



OBDA: Theory and Practice

Ian Horrocks
Information Systems Group

What is an Ontology?



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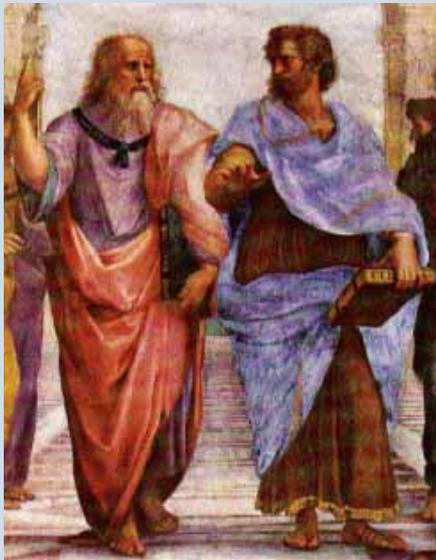
Optique



What is an Ontology?

A fundamental branch of **metaphysics**

- Studies “being” or “existence” and their **basic categories**
- Aims to find out what **entities** and **types of entities** exist



Supreme genus:

Differentiae:

Subordinate genera:

Differentiae:

Subordinate genera:

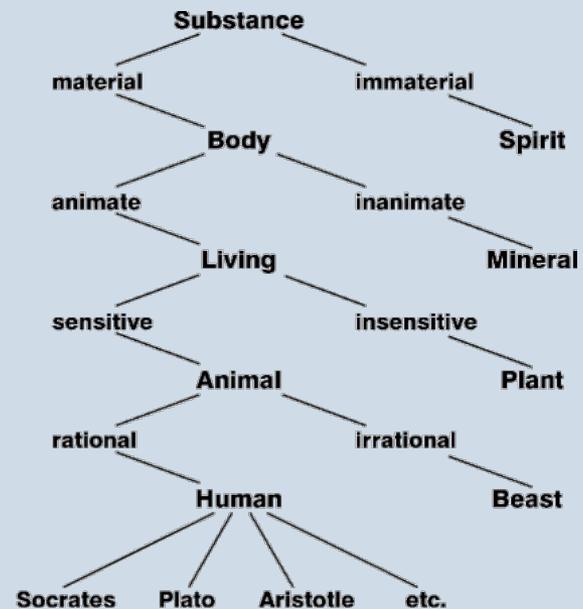
Differentiae:

Proximate genera:

Differentiae:

Species:

Individuals:



What is an Ontology?

A conceptual model of (some aspect of) the world



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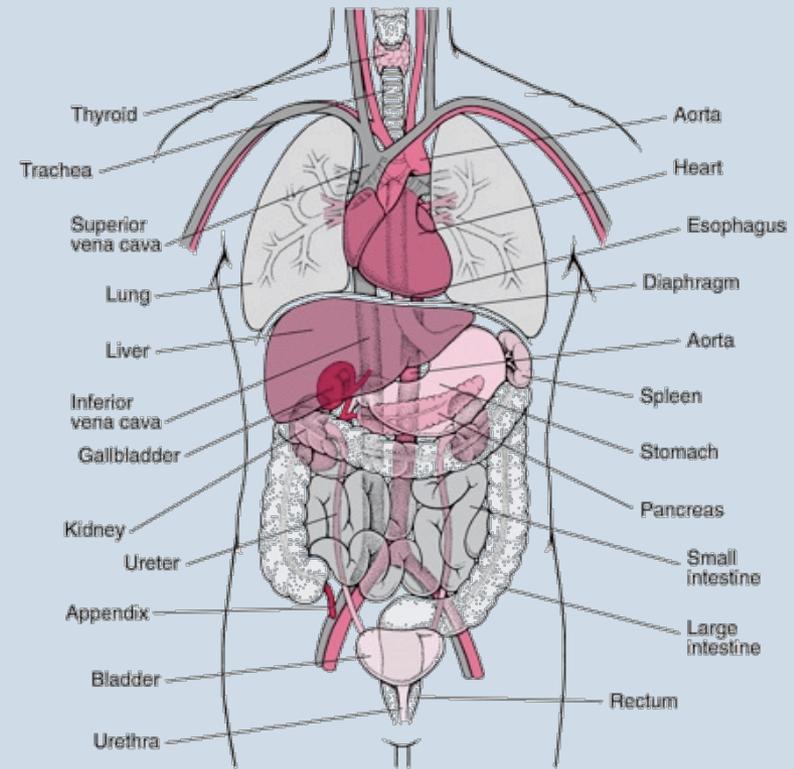
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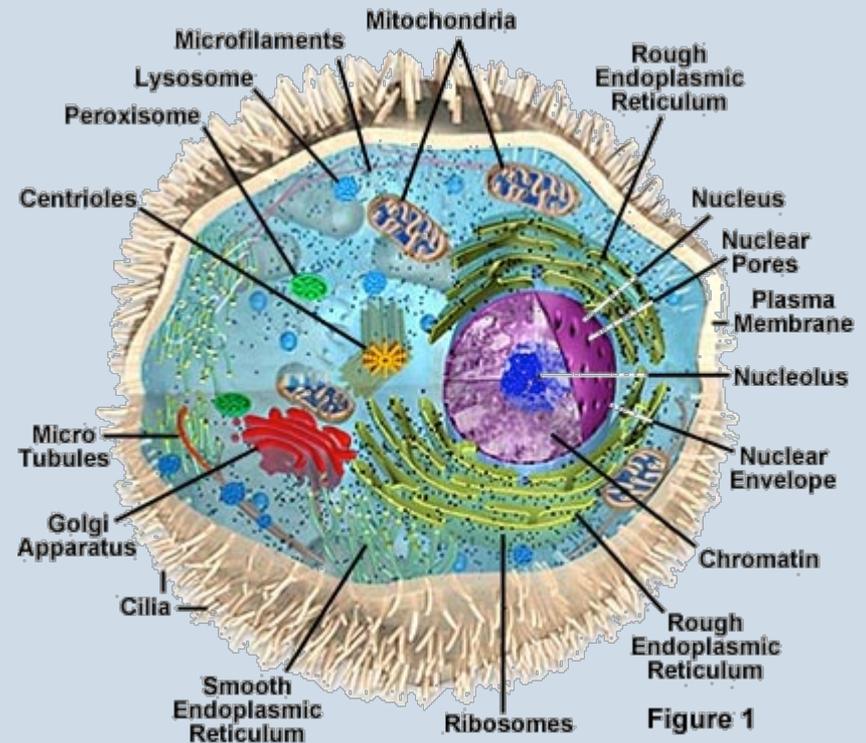
- Introduces **vocabulary** relevant to domain, e.g.:
 - Anatomy



