From Data Modeling to Ontologies
[as used in knowledge organization systems]

New requirement

• Making KOS machine-processable (machine-understandable)
  • -- a concern previously belonged to the domain of researchers in computer science and W3C pioneers
  • -- now in library and information sciences
  • -- recommendation of LC WG on Future of Bibliographic Control (Nov. 13, 2007)

Conceptual model of aboutness

• Models shown by Eeva Murtomaa and Maja Zumer for the FR-family:
  • FRAD
  • FRSAR
• A key concept here is to separate a [stuff] from what it is called, referred to, or addressed as

- Nomen
- Thema
- Appellation

Who
What
When
Where
How
Putting it together: a thesaurus entry:

<table>
<thead>
<tr>
<th>Term: Economic cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used For: Economic co-operation</td>
</tr>
<tr>
<td>Broader terms: Economic policy</td>
</tr>
<tr>
<td>Narrower terms: Economic integration European economic cooperation European industrial cooperation Industrial cooperation</td>
</tr>
<tr>
<td>Related terms: Interdependence</td>
</tr>
<tr>
<td>Scope Note: Includes cooperative measures in banking, trade, industry etc., between and among countries.</td>
</tr>
</tbody>
</table>


An RDF/XML serialization of the RDF description of the 'Economic cooperation' concept

The thesaurus becomes machine-processable, why do we still need an ontology?


What is an ontology?

• An ontology is an explicit specification of a conceptualization. -Gruber, T. (1993)

• An ontology defines the basic terms and relations comprising the vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary. -Neches, R. et al. AI Magazine, (Winter 1991): 36-56.
Concept classes and sub-classes

Properties and attributes of concepts

These are not narrower terms (NT) or sub-classes.

Concepts, properties, relations, functions, constraints, and axioms are explicitly defined.

Foundational Model of Anatomy (FMA) Ontology

Table of heart attributes:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part-whole</td>
<td>Heart is a part of a whole</td>
</tr>
<tr>
<td>A-kind-of</td>
<td>Heart is a kind of a more specific type</td>
</tr>
</tbody>
</table>


Foundational Model of Anatomy (FMA) Ontology

Relationship types

- A-kind-of
- Is-a
- Part-whole
- Sibling

Expressed in OWL Web Ontology Language

- Class Hierarchies
- Relation Hierarchies
- Constraints

Modeling concepts and relationships

- Goal
- User needs
  - Analyze, synthesize, categorize, create

- Concept
- Concept type
  - Concrete or abstract

- Relationship
  - Constraints on properties
    - Mandatory
    - Optional
    - Repeatable
    - Non-repeatable

Source: Qin, 2007
Added to RDF by OWL (1)

- **cardinality constraints** on properties,
  - e.g., a Star is memberOf exactly one Galaxy.
- specifying constraints on the **range or cardinality** of a property depend on the class of resource,
  - e.g., for a binarySystem the hasMember property has 2 values, while for a tripleSystem the same property should have 3 values.
- specifying that a given property is **transitive**
  - e.g., if A hasAncestor B, and B hasAncestor C, then A hasAncestor C.
- specifying that a given property is a **unique identifier** (or key) for instances of a particular class.

Added to RDF by OWL (2)

- **Equivalent class**
  - specifying that two different classes (having different URIrefs) actually represent the same class.
- **Same as**
  - specifying that two different instances (having different URIrefs) actually represent the same individual.
- the ability
  - to describe new classes in terms of combinations (e.g., **unions** and **intersections**) of other classes,
  - or to say that two classes are **disjoint** (i.e., no instance belongs to both classes).

Examples from SchemaWeb

- **SchemaWeb** provides a comprehensive directory of RDF schemas and OWL ontologies.
  http://www.schemaweb.info/default.aspx

Why Develop an Ontology?

- To share **common understanding** of the structure of information
  - among people
  - among software agents
- To enable **reuse** of domain knowledge
  - to avoid “re-inventing the wheel”
  - to introduce standards to allow interoperability
An ontology is an explicit description of a domain:
- concepts
- properties and attributes of concepts
- constraints on properties and attributes
- individuals (often, but not always)

An ontology defines:
- a common vocabulary
- a shared understanding

An ontology reflects shared views.

An ontology enables reuse of domain knowledge.

Properties inherited from upper class 'people'

Additional properties defined for the subclass of 'people'

Pre-defined values

An ontology allows instances

Gene Ontology

Annotations provided by specific projects

http://www.mindswap.org/people
Where are the major differences

Functions and components

- Eliminating ambiguity
- Controlling synonyms or equivalents
- Presenting explicit semantic relationships
  - Hierarchical relationships
  - Hierarchical + other associate relationships
- Presenting properties and attributes of concepts

<table>
<thead>
<tr>
<th>Function</th>
<th>Classification</th>
<th>Thesaurus</th>
<th>Ontology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine processable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Machine readable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Classification</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Thesaurus</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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</table>

Where are the major differences

Expression and encoding

**Machine processable**

- XML, RDF, SKOS

**Ontology**

- OWL
- RDF
- XML

Revised based on Qin, 2007
Where are the major differences

Primary Purposes

<table>
<thead>
<tr>
<th>Classification</th>
<th>Ontology</th>
</tr>
</thead>
<tbody>
<tr>
<td>• organizing library materials</td>
<td>• Conceptual model for a knowledge and/or application domain</td>
</tr>
<tr>
<td>Thesaurus</td>
<td></td>
</tr>
<tr>
<td>• Controlled vocabulary for representing topics in indexing and searching</td>
<td></td>
</tr>
</tbody>
</table>

Still needed? YES
Can be reused for ontology? YES
Can be re-purposed? YES

Revised based on Qin, 2007

References

- OWL Web Ontology Language Guide
  - [http://www.w3.org/TR/owl-guide/](http://www.w3.org/TR/owl-guide/)
- Semantic Web activities - OWL
  - [http://www.w3.org/2004/OWL/](http://www.w3.org/2004/OWL/)
- Ontology Libraries
  - SchemaWeb provides a comprehensive directory of RDF Schemas and OWL ontologies.
    - [http://www.schemaweb.info/default.aspx](http://www.schemaweb.info/default.aspx)
  - DAML Ontology Library, which organizes hundreds of ontologies in a variety of different ways (keyword, organization, submission date, etc.)
  - Swoogle is a search engine for Semantic Web documents, including OWL ontologies.