DATA SCIENCE MASTER

SEMANTIC KNOWLEDGE REPRESENTATION

Ontology and Ontology applications

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Semantic Knowledge Representation

Ontology
Ontology Formalisation
Ontology learning
Lab work on ontology learning
+ Project on ontology learning
from texts

Related to other courses :

- Text and Sequential Pattern Mining
- Classification and representation learning
- Clustering Analysis and Indexing

Mounira Harzallah

RDF+ interlinking
the web of Data +
SPARQL Queries

Hala Skaf

Lab work about the ontologies
of the web

Ziwei XU

Schedule

2021 01 05	C1: Ontology + Ontology applications/Ontology Formalisation (MH) (9h00-12h00)
2021 01 06	C2+LW: Ontology Building from texts /protégé (MH) (9h00-12h00)
2021 01 08	C3: Ontology Building from texts and machine learning (MH) (9h00-12h00)
2020 01 11	Project : Ontology Building from texts (autonomous work) (14h00-17h00)
2020 01 12	C5 : RDF/RDFs + Interlinking the web of data set (HS) (9h30-12h30)
2020 01 14	LW: Ontology learning from texts and machine learning (MH) (9h00-11h00)
2020 01 15	Project : Ontology Building from texts (autonomous work) (14h00-17h00))
2020 01 18	C6: SPARQL queries + Web of data/ Annotation and ontology for Wikis (HS) (9h30-12h30)
2020 01 19	LW : Ontology of the web and Information extraction (9h30- 11h30) (ZX)
2020 01 19	Project : Ontology Building from texts (autonomous work) (14h00-17h00)
2020 01 20	Project : Ontology Building from texts (autonomous work) (14h00-17h00)
2020 01 27	Project defense (9h00-11h00)

Project

Ontology learning from texts

Using

- Core ontology approach
- Natural language processing
- Textmining and Machine learning technique

Outline

1.Ontology, ontology applications and Ontology formalisation DL/OWL

2. Ontology building / Protégé

3. Ontology learning from texts and machine learning

Introduction
Definition of the vocabulary semantic

The need for understanding the semantics of vocabularies for

- Effective human communication
- Interoperating and integrating software
- Sharing knowledge

This is because two persons or two machines do not use necessary the same meaning for the same word

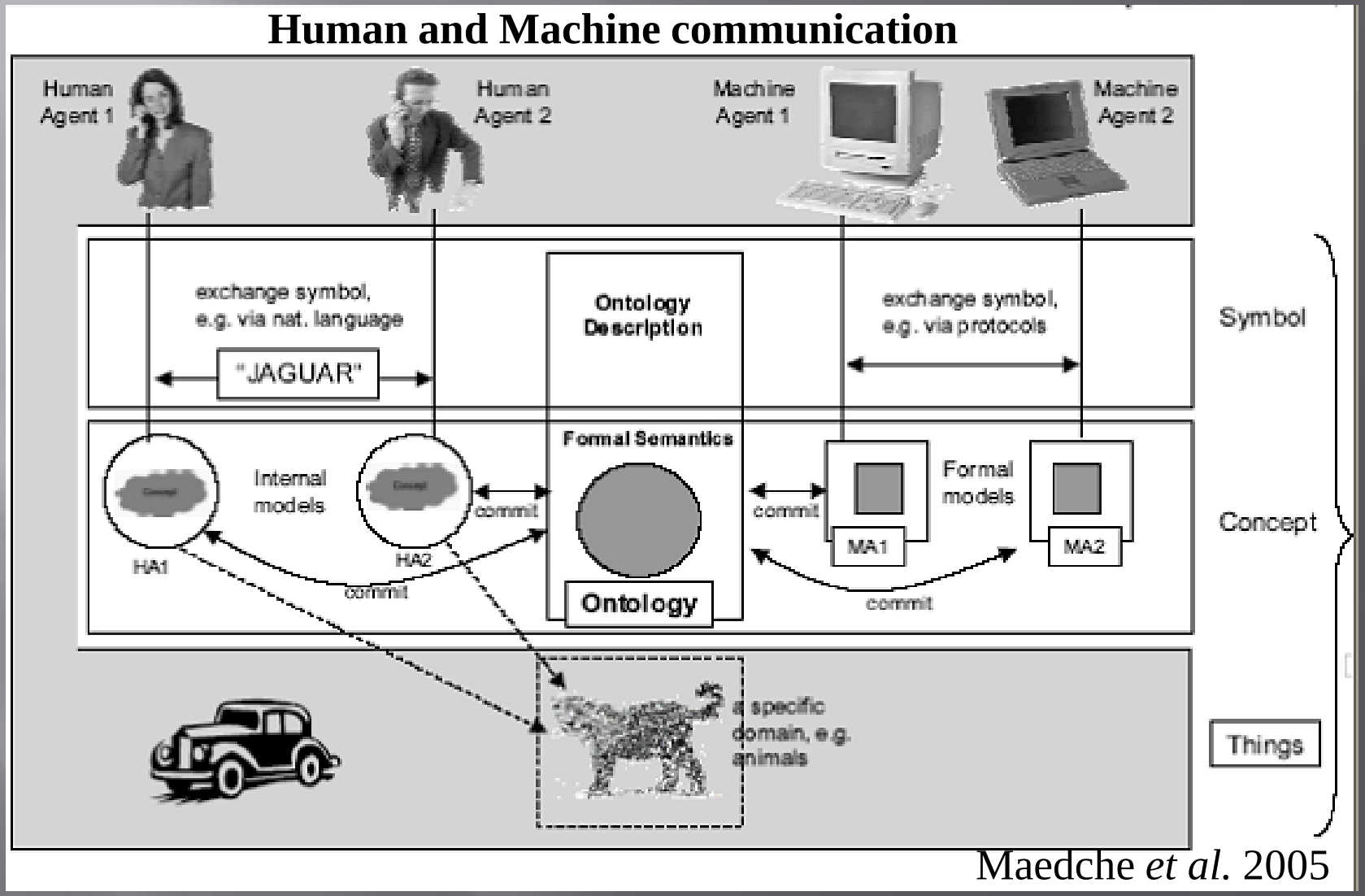
Ex. **Left** : 1. opposite of right, 2. the past tense of leave

Polysemy: is the capacity for a word to have multiple meanings

Synonymy: the state that two or more words have the same meaning Ex. buy and purchase

⇨ will lead to misunderstandings

Introduction:
Definition of the vocabulary semantic



Maedche *et al.* 2005

Introduction
From a conceptual representation to ontology

Conceptual representation is

- for a specific system or application
- its goal is not to define the semantic of its concepts
- constraints focus on data integrity

Example: according to the need of the application, we can define that a car is a specialization of a person (to represent that *"a car is owned by a person" and allowing a* car to inherit the properties of its owner)

This model is ok for a specific application but it is false semantically

It probably cannot be used by distinct software applications

Introduction
From a conceptual representation to ontology

Need a model where we consider more the semantic of concepts

Need a model for which there is a consensus for its meaning

- To be used and reused by many applications about the same domain.
- To allow a good communication
- ……

Towards Ontology

Ontology definition in AI

« an ontology is a formal, explicit specification of a shared conceptualisation » (Gruber, 1995)

- **Conceptualisation** **is an abstract, simplified view of the world that we wish to represent**
  - Identification of a list of concepts and relations of a domain

- **Explicit specification: The components of ontology should be defined with an explicit way**
  - identification of properties and rules (axioms) to define concepts and relations

- **Formal specification: interpretable by humans and processed by computers**
  - formalized usually with *a first-order logical theory*

- **Shared: ontology constitutes a consensus within a well identified community**