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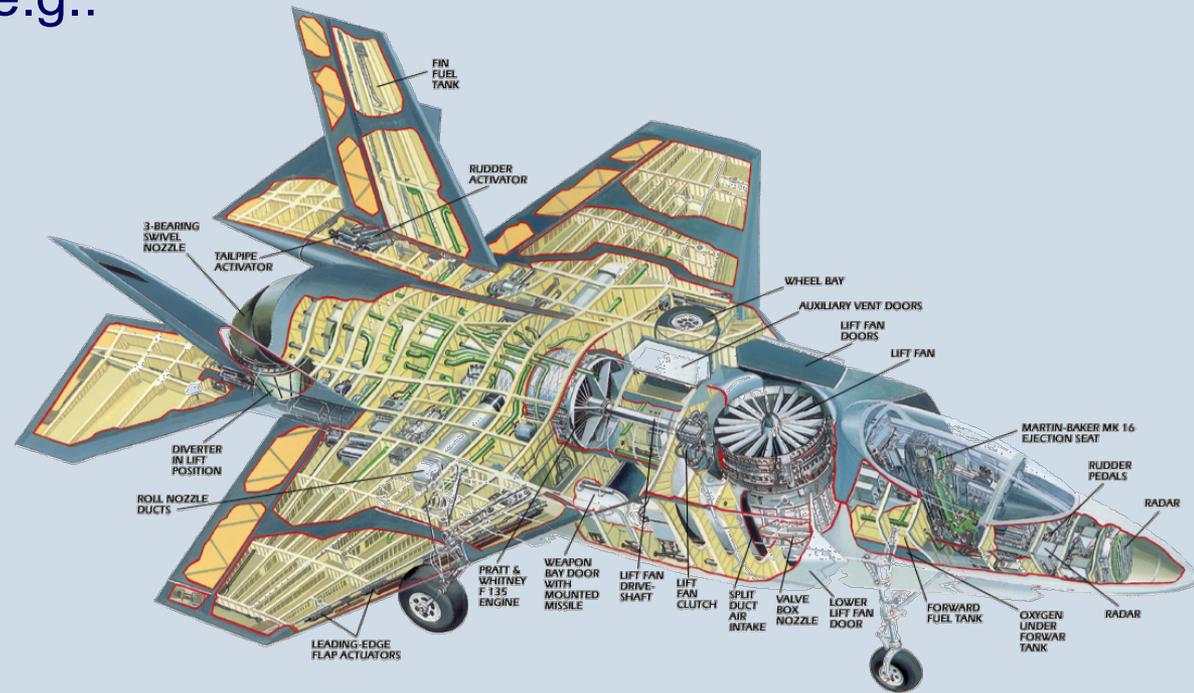
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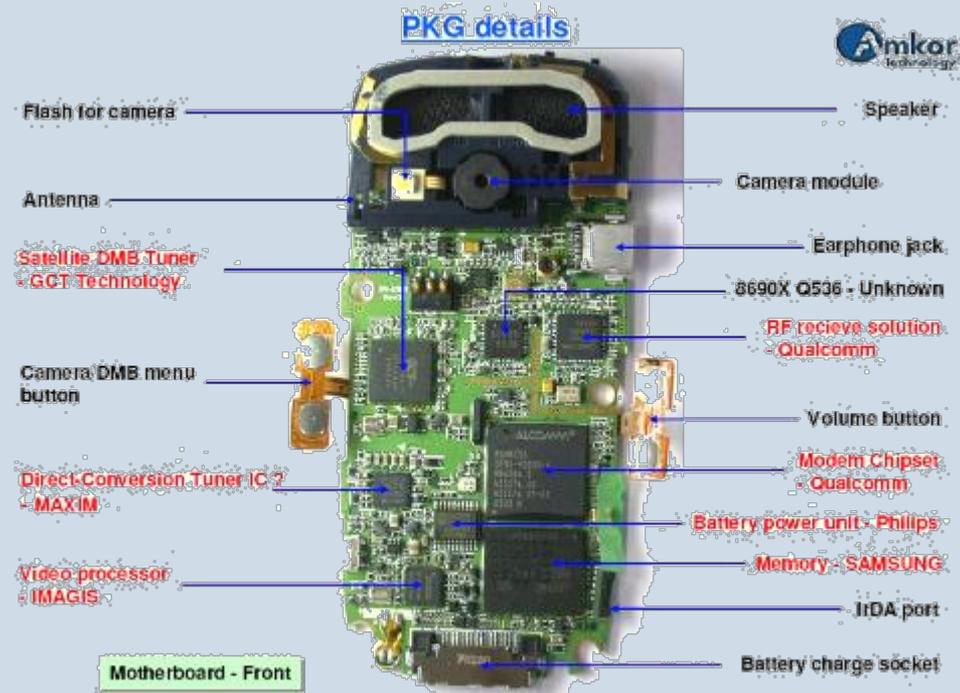
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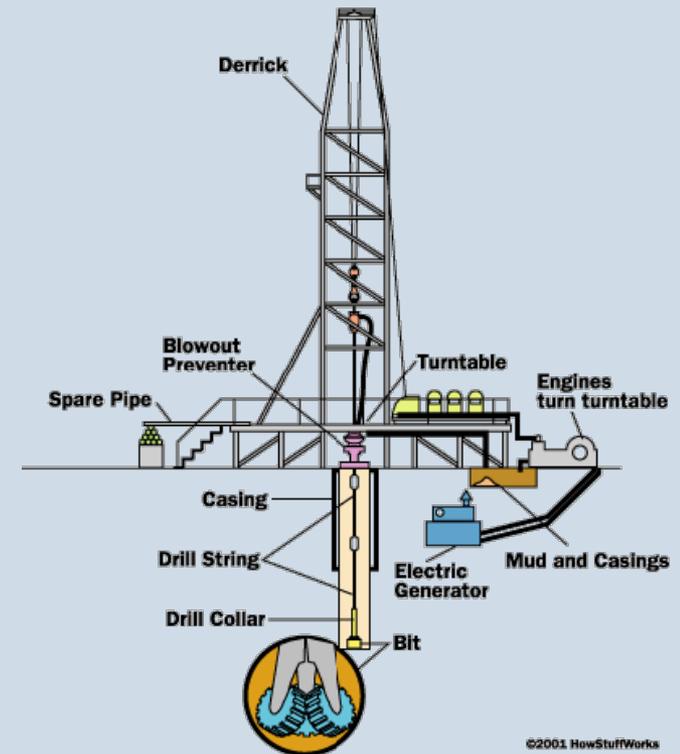
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What is an Ontology?

A conceptual model of (some aspect of) the world

- Introduces **vocabulary** relevant to domain, e.g.:
 - Anatomy
 - Cellular biology
 - Aerospace
 - Cell Phones
 - Oil and gas

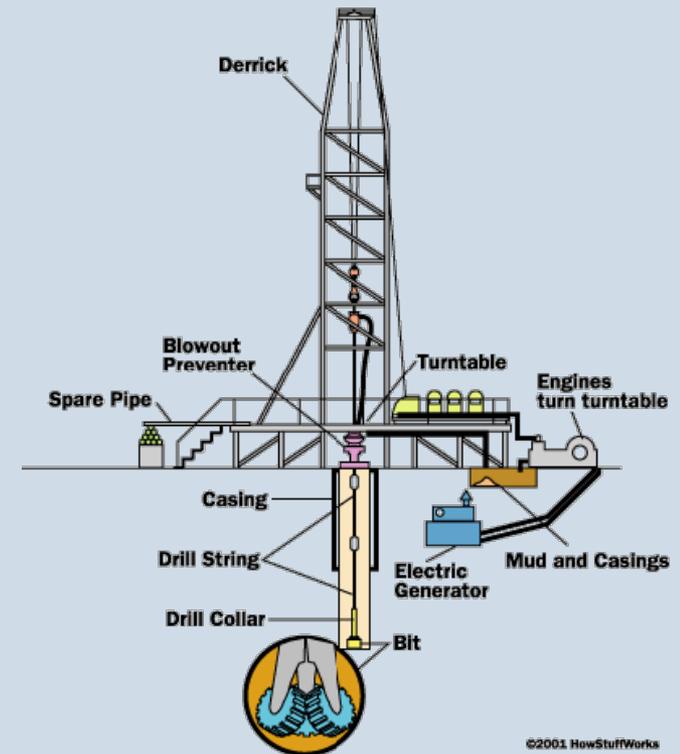


What is an Ontology?

A conceptual model of (some aspect of) the world

- Introduces **vocabulary** relevant to domain
- Specifies **meaning** (semantics) of terms

Oil pipeline is a pipeline from a facility that is an oil facility



What is an Ontology?

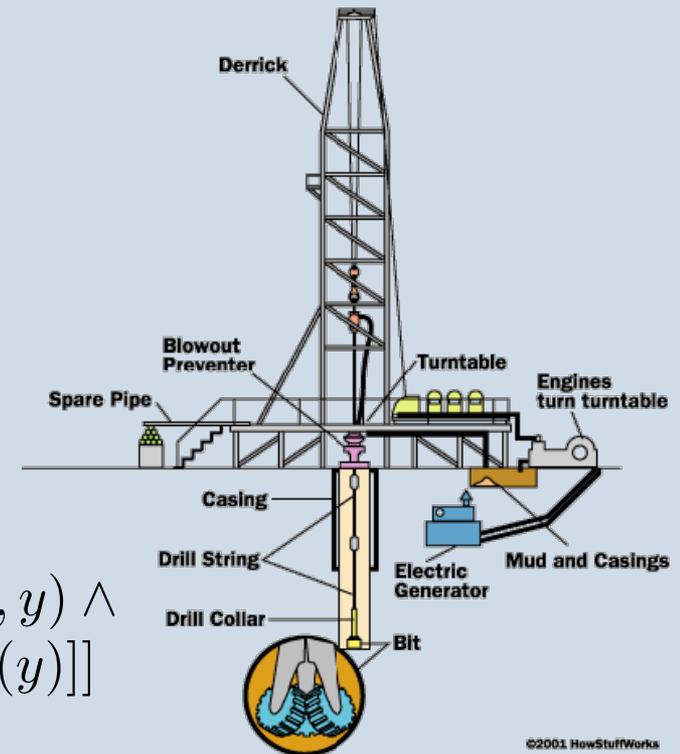
A conceptual model of (some aspect of) the world

- Introduces **vocabulary** relevant to domain
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Oil pipeline is a pipeline from a facility that is an oil facility

- **Formalised** using suitable logic

$$\forall x. [\text{OilPipeline}(x) \rightarrow \text{Pipeline}(x) \wedge \exists y. [\text{fromFacility}(x, y) \wedge \text{OilFacility}(y)]]]$$



What is an Ontology?

