RuQAR : Reasoning with OWL 2 RL Using Forward Chaining Engines

Jaroslaw Bak

Institute of Control and Information Engineering
Poznan University of Technology
Piotrowo 3a, 60-965 Poznan, Poland
Email: jaroslaw.bak@put.poznan.pl

June 6th, 2015

Outline

Outline

1. What is RuQAR?

Outline

1. What is RuQAR?
2. Motivation

Outline

1. What is RuQAR?
2. Motivation
3. The RuQAR Framework

Outline

1. What is RuQAR?
2. Motivation
3. The RuQAR Framework
   - Features

Outline

1. What is RuQAR?
2. Motivation
3. The RuQAR Framework
   - Features
   - Architecture and Implementation

Outline

1. What is RuQAR?
2. Motivation
3. The RuQAR Framework
   - Features
   - Architecture and Implementation
4. Evaluation

Outline

1. What is RuQAR?
2. Motivation
3. The RuQAR Framework
   - Features
   - Architecture and Implementation
4. Evaluation
5. Conclusions and Future Work

What is RuQAR?

What is RuQAR?

- Rule-based Query Answering and Reasoning framework

What is RuQAR?

- Rule-based Query Answering and Reasoning framework
- Supports ABox reasoning and query answering with OWL 2 RL ontologies executed by the forward chaining rule reasoners Jess and Drools

What is RuQAR?

- Rule-based Query Answering and Reasoning framework
- Supports ABox reasoning and query answering with OWL 2 RL ontologies executed by the forward chaining rule reasoners Jess and Drools
- The main goal of this tool is to provide efficient ABox reasoning as well as query answering within OWL 2 RL profile

Motivation

Motivation

- We like rules :)

Motivation

- We like rules :)
- OWL 2 RL reasoners are known to perform poorly with large ABoxes

Motivation

- We like rules :)
- OWL 2 RL reasoners are known to perform poorly with large ABoxes
- Description logic-based reasoners handle the TBox entailments better than the ABox ones

Motivation

- We like rules :)
- OWL 2 RL reasoners are known to perform poorly with large ABoxes
- Description logic-based reasoners handle the TBox entailments better than the ABox ones
- ABox reasoning can be performed more efficiently by a rule engine

Motivation

- We like rules :)
- OWL 2 RL reasoners are known to perform poorly with large ABoxes
- Description logic-based reasoners handle the TBox entailments better than the ABox ones
- ABox reasoning can be performed more efficiently by a rule engine
- The official list of OWL 2 reasoners supporting OWL 2 RL is limited

Motivation

Motivation

- An application of an OWL 2 RL reasoner together with a currently being used forward reasoning engine can be a tricky task

Motivation

- An application of an OWL 2 RL reasoner together with a currently being used forward reasoning engine can be a tricky task
- Lack of tools that can generate rules for different reasoning engines

Motivation

- An application of an OWL 2 RL reasoner together with a currently being used forward reasoning engine can be a tricky task
- Lack of tools that can generate rules for different reasoning engines
- Usually, reasoning engines require data to be stored in the main memory

Motivation

- An application of an OWL 2 RL reasoner together with a currently being used forward reasoning engine can be a tricky task
- Lack of tools that can generate rules for different reasoning engines
- Usually, reasoning engines require data to be stored in the main memory
- Lack of native and efficient rule sets that support OWL 2 RL reasoning in many popular rule engines, especially considering ABox reasoning

Motivation

- An application of an OWL 2 RL reasoner together with a currently being used forward reasoning engine can be a tricky task
- Lack of tools that can generate rules for different reasoning engines
- Usually, reasoning engines require data to be stored in the main memory
- Lack of native and efficient rule sets that support OWL 2 RL reasoning in many popular rule engines, especially considering ABox reasoning
- We really like rules ;)

RuQAR's Features

RuQAR's Features

- We aim at providing an easy-to-use framework for performing ABox reasoning with OWL 2 RL ontologies in any forward chaining rule engine which such that it can be used in many rule-based applications

RuQAR's Features

- We aim at providing an easy-to-use framework for performing ABox reasoning with OWL 2 RL ontologies in any forward chaining rule engine which such that it can be used in many rule-based applications
- An ontology needs to be transformed into rules that are readable by a chosen engine

RuQAR's Features – ASRF

RuQAR's Features – ASRF

- The Abstract Syntax of Rules and Facts (ASRF) which is used to rise an abstraction level providing more universal representation of rules and facts

