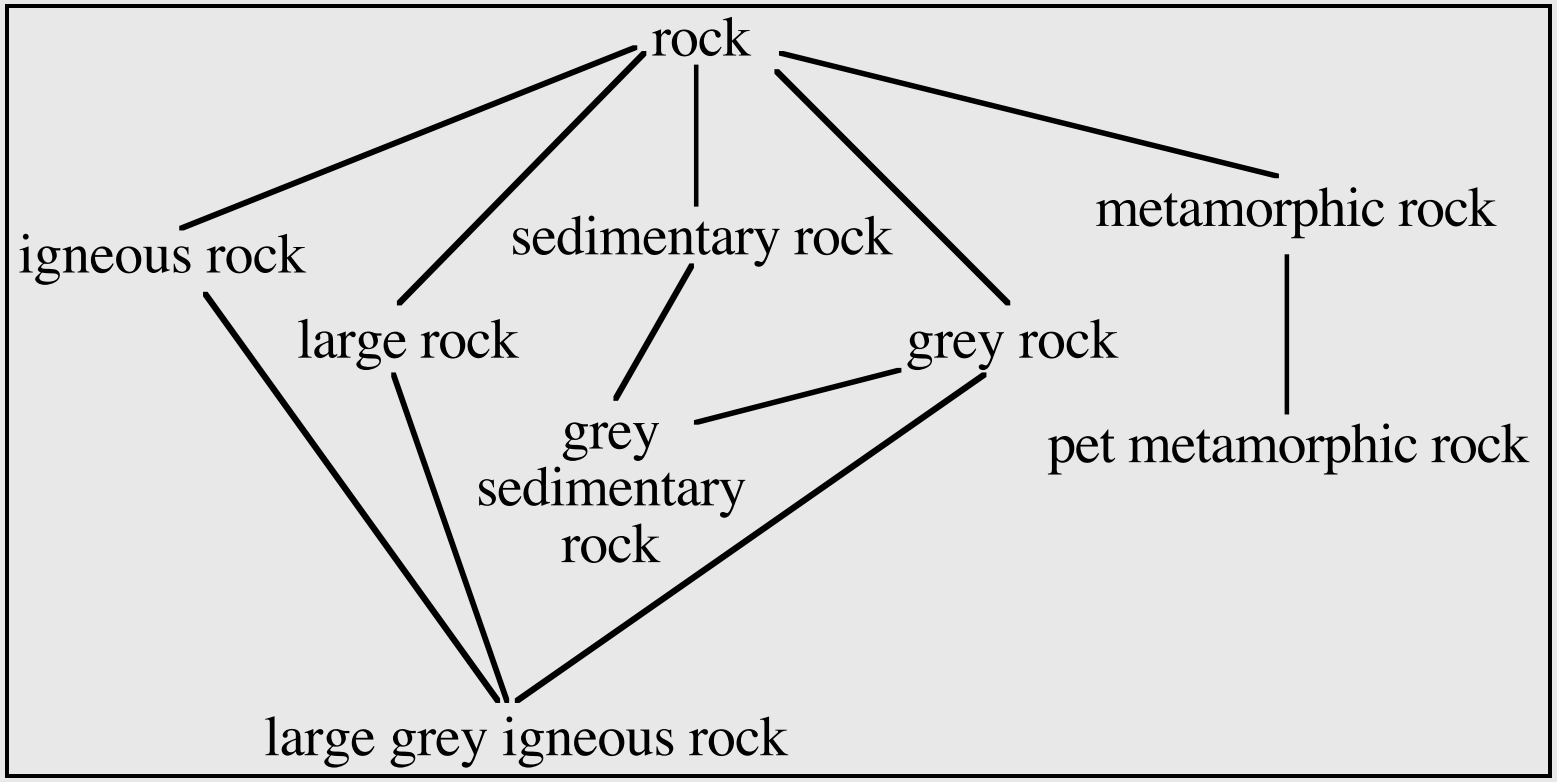
The Ontological Level

Kinds, roles, attributions

How many rock kinds are there?