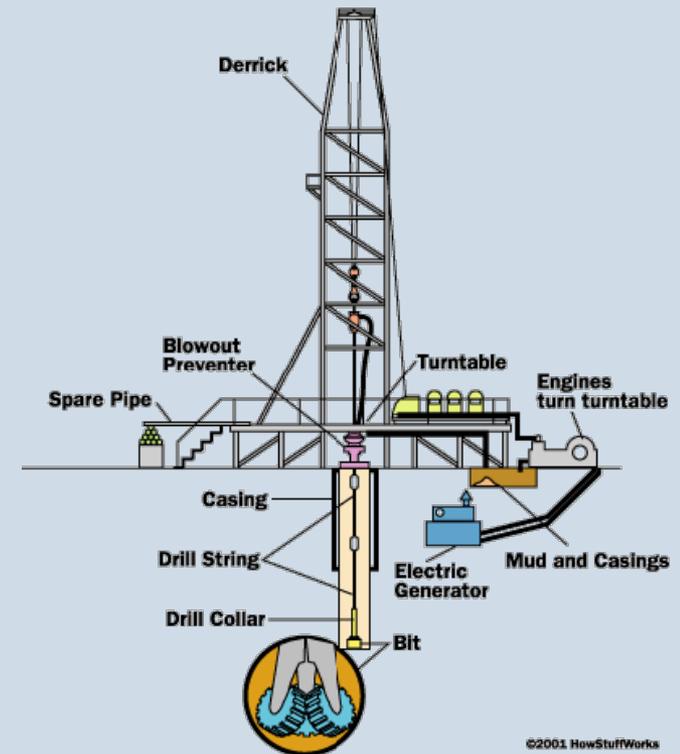
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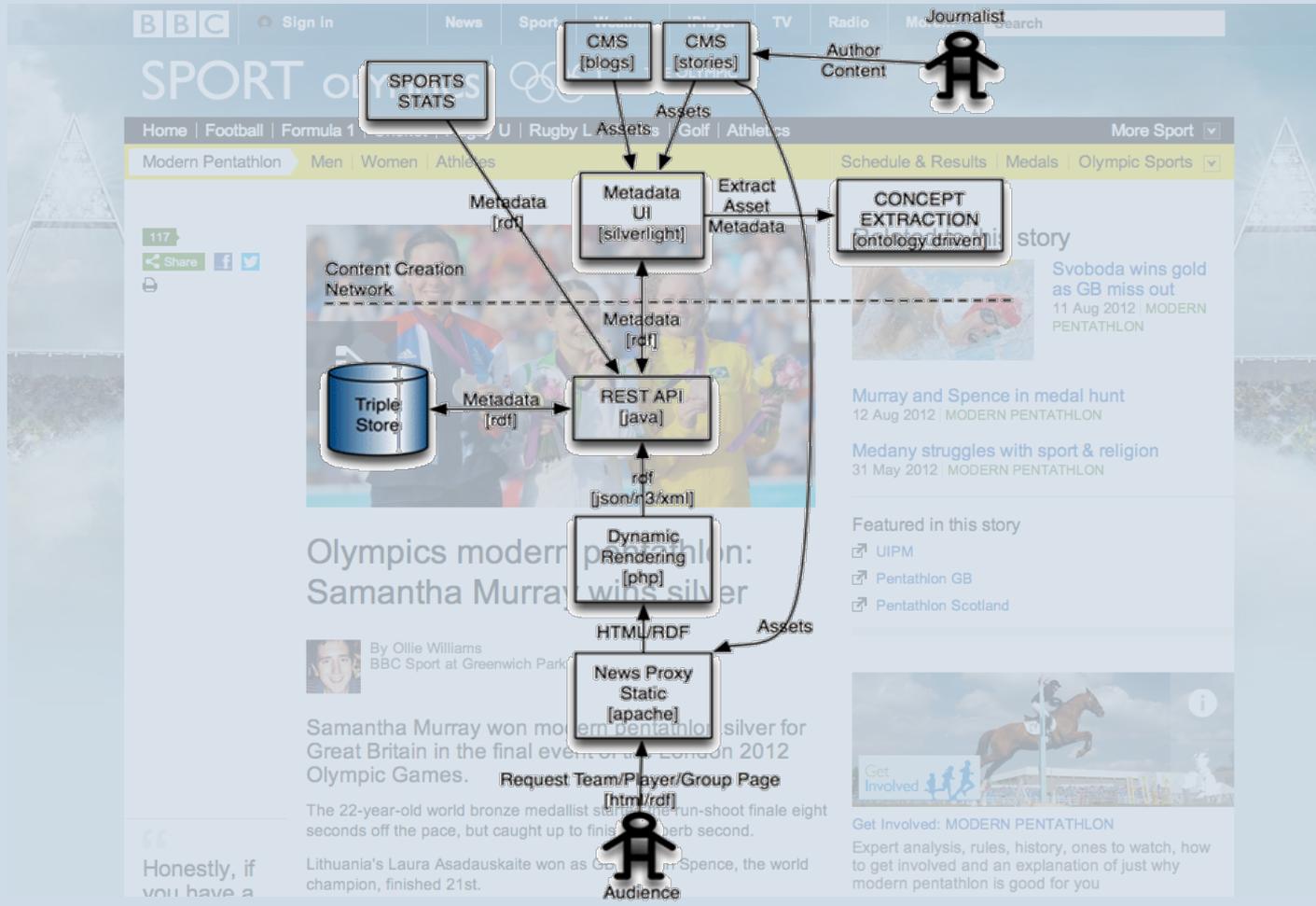
OilPipeline \sqsubseteq Pipeline \sqcap
 \exists fromFacility.OilFacility



Applications: Semantic Web

The screenshot shows the BBC Sport Olympics website. The top navigation bar includes 'Sign in', 'News', 'Sport', 'Weather', 'iPlayer', 'TV', 'Radio', 'More...', and a search box. The main header features 'SPORT OLYMPICS' and 'THE OLYMPIC BROADCASTER' with the Olympic rings logo. A secondary navigation bar lists sports: 'Home | Football | Formula 1 | Cricket | Rugby U | Rugby L | Tennis | Golf | Athletics'. A yellow bar highlights 'Modern Pentathlon' with sub-links for 'Men | Women | Athletes', and 'Schedule & Results | Medals | Olympic Sports'. The main article is titled 'Olympics modern pentathlon: Samantha Murray wins silver'. It includes a photo of three athletes on a podium, a video player, and a share button. The author is Ollie Williams. A quote from the article reads: 'Honestly, if you have a...'. The article text states: 'Samantha Murray won modern pentathlon silver for Great Britain in the final event of the London 2012 Olympic Games. The 22-year-old world bronze medalist started the run-shoot finale eight seconds off the pace, but caught up to finish a superb second. Lithuania's Laura Asadauskaite won as GB's Mhairi Spence, the world champion, finished 21st.' To the right, a 'Related to this story' section lists: 'Svoboda wins gold as GB miss out' (11 Aug 2012), 'Murray and Spence in medal hunt' (12 Aug 2012), and 'Medany struggles with sport & religion' (31 May 2012). A 'Featured in this story' section lists 'UIPM', 'Pentathlon GB', and 'Pentathlon Scotland'. At the bottom right, there is a 'Get Involved: MODERN PENTATHLON' section with a video player and text: 'Expert analysis, rules, history, ones to watch, how to get involved and an explanation of just why modern pentathlon is good for you'.

Applications: Semantic Web



Semantic Technologies

- SemWeb motivated development of **robust infrastructure**:

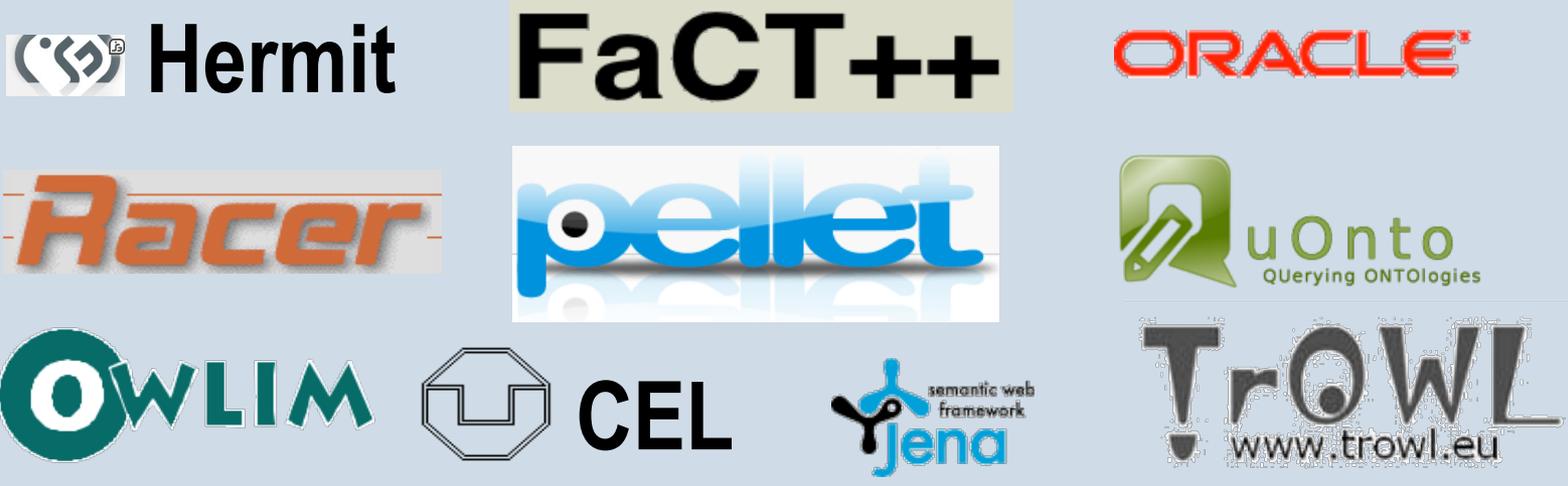
Semantic Technologies

- SemWeb motivated development of **robust infrastructure**:
 - Languages



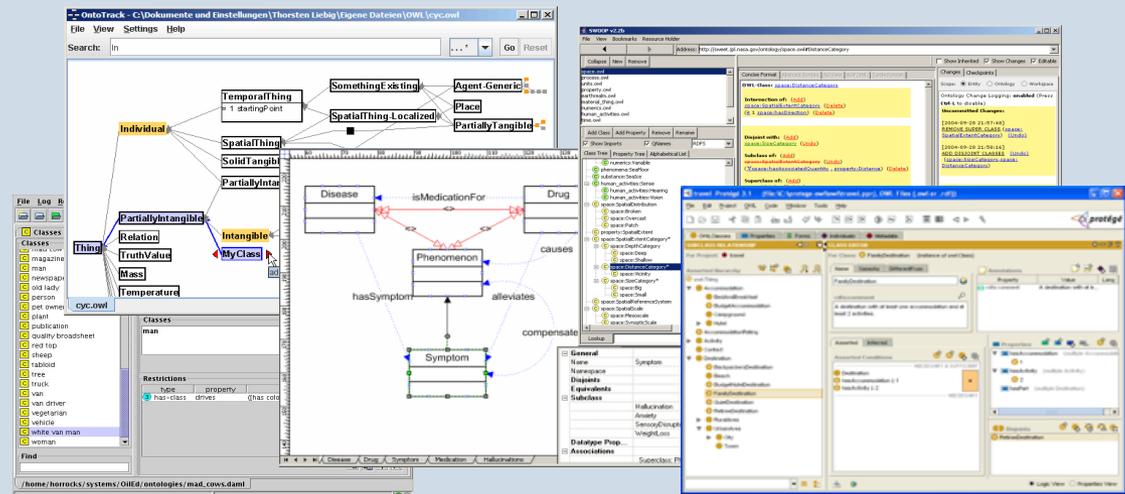
Semantic Technologies

- SemWeb motivated development of **robust infrastructure**:
 - Languages
 - Storage and querying



Semantic Technologies

- SemWeb motivated development of **robust infrastructure**:
 - Languages
 - Storage and querying
 - Development tools



