COMP318: Ontology based Information Systems

www.csc.liv.ac.uk/~valli/Comp318

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Why do we need ontologies

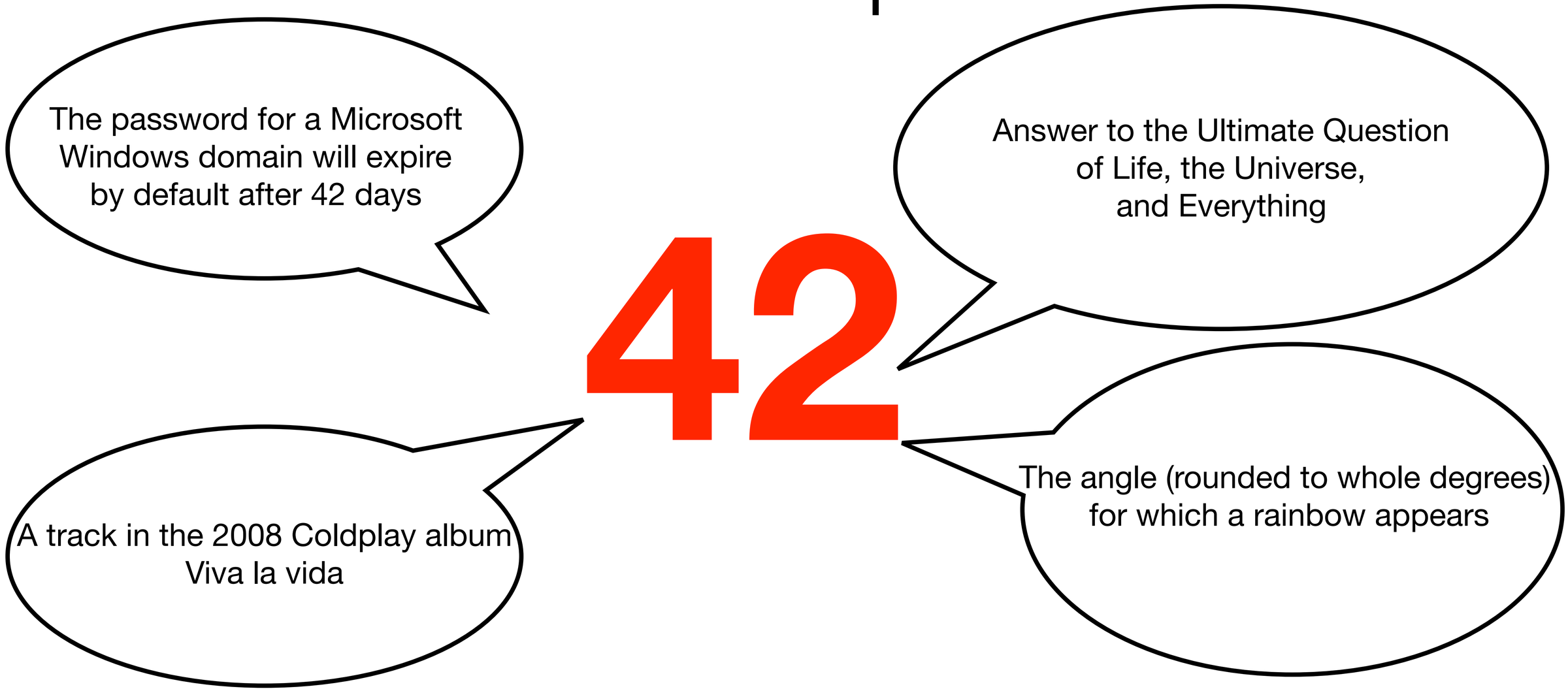
- Ontologies provide a common vocabulary and definition of rules defining the use of the terms by independently developed resources, processes, services

- That means….

An example

42

An example

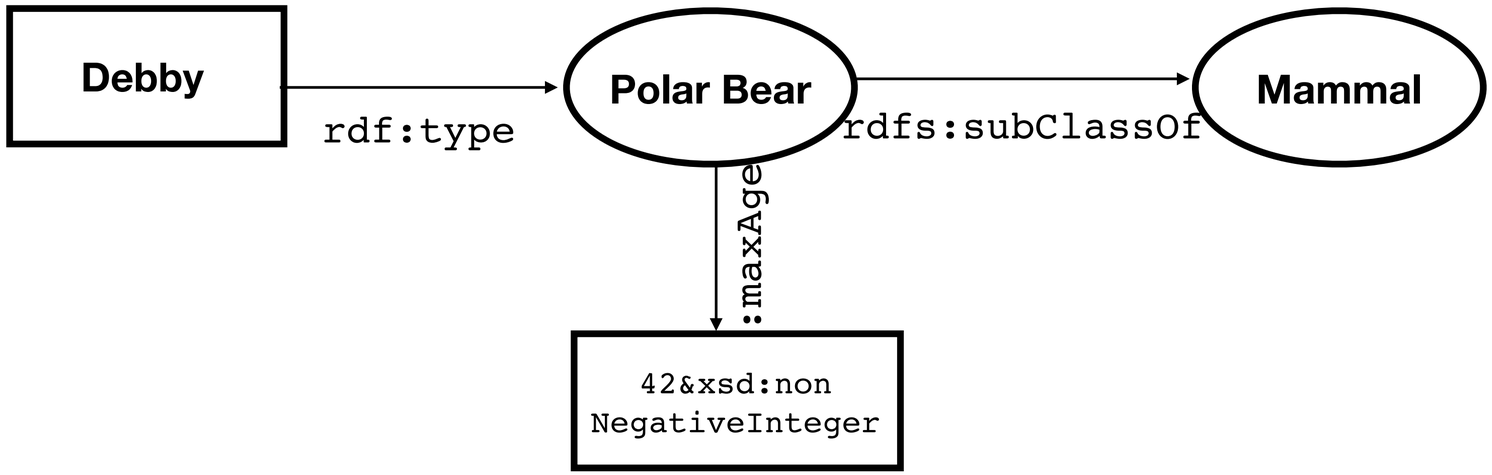

The password for a Microsoft Windows domain will expire by default after 42 days
Answer to the Ultimate Question of Life, the Universe, and Everything
42
A track in the 2008 Coldplay album Viva la vida
The angle (rounded to whole degrees) for which a rainbow appears

