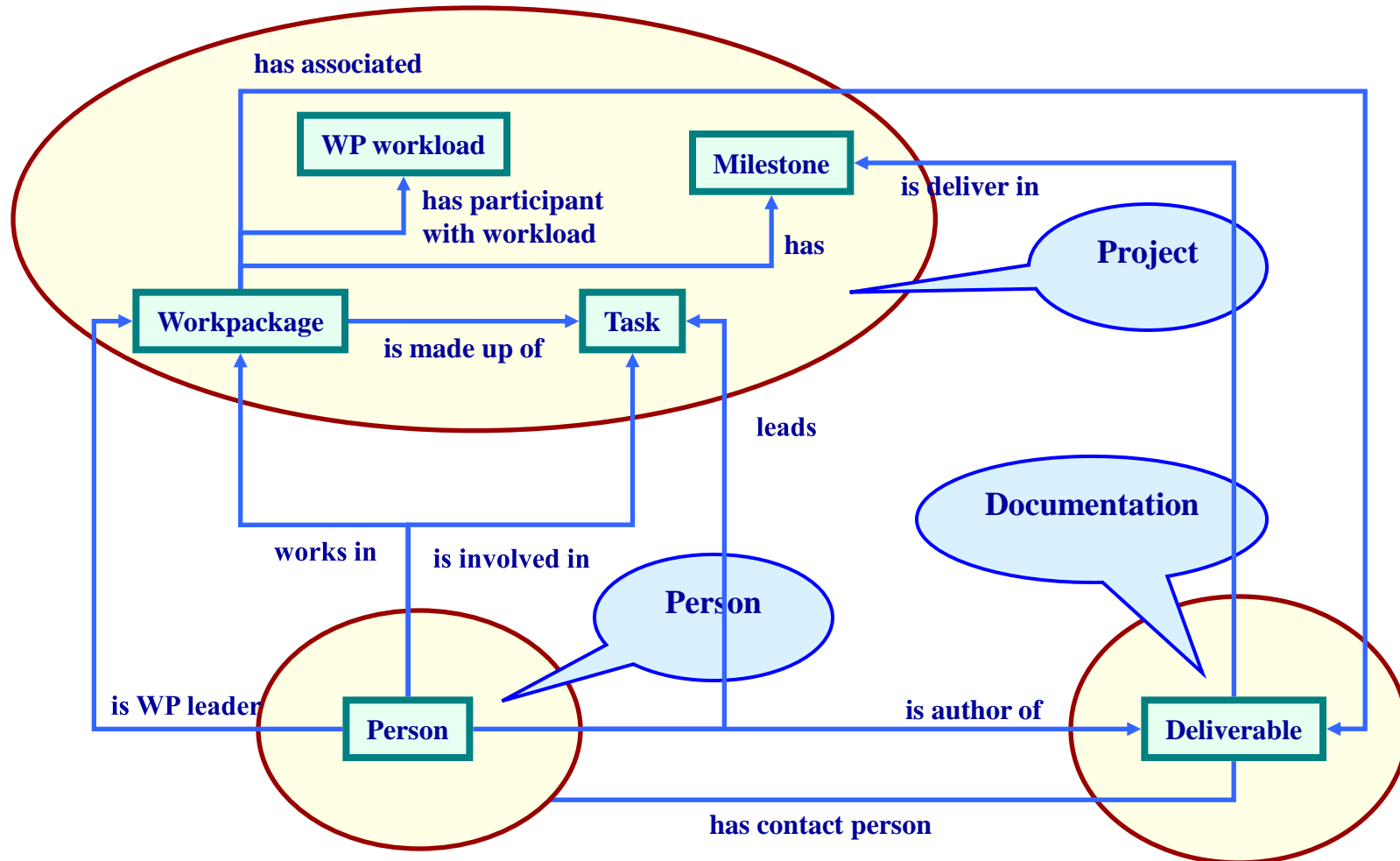


Four is an instance of **something** in the partition

Relations between concepts



Relationships between Person, Project and Documentation



Properties

Travel Protégé 3.1 beta (file:/Users/natasha/Library/Mail%20Downloads/Travel.pprj, Protégé Files (.pont and .pins))

