# Intelligent Information Systems

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Lecture Notes: Module 12

HUMAN CAPITAL
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# Ontologies

## Module 12

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# Prologue

# Ontology-What's?

"People use the word ontology to mean different things, e.g.

- glossaries and data dictionaries,
- thesauri and taxonomies,
- schema and data models, and
- formal ontologies and inference."

W. Pidcock, What are the differences between a vocabulary, a taxonomy, a thesaurus, an ontology, and a meta-model?, 2003 http://www.metamodel.com/article.php?story=20030115211223271

and in philosophical discourses (!).

# In Philosophy

**Metaphysics** -- is the study of the most general features of reality, such as existence, time, the relationship between mind and body, objects and their properties, wholes and their parts, events, processes, and causation.

**Epistemology** -- is concerned with the nature and scope of knowledge, such as the relationships between truth, belief, and theories of justification.

**Logic** -- is the study of the principles of valid inference and correct reasoning.

**Ethics** -- is concerned primarily with the question of the best way to live, and secondarily, concerning the question of whether this question can be answered.

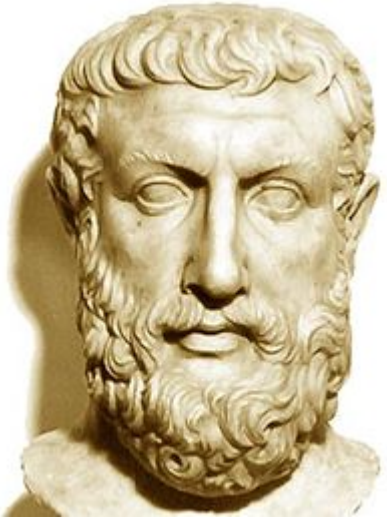
**Aesthetics** -- deals with beauty, art, enjoyment, sensory-emotional values, perception, and matters of taste and sentiment.

# Definition

# Ontology

A branch of metaphysics concerned with the nature and relations of being.

„*Ontology is the philosophical study of the nature of being, existence, or reality, as well as the basic categories of being and their relations.*”



Parmenides
early 5th century BC

http://en.wikipedia.org/wiki/Ontology

A particular theory about the nature of being or the kinds of existents.

# Towards Understanding and Problem Solving

Ontologies are established and used for:

1. Describing domains' knowledge in a generic way;
2. Providing agreed understanding of the domains.

# Ontology-What's?

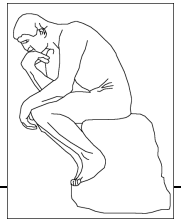
"A formal ontology is a controlled vocabulary expressed in an **ontology representation language**.

This language has a **grammar** for using vocabulary terms to express something meaningful within a specified domain of interest.

The grammar contains **formal constraints** … on how terms in the ontology's vocabulary can be used together."

