Représentation des connaissances et raisonnement

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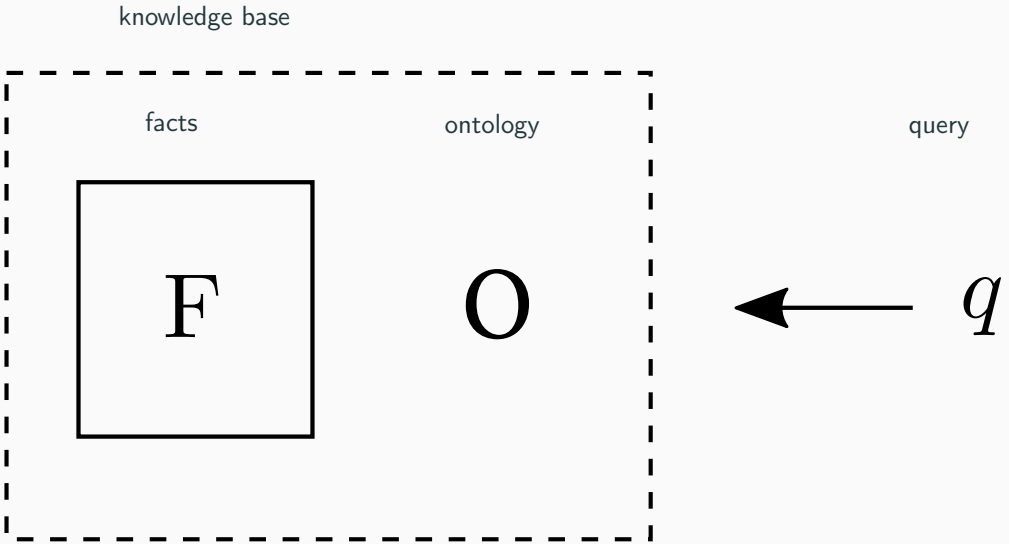
Ontology-based Query Answering Problem



Query Answering on an Example

Facts

$Human(Alice)$

$ParentOf(Bob, Alice)$

Ontology

$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$

$Human(x) \rightarrow \exists z \; ParentOf(z, x)$

Query

$Human(Bob)$?

Query Answering on an Example

Facts	**Ontology**	**Query**
$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$Human(Bob)$?
$ParentOf(Bob, Alice)$	$Human(x) \rightarrow \exists z \; ParentOf(z, x)$	

Query Answering on an Example

Facts	**Ontology**	**Query**
$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$\exists u\ ParentOf(u, Bob)$?
$ParentOf(Bob, Alice)$	$Human(x) \rightarrow \exists z\ ParentOf(z, x)$	

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$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$

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Query

$\exists u\ ParentOf(u, u)$?

Conjunctive Query Answering using Existential Rules

An **existential rule** is a FOL formula:

$$\forall \bar{x}\ \forall \bar{y}\ B(\bar{x}, \bar{y}) \rightarrow \exists \bar{z}\ H(\bar{x}, \bar{z})$$

where B and H are conjunctions of atoms

An undecidable problem

- F a set of relationnal facts
- $\mathcal{R}$ a set of existential rules
- q a conjunctive query

$$F, \mathcal{R} \text{ entails } q \ ?$$

Conjunctive Query Answering using Existential Rules

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What are the class of rule sets for which QA is always decidable ?

Decidable Query Answering: Materialization-based Approach

Saturation of facts

Facts	**Rules**	**Query**
$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$Human(Bob)$?
$ParentOf(Bob, Alice)$	$Human(x) \rightarrow \exists z\ ParentOf(z, x)$	
$Human(Bob)$		

Decidable Query Answering: Materialization-based Approach

Saturation of facts

Facts	**Rules**	**Query**
$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$\exists u\ ParentOf(u, Bob)$?
$ParentOf(Bob, Alice)$	$Human(x) \rightarrow \exists z\ ParentOf(z, x)$	
$Human(Bob)$		
$ParentOf(n_0, Bob)$		

Decidable Query Answering: Materialization-based Approach

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$Human(Bob)$		
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$\ldots$		

Decidable Query Answering: Materialization-based Approach

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$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$\exists u\ ParentOf(u, u)$?
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$ParentOf(n_0, Bob)$		
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...		

We can decide the query answering problem if the saturation is finite.

