Common Logic in Support of Metadata and Ontologies

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Open Forum 2005 on Metadata Registries
14:45 Track 1
14 April 2005

Outline

- Common Logic
  - Background
  - First order semantics
  - ISO standard features
- Representative syntax: Conceptual Graphs
- Interchange
  - Issues
- Example

Overview

- First order logic language for knowledge interchange
- Provides a core semantic framework for logic
- Provides the basis for a set of syntactic forms (dialects) all sharing a common semantics

Common Logic Participants

SCL ad-hoc working group (formed Dec 2002):

- Pat Hayes
  - IHMC, USA
- Chris Menzel
  - Texas A&M U., USA
- John Sowa
  - VivoMind, USA
- Tanel Tammet
  - U. Goteborg, Sweden
- Bill Andersen
  - OntologyWorks, USA
- Murray Altheim
  - Open University, UK
- Harry Delugach
  - U. Alabama Huntsville, USA
- Michael Gruninger
  - NIST, USA (and Canada)
Origins of Common Logic

- Conceptual Graphs, 1984
  - Linear (textual form)
  - Display (graphic form)
  - Natural language processing, knowledge based systems
- Knowledge Interchange Format (KIF) c. 1990
  - Part of the Ontolingua project at Stanford to develop ontologies
  - KIF-CGIF collaboration, 1994-1998
- Common Logic (CL) 1998-2002
- Simplified Common Logic (SCL) 2002-present
- ISO Project 24707 (Common Logic) starting June 2003

First Order Semantics

- A statement/sentence/ assertion is considered completely true or completely false
  - My name is Harry Delugach
  - NOT 2 + 2 = 5
  - Compare: Logic is easy to learn.
- Entities - things, states, attributes
  - Harry, idleness, color, etc.
- Relations - between entities, attributes
  - Marriage, eye-color, etc.
- Quantification - single instance or a set (∃, ∀)
  - Definition, uniqueness, etc.
- Negation - explicit falsehood
  - Harry is not President of the United States
- Iteration - over elements a set
  - Age of each member of a population

Comparing Formalisms

- Formalisms can be arranged by their expressivity ("power")
  - The set of things that can possibly be expressed by the language
  - E.g., first order logic does not express modalities such as possibility

Expressivity vs. Computing Complexity

- Expressivity - set of things that can be represented
- Computation complexity - amount of computer time needed to process queries, consistency checks, etc.
- As expressivity goes up, complexity goes up!
  - Compromises on completeness and soundness reduce complexity
  - Not as terrible as it sounds!
ISO WD 24707 - “the standard”

- Scope, normative references, terms, symbols
- Common Logic Core
  - Abstract syntax
    - Terms, sentences, etc.
  - Abstract Semantics
    - Interpretation of each CL expression
- Conformance
  - Three specific surface syntaxes are conformant
    - KIF, CGIF, XCL
  - Provide a mapping from your language to one of those
  - Show that the semantics of your language are preserved for every mapping into CL abstract syntax

ISO WD 24707 - Normative Annexes

- KIF (1st order)
  - Concrete syntax - KIF – EBNF grammar –
  - Show KIF to CL abstract semantics
- CGIF (1st order)
  - CGIF – EBNF grammar
  - Show CGIF to CL abstract semantics
- XCL
  - XML-based markup – EBNF grammar
  - Show XCL to CL abstract semantics

Concrete Syntaxes

- (∀)(Boy(x) → (∃)(Girl(y) & Kissed(x,y)))
- [@every *x] [If: (Boy ?x) [Then: [*y] (Girl ?y) (Kissed ?x ?y) ]]

Common Semantics

(for all (?x)(implies (and (P ?x) (R ?x)) (S ?x)))

(CL abstract semantics)
ISO WD 24707 - Informative Annexes

• Relationship to other standards and practices
  – Prolog, Z, OCL (non-ISO-std), OWL (non-ISO-std)
  – Distinguish CL from Horn clause, description logics, others
• A benchmark “fact set” of all the kinds of facts that one can have
  – Especially: meaning of negation, reasoning over sets – see well founded semantics
• Use Cases