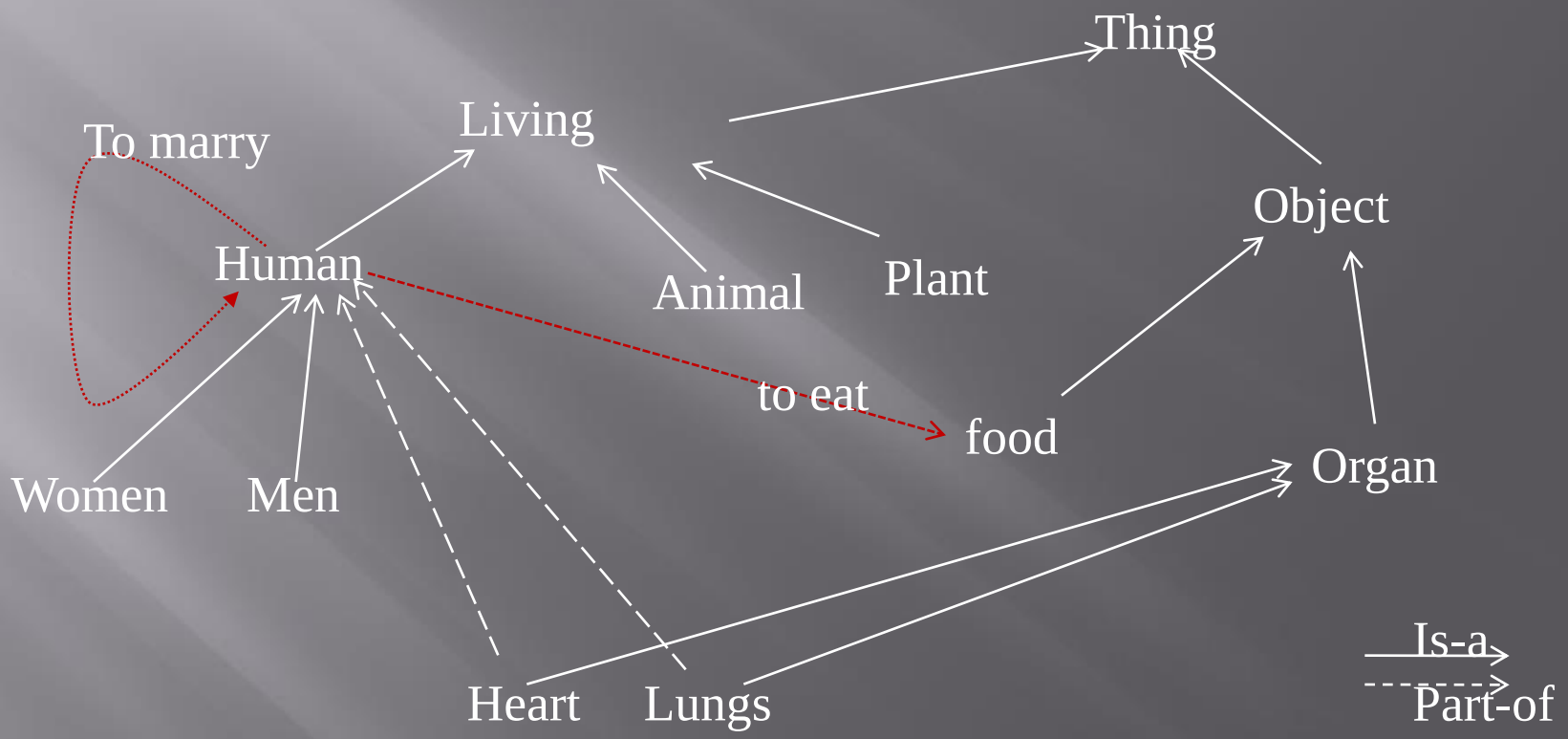
Conceptualize the domain of Human

Build an ontology for defining the concept of Human using :

- **Concepts**: Men, Woman, Living, Animal, Plant, Organ, Object, Heart, lungs, …..
- **Relation**: is-a, part-of, to eat, to marry, ……
- **Axioms**: Human and Animal are disjoints, …….

to represent is-a relation

Conceptualize the domain of Human



Axiom: Human = Women U Men, Human ⊓ Animal = ⊥

How to specify ontology concepts and relations

A concept or a relation can be defined by three methods (Triangle of semantic):

• **A set of terms** that expresses the concept i.e. a synset.

Ex. A car : auto, automobile, machine, motocar

• **Extensional method** formulates the meaning of a concept by specifying its extension, that is, every object that falls under the definition of the concept

Ex. Car: 207 red car, Picasso car, ASTRA2008, my car

• **Intentional method** is to give the meaning of a concept or a relation by specifying all their properties. It allows to determine the « intension » of a concept or a relation.

- a **car** is a **motor vehicle** with **four wheels**; usually propelled by an internal combustion engine.
- **motor vehicle** is a self-propelled **wheeled vehicle** that does not run on rails

How to specify ontology concepts and relations : Intensional specification

Relation of subsumption/Hypernym relation

Some definitions extracted from the dictionary:

- A« pneumonia » is a respiratory "disease"
- A« sole » is a flat "fish"
- An "white men" is a "men" that has a white color

- **The first concept is defined according to the second one and by adding a property that is owned by the first one and not necessary by the second**
- **The second concept generalize the first one : there is a relation of subsumption between the two concepts**
- **In ontology engineering, the term « subsumption » replaces the term « generalization /specialization » used elsewhere**

How to specify ontology concepts and relations : Intensional specification

The relation of subsumption

A subsumes B that means

- A generalize B
- All properties of A are also properties of B
- All instances of B are instances of A

Human « subsume » Men, Men « is subsumed by » Human

The relation of subsumption is transitive and reflexive

Transitive : If A subsumes B and B subsumes C then A subsumes C

Reflexive : A subsumes A

Examples of the relations of subsumption:

Is-a, sub-concept, sub-class, sub-type, kind-of

How to specify ontology concepts and relations: Intensional specification

Other relations allow to define some properties that the concept has

Semantic relations used frequently

Relation of meronymy (composition, partonomy) : "part-of", "is composed of", "compose" , etc.

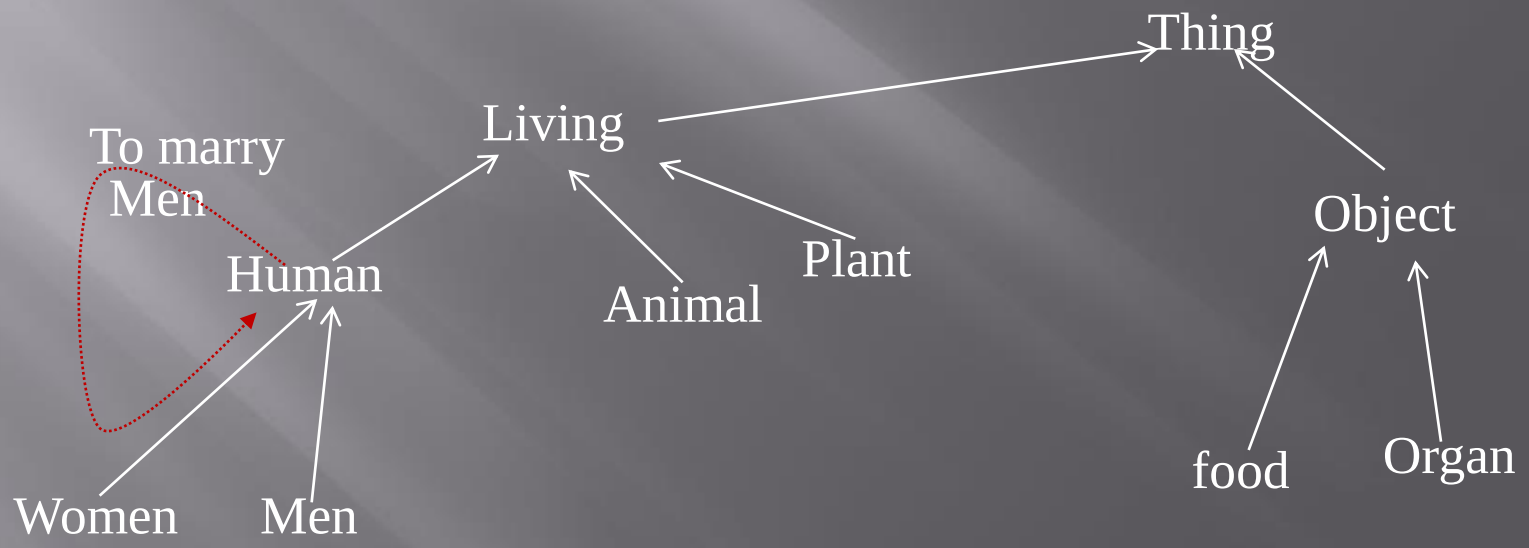
Example : a wheel composes a car
Properties : Reflexive and transitive

Relation of antonymy
Example : hot "antonym" Cold

Relation of synonymy is a relation between terms associated to a same concept.
Example : Tumor "Synonym" Cancer
Properties : Reflexive and transitive

How to specify ontology concepts and relations : Intentional specification

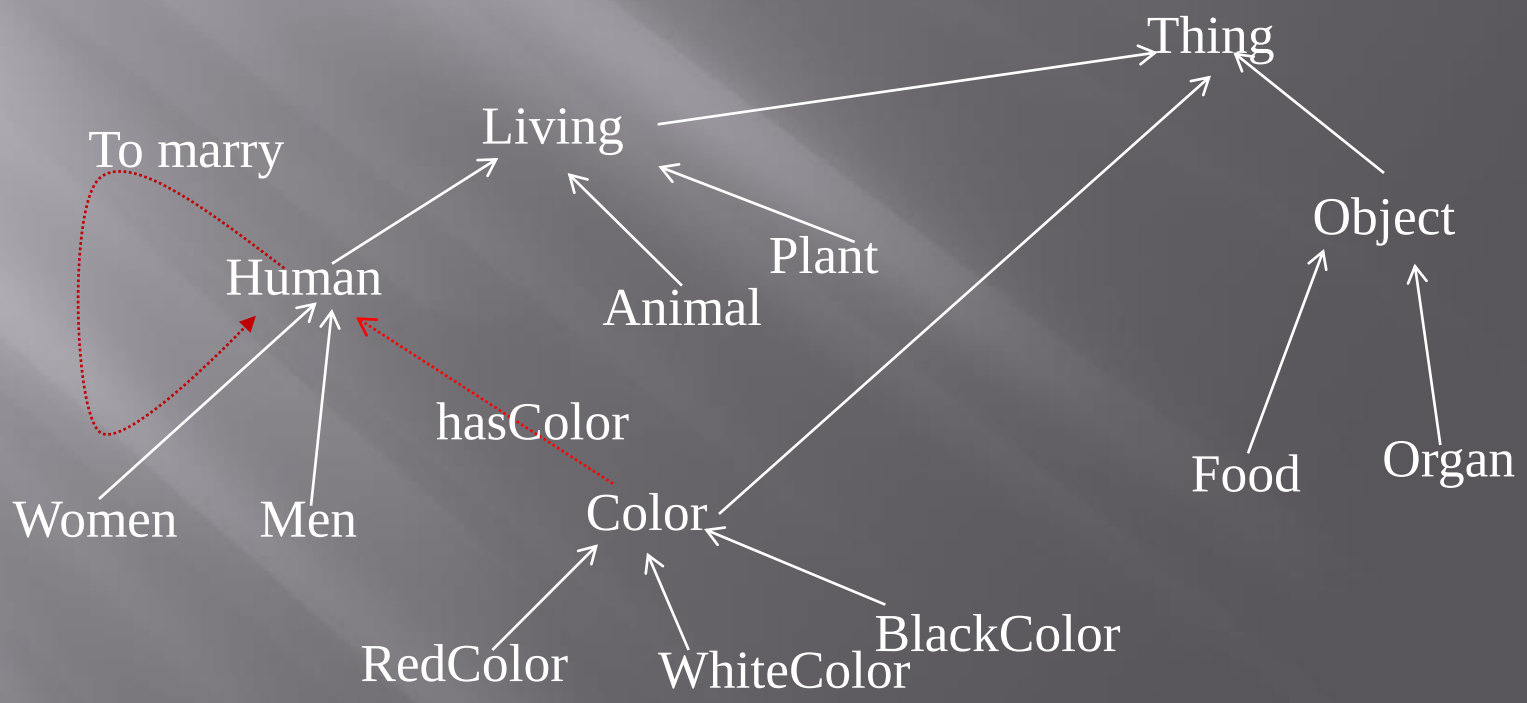
How to define the concept of White_Men ?



