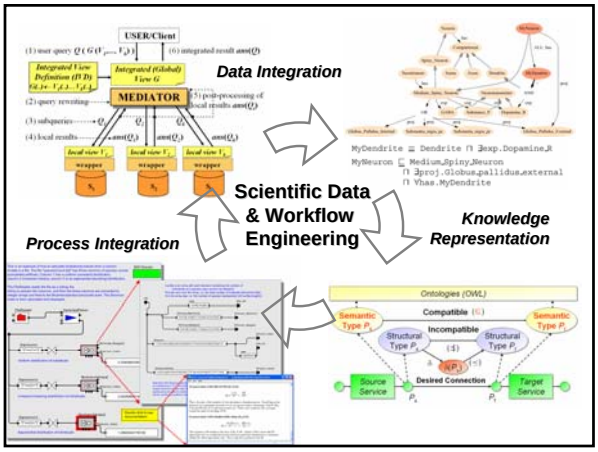
Remarks on Assignment 1

- Typo:
  - Example should be: parent(C,P) ← child(P,C).
- Whenever **not** obvious, give a plain English definition against which your Datalog rules can be compared (e.g., 1st cousins, uncles, aunts only instead of broader definitions)
- Hint/question for same_generation(X,Y):
  - Can a person be in multiple different generations?
  - If yes, what answer do you expect in such a case and what does the "system" answer then?
- Those who want to try out their rules (careful w/ the recursive ones!), use e.g. SWI-Prolog
  - http://www.swi-prolog.org/



XML-Based vs. Model-Based Mediation

CM ~ {*Descr.Logic, ER, UML, RDF/XML(-Schema), …*} CM-QL ~ {*F-Logic, OWL, …*}

Integrated-**DTD** := **XQuery**(Src1-**DTD**,...)

Ontologies DMs, PMs

Integrated-**CM** := **CM-QL**(Src1-**CM**,...)

No Domain Constraints

IF φ THEN ψ

Logical Domain Constraints

Structural Constraints (DTDs), *Parent*, *Child*, *Sibling*, ...

A = (B*|C),D
B = ...

C1 C2 R C3

Classes, Relations, *is-a*, *has-a*, ...

XML Elements

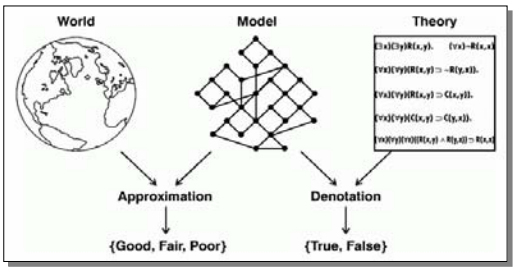
(XML) Objects

***XML* Models**

Raw Data

***Conceptual* Models**

Knowledge Representation:
Relating Theory to the World via Formal Models



Source: John F. Sowa, *Knowledge Representation: Logical, Philosophical, and Computational Foundations*

"All models are wrong, but some models are useful!"

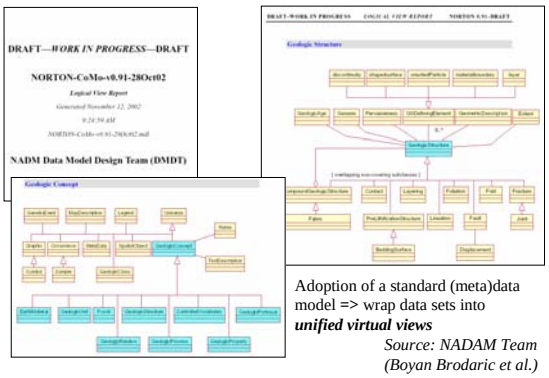
Ontology Cheat Sheet (1/2)

- What is an ontology? An ontology usually …
  - **specifies a theory** (a set of logic **models**) by …
  - **defining** and **relating** …
  - **concepts** representing features of a domain of interest
- Also overloaded (sloppy) for:
  - **Controlled vocabularies**
  - **Database schema** (relational, XML Schema/DTD, …)
  - **Conceptual schema** (ER, UML, …)
  - **Thesauri** (synonyms, broader term/narrower term)
  - **Taxonomies** (classifications)
  - **Informal/semi-formal knowledge representations**
    - "Concept spaces", "concept maps"
    - Labeled graphs / semantic networks (RDF)
  - **Formal ontologies**, e.g., in [Description] Logic (OWL)
    - "formalization of a specification"
    - ➔ constrains possible interpretation of terms

