A Description Logic Primer

Intro To KE Presentation

Introduction to Description Logics (DLs)

- Family of formal knowledge representation languages
- Backbone of OWL (Web Ontology Language)
- Decidable fragments of First-Order Logic
- Key features:
  - Formal semantics (avoids ambiguity)
  - Reasoning: infer implicit knowledge
- Tradeoff: Expressivity vs. Computational complexity

Basic Building Blocks of DL Ontologies

- Entities:
  - Concepts (Classes)
  - Roles (Properties/Relations)
  - Individuals (Named entities)

- Types of Axioms:
  - ABox: assertions (facts about individuals)
  - TBox: concept relationships (Mother $\sqsubseteq$ Parent)
  - RBox: role relationships (parentOf $\sqsubseteq$ ancestorOf)

Constructors for Concepts and Roles

- Boolean constructors: ⊓, ⊔, ¬, ⊤, ⊥
- Role restrictions: ∃ , ∀ , ≥n, ≤n
- Nominals: {john, paul, george, ringo}
- Role constructors: inverses, universal role
- Role characteristics: transitive, symmetric, reflexive

SROIQ, Semantics & Lightweight Fragments

- SROIQ: highly expressive DL, basis of OWL 2 DL
- Restrictions: simplicity, regularity (to ensure decidability)
- Semantics:
  - Interpretations assign meaning to symbols
  - Works under Open World Assumption (OWA)

- Important Fragments:
  - ALC – core DL
  - EL family – scalable, used in biomedical ontologies
  - DL-Lite – ontology-based data access
  - DLP – rule-based reasoning

OWL Relationship & Tools

- OWL: W3C standard for ontologies
- Direct Semantics (DL-based) & RDF-based semantics
- OWL DL ≈ SROIQ (with data types, keys, annotations)
- Tools & Applications:
  - Protégé ontology editor
  - Reasoners: FaCT++, HermiT, Pellet, ELK
  - Applications: Semantic Web, biomedical ontologies, knowledge graphs

Questions

1. What is the difference between $(\exists R.A) \sqcap B$ and $\exists R.(A \sqcap B)$, and how does this affect reasoning outcomes?
2. Why do lightweight DL fragments such as EL and DL-Lite exist, and in what domains are they particularly useful compared to more expressive logics like SROIQ?
3. How does OWL 2 DL relate to SROIQ, and what role do tools like Protégé and HermiT play in working with DL-based ontologies?