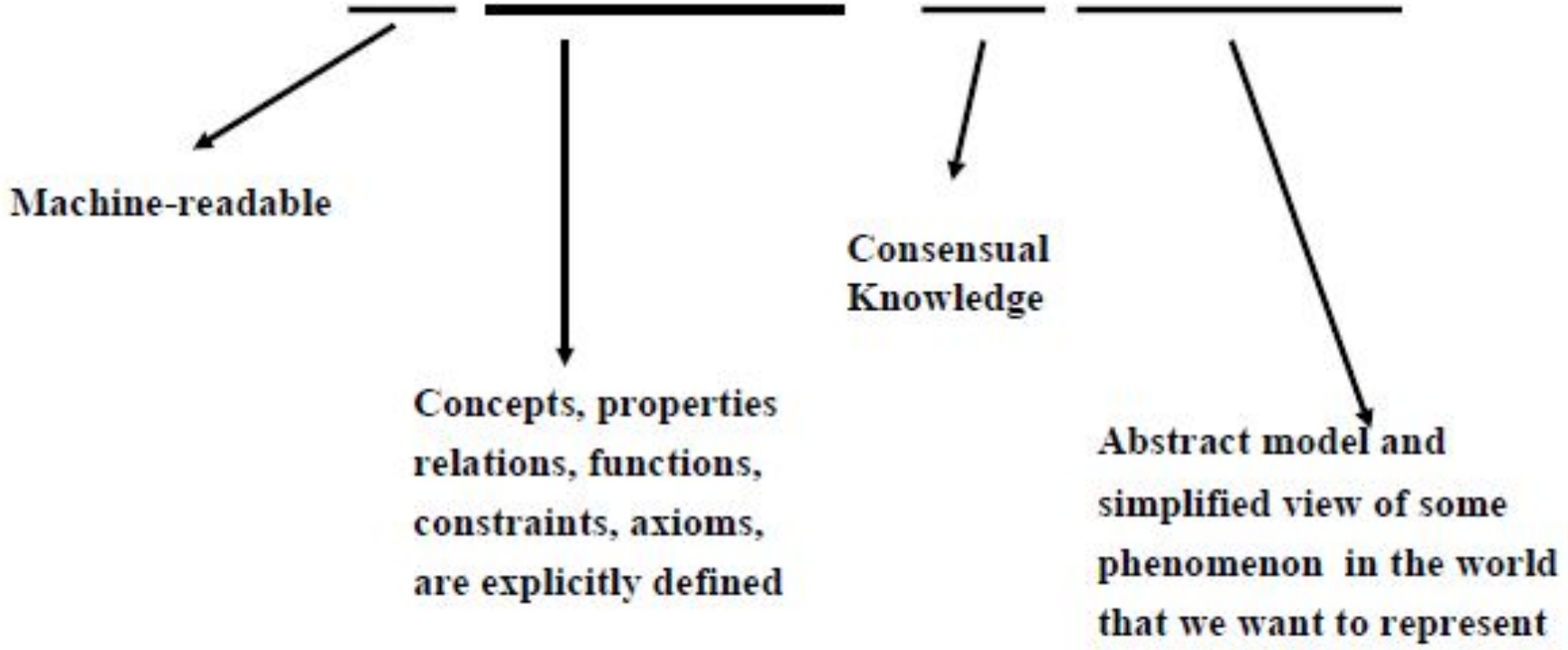
W. Pidcock, 2003

**And it allows one for carrying out inference tasks!**



# Definition

„An ontology is a formal, explicit specification of a shared conceptualization”




