Patterns for thesaurus conversion to RDF/OWL

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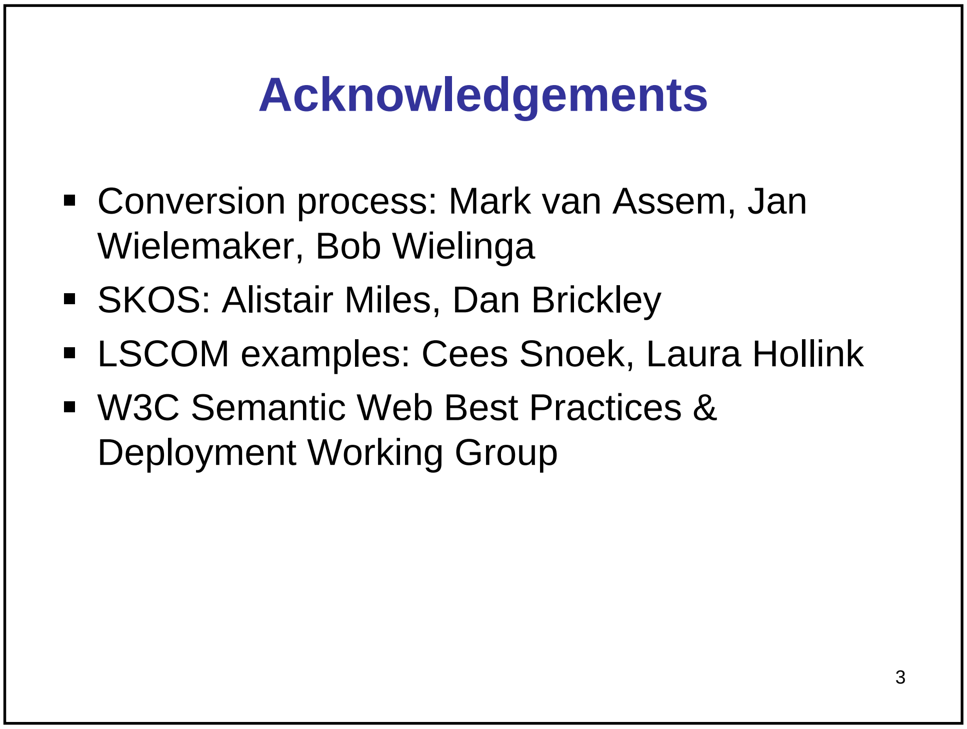
Overview

- Thesauri and thesauri standards
- Conversion process
  - – Example: Union List of Artist Names
  - – Example: WordNet 2.0
- SKOS model for thesauri
- Issues with respect to (adding) semantics



Acknowledgements

- Conversion process: Mark van Assem, Jan Wielemaker, Bob Wielinga
- SKOS: Alistair Miles, Dan Brickley
- LSCOM examples: Cees Snoek, Laura Hollink
- W3C Semantic Web Best Practices & Deployment Working Group

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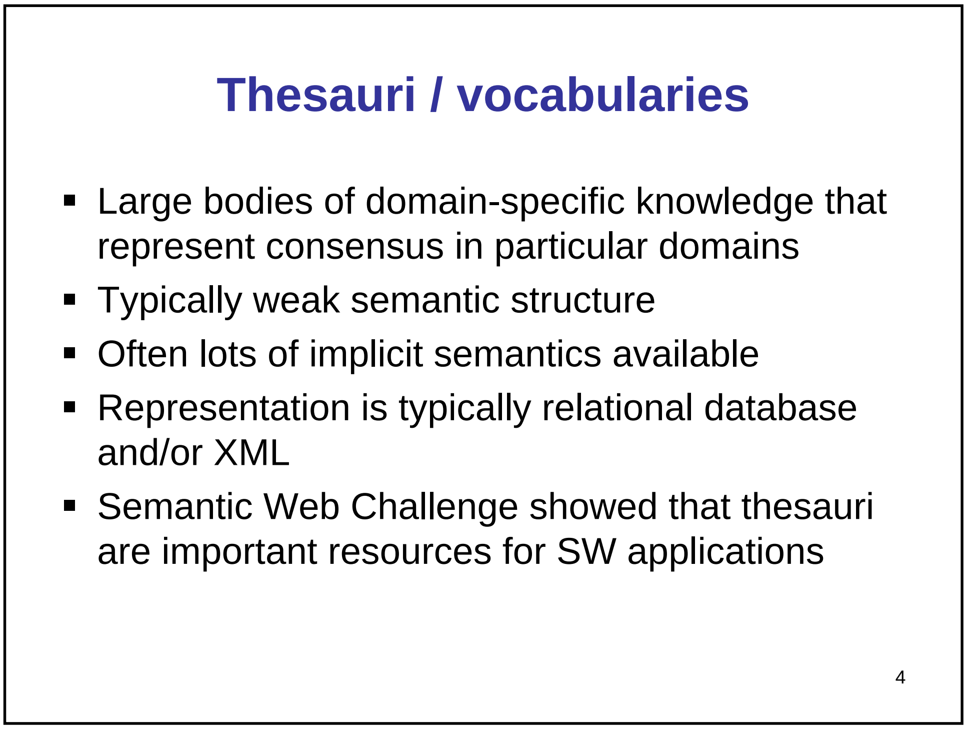

