Ontologies, the semantic web and RDF

Lecture 2 at Masaryk University

Nils Pharo

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Content

- bibliographic languages
- document languages and work languages
- subject languages - the LIS way
- ontologies - the CS way

An ontology is an explicit specification of a conceptualization.

What does this mean?

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Bibliographic languages

Document languages

– "A document is a particular space-time embodiment of information: a document language describes and provides access to this embodiment." (p. 107)

Work languages

– "describe information entities, their intellectual (as opposed to physical) attributes, and relationships among them." (p. 87)

Svenonius (2000). The Intellectual Foundation of Information Organization

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Document languages

- Production language
- Carrier language
- Location language

Purpose of document languages

- for describing the material embodiment - the manifestation of the work
  - its physical and carrier attributes
  - its publication attributes
  - its external access attributes

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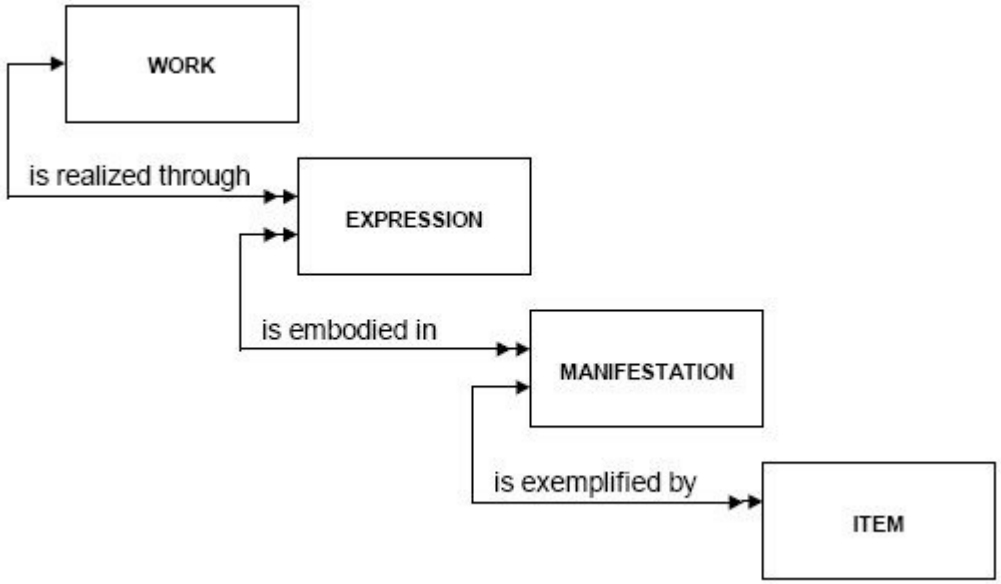
FRBR



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Work languages

- Author languages
- Title languages
- Edition languages
- Subject languages
  - Classification languages
  - Index languages

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Author, title and edition languages

- controlled and uncontrolled vocabularies
- normalized name forms for authority files
- uncontrolled names for descriptive cataloging

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Subject languages

- organized with respect to semantic strongness
  - "free keywords"
  - keyword lists
  - taxonomies
  - thesauri
  - faceted classification

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Keyword lists

- the most primitive form of controlled vocabulary
  - biology
  - horses
  - primates
  - psychology
  - wars