How to specify ontology concepts and relations : Intentional specification

How to define the concept of White_Men ?

White Men ≡Men ⊓HasColor.WhiteColor

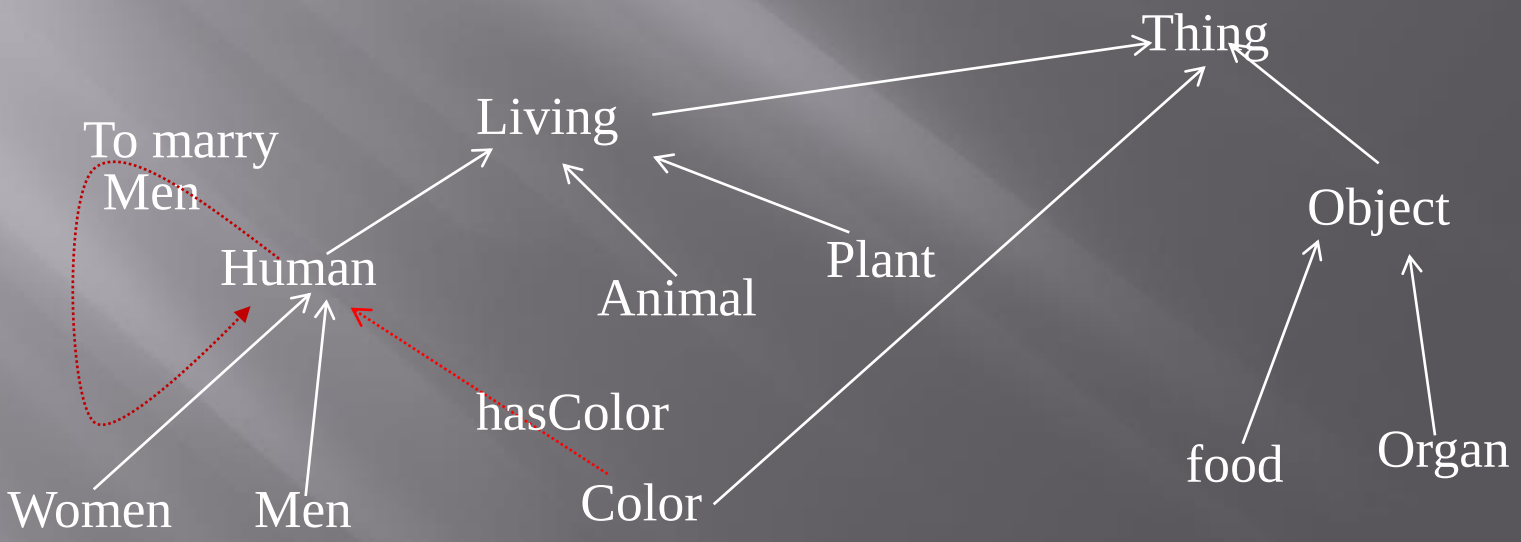


How to specify ontology concepts and relations : Intentional specification

How to define the concept of White_Men ?

White Men ≡Men ⊓HasColor.{WhiteColor}

Red, White and Black are instances/individuals of Color



How to specify ontology concepts and relations

Axioms: an axiom is an assumption that contains references to concepts or relations from the ontology, assumed true.

Axioms complete the definition of the concepts and relations

Example

ToMarry is a symmetric relation

Living ≡ Human ⊔ Animal ⊔ Vegetable

How to specify ontology components Summary

Ontology is composed of concepts, of relations between them and axioms

The relation "is-a" is a principal structuring relation within ontology.

A concept or a relation can be defined by

- A Set of properties (Intentional definition)
  - By categorization (using the is-a relation)
  - By using a relation between this concept and another concept (that is not is-a)
- A set of instances (Extensional definition)
- A set of synonyms (synonym terms associated to a concept)

Axioms

Ontology Typology

According the kinds of relations that includes

Thesaurus is an ontology that includes a list of terms related by linguistic relations (synonymy, antonym, hyperonym (is-a), meronym (part-of), etc.)

Hierarchy is an ontology that includes “is-a” or “part-of” relations (or similar relations) only

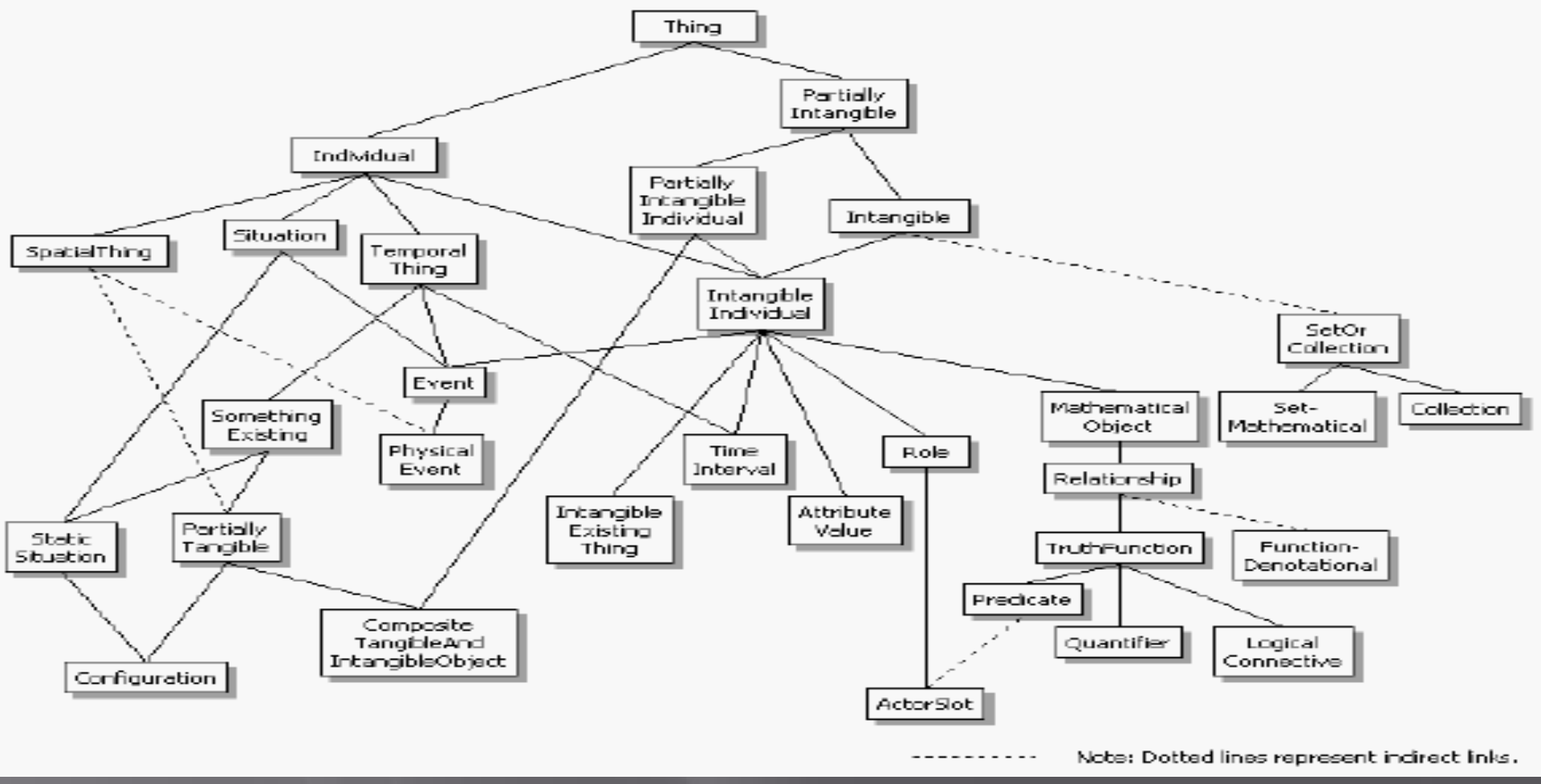
- Taxonomy: is-a (or similar) relation only
- Partonomy : part-of (or similar) relation only