Semantic Technologies

- SemWeb motivated development of **robust infrastructure**:
 - Languages
 - Storage and querying
 - Development tools
- Increasingly used in “Intelligent Information Systems”, and in particular **Ontology Based Data Access (OBDA)**



Applications: HCLS

- **OBO foundry** includes more than 100 biological and biomedical ontologies
- **Siemens** “actively building OWL based clinical solutions”
- **SNOMED-CT** (Clinical Terms) ontology
 - used in healthcare systems of more than 15 countries, including Australia, Canada, Denmark, Spain, Sweden and the UK
 - also used by major US providers, e.g., Kaiser Permanente
 - ontology provides common vocabulary for recording clinical data

Applications: Energy Supply Industry

- **EDF Energy** offer personalised energy saving advice to every customer
- **OWL ontology** used to model relevant environmental factors
- **Oxford's Hermit reasoner** used to match customer circumstances with relevant pieces of advice



Applications: Intelligent Mobile Platform

- **Samsung** developing Intelligent Mobile Platform to support context-aware applications
- IMP monitors environment via **sensor data** (GPS, compass, accelerometer, ...)
- **OWL ontology** used to model environment and **infer context** (e.g., coffee with friends)
- Applications exploit context to enable more **intelligent behaviour**



Applications: **OBDA**



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Applications: **OBDA**



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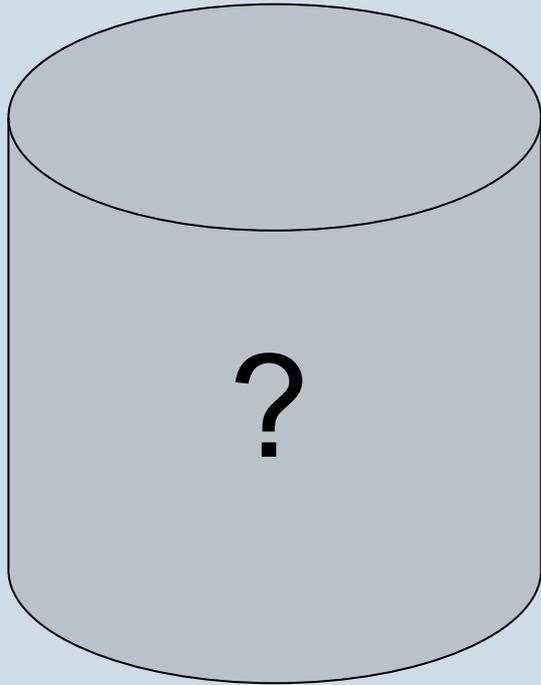


Applications: OBDA

Pipelines from
oil facilities?



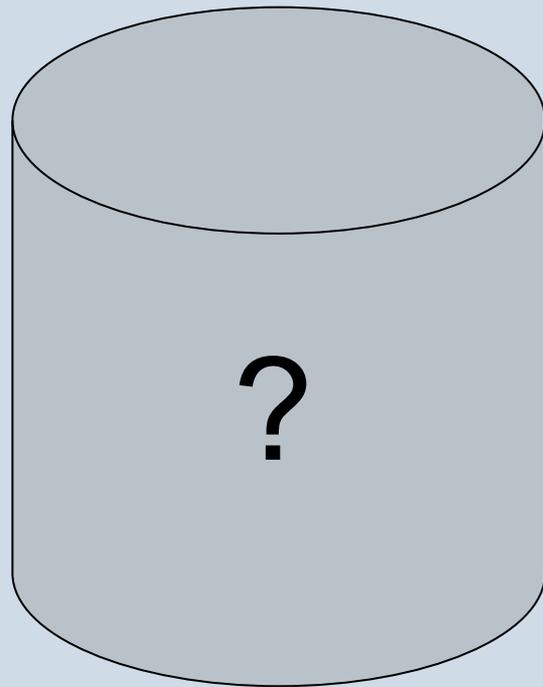
Applications: **OBDA**



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Applications: OBDA

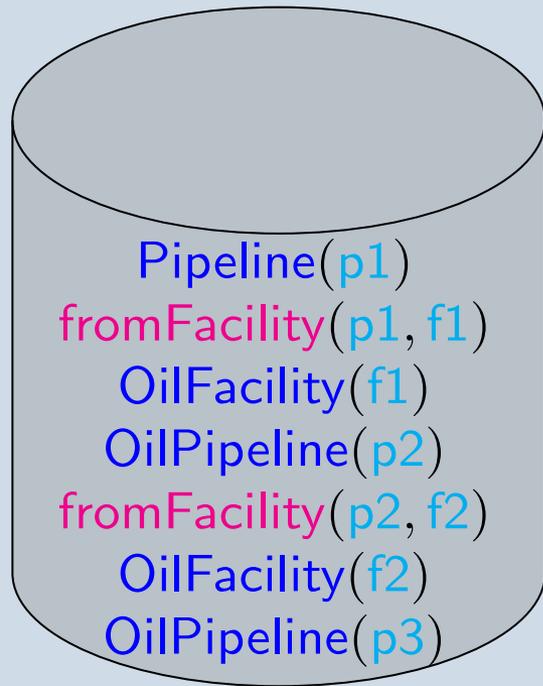


Pipelines from
oil facilities?



$Q(x) \leftarrow \text{Pipeline}(x) \wedge$
 $\text{fromFacility}(x, y) \wedge$
 $\text{OilFacility}(y)$

Applications: OBDA



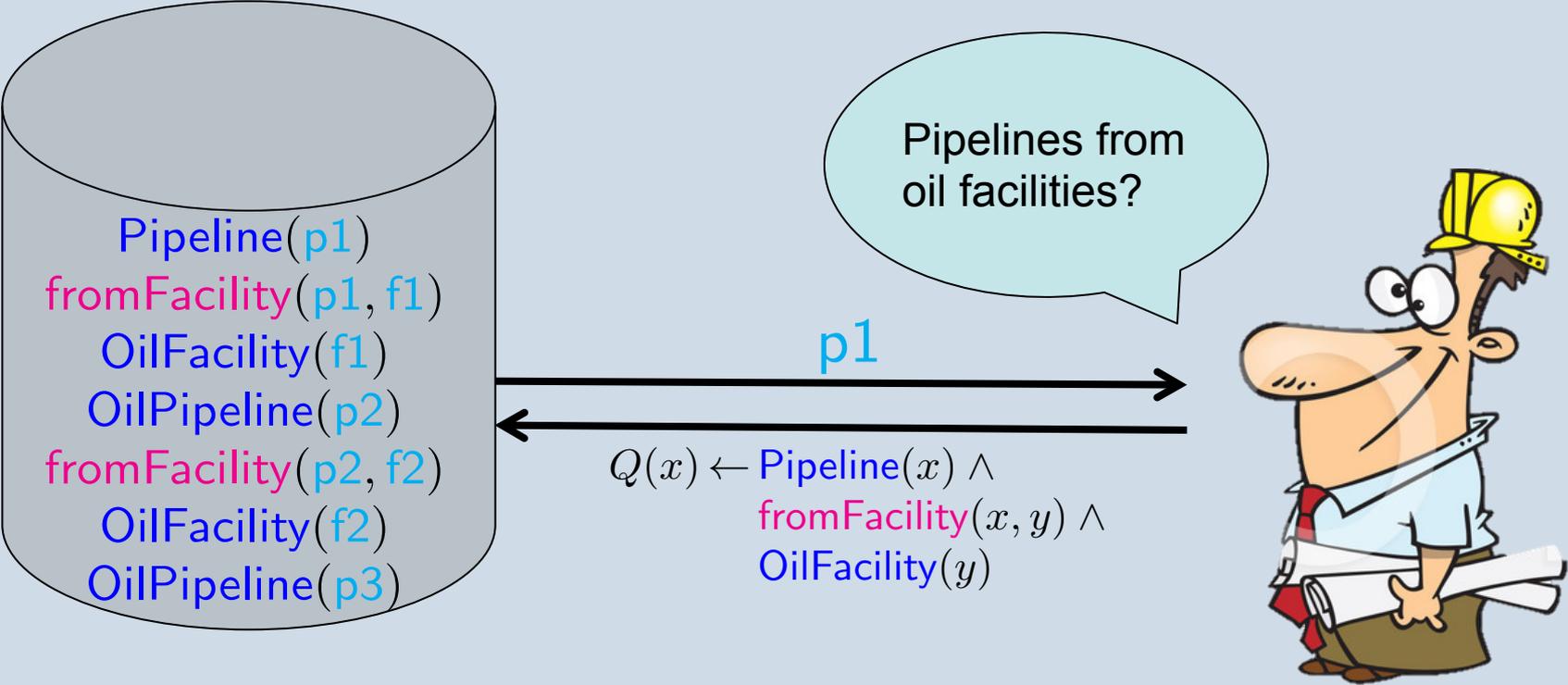
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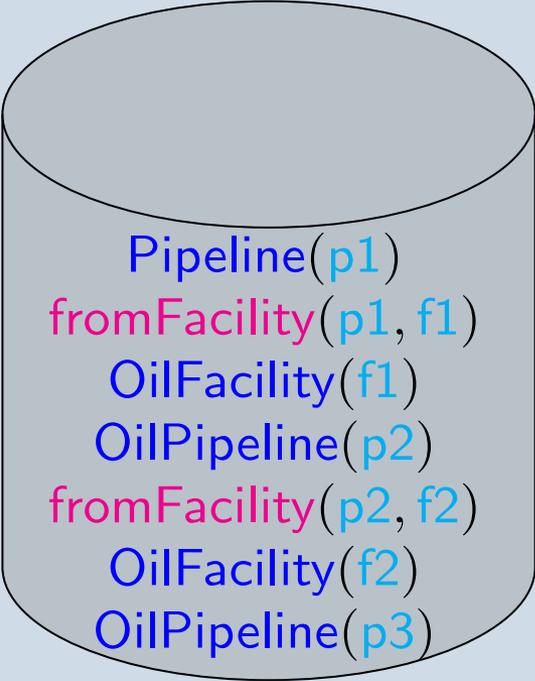
$$Q(x) \leftarrow \text{Pipeline}(x) \wedge \text{fromFacility}(x, y) \wedge \text{OilFacility}(y)$$