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Taxonomy

- hierarchical keyword list where terms are organized as subtypes/supertypes

- Animals
  - Cats
  - Dogs
  - Horses

- Food
  - Bread
  - Butter
  - Vegetables

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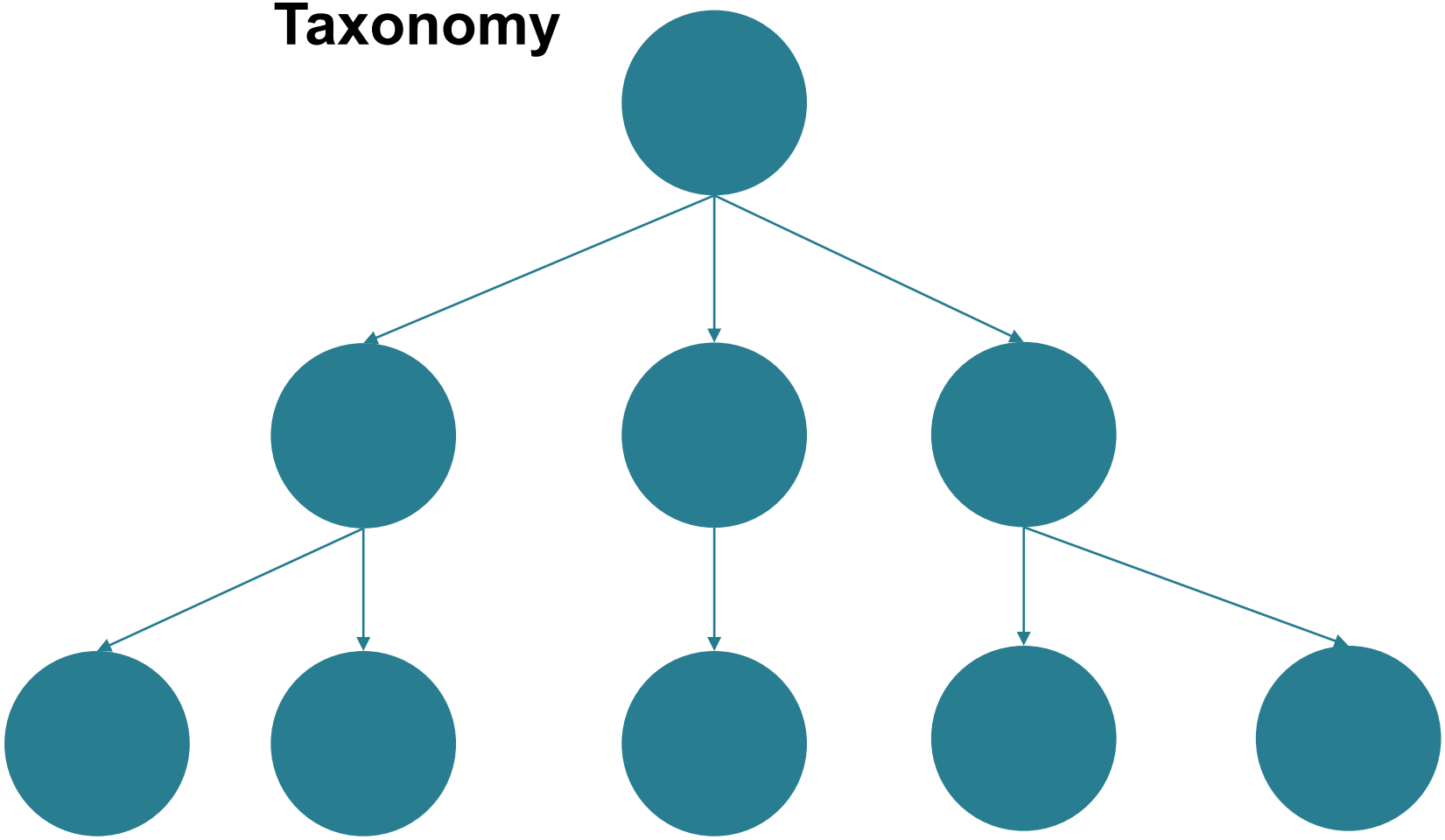
Taxonomy



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Thesauri

CHEFS

- UF Cooks
- BT Catering personnel
- RT Food preparation

Aitchison, Gilchrist & Bawden (2000). Thesaurus construction and use: a practical manual. (p. 164)