Ontology is including all kinds of relations

Ontology typology

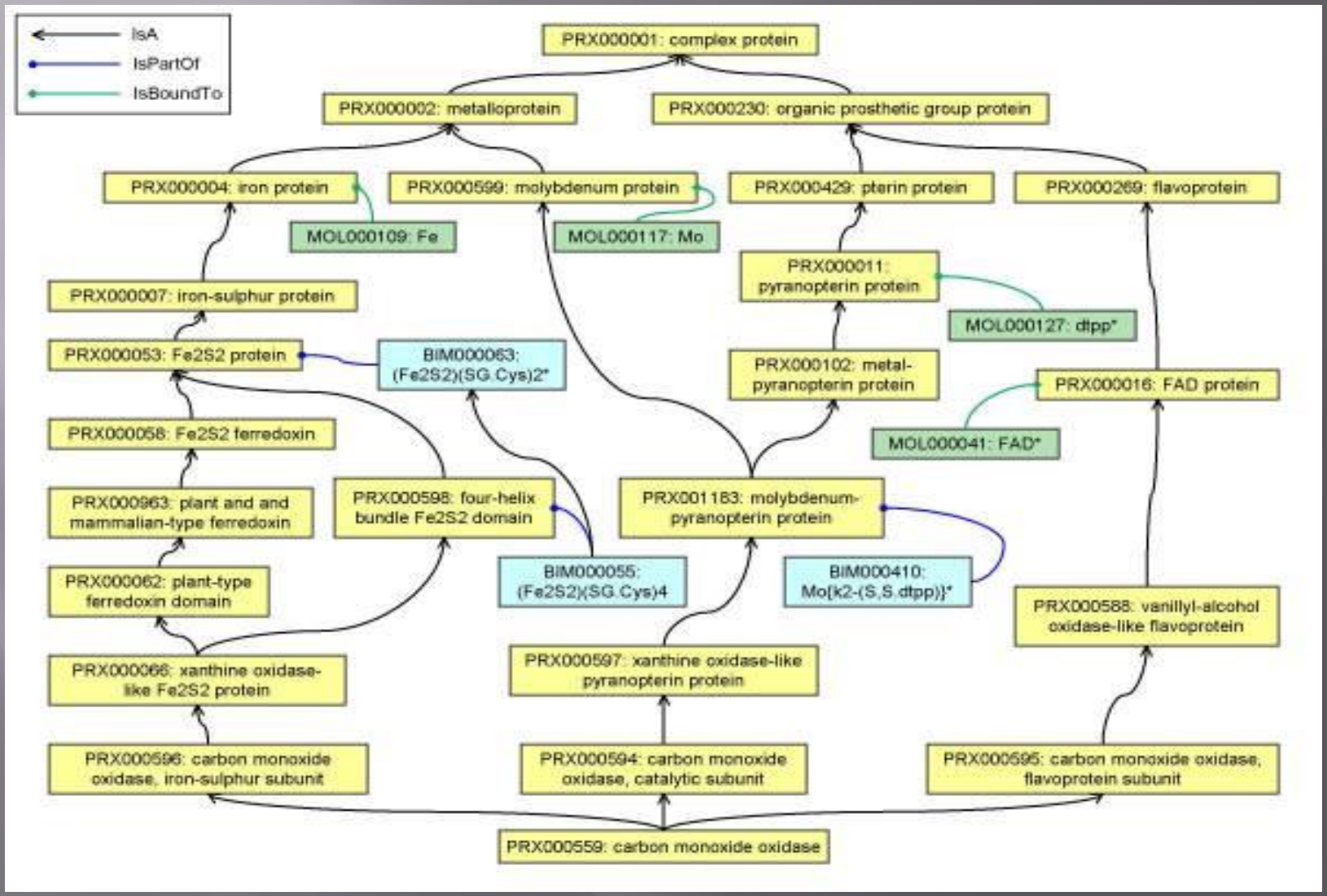
According the abstraction level of concepts

Upper ontology . CYC: is an ontology that defines universal notions. It includes abstract concepts that can be used to define a domain ontology

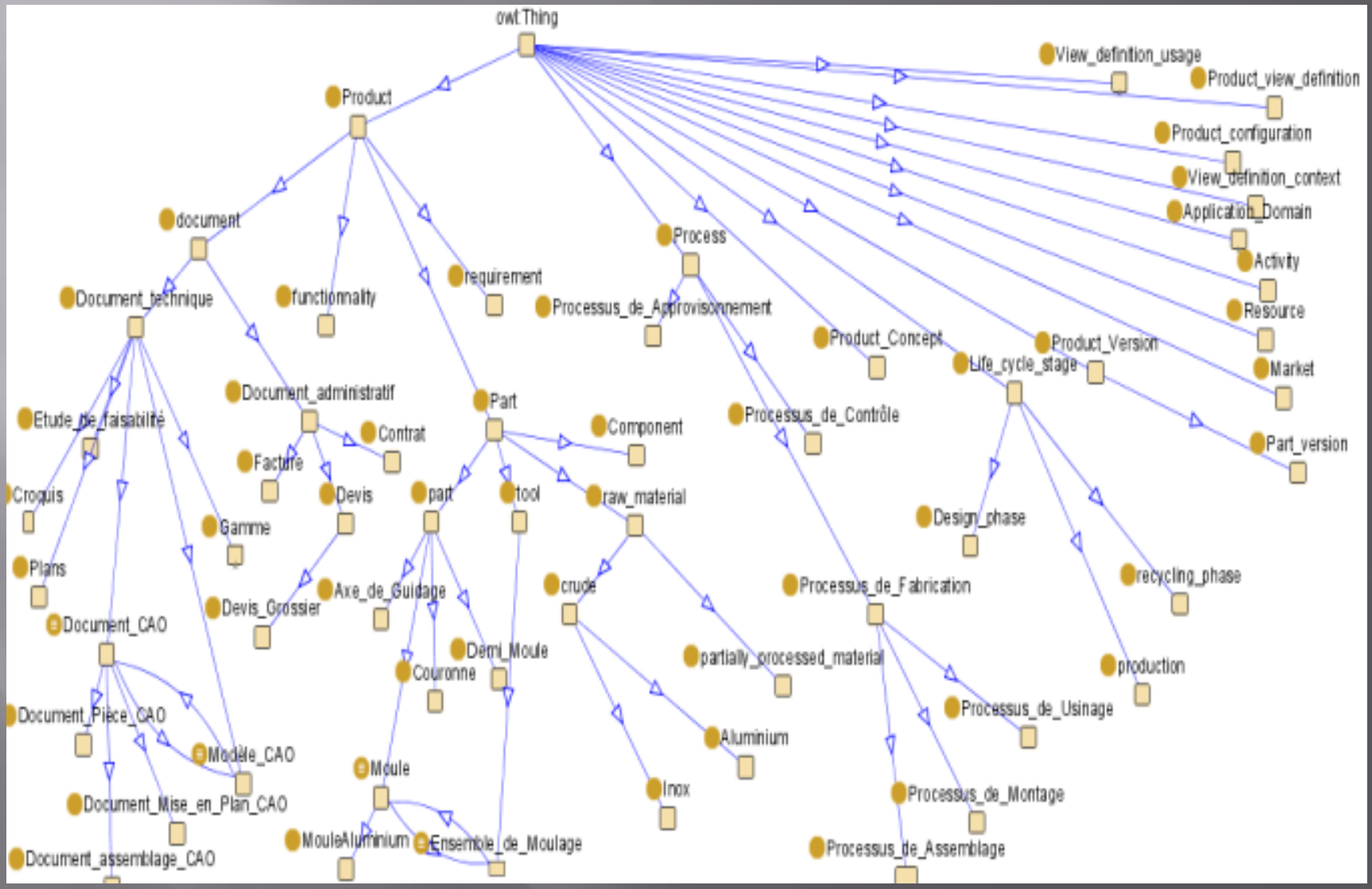


Domain Ontology

Biomedical domain

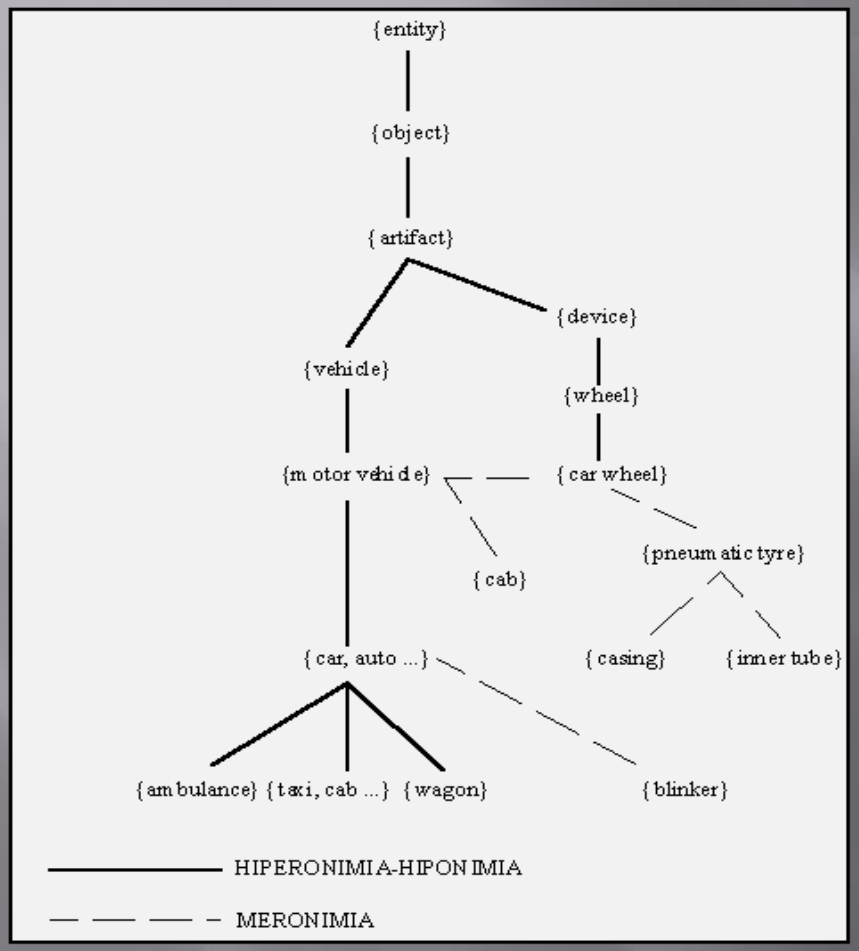


Ontology for Industrial domain



Lexical Ontology

Wordnet



Its purpose is to identify, classify define the semantic of the terms of the English language