Applications: OBDA



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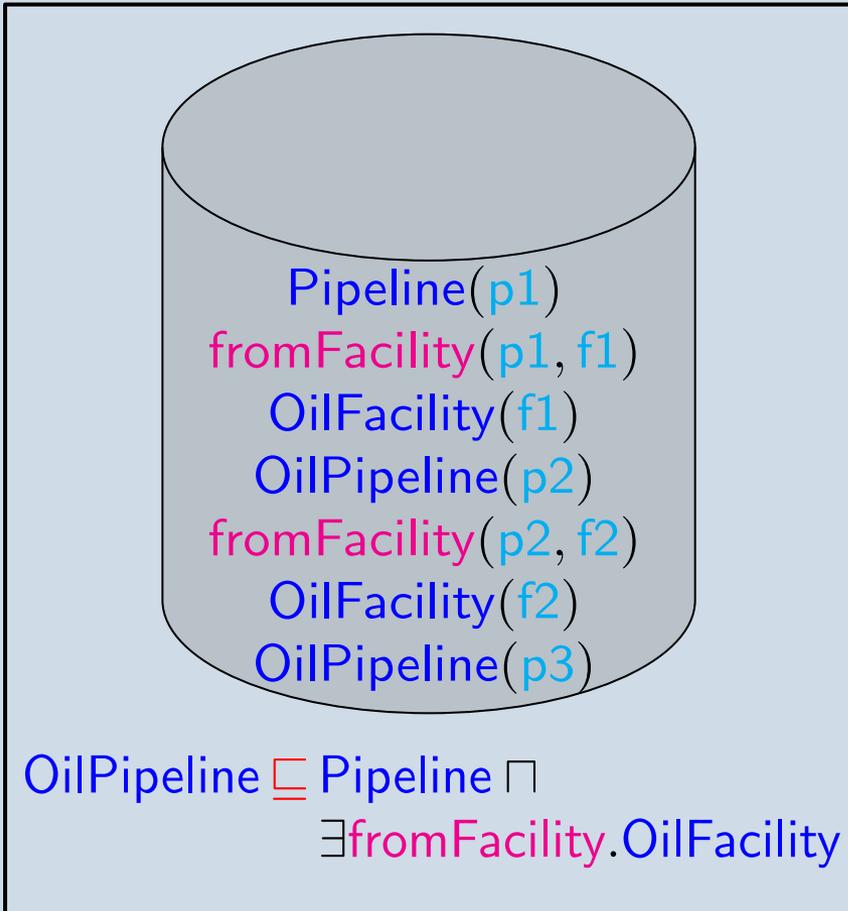
Pipeline(p1)
fromFacility(p1, f1)
OilFacility(f1)
OilPipeline(p2)
fromFacility(p2, f2)
OilFacility(f2)
OilPipeline(p3)

OilPipeline \sqsubseteq Pipeline \sqcap
 \exists fromFacility.OilFacility

Pipelines from
oil facilities?



Applications: OBDA

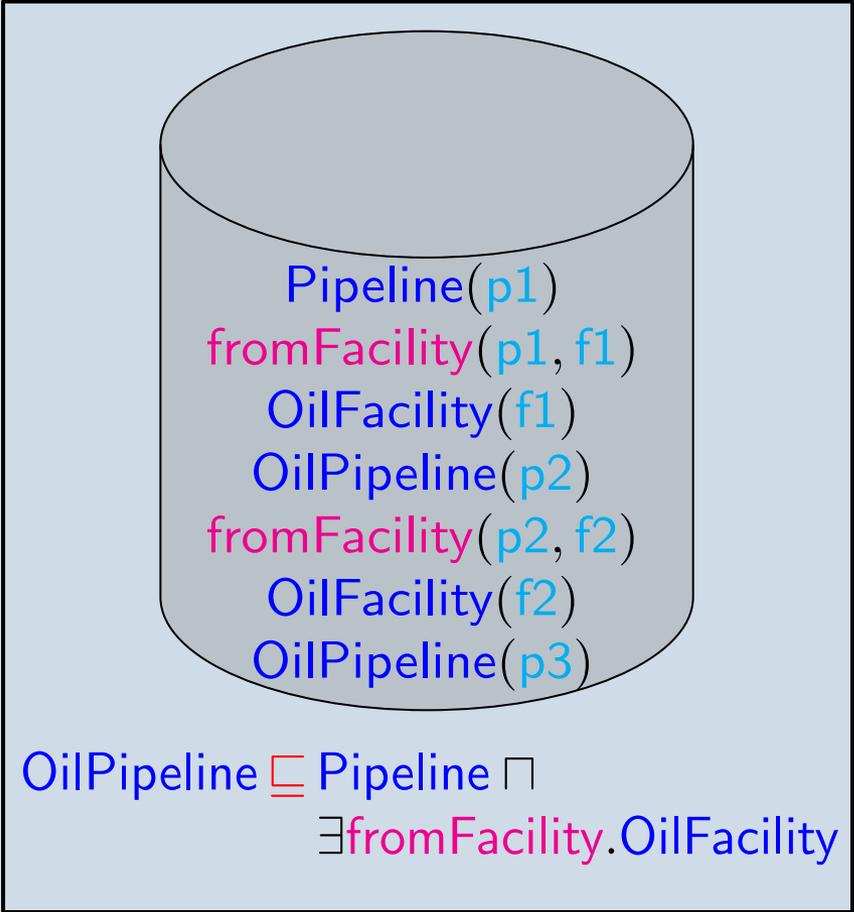


Pipelines from oil facilities?

$$Q(x) \leftarrow \text{Pipeline}(x) \wedge \text{fromFacility}(x, y) \wedge \text{OilFacility}(y)$$



Applications: OBDA



Pipelines from oil facilities?

p1, p2, p3



$$Q(x) \leftarrow \text{Pipeline}(x) \wedge \text{fromFacility}(x, y) \wedge \text{OilFacility}(y)$$



OBDA: Practical Issues

- Scalability is always an issue, particularly when we have **large and heterogeneous data sources**
- Can be a large (startup) cost for **building and maintaining ontologies (and mappings)**
- Users may still have difficulty **formulating queries**



Optique Objectives

- Provide **semantic end-to-end connection** between users and data sources



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- Provide **semantic end-to-end connection** between users and data sources
- Enable users to rapidly formulate **intuitive queries** using familiar vocabularies and conceptualisations