[From Brachman, R ., R. F ikes, et al. 1983. "Krypton: A Functional Approach to Knowledge Representation", *IEEE Computer*]

The answer

- According to Brachman & Fikes 83:
  - It's a dangerous question, only "safe" queries about analytical relationships between terms should be asked
- In a previous paper by Brachman and Levesque on ***terminological competence*** *in knowledge representation* [AAAI 82]:
  - "an *enhancement mode transistor* (which is a *kind* of transistor) should be understood as different from a *pass transistor* (which is a *role* a transistor plays in a larger circuit)"
- These issues have been simply *given up* while striving for logical simplification and computational tractability
- The OntoClean methodology, based on formal ontological analysis, allows us to conclude: ***there are 3 kinds of rocks*** (appearing in the figure)

From the logical level to the ontological level

- Logical level *(no structure, no constrained meaning)*
  - $\exists x\,(\mathrm{Apple}(x) \wedge \mathrm{Red}(x))$
- Epistemological level *(structure, no constrained meaning)*:
  - $\exists x{:}apple\ \mathrm{Red}(x)$ *(many-sorted logics)*
  - ~~$\exists x{:}red\ \mathrm{Apple}(x)$~~
  - a is a Apple with Color=red *(description logics)*
  - ~~a is a Red with Shape~~=apple
- Ontological level *(structure, constrained meaning)*
  - Some structuring choices are excluded because of ontological constraints: Apple carries an identiy condition, Red does not.

Ontology helps building "meaningful" representations

The source of all problems: (slightly) different meanings for words

- A (simple-minded) painter may intepret the words “Apple” and “Red” in a completely different way:
  - Three different reds on my palette: Orange, Appple, Cherry
- So an expression like ∃*x:red* Apple(*x*) may mean that there is an “Apple” red.
- Two different ontological assumptions behind the Red predicate:
  - adjectival interpretation: *being a red thing* doesn’t carry an identity criterion (uncountable)
  - nominal interpretation: *being a red color* does carry an identity criterion (countable)

Formal ontological distinctions help making *intended meaning* explicit

Ontological analysis can be defined as the process of ***eliciting and discovering relevant distinctions*** and relationships bound to the very nature of the entities involved in a certain domain, ***for the practical purpose of disambiguating terms*** having different interpretations in different contexts.

The Ontological Level

(Guarino 94)

Level	*Primitives*	*Interpretation*	*Main feature*
Logical	Predicates, functions	Arbitrary	Formalization
Epistemological	Structuring relations	Arbitrary	Structure
Ontological	**Ontological relations**	**Constrained** (meaning postulate s)	**Meaning**
Conceptual	Conceptual relations	Subjective	Conceptualization
Linguistic	Linguistic terms	Subjective	Language dependence

Terminological competence - kinds of relations

- Woods' "What's in a link?" (1975):

  JOHN

  HEIGHT: 6 FEET

  KISSED: MARY

- "no longer do the link names stand for attributes of a node, but rather arbitrary relations between the node and other nodes"
- different notations should be used