Kind of relations

Hypernym relation
Meronym relation
Antonym relation

Synonymy :set of synonyms **(synsets)**
A *term can be found in many several synsets*

Ontology : Interests and Applications

To explicit what is considered as implicit within a domain.

Analyze/formalise the knowledge of a domain :

→Vocabularies of an information system (KBS : Knowledge Base System)

→Vocabularies to index documents

Share of common understanding of a domain

- Between humans
- Between applications

Reuse : Reuse a knowledge representation within several KBS

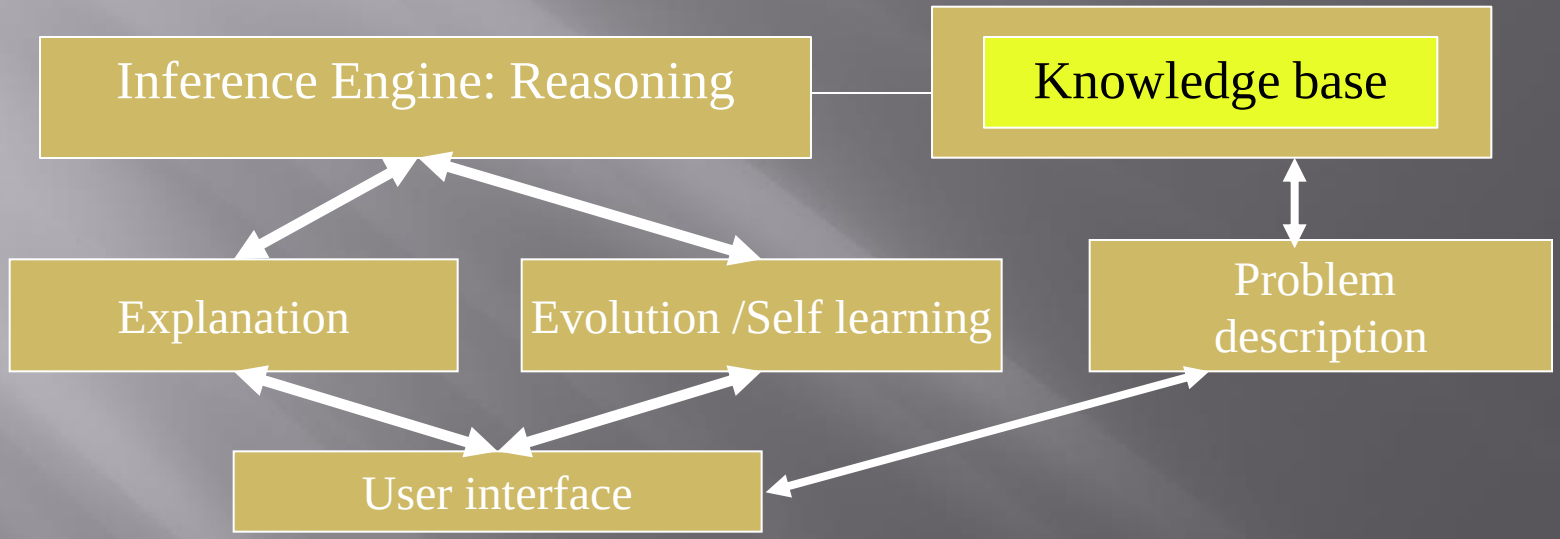
Ontology applications

- Semantic reasoning within a knowledge based system
- Comparison of objects
- Interoperability of information systems
- Information retrieval

KBS and semantic

KBS (Knwoledge-Based System) is a computer based system, which uses and generates knowledge from data, information and knowledge.

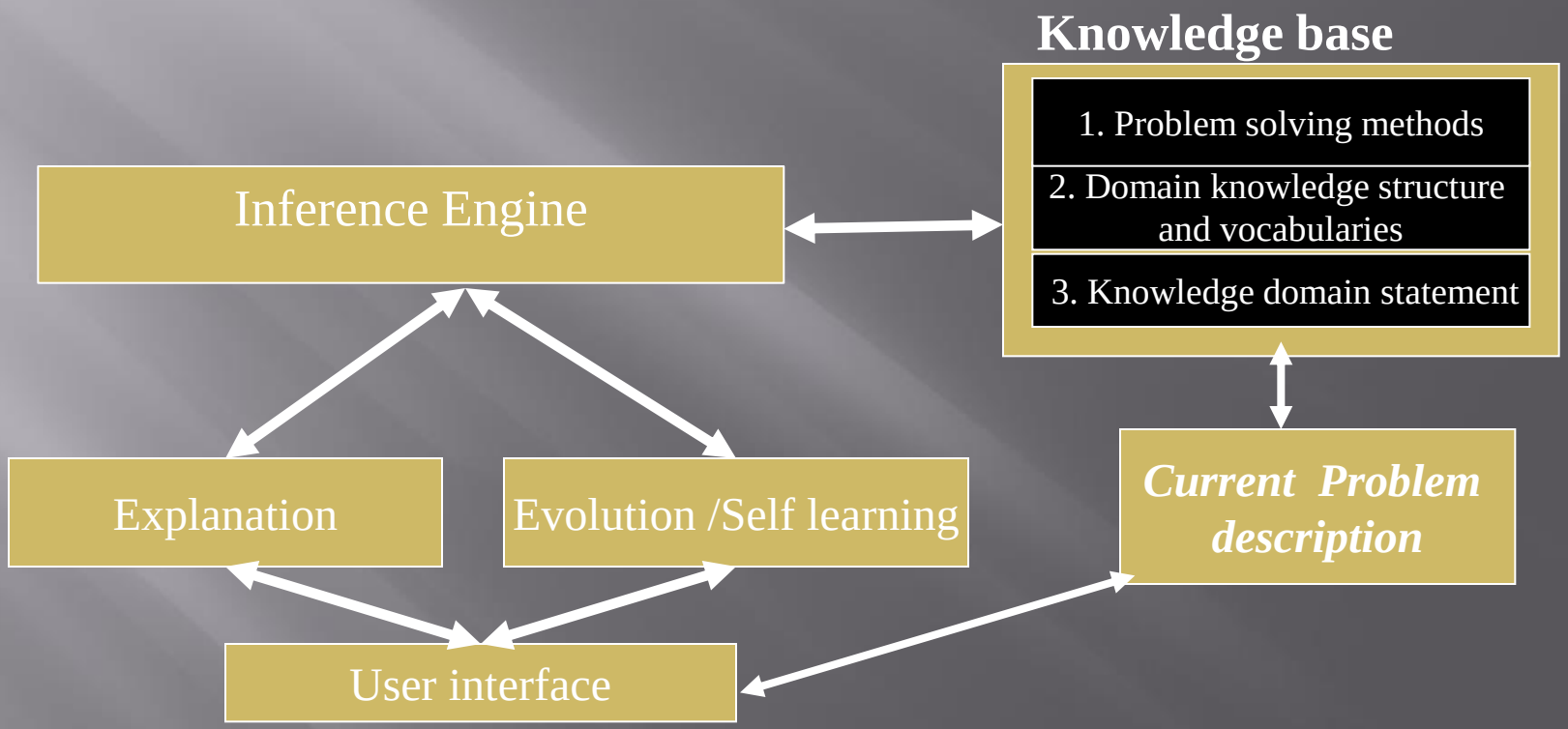
General Architecture of a KBS



Two essential Knowledge modelling principles in a KBS:

- **Reusability**: current approaches emphasis the reuse of knowledge components → ontology as a reused knowledge for faciliting knowledge engenieering process.
- **Knowledge typing**: different knowledge elements play different role in reasoning

