1. Ontologies

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Ontological Engineering

It refers to the set of activities that concern

the ontology development process,

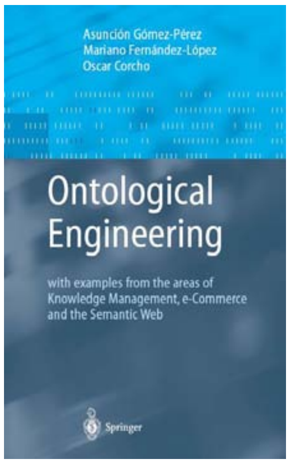
the ontology life cycle,

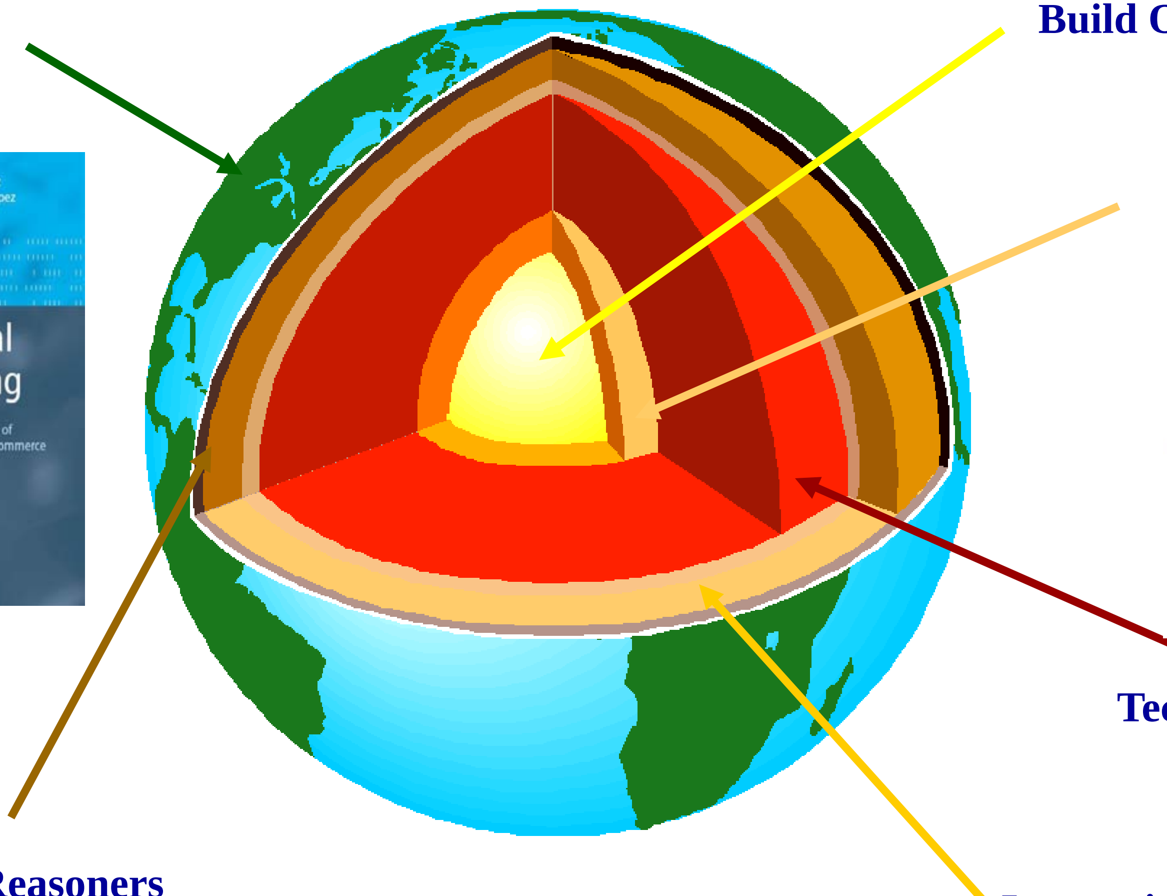
the methods and methodologies for building ontologies,

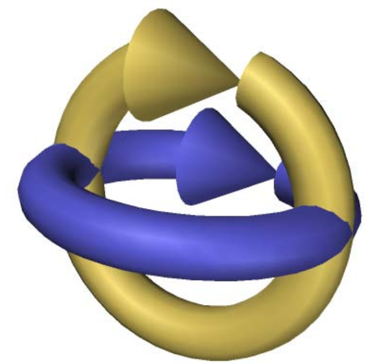
and the tool suites

and languages that support them.

Main Components







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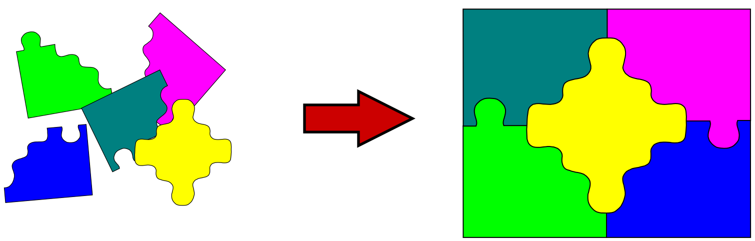
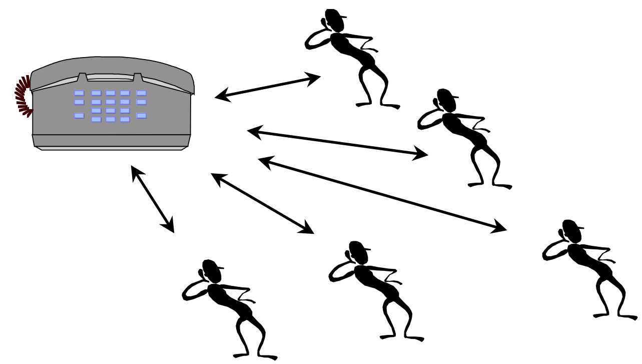
Reuse and Sharing

Reuse means to build new applications assembling components already built



Sharing is when different applications use the some resources



Advantages:

- **Less money**
- **Less time**
- **Less resources**

Areas:

- **Software**
- **Knowledge**
- **Communications**
- **Interfaces**
- **---**

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 infraestructure 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.

Reusable Knowledge Components

Ontologies

Describe domain knowledge in a generic way
and provide agreed understanding of a domain

Problem Solving Methods

Describe the reasoning process of a KBS in
an implementation and domain-independent manner

Interaction Problem

Representing Knowledge for the purpose of solving some problem

is strongly affected by the nature of the problem

and the inference strategy to be applied to the problem [Bylander et al., 88

Bylander Chandrasekaran, B. **Generic Tasks in knowledge-based reasoning.: the right level of abstraction for knowledge acquisition.** In B.R. Gaines and J. H. Boose, EDs *Knowledge Acquisition for Knowledge Based systems*, 65-77, London: Academic Press 1988.

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6. Ontological commitments
7. Ontologies reuse other ontologies
8. Searching ontologies
9. 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)

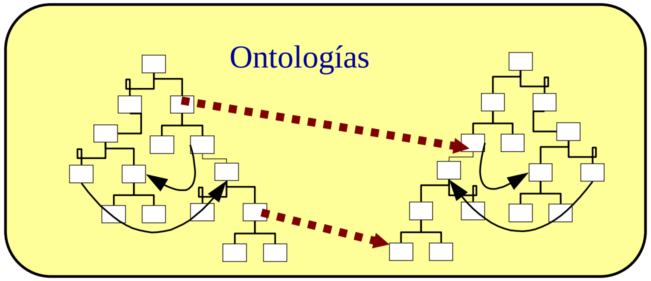
5. "An ontology is a formal, explicit specification of a shared conceptualization"

Machine-readable

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.**

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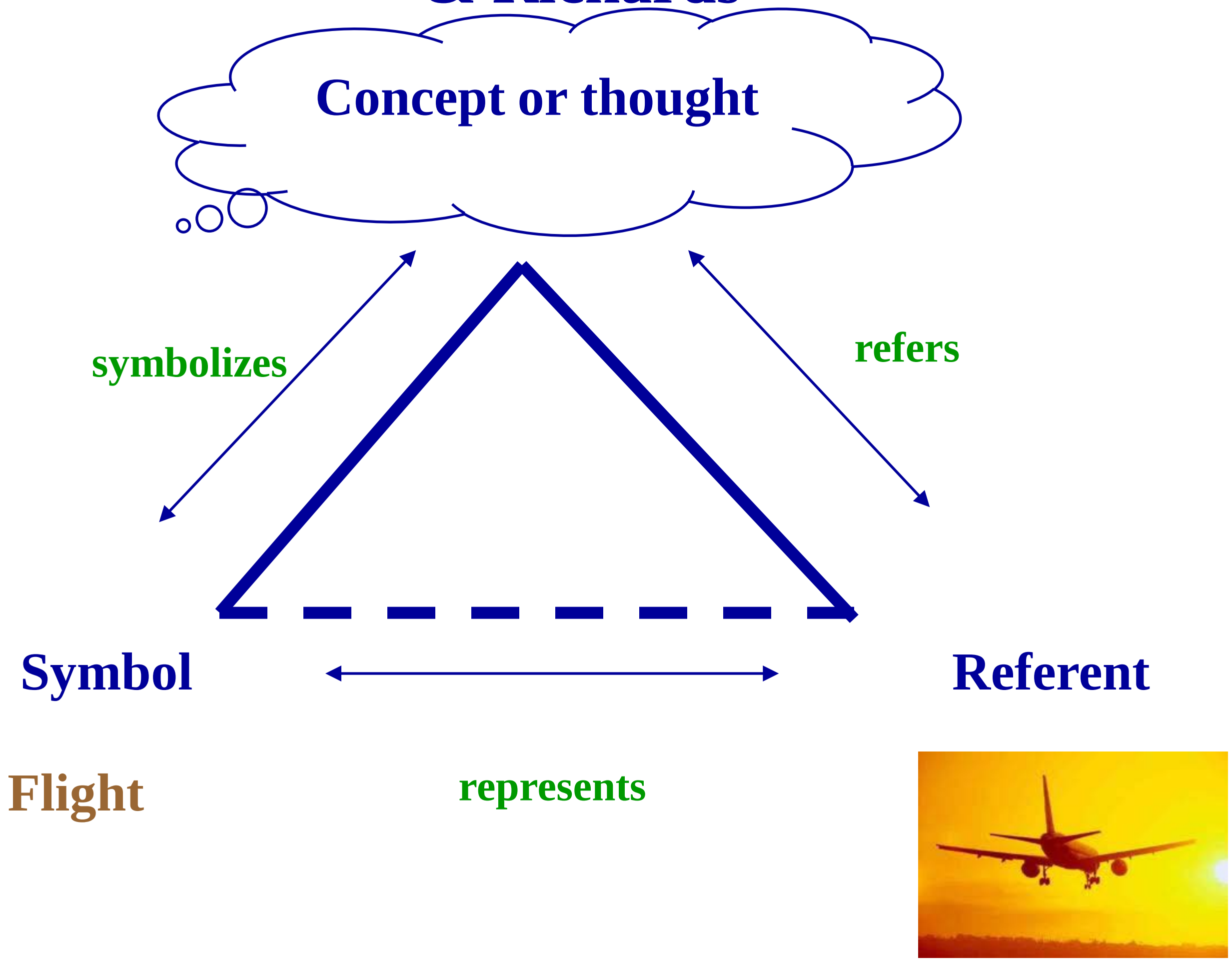
Semantic triangle by Ogden & Richards



A formation of aircraft in flight

A scheduled trip by plane between designated airports

Vuelo	Salida		Llegada	
Iberia IB 545	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 545	Santiago (SCQ), Santiago, España	06:30	Barajas (MAD), Madrid, España	07:35
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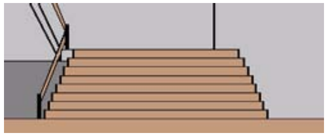
Aces VX 7290	Eldorado (BOG), Bogotá, Colombia	18:00	Rafael Nunez (CTG), Cartagena, Colombia	19:18

An instance of traveling by air

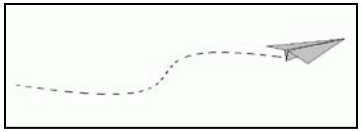
A flock of flying birds

flight

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

Components of an Ontology

Concepts are organized in **taxonomies**

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

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

Functions F: $C_1 \times C_2 \times \ldots \times C_{n-1} \text{-->} C_n$

> **Mother-of: Person --> Women**
> **Price of a used car: Model x Year x Kilometers --> Price**

Instances Elements

Axioms Sentences which are always true

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

Description of a concept

- Concepts are described according to their common features, properties or characteristics, either by intension or extension

- **Intension**
  - Set of characteristics which makes up the concept (ISO 1087-1: 2000)
  - The intension of the concept winter in polar countries includes: low temperatures, ice, wind, snow, etc.