An example

42 years

An example

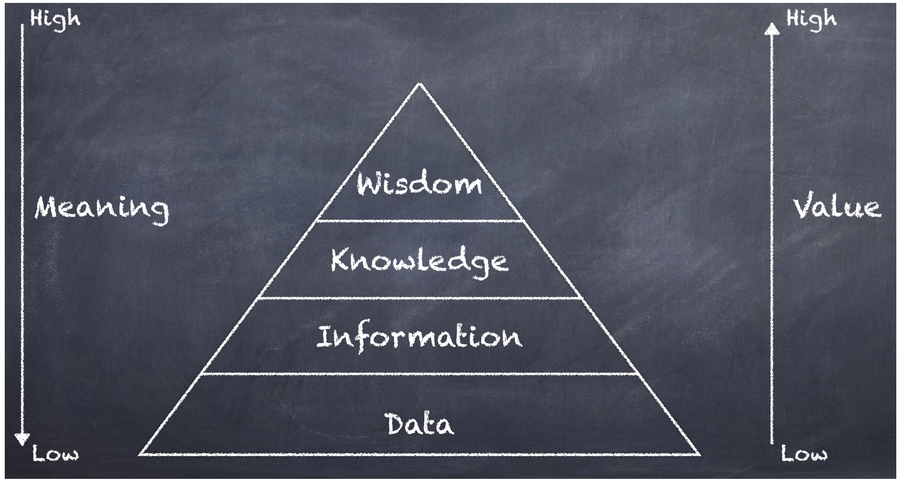
- Max recorded age for a polar bear in captivity
  - The oldest polar bear on record was Debby, who died at Assiniboine Park Zoo, Canada, in 2008 aged 42



