Knowledge Representation and Semantic Technologies

The upper layers of the Semantic Web

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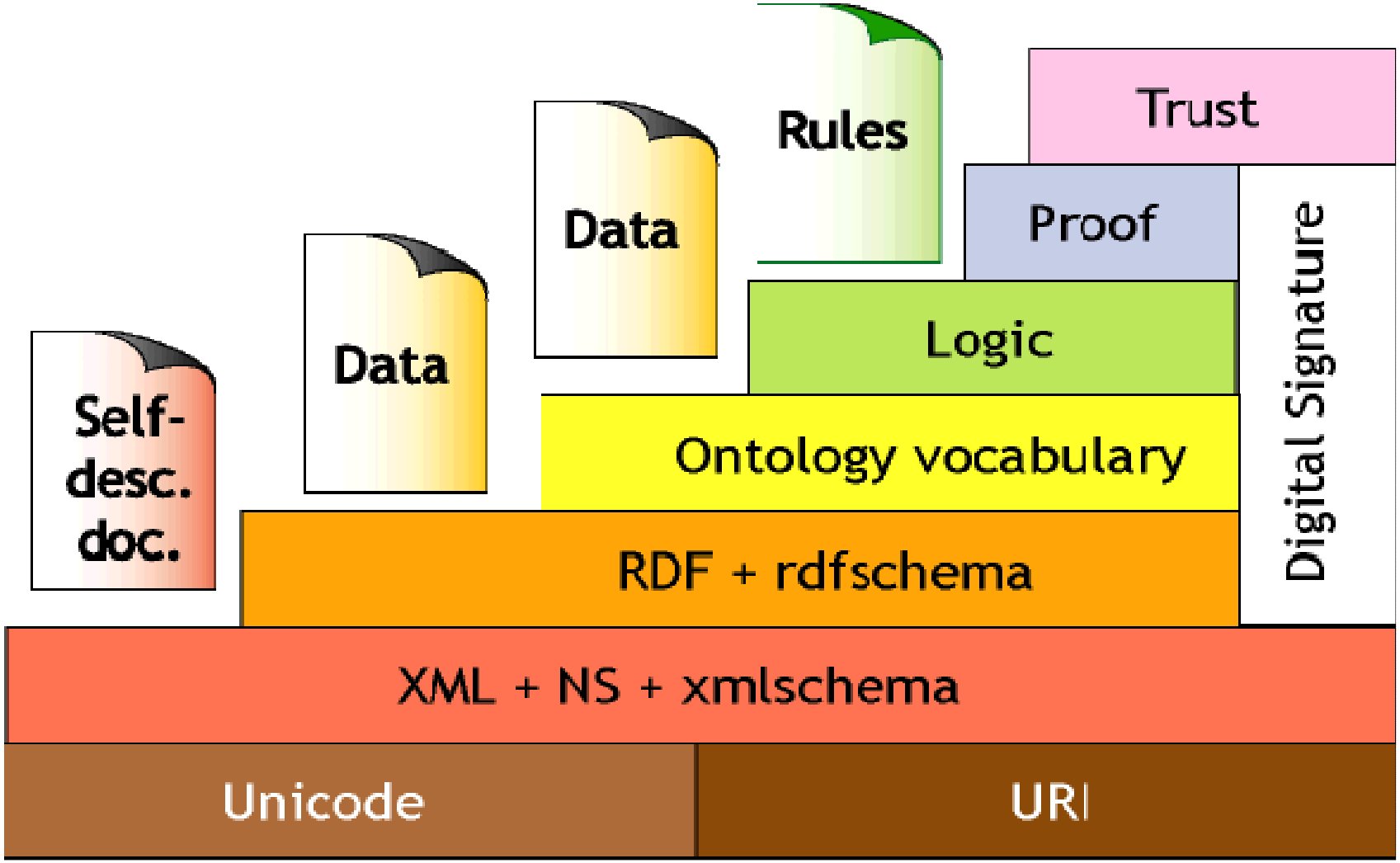
The Semantic Web Tower