Thesauri / vocabularies

- Large bodies of domain-specific knowledge that represent consensus in particular domains
- Typically weak semantic structure
- Often lots of implicit semantics available
- Representation is typically relational database and/or XML
- Semantic Web Challenge showed that thesauri are important resources for SW applications

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Example thesauri

- Domain-specific vocabularies
  - Medicine: UMLS, SNOMED, Galen
  - Art history: AAT, ULAN
  - Geography: TGN
  - Food: AgroVoc,
- Generic vocabularies
  - Lexical vocabularies: WordNet, FrameNet
  - Units and dimensions,
  - Currencies, country codes, …

ISO standard for representing thesauri

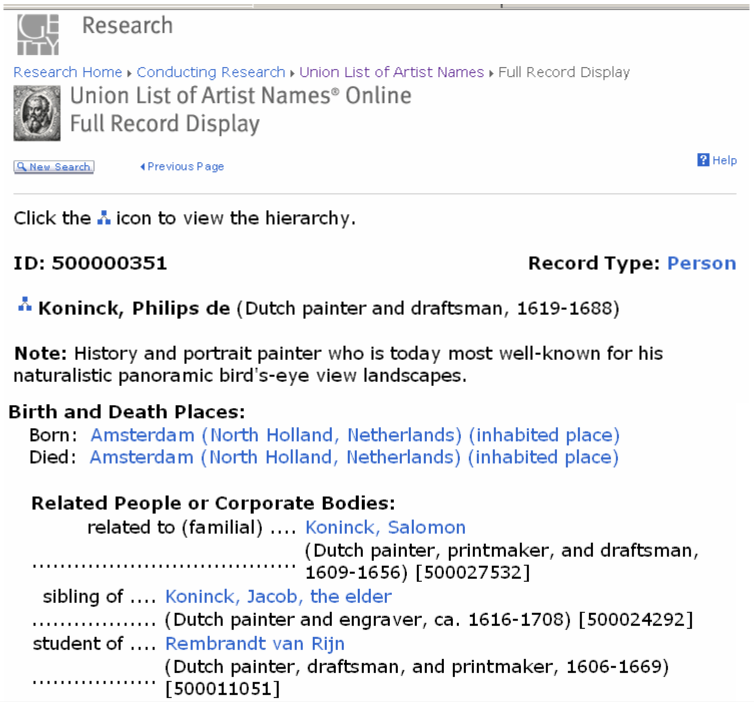
- Term
  - Preferred term (USE)
  - Non-preferred term (USED FOR)
- Hierarchical relation between terms
  - Broader/narrower term (BT/NT)
    - Generic
    - Partitive
- Association between terms (RT)

Conversion process

- Two steps
- Step 1: “As is” conversion
  - – Keep original names
  - – Make implicit semantics explicit (but this can be hard to determine)
  - – Decisions on whether to keep all information
- Step 2: adding semantics
  - – Separate file(s)
  - – Interpretation of thesauri elements, e.g. hyponym relation as **rdfs:subClassOf**
  - – May require (lots of) additional research

Example thesaurus: ULAN

- 300,000 entries
- Consists of records of “Subjects” (artists and art institutions), with biographical information (place/time birth/death) and relations to other artists (student-of, …)
- Large XML file with all data
- Basic representation:
  - – association links between subjects
  - – preferred/non-preferred terms relations between subjects and terms



Research

Research Home ▸ Conducting Research ▸ Union List of Artist Names ▸ Full Record Display

Union List of Artist Names® Online
Full Record Display

Click the icon to view the hierarchy.

ID: 500000351 **Record Type: Person**

Koninck, Philips de (Dutch painter and draftsman, 1619-1688)

Note: History and portrait painter who is today most well-known for his naturalistic panoramic bird's-eye view landscapes.

Birth and Death Places:
Born: Amsterdam (North Holland, Netherlands) (inhabited place)
Died: Amsterdam (North Holland, Netherlands) (inhabited place)

Related People or Corporate Bodies:
related to (familial) .... Koninck, Salomon
.... (Dutch painter, printmaker, and draftsman, 1609-1656) [500027532]
sibling of .... Koninck, Jacob, the elder
.... (Dutch painter and engraver, ca. 1616-1708) [500024292]
student of .... Rembrandt van Rijn
.... (Dutch painter, draftsman, and printmaker, 1606-1669) [500011051]

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XML fragment of ULAN

```
<Associative_Relationships>
  <Associative_Relationship>
    <Historic_Flag>NA</Historic_Flag>
    <Relationship_Type>
      1102/student of
    </Relationship_Type>
    <Related_Subject_ID>
      <VP_Subject_ID>500011051</VP_Subject_ID>
    </Related_Subject_ID>
  </Associative_Relationship>
</Associative_Relationship>
```

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Conversion issues

- XML and RDF/OWL are inherently different
  - XML = thesaurus document structure
  - RDF = thesaurus document content
- Redundant information in XML file

```
<Associative_Relationships>
<Historic_Flag>NA</Historic_Flag>
```