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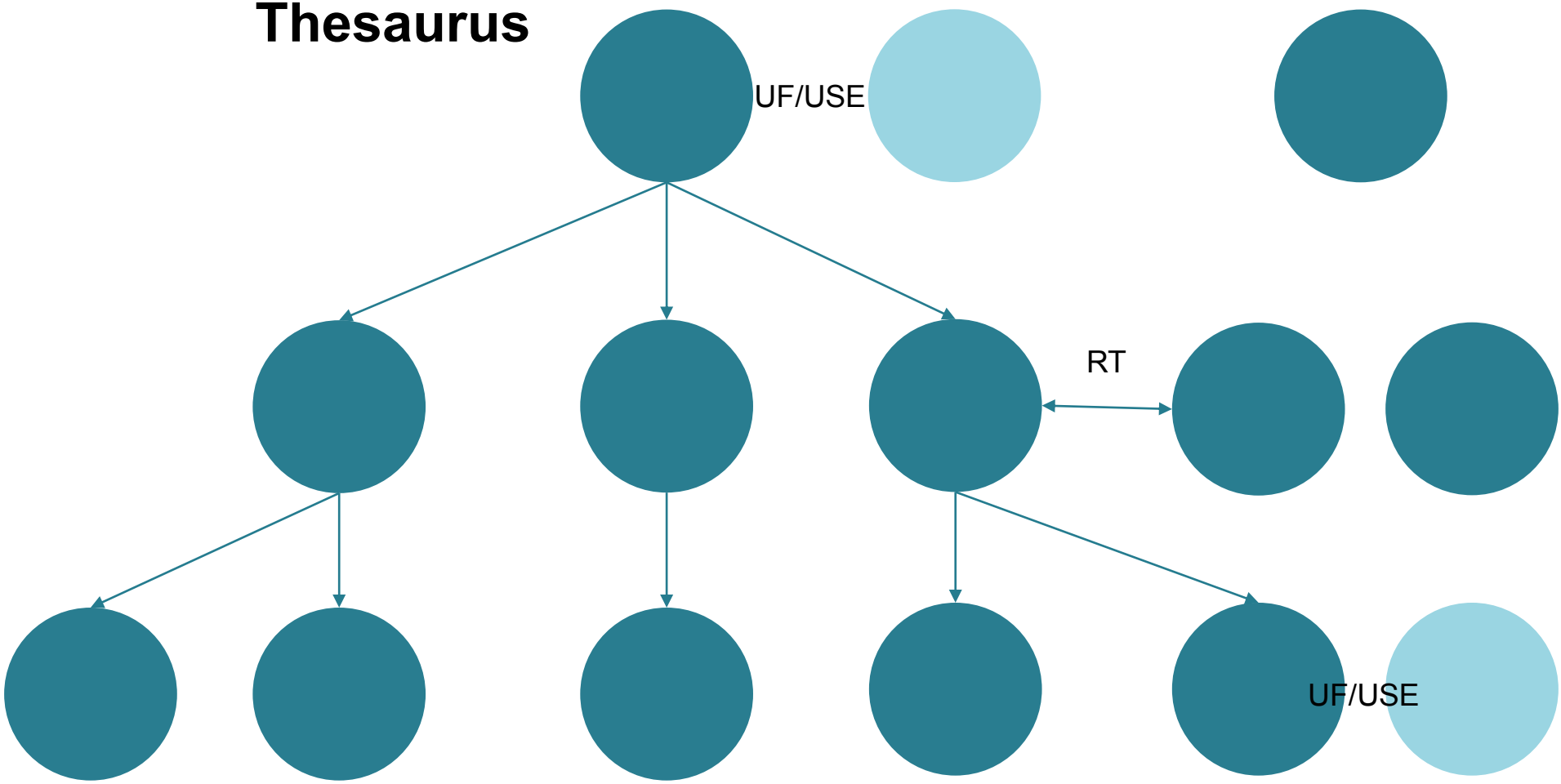
Thesaurus



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Thesaurus construction rules