Class: PolarBear SubClassOf: Mammal and maxAge only 42

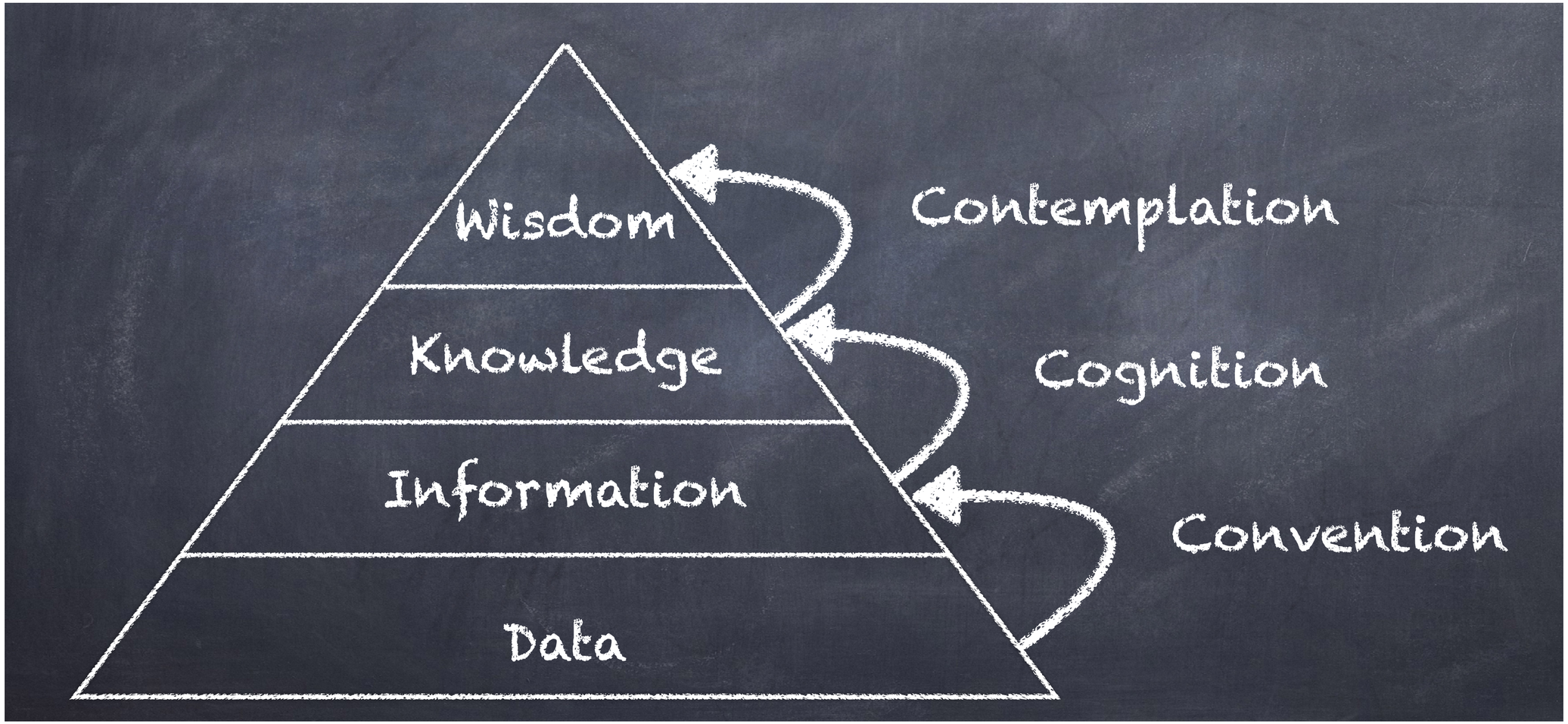
DIKW model

- **Data**: unorganised and unprocessed discrete, objective facts or observations
  - have no meaning or value because of lack of context and interpretation (e.g. raw data)
- **Information**: organised or structured data, processed in such a way that the information now has relevance for a specific purpose or context
  - meaningful, valuable, useful and relevant
  - that which reduces uncertainty (Shannon)
- **Knowledge**: Different perspectives:
  - a mix of contextual information, values, experience and rules;
  - know-how;
  - information combined with understanding and capabilitiy;
  - belief structuring" and "internalization with reference to cognitive frameworks
- **Wisdom**: the knowledge and insights into a learning experience that guides our actions
  - evaluated understanding

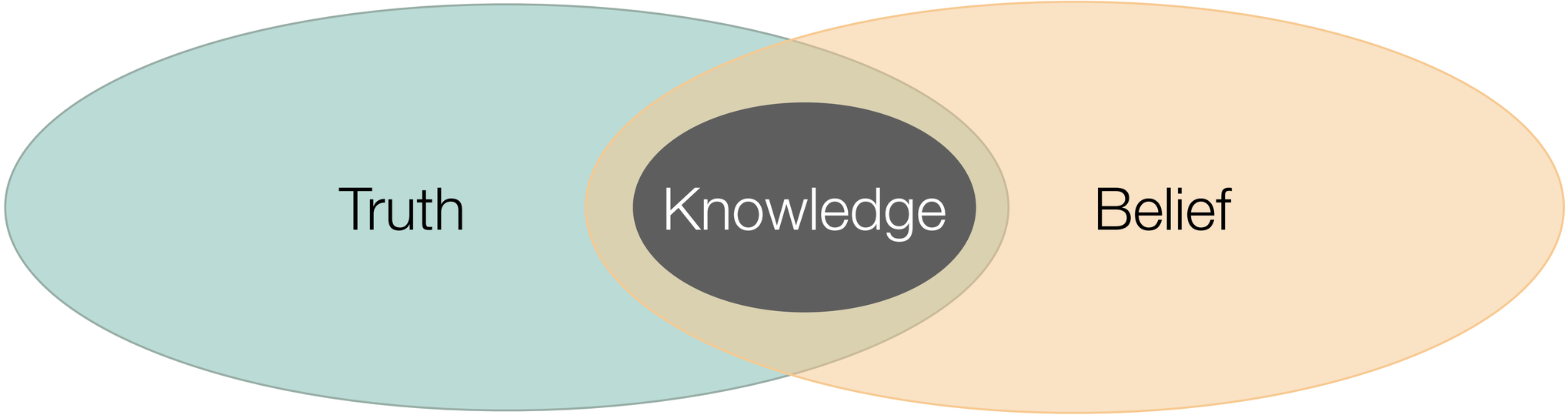


“*Big data is not knowledge*”
Y. Frégnac, Science 358, 6362 (2017)

DIKW model


Wisdom
Knowledge
Information
Data
Contemplation
Cognition
Convention

What is knowledge

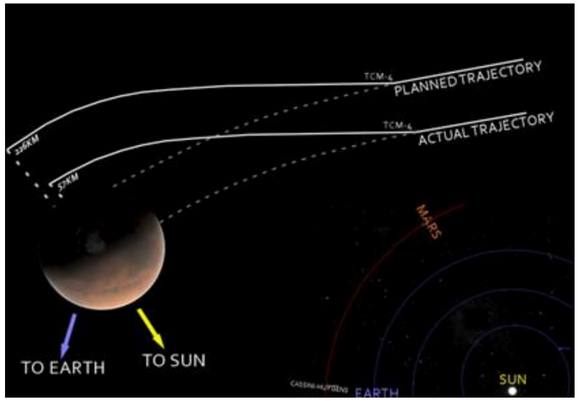


Knowledge sharing

- Sharing knowledge depends on having:
  - common symbols and concepts (**Syntax**)
  - agreement about their meaning (**Semantics**)
  - classification of concepts (**Taxonomy**)
  - associations and relations of concepts (**Thesauri**)
  - rules and knowledge about which relations are allowed and make sense (**Ontologies**)