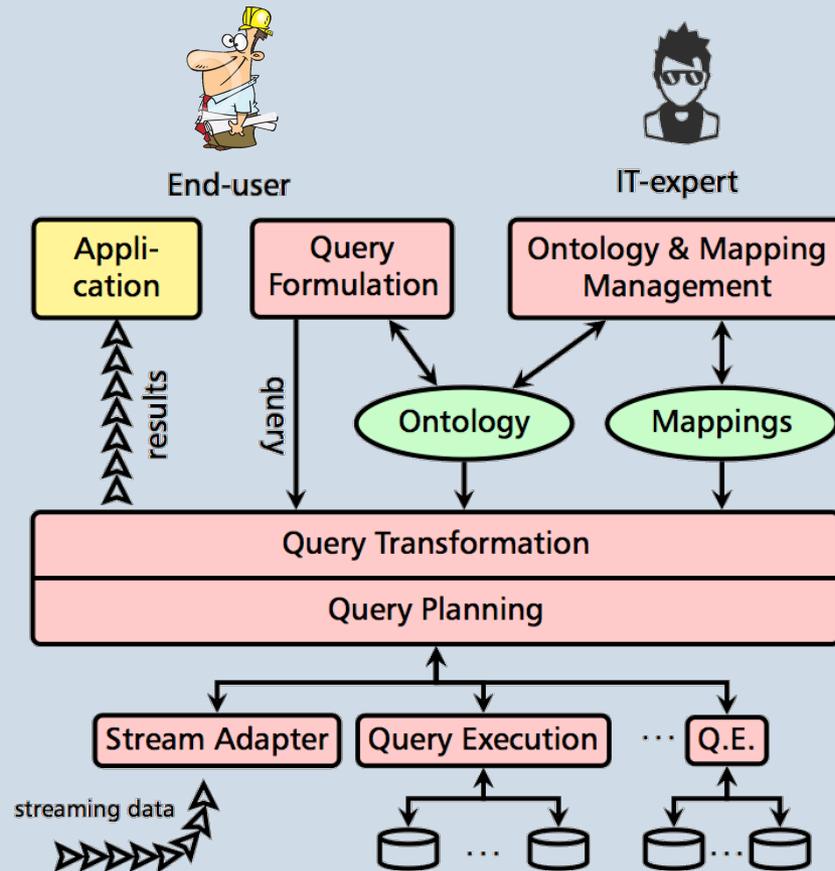


Optique Objectives

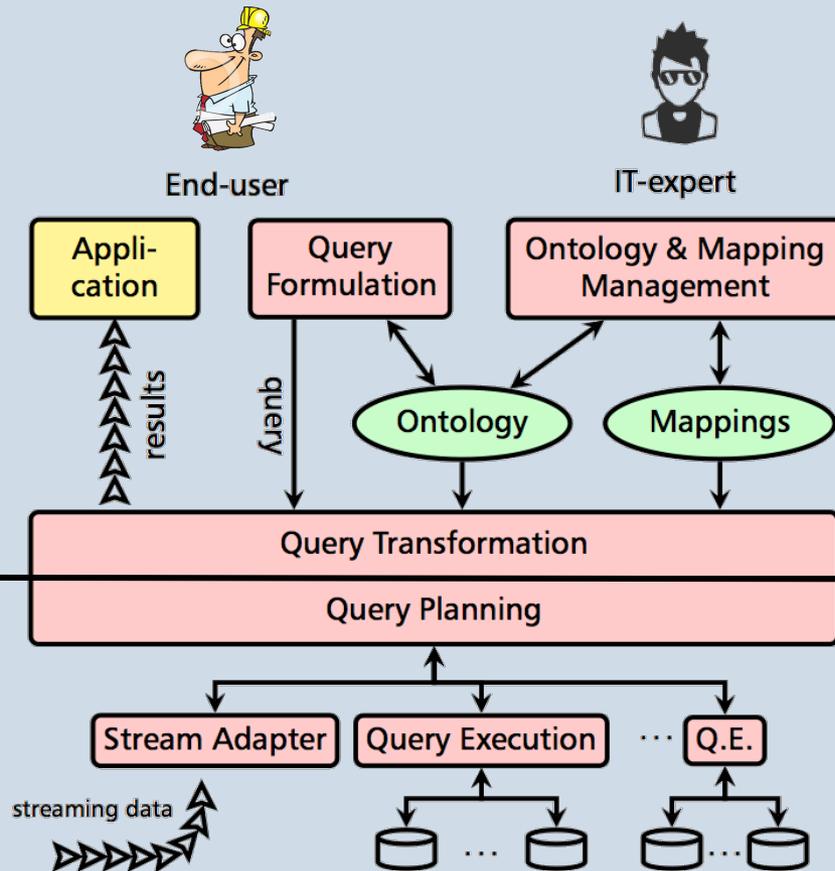
- Provide **semantic end-to-end connection** between users and data sources
- Enable users to rapidly formulate **intuitive queries** using familiar vocabularies and conceptualisations
- Return **timely answers** from large scale and heterogeneous data sources



Optique[™] Solution



Optique[®] Solution

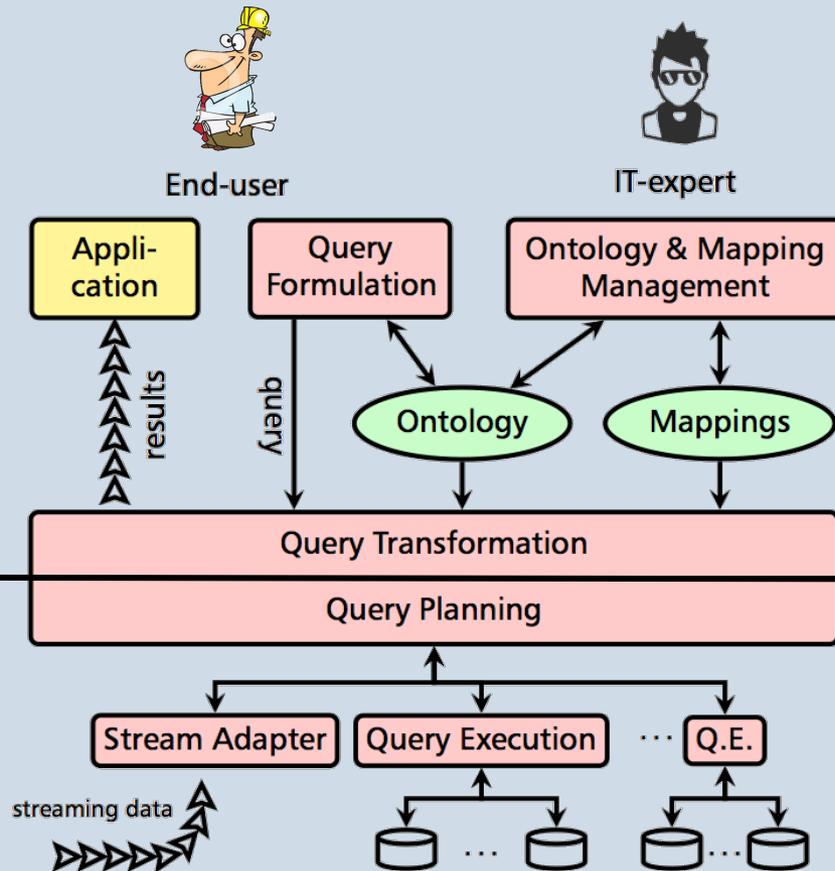


Optique Solution



Query rewriting:

- uses ontology & mappings
- computationally hard
- ontology & mappings small



Optique Solution



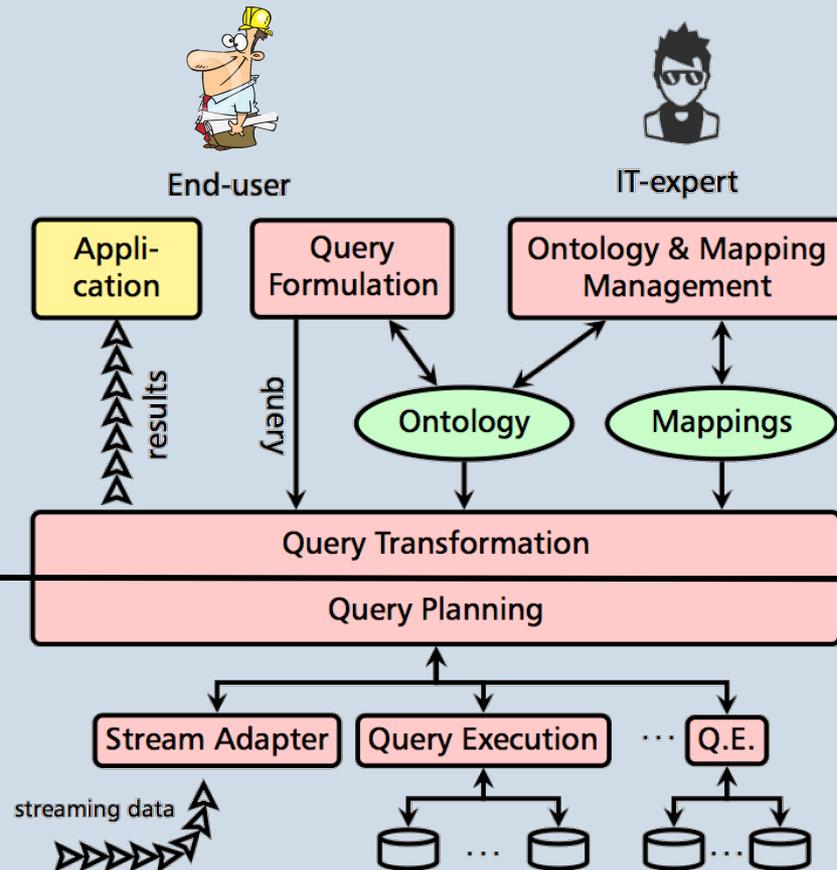
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Query evaluation:

- ind. of ontology & mappings
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Query Rewriting

Given ontology \mathcal{O} query Q and mappings \mathcal{M} :



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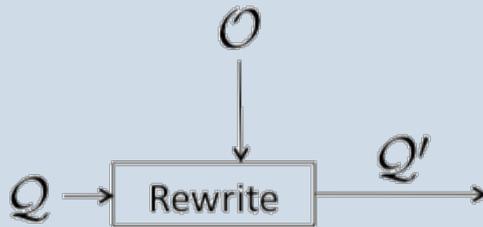
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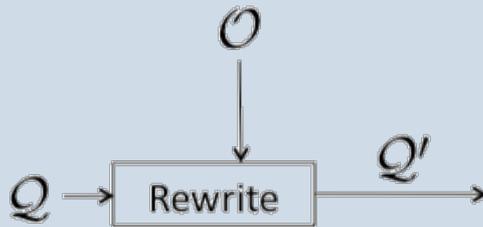
- **Rewrite** $Q \rightarrow Q'$ s.t. answering Q' without \mathcal{O} equivalent to answering Q w.r.t. \mathcal{O} *for any dataset*



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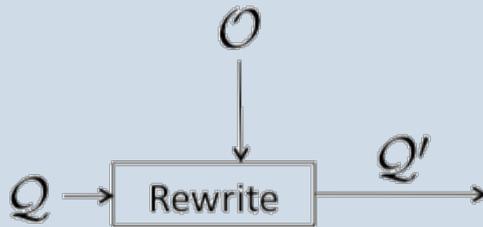


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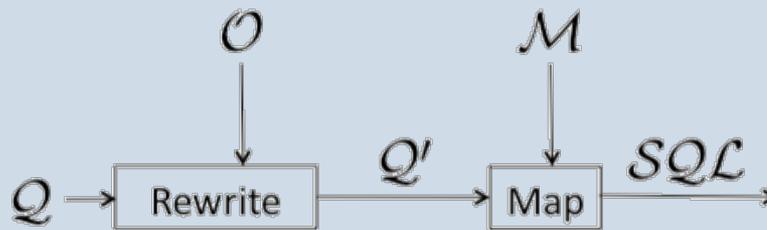


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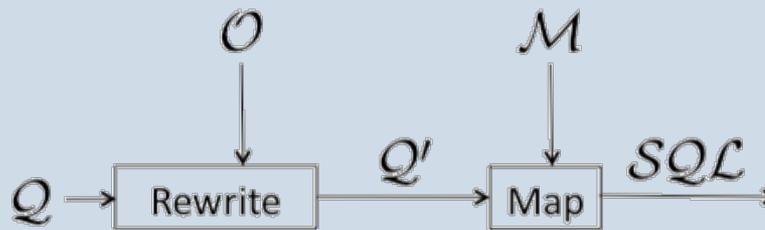