- **Extension**
  - Totality of objects to which a concept corresponds (ISO 1087-1: 2000)
  - The extension of the concept planet includes: *Mercury*, *Venus*, *Earth*, *Mars*, *Jupiter*, *Saturn*, *Uranus*, *Neptune and Pluto.*

Characteristics of a concept

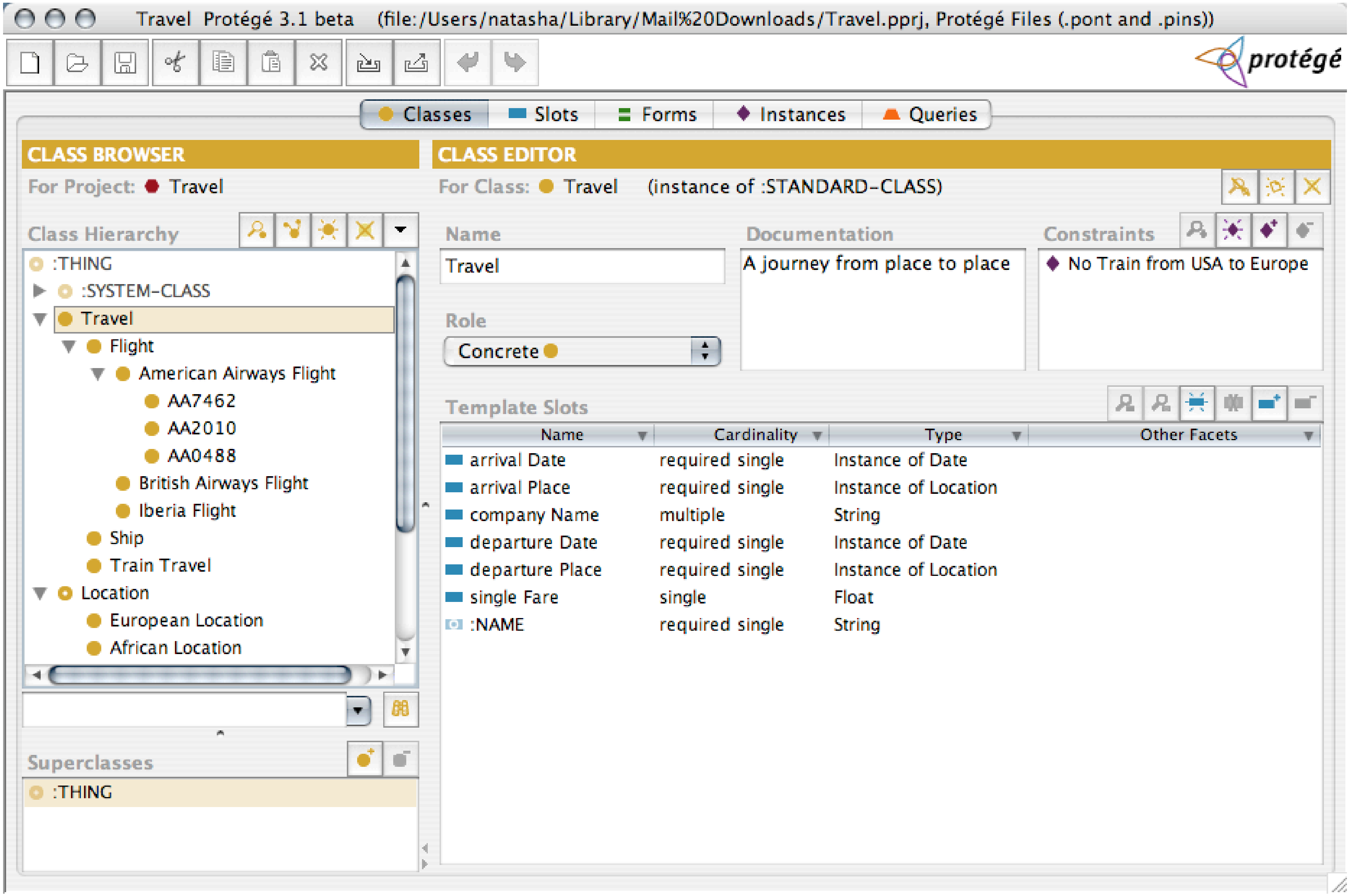
- **According to the importance in forming a concept**
  - **essential**: indispensable to understand and distinguish a concept
    - *The back of a seat distinguishes a stool and a chair.*
  - **complementary**: *colour, material, shape, …*

- a device;
- ivory-coloured;
- hand-manoeuvred along a firm, flat surface;
- has a ball on its underside;
- has three buttons;
- has a wire for connecting to a computer;
- rollers detect the movement of the ball;
- the ball controls the movement of a cursor on a computer display screen.

- a device;
- blue and grey;
- hand-manoeuvred along a firm, flat surface;
- has a ball on its underside;
- has two buttons;
- has a wire for connecting to a computer;
- without rollers;
- the ball controls the movement of a cursor on a computer display screen.

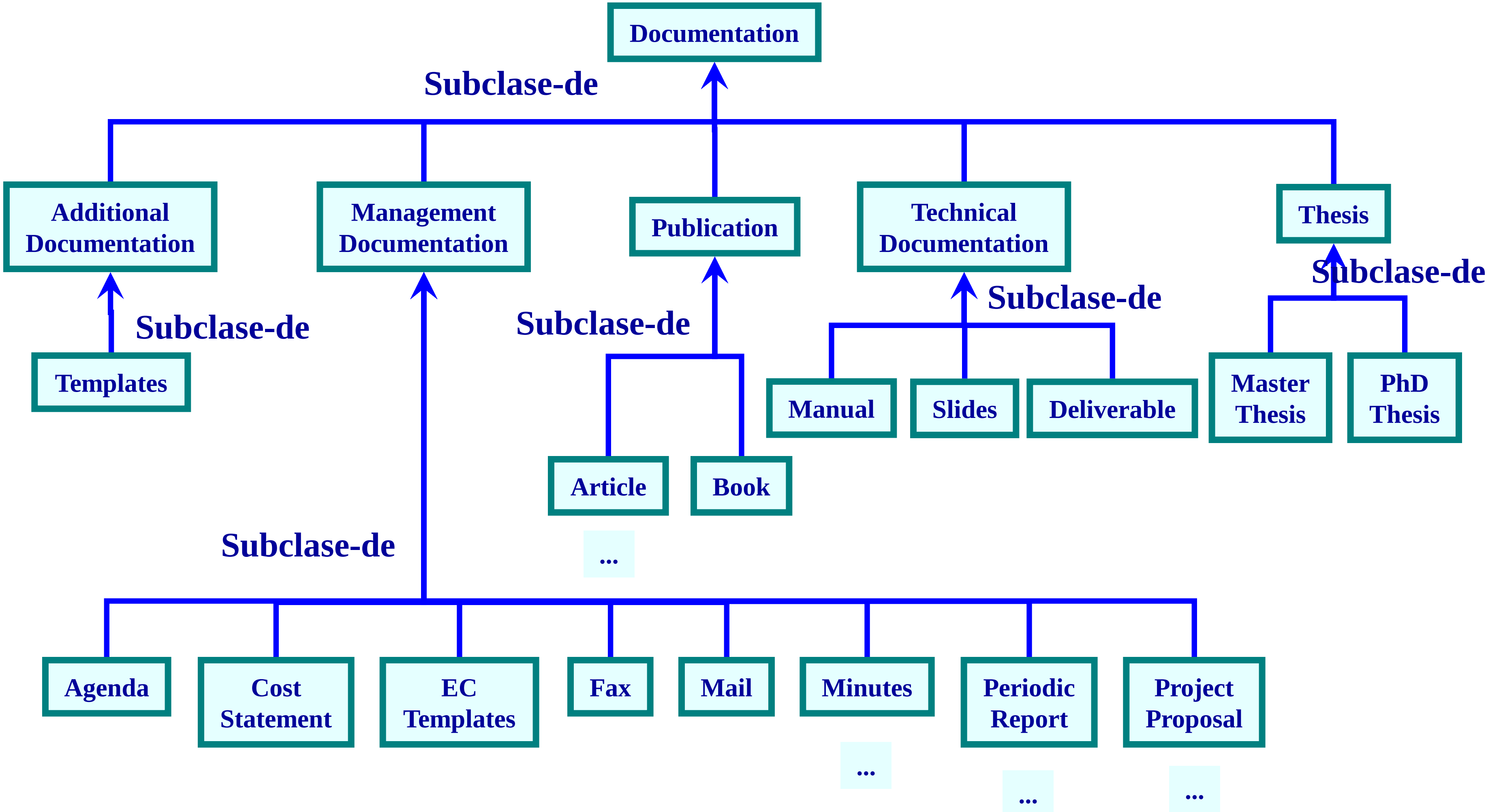
- a device;
- black-grey;
- hand-manoeuvred along a firm, flat surface;
- has a ball on its underside;
- has two buttons;
- has a wire for connecting to a computer;
- rollers detect the movement of the ball;
- the ball controls the movement of a cursor on a computer display screen.

Properties



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

Documentation Taxonomy



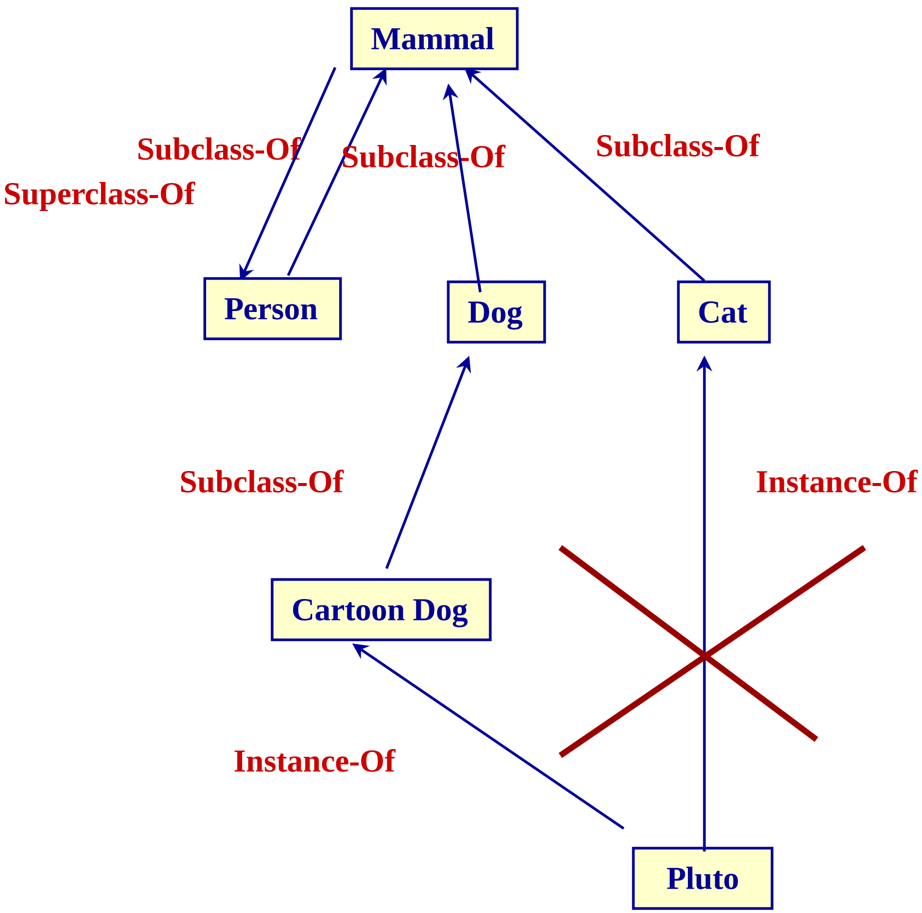
Modelling disjoint knowledge

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)

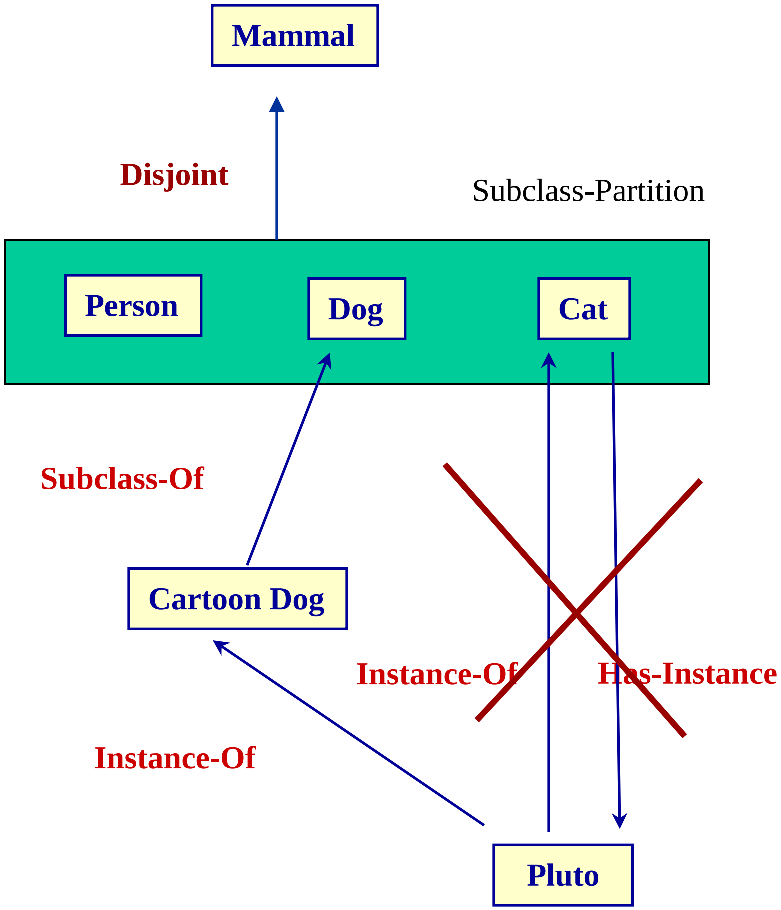


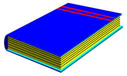
A. Gómez-Pérez. *Evaluation of Ontologies.* **International Journal of Intelligent Systems.** Vol. 16, Nº3. March 2001. PP391-410

Pluto could be an instance of cat and dog

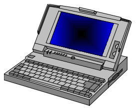
Semantic Error

Why disjoint knowledge is important (II)