NASA and ontology standardisation

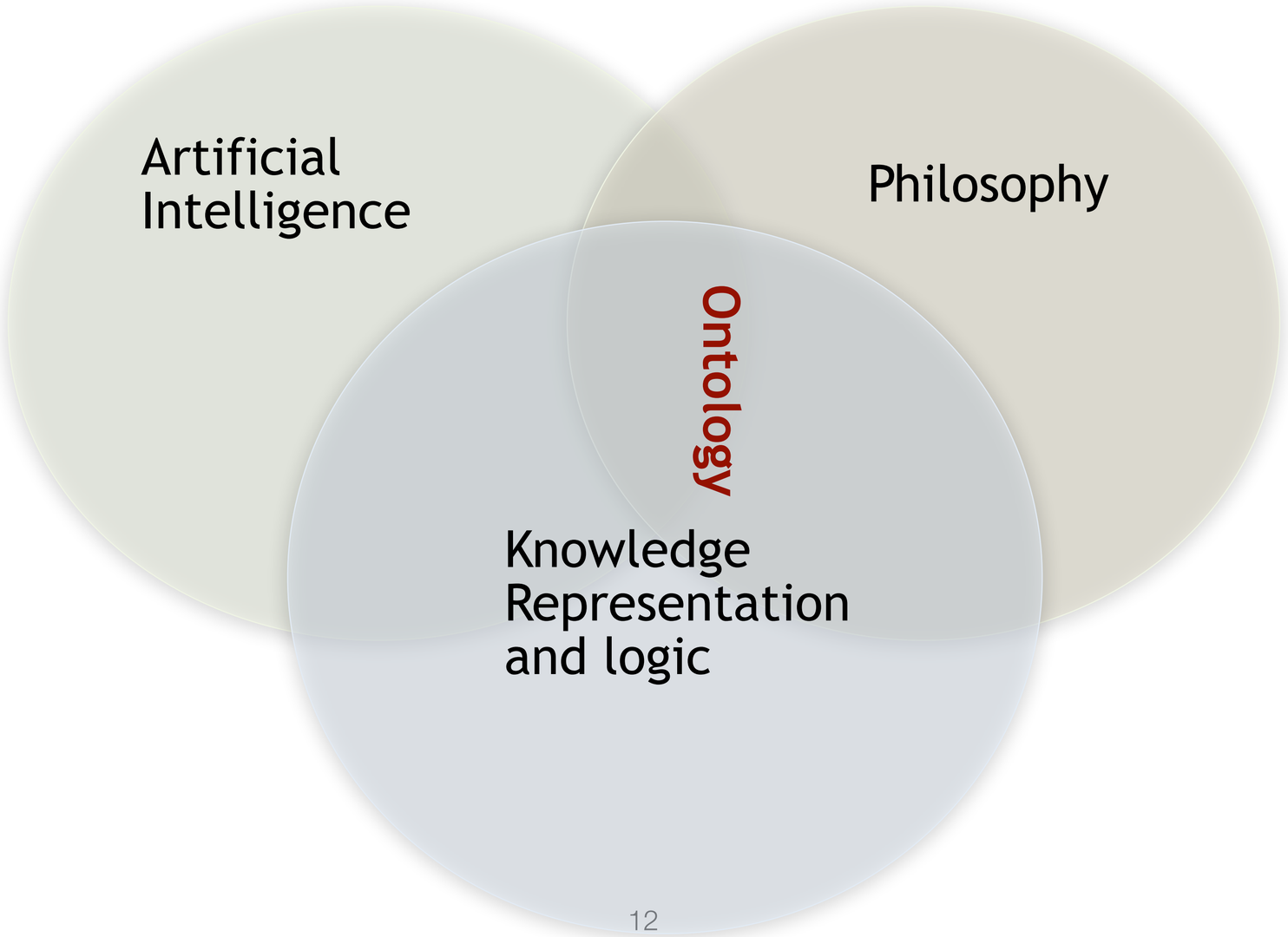
- NASA metric confusion caused the Mars Orbiter loss in 1999.



the failure to use metric units in the coding of a ground software file, "Small Forces," used in trajectory models. Specifically, thruster performance data in English units instead of metric units was used in the software application code titled SM_FORCES (small forces). The output from the SM_FORCES application code as required by a MSOP Project Software Interface Specification (SIS) was to be in metric units of Newton-seconds (N-s). Instead, the data was reported in English units of pound-seconds (lbf-s).

