

Expressing Classification Schemes with OWL 2 Web Ontology Language

-- ISSUES AND OPPORTUNITIES

Marcia Lei Zeng
Kent State University

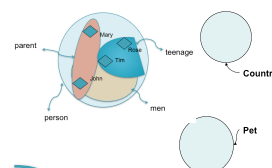
Michael Panzer
OCLC

Athena Salaba
Kent State University

ISKO-2010, Rome ©ZengPanzerSalaba

Considering basic functional requirements

- presenting listed classes
- sub-classifying existing classes (& basic types of relationship)
- describing built classes
- constructing classes from existing ones (define new classes)
- presenting and establishing more complicated kinds of relationships



Can be done with
many languages,
e.g., SKOS,
RDFs, OWL



ISKO-2010, Rome ©ZengPanzerSalaba

3. WHEN OWL MEETS CLASSIFICATION

- 3.1 OWL for complex class expressions
- 3.2 OWL axioms for relationships between class expressions
- 3.3 OWL properties and restrictions for more complicated class expressions and relationships

ISKO-2010, Rome ©ZengPanzerSalaba

Our interests in OWL

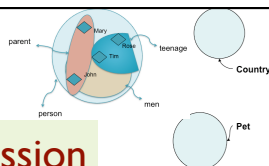
Class expression

- Built classes
- Classes to be built according to rules and instructions
 - Class : Class
 - Class + Auxiliary Table
 - Class + Added Table
 - Class + implied example

Relationship expression

- *Typical Class-to-class*
 - SubClassOf
 - DisjointClasses
 - EquivelantClasses
- *More complicated*
 - Class-to-class
 - Class-to-topic
 - Index terms
 - Class-here
 - Class-elsewhere
 - See reference
 - ...

ISKO-2010, Rome ©ZengPanzerSalaba



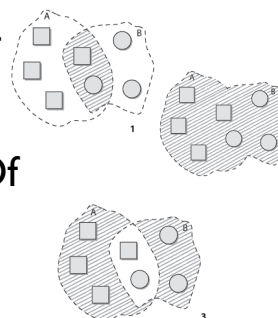
Class expression

- Built classes
 - Classes to-be-built according to rules and instructions
 - Class : Class
 - Class + Auxiliary Table
 - Class + Added Table
 - Class + implied example
- OWL supports various ways of describing classes**
- class identification
 - the enumeration of individuals that form class instances
 - the intersection and union of two or more class descriptions
 - the complement of a class description
 - property restrictions

ISKO-2010, Rome ©ZengPanzerSalaba

3.1 OWL for complex class expressions

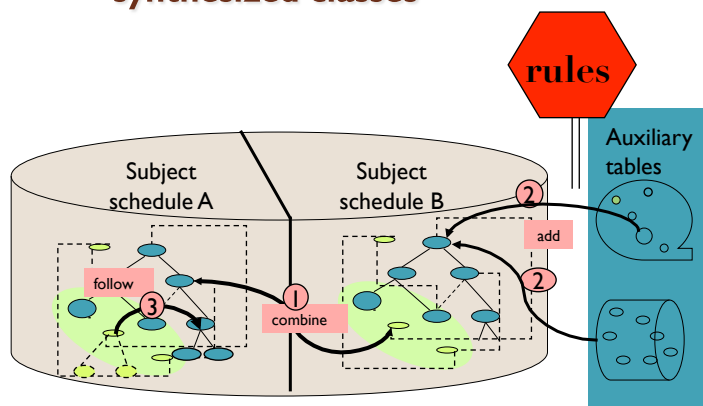
- OWL provides for the standard set-theoretic operations on class expressions.
 - ObjectIntersectionOf
 - ObjectUnionOf
 - ObjectComplementOf



ISKO-2010, Rome ©ZengPanzerSalaba

Complex class expressions are needed for synthesized classes

To accommodate new subjects and reflect the nature of interdisciplinary, instructions are provided to the classifier to **construct** a number in practice:



1. by adding numbers from other parts of the schedule,
2. by adding numbers from a table, or
3. by basing it on a pattern defined in another part of the schedule.

ISKO-2010, Rome ©ZengPanzerSalaba

- Classification numbers may be built according to rules
- Theoretically unlimited classes can be built
- Example from DDC:

rules

821.008 Collections of English poetry

is built with

82 (following the instruction at **820.1-828 Subdivisions of English literature**)

plus **100** (following the instruction at **T3B--1001-T3B--1009 Standard subdivisions; collections; history, description, critical appraisal**)

plus **8 Collections of literary texts** from the add table at **T3B--1-T3B--8 Specific forms**.