- three types of relationships: hierarchical, equivalence and associative
- scope notes are used to provide definitions, restrict use, clarify content of term etc
- standards (ISO 2788 and ISO 5964) that prescribe the implementation of the relationships
- recommendations for what associative relationships to be realised

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Facetted classification

- Wine
  - by region
    - France
    - Germany
    - Italy
  - by colour
    - Red
    - White
    - Rose
  - by price
    - less than 100 NOK
    - between 100 and 200 NOK
    - more than 200 NOK

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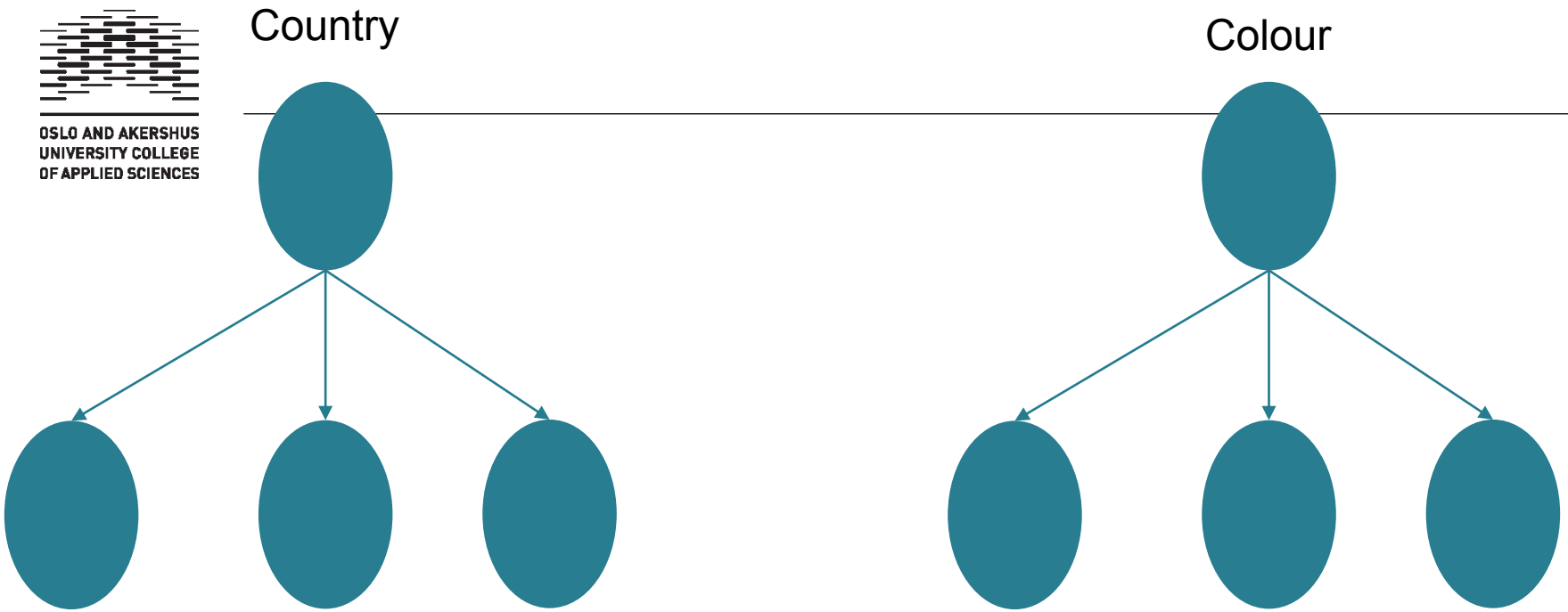

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Charateristics of facetted classification

- no "standard"
- guidelines, e.g. Spiteri (1998). A simplified model for facet analysis
- Ranganathan's Colon classification

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Enter ontologies

- Original definition (from philosophy): the branch of metaphysics dealing with the nature of being.