NASA Mishap Investigation Board Report

Ontology


Artificial
Intelligence
Philosophy
Ontology
Knowledge
Representation
and logic

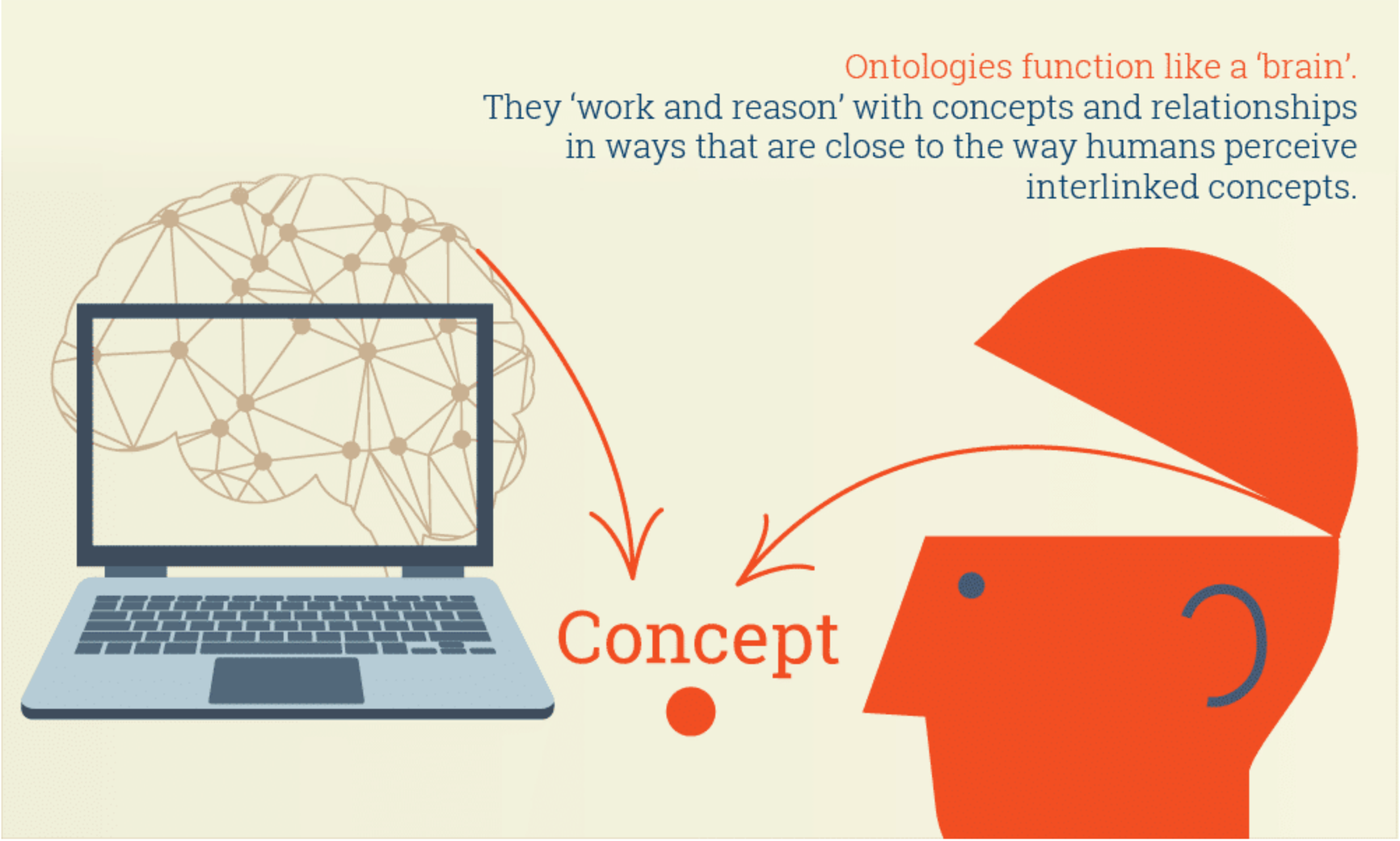
From philosophy to computer science

- Socrates questions of being, Plato's studies of epistemology:
  - the nature of knowledge

- Aristotle's classifications of things in the world and contribution to syllogism and inductive inference:
  - logic as a precise method for reasoning about knowledge

- In computer science an unambiguous description of the concepts and relationships that can exist for one or more agents, so they can ***understand***, ***share***, and ***use*** this description to accomplish (***cooperatively***) some task on behalf of users

Ontologies are the “brain” of your app



picture by ontotext

So what is an ontology then?

"...An ontology is a (formal), explicit specification of a shared conceptualisation..."

formal: an ontology should be machine-readable

shared: an ontology captures consensual knowledge, that is not private to some individual, but accepted by a group

explicit: the types of concepts used, and the constraints on their use are explicitly defined

conceptualisation: an abstract model of some phenomenon in the world which identifies the relevant concepts of that phenomenon

What is a conceptualisation

- **Conceptualisation**: the formal structure of reality as perceived and organised by an agent, independently of:
  - the vocabulary used (i.e., the language used)
  - the actual occurrence of a specific situation

- Different situations involving the same objects, described by different vocabularies, may share the same conceptualisation.