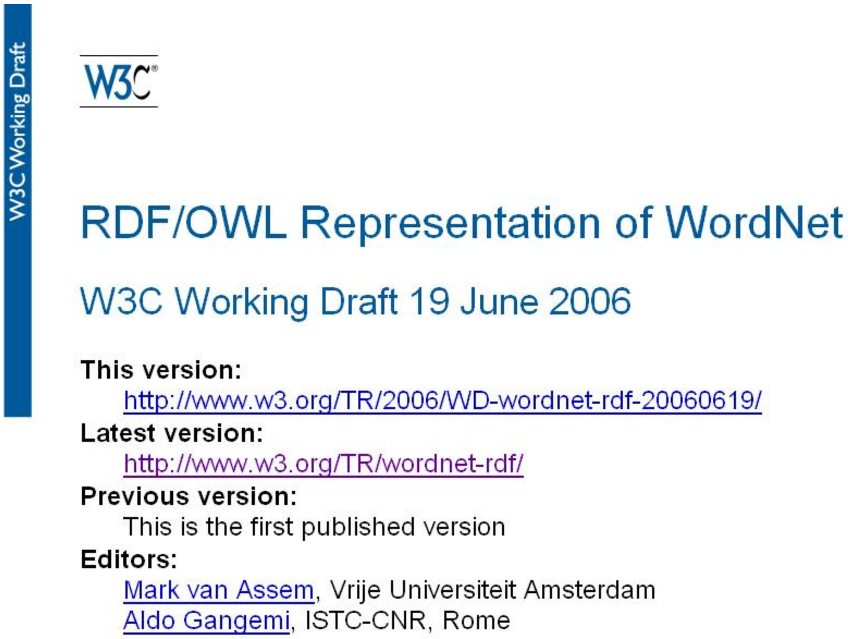
- How to represent “student of”?
  - Subproperty of **Associative_Relationship** is probably preferred
  - Needs to be derived from the data; not part of schema

XML fragment of ULAN (2)

```
<Non-Preferred_Term>
  <Term_Text>Koning, Philips Aertsz. de</Term_Text>
  <Term_ID>1500207734</Term_ID>
  <Display_Order>34</Display_Order>
  <Vernacular>Vernacular</Vernacular>
</Non-Preferred_Term>
```

Conversion issues

- Do we include all information in the conversion?
  - Display-order example
  - Source and revisions information
- Should each term have a URI?
- Making language explicit
  - “vernacular” means the string is written in the original language
  - Multi-linguality is an important issue for thesauri



RDF/OWL Representation of WordNet

W3C Working Draft 19 June 2006

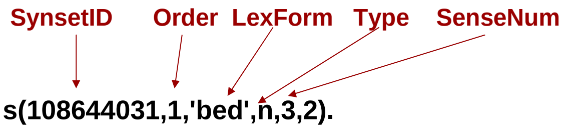
This version:
http://www.w3.org/TR/2006/WD-wordnet-rdf-20060619/

Latest version:
http://www.w3.org/TR/wordnet-rdf/

Previous version:
This is the first published version

Editors:
Mark van Assem, Vrije Universiteit Amsterdam
Aldo Gangemi, ISTC-CNR, Rome

WordNet: internal representation

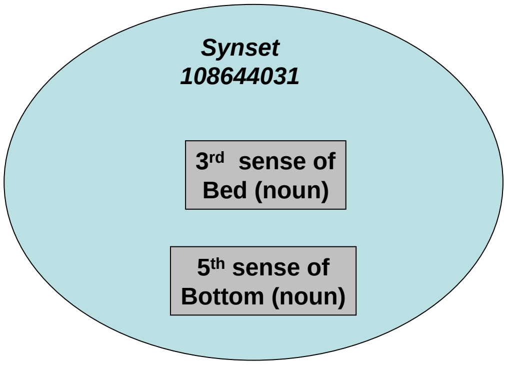


s(108644031,1,'bed',n,3,2).
s(108644031,2,'bottom',n,5,1).

s(102719813,1,'bed',n,1,51).
s(102720436,1,'bed',n,2,3).

g(108644031,'(a depression forming the ground under a body of water; "he searched for treasure on the ocean bed")').
g(102719813,'(a piece of furniture that provides a place to sleep; "he sat on the edge of the bed"; "the room had only a bed and chair")').
g(102720436,'(a plot of ground in which plants are growing; "the gardener planted a bed of roses")').

a depression forming the ground under a body of water; "he searched for treasure on the ocean bed


Synset 108644031

3rd sense of Bed (noun)

5th sense of Bottom (noun)

WordNet URI s

- What URIs should be chosen?
  - SynSet, WordSense, Word
- URI name:
  - ID? => difficult for human interpretation
  - Concatenated unique, human readable

wn:synset-bank-noun-2

First sense in synset denoted by second sense of “bank”