- Adapted by computer scientists to facilitate artificial intelligence: "An ontology is an explicit specification of a conceptualization.[...] For AI systems, what "exists" is that which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse." Gruber (1993). Toward Principles for the Design of Ontologies Used for Knowledge Sharing

Ontologies

- Eye
  - Synonym:
    - Orbital part of face
    - Orbital region
  - Part:
    - Upper eyelid
    - Lower eyelid

From: Digital Anatomist Foundational Model of Anatomy ontology

Domain ontologies and top ontologies

- Domain ontologies models a specific domain, e.g. the human body, libraries, bread etc.
- Top ontologies describe concepts that are sharable across many domains.

Ontology components

- instances (individuals, entities, things)
- classes (types)
- properties (attributes, characteristics)
- relationships (relations)
- rules and constraints

Classes and instances

- instances represent concrete individuals or objects
- classes represent the collection of objects or individuals
- classes may contain other classes

Nils Pharo is an instance of the class person

Properties

used to denote aspects of the classes, instances and relationships

- <has a name> Fido
- <has a value> $1000
- <has an age> 5 years
- <has breed> boxer
- <has domain>
- <value range>
- <has an identifier>
- etc.

Relationships

specify how objects are related to other objects in the ontology, the most prominent being

- hierarchical superclass/subclass-relationships
  - dog <is a subclass of> mammal
- part-relationships
  - tail <is part of> dog

However, other forms of hierarchical relationships as well as relationships representing associative relations can be implemented

The structure of ontologies

- a hierarchical basic structure
- properties can be inherited
  - from superclass to subclass
  - Mammal *has hair*
  - Dog *has hair*
- instances can belong to multiple classes
  - Fido <is a> dog
  - Fido <is a> brown thing

Rules and constraints

to secure against illogical inferences, specify cardinality, and clarify the kinds of statements than can be used for specific classes, e.g.

- an animal cannot be both a carnivore and a herbivore
- an employee needs to be at a certain level of authencity to get access to high-security information
- a month cannot have more than 31 days

Purpose of ontologies

- model (a restricted part of) the world
- to make it possible for computers to infer things about the world
  - needs to be explicit!
- Open world assumption; a statement may be true irrespective of whether or not it is known to be true (Wikipedia article)

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Ontology questions

- how to model?
- are instances part of the ontology?
- what is the appropriate level of abstraction?
- what do the classes/instances refer to?

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Ontologies compared to old knowledge organization systems

- more flexible
- less standardized

- solution for merging and sharing
- solutions for identity

Ontology standard languages

- Topic maps (ISO)
- RDF/OWL (W3C)

Group work

– Create a simple ontology on a topic of your own choice!

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Content

- the semantic web
- why do we need it?
- the RDF standard
- interoperability recapitulated
- the data silo problem
- linked data

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The semantic web

"The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF)." (http://www.w3.org/2001/sw/)

Challenges for the World Wide Web

The current Web is challenged on several areas

– too much noise
– internal systems with bad communication capabilities (data silos)
– large costs of communication

The noise problem

– more sophisticated IR-systems might help a bit
– needs more sophisticated mark-up

e.g.