Classes Slots Forms Instances Queries

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For Project: ● Travel

Class Hierarchy

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 - American Airways Flight
 - AA7462
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 - AA0488
 - British Airways Flight
 - Iberia Flight
 - Ship
 - Train Travel
 - Location
 - European Location
 - African Location

Superclasses

- :THING

CLASS EDITOR

For Class: ● Travel (instance of :STANDARD-CLASS)

Name: Travel

Documentation: A journey from place to place

Constraints: ♦ No Train from USA to Europe

Role: Concrete ●

Template Slots

Name	Cardinality	Type	Other Facets
arrival Date	required single	Instance of Date	
arrival Place	required single	Instance of Location	
company Name	multiple	String	
departure Date	required single	Instance of Date	
departure Place	required single	Instance of Location	
single Fare	single	Float	
:NAME	required single	String	

Example of axioms

```
(define-axiom No-Train-from-USA-to-Europe
  "It is not possible to travel from the USA to Europe by train"
  := (forall (?travel)
      (forall (?city1)
        (forall (?city2)
          (=> (and (Travel ?travel)
                  (arrivalPlace ?travel ?city1)
                  (departurePlace ?travel ?city2)
                  (EuropeanLocation ?city1)
                  (USALocation ?city2))
              (not (TrainTravel ?travel)))))))

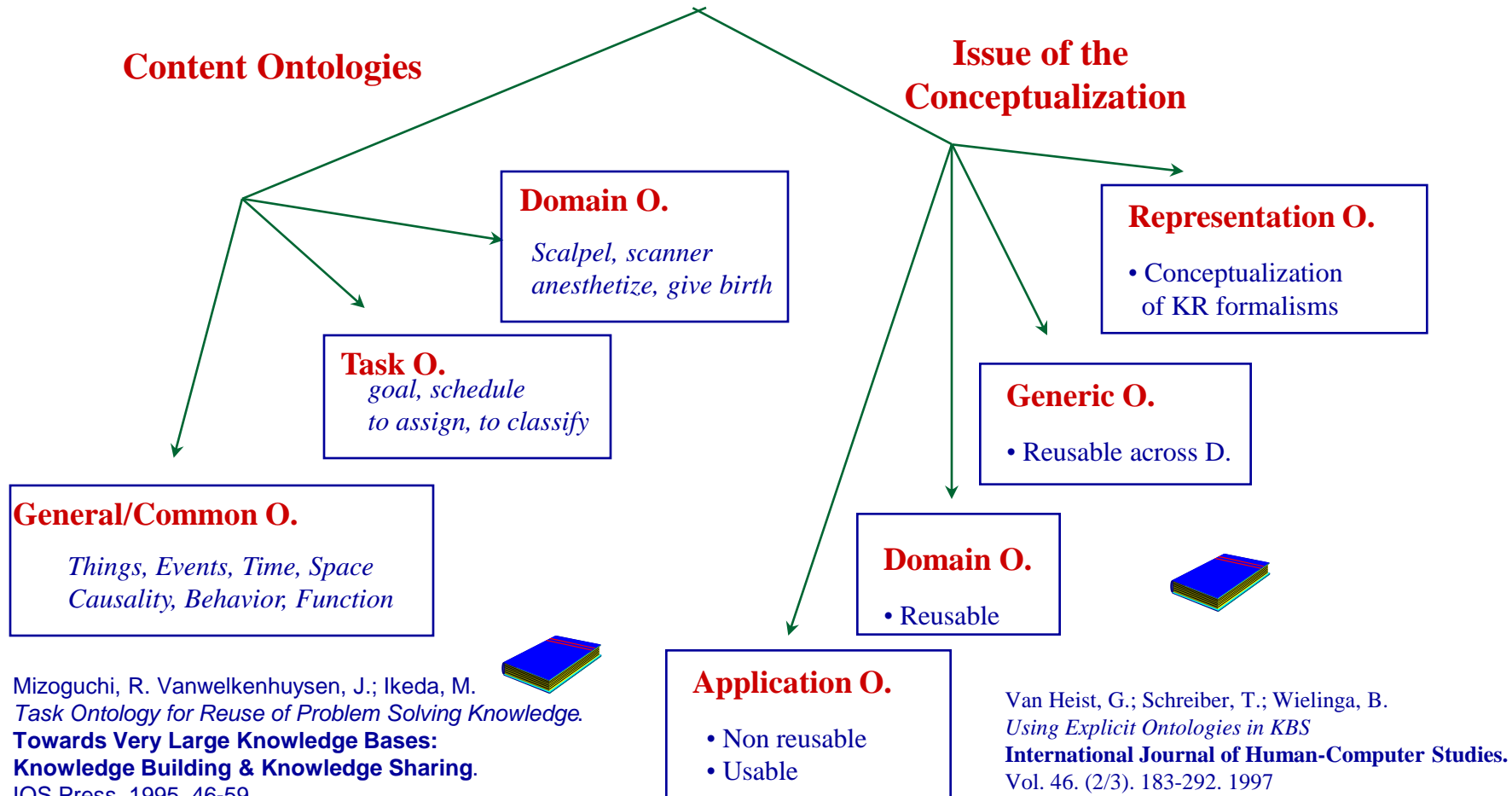
(define-axiom No-Train-between-USA-and-Europe
  "It is not possible to travel by train between the USA and Europe"
  := (forall (?travel)
      (forall (?city1)
        (forall (?city2)
          (=> (and (Travel ?travel)
                  (arrivalPlace ?travel ?city1)
                  (departurePlace ?travel ?city2)
                  (or (and (EuropeanLocation ?city1)
                          (USALocation ?city2))
                      (and (EuropeanLocation ?city2)
                          (USALocation ?city1))))
              (not (TrainTravel ?travel)))))))
```