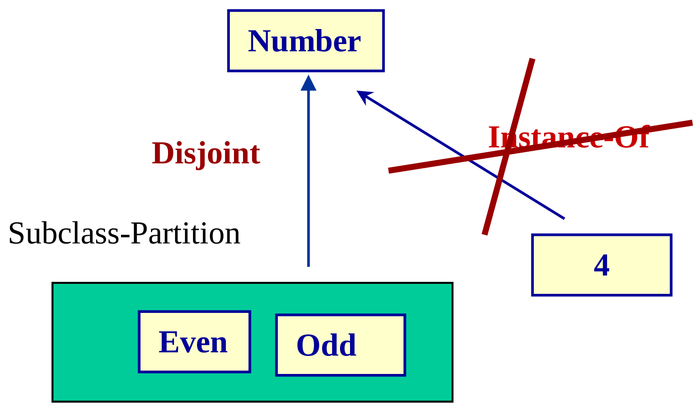


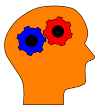
A. Gómez-Pérez. *Evaluation of Ontologies.* **International Journal of Intelligent Systems.** Vol. 16, Nº3. March 2001. PP391-410



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

Why disjoint knowledge is important (III)

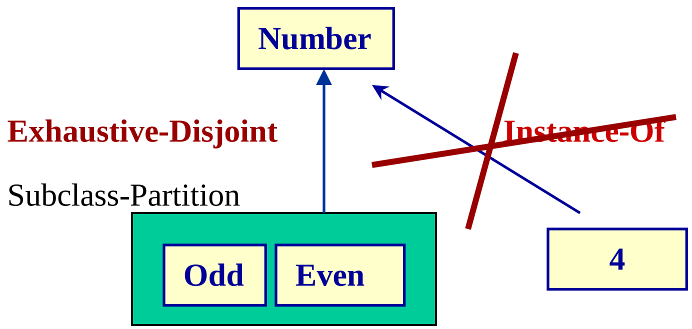


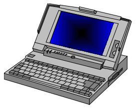


Four is an instance of Odd

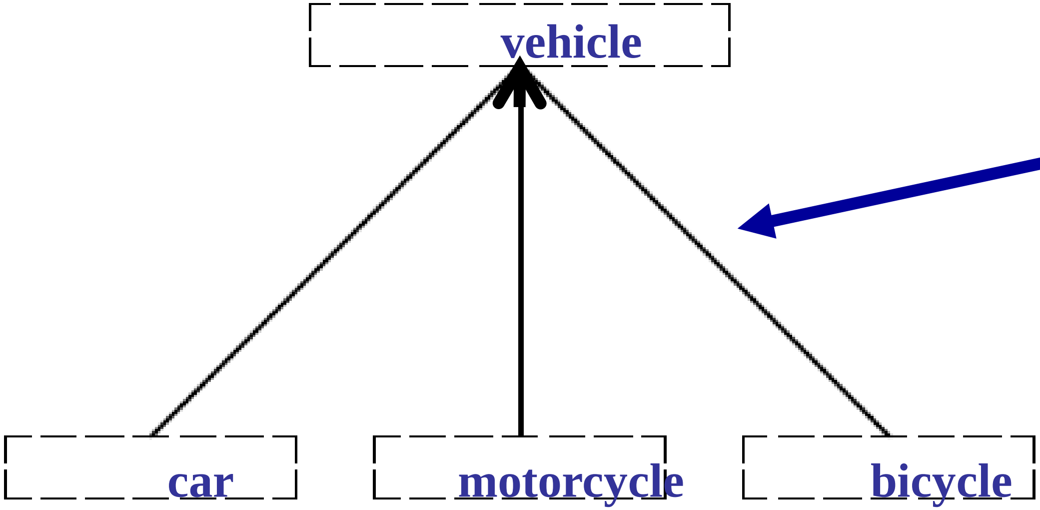
A. Gómez-Pérez. *Evaluation of Ontologies*.**International Journal of Intelligent Systems.** Vol. 16, Nº3. March 2001. PP391-410

Why disjoint knowledge is important (IV)





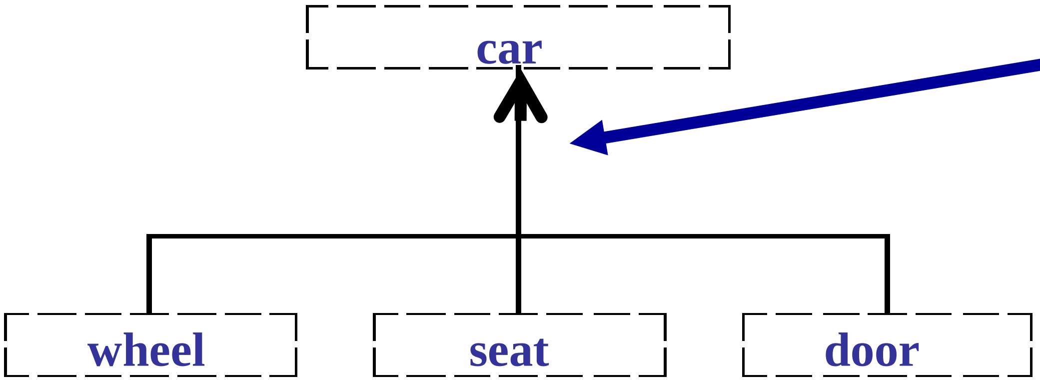
Four is an instance of something in the partition



Tree diagram

Generic concept relations

Subclase de



Rake diagrams

Partitive relations

Parte de

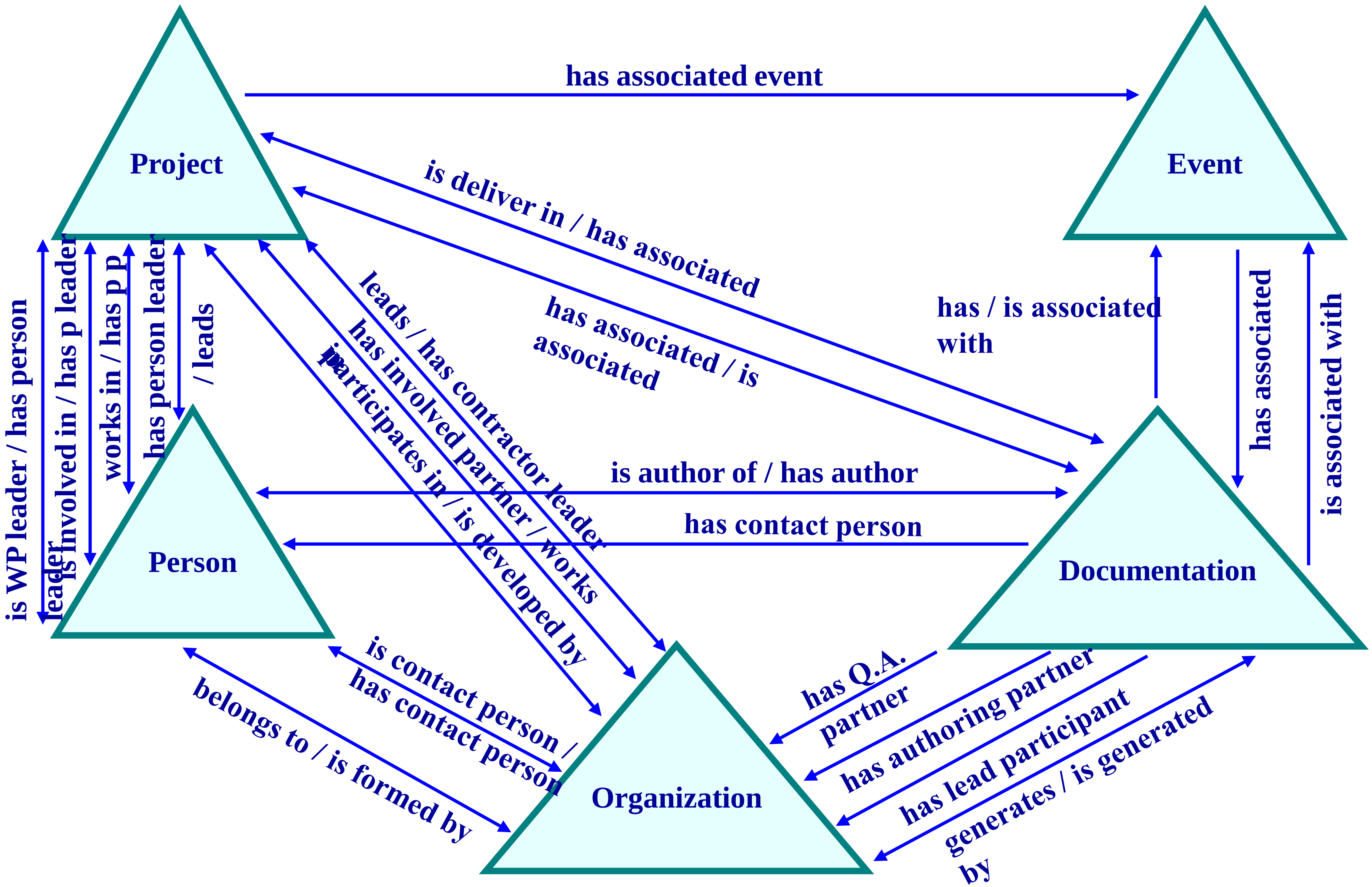
Ejemplos de relaciones Parte de

Relación	Ejemplo
componente - objeto	*pedal - bicicleta*
miembro - colección	*barco - flota*
porción - masa	*rebanada - pan*
material - objeto	*acero - coche*
fase - actividad	*pagar - comprar*
lugar - área	*oasis - desierto*

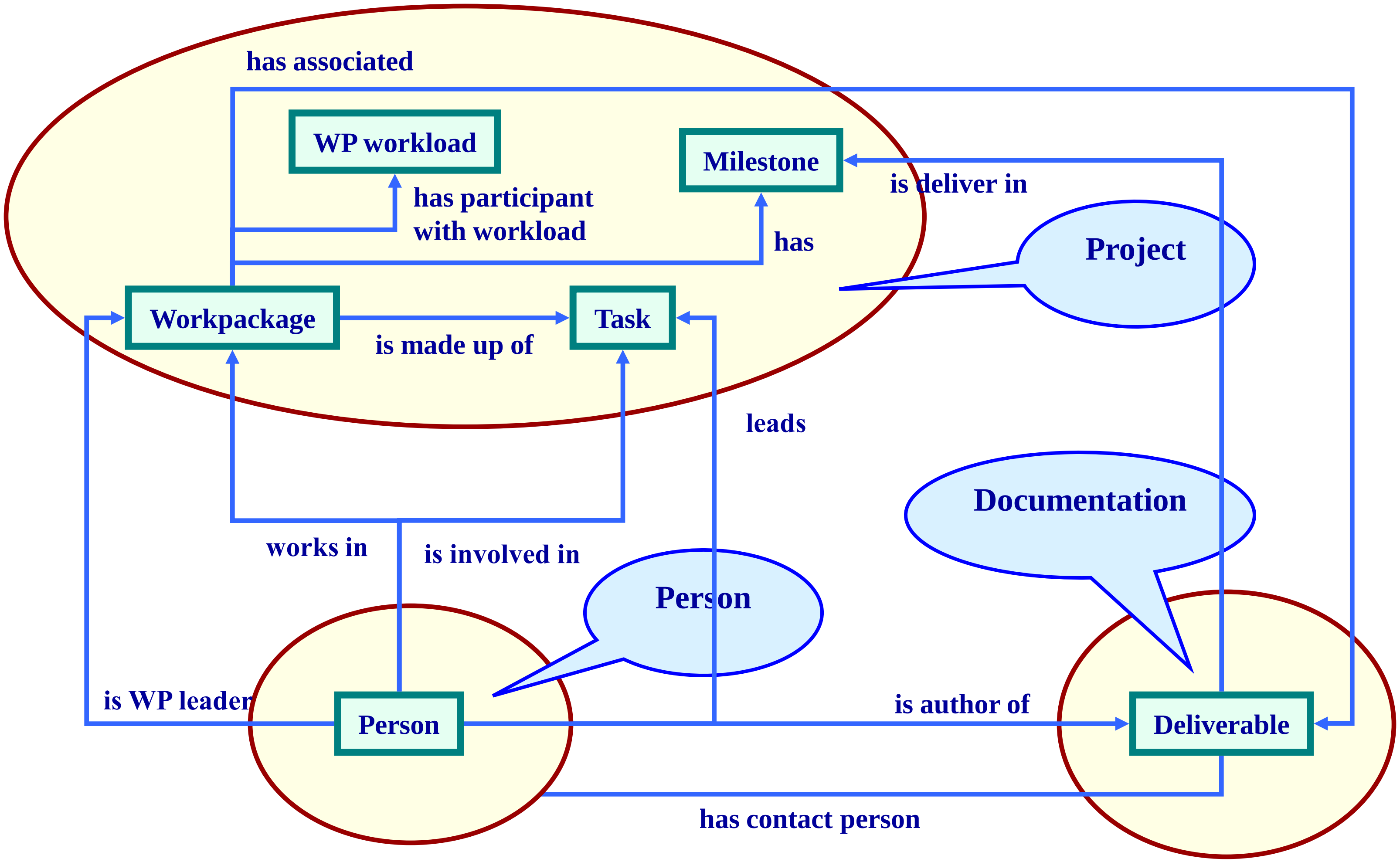
Tabla II.2: Modelo de Winston *et al.* (1987)

Climent, S. 1999 *Individuación e información parte-todo. Representación para el procesamiento computacional del lenguaje*