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

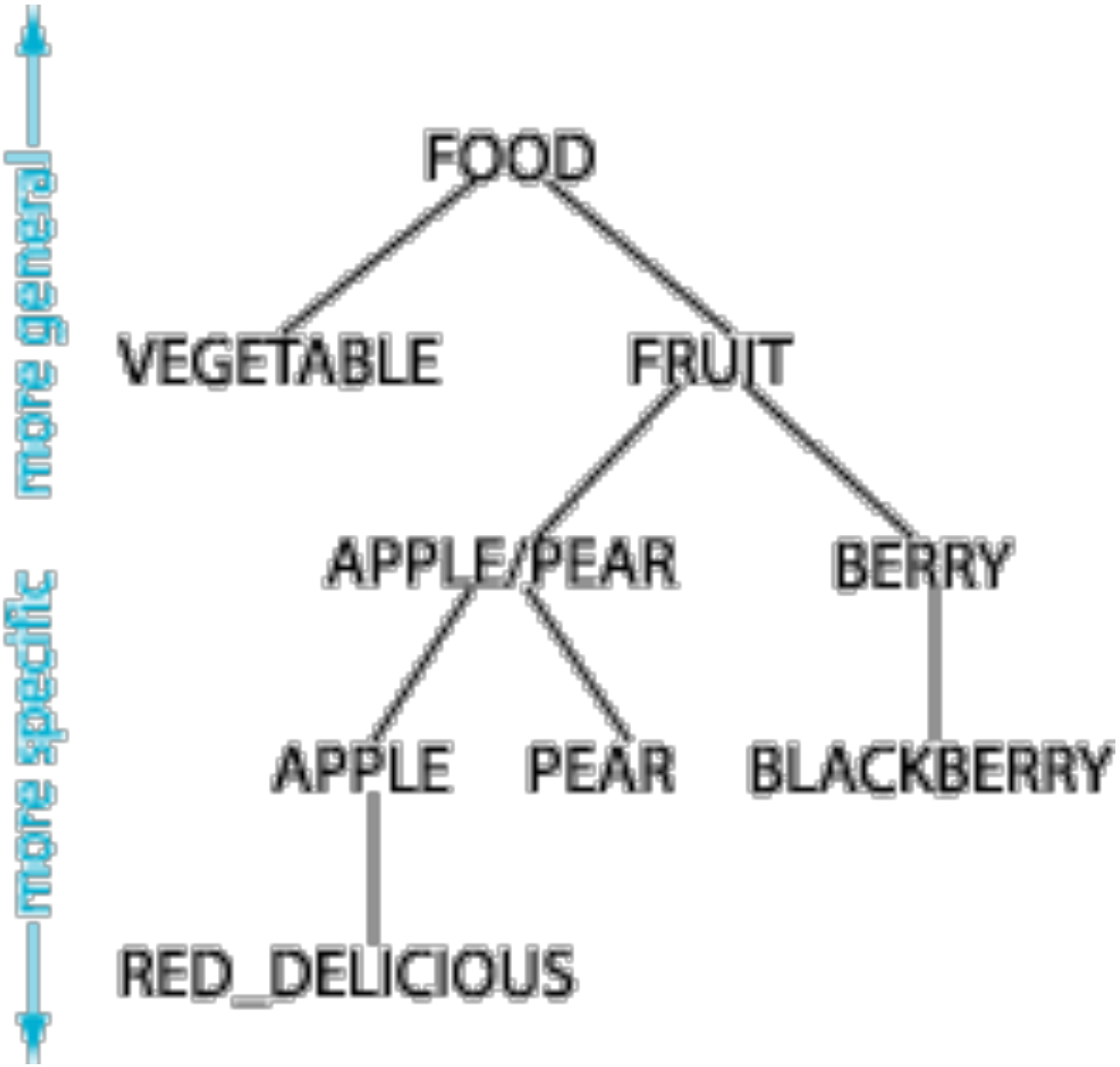
# More Definitions

| | |
|---|---|
| 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 RE, Finin T, Gruber TR, Senator T, Swartout WR (1991) *Enabling technology for knowledge sharing.* **AI Magazine** 12(3):36–56 |
| 2. "An ontology is an explicit specification of a conceptualization" |  Gruber TR (1993a) *A translation approach to portable ontology specification.* **Knowledge Acquisition** 5(2):199–220 |
| 3. "An ontology is a formal, explicit specification of a shared conceptualization" |  Studer R, Benjamins VR, Fensel D (1998) *Knowledge Engineering: Principles and Methods.* **IEEE Transactions on Data and Knowledge Engineering** 25(1-2):161–197 |
| 4. "A logical theory which gives on explicit, partial account of a conceptualization" |  Guarino N, Giaretta P (1995) *Ontologies and Knowledge Bases: Towards a Terminological Clarification.* In: Mars N (ed) **Towards Very Large Knowledge Bases: Knowledge Building and Knowledge Sharing (KBKS'95).** University of Twente, Enschede, The Netherlands. IOS Press, Amsterdam, The Netherlands, pp 25–32 |
| 5. "A set of logical axioms designed to account for the intended meaning of a vocabulary" |  Guarino N (1998) *Formal Ontology in Information Systems.* In: Guarino N (ed) 1st International Conference on **Formal Ontology in Information Systems (FOIS'98).** Trento, Italy. IOS Press, Amsterdam, pp 3–15 |

