Ontologies

Electronic Business Technologies

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Motivation

Battery

- Different features
- Different prices
- Different utilities
Ontology

• Origin in philosophy:
  – Specification of what exists or what we can say about the world

• In AI systems:
  – what "exists" is what can be represented

• Popular topic since the early ninety

• Several communities of AI research:
  – Knowledge Engineering/Representation
  – Natural Language Processing
  – Intelligent Information
  – Information Retrieval on the Web

Ontology

• Reason for the popularity: mainly due to the promise of a shared and common understanding of some domain of knowledge that can be communicated between people and computer
What is an ontology?

• “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 et al., 1991]

• “An ontology may take a variety of forms, but necessarily it will include a vocabulary of terms, and some specification of their meaning. This includes definitions and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms” [Uschold & Jasper, 1999]

What is an ontology?

• “is an explicit specification of a conceptualization” [Gruber, 1993]
  – Conceptualisation: is a set of definitions that allows one to construct expressions about some physical domain.
  – Explicit: means that the concepts and relationships of the abstract model are given explicit terms and definitions.

• “is a formal specification of a shared conceptualization” [Borst, 1997]
  – Formal: Refers to the fact that an ontology should be machine-readable.
  – Shared: reflects the notion that the ontology captures consensual knowledge, that is, it is not the privilege of some individual, but accepted by a group.
What is an ontology?

• The ontology community distinguishes between: ontologies that are mainly a taxonomy; and ontologies that model the domain more deeply providing more constraints on the semantics of the domain.

**Lightweight:**
– make scarce or no use of axioms to model knowledge and clarify the meaning of concepts in the domain.
– include concepts, relationships between concepts and properties that describe these concepts.

**Heavyweight:**
– make intensive use of axioms to model knowledge and restrict domain semantics.
– add axioms and restrictions to lightweight ontologies.

Ontology

Issues to discuss:

• Ontology construction
  – methodology
  – tools
  – languages

• Ontology Learning
• Ontology Mapping
• Ontology Translation and Interoperability
• Applications
Ontology construction

Methodology? Tools?

Language?

Ontology construction

• Developing an ontology involves (basically):
  – Define domain and scope

Example
  – Domain: Wine representation
  – Scope: applications that suggest combinations of wines and food

Other scopes:
  – Helping clients in the restaurant to decide which wine to ask
  – Helping buyers of wine
  – Helping transactions between wine producer and wine reseller
Ontology construction

• Define classes in the ontology
• Organize classes in a taxonomy (subclass-superclass)

- Wine
  - White Wine
  - Red Wine
- Rose Wine
  - Beaujolais
  - Red Burgundy
  - Red Bordeaux
- Producer

Ontology construction

• Define attributes (slots)

- Color
- Shape
- Taste
- Alcoholic content
Ontology construction

- Define relations

<table>
<thead>
<tr>
<th>Name</th>
<th>Documentation</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer</td>
<td></td>
<td></td>
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<tr>
<td>Role</td>
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<tr>
<td>Concrete</td>
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<table>
<thead>
<tr>
<th>Template Slots</th>
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<tr>
<td>Name</td>
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<td>S produces</td>
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</table>

Ontology construction

- Define instances: elements
- Define axioms: sentences that are always true
- Define functions: example, price calculation
- ....
Ontology construction

Questions about methodology, tools and languages:

- What methodologies are available for building ontologies, or to reuse existing ontologies?
- What is the life cycle of an ontology?
- What tools support the process of developing an ontology?
- What language should be used?
- Which expressivity has a language of ontology?
- The language chosen is appropriate for the exchange of information between different applications?

Methodologies for Ontology construction

- Enterprise Ontology
- TOVE (Toronto Virtual Enterprise)
- METHONTOLOGY
- On-To-Knowledge
Methodologies for Ontology construction

**Enterprise Ontology** - Uschold and King’s Method [Uschold e King, 1995]

1. Identify the ontology proposal
2. Build the ontology: capture, codify and integrate appropriate knowledge from existing ontologies
3. Evaluate the ontology
4. Document the ontology

**TOVE** (Toronto Virtual Enterprise) [Grüninger e Fox, 1995]

1. Identify motivation scenarios
2. Formulate questions to answer
3. Formulate questions in FOL
4. Specify axioms
5. Evaluate the ontology
Methodologies for Ontology construction

**Methontology** [Gómez-Pérez, 1998]
- Specify requirements
- Conceptualize the domain of knowledge
- Formalize the conceptual model in a formal language
- Implement a formal model
- Maintain the implemented ontologies

- Activities performed during the construction process:
  - Knowledge acquisition
  - Integration
  - Evaluation
  - Documentation

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**On-To-Knowledge** [Staab et al., 2001]

- **Kick-off**
  - requisitos da ontologia são capturados e especificados, (ii) questões de competência são identificadas, (iii) ontologias potencialmente reusadas são estudadas e uma versão “draft” da ontologia é construída
- **Refinement**
  - uma ontologia madura e orientada a aplicação é construída
- **Evaluation**
  - requisitos e questões de competência são checados e a ontologia é testada no ambiente da aplicação
- **Maintenance**
Methodologies for Ontology construction