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Types of Ontologies



Knowledge Representation Ontologies

- The Frame Ontology and the OKBC Ontology

(<http://ontolingua.stanford.edu>)

- RDF and RDF Schema knowledge representation ontologies

(<http://www.w3.org/1999/02/22-rdf-syntax-ns>

<http://www.w3.org/2000/01/rdf-schema>)

- OIL knowledge representation ontology

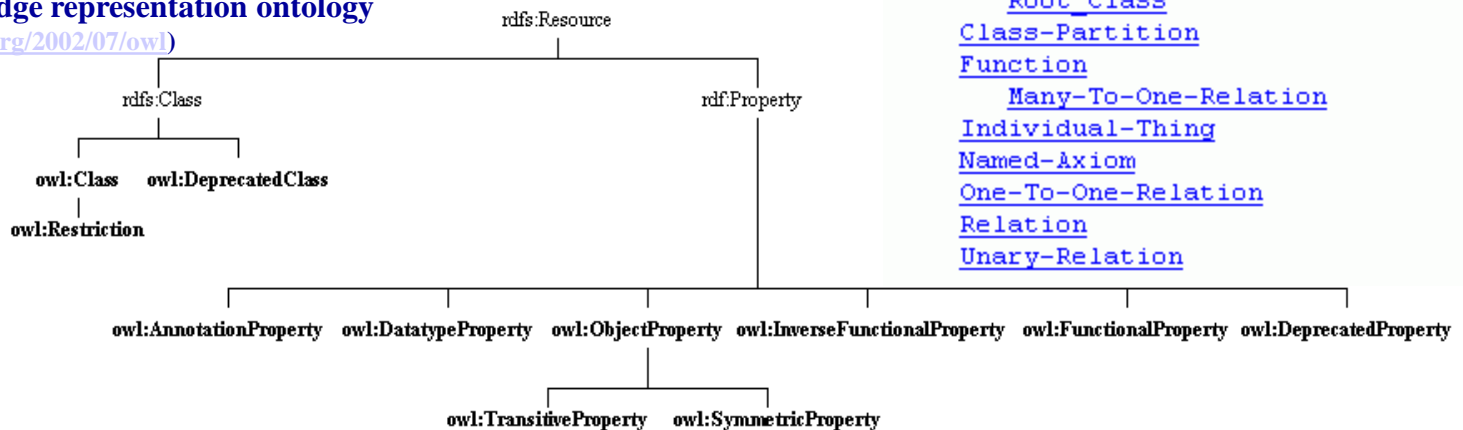
(<http://www.ontoknowledge.org/oil/rdf-schema/2000/11/10-oil-standard>)

- DAML+OIL knowledge representation ontology

(<http://www.daml.org/2001/03/daml+oil>)

- OWL knowledge representation ontology

(<http://www.w3.org/2002/07/owl>)



Class hierarchy (23 classes defined):

Binary-Relation

Antisymmetric-Relation

Asymmetric-Relation

Partial-Order-Relation

Total-Order-Relation

Irreflexive-Relation

Asymmetric-Relation

Many-To-Many-Relation

Many-To-One-Relation

One-To-Many-Relation

Reflexive-Relation

Equivalence-Relation

Partial-Order-Relation ...