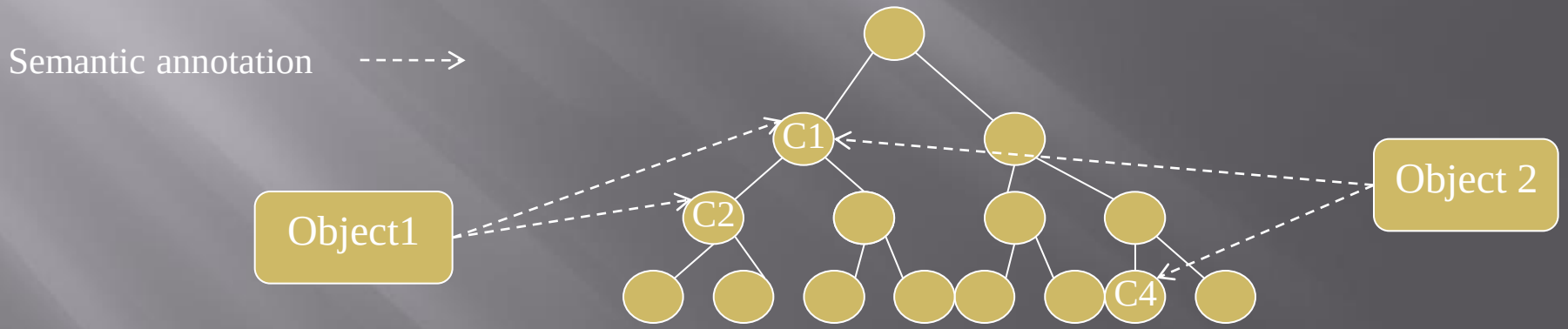
Ontology applications: Ontology within a KBS



Ontology applications : Semantic Annotations

Semantic annotation with ontology is to associate one or several concepts of ontology to a given object to define partially or completely its semantic

Examples of an object: a document, a service, a photo, a gene



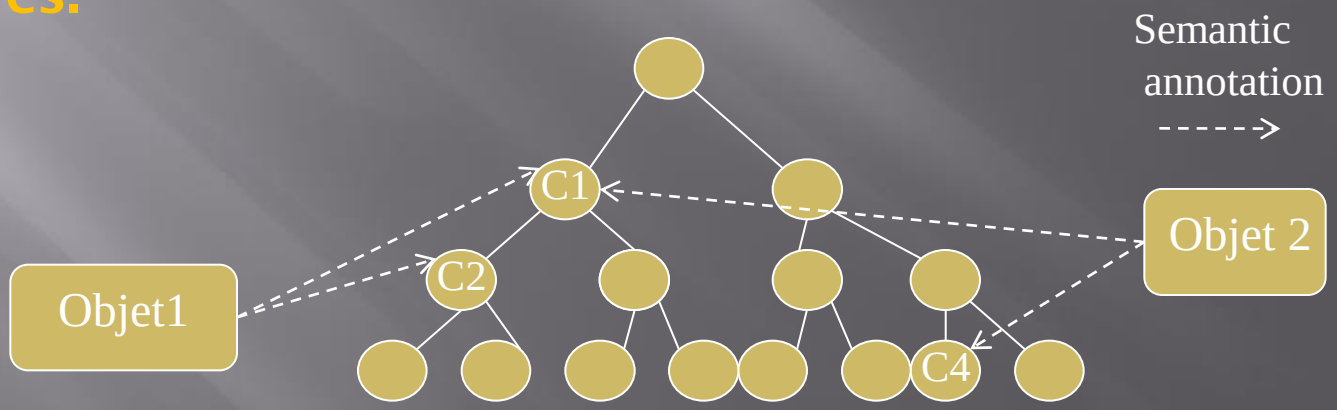
Object1 is annotated by{C1, C2}, Object2 is annotated by {C1,C4}

Ontology Applications : Object comparison

Comparison of annotated objects is about the comparison of objects by comparing their semantic annotations.

Object annotations can be done by the same ontology or by several ontologies.

The comparison of objects are performed using **semantic similarity measures.**

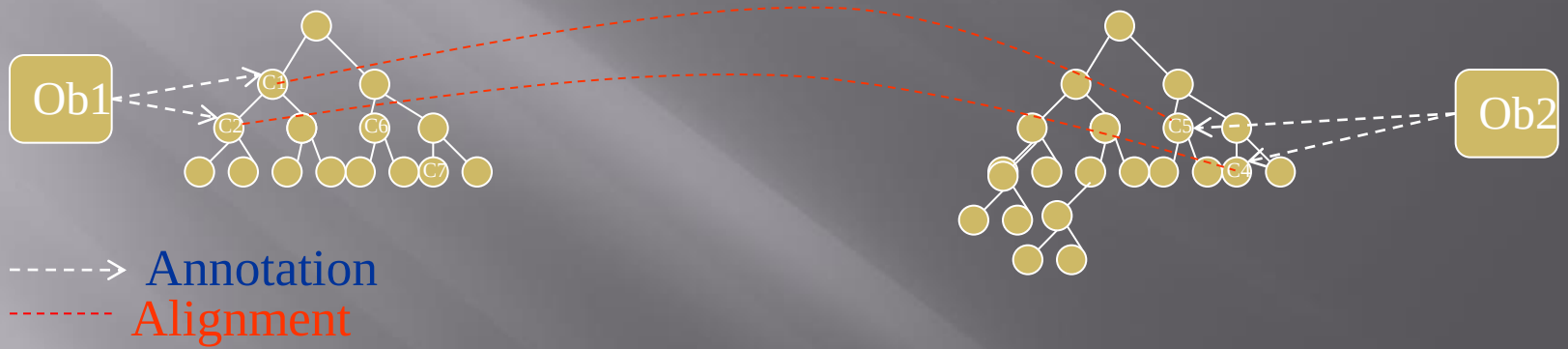


Ms(Object1, Object2) = Ms({C1, C2}, {C1,C4})

Ontology Applications : Object comparison

Object 1 and Object 2 are annotated by two different ontologies

Need to align these ontologies to allow comparing the objects annotated by them



Ms(Object1, Object2) = Ms ({C1, C2}, {C5,C4})

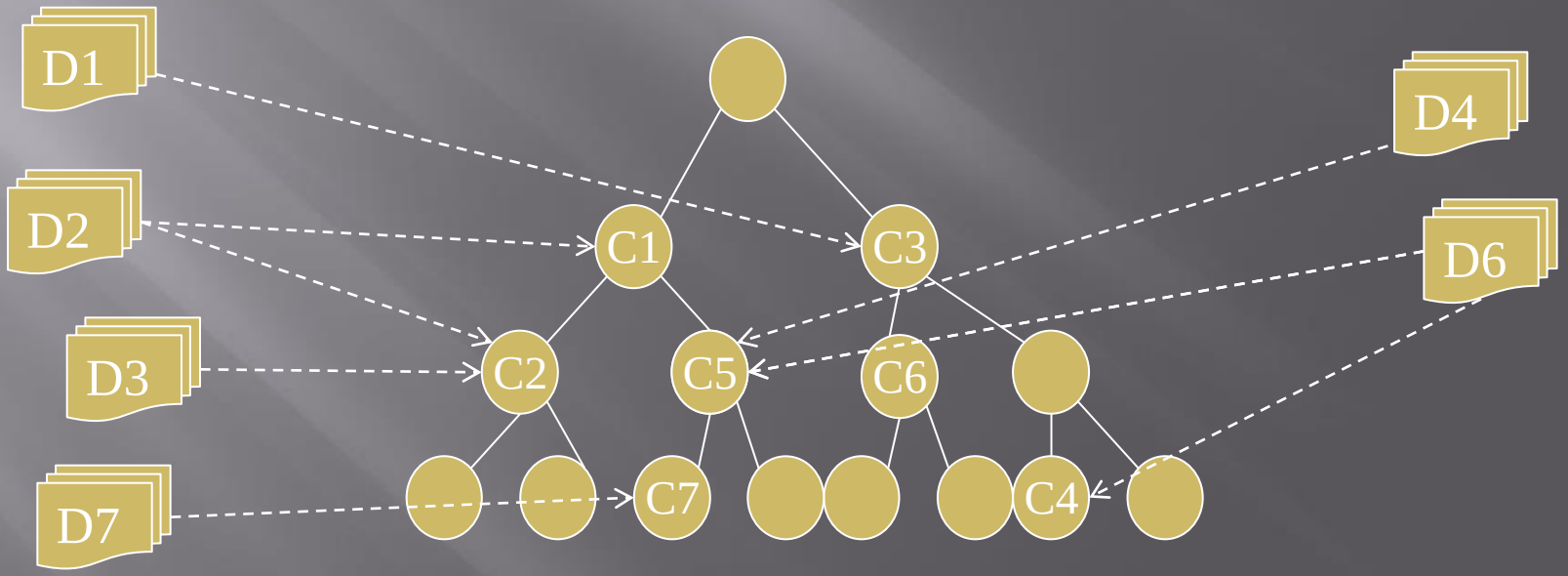
Ontology alignment is the process of determining correspondences between concepts of two ontologies:

- For each pair (Ci, Cj) a value of the similarity measure is associated
- Ci belongs to the first ontology and Cj belongs to the second ontology

Ontology Applications: Semantic information retrieval

- Annotation of documents with concepts of one or several ontologies
- Search queries for documents annotated by concepts semantically close to the target terms