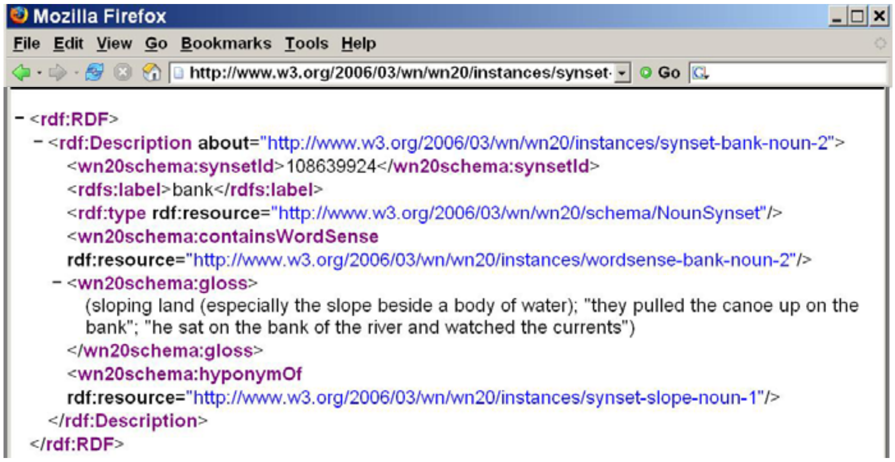
wn:wordsense-bank-noun-1
wn:word-bank

Implicit WordNet semantics

“The ent *operator specifies that the second synset is an entailment of first synset. This relation only holds for verbs. “*

- Example: [breathe, inhale] entails [sneeze, exhale]
- Semantics (OWL statements):
  - Transitive property
  - Inverse property: entailedBy
  - Value restrictions for VerbSynSet (subclass of SynSet)

Query for WordNet URI returns “concept-bounded description”

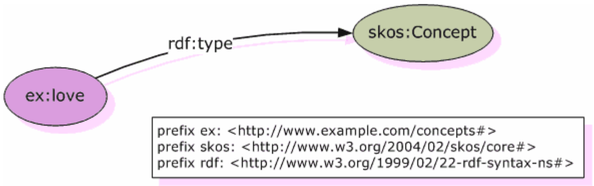

Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://www.w3.org/2006/03/wn/wn20/instances/synset·
Go

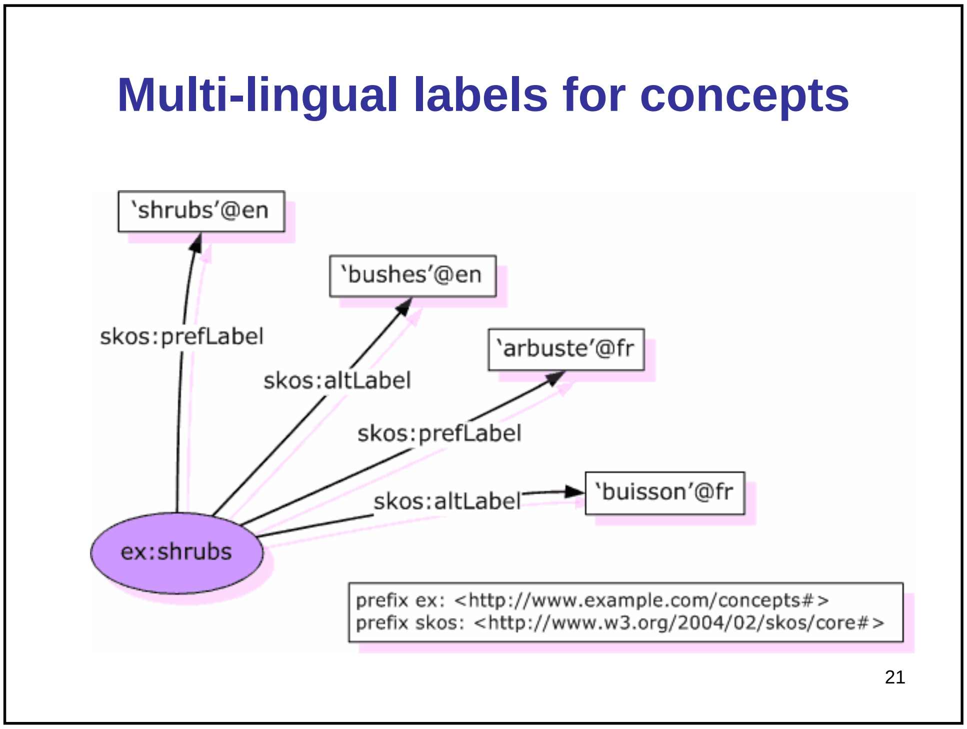
```
- <rdf:RDF>
  - <rdf:Description about="http://www.w3.org/2006/03/wn/wn20/instances/synset-bank-noun-2">
      <wn20schema:synsetId>108639924</wn20schema:synsetId>
      <rdfs:label>bank</rdfs:label>
      <rdf:type rdf:resource="http://www.w3.org/2006/03/wn/wn20/schema/NounSynset"/>
      <wn20schema:containsWordSense
      rdf:resource="http://www.w3.org/2006/03/wn/wn20/instances/wordsense-bank-noun-2"/>
    - <wn20schema:gloss>
        (sloping land (especially the slope beside a body of water); "they pulled the canoe up on the
        bank"; "he sat on the bank of the river and watched the currents")
      </wn20schema:gloss>
      <wn20schema:hyponymOf
      rdf:resource="http://www.w3.org/2006/03/wn/wn20/instances/synset-slope-noun-1"/>
    </rdf:Description>
  </rdf:RDF>
```