Cantilever bridge

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Internal systems problem

- difficult to share data
- difficult to compare data
- difficult to reuse data

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Costs of communication

End-users need to

- collect
- interpret
- compare
- connect

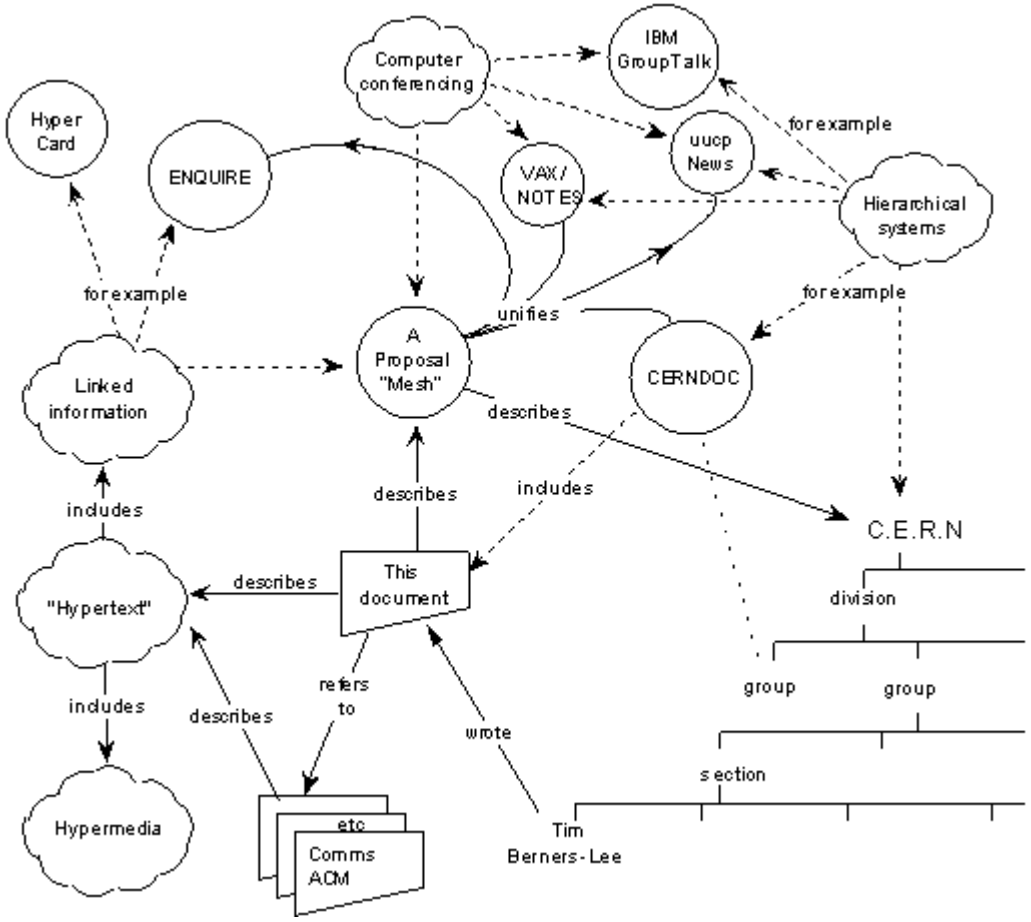
information themselves

Is the semantic web the solution?

- partial solution
- problem/domain dependent

The web for computer applications

- the SW is not intended to be interpreted by humans
- data semantically marked up and structured to be processed by intelligent agents
- SW is an extension of the Web
- SW is a web of data



– From [Tim Berners-Lee's 1989] proposal

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Ontologies, modelling domains for the semantic web

"An ontology is an explicit representation of a conceptualization" (Gruber, 1992)

- concepts and concretes modelled as classes (man)
- relationships (<is a> mammal)
- properties (<has name>
- constraint rules

to provide a: "shared and common understanding of a domain that can be communicated between people and application systems" Towards the semantic web, 2003

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Technologies for developing the semantic Web

W3C standard technologies

- XML
- RDF
- RDF Schema (RDFS)
- OWL (Web Ontology Language)

XML

– XML represents internal metadata to the item/document

Example: <author>Tim Berners-Lee</author>

RDF

- W3C standard (recommendation, 22.02.99)
- http://www.w3.org/RDF
- semantic Web - http://www.w3.org/2001/sw/
- tool for embedding metadata in digital documents