Relations between concepts



Relationships between Person, Project and Documentation

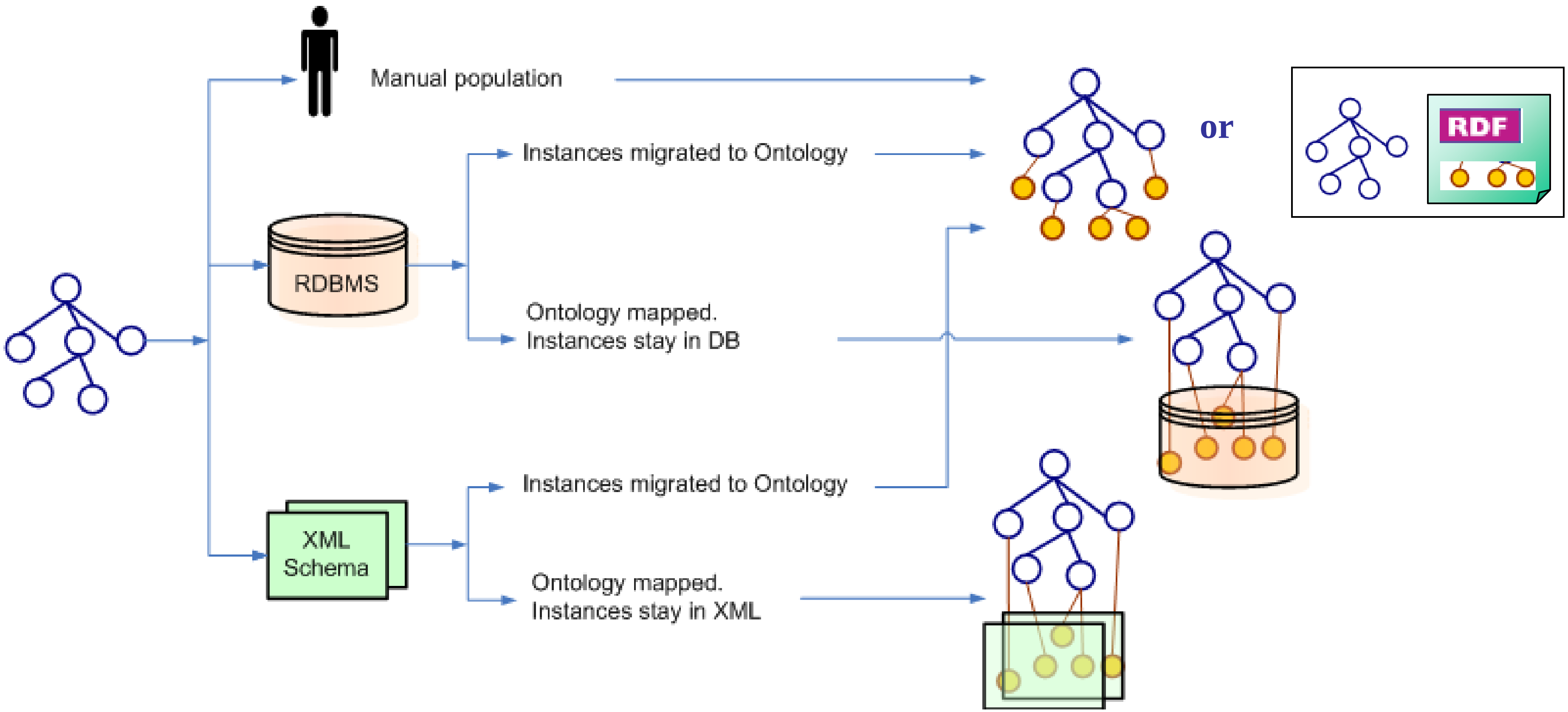


Example of axioms

```
(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)))))))
```

Where are the instances?



Key aspects of Ontological Engineering

- Ontologies
  - Single versus network of ontologies?
  - Are ontologies built from scratch or reusing knowledge-aware resources?
  - Are mappings used for solving conceptual mistmaches?
- Instances
  - Where are the data/instances?
    - Instances are in the ontology
    - Instances are in RDF files independently of the ontology
    - Data are kept in the original sources
  - Are instances distributed or centralized?
  - Have instances a very high rate of changes?
  - Heterogeneous provenance of instances
  - Degrees of data quality
  - Permissions

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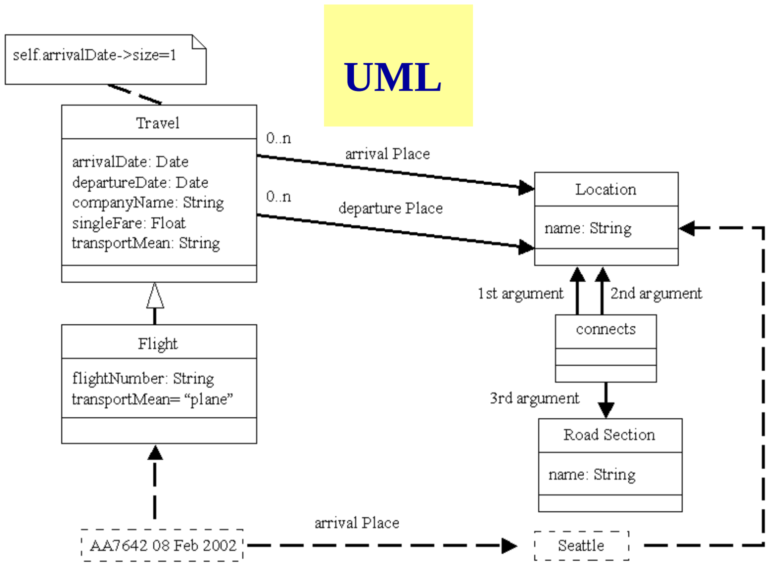
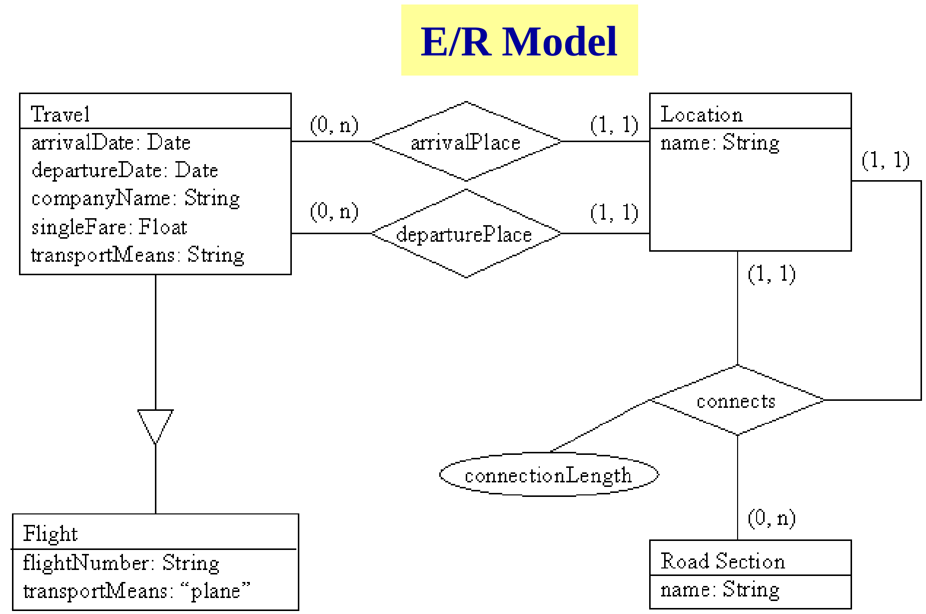
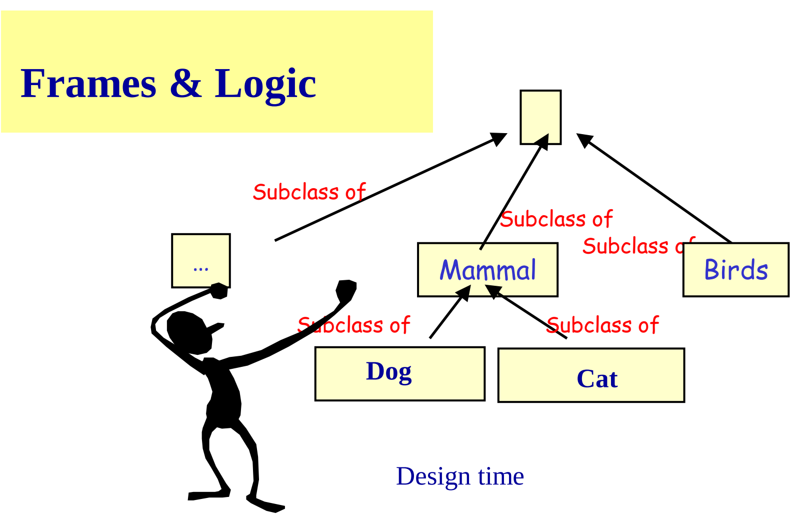
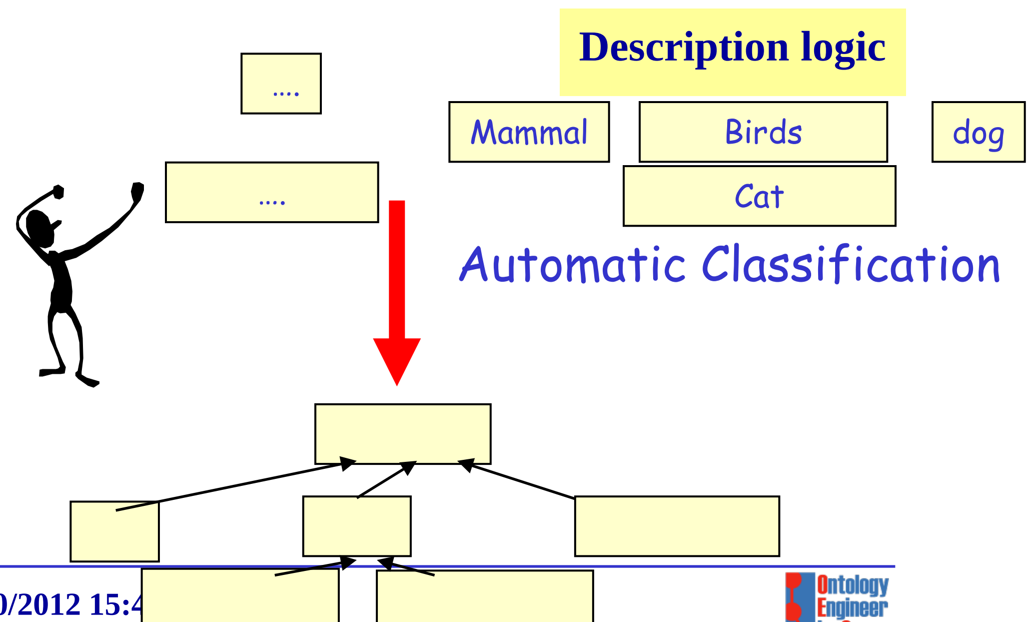
Approaches for building ontologies









Using Frames and First Order Logic for Modeling Ontologies

```
(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)))
```

```
(define-instance AA7462-Feb-08-2002 (AA7462)
:def ((singleFare AA7462-Feb-08-2002 300)
     (departureDate AA7462-Feb-08-2002 Feb8-2002)
     (arrivalPlace AA7462-Feb-08-2002 Seattle)))
```

```
(define-function Pays (?room ?discount) :-> ?finalPrice
  "Price of the room after applying the discount"
:def (and (Room ?room) (Number ?discount)
          (Number ?finalPrice)
          (Price ?room ?price))
:lambda-body
          (- ?price (/ (* ?price ?discount) 100)))
```

```
(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))))))
```

Using Description Logics for Modeling Ontologies

```
(defconcept Travel
  "A journey from place to place"
:is-primitive
 (:and
   (:all arrivalDate Date)(:exactly 1 arrivalDate)
   (:all departureDate Date)(:exactly 1
departureDate)
   (:all companyName String)
   (:all singleFare Number)(:at-most singleFare 1)))
```

```
(tellm (AA7462 AA7462-08-Feb-2002)
      (singleFare AA7462-08-Feb-2002 300)
      (departureDate AA7462-08-Feb-2002 Feb8-2002)
      (arrivalPlace AA7462-08-Feb-2002 Seattle))
```

```
(defrelation Pays
:is
 (:function (?room ?Discount)
  (- (Price ?room) (/(*(Price ?room) ?Discount) 100)))
:domains (Room Number)
:range Number)
```

```
(defrelation connects
  "A road connects two different cities"
:arity 3
:domains (Location Location)
:range RoadSection
:predicate
  ((?city1 ?city2 ?road)
   (:not (part-of ?city1 ?city2))
   (:not (part-of ?city2 ?city1))
   (:or (:and (start ?road ?city1)(end ?road ?city2))
        (:and (start ?road ?city2)(end ?road ?city1)))))
```

Different Approaches to Build Ontologies

•The formalism and the language limit the kind of knowledge that can be represented

•All the aforementioned formalisms allow representing: classes, organized in class taxonomies, attributes, and binary relations

•Only AI formalisms are specially prepared to model formal axioms either as independent components in the ontology or embedded in other components

•A domain model is not necessarily an ontology only because it is written in Ontolingua or OWL, for the same reasons that we cannot say that a program is a knowledge-based system because it is written in Prolog

•Although some languages are more appropriate than others to represent ontologies, a model is an ontology only if it is agreed and machine readable

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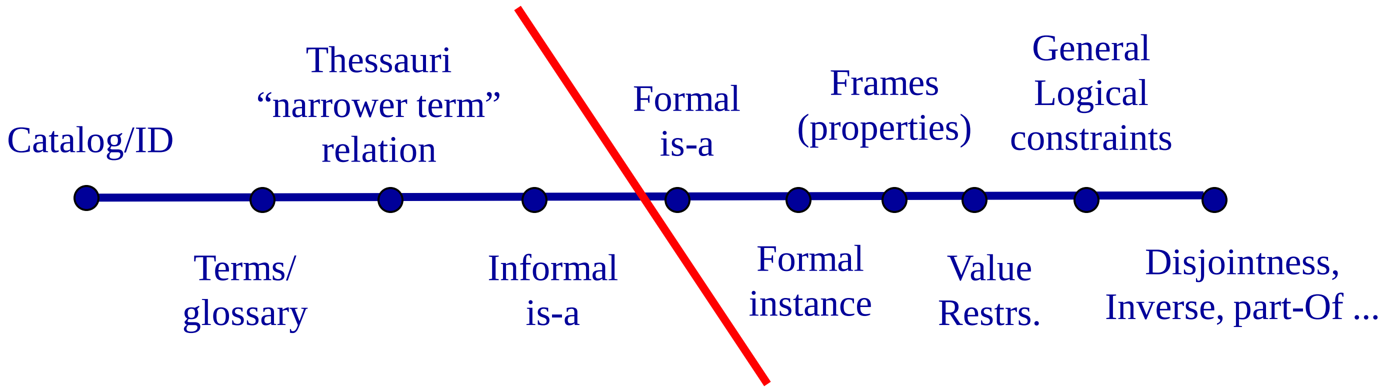
Types of Ontologies
Lassila and McGuiness Classification



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

Catalog/ID Glossary Thessaurus Informal is-a

Informal is-a

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

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 ... nd ball"

; "a ball of fire"

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 wh to which meaning or synset, please click on it. Two thing 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 t synonyms (representing the synset). In addition, the 'meaning' opens its content and pr pointers associated with the selected part of speech. A click on one of these pointers, e explore the broad ... synset.