Structured concepts: a broader picture

JOHN

- HEIGHT: 6 FEET
- RIGHT-LEG: BROKEN
- MOTHER: JANE
- KISSED: MARY
- JOB: RESEARCHER

intrinsic quality

part

role

external relation

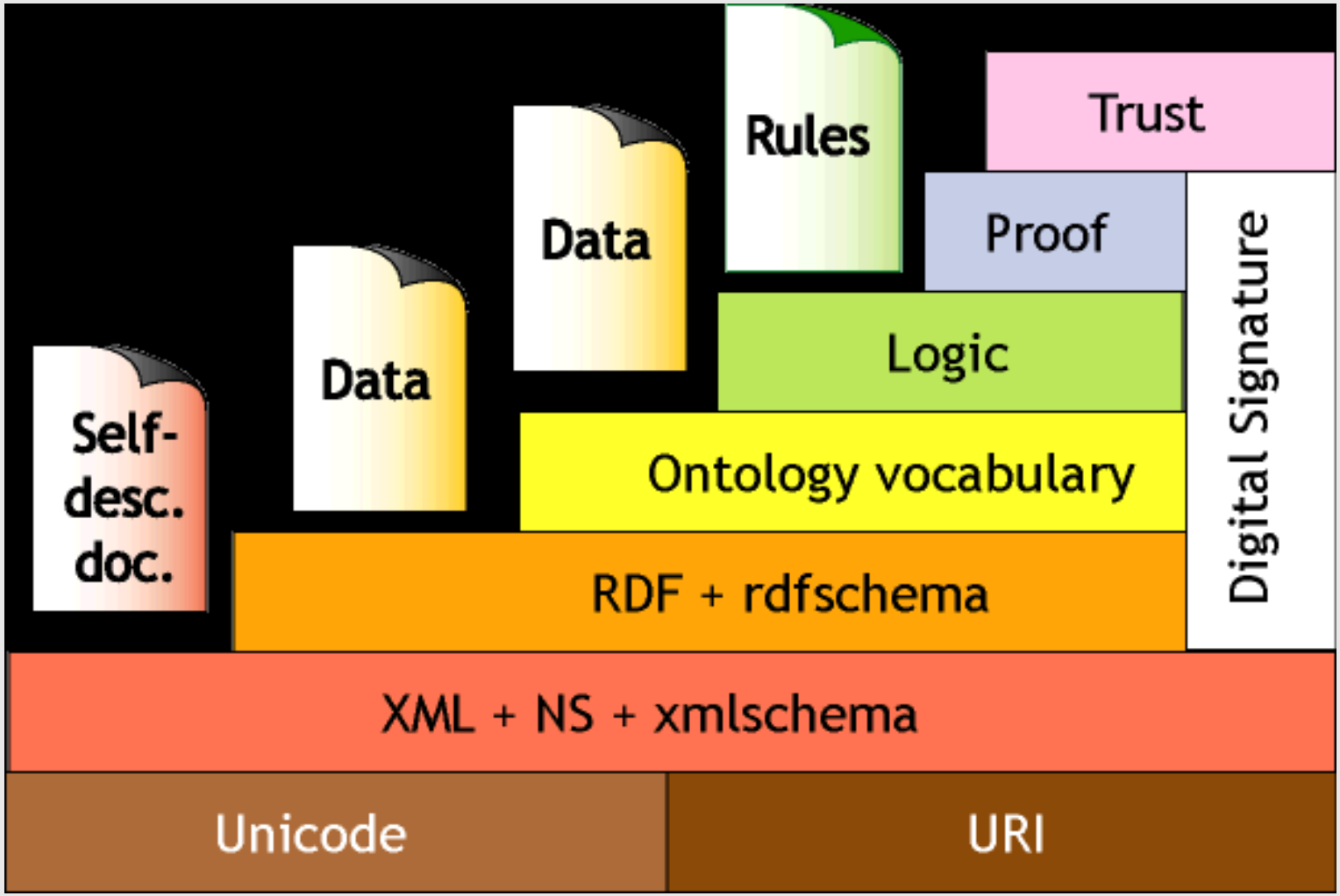
relational quality

We need different primitives to express ***different structuring relationships*** among concepts

