Database Backend for Description Logics

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Outline

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Conversation Understanding

Ken 7 to 14 year olds need plenty of computer counseling.

Jen Yeah, in another job that requires people skills!

Jen Thats true Ken- a benefit.

Ken Who knows... perhaps they need help with their spread sheets near income tax time!

Lance Actually, a computer expert at the Y would be nice... I tried to change my address to one outside Albany the other day but the guy at the desk said the computer system refused the zip code, heh.

Jen Hehe.

Jen I think the job descrip is lacking tonight.

Jen It doesn't ally say what you'd be doing-counselor, etc. Just says working with 7-14.

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Conversation Understanding

- We can extract topics and polarities:
  computer conseling {Positive, negative, neutral}
- Using background knowledge, it's possible to learn more about the topic and speakers' attitude.
  - WordNet example: something that provides direction or advice as to a decision or course of action
  - Using synonym(computer, IT), we may find related IT counseling companies.
  - Limited use cases for seperate conversations; Aggregation may produce better results[1].

[1] http://www.technologyreview.com/view/421201/how-to-use-twitter-for-personal-data-mining

Conversation Understanding

```
{"conversation":{
  "name":"Interview Discussion",
  "id":"http://CUBISM/api/1.0/conversations/5.json",
  "topics":[
    {
      "id":"http://CUBISM/api/1.0/conversations/5/topics/1.json",
      "name":"topic A",
      "belief":"belief of system about topic A",
      "viewpoints":[
        {
          "speaker-id":"http://CUBISM/api/1.0/speakers/2.json",
          "belief":"belief of speaker 2 about topic a",
          "viewpoints":[
            {
              "speaker-id":"http://CUBISM/api/1.0/speakers/3.json",
              "belief":"belief of speaker two about speaker 3's belief about topic A"
            }
          ]
        }
      ]
    }
  ]
}}
```

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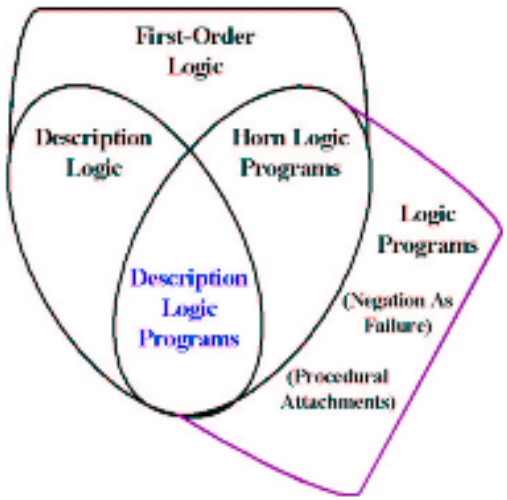
Description Logic



Description Logic
ABox Axioms

ABox axioms capture knowledge about named individuals (facts).

Example

parentOf(Julia,John)
bornIn(John,LA)

```
Declaration( NamedIndividual( :John ) )
Declaration( NamedIndividual( :Julia ) )
Declaration( NamedIndividual( :LA ) )
Declaration( ObjectProperty( :parentOf ) )
Declaration( ObjectProperty( :bornIn ) )

ObjectPropertyAssertion( :parentOf :Julia :John )
ObjectPropertyAssertion( :bornIn :John :LA )
```

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Description Logic

TBox Axioms

TBox axioms describe relationships between concepts (rules).

Example

$\mathsf{Man}(x) \wedge \mathsf{hasBrother}(x, y) \wedge \mathsf{hasChild}(y, z) \rightarrow \mathsf{Uncle}(x)$

$\mathsf{Man} \sqcap \exists \mathsf{hasBrother}.\exists \mathsf{hasChild}.\top \sqsubseteq \mathsf{Uncle}$

```
Declaration( Class( :Man ) )
Declaration( Class( :Uncle ) )
Declaration( ObjectProperty( :hasBrother ) )
Declaration( ObjectProperty( :hasChild ) )

SubClassOf(
  ObjectIntersectionOf(
    :Man
    ObjectSomeValuesFrom(
      :hasBrother
      ObjectSomeValuesFrom(
        :hasChild
        owl:Thing
      )
    )
  )
  :Uncle
)
```

Description Logic
SWRL Rules

```
Person(?x), hasParent(?x, ?y), hasParent(?x, ?z), hasSpouse(?y, ?z) ->
      ChildOfMarriedParents(?x)
```

SWRL can be used to model such rules. It supports general *Horn rules*:

```
hasParent(?x1,?x2), hasBrother(?x2,?x3) -> hasUncle(?x1,?x3)
Student(?x1) -> Person(?x1)
Artist(?x), artistStyle(?x,?y), Style(?y), creator(?z,?x) -> style/period(?z,?y)
Artist(?x), (<=1 artistStyle)(?x), creator(?z,?x) -> (<=1 style/period)(?z)
```