SMART THESAURUS MUSIC supports the following lexical relationships:

Noun

[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

Tipos de relaciones

Verb

[1] Hypernym or broader term (...is a kind of)

[2] Hyponym or narrower term (kinds of ...)

[3] Related verbs

[4] Related nouns

Thessaurus

GOBIERNO DE ESPAÑA · MINISTERIO DE FOMENTO · Dirección General del Instituto Geográfico Nacional

Archivo Edición Formato Ayuda

Catalog/ID

NOMENCLÁTOR GEOGRÁFICO
ENTIDADES

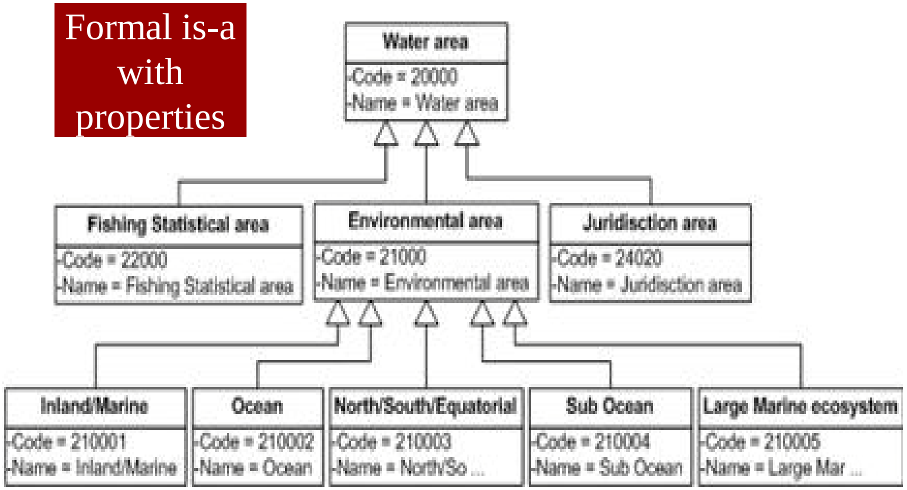
Nación
Región geográfica
Capital de Nación
Elevación orográfica
Comunidad Autónoma
Llanura/Raso
Ciudad con Estatuto de Autonomía
Depresión orográfica
Capital de Comunidad Autónoma
Accidente costero
Provincia
Accidente marítimo
Capital de Provincia
Accidente hidrográfico
Coprincipado
Corriente fluvial
Capital de Coprincipado
Canal
Comarca
Embalse
Capital de Comarca
Lago/Laguna
Isla Humedal
Capital de Isla
Isla fluvial
Municipio
Isla marítima
Capital de Municipio
Garganta/Hoz
E.A.T.I.M.
Lugar/Paraje
Capital de E.A.T.I.M.
Paso/Collado
Población
Puerto de montaña
Comunidad de Municipios
Puerto comercial
Enclave
Helipuerto comercial
Territorio anejo
Aeródromo/Aeropuerto
Territorio autonómico
Estación de ferrocarril
Zona neutral

```
! Fichero creado por gen...
! Diccionario de conversión DGN -> EDM.
! FORMATO:
!   Tipo_dgn Entidad Tipo_istram Grupo código_bcn Cerrado Trato
!
! Tipo_ dgn...NNSCCCGG                          Codigo_bcn...TTGGSS
!         NN   : Nivel elemento                         TT : Tema
!         S    : Estilo linea dgn                       GG : Grupo
!         CCC  : Color   linea dgn                      SS : Subgrupo
!         GG   : Grosor  linea dgn
!
! Entidad                                      Tipo_istram....???
!           104  : polilinea
!           203  : célula se convierte a simbolo
!            -1  : célula se explota en sus componentes
!           304  : rótulo
!
! Grupo
!              0  : sin determinar
!              1  : carreteras
!              2  : hidrografia
!              3  : conducciones
!              4  : administrativo
!
!              En textos el grupo corresponde a la fuente Microstatio
!
! Cerrado
!        en lineas                                   en textos
!                      1  : perimetral                      n : altu
!                      0  : entidad lineal abierta
!                     -1  : cultivo perimetral
!                     -2  : cultivo linea abierta
!
! Trato
!    I: Intocable   A: Altimetria   N: No tratar   T: Textos Asociad
!    S: Textos Sueltos   C: Cultivo   F: Solo salida !: Tratar norm
!                                   TTGGSS
02000900    104      1    0    090101    1    !I    Marco de hoja
02300902    104      2    0    100200    0    !     Base Geodésica de M
06003900    104      3    0    025102    0    !     Acantilado
06006900    104      4    0    025302    0    !     Costa rocosa no aca
06009900    104      5    2    037402    1    !     Playa fluvial de gu
06012900    104      6    0    025501    1    !     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    !     Vertedero. Contorno
11003003    104     11    1    062202    0    !     Autopista. Enlace
11012000    104     12    0    056091    1    !I    Patio. Contorno
13003300    104     13    1    060101    0    !     Autopista. Eje
13303300    104     14    1    060131    0    !     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    !     Autovia. Enlace
15003004    104     18    1    060701    0    !     Autovia
```

Informal is-a

Formal is-a — Formal instance — Frames (properties) — Value Restrs. — General Logical constraints — Disjointness, Inverse, part-Of ...

Formal is-a with properties



General Logical constraints

```
(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)))))
```

Value Restrs.

```
(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)))
```

Disjointness

```
(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)))
```

Types of Ontologies

Content Ontologies

Domain O.

Scalpel, scanner
anesthetize, give birth

Task O.

goal, schedule
to assign, to classify

General/Common O.

Things, Events, Time, Space
Causality, Behavior, Function

Mizoguchi, R. Vanwelkenhuysen, J.; Ikeda, M.
Task Ontology for Reuse of Problem Solving Knowledge.
Towards Very Large Knowledge Bases:
Knowledge Building & Knowledge Sharing.
IOS Press. 1995. 46-59.

Issue of the Conceptualization

Representation O.

- Conceptualization of KR formalisms

Generic O.

- Reusable across D.

Domain O.

- Reusable

Application O.

- Non reusable
- Usable

Van Heist, G.; Schreiber, T.; Wielinga, B.
Using Explicit Ontologies in KBS
International Journal of Human-Computer Studies.
Vol. 46. (2/3). 183-292. 1997

Knowledge Representation Ontologies

Knowledge Representation (KR) ontologies capture the representation primitives used to formalize knowledge under a given KR paradigm.

- **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)

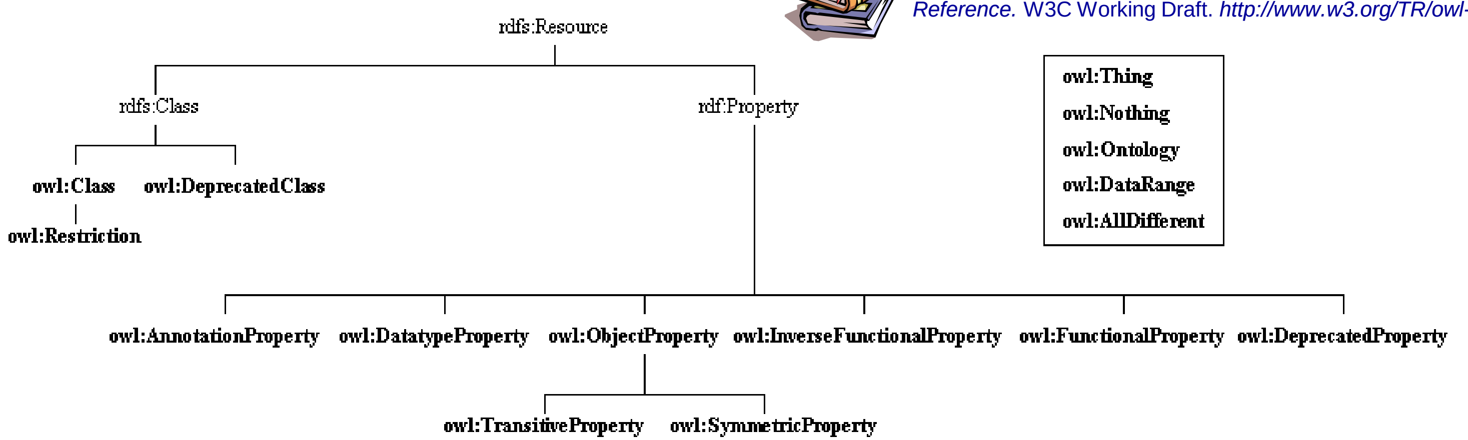
- **OWL knowledge representation ontology**
  (http://www.w3.org/2002/07/owl)

•Gruber TR (1993a) *A translation approach to portable ontology specification*. Knowledge Acquisition 5(2):199–220

•Chaudhri VK, Farquhar A, Fikes R, Karp PD, Rice JP (1998) *Open Knowledge Base Connectivity 2.0.3*. Technical Report. *http://www.ai.sri.com/~okbc/okbc-2-0-3.pdf*

Lassila O, Swick R (1999) *Resource Description Framework (RDF) Model and Syntax Specification*. W3C Recommendation. *http://www.w3.org/TR/REC-rdf-syntax/*

Dean M, Schreiber G (2003) *OWL Web Ontology Language Reference.* W3C Working Draft. *http://www.w3.org/TR/owl-ref/*



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

Top-level Ontologies

Top-level Ontologies or Upper-level Ontologies describe very general concepts and provide general notions under which all root terms in existing ontologies should be linked.

•Top-level ontologies of universals and particulars (http://webode.dia.fi.upm.es/)

•Guarino N, Welty C (2000) *A Formal Ontology of Properties*. In: Dieng R, Corby O (eds) 12th International Conference in Knowledge Engineering and Knowledge Management (EKAW'00). Juan-Les-Pins, France. (Lecture Notes in Artificial Intelligence LNAI 1937) Springer-Verlag, Berlin, Germany, pp 97–112

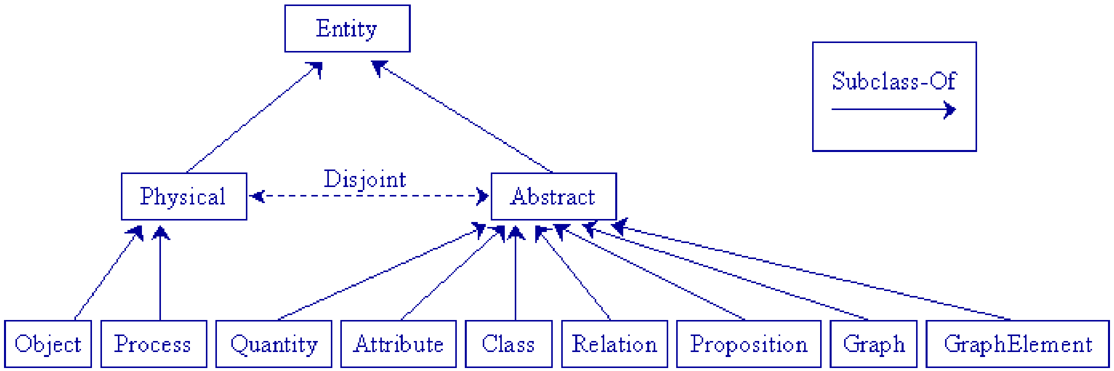
•Gangemi A, Guarino N, Oltramari A (2001) *Conceptual analysis of lexical taxonomies: the case of Wordnet top-level*. In: Smith B, Welty C (eds) International Conference on Formal Ontology in Information Systems (FOIS'01). Ogunquit, Maine. ACM Press, New York, pp 3–15

•Sowa's top-level ontology (http://www.jfsowa.com/ontology/toplevel.htm)

Sowa JF (1999) *Knowledge Representation: Logical, Philosophical, and Computational Foundations*. Brooks Cole Publishing Co., Pacific Grove, California

•Cyc's upper ontology (http://www.cyc.com/cyc-2-1/cover.html)

Lenat DB, Guha RV (1990) *Building Large Knowledge-based Systems: Representation and Inference in the Cyc Project*. Addison-Wesley, Boston, Massachusetts