Symmetric-Relation

Equivalence-Relation

Transitive-Relation

Equivalence-Relation

Partial-Order-Relation ...

Weak-Transitive-Relation

Class

Root_Class

Class-Partition

Function

Many-To-One-Relation

Individual-Thing

Named-Axiom

One-To-One-Relation

Relation

Unary-Relation

Definition of the relation **SUBCLASS-OF** in the Frame Ontology

(define-relation Subclass-Of (?child-class ?parent-class)

"Class C is a subclass of parent class P if and only if every instance of C is also an instance of P. A class may have multiple superclasses and subclasses. Subclass-of is transitive: if (subclass-of C1 C2) and (subclass-of C2 C3) then (subclass-of C1 C3). Object-centered systems sometimes distinguish between a subclass-of relationship that is asserted and one that is inferred. For example, (subclass-of C1 C3) might be inferred from asserting (subclass-of C1 C2) and (subclass-of C2 C3)..."

:iff-def

```
(and (Class ?parent-class)
      (Class ?child-class)
      (forall (?instance)
        (=> (Instance-Of ?instance ?child-class)
              (Instance-Of ?instance ?parent-class))))
```

:axiom-constraints

(Transitive-Relation Subclass-Of)

:issues

((:see-also direct-subclass-of)

(:see-also "In CycL, subclass-of is called #%allGenls because it is a slot from a collection to all of its generalizations (superclasses)."

"In the KL-ONE literature, subclass relationships are also called subsumption relationships and ISA is sometimes used for subclass-of."

("Why is it called Subclass-of instead of subclass or superclass?"

