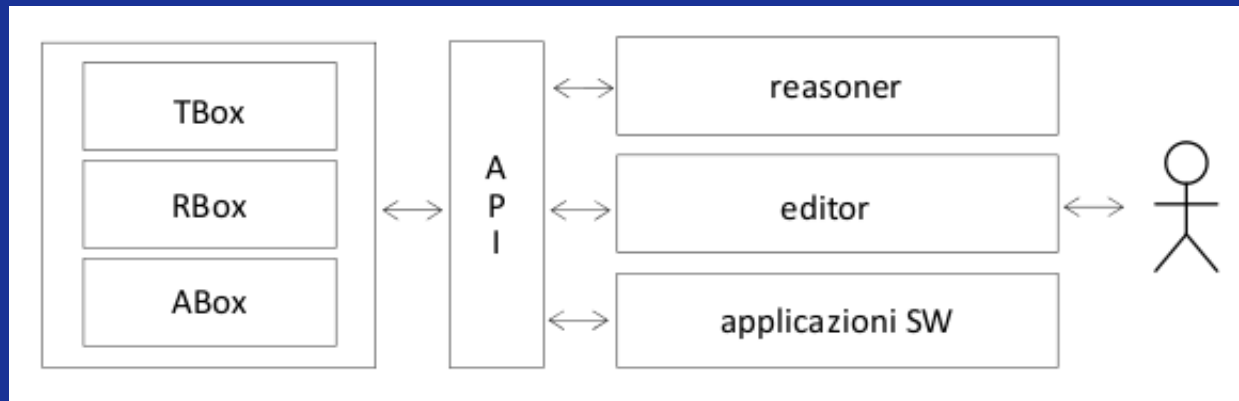


12 – Reasoning

- *Knowledge bases* differ from *data bases* as they allow to *infer* new axioms from the ones which have already been stated explicitly
- The process to deduce new axioms as logical consequences of others is called *reasoning*
- The tools/services which are used to perform reasoning are called *reasoners*
- Information inferred by reasoners can be added to the knowledge base itself, or returned at query time

- Definition by Tom Gruber: “An ontology is a specification of a conceptualization” (see [here](#))
 - Ontologies need to be shared and agreed to be useful
 - An ontology can be seen as a finite set of *axioms* describing the contents of a knowledge base
- The knowledge bases we are focusing on rely on a very specific model, based on *Description Logics*, divided in:
 - a *Terminological Box (TBox)*, where the main concepts (or *classes*) are defined;
 - a *Role Box (RBox)*, where properties (or *roles*) and relations between concepts are defined;
 - an *Assertion Box (ABox)*, where assertion (or *facts*) concerning specific individuals are specified.

- Architecture of a DL-based KBS, courtesy of prof. Marco Colombetti (original document [here](#))



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Ontology Elements

- Concepts/Classes
 - Taxonomy
- Properties/Roles
 - Object vs Datatype properties
- Assertions/Facts
 - Individuals and relations between them

- Let's build a sample ontology: the editor we use is **Protégé**

The screenshot displays the Protégé ontology editor interface. The main window shows the 'Class hierarchy' tab, which displays a tree structure of classes: Thing, Gender, Person, Man, Father, Woman, and Mother. The 'Man' class is selected, and its 'Class Annotations' tab is active, showing a list of annotations. The 'Description: Man' tab is also active, showing the class description: 'Person and (hasGender some Male)'. The 'Superclasses' section shows 'Person' as a superclass. The 'Disjoint classes' section shows 'Woman' as a disjoint class. The 'Object property hierarchy' tab is also visible, showing a tree structure of object properties: topObjectProperty.

File Edit Ontologies Reasoner Tools Refactor Tabs View Window Help

Ontology1292399348398 (<http://www.semanticweb.org/ontologies/2010/11/Ontology1292399348398.owl>)

Active Ontology Entities Classes Object Properties Data Properties Individuals OWLViz DL Query OntoGraf

Class hierarchy Class hierarchy (inferred)

Class hierarchy: Man

- Thing
 - Gender
 - Person
 - Man
 - Father
 - Woman
 - Mother

Class Annotations Class Usage

Annotations: Man

Annotations +

Description: Man

Equivalent classes +

- Person and (hasGender some Male)

Superclasses +

- Person

Inherited anonymous classes

Members +

Keys +

Disjoint classes +

- Woman

Individuals by type Annotation property hierarchy Datatypes

Object property hierarchy Data property hierarchy

Object property hierarchy:

- topObjectProperty

To use the reasoner click Reasoner->Start Reasoner Show Inferences

Reasoning on an ontology

- Reasoning can be based
 - on the ontology facts alone (i.e. What you can describe with OWL)
 - on the ontology facts plus some *rules* (i.e. What you can describe with OWL + a set of inference rules)
- According to the expressivity of an ontology, reasoning can become more and more complex (and computationally intensive)

- **Semantic Web Rule Language** (SWRL) is an OWL-compatible version of the Datalog rule language

- Rules are in the form:

$$X_1 \wedge \dots \wedge X_n \rightarrow Y$$

- Example:

$\text{brotherOf}(?x,?z) \wedge \text{parentOf}(?z,?y) \rightarrow \text{uncleOf}(?x,?y)$

- Reasoning:

- OWL+rules might become undecidable
- need for a *safe mode* where expressivity is diminished but decidability is granted => variables in rules can be substituted only by *existing individuals* in the KB

■ Some Web references:

- Inference on the Semantic Web:
<http://www.slideshare.net/onlyjiny/inference-on-the-semantic-web>
- Prof. Colombetti's material from the course "Ingegneria della Conoscenza" at Politecnico di Milano: <http://home.dei.polimi.it/colombet/IC/>

■ Tools:

- Protégé: <http://protege.stanford.edu>