soccer

football

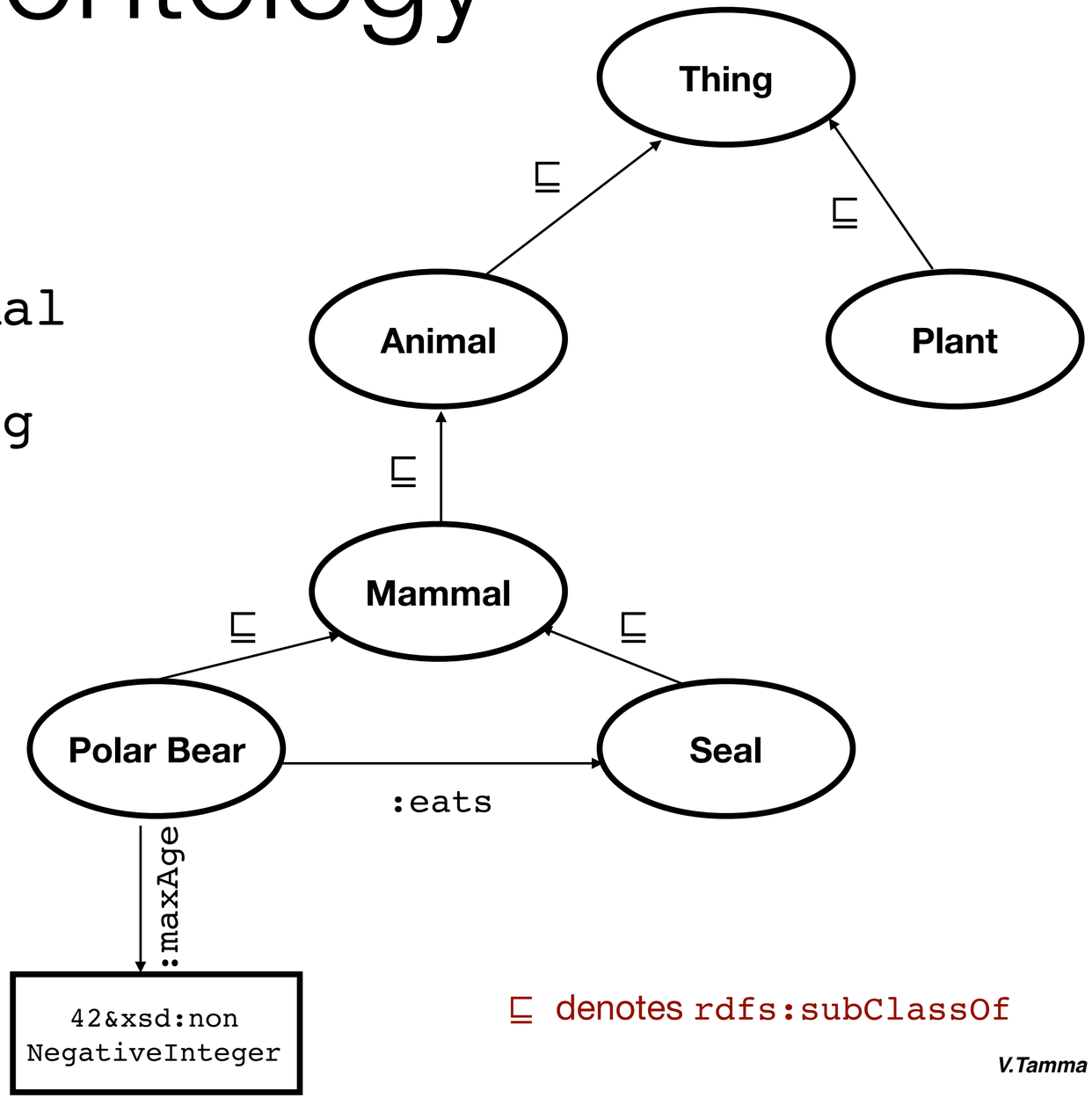
Who is using ontologies

"Who's doing this? ***75% of the Fortune 500*** *companies have some kind of* ***smart data or semantics program underway****, most under the banner of 360° initiatives, comprehensive enterprise data systems, or machine learning/ data science projects.* ***Amazon has recently added linked data capabilities*** *to their AWS infrastructure with the Neptune project, and* ***social media giants have built their entire data infrastructure around smart ontological data****. Moreover, China, Japan, England, the OECD, and the United States have all* ***moved critical data resources into semantic form****, and* ***semantics has become one of the hottest areas for investment banks such as Wells Fargo, Morgan Stanley, Citigroup, Goldman Sachs and others****. It even ties into such cutting-edge technologies as Blockchain and the Internet of Things."*

Forbes, July 2018

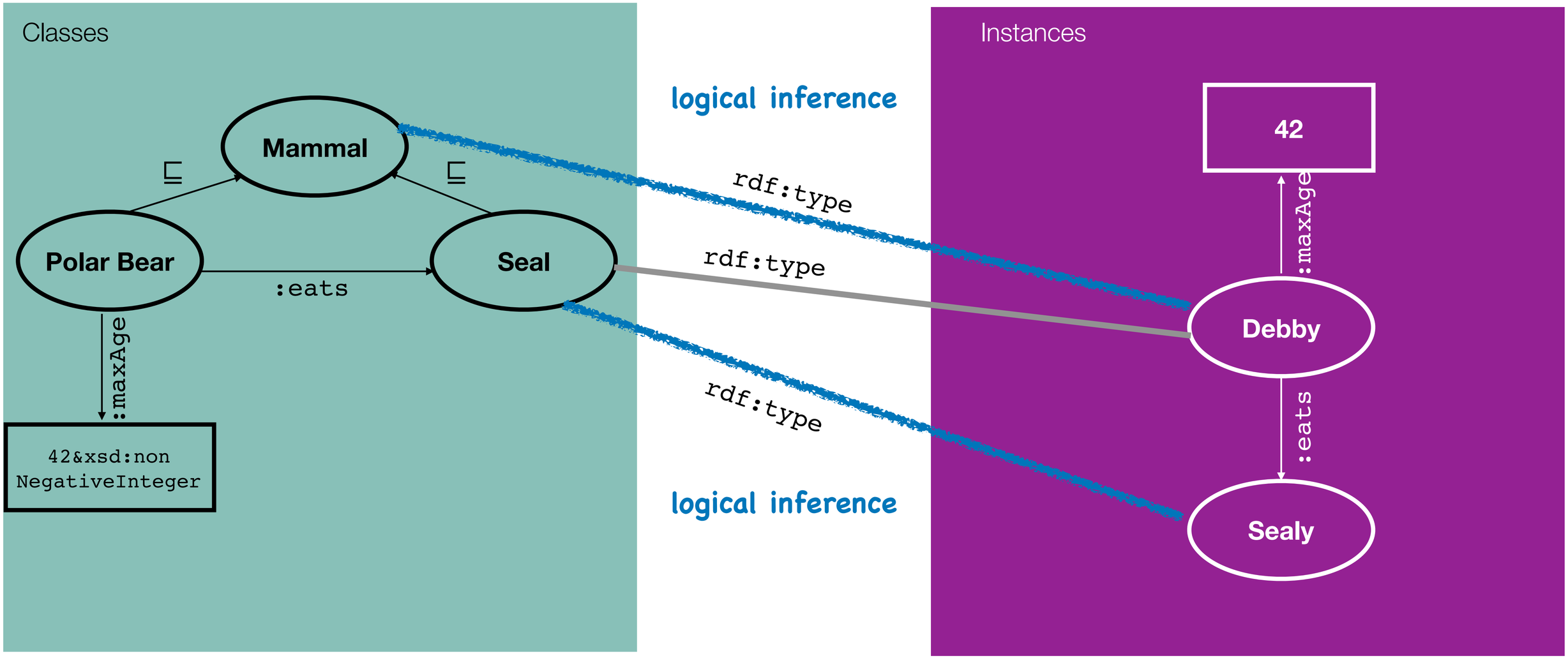
A simple ontology

- `Class: PolarBear SubClassOf: Mammal and maxAge only 42`
- `Class: Mammal SubClassOf: Animal`
- `Class: Animal SubClassOf: Thing`
- `Class: Plant SubClassOf: Thing`
- `Class: Seal SubClassOf: Mammal`
- `ObjectProperty: eats`
- `Domain: PolarBear`
- `Range: Seal`