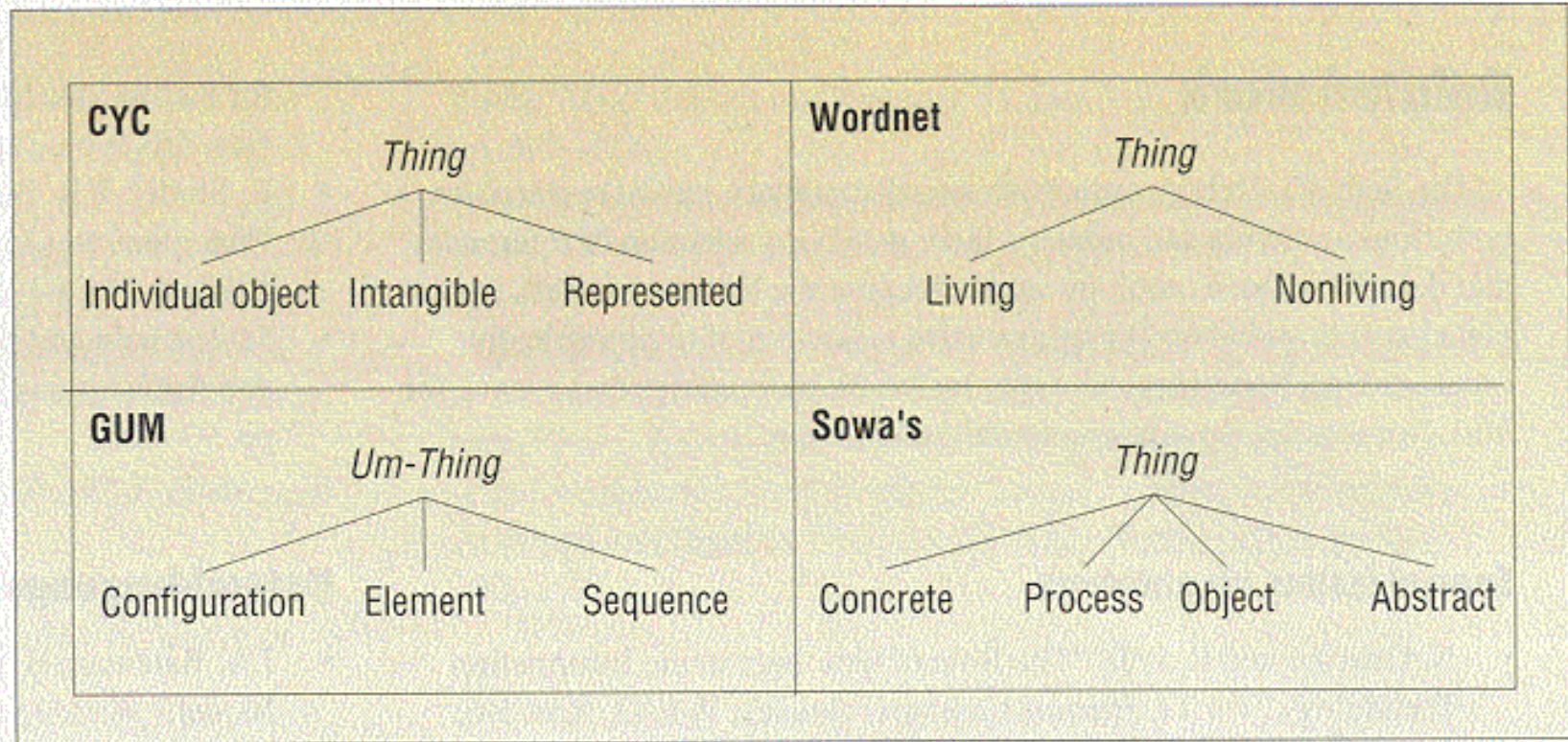
"Because the latter are ambiguous about the order of their arguments. We are following the naming convention that a binary relationship is read as an English sentence 'Domain-element Relation-name Range-value'. Thus, 'person subclass-of animal' rather than 'person superclass animal'."))



<http://www.ksl.stanford.edu>

One Unique Top-Level Ontology?

Various proposals



Domain Ontologies: e-Commerce Ontologies

- The United Nations Standard Products and Services Codes (UNSPSC)

(<http://www.unspsc.org/>)

- NAICS (North American Industry Classification System)

(<http://www.census.gov/epcd/www/naics.html>)

- SCTG (Standard Classification of Transported Goods)

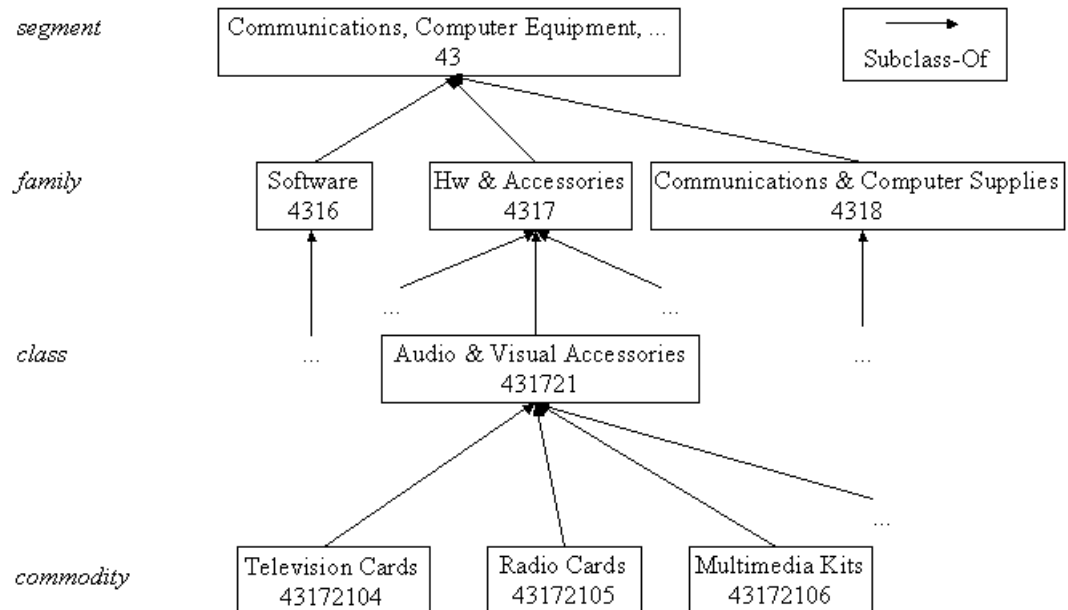
(<http://www.statcan.ca/english/Subjects/Standard/sctg/sctg-menu.htm>)