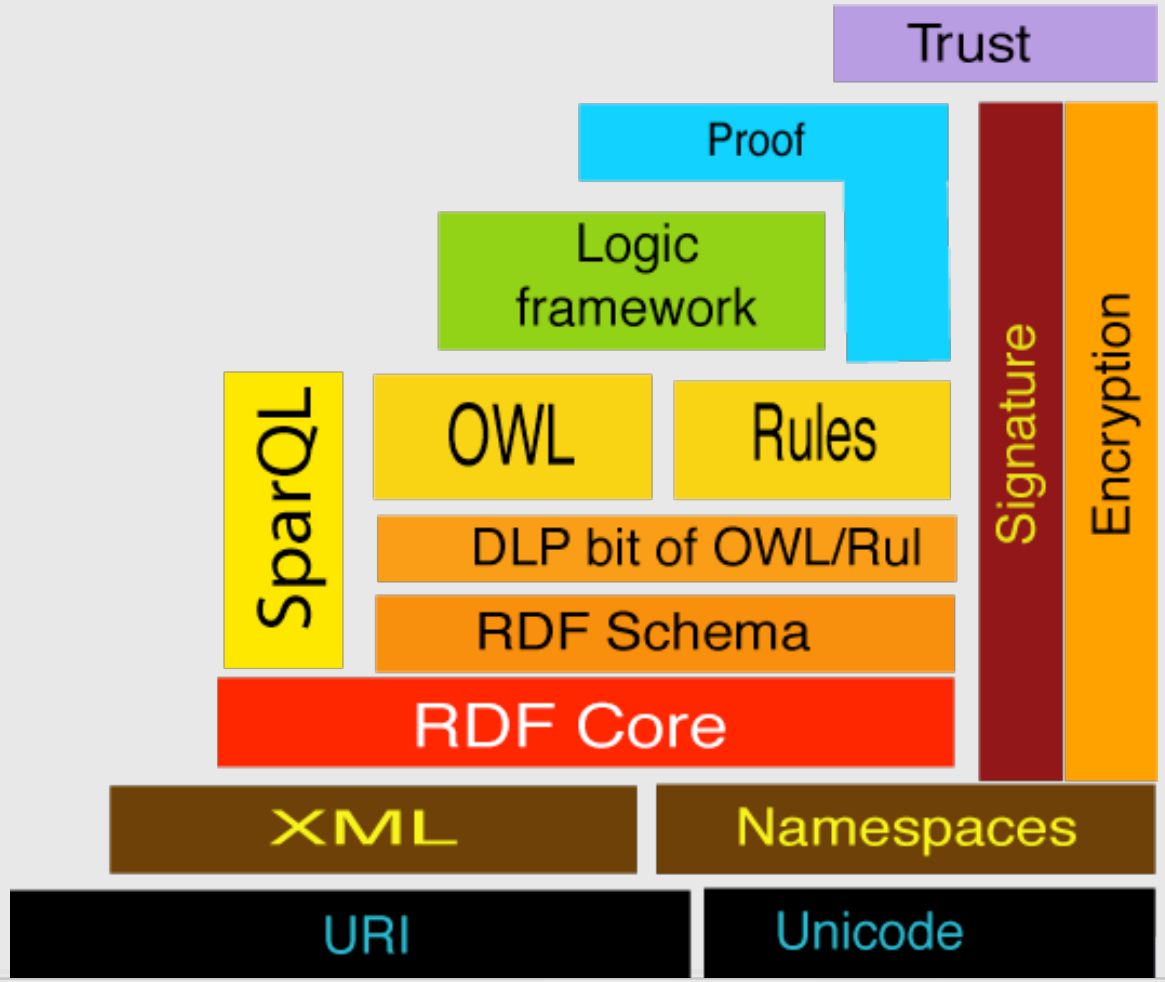
We need to represent ***non-structuring relationships*** separately

Current description logics tend to collapse **EVERYTHING**!