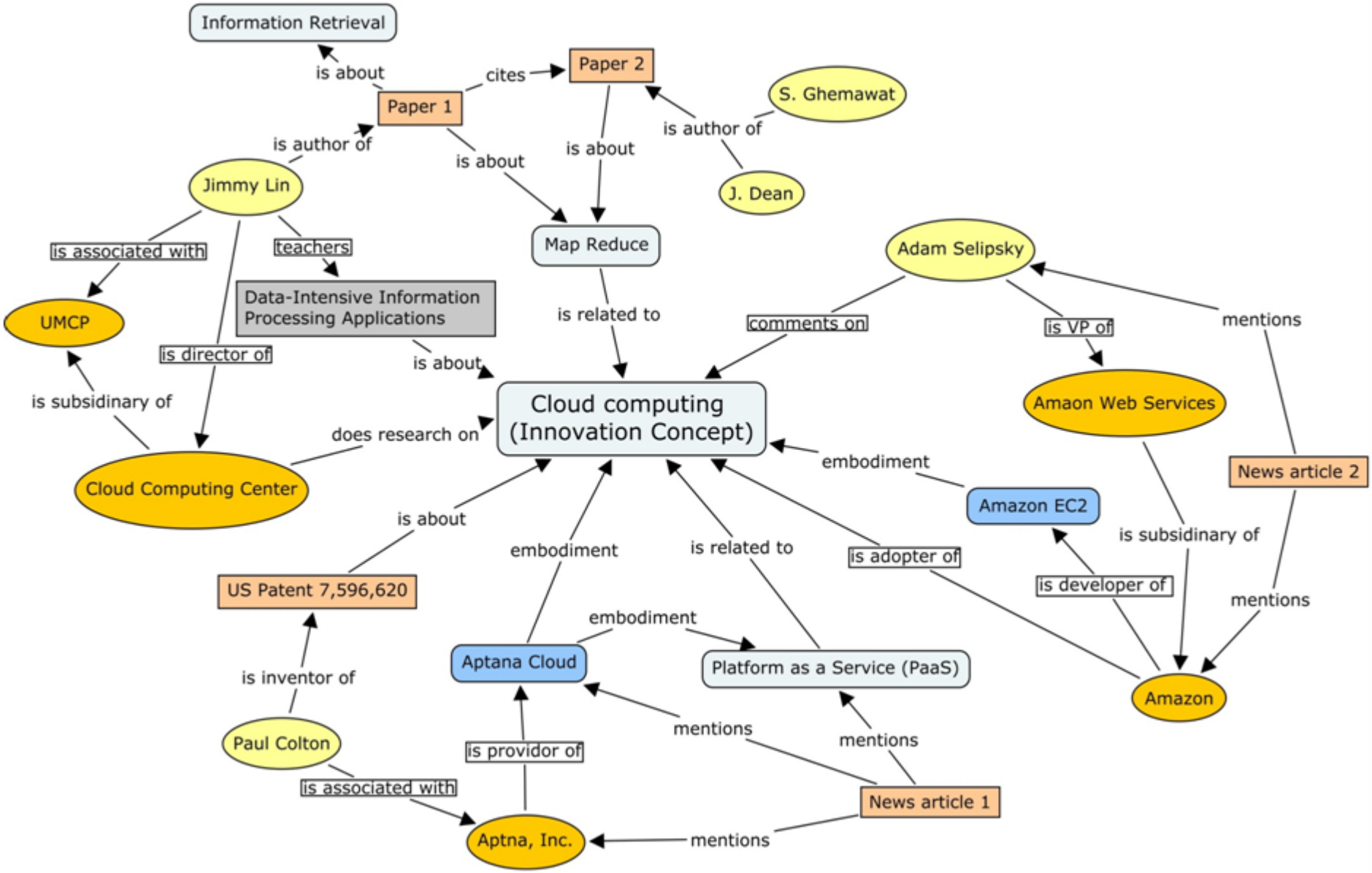
Source: *Ontological Engineering, A. Gómez-Pérez, M. Fernández-López, O. Corcho*