- E-cl@ss

(<http://www.eclasse.de/>)

- RosettaNet

(<http://www.rosettaneet.org/>)



Domain Ontologies: Medical Ontologies

- GALEN (<http://www.opengalen.org/>)



Rector AL, Bechhofer S, Goble CA, Horrocks I, Nowlan WA, Solomon WD (1997) *The GRAIL concept modelling language for medical terminology*. Artificial Intelligence in Medicine 9:139–171

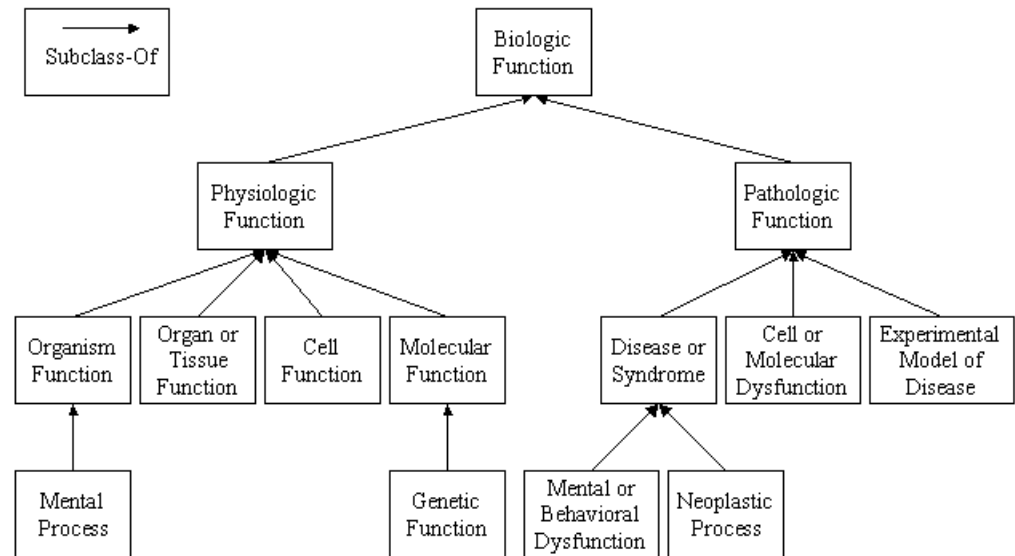
- UMLS (Unified Medical Language System)

(<http://www.nih.gov/research/umls/>)

- ON9 (<http://saussure.irmkant.rm.cnr.it/ON9/index.html>)



Gangemi A, Pisanelli DM, Steve G (1998) *Some Requirements and Experiences in Engineering Terminological Ontologies over the WWW*. In: Gaines BR, Musen MA (eds) 11th International Workshop on Knowledge Acquisition, Modeling and Management (KAW'98). Banff, Canada, SHARE10:1–20

