First-Order Logic

- First-Order Predicate Calculus
- Predicate Calculus
- FOL
- FOPC

Makes a stronger set of ontological commitments than propositional logic.

The world consists of **objects** that is thinks with individual identities and **properties** that distinguish them from other objects.

**relations** between **objects**.

**functions**
First-Order Logic

- **Objects:** people, houses, colors, numbers
- **Relations:** brother of, bigger than, part of, has color, owned.
- **Properties:** red, round, prime
- **Functions:** father of, best friend.
First-Order Logic

- **Term:** A Logical Expression that refers to an object.
  
  \[
  \text{john} \\
  \text{fatherof(john)}
  \]

- **Atomic Sentences:**
  
  \[
  \text{brother(john, richard)} \\
  \text{married(fatherof(richard), motherof(john))}
  \]

- **Complex Sentences:**
  
  \[
  \text{brother(richard, john)} \land \text{brother(john, richard)}
  \]
First-Order Logic

Quantifiers, Variables

- **Universal Quantification:** \( \forall \)
  \[ \forall x \text{ cat}(x) \rightarrow \text{mammal}(x) \]
  \[ \forall x \text{ man}(x) \rightarrow \text{mortal}(x) \]

- **Existential Quantification:** \( \exists \)
  \[ \exists x \text{ sister}(x, \text{spot}) \land \text{cat}(x) \]

- **terms:**
  \[ a, \text{fatherof}(a), x \]

- **ground terms:**
  \[ a, \text{fatherof}(a) \]
First-Order Logic

Syntax

\[ \text{AtomicSentence} \Rightarrow \text{Predicate}(\text{term}_1 \ldots) \]
\[ \quad \text{term} = \text{term} \]

\[ \text{term} \Rightarrow \text{Function}(\text{term}_1 \ldots) \]
\[ \quad \text{constant} | \text{variable} \]

\[ \text{Sentence} \Rightarrow \text{AtomicSentence} \]
\[ \quad \text{Sentence Connective Sentence} \]
\[ \quad \text{Quantifier Variable Sentence} \]
\[ \quad \neg \text{Sentence} \]
\[ \quad (\text{Sentence}) \]
First-Order Logic

Syntax

Connective ⇒ ∧ | ∨ | ≡
Quantifier ⇒ ∀ | ∃
Constant ⇒ a | john | …
Variable ⇒ x | s | …
Predicate ⇒ before | hascolor | …
Function ⇒ mother | leftlegof | …
Application

Temporal Reasoning

- TMM – Time Map Manager (Brown, Yale, Honeywell, Nasa)
- Specialized Temporal Reasoning System
- Reasoning about the ordering an extent of events and the resulting changes in the state of the world.
- Applied to very large problems – 10,000 activities.
- Scheduling for a circuit board manufacturing plant, science modules on Space Shuttle.
Application

Semantic Web

- Syntactic Web vs Semantic Web
- HTML, XML
- Ontologies, Description Logics
- Web Search, Electronic Commerce
- Web Services
- http://www.semanticweb.org