The Logic/Proof/Trust layers

SW Stack upper layers:

- the Logic layer enables the writing of **rules**
- the Proof layer executes the rules
- the Trust layer decides whether to trust the given proof or not

technology for these layer at a very early stage:

- few standards exist
- open architectural issues

The notion of rule

- rule = “if-then” statement
- a rule can be static or dynamic
  - static rule (implication): if condition C1 is true then conclude that also condition C2 is true
  - dynamic rule: if event E occurs and condition C holds then execute action A
- semantics of rules:
  - procedural (operational)
  - declarative

Rule bases as knowledge bases

- static rules may be considered as statements expressing knowledge
- rule base = knowledge base
- interpretation of a rule similar (but not equal) to the boolean implication operator
- “constructive” (one-way) implication (contrapositive does not hold)
- more generally, semantics of rules based on (various notions of) **closed-world assumption**

Expressive limitations of DLs and OWL

- the typical expressiveness of Description Logics does not allow for addressing the following aspects:
- defining **predicates of arbitrary arity** (not just unary and binary) using **variable quantification** beyond the tree-like structure of DL concepts (many DLs are subsets of the two-variable fragment of FOL)
- formulating **expressive queries** over DL knowledge bases (beyond concept subsumption and instance checking)
- formalizing various **forms of closed-world reasoning** over DL KBs (DLs and OWL have an open-world semantics)
- more generally, expressing forms of **nonmonotonic knowledge**, like default rules

Default mechanisms

- example: suppose the OWL ontology models a domain of people
- we would like to model a "**default rule**" that states that, in the absence of a specific assertion (stating that the person is blind) a person is not blind
- the above kind of information **cannot** be expressed in an OWL TBox
  - the only way to express it in OWL is to add one ABox assertion (which states that the person is not blind) for every person in the domain
- semantics based on closed-world assumption are needed to express default mechanisms

Rule formalisms

- static rules:
  - logic programming languages:
    - Prolog
    - answer set programs
    - nonmonotonic Datalog
- dynamic rules:
  - ECA rules
  - production rules
  - ...

Logic programming: Prolog

Prolog rule: statement of the form

- a :– b1, b2, ... , bn
- intuitive reading:

  "if b1 and b2 and ... and bn, then a"
- a = rule head
- b1, b2, ... , bn = rule body
- a and all bi's are first-order atoms
- some bi may be negated

Logic programming

examples:

- uncle(x,y) :- father(x,z), brother(z,y).
- grandparent(x,z) :- parent(x,y), parent(y,z).

recusive rules:

- ancestor(x,y) :- parent(x,y).
- ancestor(x,y) :- parent(x,z), ancestor(z,y).

use of negation:

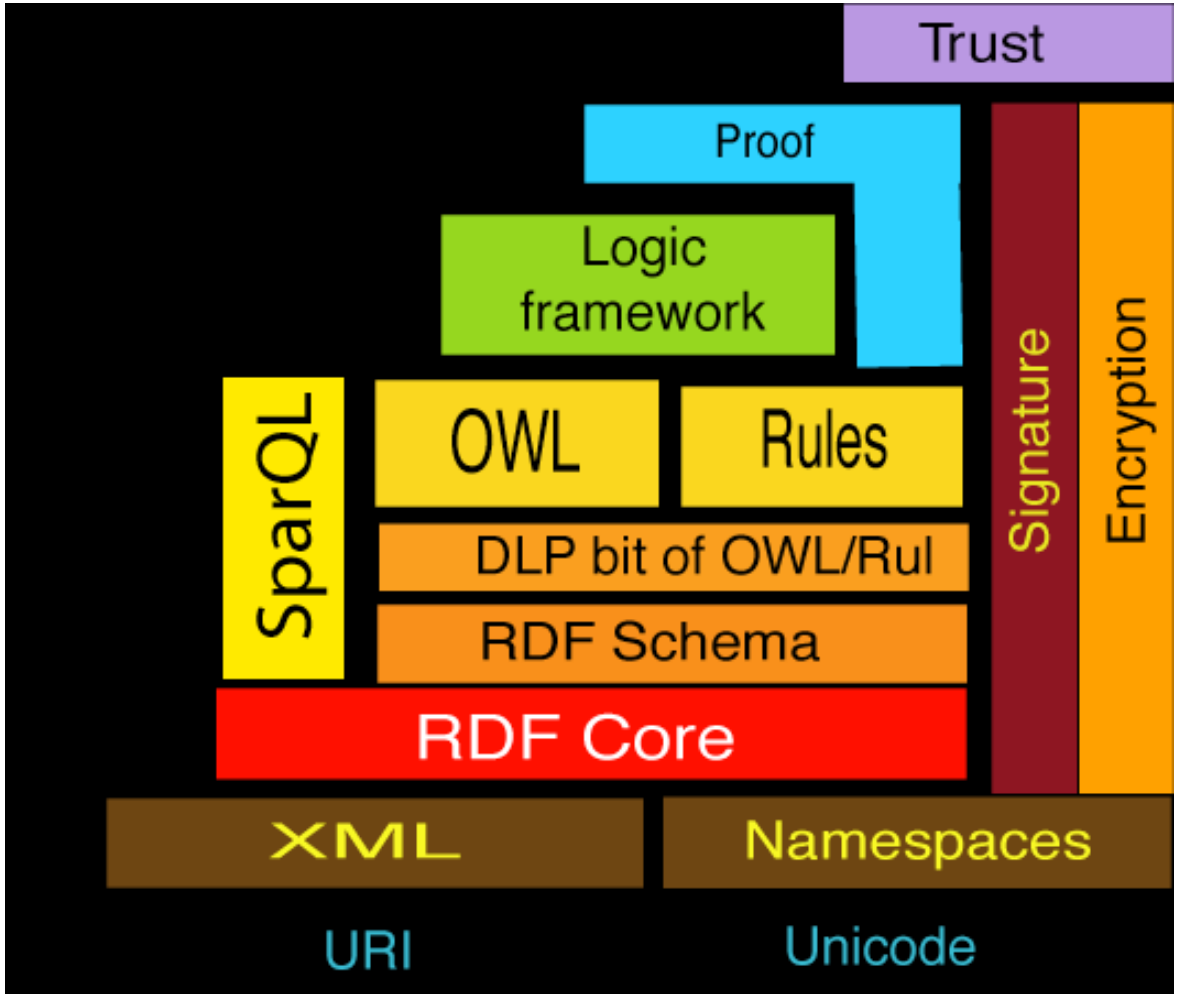
- innocent(x) :- person(x), not guilty(x),

Rules as an alternative ontology language

general idea: use rules as an ontology language

- first proposal: use rule-based languages **instead** of OWL
  - change of the Semantic Web Stack
- second proposal: use rule-based languages AND OWL as ontology languages
  - different change of the Stack (two-stack)
  - rules are not **on top** of OWL anymore, they are **besides** OWL

One-stack vs. two-stack architecture



RIF

- RIF (Rule Interchange Format) = W3C Working Group
- aim: providing standards for **rules interchange**
- recommendation (June 2010) of six new standard formats

