Practical Reasoning with OWL and Rules

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Semantic Web Technology Showcase
ESTC 2007
So what is reasoning?
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Reasoning is . . .

. . . the evaluation of ontologies according to their spec
(and, besides, hard to define in general . . . )
Reasoning for the Semantic Web

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⇝ essential background technology for semantic knowledge representation

Main tasks for backends in semantic systems:

- ontology management
- inferencing
- query answering
KAON2: OWL reasoner and ontology management API

- Reasoner optimised for large ABoxes
- API for ontology manipulation and serialisation
- Database bindings
- DIG and SPARQL interfaces

Binaries available from http://kaon2.semanticweb.org
Reasoning Support in KAON2

- Supported language: OWL DL without *enumerated classes* (nominals) but with *qualified cardinality restrictions*.
- Algorithm not based on tableau method
- Using first-order resolution calculus
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KAON2 computes inferences in two processing steps:

1. OWL DL ABox
2. OWL DL TBox (w/o nominals)
3. OWL DL query
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   - Transformation to disjunctive datalog program
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4. Disjunctive datalog engine
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KAON2 computes inferences in two processing steps:

1. **OWL DL ABox** → **Disjunctive datalog engine**
2. **OWL DL TBox (w/o nominals)** → Transformation to disjunctive datalog program → **OWL DL query**

Datalog can be cached and reused for various queries.
Recall: $P \subseteq NP$
KAON2 Complexity and Performance

Recall: $P \subseteq NP \subseteq PSPACE$
Recall: $P \subseteq \text{NP} \subseteq \text{PSPACE} \subseteq \text{EXPTIME}$
KAON2 Complexity and Performance

Recall: $P \subseteq NP \subseteq PSPACE \subseteq \text{ExpTime} \subseteq \text{NExpTime}$
KAON2 Complexity and Performance

Recall: $P \subseteq NP \subseteq PSPACE \subseteq \textbf{ExpTime} \subseteq \text{NEExpTime}$

1. Process query and TBox to obtain disjunctive datalog $\leadsto \textbf{ExpTime}$
2. Add ABox
3. Use Datalog reasoner for query answering $\leadsto \text{NP}$ (w.r.t. ABox)

Features
- TBox translation not necessary for every query
- Datalog-reasoning exploits well-known optimisation strategies (e.g. magic sets)
- Data complexity is NP
- Overall algorithm is worst-case optimal ($\textbf{ExpTime}$)
Inferencing in OWL DL is intractable – can we only ever deal with small ontologies?
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Sİ Investigation of tractable fragments of OWL

- OWL Lite is not suitable ($\text{ExpTime}$)
- Proposed languages: DL Lite ($\text{LogSpace}$), $\mathcal{EL}^{++}$ ($\text{PTime}$), Horn-$\mathcal{SHIQ}$ ($\text{PTime}$ for instance data)
- KAON2 supports Horn-$\mathcal{SHIQ}$: precompile ontology to Datalog program (no disjunctions)

Sİ Suitable for non-trivial ontologies with large ABoxes
Various proposals for Semantic Web rule languages:

- First-Order Logic: SWRL
- Logic Programming: F-Logic, Prolog, WRL, ...

\(\Rightarrow\) partially reconciled in various approaches

Tutorial tomorrow: “Answer-Set Programming for the Semantic Web”

\(\Rightarrow\) rule interchange format under development (W3C RIF)
Ontologies and Rules

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**Rules in KAON2**

- support for decidable fragment of SWRL: DL-safe rules
- intuition: restrict SWRL rules to *known individuals*
- no increase of reasoning complexity
The NeOn Toolkit

Ontology engineering environment – www.neon-toolkit.org

- Supports the lifecycle of networked ontologies
  - Modeling
  - Collaboration
  - Integration/modularization of ontologies
  - Verification/testing
  - Deployment
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  - Based on Eclipse
  - Succeeds ontoprise’s OntoStudio
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- Dual language approach
  - Frame-like modeling with FLogic rules
  - OWL DL modeling
# NeOn Toolkit Architecture

## GUI Components
- Standard GUI components (class tree, etc.)
- Text-based Interfaces
- Graph-based Interfaces

## Engineering Components
- Property Editors
- Mapping Editors
- Visualisation Algorithms
- Tightly Coupled Components
- Data Annotation
- Translation
- Collaboration Support
- Loosely Coupled Services
- Security
- Service Infrastructure
- Orthogonal Functionality

## KAON2/OntoBroker
- OWL
- Frames/ Rules
- Reasoner
- Model API
- Storage
- Basic Query
- Repository Service
- Query
- Metadata
- Registry Service
- Security
- Versioning
- Orthogonal Functionality
Querying Ontologies

How to query OWL ontologies?
SPARQL mostly a query language for RDF(S)
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Conjunctive queries

The knowledge base can be queried for conjunctions of

- terms $A(x)$ and $\neg A(x)$ where $A$ is a concept name, and
- terms $R(x, y)$ where $R$ is a simple role (one without transitive subroles).
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KAON2 support: conjunctive queries for known individuals
⇝ similar to DL-safe rules

Conjunctive queries for OWL DL and OWL 1.1: current research
Outlook

KAON2

- Ontology management and reasoning for (part of) OWL
- Partial support for SWRL rules and conjunctive queries
- Free for non-commercial use – commercial support by ontoprise

http://kaon2.semanticweb.org

NeOn Toolkit

- Novel ontology engineering environment
- Official launch: next week at ESWC!

4th June 2007, 18:20
Congress Center Innsbruck, Freiburg Hall, 3rd floor
http://www.neon-toolkit.org

Future work

- Tractable OWL variants
- Improved querying for OWL
- OWL 1.1