Conclusions:

• Methontology:
  – recommended by FIPA (Foundation for Intelligent Physical Agents)

• Proposals not unified:
  – each group applies its own approach

Tools for Ontology construction

<table>
<thead>
<tr>
<th>Ontolingua</th>
<th>WebONTO</th>
<th>WebODE</th>
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<tbody>
<tr>
<td>Protégé</td>
<td>OntoEdit</td>
<td>OilEd</td>
</tr>
<tr>
<td>Apollo</td>
<td>SymOntoX</td>
<td>OntoSaurus</td>
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<tr>
<td>DagEdit</td>
<td>DOE</td>
<td>IsaViz</td>
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<tr>
<td>SemTalk</td>
<td>OntoBuilder</td>
<td>DUET</td>
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</tbody>
</table>
Tools for Ontology construction

Protégé [Noy et al., 2000]  
http://protege.stanford.edu

- Developed by the Medical Informatics group, Stanford University

Main features:
- Open Code
- Standalone application
- Extensible architecture
- Ontology Editor + plugins (library of functionalities)
- Currently imports/exports to Flogic, Jess, OIL, XML, Prolog, OKBC access
Tools for Ontology construction

WebODE [Arpírez et al. 2001; Corcho et. al, 2002]
http://delicias.dia.fi.upm.es/webODE

– Developed by the Artificial Intelligence Laboratory, Technical University of Madrid

Main features:
– Extensible architecture
– Web application
– Import/export to XML, RDF(S), OIL, DAML+OIL, CARIN, Flogic, Jess, Prolog
– Ontologies stored in relational databases
– Documentation services, evaluation services and merging of ontologies

Tools for Ontology construction

• OntoEdit [Sure et al., 2002]
http://ontoserver.aifb.uni-karlsruhe.de/ontoedit

– Developed by AIFB (Institutf ür Angewandte Informatik und Formale Beschreibungsverfahren), University of Karlsruhe

Main features:
– Extensible architecture, based in plugins
– Import/export for Flogic, XML, RDF(S), DAML+OIL
– Two versions: OntoEditFree e OntoEditProfessional
Tools for Ontology construction: comparison

- **Expressiveness:**
  - All the tools allow to represent classes, relations, attributes, instances and axioms.

- **Interoperability**
  - Many of the tools import and export for XML and markup languages.
  - There is no study on the quality of translators.
  - There is no results on the exchange of ontologies between different tools.

- **Methodology**
  - WebODE supports Methontology
  - OntoEdit supports On-To-Knowledge

- **Cooperative and Collaborative Ontology Construction**
  - WebODE has the more advanced features

Languages for Ontology construction

<table>
<thead>
<tr>
<th>Traditional ontology languages</th>
<th>Cyc</th>
<th>Ontolingua</th>
<th>F-Logic</th>
<th>CML</th>
<th>OCML</th>
<th>Loom</th>
<th>KIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard languages for Web</td>
<td>XML</td>
<td>RDF</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Web-based ontology languages</td>
<td>OIL</td>
<td>DAML+OIL</td>
<td>SHOE</td>
<td>XOL</td>
<td>OWL</td>
<td></td>
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</table>
Ontology Learning

- Ontology learning, set of methods and techniques used for:
  - building an ontology from scratch
  - enriching, or adapting an existing ontology in a semi-automatic fashion using several sources

- Several approaches exist, using sources like:
  - texts, instances, databases schemes, XML schemes, ...

- The most widely used and interesting in the Semantic Web context is the approach based on texts

- Ontology Learning from texts:
  - extract ontologies by applying natural language analysis and machine learning/linguistic techniques

Ontology Learning: tools

Tools based on natural language analysis and machine learning techniques:

- Conceptual Clustering, concepts are grouped according to the semantic distance between each other to make up hierarchies.
  ASIUM [Faure e Nedellec, 1999], Mo’K [Bisson et al., 2000] e SVETLAN [Chaelandar e Grau, 2000]

- Lexical and Syntatic Analysis

- Statistical Approach
  Text-To-Onto [Maedche e Staab, 2001]
Ontology Mapping

- **Ontology Mapping** can be defined as a function that associates terms and expressions defined in a source ontology with terms and expressions defined in a target ontology.

Main tools:
- Chimaera, PROMPT, OBSERVER, OntoMorph, Auto-Categorizer, WebPicker

Ontology Mapping

- Is a difficult task because:
  - it requires a thorough verification of inheritance, consistency of inference, ...
  - the relationships can be many-to-one, one-to-many, many-to-many, within a domain or across domains.

- Many tools are limited to:
  - verify classes or relations
  - check consistency
  - provide a list of recommendations of what to do
Translation and Interoperability

- Ontologies are built using different languages
  - Each language has its syntax, expressiveness and reasoning ability
  - based on different paradigms (frames, first-order logic, description logic, etc.)