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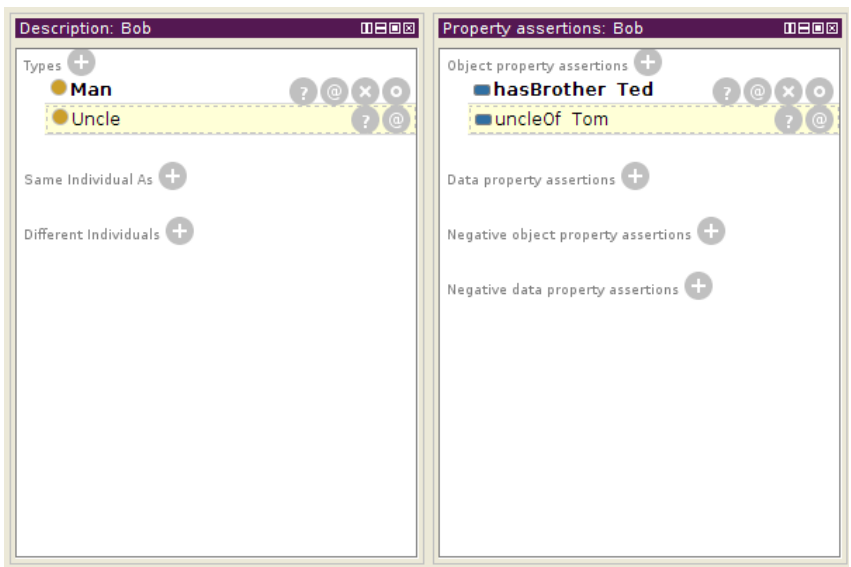
The HermiT Reasoner

- HermiT is a reasoner for ontologies written in OWL.
- ABox assertions:

```
Man(Bob), Man(Ted), Man(Tom),
hasBrother(Bob, Ted), hasChild(Ted, Tom)
```

- DL Rule:

  $\text{Man} \sqcap \exists \text{hasBrother}.\exists \text{hasChild}.\top \sqsubseteq \text{uncleOf}$



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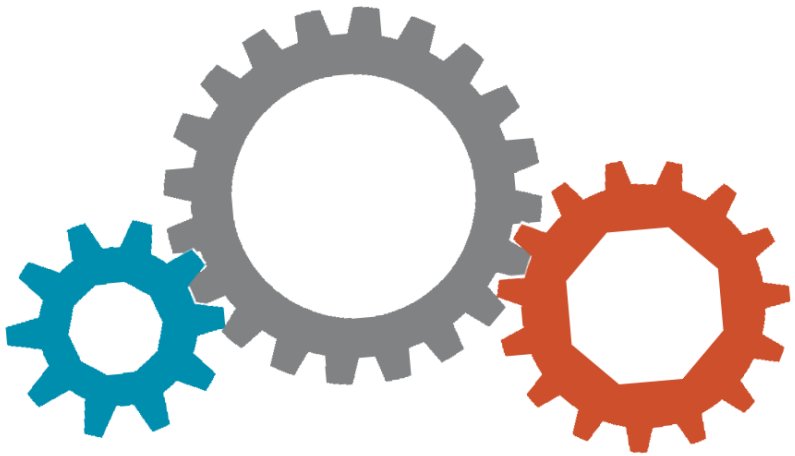
Implementation Overview



String-Based Implementation

- $\text{Man}(x) \wedge \text{hasBrother}(x, y) \wedge \text{hasChild}(y, z) \rightarrow \text{Uncle}(x)$
  $\text{Man} \sqcap \exists \text{hasBrother}.\exists \text{hasChild}.\top \sqsubseteq \text{Uncle}$

Table: DL Axioms

propId	**axiom**
1	SubClassOf(ObjectIntersectionOf(:Man ObjectSomeValuesFrom(:hasBrother ObjectSomeValuesFrom(:hasChild owl:Thing))) :Uncle)

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Triple-Based Implementation

- $\text{Man}(x) \wedge \text{hasBrother}(x, y) \wedge \text{hasChild}(y, z) \rightarrow \text{Uncle}(x)$
  $\text{Man} \sqcap \exists \text{hasBrother}.\exists \text{hasChild}.\top \sqsubseteq \text{Uncle}$

Table: DL Axioms

propId	axiom	x	y	z
1	someValuesFrom	t1	hasChild	OWL:Thing
1	someValuesFrom	t2	hasBrother	t1
1	classIntersection	t3	Man	t2
1	subClassOf	t3	Uncle	null

