Description Logics

Languages designed to reason about sets of objects:

$$\text{person} \sqcap (\leq 3 \text{ child}) \sqcap (\forall \text{ child} . \text{ smart})$$

Language contains:

- Classes (relations of arity 1): person, parent, mammal, ...
- Roles and attributes (relations of arity 2): parent, child, spouse, ...
- Individuals (constants): Craig, Mary, ...

A knowledge base contains: a terminology and a set of ground atomic facts.

Description Logics Terminologies

A terminology is a set of complex concept descriptions:

$C_1 =$ Movie $\sqcap$ (≤ 6 Actor) $\sqcap$ ($\forall$ Actor . (Italian $\sqcup$ French)) $\sqcap$

($\exists$ Actor . OscarWinner)

Subsumption: the concept above is subsumed by:

$C_2 =$ Movie $\sqcap$ (≤ 8 Actor) $\sqcap$ ($\forall$ Actor .European)

Ground facts can either be of primitive concepts and roles or of complex ones:

Movie(M1), Actor(M1,A1), C1(M2).

Description Logic Semantics

Interpretation mapping ϕ: (as in first order logic)

Maps every individual to an element of a (non-empty) domain $\mathcal{O}$.

Unique names assumption: $a \neq b \Rightarrow \phi(a) \neq \phi(b)$.

Every concept is mapped to a subset of $\mathcal{O}$.

Every role is mapped to a subset of $\mathcal{O} \times \mathcal{O}$.

Complex concepts must satisfy meaning of constructors:

$\phi(C \sqcap D) = \phi(C) \cap \phi(D)$;
$\phi(\geq\ n\, R) = \{d \in \mathcal{O} \mid \sharp\{e \mid (d, e) \in \phi(R)\} \geq n\}$

Description Logic Semantics

Reasoning services of a description logic system:

- Subsumption: is the concept C_1 subsumed by C_2?
- Classification: place a concept C in the concept hierarchy.
- Instance checking: is the individual o an instance of the concept C?
- Recognition: to what concepts does o belong?
- Satisfiability: is the knowledge base consistent?

Description Logic Systems

Systems based on description logics tradeoff expressive power for tractability or completeness.

- CLASSIC (AT&T): polynomial time subsumption.
- KRIS, BACK (Germany): very expressive, exponential time subsumption.
- LOOM (ISI): very expressive, incomplete subsumption reasoning.

Applications of description logics systems:

configuration, natural language, data archeology, software engineering, information integration.

A Hybrid Decidable Logic

Description Logics and Horn rules are both decidable subsets of first-order logic.

Can we combine their expressive power and still get a decidable logic?

Yes & No.

CARIN: [Levy & Rousset, 1996]: Horn rules where the predicates may be part of Description logic terminologies.

Decidable when

- there is no recursion, or
- description logic is carefully restricted.