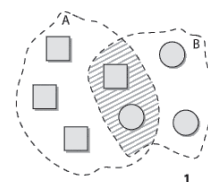
821 English poetry
 821.008 English poetry--collections
 821.00803543 Love--poetry--English literature--collections, ...
 821.0080355 English poetry--social themes--collections, ...
 821.008036 English poetry--nature--collections, ...
 821.0080382 English poetry--religious themes--collections, ...
 821.009 English poetry--history and criticism
 821.04 English poetry--lyric poetry, ...
 821.0708 Humorous poetry--English literature--collections, ...

Source: [One Zero or Two?](#) Dewey Blog. September 28, 2006

http://ddc.typepad.com/025431/1ddc_up_of_the_week/

The *intersection* of two classes

- -- consists of exactly those individuals which are instances of both classes.
- Apply to: constructing a number by adding notation from the tables or other parts of the schedules to a base number
 - Class : Class
 - Class + Auxiliary Table
 - Class + Added Table
 - Class + Implied example



ISKO-2010, Rome ©ZengPanzerSalaba

ObjectIntersectionOf

- DDC: **616.1203 Heart diseases—rehabilitation**

built with:

- **616.12 Diseases of heart**
- + **03 Rehabilitation** from the add table under **616.1–616.9 Specific diseases**
- following the add footnote at **616.12**: “Add as instructed under 616.1–616.9”.

EquivalentClasses(
 :616.1203
 ObjectIntersectionOf(:616.12 :03)
)

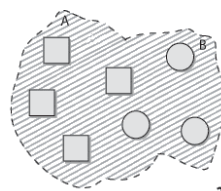
ISKO-2010, Rome ©ZengPanzerSalaba [In Functional-Style Syntax]

The *union* of two classes

--contains every individual which is contained
in at least one of these classes

ObjectUnionOf

- Union classes, e.g.,
 - 641 Food and Drink
 - 020 Library & Information Science
 - 025.24 Information Storage and Retrieval System
- Notes:
 - “class here”
 - “including”



ISKO-2010, Rome ©ZengPanzerSalaba

Example from DDC

025.04 Information Storage and Retrieval Systems

11	Search Results	Record 11 of 40
Class Number:	025.04	
Caption:	Information storage and retrieval systems	
	Main Classes	
000	Computer science, information & general works	
020	Library & information sciences	
025	Operations of libraries, archives, information centers	
025.04	Information storage and retrieval systems	
025.04082	Women--information systems use	
025.04087	Disabled persons--information systems use	
025.042	World Wide Web	

Notes

“including”

Including recall, precision, relevance

“class here”

Class here search and retrieval in information storage and retrieval systems; front-end systems; comprehensive works on online catalogs integrated with information storage and retrieval systems, on automated storage, search, retrieval of information; interdisciplinary works on databases

“class
elsewhere”

Class aspects of information storage for specific types of retrieval systems with the aspect for the type of system, e.g., mark-up languages for web retrieval systems 006.74, record formats for bibliographic retrieval systems 025.316.

For computer science aspects of information storage and retrieval systems, of databases, see 005.74;

For information storage and retrieval systems, bibliographies of web sites, digital libraries devoted to specific subjects, see 025.06.

For a specific kind of information storage and retrieval system, see the kind, e.g., online catalogs 025.3132.

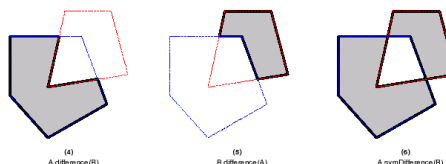
See also 658.4038011 for management use of information storage and retrieval systems.

See Manual at 025.04, 025.06 vs. 005.74.

ISKO-2010, Rome ©ZengPanzerSalaba

The *complement* of a class

-- corresponds to logical negation: It consists of exactly those objects which are not members of the class itself.