SKOS:
pattern for thesaurus modeling

- Based on ISO standard
- RDF representation
- Documentation:

  http://www.w3.org/TR/swbp-skos-core-guide/
- Base class: SKOS **Concept**


rdf:type
skos:Concept
ex:love
prefix ex: <http://www.example.com/concepts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>
prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>



Multi-lingual labels for concepts

ex:shrubs

skos:prefLabel

'shrubs'@en

skos:altLabel

'bushes'@en

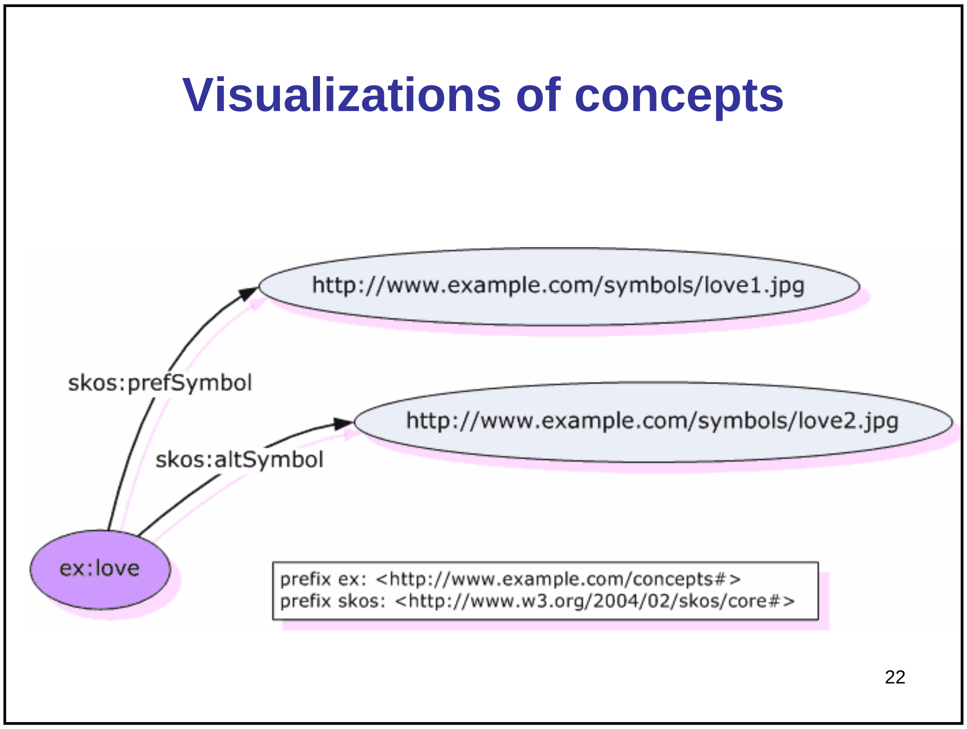
skos:prefLabel

'arbuste'@fr

skos:altLabel

'buisson'@fr

prefix ex: <http://www.example.com/concepts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>



Visualizations of concepts

ex:love

skos:prefSymbol

http://www.example.com/symbols/love1.jpg

skos:altSymbol

http://www.example.com/symbols/love2.jpg

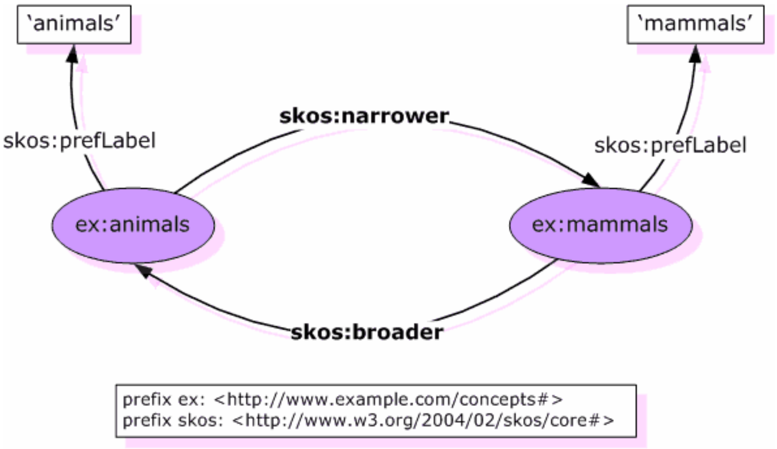
prefix ex: <http://www.example.com/concepts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>

Documenting concepts

```
skos:note
|
+-- skos:definition
|
+-- skos:scopeNote
|
+-- skos:example
|
+-- skos:historyNote
|
+-- skos:editorialNote
|
+-- skos:changeNote
```