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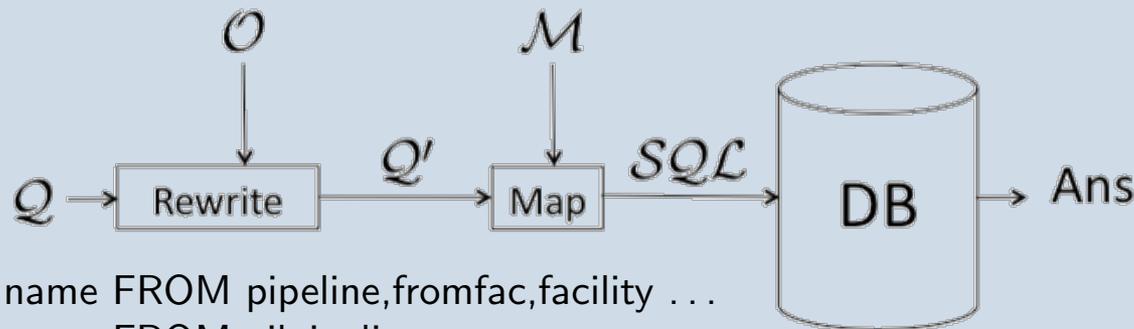


SELECT name FROM pipeline,fromfac,facility ...
UNION SELECT name FROM oilpipeline

Query Rewriting

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- **Evaluate** (SQL) query against DB



SELECT name FROM pipeline,fromfac,facility ...
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Optique Solution



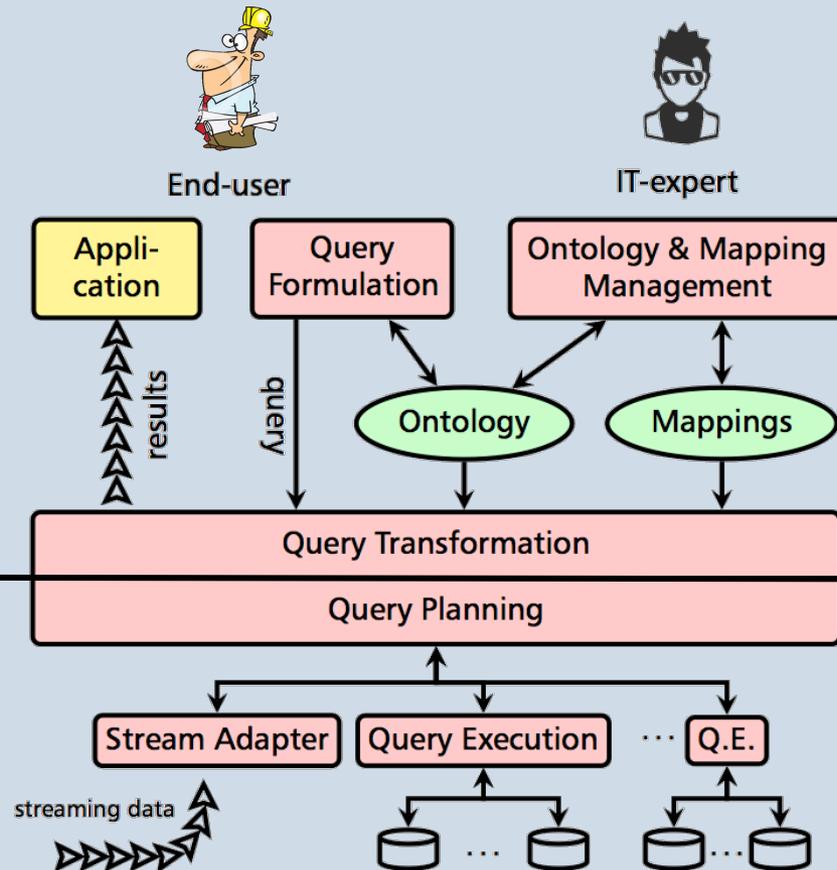
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Query evaluation:

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Optique Solution



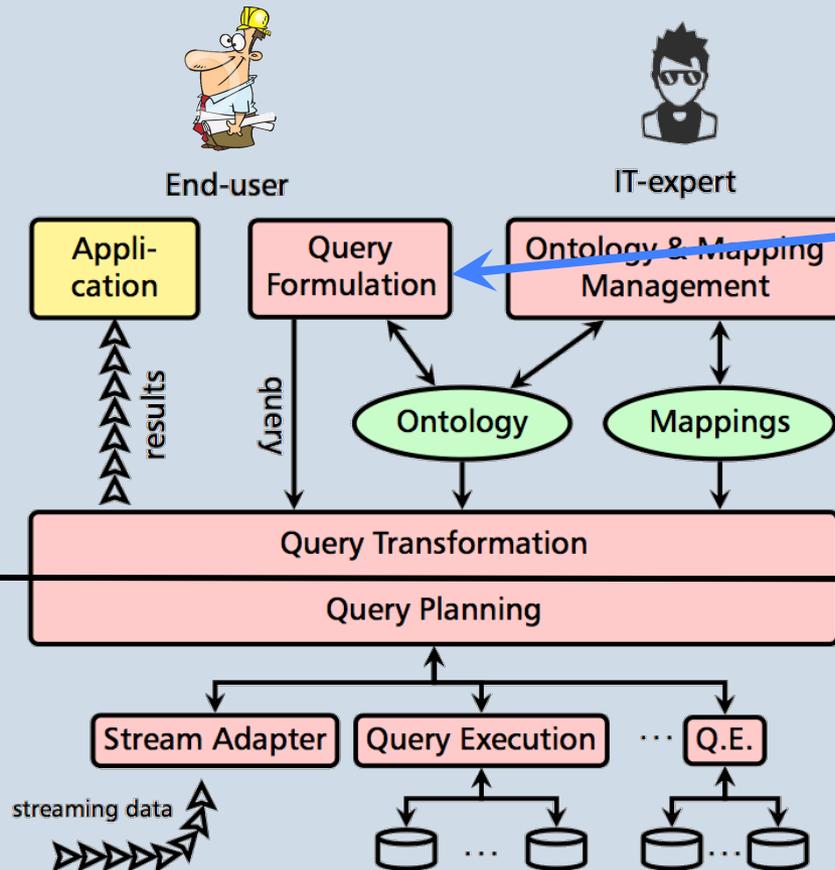
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Other features:

support for query formulation

Query Formulation

The screenshot displays a user interface for query formulation, divided into two main sections: a sidebar on the left and a main panel on the right.

Sidebar (Left):

- Search bar: Search...
- Wellbores**: Wellbore description goes here... (300 items)
- Cores**: Core description goes here... (900 items)
- Stratigraphic Units**: Stratigraphic Unit description goes here... (200 items)

Main Panel (Right):

- Search bar: Search...
- Interval**: Input field for name.
- A field**: Yes/No toggle switch.
- A field**: Range slider with value 50.
- A field**: Range slider with values 40 and 80.

Diagram (Bottom):

A horizontal flow diagram showing the relationships between data entities: Query — Well — Wellbore — Core — DepthInterval.



Optique Solution



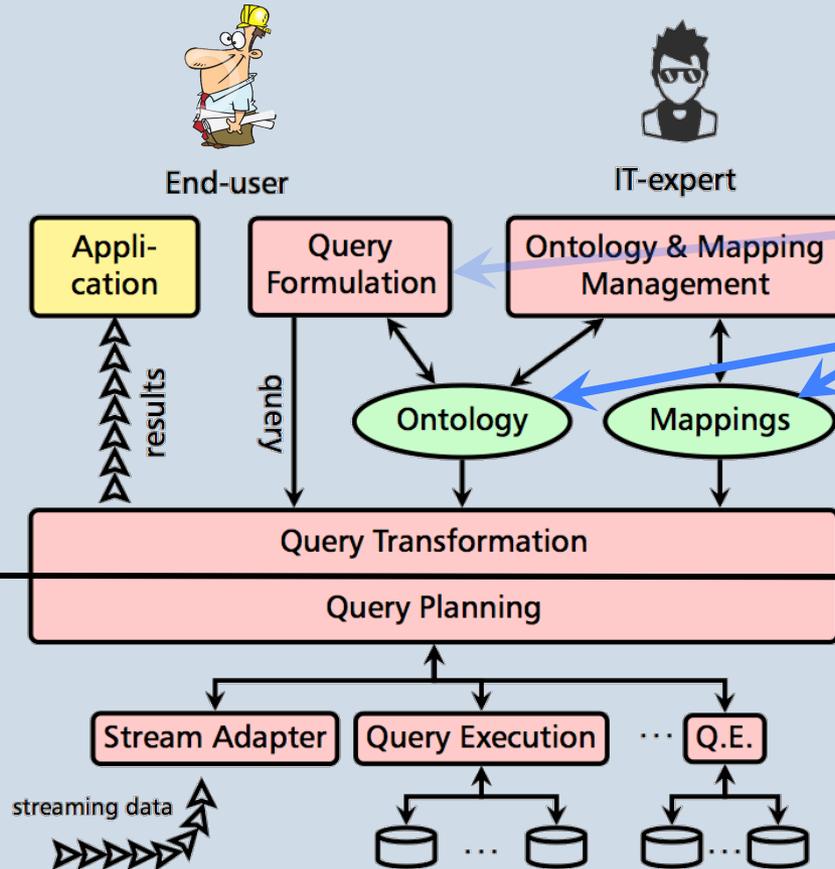
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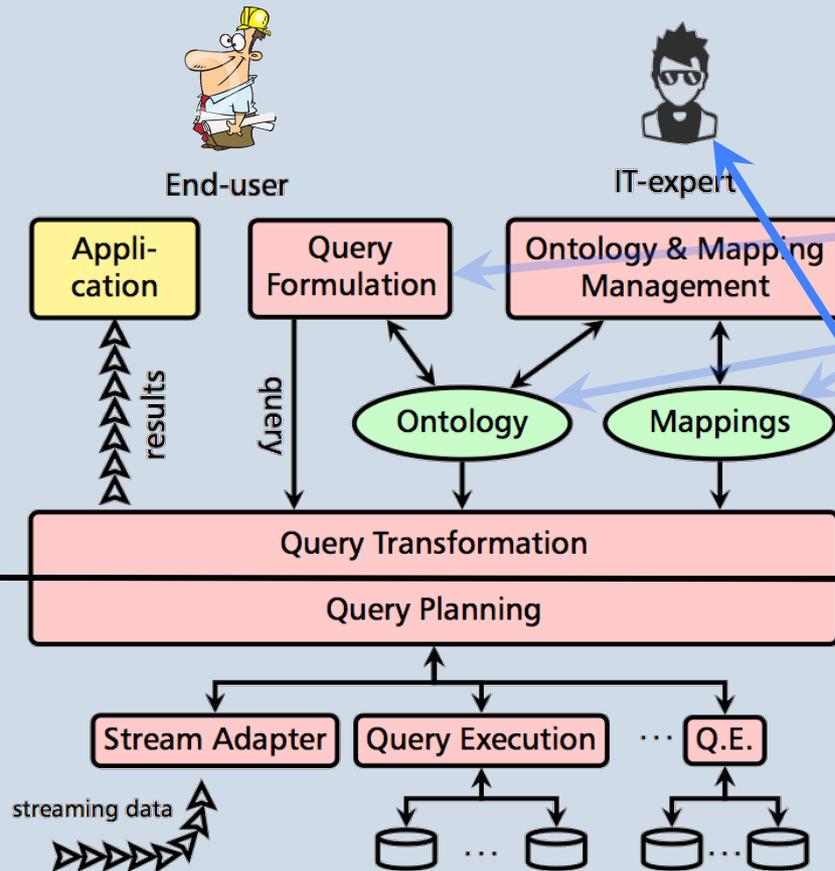
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- Ontology & mappings extended “on the fly”
- IT-expert oversees O&M management