ObjectComplementOf

e.g.,

025.24 Information Storage and Retrieval System

Notes:

For computer science aspects of information storage and retrieval systems, of databases, see 005.74

ISKO-2010, Rome ©ZengPanzerSalaba

Review: Our interests in OWL

Class expression

- Built classes
- Classes to be built according to rules and instructions
 - Class : Class
 - Class + Auxiliary Table
 - Class + Added Table
 - Class + implied example

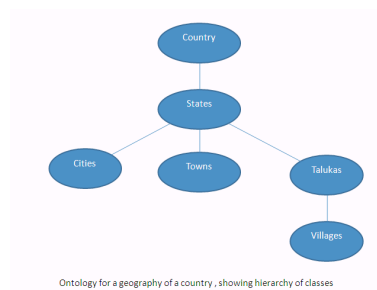
Relationship expression

- *Typical Class-to-class*
 - SubClassOf
 - DisjointClasses
 - EquivelantClasses
- *More complicated*
 - Class-to-class
 - Class-to-topic
 - Index terms
 - Class-here
 - Class-elsewhere
 - See reference
 - ...

ISKO-2010, Rome ©ZengPanzerSalaba

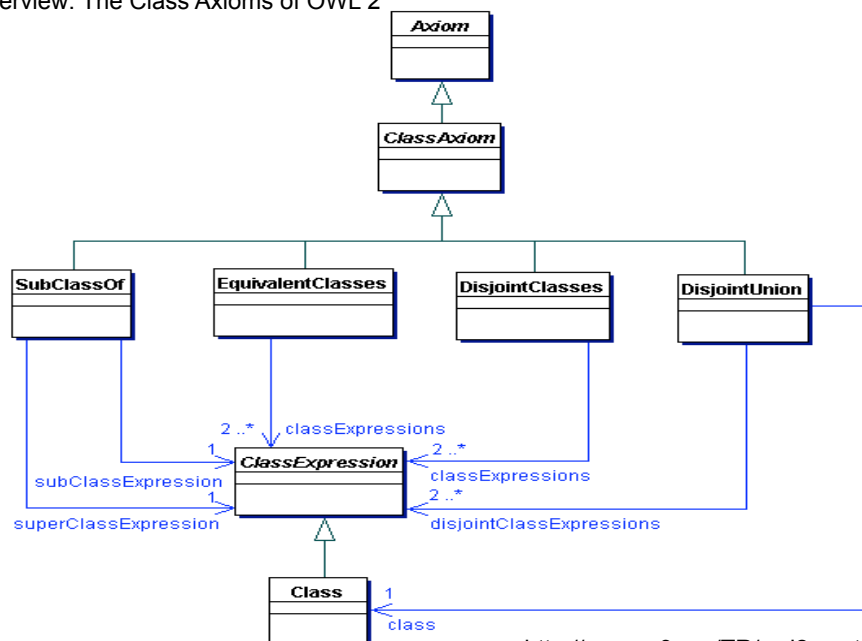
3.2 AXIOMS for relationships between class expressions

- OWL 2 provides axioms (statements that say what is true in the domain) that allow relationships to be established between class expressions:
 - SubClassOf
 - EquivalentClasses
 - DisjointClasses
 - DisjointUnion



ISKO-2010, Rome ©ZengPanzerSalaba

Overview: The Class Axioms of OWL 2

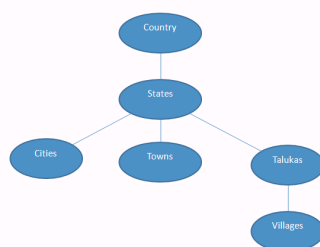


<http://www.w3.org/TR/owl2-syntax/>
#Inverse Object Properties

SubClassOf axiom

- **SubClassOf** axiom: allows one to state that each instance of one class expression is also an instance of another class expression, and thus to construct a *hierarchy* of classes.

Subclass axioms are a fundamental type of axioms in OWL 2 and can be used to construct a class hierarchy.

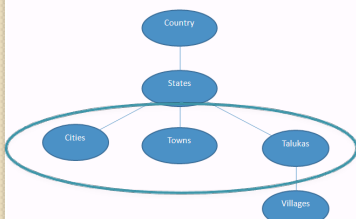


Ontology for a geography of a country, showing hierarchy of classes

ISKO-2010, Rome ©ZengPanzerSalaba

DisjointClasses axiom

- **DisjointClasses** axiom: allows one to state that several class expressions are *pairwise disjoint* — that is, they have no instances in common.
- **DisjointUnion** class expression: allows one to define a class as a *disjoint union* of several class expressions and thus to express *covering* constraints. Such axioms are sometimes referred to as covering axioms.