Ontology Cheat Sheet (2/2)

- What are ontologies used for?
  - **Conceptual models** of a domain or application, (communication means, system design, …)
  - **Classification** of …
    - concepts (taxonomy) and
    - data/object instances through classes
  - **Analysis** of ontologies e.g.
    - **Graph queries** (reachability, path queries, …)
    - **Reasoning** (concept subsumption, consistency checking, …)
  - **Targets for semantic data registration**
  - **Conceptual indexes** and views for
    - **searching**,
    - **browsing**,
    - **querying**, and
    - **integration** of registered data

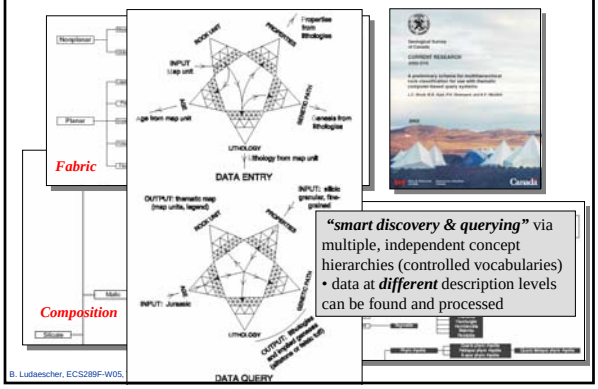
Smarter (Meta)data I: Logical Data Views



Adoption of a standard (meta)data model => wrap data sets into ***unified virtual views***

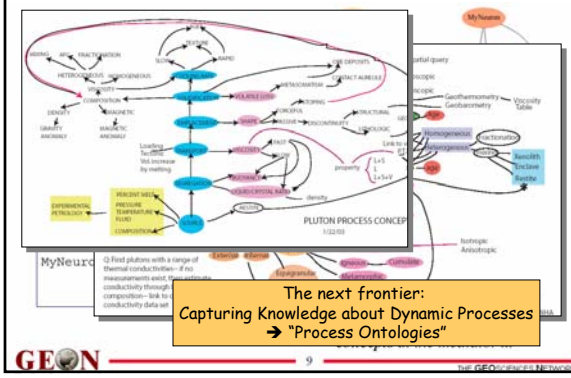
Source: NADAM Team (Boyan Brodaric et al.)

Smarter Metadata II: Multihierarchical Rock Classification for "Thematic Queries" (GSC) –– or: *Taxonomies are not only for biologists ...*



"smart discovery & querying" via multiple, independent concept hierarchies (controlled vocabularies)
• data at ***different*** description levels can be found and processed

Smarter Metadata III: Source Contextualization & Ontology Refinement



The next frontier:
Capturing Knowledge about Dynamic Processes
➔ "Process Ontologies"

1st Attempt: Ontologies in CS

- An ontology is ...
  - an *explicit specification of a conceptualization* [Gruber93]
  - a *shared understanding of some domain of interest* [Uschold, Gruninger96]
- Some aspects and parameters:
  - a formal specification (*reasoning* and "*execution*")
  - ... of a conceptualization of a domain (*community*)
  - ... of some part of world that is of interest (*application*)
- Provides:
  - A *common vocabulary* of terms
  - Some specification of the *meaning of the terms* (semantics)
  - A *shared "understanding"* for people and machines

Ontology as a philosophical discipline

- Ontology as a *philosophical discipline*, which deals with the nature and the organization of reality:
  - Ontology as such is usually contrasted with *Epistemology*, which deals with the nature and sources of our knowledge [a.k.a. Theory of Knowledge]. Aristotle defined Ontology as the science of being as such: unlike the special sciences, each of which investigates a class of beings and their determinations, Ontology regards all the species of being *qua* being and the attributes which belong to it *qua* being" (Aristotle, *Metaphysics*, IV, 1).
- In this sense Ontology tries to answer to the question: *What is being? What exists?* (the nature of being, not an enumeration of "stuff" around us…)

Some different uses of the word "Ontology" [Guarino'95]