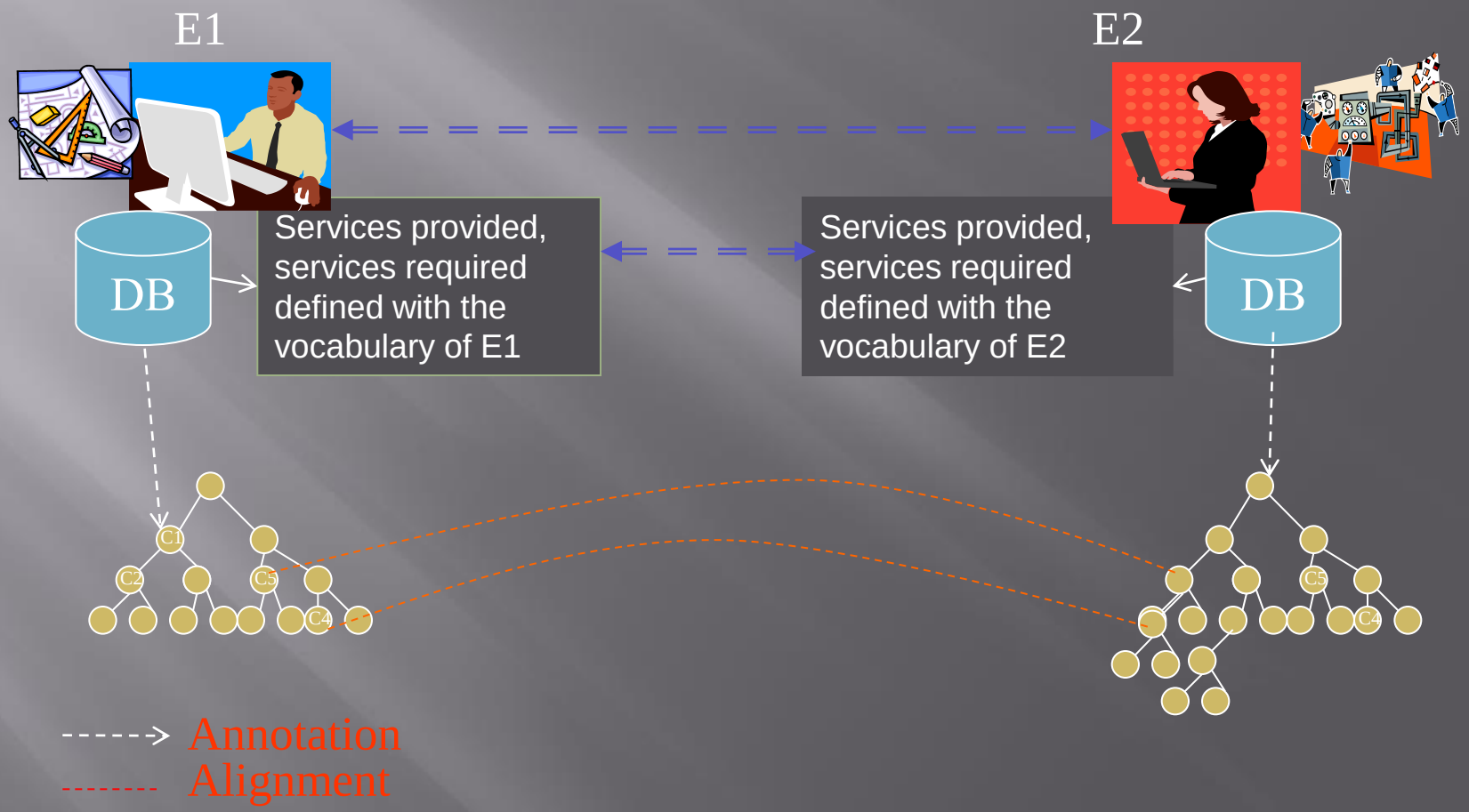
To search for documents related to C5 : documents annotated by concepts synonyms of C5 or semantically close to C5



Result of an exact search: D4 and D6

Result of a large search: D4, D6, D2 and D7

Ontology Applications: System Interoperability



Ontology applications :

Ontology offline → Ontology online

Many informations on the web
Big data on the web

} **We can extract knowledge**

↓

Data heterogeneity

↓

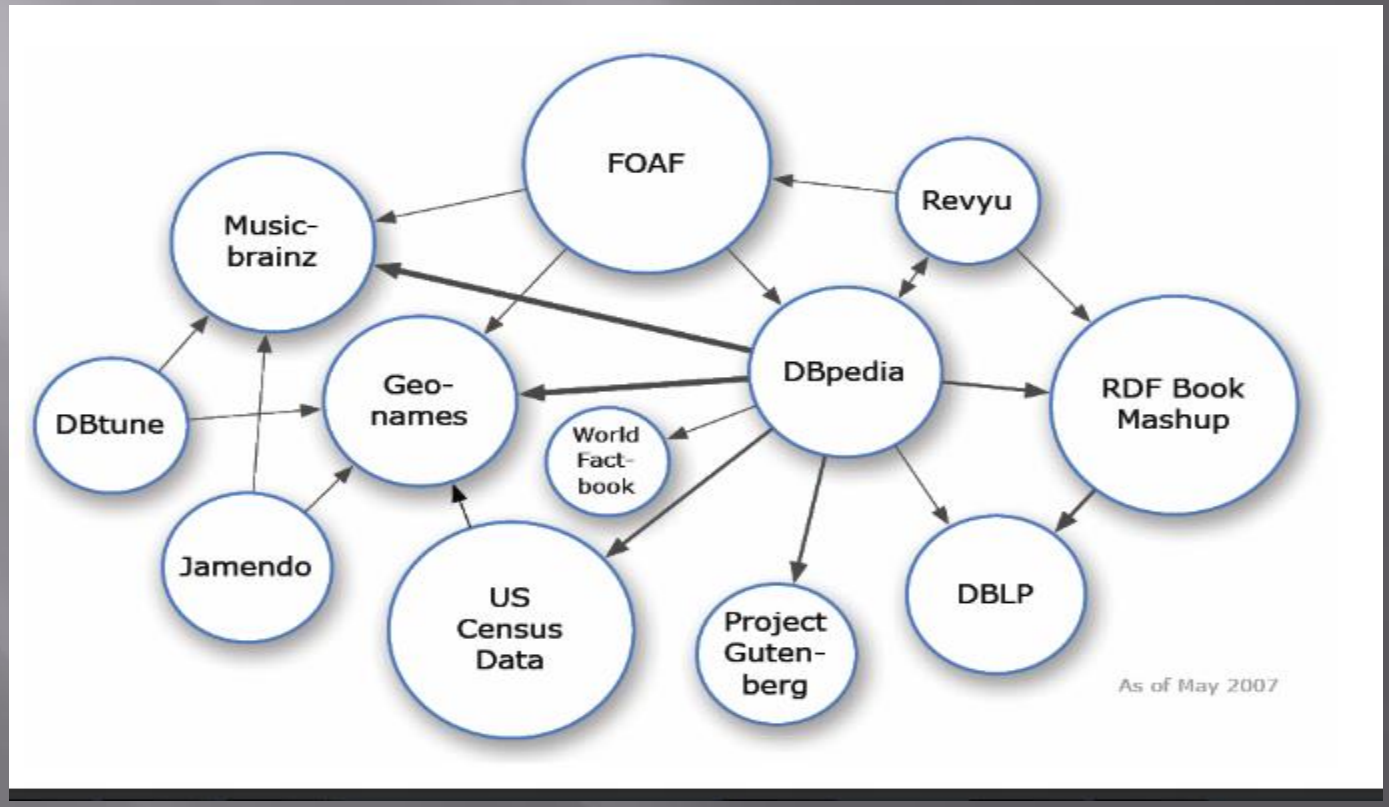
Web of data
+
Ontology

} Web information retrieval
Knowledge extraction
web object comparison

Is there an ontology for the web ?
Is it possible to build an ontology for the web ?