Optique Solution



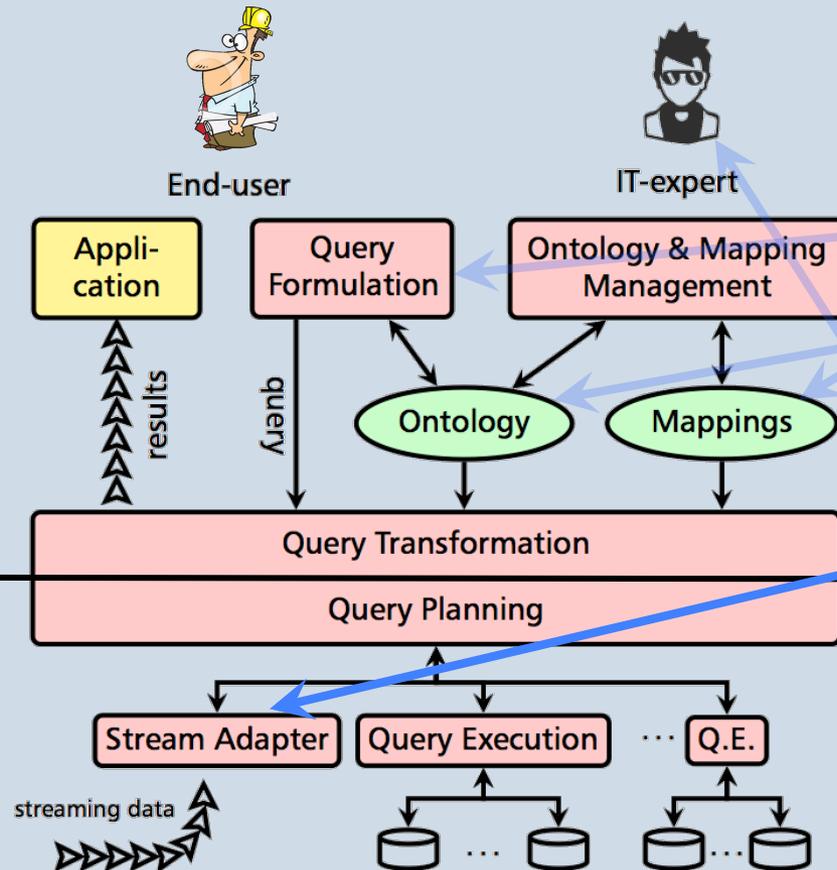
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- IT-expert oversees O&M management
- Adapter to support streaming data

Optique Solution



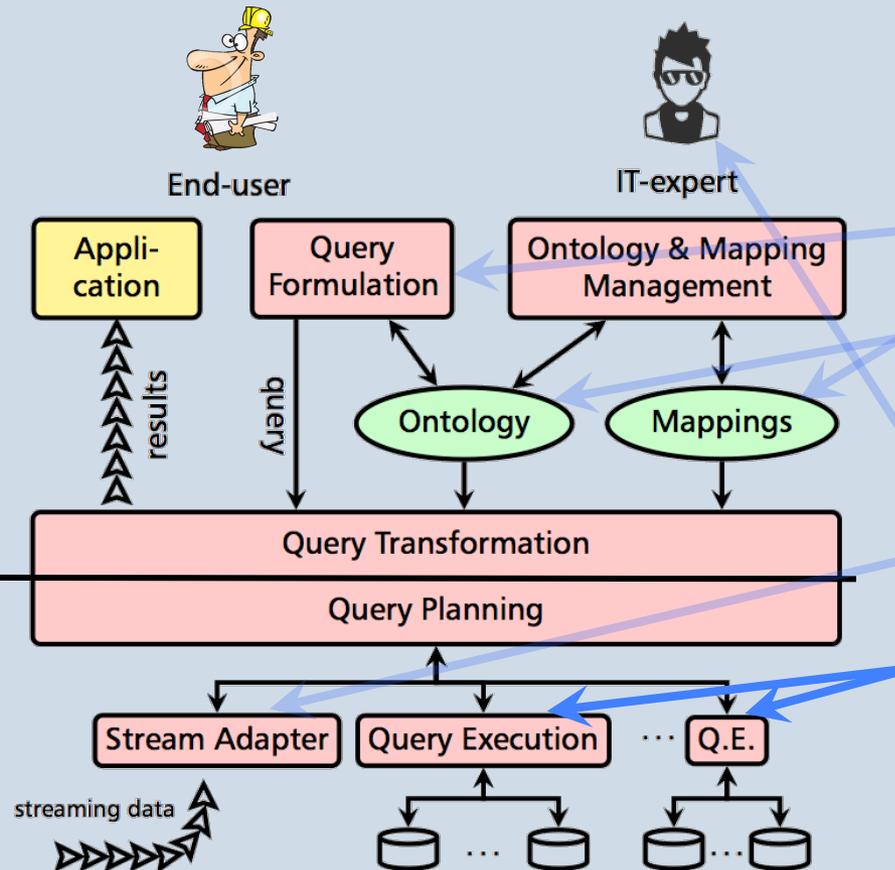
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Other features:

- support for query formulation
- Ontology & mappings extended “on the fly”
- IT-expert oversees O&M management
- Adapter to support streaming data
- Distributed query execution



UiO : University of Oslo



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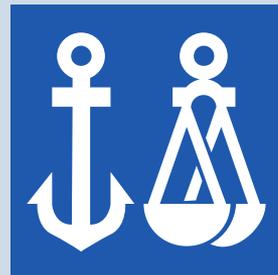


Statoil



National and Kapodistrian
UNIVERSITY OF ATHENS

SIEMENS



SAPIENZA
UNIVERSITÀ DI ROMA

TUHH

Hamburg University of Technology
Department of Telecommunications



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LIBERA UNIVERSITÀ DI BOLZANO
FREE UNIVERSITY OF BOZEN · BOLZANO

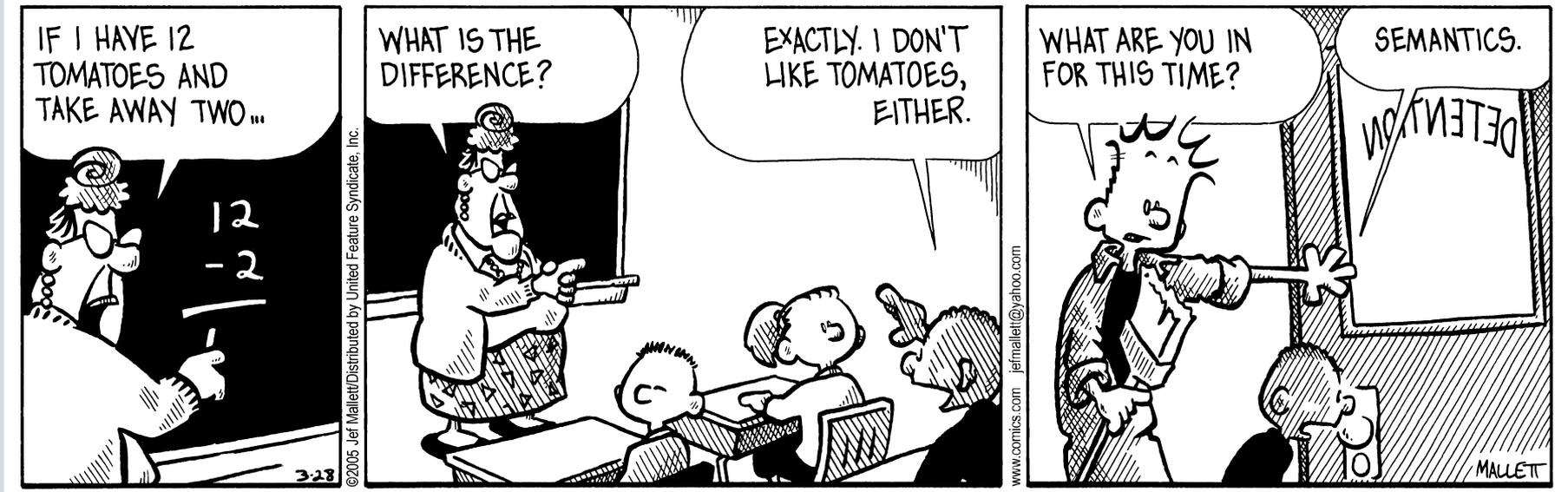


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Thank you for listening



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Any questions?



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