Description Logic

Representation, Reasoning, Tableau Algorithm, Subsumption, DL Extensions, Querying, Ontologies

Description Logic is the mathematics of the knowledge graph.

Description Logic is the discipline of mathematics concerned with knowledge representation and reasoning. There are many ways to represent knowledge as data but where Description Logic excels is doing this in such a way that greatly facilitates reasoning.

DL builds on a number of areas of mathematics such as the decidable fragment of First Order Logic and model theory, and pays attention to complexity theory.

There are a variety of Description Logics (DLs), and we compare and contrast a number of these. More advanced DLs feature richer expressivity, but also come with increased complexity in reasoning (especially for large knowledge bases), so it is important to understand the tradeoff.

A good understanding of Description Logic is essential when working with graph stores, reasoners and semantic query languages. DL provides the mathematical formalism that underpins the semantic web, the W3C OWL Language and the reasoners that process it.

Target Audience

This course will be of keen interest to mathematicians and software developers who wish to understand Description Logic - the mathematical foundations behind the Semantic Web and W3C specifications such as OWL, RDF and SPARQL.

Prerequisites

Good foundational mathematical education along with some programming experience, as we include exploring Description Logic from a computational viewpoint.

Attendees can select which programming language they wish to use in the labs, as all concepts will be developed from first principles.

Contents of One-Day Training Course

Description Logic Overview

Relationship to first order logic
Description based on concept, role and individual plus operators
TBox and ABox
Importance of inferencing
Constructing a mathematical model

DL Basics

Defining a simple DL
How to represent knowledge using it
What services could we layer on top of it?

Model Theory

An interpretation is a mapping for concepts, roles etc. and is a model if certain conditions hold
Relationship between DL & Model theory

Knowledge Services

Subsumption / Consistency
Inferencing
Satisfiability
Querying

Tableau Algorithm

More expressive DL needs richer reasoner
Outline of tableau algorithm
Variants
DeMorgan's theorem

DL Extensions (extra letters)

Nominals
Cardinality restrictions
Inverses
Temporal
Extra role constructors
Concrete domains

Family of Logics

SHOIN (OWL DL)
SROIQ (full OWL2)
SHIF (OWL-Lite)
… lots more

Resources

Tooling
Frameworks
Servers
Reasoners

Advanced Topics

Automata as a specialist alternative to the tableau algorithm
Study of complexity on relation to DLs
Scalability (very large knowledge bases)
Fixpoints

Use of DL in OWL

The W3C semantic web defines the Web Ontology language (OWL) which is based on description logic
The DL terms (individual, concept, role) map to OWL terms (individual, class, prop)

Ontologies vs. SQL databases

There are similarities & differences (TBox = schema, ABox = data)
Open vs. closed world assumption
Incomplete information
Role that reasoning plays
Unique name assumption

Query Answering

How it works (query processing)
Covers given and inferred knowledge
Re-writability