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Belief Modeling

```
Env (id INT,
    parent_id INT REFERENCES Env(id),
    label TEXT);

Axioms (id INT, type INT,
      x INT, y INT, z INT);

Axioms (id INT, label TEXT);

Beliefs (believer INT REFERENCES Env(id),
       belief INT REFERENCES Axioms(id));
```

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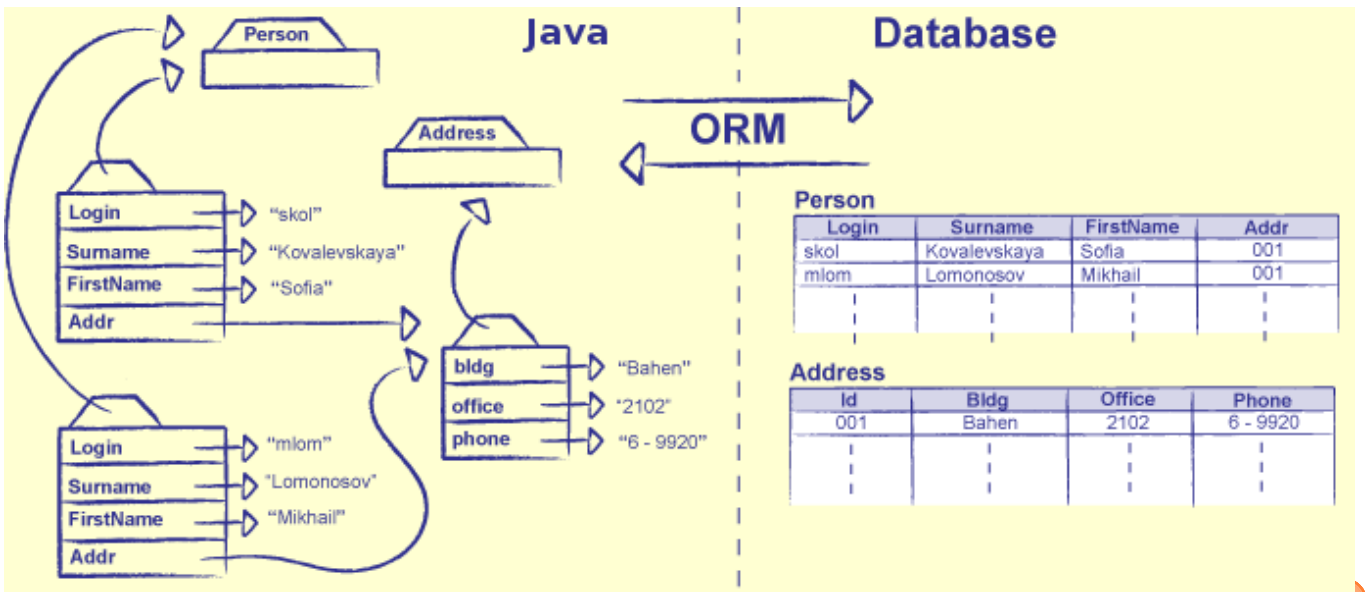
Object-Relational Mapping (ORM)

- Object-relational mapping maps database rows directly to OOP objects.
- The ORM libraries manage SQL queries that implement the mapping.



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ORM-Based Architecture

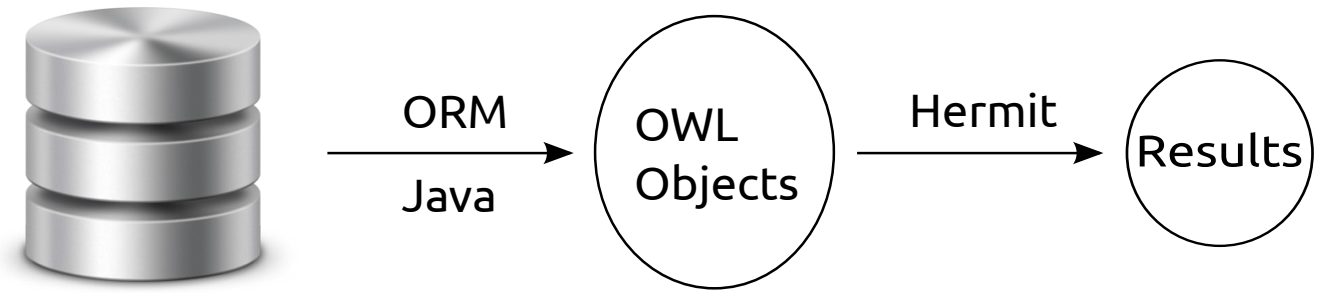

Figure: ORM-Based Architecture

Evaluation

- String-Based implementation:
  - Easy to implement;
  - More generalizable;
  - Hard to query; need external parsers.
- Triple-Based implementation:
  - Support more queries;
  - Not convenient for complex rules.

Questions?

Thank you!

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