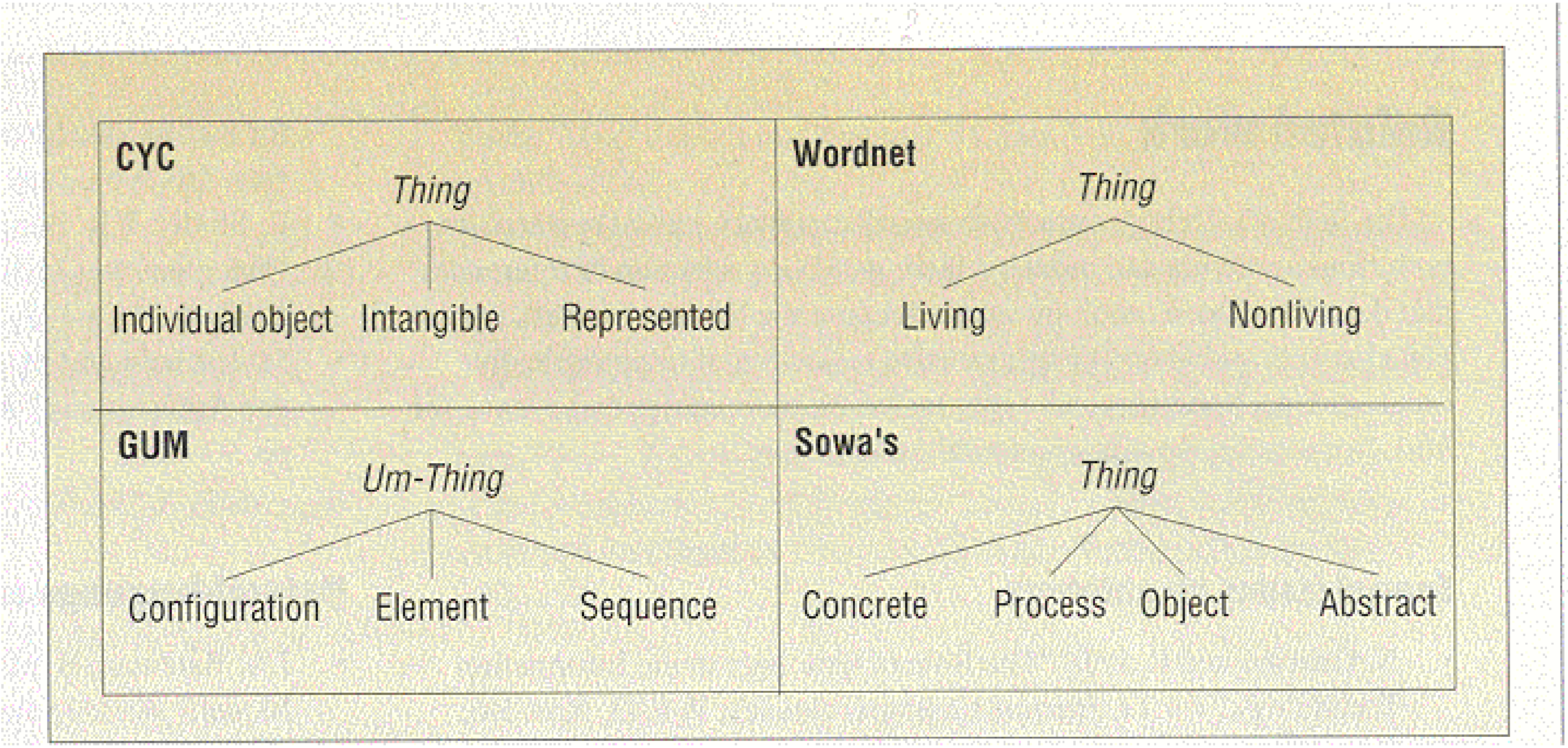


•The Standard Upper Ontology (SUO) (http://suo.ieee.org/)

Pease RA, Niles I (2002) *IEEE Standard Upper Ontology: A Progress Report*. The Knowledge Engineering Review 17(1):65–70

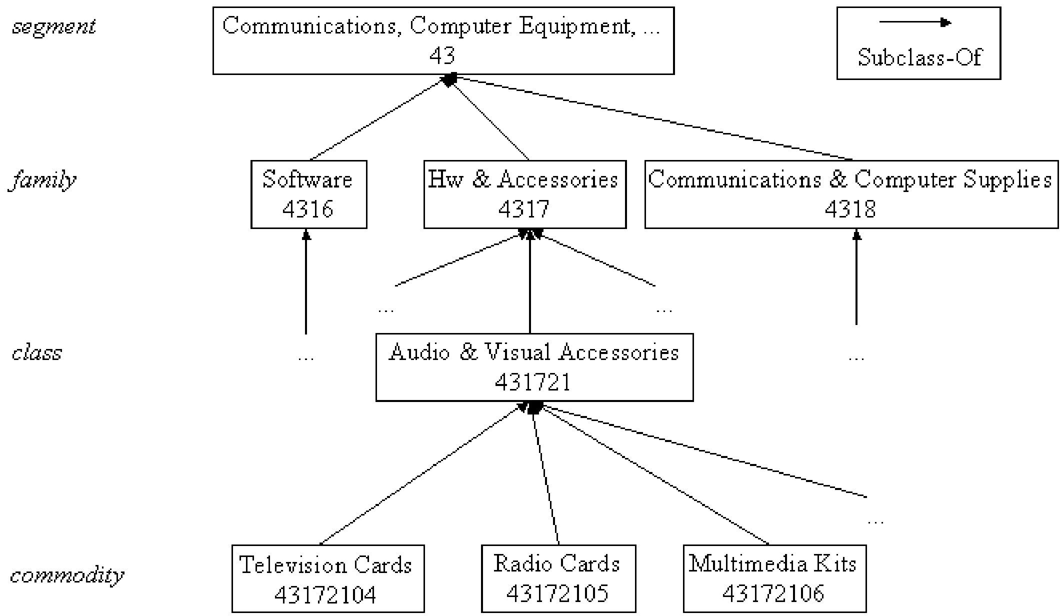
One Unique Top-Level Ontology?

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.eclass.de/)
- **RosettaNet** (http://www.rosettanet.org)



Domain Ontologies: Medical Ontologies

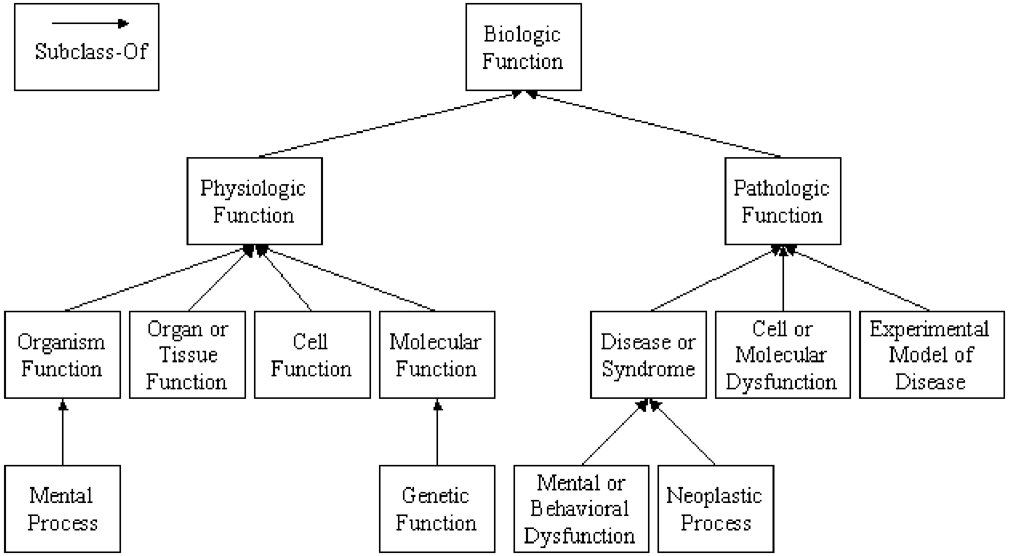
•**GALEN** (http://www.opengalen.org/)

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



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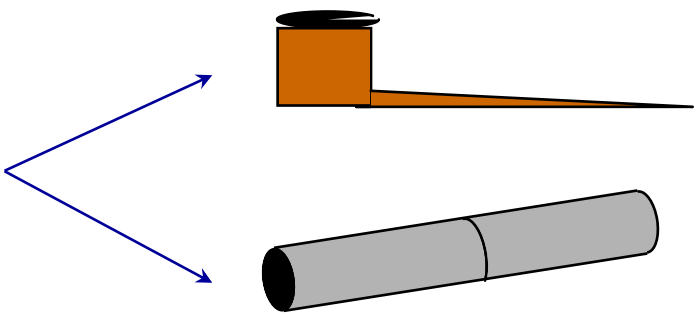
Ontological Commitments

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

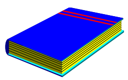
An agent commits (conforms) to an ontology if it "acts" consistently with the definitions

Example: What is a pipe?



9 definitions of the term flight from wordnet

Identification of the ontological commitment



- 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

WordNet

a lexical database for the English language

cognitive science laboratory | princeton university | 221 nassau st. | princeton, nj 08542

- About WordNet
- Use WordNet online
- Download WordNet 1.7
- Changes in version 1.7
- Frequently asked questions
- WordNet manuals
- Glossary of terms
- Current events
- Publications
- License & commercial use
- Related projects

Search word: flight [Find valid searches]

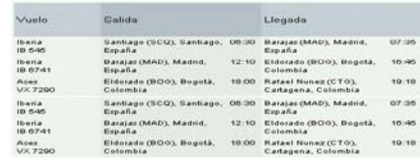
WordNet 1.6 overview for "flight"

The **noun** "flight" has 9 senses in WordNet.

1. **flight** – (a formation of aircraft in flight)
2. **flight**, flying – (an instance of traveling by air; "flying was still an exciting adventure for him")
3. **flight**, flight of stairs, flight of steps – (a set of steps between one floor or landing and the next)
4. escape, **flight** – (the act of escaping physically, "he made his escape from the mental hospital", "the canary escaped from its cage", "his flight was an indication of his guilt")
5. **flight** – (a unit of the US air force smaller than a squadron)
6. **flight** – (passing above and beyond ordinary bounds, "a flight of fancy", "flights or rhetoric", "flights of imagination")
7. trajectory, **flight** – (the path followed by a moving object)
8. **flight** – (a flock of flying birds)
9. **flight** – (a scheduled trip by plane between designated airports, "I took the noon flight to Chicago")

A formation of aircraft in flight

A scheduled trip by plane between designated airports



Vuelo	Salida		Llegada	
Iberia IB 546	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 546	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

An instance of traveling by air

OC_1 OC_9

OC_2 OC_8

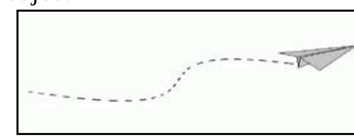
A flock of flying birds

flight

A set or steps between one floor or landing for him

OC_3 OC_4 OC_5 OC_6 OC_7

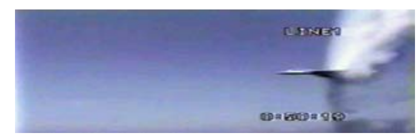
The path followed by a moving object



The act of escaping physically

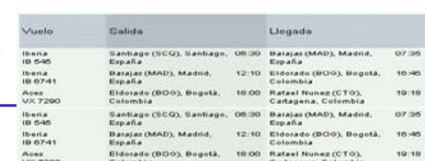
A unit of the US air force smaller than a squadron

Passing above and beyond ordinary bounds



(**define-class** Flight (?X)
"A journey by plane"
:axiom-def
(**and** (**Subclass-Of** Flight Travel)
(**Template-Facet-Value** Cardinality
flightNumber Flight 1))
:class-slots ((transportMeans "plane")))

flight



Vuelo	Salida		Llegada	
Iberia IB 546	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
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Aces VX 7290	Eldorado (BOG), Bogotá, Colombia	18:00	Rafael Nunez (CTG), Cartagena, Colombia	19:18