- Ontologies are built using different development tools
  - Each tool exports/imports ontologies for one or more languages

Translation problem
- arises when we decided to reuse an ontology or part of it, with a tool or language different from that in which the ontology is available.

Ontology tools should be able to:
- exchange ontologies between them
- export/import ontologies in different formats

If we refer to the exchange of ontologies between different tools, the problem of translation is also known as interoperability between ontology tools.
Translation and Interoperability

• An initial proposal was:
  – use KIF as a format of knowledge exchange in the Ontolingua Server
  – which would reduce the number of translators to be developed

  *Ontolingua* provides a distributed collaborative environment to browse, create, edit, modify, and use ontologies (http://ksl.stanford.edu/software/ontolingua)

• Proposal failed:
  – very poor translation quality
  – facilities for export but not import, each developer had to build their own translators to Ontolingua and KIF

• New tools for ontology construction
  – have created their own translators for different languages

Conclusions

– Problem of translation has not been addressed in an integrated way. Integrated means:
  • examine in depth all the problems that appear in translations
  • propose theoretical solutions to these problems
  • simultaneously provide technological solutions to solve the problems

– No current proposal addresses the problem of the loss of information in translation
Ontology: applications

• Knowledge Management
  – integration of heterogeneous, distributed and semi-structured information resources

• Electronic Commerce
  – business relationships (buy/sell) between business entities (especially B2B)
  – places such as Yahoo organize your content into categories to help users to navigate
  – the United Nations Standard of Products and Services Code <http://www.unspsc.ORG/> contains a taxonomy that organizes products and services to facilitate transactions between B2B sites that agree with the vocabulary defined there (ontological commitment)

Aplicações de Ontologias

• Intelligent Information
  – Search engines like Google and AltaVista use ontologies to implement semantic queries that improve the classic search by keyword.

• Natural Language Processing
  – Ontologies like WordNet are used to represent grammatical structures that allow to perform semantic analysis of texts by reducing the ambiguity of natural language semantics.
  http://www.cogsci.princeton.edu/~wn/

• Enterprise Modelling
  – Ontologies support the organizational memory of an enterprise, that allows the interoperation of departments/areas by using a common vocabulary and pre-defined rules. Examples of these ontologies can be found in TOVE and The Enterprise Ontology.
Conclusions

There is a need to work on creating tools that facilitate:

- Ontology development throughout all the life cycle, including: integration, merging, reengineering, content evaluation, translation into different languages and formats, and content exchange with other tools

- Ontology management: configuration and ontology evolution management

- Ontology support: schedule, documentation, advanced techniques for viewing the contents of the ontology, etc.

- Methodological support for building ontologies

Some bibliography


Some bibliography

Some bibliography


Ontology

- Common and shared understanding about a domain
- Agents can use ontologies that are not exactly equal to represent their vision of the domain

- Institutional Ontology
  - defines a business vocabulary to be used by all agents
  - includes: Concepts, AgentActions, Predicates
Interoperability problem

- In a decentralized and distributed environment, interoperability refers to how the communication takes place between humans and software agents.

- Ontologies are developed by different and heterogeneous people and continue to evolve over time.
Ontology services

In solving the interoperability problem in e-commerce, particularly in B2B transactions, some ontology services are particularly useful:

- Definition of attributes’ dependencies for each product
- Translation of terms between two ontologies for the same domain
- Conversion of values (eg different metrics)
- Report on mandatory or different attributes that are under negotiation

Ontology-based Services Agent

present in the Electronic Institution

Ontology Services Agent (OSAg)

- The Electronic Institution integrates (among others) an Ontology–based Services Agent (OSAg)

- OSAg offers the following services:
  - Matching terms
  - Conversion of units

- Matching terms
  - when an agent does not understand the contents of a message
  - based on lexical and semantic similarity measures
    - comparison of attributes, relationships between concepts, and concepts descriptions
Matching terms (OSAg)

• Syntactic Similarity between attributes
  – Calculates a comparison value “3-gram”
  \[ \frac{\sum_{i=1}^{n} \max_{j} r_{n-grams}}{n} \]
  for each data type: string, integer, float, boolean, has-part

  \[ \text{Maxi} \] is the maximum of all comparison results that exist for one attribute type

• Syntactic Similarity between descriptions
  – Only used the most representative words
  – A “3-grams” matrix is calculated between each word of description
  – is used the formula \( r_{n-grams} \)

Matching terms (OSAg)

• Semantic Similarity
  – Semantic Similarity mesure LCH (Leacock-Chodorow), based on “WordNet”
  – \[ \frac{\sum_{i=1}^{n} \text{result method}_i \times \text{weighting}_i}{3} \]

• Final Similarity value
  – weak correspondence (0.55 – 0.59)
  – approximate correspondence (0.6-0.69)
  – strong correspondence (0.7 – 1.0)
Ontologia

- Ontology Services
  - Institutional ontology defines a business vocabulary
  - Ontology-based Services Agent solves the interoperability problem