RuQAR's Features – ASRF

- The Abstract Syntax of Rules and Facts (ASRF) which is used to rise an abstraction level providing more universal representation of rules and facts
- ASRF enables easy translation into the language of any rule engine

RuQAR's Features – ASRF

- The Abstract Syntax of Rules and Facts (ASRF) which is used to rise an abstraction level providing more universal representation of rules and facts
- ASRF enables easy translation into the language of any rule engine
- An implementation of mappings between ASRF and the language of the engine is required

RuQAR's Features – ASRF Example

```
Rule ClassHierarchyRule_1_LUBM
If
  (Triple
      (Subject ?x)
      (Predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
      (Object "http://swat.cse.lehigh.edu/onto/univ-bench.owl#ResearchAssistant"))

Then
  (Triple
      (Subject ?x)
      (Predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
      (Object "http://swat.cse.lehigh.edu/onto/univ-bench.owl#Person"))
End
```

RuQAR's Features – ASRF Example

```
Rule ClassHierarchyRule_1_LUBM
If
  (Triple
     (Subject ?x)
     (Predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
     (Object "http://swat.cse.lehigh.edu/onto/univ-bench.owl#ResearchAssistant"))

Then
  (Triple
     (Subject ?x)
     (Predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
     (Object "http://swat.cse.lehigh.edu/onto/univ-bench.owl#Person"))
End
```

```
  (Triple
     (Subject "http://www.Department6.University0.edu/GraduateStudent22")
     (Predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
     (Object "http://swat.cse.lehigh.edu/onto/univ-bench.owl#ResearchAssistant"))

  (Triple
     (Subject "http://www.Department6.University0.edu/GraduateStudent22")
     (Predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
     (Object "http://swat.cse.lehigh.edu/onto/univ-bench.owl#Person"))
```

RuQAR's Features – Transformation Schema

RuQAR's Features – Transformation Schema

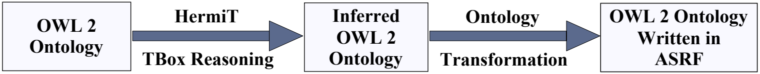
- We transform an OWL 2 ontology into a set of rules and a set of facts expressed in ASRF

RuQAR's Features – Transformation Schema

- We transform an OWL 2 ontology into a set of rules and a set of facts expressed in ASRF

RuQAR's Features – Transformation Schema

- We transform an OWL 2 ontology into a set of rules and a set of facts expressed in ASRF



RuQAR's Features – Transformation Schema

Table: Currently supported OWL 2 RL entailment rules.

OWL 2 RL Specification Table	Supported Rules
Table 4. The Semantics of Equality	eq-sym, eq-trans, eq-rep-p eq-rep-s, eq-rep-o
Table 5. The Semantics of Axioms about Properties	prp-dom, prp-rng, prp-fp, prp-ifp, prp-symp, prp-trp, prp-eqp1, prp-spo1, prp-eqp2, prp-inv1, prp-inv2
Table 6. The Semantics of Classes	cls-int1, cls-int2, cls-uni, cls-svf1, cls-svf2, cls-avf, cls-hv1, cls-hv2, cls-maxc2
Table 7. The Semantic of Class Axioms	cax-sco, cax-eqc1, cax-eqc2

RuQAR's Features – Jess, Drools, SWRL

RuQAR's Features – Jess, Drools, SWRL

- ASRF sets can be translated into Drools and Jess languages

RuQAR's Features – Jess, Drools, SWRL

- ASRF sets can be translated into Drools and Jess languages
- Semantic Web Rule Language is also supported

RuQAR's Features – Jess, Drools, SWRL

- ASRF sets can be translated into Drools and Jess languages
- Semantic Web Rule Language is also supported
- RuQAR checks whether a rule is safe or not

RuQAR's Features – Database Mapping

RuQAR's Features – Database Mapping

- Mapping method between an ontology and a relational database (R2RML is an ongoing work)

RuQAR's Features – Database Mapping

- Mapping method between an ontology and a relational database (R2RML is an ongoing work)
- Query answering functions

RuQAR's Features – Database Mapping

- Mapping method between an ontology and a relational database (R2RML is an ongoing work)
- Query answering functions
- Storing ABox in a relational database using simple mappings

