Towards Ontological Context Mediation for Semantic Web Database Integration: Translating COIN Ontologies Into OWL

Sumit Bhansali, Benjamin Grosof, Stuart Madnick

Massachusetts Institute of Technology, Sloan School of Management

50 Memorial Drive, Cambridge, MA 02142, USA

{bhansali, bgrosof, smadnick}@mit.edu
Overview I

• **Context Interchange (COIN)** is an approach to **information integration**. It uses **ontological mappings** and enables powerful **context-sensitive query mediation** for semantic integration of knowledge across multiple **heterogeneous database sources**.

• **Existing COIN applications** include:
  • **financial**: reporting and analysis
  • **travel**: airfare and car-rental aggregators
Overview II

• COIN’s original development preceded the Semantic Web.

• How best to combine COIN’s capabilities with those of OWL and RuleML?
  • This paper provides a big first step
Overview III

• We present a translation of COIN’s ontology representation into OWL Description Logic.

• We identify at a high level how to use RuleML LP rules together with ontologies to perform COIN-type reasoning such as mapping of ontologies and mediation of queries.
COIN Ontological Model’s Translation to OWL I

- Semantic Type $\rightarrow$ OWL Class
- Attribute $\rightarrow$ OWL Property
- Source Relation $\rightarrow$ OWL Class
- Source Relation Column $\rightarrow$ OWL Property
- is-a inheritance link -> subClassOf axiom
COIN Ontological Model’s Translation to OWL II

- **Context** → instance of COINContext Class
- **Modifier** → OWL Property

Actually, only RDF-Schema features are used:
- rdfs:class
- rdfs:property
- rdfs:subClassOf
- rdfs:domain
- rdfs:range
Kinds of Reasoning in COIN

COIN does several kinds of reasoning:

• **Ontological mapping**

• **Query mediation**
  
  ➤ Abduction
  
  ➤ **Constraint Handling & Equation Solving**
Use Rules for COIN Reasoning

• Description Logic *alone* is not well-suited for COIN reasoning – OWL is not enough

• Want Logic Program (LP) Rules – RuleML

• RuleML can express the DLP subset of OWL
  ➢ DLP = Description Logic Programs knowledge representation

• Future Direction for Work: Use RuleML to express rules to do COIN-type reasoning

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Use Rules for COIN Reasoning II

• **Challenge for Future** – how to treat abductive reasoning, constraint handling rules in the context of the Semantic Web
MORE ABOUT COIN
FOLLOWS
COIN Motivation

• Distributed databases makes many disparate sources available.
• The web is making even more semi-structured sources available.
  -- With XML and Web Wrapping, these can be treated as databases.
• Schema integration addresses the problem of syntactic inconsistencies.
  -- i.e., differing structures.
• How do we address semantic inconsistencies.
  -- i.e., differing meanings.
  (e.g., what does “price” really mean?)
MIT Sloan COntext INterchange (COIN) Project

Applications

OUTPUT PROCESSING

CONTEXT MEDIATION
* Automatic conflict detection and conversion
  - Source selection

INPUT PROCESSING
* Automatic web wrapping
  - Semi-structured text
  - Multi-source query plan and execution

Web Pages

TRUSTED AGENTS

Sources

Databases

APPLICATIONS: Financial services, electronic commerce

Receivers

ODBC Driver

Web - Publishing

Browsers

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Role Of Context

CONTEXT VARIATIONS:
- GEOGRAPHIC (US vs. UK)
- FUNCTIONAL (MARKETING vs. FINANCE)
- ORGANIZATIONAL (CITIBANK vs. CHASE)

Data: Databases Web data E-mail
### Types of Context

<table>
<thead>
<tr>
<th></th>
<th>Example</th>
<th>Temporal</th>
</tr>
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</table>
| Surface | Currency: $ vs €  
Scale factor: 1 vs 1000 | Francs before 2000, € thereafter              |
| Ontological | Revenue: Includes vs excludes interest | Revenue: Excludes interest before 1994 but incl. thereafter |
COIN - Summary

• Tremendous opportunity to gather and integrate information from many diverse sources
• But … need to overcome many context challenges
• Context-type “metadata” plays a critical role
• COIN technology can be an important aid for semantically meaningful information integration:
  - Scalable
  - Extensible
  - Application Domain Merging
  - Reuse and extension of ontologies and contexts
COIN ONTOLOGICAL MODEL I

Main components are –

- Semantic Types
- Attributes
- Modifiers
- Contexts
- Conversion Functions
- Elevated Relations
COIN ONTOLOGICAL MODEL II

Attributes and Modifiers

• Properties of semantic types specified by attributes and modifiers.

**Attributes** define the state of object or relationship between objects.

*Example: “city” is an attribute of semantic type “location”*

**Modifiers** are specialized attributes that take on different values in different contexts.

*Example: “tempUnit” is a modifier of semantic type “temperature”. It has value “celsius” in metric ctxt and “fahrenheit” in imperial ctxt.*
COIN ONTOLOGICAL MODEL III

Contexts and Elevation Axioms

Elevation Axioms relate the source relations to the domain model. Each primitive source database relation is mapped to a semantic relation.

Semantic Relations are obtained by mapping each primitive column to a semantic type in a particular context.

Example: In the context metric units, the primitive source relation column “city” is mapped to the semantic type “location” in the domain model.
COIN DOMAIN MODEL EXAMPLE

Ontology

Physical Measurements

Location

Temperature

C_USA

city->Location
state->Location
country->Location
temp->Temperature

Basic

Weatheruk

Weatherusa

(city, state, country, temp)

(city, state, country, temp)

C_UK

city->Location
state->Location
country->Location
temp->Temperature

Elevation Axioms

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