Common Logic in Support of Metadata and Ontologies

Harry S. Delugach
Intelligent Systems Laboratory
University of Alabama in Huntsville, USA

UAH The University of Alabama in Huntsville

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

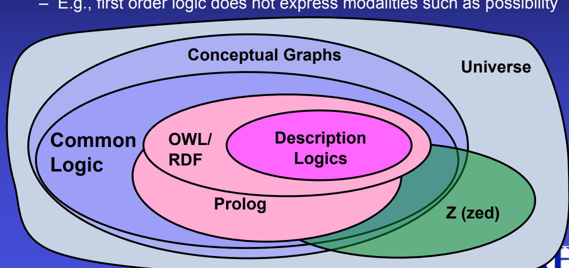
- Conceptual Graphs, 1984
  - Linear (textual form)
  - Display (graphic form)
  - Natural language processing, knowledge based systems
- Knowledge Interchange Format (KIF) c. 1990
  - Part of the Ontolingua project at Stanford to develop ontologies
- KIF-CGIF collaboration, 1994-1998
- Common Logic (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

- <u>Expressivity</u> - set of things that can be represented
- <u>Computation complexity</u> - 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"

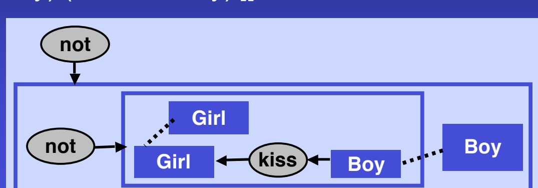
- Scope, normative references, terms, symbols
- Common Logic Core
  - Abstract syntax
    - Terms, sentences, etc.
  - Abstract Semantics
    - Interpretation of each CL expression
- Conformance
  - Three specific surface syntaxes are conformant
    - KIF, CGIF, XCL
  - Provide a mapping from your language 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

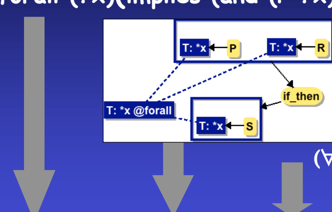
Concrete Syntaxes

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



Common Semantics

(forall (?x)(implies (and (P ?x) (R ?x)) (S ?x)))



(∀x)(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

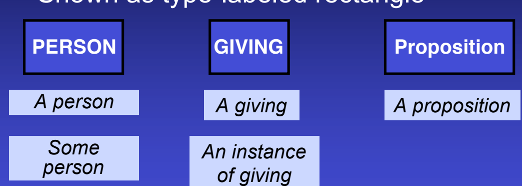
A Syntactic Form: Conceptual Graphs

- 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

Intelligent Systems Laboratory UAH

Concept

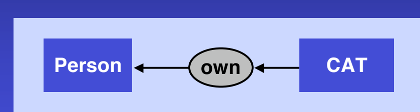
- Any distinguishable idea
- Shown as type-labeled rectangle



Intelligent Systems Laboratory UAH

Relation

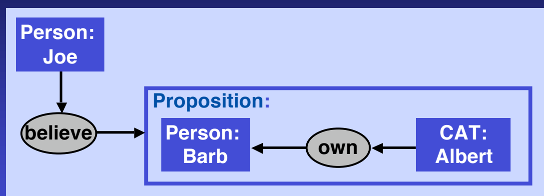
- Relation
  - Relationship between two or more concepts
  - Shown as oval or circle
  - *The owner of a CAT is a Person.*



Intelligent Systems Laboratory UAH

Context

- A concept that encloses an entire proposition

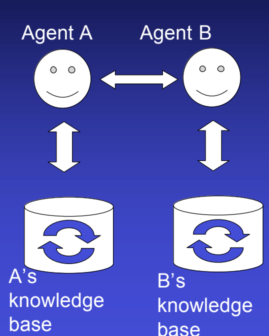


Person "Joe" believes (the proposition) that the owner of the cat "Albert" is Person "Barb"

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



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.

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))

Intelligent Systems Laboratory UAH

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.

Intelligent Systems Laboratory UAH

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)))))

Intelligent Systems Laboratory UAH

Applications of Common Logic

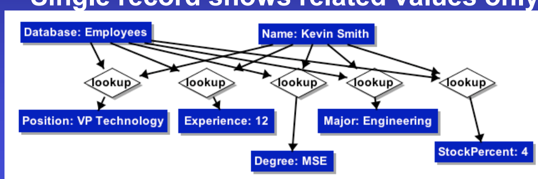
- Constraints among data elements in a database
- Semantics of administered items in metadata registries
  - Bridge the gap between TC 37's view of a data element and 11179's view of a data element
- Ontology definition
- Automated reasoning and inference

Intelligent Systems Laboratory UAH

Database Values As Concepts

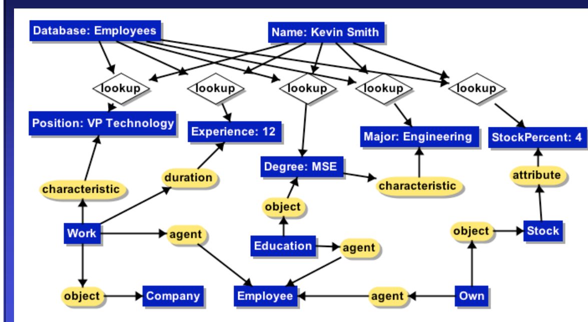
Name	Position	Yrs Experience	Degree	Major	Percent Stock
Karen Jones	VP Marketing	18	MBA	Marketing	3
Kevin Smith	VP Technology	12	MSE	Engineering	4
Keith Williams	VP Finance	15	BS	Accounting	3
…	…	…	…	…	…

- Single record shows related values only



Intelligent Systems Laboratory

Database Values With Semantics



Intelligent Systems Laboratory