RuQAR's Features – Database Mapping

$$SELECT\ Col_1\ FROM\ *\ WHERE\ (Col_1\ is\ not\ NULL);$$

$$SELECT\ Col_1,\ Col_2\ FROM\ *\ WHERE\ ((Col_1\ is\ not\ NULL)\ AND\ (Col_2\ is\ not\ NULL));$$

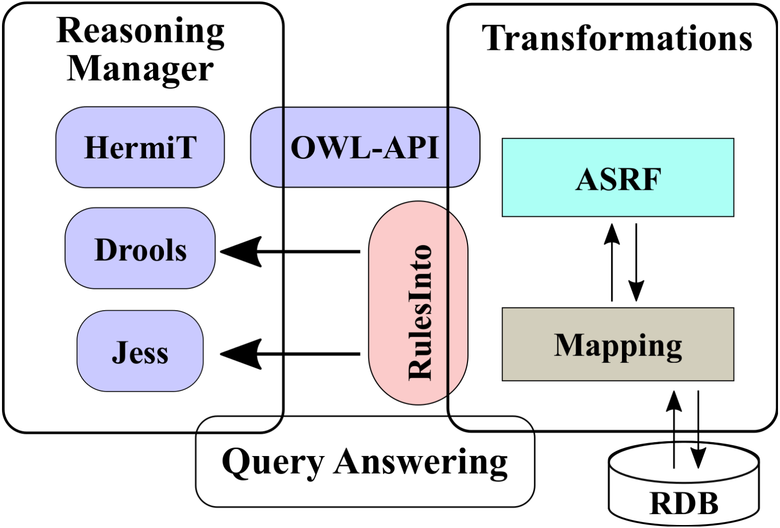
$$SELECT\ Col_1,\ Col_2,\ Col_3\ FROM\ *\ WHERE$$
$$((Col_1\ is\ not\ NULL)\ AND\ (Col_2\ is\ not\ NULL))\ AND\ (Col_3\ is\ not\ NULL));$$

where:

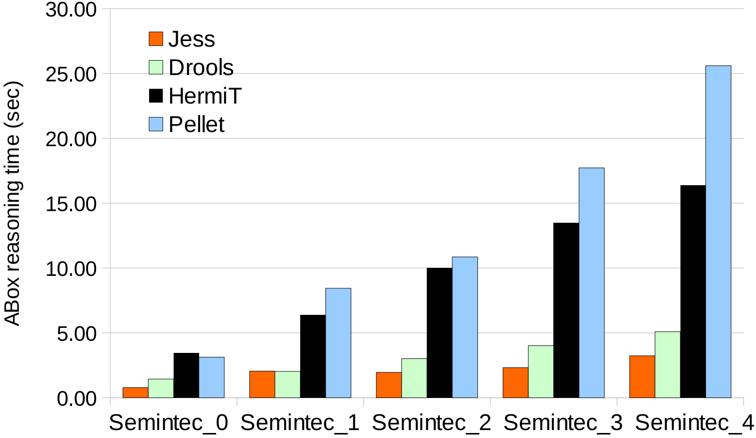
- COl_x are the attributes (columns) that occur in the result of a query,
- $*$ is an SQL statement; it can contain SQL commands - e.g. nested *Select* query or a table name,
- $(COL_x\ is\ not\ NULL)$ means NULL results are not allowed.