Semantic relation:
broader and narrower

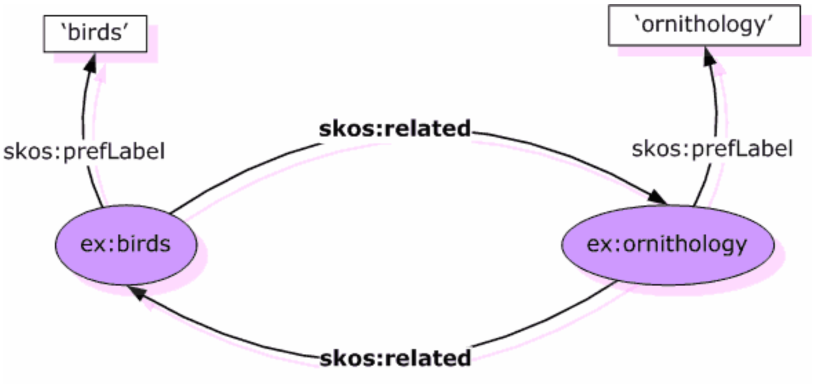
- No subclass semantics assumed!



prefix ex: <http://www.example.com/concepts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>

Semantic relations: related

- Symmetry is issue (OWL use)



'birds'

'ornithology'

skos:prefLabel

skos:related

skos:prefLabel

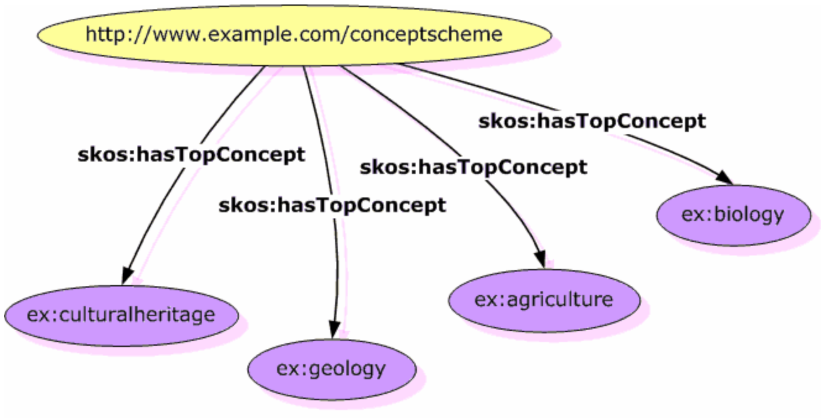
ex:birds

ex:ornithology

skos:related

```
prefix ex: <http://www.example.com/concepts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>
```

Defining the top level of the hierarchy



http://www.example.com/conceptscheme

skos:hasTopConcept

skos:hasTopConcept

skos:hasTopConcept

skos:hasTopConcept

ex:biology

ex:agriculture

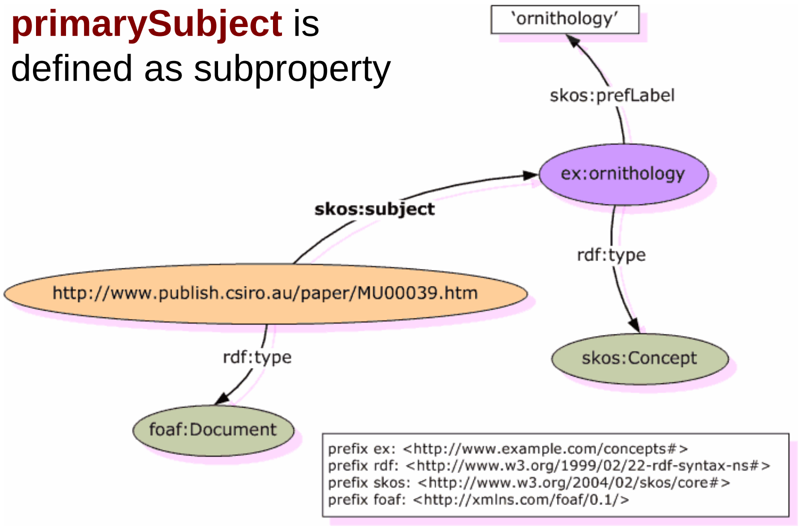
ex:culturalheritage

ex:geology

```
prefix ex: <http://www.example.com/concepts#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>
```

Indexing a resource with a SKOS concept

- **primarySubject** is defined as subproperty



```
prefix ex: <http://www.example.com/concepts#>
prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>
prefix foaf: <http://xmlns.com/foaf/0.1/>
```

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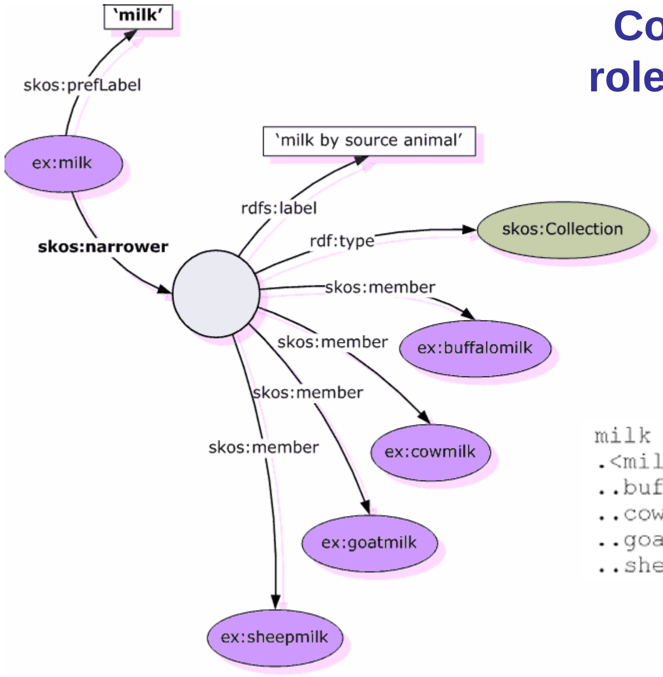
Collections: role-type trees



```
milk
.<milk by source animal>
..buffalo milk
..cow milk
..goat milk
..sheep milk
```

