prolog 2007:
Introduction to Knowledge Engineering
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That's Trondheim ...

Outline
• World Wide Web
• Web 2.0
• Semantic Web
• Data, Information, and Knowledge
• XML and OWL
• Ontologies in Practice
• Conclusions
World Wide Web

- Integration of different data types and services
- Simple and freely available standards and protocols
- Client-server architecture or peer to peer
- Compatible upgrades by W3C (World Wide Web Consortium)
- ICANN (Internet Corporation for Assigned Names and Numbers) coordinates the unique identifiers (domain names, IP addresses, etc.)
- Platform independent
- Decentralized resources (hardware and software)

World Wide Web

- Encryption and secure connections
- Free tools for authoring, searching, communicating, etc.
- Integration of text, links, pictures, audio and video files, etc.
- Hypertext using HTML - Layout (Hypertext Markup Language)
- Simple elements called tags

\[ <A \text{ HREF="... "} \ldots \text{ </A}> \]

- Spam
- Security and privacy problems
- Energy intensive
- Currently over 80% of the world population cannot access the WWW
- Author or user?
- Web content for humans

Internet Penetration by World Region

- North America
- Australia/Oceania
- Europe
- Latin America
- Asia
- Middle East
- Africa
- World Avg.
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Web 2.0

- First Web 2.0 conference was held October 5-7, 2004 in San Francisco
- Services like weblogs, social bookmarking, wikis, etc.

Social Bookmarking

- Keep links to your favorite articles, blogs, music, reviews, recipes, and more, and access them from any computer on the web.
- Share favorites with friends, family, coworkers, and the del.icio.us community.
- Discover new things. Everything on del.icio.us is someone’s favorite -- they’ve already done the work of finding it. So del.icio.us is full of bookmarks about technology, entertainment, useful information, and more.
Social Bookmarking

Tags
One-word descriptors;
Assign them to your bookmarks;
Similar to keywords but non-hierarchical;
Assign as many tags to a bookmark and rename or delete them later;
Tagging is easier and more flexible than using categories or folders.

Feedback from a user
"Feedback is immediate. As soon as you assign a tag to an item, you see the cluster of items carrying the same tag. If that’s not what you expected, you’re given incentive to change the tag or add another ... you can adapt to the group norm, keep your tag in a bid to influence the group norm, or both."

Folksonomy
The emerging category structure that results from the combination of a large number of users tagging resources for their own use.
Social Bookmarking

From Folksonomy to Taxonomy ...

Websites like Yahoo! organize and present links in a fixed hierarchy (taxonomy)

Taxonomy directed folksonomies: Text analysis of the website using a lexical database like WordNet

- English nouns, verbs, adjectives and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept with 206941 word-sense pairs.
- Synsets are interlinked by means of conceptual-semantic and lexical relations resulting in a network of meaningfully related words and concepts.
- WordNet is also freely and publicly available (http://wordnet.princeton.edu/)
- Tags could be suggested by using the lexical database

Using folksonomies to create simple ontologies

- Examine which tags are used in combination to estimate the relations among these tags
- Map the tags to a lexical database
- Learn additional relations based on the tag clouds and the lexical database

Semantic Web

The Semantic Web is a vision for the future of the Web [...] information is given explicit meaning, [...] machines automatically process and integrate information available on the Web.

If machines are expected to perform useful reasoning tasks on these documents, the language must go beyond the basic semantics of RDF Schema.

Requirements for Ontology Languages

Ontology languages allow users to write explicit, formal conceptualizations of domain models.

The main requirements are:

- a well-defined syntax
- efficient reasoning support
- a formal semantics
- sufficient expressive power
- convenience of expression

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• Class membership
  If \( x \) is an instance of a class \( C \), and \( C \) is a subclass of \( D \),
  then we can infer that \( x \) is an instance of \( D \).

• Equivalence of classes
  If class \( A \) is equivalent to class \( B \), and class \( B \) is equivalent to class \( C \),
  then \( A \) is equivalent to \( C \), too.

Reasoning About Knowledge in Ontology Languages

Reasoning support is important for...
... checking the consistency of the ontology and the knowledge.
... checking for unintended relationships between classes.
... automatically classifying instances in classes.

Checks like the preceding ones are valuable for...
... designing large ontologies, where multiple authors are involved.
... integrating and sharing ontologies from various sources.