RDF describes

- things (subjects)
- properties (predicate)
- values (objects)

preferably identified by URIs

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Domain independent

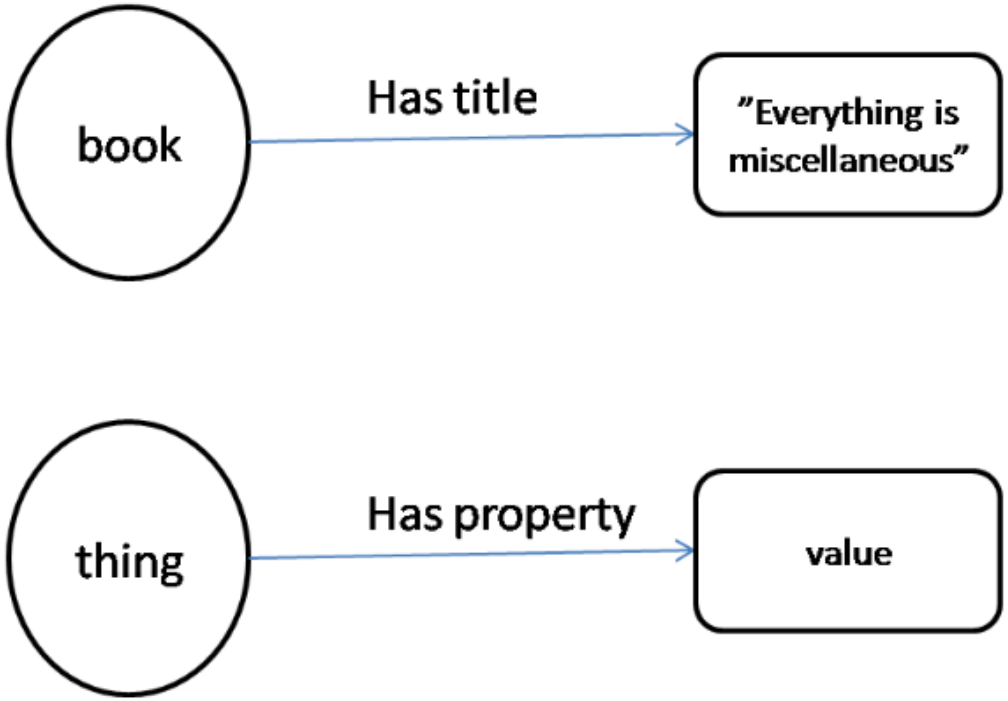
- RDF is a domain independent data model
- RDF describes triples representing things that have properties with values

<thing>Nils Pharo <property> is a teacher of <value> Digital knowledge organization

Relational database model

Books		
Isbn	**Author**	**Title**
1-932394-20-6	Thomas B. Passin	Explorer's guide to the Semantic Web
0-262-19433-3	Elaine Svenonius	The intellectual foundation of information organization
0-8050-8043-8	David Weinberger	Everything is miscellaneous

RDF model


book
Has title
"Everything is miscellaneous"
thing
Has property
value

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RDF example

http://www.jbi.hio.no/bibin/dig_korg/sem_web.htm has a **creator** whose value is **Nils Pharo**

In RDF/XML syntax:

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
syntax-ns#"
xmlns:dc="http://purl.org/dc/elements/1.1/">
<rdf:Description
rdf:about="http://www.jbi.hio.no/bibin/dig_korg/sem_web.htm
">
<dc:Creator>Nils Pharo</dc:Creator>
</rdf:Description> </rdf:RDF>
```

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Bibliographic RDF example

```
<?xml version="1.0"?>
<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:dc="http://purl.org/dc/elements/1.0/"
xmlns:rev="http://en.wikipedia.org/wiki/Book_review">
<rdf:Description
rdf:about="http://www.oreilly.com/catalog/9780596527341/">
<dc:title>Information Architecture for the World Wide
Web</dc:title>
<dc:creator>Peter Morville</dc:creator>
<dc:creator>Louis Rosenfeld</dc:creator>
<dc:publisher>O'Reilly</dc:publisher>
<dc:date>2006</dc:date>
<dc:language>en</dc:language>
<rev:review rdf:resource="http://www.digital-
web.com/articles/information_architecture_for_the_world_wide_web_3r
d_edition/"/>
</rdf:Description>
</rdf:RDF>
```

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Bibliographic example 2