Ontology for a geography of a country, showing hierarchy of classes

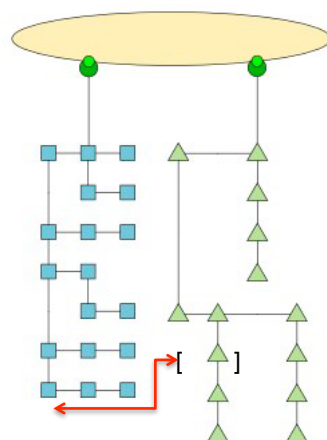
ISKO-2010, Rome ©ZengPanzerSalaba

EquivalentClasses axiom

- **EquivalentClasses** axiom: allows one to state that several class expressions are *equivalent* to each other.
- Can be used in classifications for
 - building equivalent classes
 - expressing equivalent classes → see example
 - etc.

ISKO-2010, Rome ©ZengPanzerSalaba

EquivalentClasses axiom for Alternative Classes



Example from Chinese Library Classification (CLC):

X17 Environmental Biology

.....

[Q89 Environmental Biology]

Preferred class: **X17**

EquivalentClasses (:X17 : Q89)

However this is not enough. There are also certain relationship types and constraints between the classes.

ISKO-2010, Rome ©ZengPanzerSalaba

Review: Our interests in OWL

Class expression

- Built classes
- Classes to be built according to rules and instructions
 - Class : Class
 - Class + Auxiliary Table
 - Class + Added Table
 - Class + implied example

Relationship expression

- *Typical Class-to-class*
 - SubClassOf
 - DisjointClasses
 - EquivalentClasses
- *More complicated*
 - Class-to-class
 - Class-to-topic
 - Index terms
 - Class-here
 - Class-elsewhere
 - See reference
 - ...

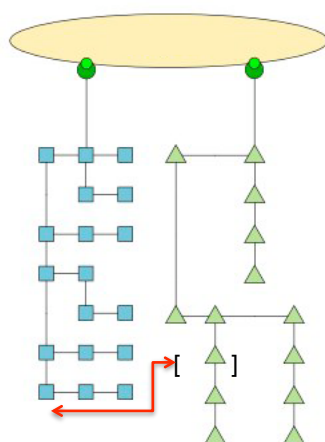
ISKO-2010, Rome ©ZengPanzerSalaba

3.3 Properties and restrictions for more complicated class expressions and relationships

- *More complicated relationships*
 - Class-to-class
 - Class-to-topic
 - Index terms
 - Class-here
 - Class-elsewhere
 - See reference
 - ...

ISKO-2010, Rome ©ZengPanzerSalaba

1) Symmetric Object Property



CLC's alternative classes

X17 Environmental Biology

.....

[Q89 Environmental Biology]

Preferred class: **X17**

```
EquivalentClasses (
  :X17
  SymmetricObjectProperty (:isAlternativeClass : Q89)
)
```

ISKO-2010, Rome ©ZengPanzerSalaba

2) Inverse object properties

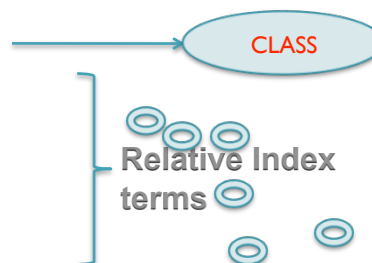
- **inverse** object properties -- allow for bidirectional navigation in class expressions and axioms.
 - Could be useful for the expressions of a class and its related index entries
 - e.g., we can establish such a property relation:


```
InverseObjectProperties( :hasIndexTerm
                          :isIndexTermOf )
```

ISKO-2010, Rome ©ZengPanzerSalaba

- DDC: 616 Diseases:

Clinical medicine
 Diseases—humans—medicine
 Illness—medicine
 Internal medicine
 Physical illness—medicine
 Sickness—medicine



```

InverseObjectProperties( :hasIndexTerm :isIndexTermOf )
EquivalentClasses(
  :616
  ObjectInverseOf (
    ObjectOneOf( :Clinical medicine :Diseases—humans—
      medicine :Illness—medicine :Internal medicine :Physical
      illness—medicine :Sickness—medicine)
  )
)

```

ISKO-2010, Rome ©ZengPanzerSalaba

3) Restrictions



- Define a condition for property values
- Classes are created by restricting the property values on its individuals