# Example

# Taxonomy is Ontology



# Innovation Ontology




Source: *http://stick.ischool.umd.edu/innovation_ontology.html*

# Tools

# Ontology Building Process

- Define the domain and scope of the ontology.
- Check out whether there already exist an ontology addressing your area of interest. If so, check out whether one can use it for one's purposes and under which conditions (licenses).
- Define the dictionaries to be used for the ontology.
- Define the classes of objects and their attributes (including domains of their values) and as well as relationships between the classes (e.g. hierarchy/taxonomy).
- Set up the model by means of a chosen representation methodology, e.g. semantic network, frames, logic.
- Implement the model. Typically, to this end one a applies ready-to-use framework/language, e.g. `owl language and Protégé framework.

# Ontology Languages

- Common logic is ISO standard 24707, a specification for a family of ontology languages that can be accurately translated into each other.
- The Cyc project has its own ontology language called CycL, based on first-order predicate calculus with some higher-order extensions.
- The Gellish language includes rules for its own extension and thus integrates an ontology with an ontology language.
- IDEF5 is a software engineering method to develop and maintain usable, accurate, domain ontologies.
- KIF is a syntax for first-order logic that is based on S-expressions.
- Rule Interchange Format (RIF) and F-Logic combine ontologies and rules.
- OWL is a language for making ontological statements, developed as a follow-on from RDF and RDFS, as well as earlier ontology language projects including OIL, DAML and DAML+OIL. OWL is intended to be used over the World Wide Web, and all its elements (classes, properties and individuals) are defined as RDF resources, and identified by URIs.
- XBRL (Extensible Business Reporting Language) is a syntax for expressing business semantics.

Source: *http://en.wikipedia.org/wiki/Ontology_engineering*

# Ontology in OWL

Here there are two fragments of a certain ontology that describes the realm of animals. The first item is a definition of a class; the second one defines the proprties of an object.