1. Ontology as a philosophical discipline
2. Ontology as a an informal conceptual system
3. Ontology as a formal semantic account
4. Ontology as a specification of a "conceptualization"
5. Ontology as a representation of a conceptual system via a logical theory
   - 5.1 characterized by specific formal properties
   - 5.2 characterized only by its specific purposes
6. Ontology as the vocabulary used by a logical theory
7. Ontology as a (meta-level) specification of a logical theory

http://ontology.ip.rm.cnr.it/Papers/KBKS95.pdf

Ontologies vs Knowledge Bases

- An ontology is a *particular* KB, describing facts assumed to be *always true* by a community of users:
  - in virtue of the agreed-upon meaning of the vocabulary used (analytical knowledge):
    - black => not white
  - ... whose truth does not descend from the meaning of the vocabulary used (non-analytical, common knowledge)
    - Rome is the capital of Italy
- An *arbitrary* KB may describe facts which are *contingently true*, and relevant to a particular *epistemic state:*
  - Mr Smith's pathology is either cirrhosis or diabetes

Formal Ontology [Guarino'96]

- Theory of formal distinctions
  - among things
  - among relations
- Basic tools
  - Theory of *parthood* (*Mereology*)
    - What counts as a *part* of a given entity? What properties does the *part* relation have? Are the different *kinds* of parts?
    - part_of(X,Y) is often modeled as a ***partial order***, i.e.
      - part_of(X,X) (reflexivity)
      - part_of(X,Y) /\ part_of(Y,X) ➔ X = Y (antisymmetry)
      - part_of(X,Y) /\ part_of(Y,Z) ➔ part_of(X,Z) (transitivity)
    - Let's say has_a(X,Y) ➔ part_of(Y,X)
    - What's wrong with this:
      - has_a(orchestra, musician)
      - has_a(musician, arm)
      - Therefore (transitivity) has_a(orchestra, arm)

Formal Ontology [Guarino'96]

- Theory of formal distinctions
  - among things
  - among relations
- Basic tools
  - …
  - Theory of *integrity*
    - What counts as a *whole*? In which sense are its parts *connected*?
  - Theory of *identity*
    - How can an entity change while keeping its identity? What are its essential properties? Under which conditions does an entity loose its identity? Does a change of "point of view" change the identity conditions?
  - Theory of *dependence*
    - Can a given entity exist alone, or does it depend on other entities?

Why develop an ontology?

- To make domain assumptions **explicit**
  - Easier to change domain assumptions
  - Easier to understand, update, and integrate legacy data
  - ➔ data integration
- To separate domain knowledge from operational knowledge
  - Re-use domain and operational knowledge separately
- A community reference for applications
- To share a consistent understanding of what information means.

[Source: Carole Goble, Nigel Shadbolt, Ontologies and the Grid Tutorial]

What is being shared?

Metadata

- Data describing the content and meaning of resources and services.
- But everyone must speak the same language…

Terminologies

- Shared and common vocabularies
- For search engines, agents, curators, authors and users
- But everyone must mean the same thing…

Ontologies

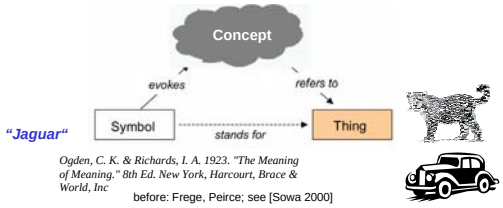
- Shared and common understanding of a domain
- Essential for search, exchange and discovery

➔ Ontologies aim at sharing meaning

[Source: Carole Goble, Nigel Shadbolt, Ontologies and the Grid Tutorial]

Origin and History

- Humans require words (or at least symbols) to communicate efficiently. The mapping of words to things is indirect. We do it by creating *concepts* that refer to things.
- The relation between symbols and things has been described in the form of the *meaning triangle*:



Ogden, C. K. & Richards, I. A. 1923. "The Meaning of Meaning." 8th Ed. New York, Harcourt, Brace & World, Inc

before: Frege, Peirce; see [Sowa 2000]

[Carole Goble, Nigel Shadbolt, Ontologies and the Grid Tutorial]

Human and machine communication

[Maedche et al., 2002]