The semantic web architecture [Tim Berners Lee 2000]



The Semantic Web Architecture (revised)



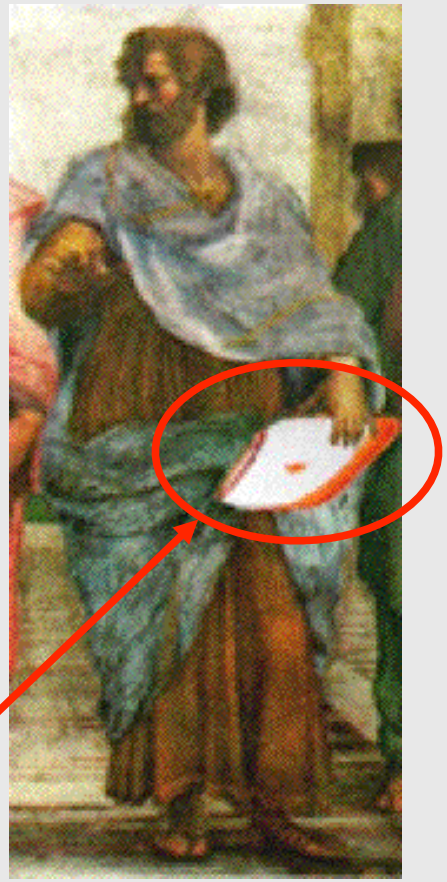
The current status of Semantic Web

- Much less ambitious than people believe
- The semantic web is *a web of data* (and relations - thanks to RDF), not a *web of content!*
- Interoperability? Only locally, where the meaning of categories and relations is *known in advance*

The formal tools of ontological analysis

- Theory of Essence and Identity
- Theory of Parts (Mereology)
- Theory of Unity and Plurality
- Theory of Dependence
- Theory of Composition and Constitution
- Theory of Properties and Qualities

The basis for a common ontology vocabulary



Idea of Chris Welty, IBM Watson Research Centre, while visiting our lab in 2000

Ontology-driven information systems

Ontology-Driven Information Systems

- Every IS ***has*** its own ontology (either implicit or explicit)
- The ODIS perspective: ***explicit*** ontologies play a ***central*** role, driving ***all*** aspects and components of an IS

- Two (main) dimensions to assess the role of an explicit ontology:
  - ***temporal dimension:*** development time vs. run time
  - ***structural dimension:*** impact on the various IS components:
    - ***database component***
    - ***application program***
    - ***user interface***

Temporal dimension: *development time*

- Two scenarios:
  - A pre-existing ***ontology library*** containing domain and task ontologies as "main building blocks" to be adapted and rused
    - standard IS: the ontology content is *embedded* in the standard components
    - ODIS: an *application ontology* is built by specializing domain and task ontologies taken from the library
  - Only an ***upper-level ontology*** available: not building blocks, but ***conceptual tools*** (analogous to other CASE tools)
- Two kinds of development:
  - IS ***engineering***
  - IS ***re-engineering***

Temporal dimension: *run time*

- Ontology-***aware*** IS: the IS just uses the ontology for some specific purpose
- Ontology-***driven*** IS: the ontology is a ***central component*** of the IS, cooperating at run time towards its "higher" overall goal

- Important application: ***inter-agent communication***

Structural dimension:
the database component

- Development time:
  - support to ***requirement analysis and conceptual modelling*** (integrated with lexical resources like WordNet)
  - development of a ***global conceptual schema*** (DB integration)
- Run time:
  - mediation-based approach to ***information integration***
  - ***intensional queries***

Structural dimension:
the user-interface component

- Development time:
  - Generation of ***form-based interfaces*** (constraints checking)
- Run time:
  - Support ***quering and browsing the ontology*** itself:
    - better understanding of the vocabulary
    - queries at the desired level of specificity
  - ***Vocabulary detaching***:
    - user free to adopt his own NL terms (mapped - after disambiguation - to the IS vocabulary with the help of the ontology)

Structural dimension:
the application program component

- Development time:
  - Generation of the static part of a program (type structure)
  - Support to OO design

- Run time:
  - Explicit account of the ***ontological commitment*** of an application program
  - Increase of the ***transparency*** of application software