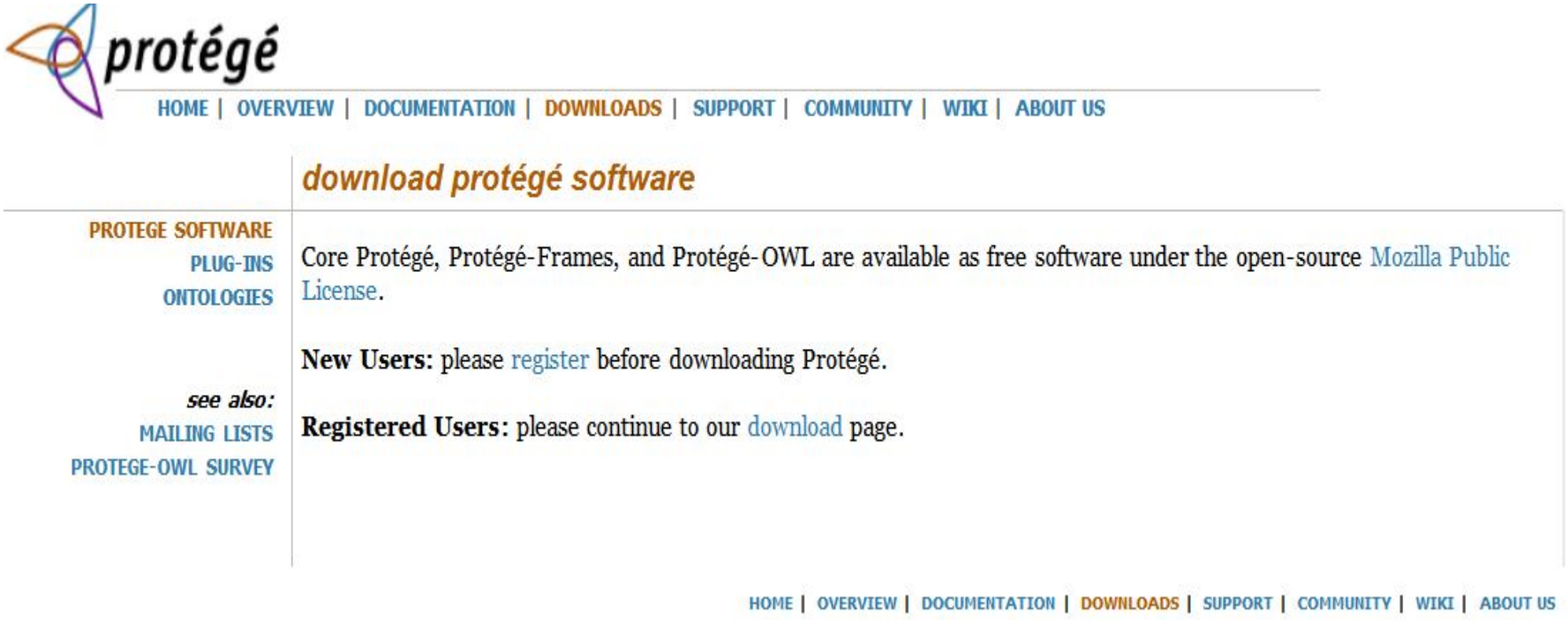
```
Class(pp:animal partial
  restriction(pp:eats someValuesFrom(owl:Thing)))
Class(pp:person partial pp:animal)
Class(pp:man complete
  intersectionOf(pp:person pp:male pp:adult))
Class(pp:animal+lover complete
  intersectionOf(pp:person
          restriction(pp:has_pet minCardinality(3))))

ObjectProperty(pp:eaten_by)
ObjectProperty(pp:eats inverseOf(pp:eaten_by)
                       domain(pp:animal))
ObjectProperty(pp:has_pet domain(pp:person)
                          range(pp:animal))
ObjectProperty(pp:is_pet_of inverseOf(pp:has_pet))
DataProperty(pp:service_number range(xsd:integer))

SubPropertyOf(pp:has_pet pp:likes)
```

# Ontology Framework

**Protégé** is a free, open source ontology editor and a knowledge acquisition system.

It is being developed at Stanford University in collaboration with the University of Manchester.

**http://protege.stanford.edu/download/download.html**



# Readings

1. Arp R., Smith B., Spear A.,D.: “Building Ontologies with Basic Formal Ontology”, MIT Press, 2015.
2. Gellish-Net: http://www.gellish.net/
3. Goczyła K.: “Ontologie w systemach informatycznych”, Akademicka Oficyna Wydawnicza EXIT, 2011.
4. Guarino N., Giaretta P.: „Ontologies and Knowledge Bases: Towards a terminological Clarification”. [w:]: Mars N. (ed.) Towards Very Large Knowledge WP of Building and Knowledge Sharing (KBKS’95). University of Fwente Enschede, Amsterdam: IOS Press, 1995.
5. Mizoguchi R., Vanwelkenhuysen J., Ikeda M.: „Task Ontology for reuse of problem solving knowledge”, [in:] Mars N. (ed) Towards Very Large Knowledge Bases: Knowledge Building and Knowledge Sharing (KBKS’95). University of Twente, Enschede, The Netherlands. IOS Press, Amsterdam, The Netherlands, pp 46-57.
6. Studer R., Benjamins V. R., Fensel D.: „Knowledge engineering: Principles and Methods”, Data and Knowledge Engineering, vol. 25 no. 1-2 1998, pp. 161-197.
7. The Syntax of CycL: http://www.cyc.com/documentation/ontologists-handbook/cyc-basics/syntax-cycl/

# Epilogue

*Ontology recapitulates philology.*

– James Grier Miller

# *„The world is everything that is the case.”*


Ludwig Wittgenstein, *Tractatus Logico Philosophicus*

# Thank you!

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