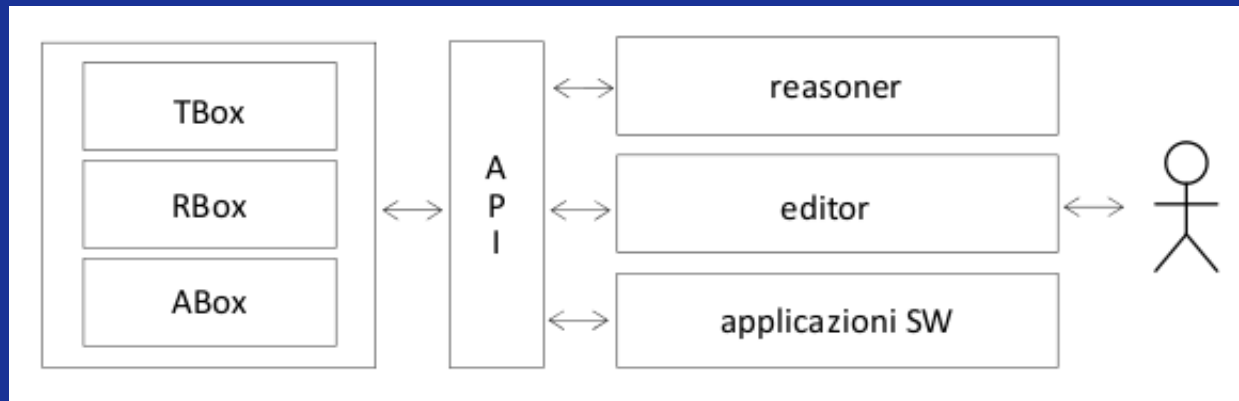


14 – Reasoning

- *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 top menu bar includes File, Edit, Ontologies, Reasoner, Tools, Refactor, Tabs, View, Window, and Help. The current ontology is 'Ontology1292399348398' with the URL 'http://www.semanticweb.org/ontologies/2010/11/Ontology1292399348398.owl'. The 'Active Ontology' tab is selected, showing a class hierarchy for 'Man'. The hierarchy includes 'Thing', 'Gender', 'Person', 'Man', 'Father', 'Woman', and 'Mother'. The 'Class Annotations' tab is active, showing 'Annotations: Man' and 'Description: Man'. The description for 'Man' is 'Person and (hasGender some Male)'. The 'Superclasses' section shows 'Person'. The 'Disjoint classes' section shows 'Woman'. The 'Object property hierarchy' tab is also visible, showing 'topObjectProperty'. At the bottom, there is a note: 'To use the reasoner click Reasoner->Start Reasoner' and a checked checkbox for '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>