A Syntactic Form: Conceptual Graphs

• Introduced by John Sowa in 1984
• Focus of seven workshops and twelve international conferences since 1986
• Studied by researchers in 11 countries
• Included in hundreds of research papers published in five languages
• 13th Intl Conference on Conceptual Structures (ICCS’05) in Kassel, Germany

Concept

• Any distinguishable idea
• Shown as type-labeled rectangle

Relation

• Relation
  – Relationship between two or more concepts
  – Shown as oval or circle
  – The owner of a CAT is a Person.
**Context**

- A concept that encloses an entire proposition

Person: Joe

Proposition: Person: Barb own CAT: Albert

Person “Joe” believes (the proposition) that the owner of the cat “Albert” is Person “Barb”

**Logical Operations**

- AND
  - Harry is male AND Harry has brown eyes
- NOT
  - NOT Harry is a millionaire
- FORALL
  - FORALL X in { a, b, c, d }

**Knowledge Interchange**

Agent A

A and B, each have a first-order formalization of some knowledge.

A and B wish to communicate their knowledge to each other so as to draw some conclusions.

Any inferences that B draws from A’s input should also be derivable by A, and vice versa.

Common Logic provides a framework to support this.

Agent B

**Meaningful Interchange**

- Any meaningful exchange of utterances depends upon the prior existence of an agreed set of semantic and syntactic rules
  -- ISO TR 9007:1987 (“Helsinki principles”)
- The recipients of the utterances must use only these rules to interpret the received utterances, if it is to mean the same as that which was meant by the utterer
  -- ISO TR 9007:1987 (“Helsinki principles”)
Example: Interchange

1. CGIF concrete syntax:
   
   [Jack: *a] [Jill: *b] (married ?a ?b)

2. Map 1 to CL abstract semantics:
   
   (married Jack Jill)

3. Map 2 to KIF concrete syntax:
   
   (married (Jack) (Jill))

Issue - Different Axiomatic Styles

- A and B may have made divergent assumptions about the logical signatures of their formalizations.
  - A uses relation name — B uses function
  - A and B use same relation with different argument orderings or different numbers of arguments.
  - A particular concept, such as marriage, might be represented by A as an instance of a marriage event, but by B as a relation.
- Can be solved by mappings between the logical forms of such divergent choices,
  - CL removes conventional limitations on first-order signatures
    - For example, a name in CL may serve both as an individual name and as a relation name.

Achieving Semantic Consistency

- System A:
  
  (married Jack Jill)

- System B:
  
  (married (roleset: (husband Jack) (wife Jill)))

- How does System B “understand” System A?
  - Provide equivalences to System B
    - (forall (x y)
      (implies (married x y) (married (roleset: (husband x) (wife y)))))

Applications of Common Logic

- Constraints among data elements in a database
- Semantics of administered items in metadata registries
  - Bridge the gap between TC 37’s view of a data element and 11179’s view of a data element
- Ontology definition
- Automated reasoning and inference
Database Values As Concepts:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Yrs Experience</th>
<th>Degree</th>
<th>Major</th>
<th>Percent Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karen Jones</td>
<td>VP Marketing</td>
<td>18</td>
<td>MBA</td>
<td>Marketing</td>
<td>3</td>
</tr>
<tr>
<td>Kevin Smith</td>
<td>VP Technology</td>
<td>12</td>
<td>MSE</td>
<td>Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Keith Williams</td>
<td>VP Finance</td>
<td>15</td>
<td>BS</td>
<td>Accounting</td>
<td>3</td>
</tr>
</tbody>
</table>

- Single record shows related values only

Database Values With Semantics:

- Database Employees
- Name: Kevin Smith
- Position: VP Technology
- Experience: 12
- Degree: MSE
- Major: Engineering
- Percent Stock: 4

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