Decidable Query Answering: Query Rewriting Approach

Rewriting of the query

Facts	**Rules**	**Query**
$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$Human(Bob)$
$ParentOf(Bob, Alice)$		?

Decidable Query Answering: Query Rewriting Approach

Rewriting of the query

Facts	**Rules**	**Query**
$Human(Alice)$	$Human(x) \wedge ParentOf(y, x) \rightarrow Human(y)$	$Human(Bob)$
$ParentOf(Bob, Alice)$		$\vee \exists x\ Human(x) \wedge ParentOf(Bob, x)$
		?

Decidable Query Answering: Query Rewriting Approach

Rewriting of the query

Facts	**Rules**	**Query**
$Human(Alice)$ $ParentOf(Bob, Alice)$	$AncestorOf(x, y) \wedge ParentOf(y, z) \rightarrow AncestorOf(x, z)$	$\exists u\ AncestorOf(u, Bob)$?

Decidable Query Answering: Query Rewriting Approach

Rewriting of the query

Facts

$Human(Alice)$

$ParentOf(Bob, Alice)$

Rules

$AncestorOf(x, y) \wedge ParentOf(y, z) \rightarrow AncestorOf(x, z)$

Query

$\exists u\ AncestorOf(u, Bob)$
$\vee\ \exists u, y\ AncestorOf(u, y) \wedge ParentOf(y, Bob)$?

Decidable Query Answering: Query Rewriting Approach

Rewriting of the query

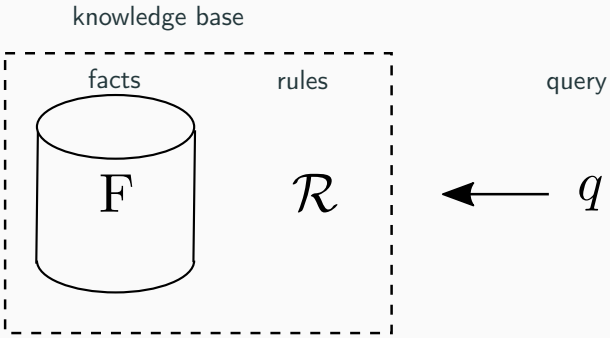
Facts	**Rules**	**Query**
$Human(Alice)$ $ParentOf(Bob, Alice)$	$AncestorOf(x, y) \wedge ParentOf(y, z) \rightarrow AncestorOf(x, z)$	$\exists u\ AncestorOf(u, Bob)$ $\vee\ \exists u, y\ AncestorOf(u, y) \wedge ParentOf(y, Bob)$ $\vee\ \exists u, y, y'\ AncestorOf(u, y') \wedge ParentOf(y', y) \wedge ParentOf(y, Bob) \ldots$?

We can decide the query answering problem if the query rewriting is finite.

Rule Sets with Decidable Query Answering

- Finite saturation rule set : Datalog
- Finite rewriting rule set : DL_{lite}
- Bounded tree width rule set : most of the DLs

In Practice: Ontology-based Data Management



Materialization-based approach

- Time and stockage for saturation
- Good query time
- Updates require a saturation maintenance

Query rewriting approach

- Query rewriting may be large
- Updates for free

Current Research Topics

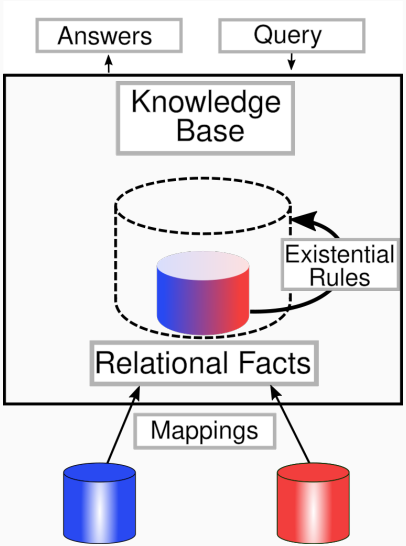
Handling infinite saturation

- Take advantage of regularity of saturation
- Create a finite representation of the infinite saturation

Pruning infinite rewriting

- Take advantage of the facts at hand
- Avoid unnecessary rewriting steps

Ontology-Based Data Access



- Integrating the facts coming from heterogeneous sources through mappings
- Use ontologies to manage the semantic heterogeneity
- Mediation-based approach :
  1. query rewriting with the rules and mappings
  2. evaluation using mediator engine