Semant Web Application FOAF

The Friend of a Friend (FOAF) project:

• is creating a Web of machine-readable pages describing people, the links between them and the things they create and do
• applies simple technology that makes it easier to share and use information about people and their activities (eg. photos, calendars, weblogs)
• FOAF uses W3C's RDF technology to integrate information from your home page with that of your friends, and the friends of your friends, and their friends...
• FOAF-a-matic is a simple Javascript application that allows you to create a FOAF ("Friend-of-A-Friend") description of yourself
• Make file publically accessible (foaf.rdf) and link it on your website

Reasoning in Practice

Reasoning About Knowledge in Ontology Languages

ML
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Definitions

- Data
  "input signals to sensory and cognitive processes"
- Information
  "data with an associated meaning"
- Knowledge
  "the whole body of data and information together with cognitive machinery that people are able to exploit to decide how to act, to carry out tasks and to create new information"
### Examples

- Some pieces of data
  - `a := 15`
  - `b := "Huber"`

- A piece of information
  - `<region ref="CentralCoastRegion"/>

- A piece of knowledge
  - `<owl:equivalentClass id="ConsumableThing"/>
  - `<owl:equivalentClass id="NonConsumableThing"/>
  - `<owl:complementOf rdf:resource="#ConsumableThing"/>

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### XML

- `<?xml version = "1.0"?>
  <buecher schlagwort = "semantic web">
    <buch>
      <titel>Visualizing the Semantic Web</titel>
      <isbn>1-85233-576-9</isbn>
      <ed>
        <vorname>Vladimir</vorname>
        <nachname>Geroimenko</nachname>
      </ed>
      <seiten>202</seiten>
      <photo filename = "vis_semweb.jpg" />
    </buch>
  </buecher>`

- `xmlns = "http://www.w3.org/1999/xhtml"`
From XML to OWL

- XML provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents.
- XML Schema is a language for restricting the structure of XML documents and also extends XML with data types.
- RDF is a data model for objects ("resources") and relations between them, provides a simple semantics for this data model, and these data models can be represented in an XML syntax.
- RDF Schema is a vocabulary for describing properties and classes of RDF resources, with a semantics for generalization-hierarchies of such properties and classes.
- OWL adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes.

**OWL Lite Constructs: Simple Classes and Individuals**

Simple Named Classes:
- Class
  - rdfs:subClassOf

Individual

Defining Properties:
- rdf:Property
  - subproperties:
    - owl:ObjectProperty
      (Instance - Instance)
    - owl:DatatypeProperty
      (Instance - rdfs:Literal / XML Schema datatypes)
  - rdfs:subPropertyOf
  - rdfs:domain
  - rdfs:range

Properties of Individuals

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Properties of Individuals
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An African Wildlife Ontology – Class Hierarchy

An African Wildlife Ontology – Schematic Representation

An African Wildlife Ontology – Properties

<owl:TransitiveProperty rdf:ID="is-part-of"/>
<owl:ObjectProperty rdf:ID="eats">
  <rdfs:domain rdf:resource="#animal"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="eaten-by">
  <owl:inverseOf rdf:resource="#eats"/>
</owl:ObjectProperty>
<owl:Class rdf:ID="plant">
    <rdfs:comment>Plants are disjoint from animals.</rdfs:comment>
    <owl:disjointWith="#animal"/>
</owl:Class>

<owl:Class rdf:ID="tree">
    <rdfs:comment>Trees are a type of plant.</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#plant"/>
</owl:Class>

<owl:Class rdf:ID="branch">
    <rdfs:comment>Branches are parts of trees.</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#tree"/>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#is-part-of"/>
            <owl:allValuesFrom rdf:resource="#branch"/>
        </owl:Restriction>
    </owl:Restriction>
</owl:Class>

<owl:Class rdf:ID="leaf">
    <rdfs:comment>Leaves are parts of branches.</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#branch"/>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#is-part-of"/>
            <owl:allValuesFrom rdf:resource="#branch"/>
        </owl:Restriction>
    </owl:Restriction>
</owl:Class>

<owl:Class rdf:ID="carnivore">
    <rdfs:comment>Carnivores are exactly those animals that eat also animals.</rdfs:comment>
    <owl:intersectionOf rdf:parsetype="Collection">
        <owl:Class rdf:about="#animal"/>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#eats"/>
            <owl:someValuesFrom rdf:resource="#animal"/>
        </owl:Restriction>
    </owl:IntersectionOf>
</owl:Class>
Herbivores are exactly those animals that eat only plants or parts of plants.

An African Wildlife Ontology – Herbivores

Giraffes are herbivores, and they eat only leaves.

An African Wildlife Ontology – Giraffes
Lions are animals that eat herbivores.  

Plants eaten both by herbivores and carnivores.
What problem would emerge if we replace `owl:someValuesFrom` by `owl:allValuesFrom` in the definition of carnivores?

Please enter your conclusions ...

- Verwenden Sie Web 2.0 Tools?
- Hatten Sie schon mal mit Semantic Web zu tun?
- Könnte Ihnen eine Ontologie, die Wissen über das Studium und die Technische Universität zur Verfügung stellt, nützlich sein?
- Wenn Sie ein Semantic Web Tool entwickeln würden, welches fänden Sie nützlich und interessant?