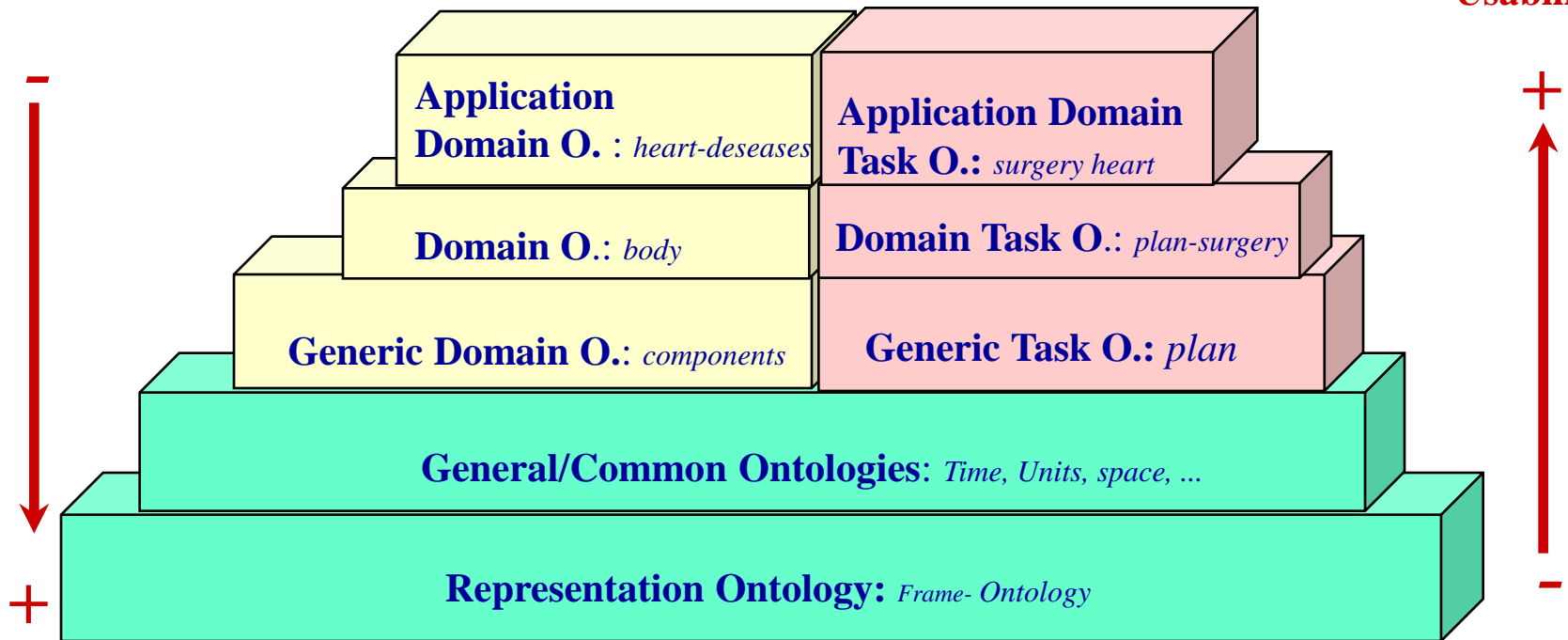


Libraries of Ontologies

Example library

Reusability

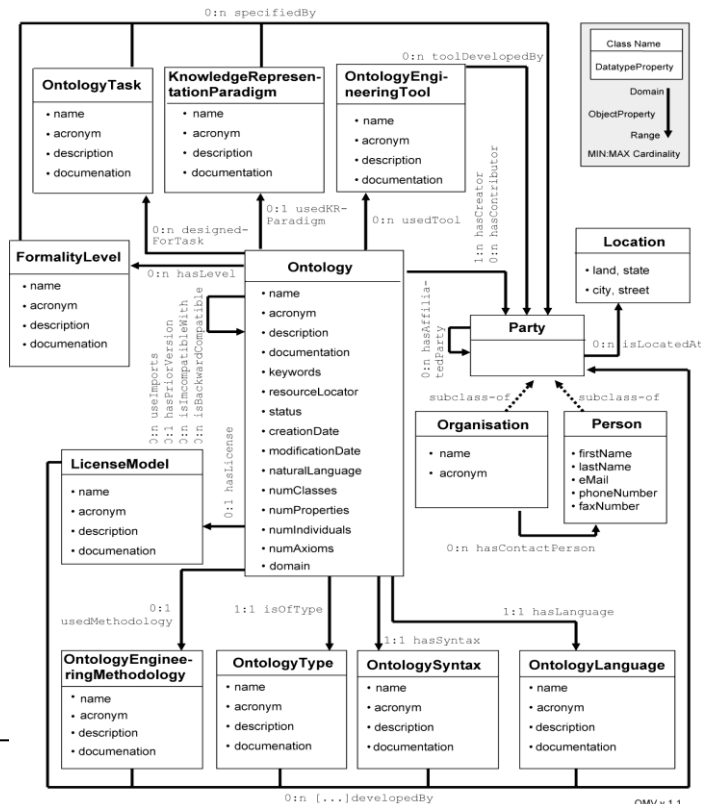
Usability



<http://delicias.dia.fi.upm.es/mirror-server/ont-serv.html>

Searching Ontologies

• OMV: Ontology Metadata Vocabulary



• Ontology registries





watson

exploring the semantic web

[What is it?](#) - [Submit URI](#) - [Website](#) - [Blog](#) - [Mailing List](#)
 [Search Options](#)