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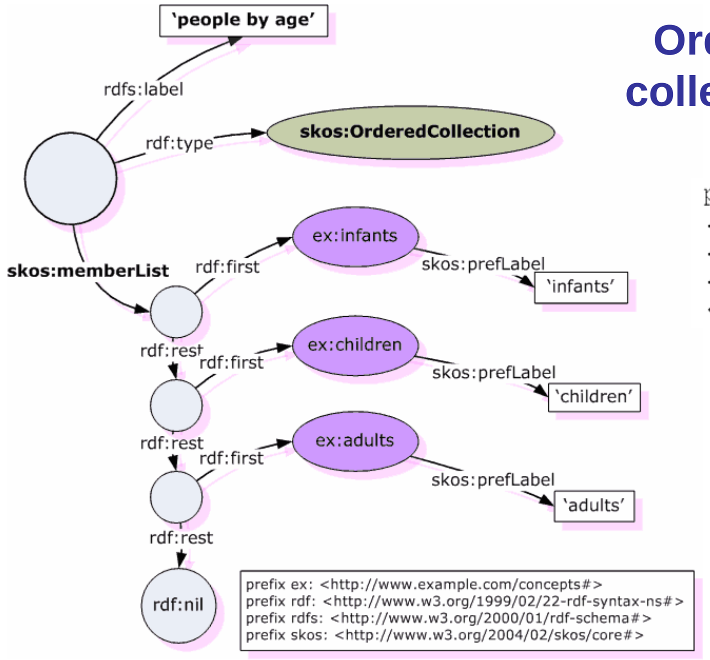
Ordered collections



```
prefix ex: <http://www.example.com/concepts#>
prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
prefix skos: <http://www.w3.org/2004/02/skos/core#>
```

```
people
.<people by age>
..infants
..children
..adults
```

Recipes for vocabulary URIs

- Simplified rule:
  - Use “hash" variant” for vocabularies that are relatively small and require frequent access

    http://www.w3.org/2004/02/skos/core#Concept
  - Use “slash” variant for large vocabularies, where you do not want always the whole vocabulary to be retrieved

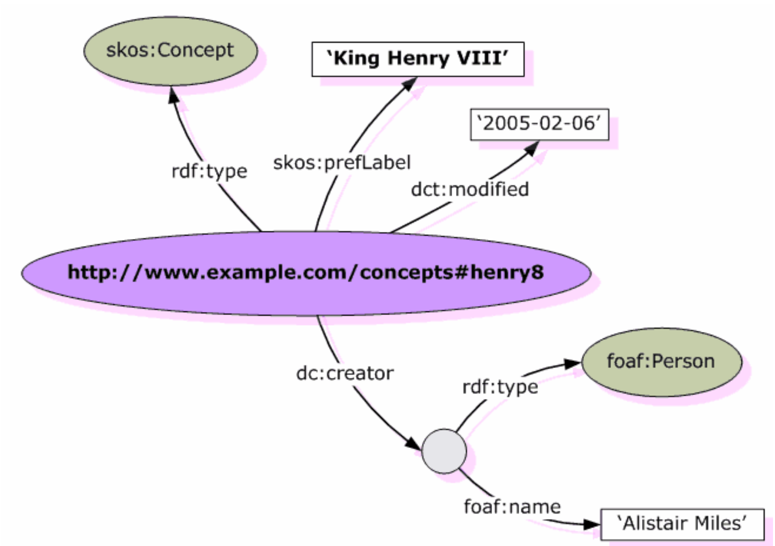
    http://xmlns.com/foaf/0.1/Person
- For more information and other recipes, see:

  http://www.w3.org/TR/swbp-vocab-pub/

Adding semantics

- Adding OWL statements
- Interpretations of thesaurus relations such as **narrower** as subclass-of are often imprecise (but can still be useful)
- Learning relations between thesauri is important form of additional semantics
  - Example: AAT contains styles; ULAN contains artists, but there is no link
  - Availability of this kind of alignment knowledge is extremely useful

SKOS semantics: concepts are not the real things



SKOS semantics inference rules (1)

- Collection membership rule

(?i skos:subject ?x) (?x skos:broader ?y)

-> (?i skos:subject ?y)

- If a painting of Van Gogh has as **subject SunFlowers** and if **Flowers** is a **broader** term of **SunFlowers**, then **Flowers** is also the **subject** of the painting.