RuQAR's Architecture and Implementation

RuQAR's Architecture and Implementation

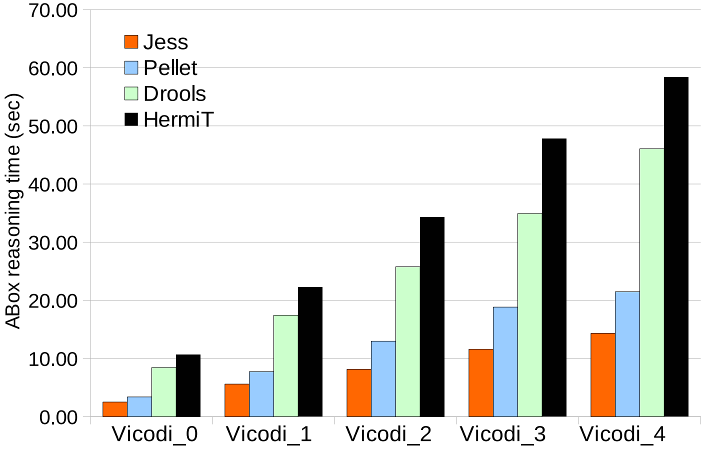


Evaluation

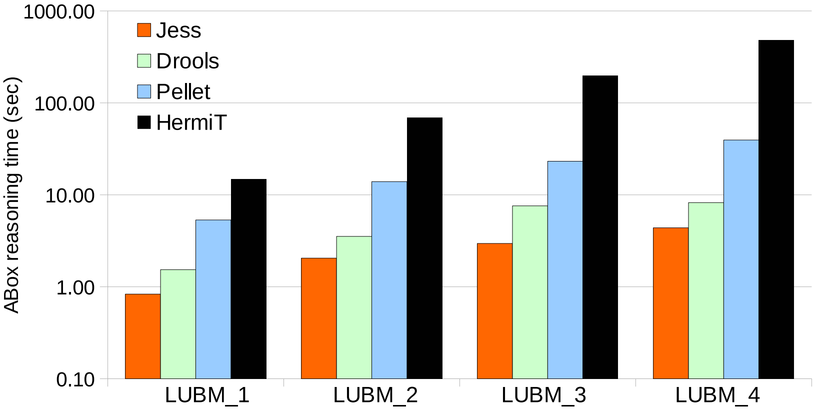


30.00
25.00
20.00
15.00
10.00
5.00
0.00
ABox reasoning time (sec)
Jess
Drools
HermiT
Pellet
Semintec_0
Semintec_1
Semintec_2
Semintec_3
Semintec_4

Evaluation


70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
ABox reasoning time (sec)
Jess
Pellet
Drools
HermiT
Vicodi_0
Vicodi_1
Vicodi_2
Vicodi_3
Vicodi_4

Evaluation



1000.00
100.00
10.00
1.00
0.10
ABox reasoning time (sec)
Jess
Drools
Pellet
HermiT
LUBM_1
LUBM_2
LUBM_3
LUBM_4

Conclusions

Conclusions

RuQAR is a tool that:

Conclusions

RuQAR is a tool that:

- performs ABox reasoning and query answering with OWL 2 RL ontologies executed by forward chaining rule reasoners

Conclusions

RuQAR is a tool that:

- performs ABox reasoning and query answering with OWL 2 RL ontologies executed by forward chaining rule reasoners
- translates an OWL 2 ontology into rules

Conclusions

RuQAR is a tool that:

- performs ABox reasoning and query answering with OWL 2 RL ontologies executed by forward chaining rule reasoners
- translates an OWL 2 ontology into rules
- allows for using SWRL rules together with ontologies

Conclusions

RuQAR is a tool that:

- performs ABox reasoning and query answering with OWL 2 RL ontologies executed by forward chaining rule reasoners
- translates an OWL 2 ontology into rules
- allows for using SWRL rules together with ontologies
- provides functions to manage reasoning engines

Conclusions

RuQAR is a tool that:

- performs ABox reasoning and query answering with OWL 2 RL ontologies executed by forward chaining rule reasoners
- translates an OWL 2 ontology into rules
- allows for using SWRL rules together with ontologies
- provides functions to manage reasoning engines
- can store OWL individuals in a relational database

Conclusions

RuQAR is a tool that:

- performs ABox reasoning and query answering with OWL 2 RL ontologies executed by forward chaining rule reasoners
- translates an OWL 2 ontology into rules
- allows for using SWRL rules together with ontologies
- provides functions to manage reasoning engines
- can store OWL individuals in a relational database
- is the first implementation of the OWL 2 RL reasoning in Drools and Jess that implements directly the semantics of OWL 2 RL which can be applied in any application requiring efficient ABox reasoning

...and Future Work

...and Future Work

We plan to:

...and Future Work

We plan to:

- develop an interface that is based on the R2RML specification

...and Future Work

We plan to:

- develop an interface that is based on the R2RML specification
- include more optimizations in query answering as well as reasoning

...and Future Work

We plan to:

- develop an interface that is based on the R2RML specification
- include more optimizations in query answering as well as reasoning
- provide queries execution with graphical answers

...and Future Work

We plan to:

- develop an interface that is based on the R2RML specification
- include more optimizations in query answering as well as reasoning
- provide queries execution with graphical answers
- use the NPD Benchmark for an evaluation

Thank you for listening!

More information available at:

http://etacar.put.poznan.pl/jaroslaw.bak/RuQAR.php

Questions?