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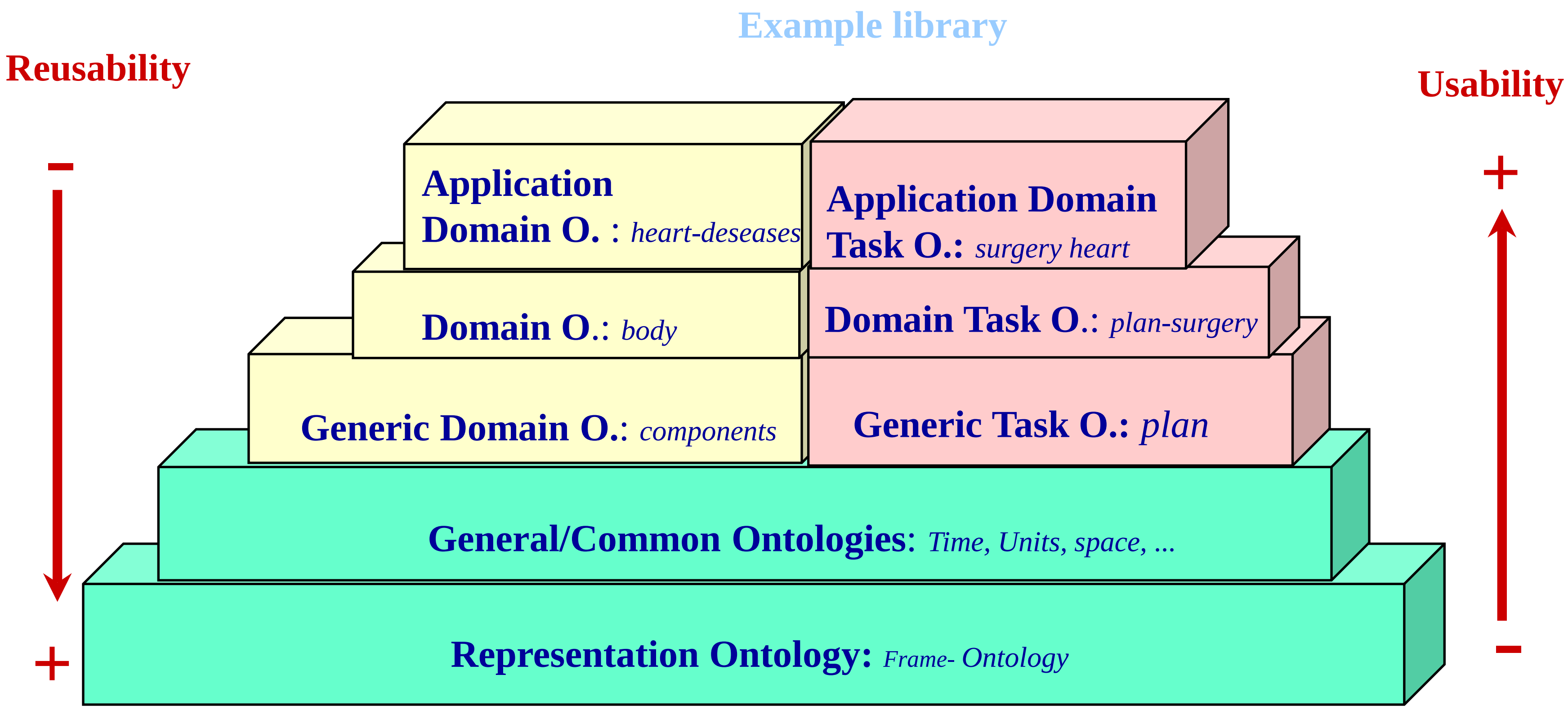
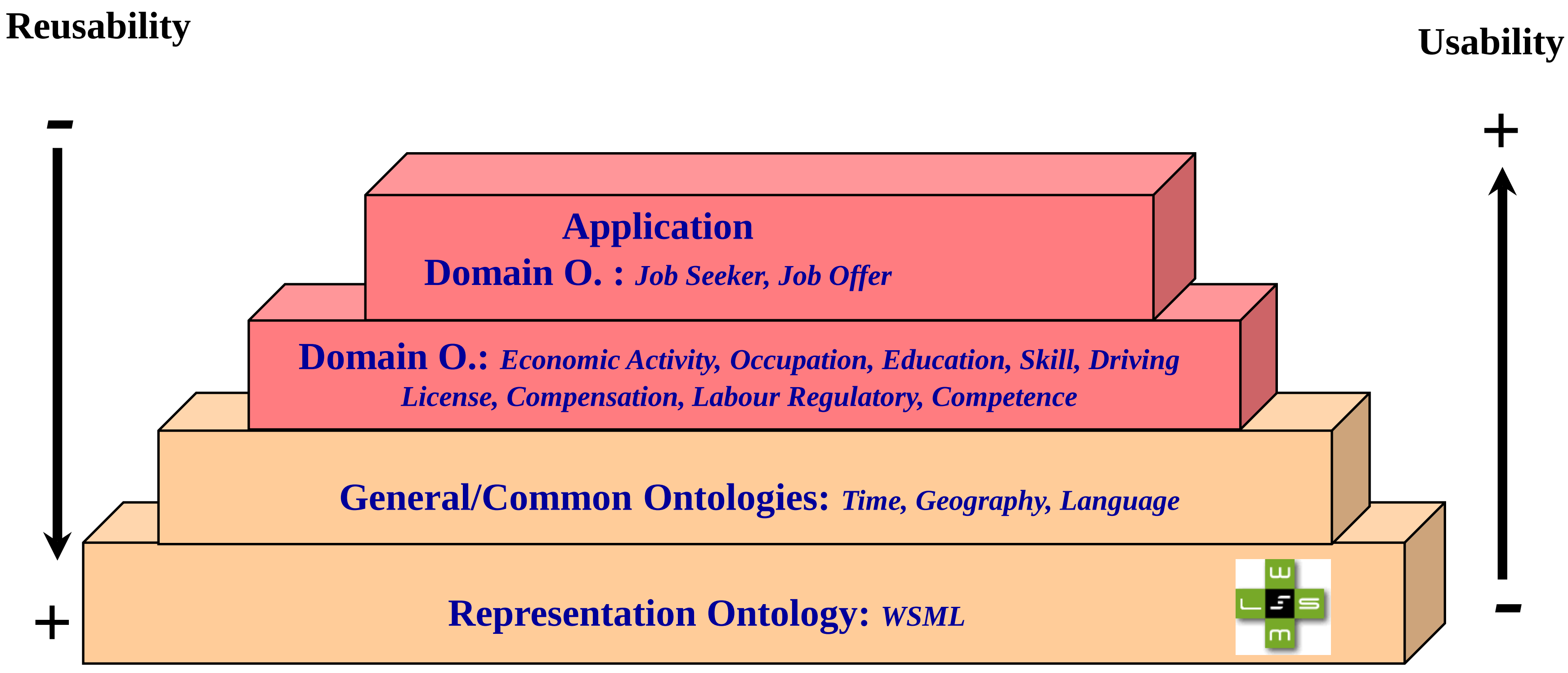
Libraries of Ontologies



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

Modular approach for ontology construction



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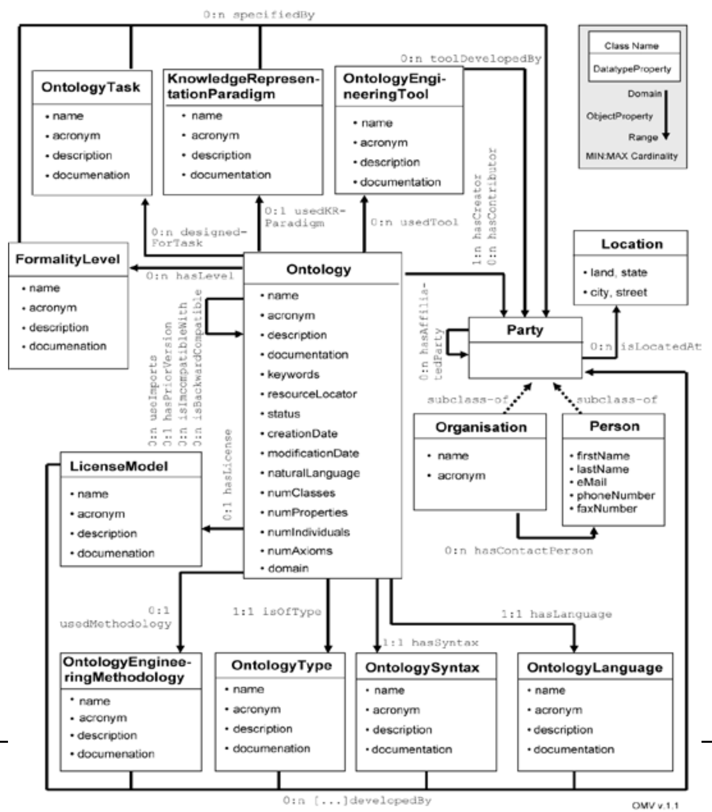
1. Reuse and Sharing
2. Definitions of Ontologies
3. Modeling of Ontologies
4. Approaches for building ontologies
5. Type of Ontologies
6. Ontological commitments
7. Ontologies reuse other ontologies
8. Searching ontologies
9. Relevant ontologies

Searching Ontologies

- OMV: Ontology Metadata Vocabulary



- Ontology registries

OYSTER

Onthology.org

knowledge zone one stop shop for ontologies

Swoogle semantic web search 2006

watson exploring the semantic web

Table of Content

Linguistic Ontologies

•**WordNet** (http://www.hum.uva.nl/~ewn/gwa.htm)

•Miller GA (1995) *WordNet: a lexical database for English*. Communications of the ACM 38(11):39–41

•Miller GA, Beckwith R, Fellbaum C, Gross D, Miller K (1990) *Introduction to WordNet: An on-line lexical database*. International Journal of Lexicography 3(4):235–244

•**EuroWordNet** (http://www.hum.uva.nl/~ewn/)

•Vossen P (ed) (1999) *EuroWordNet General Document. Version 3*. http://www.hum.uva.nl/ewn/

•Vossen P (ed) (1998) *EuroWordNet: A Multilingual Database with Lexical Semantic Networks*. Kluwer Academic Publishers, Dordrecht, The Netherlands

•**The Generalized Upper Model** (http://www.darmstadt.gmd.de/publish/komet/gen-um/newUM.html)

Bateman JA, Fabris G, Magnini B (1995) *The Generalized Upper Model Knowledge Base: Organization and Use*. In: Mars N (ed) Second International Conference on Building and Sharing of Very Large-Scale Knowledge Bases (KBKS '95). University of Twente, Enschede, The Netherlands. IOS Press, Amsterdam, The Netherlands, pp 60–72

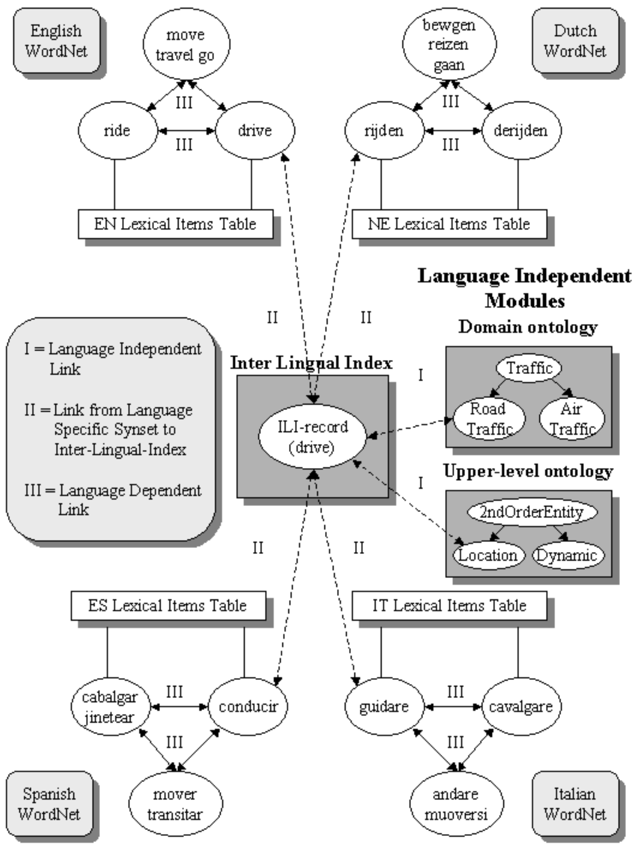
•**The Mikrokosmos ontology** (http://crl.nmsu.edu/mikro **[user and password are required]**)

•Mahesh K (1996) *Ontology development for machine translation: Ideology and Methodology*. Technical Report MCCS-96-292. Computing Research Laboratory, New Mexico State University, Las Cruces, New Mexico. http://citeseer.nj.nec.com/mahesh96ontology.html

•Mahesh K, Nirenburg S (1995) *Semantic classification for practical natural language processing*. In: Schwartz RP, Kwasnik BH, Beghtol C, Smith PJ, Jacob E (eds) 6th ASIS SIG/CR Classification Research Workshop: An Interdisciplinary Meeting. Chicago, Illinois, pp 79–94

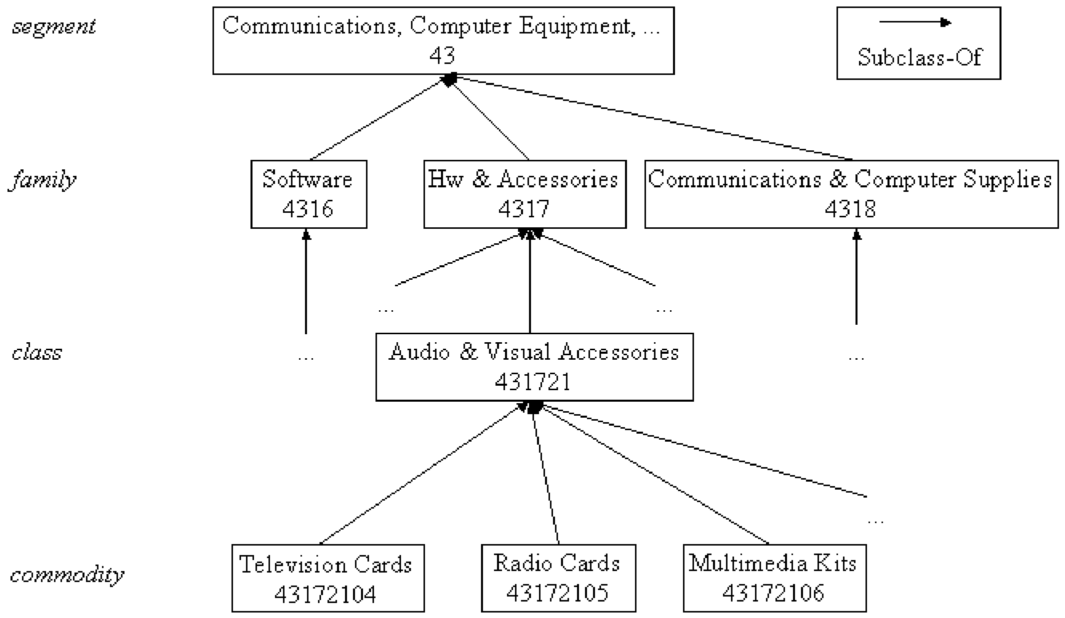
•**SENSUS** (http://www.isi.edu/natural-language/projects/ONTOLOGIES.html)

Swartout B, Ramesh P, Knight K, Russ T (1997) *Toward Distributed Use of Large-Scale Ontologies*. In: Farquhar A, Gruninger M, Gómez-Pérez A, Uschold M, van der Vet P (eds) AAAI'97 Spring Symposium on Ontological Engineering. Stanford University, California, pp 138–148



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.eclass.de/)
- **RosettaNet** (http://www.rosettanet.org)