```
<rdf:Description rdf:about="http://www.digital-
web.com/articles/information_architecture_for_the_world_wid
e_web_3rd_edition/">
<dc:title> A review of Information Architecture for the
World Wide Web, 3rd edition</dc:title>
<dc:creator>Lee McKusick</dc:creator>
<dc:publisher>PenLUG</dc:publisher>
<dc:date rdf:datatype=
"http://www.w3.org/2001/XMLSchema#date">2006-23-
12</dc:date>
<rev:review_of
rdf:resource="http://www.oreilly.com/catalog/9780596527341/
"/>
</rdf:Description>
</rdf:RDF>
```

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Notation 3

A simpler syntax for human readiability

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-
ns#"
xmlns:dc="http://purl.org/dc/elements/1.1/">
<rdf:Description
rdf:about="http://www.jbi.hio.no/bibin/dig_korg/sem_web.htm">
<dc:Creator>Nils Pharo</dc:Creator>
<dc:Subject>Semantic Web</dc:Subject>
</rdf:Description> </rdf:RDF>
```

equals:

```
<@prefix dc: <http://purl.org/dc/elements/1.1/>.
<@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
<http://www.jbi.hio.no/bibin/dig_korg/sem_web.htm> dc:Creator
"Nils Pharo" ;
dc:Subject "Semantic Web" .
```

RDF describes instances

The rdf:type property can be used to state that a resource is an instance of a class

- RDF schema is a simple ontology language
- OWL is a full ontology language

RDF schema

- RDF schema is used for defining RDF terminologies
- RDF schema is a type system for RDF
- RDF schema makes semantic information machine-accessible
- RDF schema is a simple ontology language

Example: the statement "Nils Pharo is a teacher of Digital knowledge organization" can be used to deduce that "Nils Pharo is a member of the academic staff" and that "Nils Pharo is involved with Digital knowledge organization"

key components: class, subclass relations, property, subproperty relations, domain and range constraints

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RDFS example

```
<?xml version="1.0"?>
<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xml:base="http://example.org/staff#">
<rdf:Description rdf:ID=”Employee">
<rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-
schema#Class"/>
</rdf:Description>
<rdf:Description rdf:ID=”Teacher">
<rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-
schema#Class"/>
<rdfs:subClassOf rdf:resource="#Employee"/>
</rdf:Description>
</rdf:RDF>
```

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RDFS example 2

```
<?xml version="1.0"?>

<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xml:base="http://example.org/staff#">
<rdfs:Class rdf:ID=”Employee" />

<rdfs:Class rdf:ID=”Teacher">
  <rdfs:subClassOf rdf:resource="#Employee"/>
</rdfs:Class>
<rdf:Property rdf:ID=”employedBy”/>
</rdf:RDF>
```

RDFS example 3 (Notation 3-format)

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema# >.
@prefix rdf: < http://www.w3.org/1999/02/22-rdf-syntax-ns#
>.
<http://example.org/staff#Employee> a rdfs:Class .
<http://example.org/staff#Teacher> a rdfs:Class ;
rdfs:subClassOf <http://example.org/staff#employee>
```

OWL -Web ontology language

- funded on DAML+OIL
- OWL is a richer ontology language than RDF schema
- 3 versions supporting different levels of complexity; Full, DL, and Lite

can be used to specify that: "academic staff members must teach at least one course" or "every book must have a title"

OWL elements

- OWL uses RDF, RDF schema and its own terminology to define ontologies:
- Web Ontology Language: OWL by Grigoris Antoniou and Frank van Harmelen which includes an example of an OWL-defined ontology
- W3 org's OWL guide

Assignment

Model the hierarchical parts of the ontology you constructed previously with the use of RDF and RDFS