[What is it?](#) - [Submit URI](#) - [Website](#) - [Blog](#)

 Found 292 semantic documents - [Search Options](#)

[What is it?](#) - [Submit URI](#) - [Website](#) - [Blog](#) - [Mailing List](#)

 Found 292 semantic documents - [Search Options](#)

- <http://www.hyphen.info/RDF/RAE/rae-uoa16-publications.rdf>
 - http://www.hero.ac.uk/rae/#Journal-meat_science:1999
 - http://www.hero.ac.uk/rae/#Journal-meat_science:1998
 - http://www.hero.ac.uk/rae/#Journal-meat_science:2000
 - http://www.hero.ac.uk/rae/#Journal-meat_science:1997
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 - http://www.hero.ac.uk/rae/#Journal-meat_science:1996
 - http://www.hero.ac.uk/rae/#Journal-meat_science:2000 [More...](#)
- <http://secse.atosorigin.es:10000/ontologies/cyc.owl>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Chicken-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Goose-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Duck-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#CornishHen-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Turkey-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Poultry-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#KosherUtensil-Meat>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#GroundBeef>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Mutton>
 - <http://paoli.open.ac.uk/watson-cache/5/4b6/466d/b79a5/f1f2298c82/d30800bfaeff211a#Beef> [More...](#)

<http://www.ars.com/2003/04/01/ars>

- <http://neuroscientific.net/bio-zen.owl>
 - <http://www.loa-cnr.it/ontologies/DOLCE-Lite#amount-of-matter>
- <http://www.hyphen.info/RDF/RAE/rae-uoa44-publications.rdf>
 - <http://www.hero.ac.uk/rae/#H-0153:UoA-44:Id-219109:PubNum-4>
- <http://ontologyportal.org/translations/SUMO.owl.txt>
 - <http://kmi-web05.open.ac.uk:81/cache/0/339/c2ff21d76/1013cd189c/557c6d296bdc6957c#Meat>
 - <http://kmi-web05.open.ac.uk:81/cache/0/339/c2ff21d76/1013cd189c/557c6d296bdc6957c#Beverage>
- <http://reliant.tekknowledge.com/DAML/SUMO.daml>
 - <http://kmi-web05.open.ac.uk:81/cache/1/f5d/857a/f0cae/8b96c6b3ac/1e19b0c5cf7f2a849#Meat>
 - <http://kmi-web05.open.ac.uk:81/cache/1/f5d/857a/f0cae/8b96c6b3ac/1e19b0c5cf7f2a849#Beverage>
- <http://reliant.tekknowledge.com/DAML/SUMO.owl>
 - <http://kmi-web05.open.ac.uk:81/cache/c/7a4/11d2/d58c5/c6f902b40b/2bdd54d158be86601#Meat>
 - <http://kmi-web05.open.ac.uk:81/cache/c/7a4/11d2/d58c5/c6f902b40b/2bdd54d158be86601#Beverage>
- <http://www.ling.helsinki.fi/kit/2004k/ct310seml/Owl/wine.daml.rdf>
 - <http://potato.cs.man.ac.uk/ontologies/booze#MEAT>
 - <http://potato.cs.man.ac.uk/ontologies/booze#RED-MEAT>

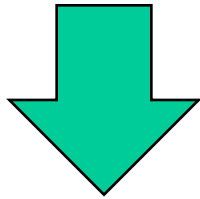
Label: RED-MEAT

Comment:

 - <http://potato.cs.man.ac.uk/ontologies/booze#LIGHT-MEAT-FOWL>

What is an Ontology?

Shared understanding of a domain



Repository of vocabulary

- Formal definitions
- Informal definitions