Quantifier Restrictions (Existential $\exists$, Universal $\forall$)	{		allValuesFrom
			someValuesFrom
Has Value Restriction ($\exists$)	←		hasValue
Cardinality Restrictions (Min $\geq$, Equal $=$, Max $\leq$)	{		minCardinality
			maxCardinality
			cardinality

ISKO-2010, Rome ©ZengPanzerSalaba

Restrictions can be applied to deal with class–topic relationships

Topical neighborhood shaped by (among other things):

Inclusion of topics

Caption **370.113 Vocational education**

Class-here note **Class here career education, occupational training, vocational schools**

Exclusion of topics

Class-elsewhere note **Class on-the-job training, vocational training provided by industry in 331.2592**

See reference **For vocational education at secondary level, see 373.246; for adult vocational education, see 374.013**

ISKO-2010, Rome ©ZengPanzerSalaba

Class description example

Description: 782.292

Equivalent classes +

Superclasses +

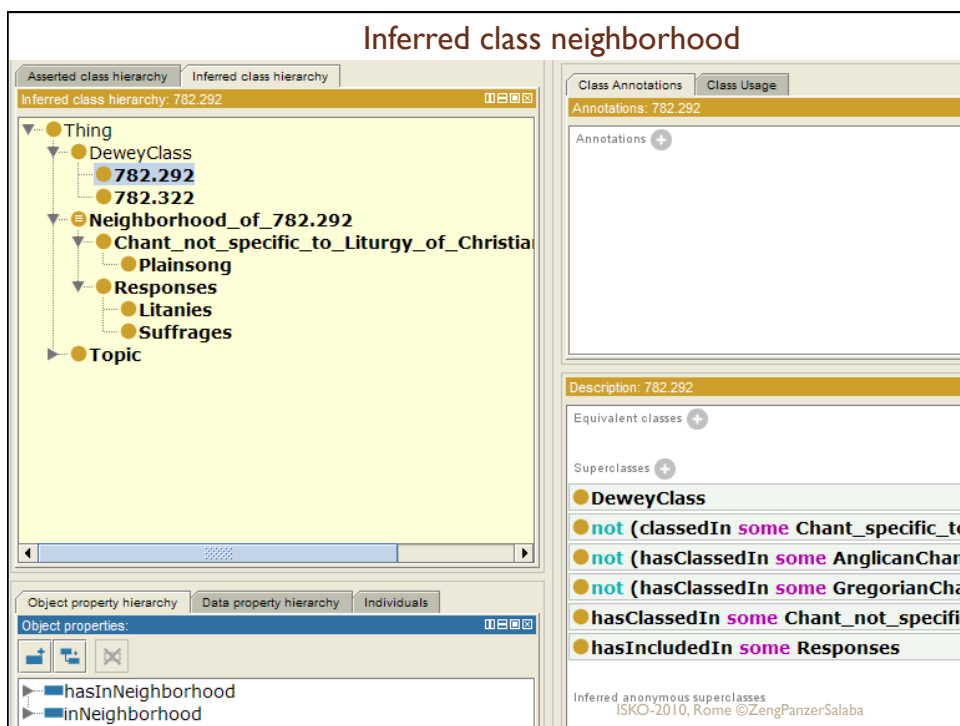
- **DeweyClass**
- **not (classifiedIn some Chant_specific_to_Liturgy_of_Christian_Denominations)**
- **not (hasClassedIn some AnglicanChant)**
- **not (hasClassedIn some GregorianChant)**
- **hasClassedIn some Chant_not_specific_to_Liturgy_of_Christian_Denominations**
- **hasIncludedIn some Responses**

Inferred anonymous superclasses

Members +

Disjoint classes +

ISKO-2010, Rome ©ZengPanzerSalaba



Summary: Our interests in Expressing Classification Schemes with OWL

Class expression

- Built classes
- Classes to be built according to rules and instructions
 - Class : Class
 - Class + Auxiliary Table
 - Class + Added Table
 - Class + implied example

Relationship expression

- Typical Class-to-class
 - SubClassOf
 - DisjointClasses
 - EquivalentClasses
- More complicated
 - Class-to-class
 - Class-to-topic
 - Index terms
 - Class-here
 - Class-elsewhere
 - See reference
 - ...

ISKO-2010, Rome ©ZengPanzerSalaba