SKOS semantics inference rules (2)

- Collectable property rule

(?x ?p ?c) (?c skos:member ?m)

(?p rdf:type skos:collectableProperty)

-> (?x ?p ?m)

- If **GoatMilk** is a member of the collection **<milk by source animal>,** and the latter is a **narrower** concept for **Milk**, and **narrower** is a **collectableProperty**, then **GoatMilk** is also a **narrower** concept of **Milk**
- **broader** and **related** are also collectable

Metamodelling for thesauri: should terms be classes or instances?

- Many thesauri have a inherent metamodeling aspects:
  - The structure of the thesaurus: concepts, relations
  - The actual terms also have a class flavor
- Engineers feel compelled to choose which level to represent as classes
  - Treating terms as classes looses the semantics of the structure-level model

    Sneeze is an instance of Verb
  - Treating terms as instances loses the semantics of term relations

    Bank is a subclass of FinancialInstitution

Metamodelling

- OWL DL requires strict separation of classes and instances
- But on the Semantic Web my instances may be your classes!
- Metamodelling features especially required in vocabulary/ontology mapping and/or interpretation
- Cf. Protégé metamodelling facilities
- OWL 1.1 (not standardized) allows limited metamodelling within OWL DL scope

Example: WordNet

```
Class(LexicalConcept)
 Class(Noun subClassOf(LexicalConcept))
 Property(hyponymOf
    domain(LexicalConcept)
    range(LexicalConcept))
 Individual(1000768 type(LexicalConcept)
    wordForm(Human))
```

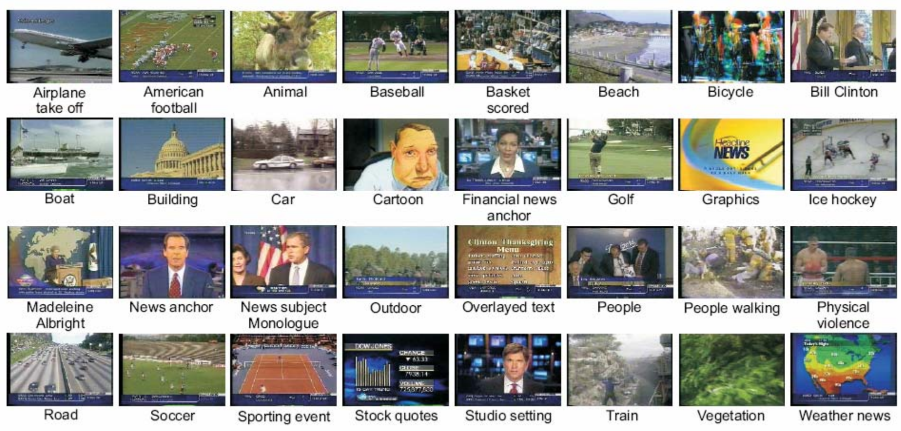
Problem: how to use the hyponym hierarchy as a subclass hierarchy?

RDF solution: use metamodelling

```
subClassOf(LexicalConcept Class)
subPropertyOf(hyponymOf subClassOf)
subPropertyOf(wordForm rdfs:label)
```

- Corresponds to our intuition that WordNet model is a metamodel

Concepts for video detectors (Snoek et al)



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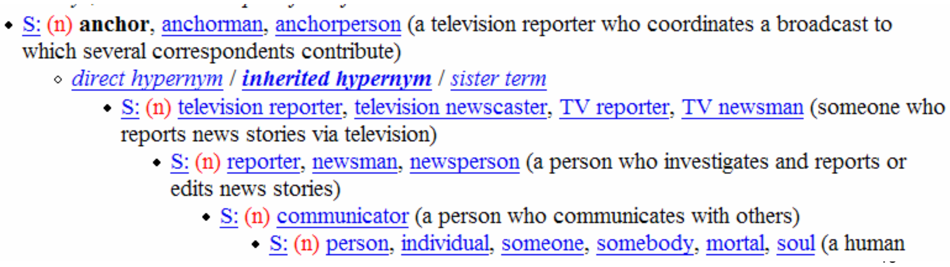
LSCOM lexicon: 110 – Female Anchor

- Composite concept
- Alignment needed with general resource to understand semantics



- S: (n) **anchor**, anchorman, anchorperson (a television reporter who coordinates a broadcast to which several correspondents contribute)
  - *direct hypernym* / ***inherited hypernym*** / *sister term*
    - S: (n) television reporter, television newscaster, TV reporter, TV newsman (someone who reports news stories via television)
      - S: (n) reporter, newsman, newsperson (a person who investigates and reports or edits news stories)
        - S: (n) communicator (a person who communicates with others)
          - S: (n) person, individual, someone, somebody, mortal, soul (a human

Issues

- Many thesauri do not have a rich semantic structure like WordNet
- Need for learning additional semantic relations between thesaurus concepts
- Result: “ontologizing thesauri”

New W3C work: Semantic Web Deployment Working Group

- Mission to help in vocabulary deployment
- Chartered to standardize SKOS

  Pattern for RDF/OWL representation of (ISO-compliant) thesauri
- Guidelines for adding semantics to existing vocabularies

http://www.w3.org/2006/07/SWD/