Domain Ontologies: Medical Ontologies

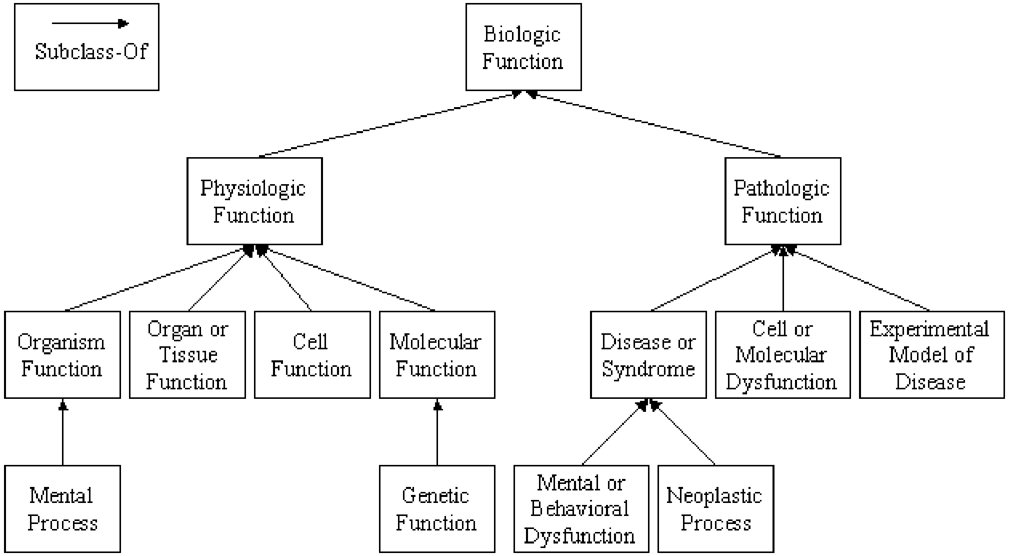
•GALEN http://www.co-ode.org/galen/

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

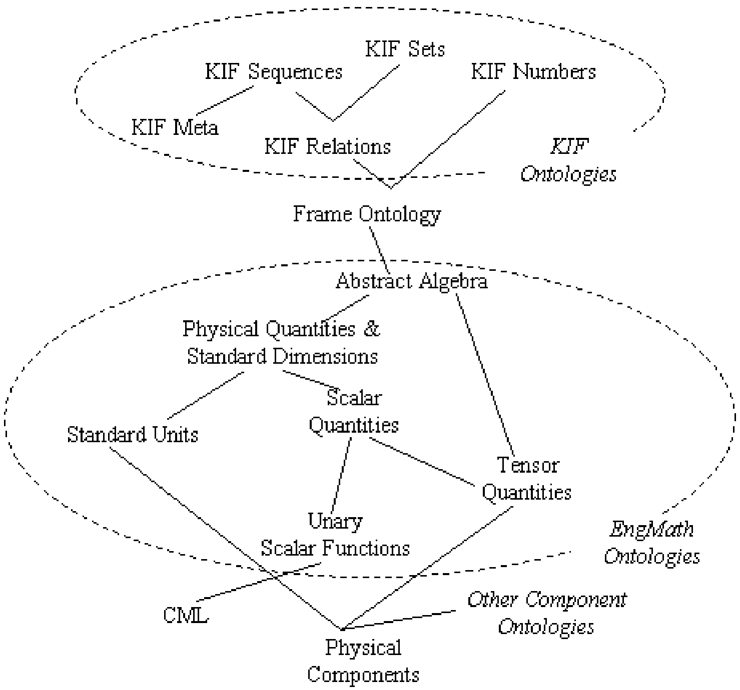
•UMLS (Unified Medical Language System)
(http://www.nih.gov/research/umls/)

•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



Domain Ontologies: Engineering Ontologies



•EngMath

Gruber TR, Olsen G (1994) *An ontology for Engineering Mathematics*. In: Doyle J, Torass Sandewall E (eds) Fourth International Conference on Principles of Knowledge Representation and Reasoning. Bonn, Germany. Morgan Kaufmann Publishers, San Francisco, California, pp 258–269

•PhysSys

Borst WN (1997) *Construction of Engineering Ontologies*. Centre for Telematica and Information Technology, University of Tweenty. Enschede, The Netherlands

Domain Ontologies: Enterprise Ontologies

- **Enterprise Ontology** (http://www.aiai.ed.ac.uk/~entprise/enterprise/ontology.html)

Uschold M, King M, Moralee S, Zorgios Y (1998) *The Enterprise Ontology*. The Knowled Engineering Review 13(1):31–89

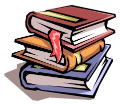
- **TOVE** (http://www.eil.utoronto.ca/tove/toveont.html)

Fox MS (1992) *The TOVE Project: A Common-sense Model of the Enterprise*. In: Belli F, Radermacher FJ (eds) Industrial and Engineering Applications of Artificial Intelligence and Expert Systems. (Lecture Notes in Artificial Intelligence LNAI 604) Springer-Verlag, Berlin, Germany, pp 25–34

- Enterprise Ontologies
  - Enterprise Design Ontology
  - Project Ontology
  - Material Flow Ontology
  - Business Process Ontology
- Derivative Ontologies
  - Transportation Ontology
  - Inventory Ontology
  - Quality Ontology
  - Product Design Ontology
  - Goals Ontology
  - Scheduling Ontology
  - Operating Strategies Ontology
  - Product Requirements Ontology
  - Information Resource Ontology
  - Intended Action Ontology
  - Electro Mechanical Product Ontology
- Core Ontologies
  - Product Ontology
  - Service Ontology
  - Activity Ontology
  - Organization Ontology
  - Resource Ontology

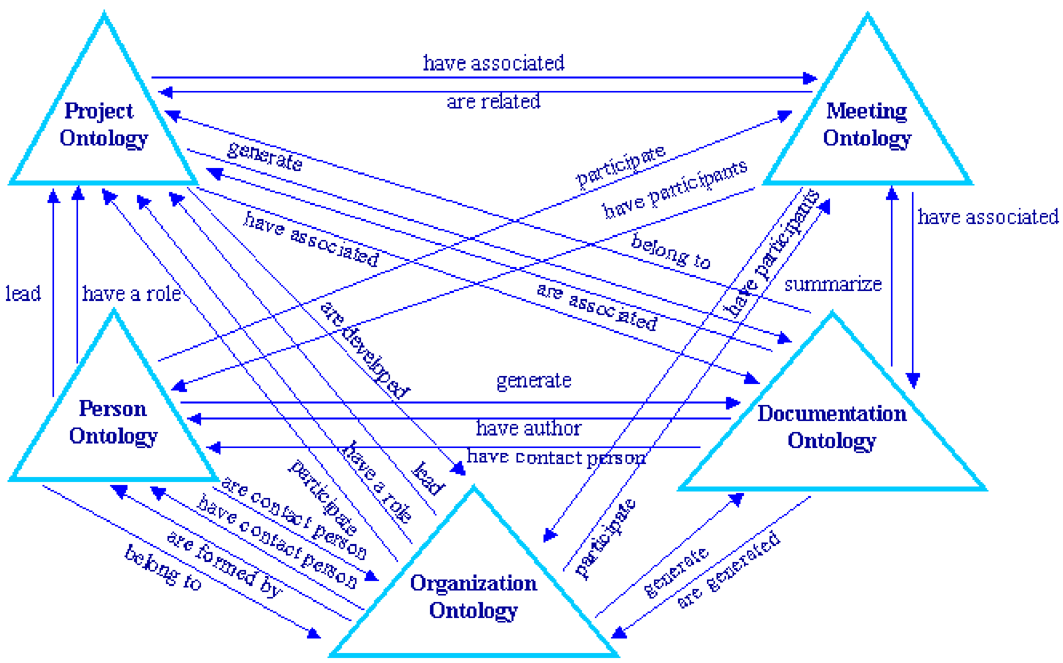
Domain Ontologies: Knowledge Management Ontologies

•(KA)² ontologies (http://ka2portal.aifb.uni-karlsruhe.de)



Decker S, Erdmann M, Fensel D, Studer R (1999) *Ontobroker: Ontology Based Access to Distributed and Semi-Structured Information*. In: Meersman R, Tari Z, Stevens S (eds) Semantic Issues in Multimedia Systems (DS-8), Rotorua, New Zealand. Kluwer Academic Publisher, Boston, Massachusetts. pp 351–369

•R&D projects (http://www.esperonto.net/)



Linked data ontologies

http://www4.wiwiss.fu-berlin.de/bizer/pub/LinkedDataTutorial/#whichvocabs

4. Which vocabularies should I use to represent information

In order to make it as easy as possible for client applications to process your data, you should reuse term only define new terms yourself if you can not find required terms in existing vocabularies.

4.1 Reusing existing terms

A set of well-known vocabularies has evolved in the Semantic Web community. Please check whether you before defining any new terms:

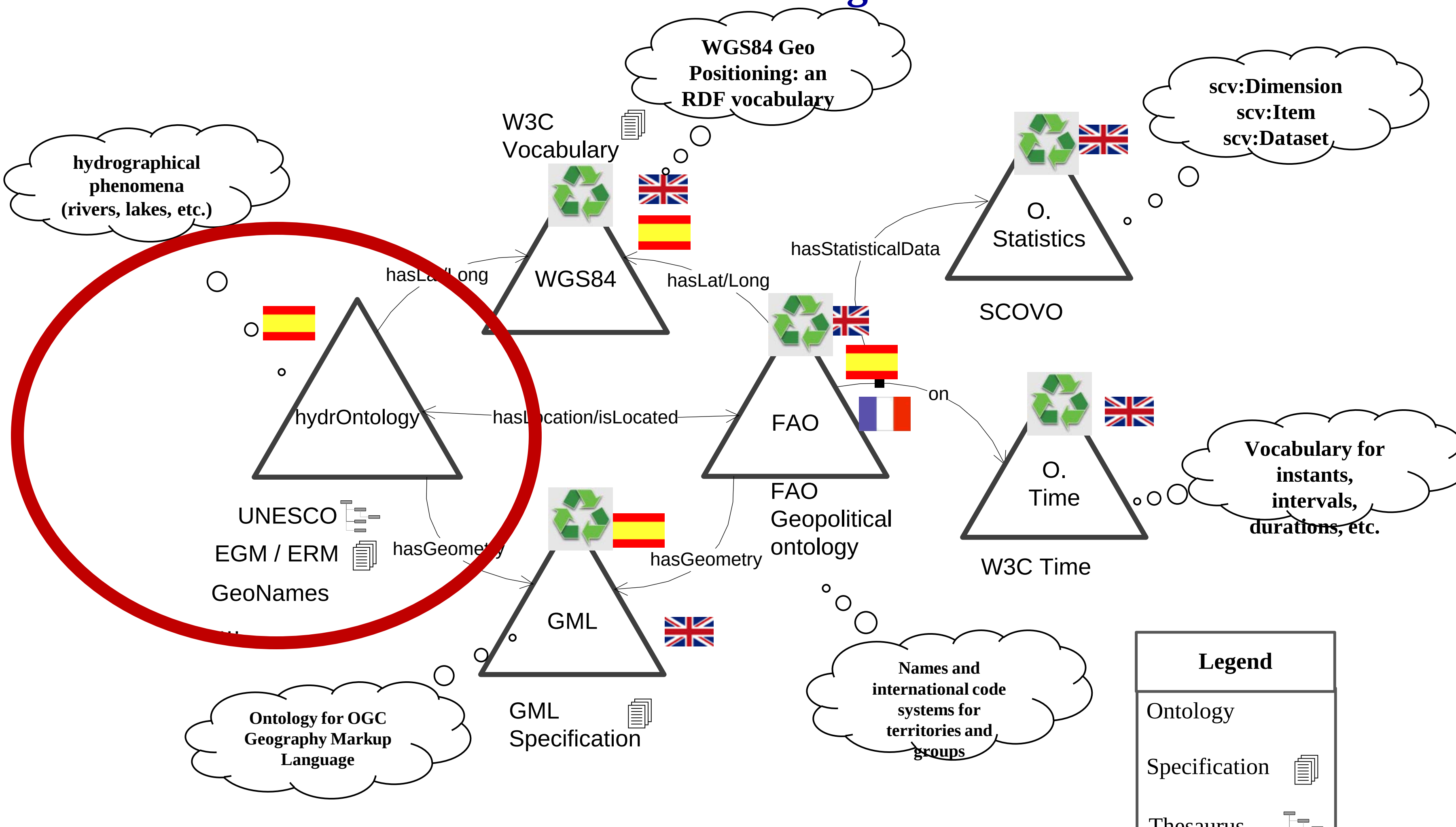
- Friend-of-a-Friend (FOAF), vocabulary for describing people.
- Dublin Core (DC) defines general metadata attributes. See also their new domains and ranges drat
- Semantically-Interlinked Online Communities (SIOC), vocabulary for representing online communitie
- Description of a Project (DOAP), vocabulary for describing projects.
- Simple Knowledge Organization System (SKOS), vocabulary for representing taxonomies and loos
- Music Ontology provides terms for describing artists, albums and tracks.
- Review Vocabulary, vocabulary for representing reviews.
- Creative Commons (CC), vocabulary for describing license terms.

This is not enough

Linked data ontologies

- Features
  - Lightweight :
    - Taxonomies and a few properties
  - Consensuated vocabularies
    - To avoid the mapping problems
  - Multilingual
    - Linked data are multilingual
- The NeOn methodology can help to
  - Re-enginer Non ontological resources into ontologies
    - Pros: use domain terminology already consensuated by domain experts
  - Withdraw in heavyweight ontologies those features that you don't need
  - Reuse existing vocabularies

Geolinked data ontologies



Classes	33	33
Object Properties	44	44
Data Properties	318	318

reused

Following the INSPIRE (INfrastructure for SPatial InfoRmation in Europe) recommendation. hydrOntology,SCOVO, FAO Geopolitcal, WGS84, GML, and Time

What is an Ontology?

Shared understanding of a domain

Repository of vocabulary

- Formal definitions
- Informal definitions