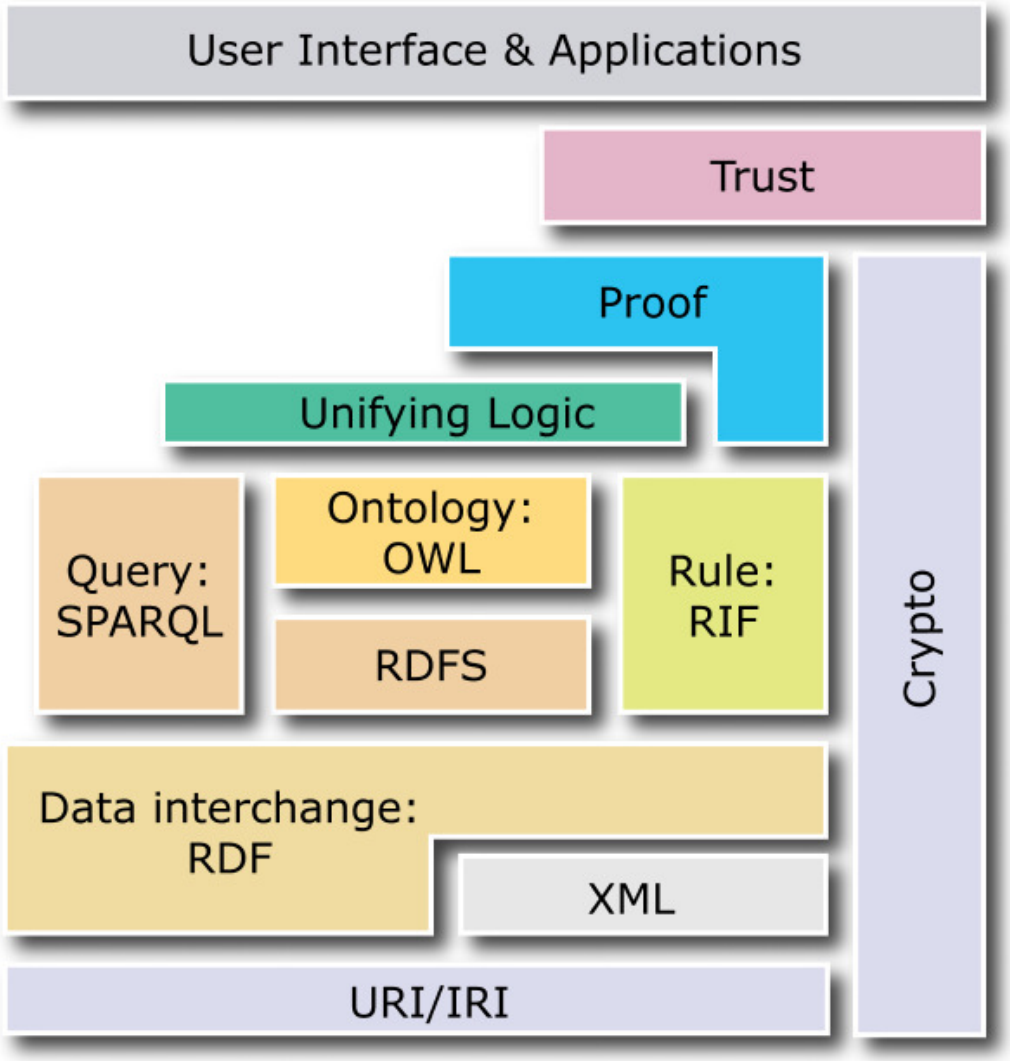
RIF

Six new standards (June 2010):

- **RIF Core Dialect**, which provides a standard, base level of functionality for interchange
- **RIF Basic Logic Dialect** and **RIF Production Rule Dialect** provide extended functionality matching two common classes of rule engines
- **RIF Framework for Logic Dialects** describes how to extend RIF for use with a large class of systems
- **RIF Datatypes and Built-Ins 1.0** borrows heavily from XQuery and XPath for a set of basic operations
- **RIF RDF and OWL Compatibility** specifies how RIF works with RDF data and OWL ontologies

See **`http://www.w3.org/TR/rif-overview/`**

The Semantic Web cake revisited



Proof layer

- main purpose: to provide explanations about the answers given by automated agents that consume the provided information
- = **provenance** problem
- very few results so far:
  - general OWL-DL ontologies
  - fragments of OWL-DL
  - some rule languages

Trust layer

- Trust layer: research at an early stage
- strictly depends on the choices concerning the lower layers
- some preliminary results:
  - provenance/pinpointing in Description Logic ontologies: finding the explanation for an answer
  - techniques for authorization
  - quality of the answers / ranking (top-k answers)