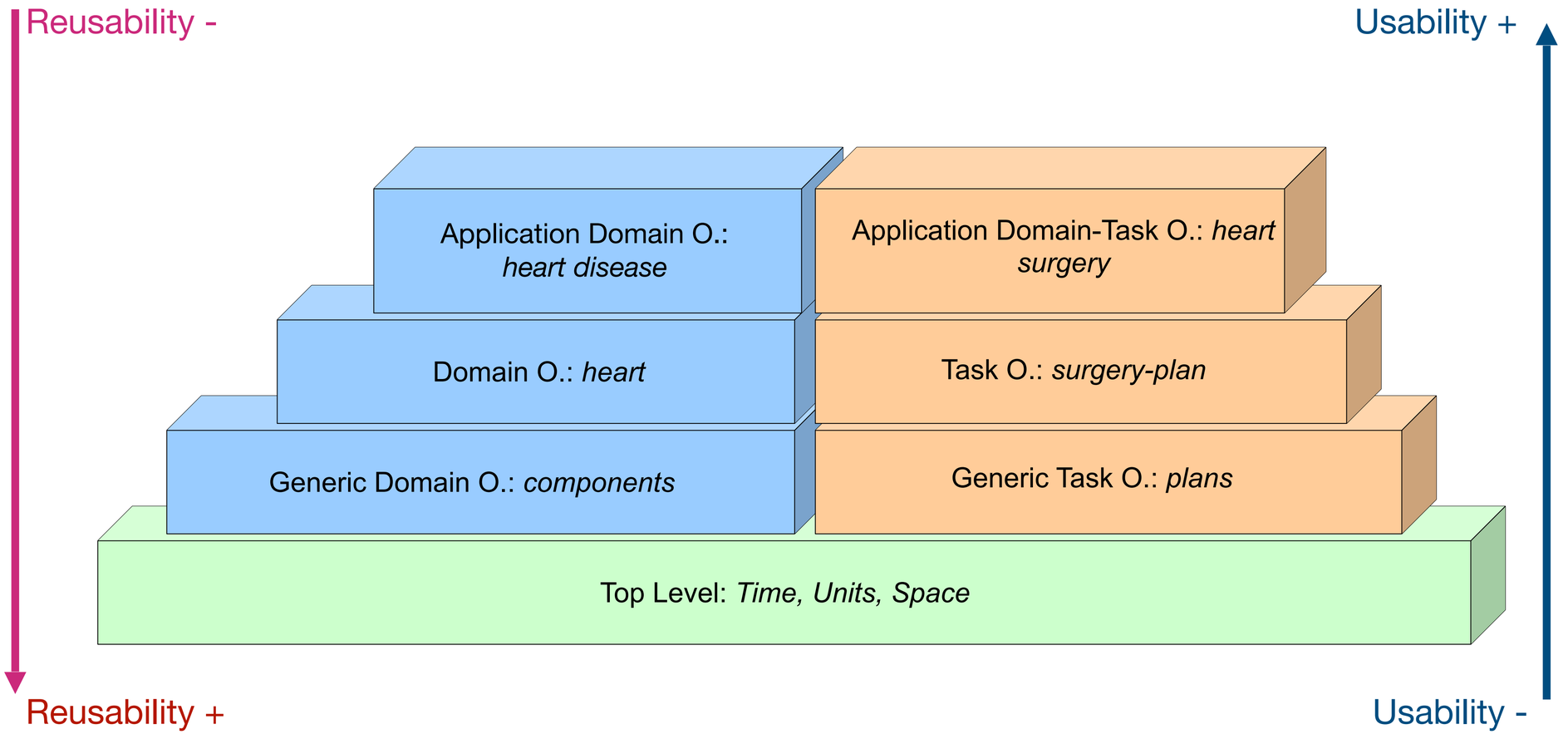


⊑ denotes `rdfs:subClassOf`

A simple ontology: inferences



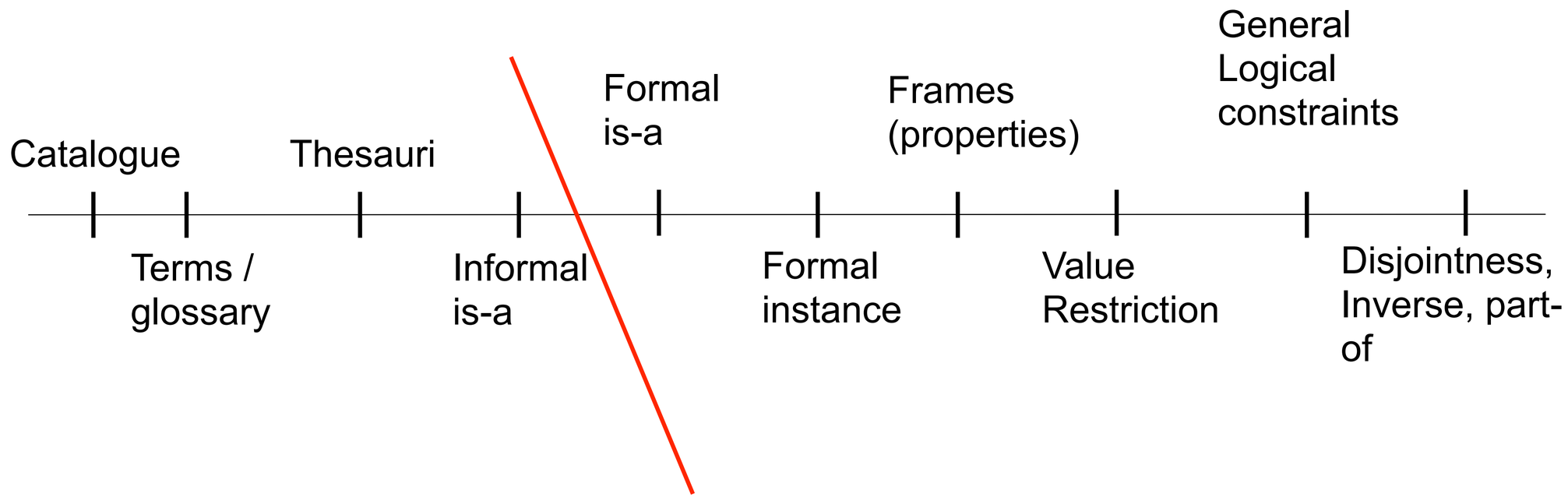
Types of Ontologies



Types of ontologies

- **Top level ontology:** general, cross domain ontologies;
  represent very general concepts as e.g., Time, Space, Event; independent of a specific domain or problem
  - also called Upper Ontology or Foundational Ontology
- **Domain ontology:** fundamental concepts according to a generic domain;
  - specialises terms introduced in top-level ontology
- **Task ontology:** fundamental concepts according to a general activity or task; specializes terms introduced in top-level ontolog
- **Application ontology:** specialized ontology focussed on a specific task and domain;
  - often a specialization of both task and domain ontology; often specify roles played by domain entities for specific activity