Linked Ontologies for linked-data

- Light ontology to annotate data
- Aligned /linked ontologies for linked data

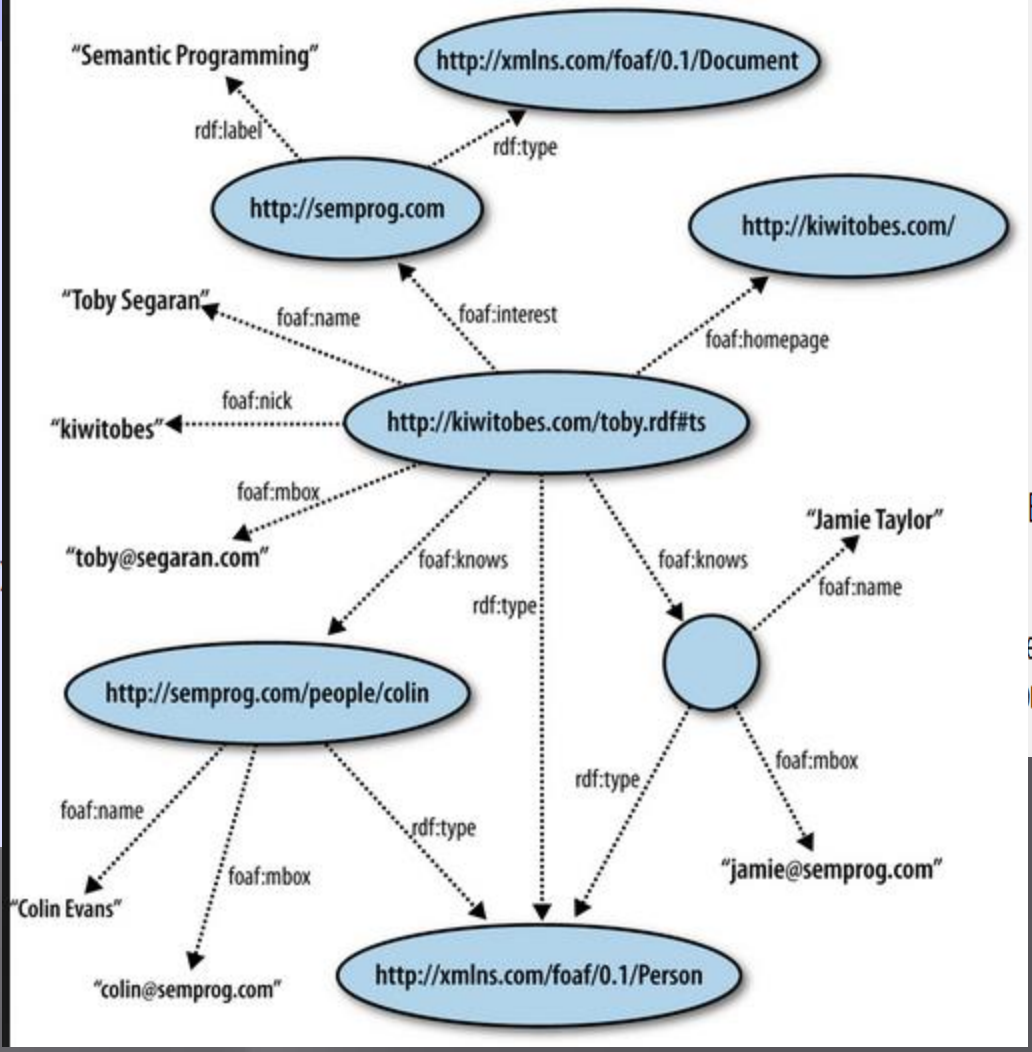


FOAF ontology « Friend of a friend » to link people and information using the Web

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

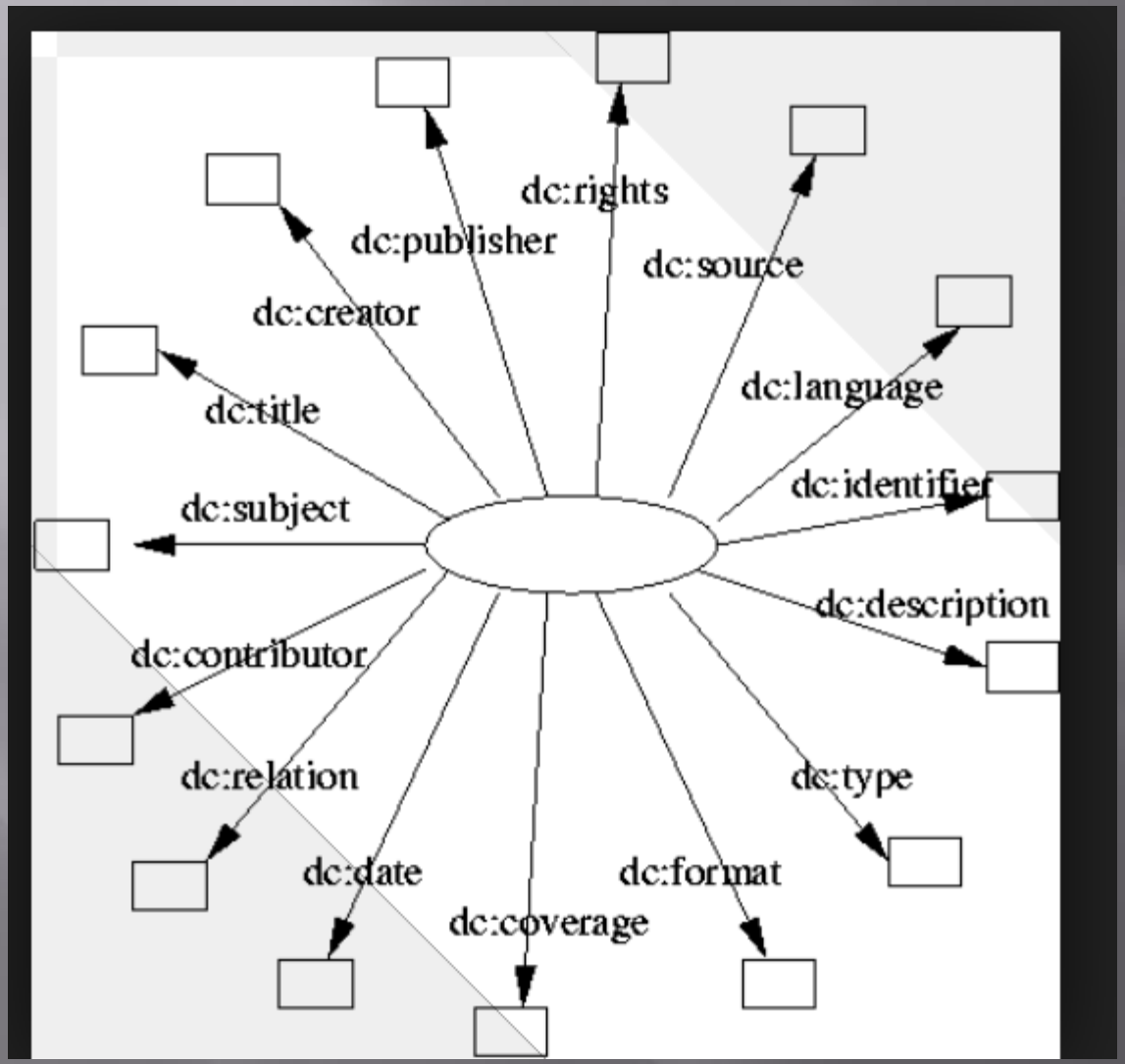
Property: foaf:maker



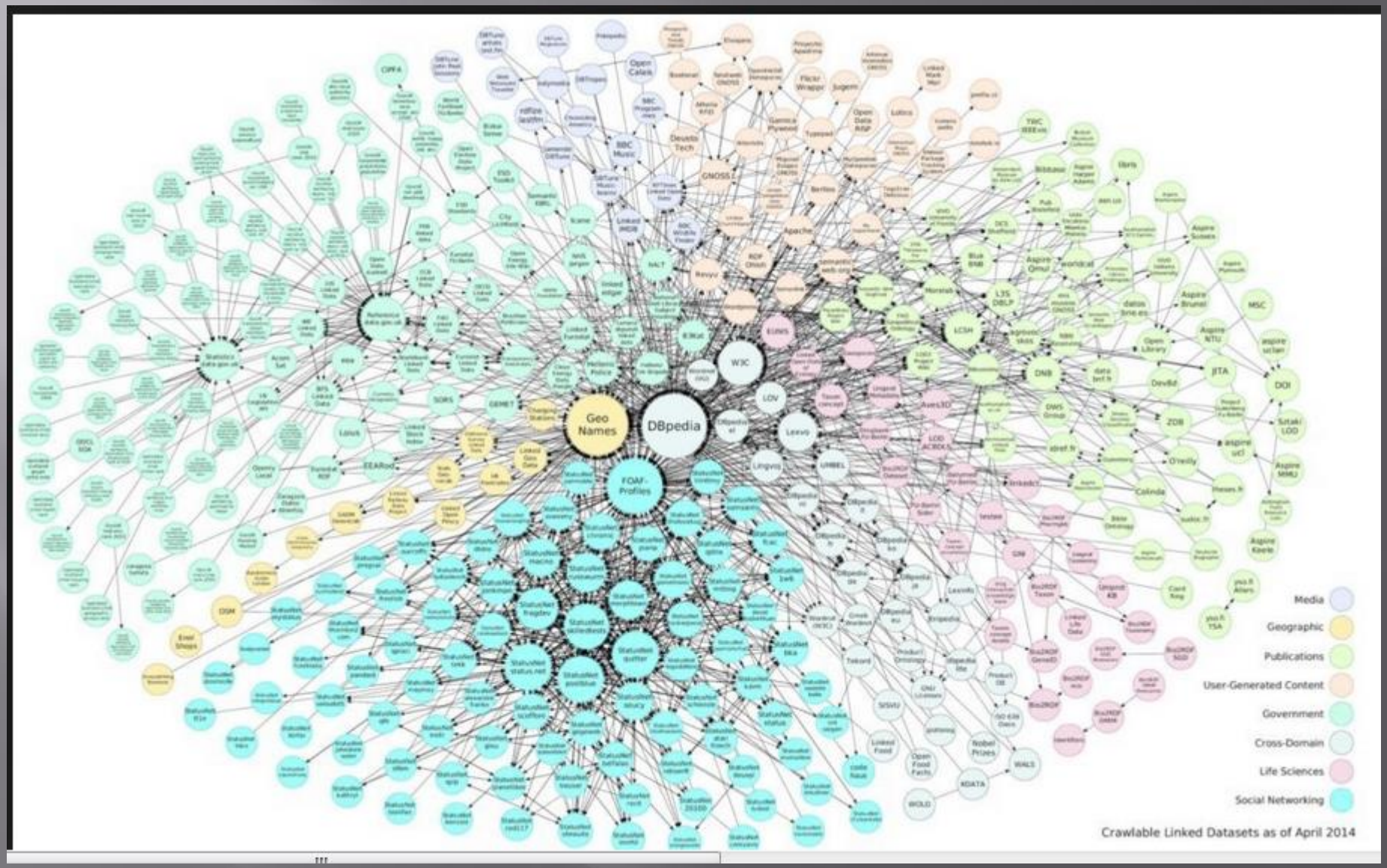
Brickley', we can

e creators, rather
r details.

Dublin Core terms to describe documents on the web



Linked Ontologies for linked-data



Linked ontologies for linked-data