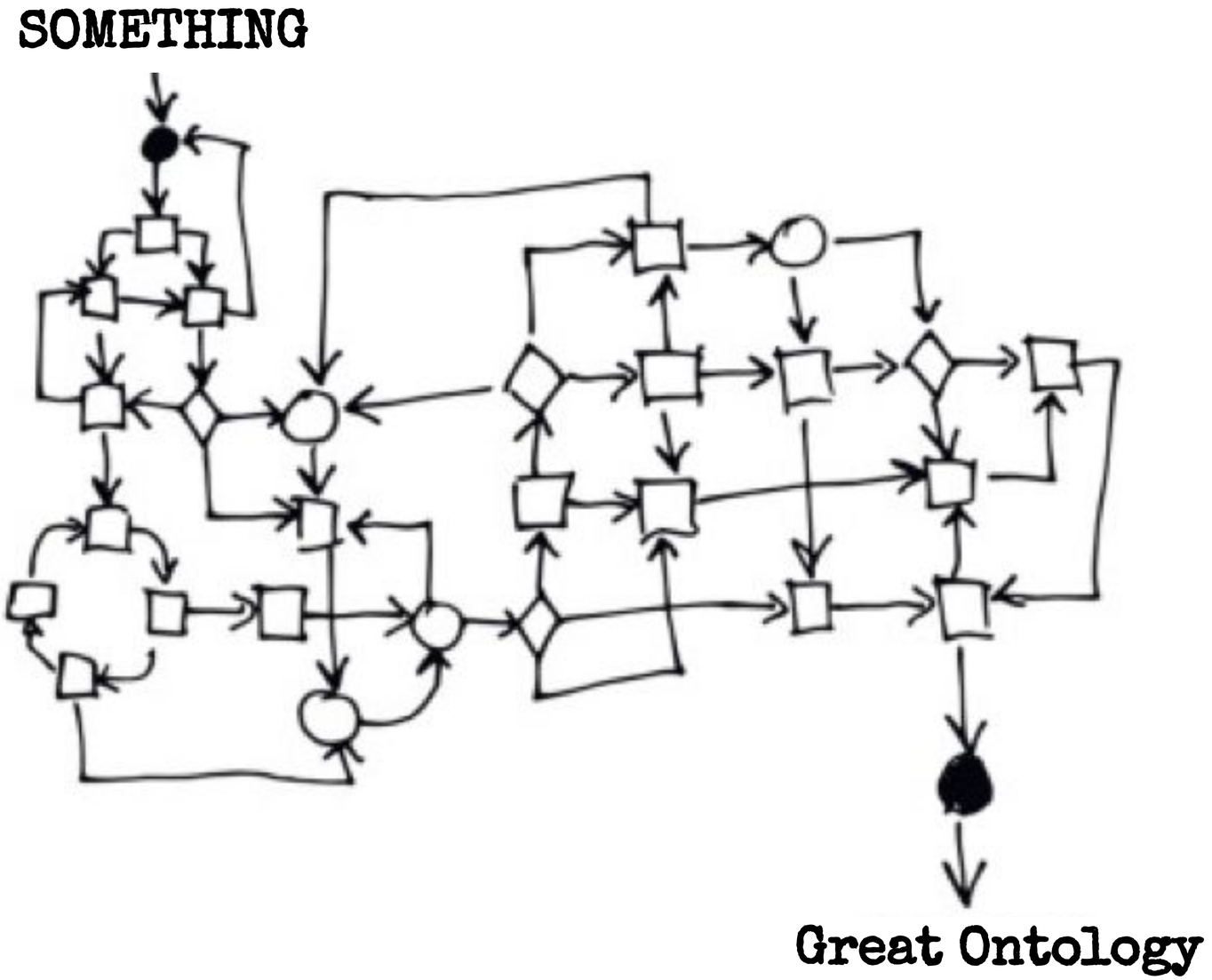
Level of Granularity



Level of Granularity

- An ontology specifies a rich description of the:
  - Terminology, concepts, vocabulary
  - Properties explicitly describing concepts
  - Relations among concepts
  - Rules distinguishing concepts,
    - refining definitions and relations (constraints, restrictions, regular expressions) relevant to a particular domain or area of interest.

Ontology development process



Ontology Engineering

"*The set of activities that concern the ontology development process, the ontology life cycle, and the methodologies, tools and languages for building ontologies*"

Gomez-Perez et al, 2004

Ontology Engineering

- Defining terms in the domain and relations among them
  - Defining concepts in the domain (**classes**)
  - Arranging the concepts in a hierarchy (**subclass-superclass hierarchy**)
  - Defining which attributes and properties classes can have
    - and constraints on their values
  - Defining individuals and filling in property values

Methodological questions

- What part of the domain do we need to model?
- What are the constraints on the use of this knowledge?
- How can tools and techniques best be applied?
- Which languages and tools should be used in which circumstances, and in which order?
- What about issues of quality control and resource management?
  - Many of these questions for ontology engineering have been studied in other contexts
    - E.g. software engineering, object-oriented design, and knowledge engineering

Summary

- What are ontologies
  - and what do we use them for
- Types of ontology
- Ontology engineering