



NANYANG
TECHNOLOGICAL
UNIVERSITY

i-OntoLearning: Ontological support for rich learning

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Why ontology-based learning?

- Existing e-learning system:
 - Poor integration of knowledge
 - Weak application of foundation course



LEARNING MATERIALS

MERLOT defines a learning material as "any digital entity designed to meet a specific learning need and be reused to support learning".

How IT Materials are Categorized:

The Information Technology Collection contains an [array of IT learning materials](#) for classroom.

Discipline materials are subdivided into the several categories below. You can see a category by clicking the links below or using the MERLOT basic or advanced search.

[Applications](#)
[Computer Information Systems](#)
[Database](#)
[E-commerce](#)
[Hardware](#)
[Information Literacy](#)
[Networking](#)
[Operating Systems](#)
[Programming](#)
[Security](#)
[Software Engineering](#)



- Learning repositories
 - Good search capabilities if you know what you're looking for
 - Little linkage to one's specific program curricula

http://www.ucalgary.ca/commons/careo/repository.htm

CAREO, Campus Alberta Repository of Educational Objects

<<Repositories>>

OVERVIEW

Online Repositories are designed to store, organize and control access to digital materials. Their goal is to allow a user to have easy access to the information in which they are interested. Defining the user and providing the tools for them to find relevant information are some of the main activities associated with creating and maintaining an online repository. Below are several examples of working repositories and metadata, one of the main tools used in organizing them.

RESOURCES	METADATA
REPOSITORIES Repository Directory <input type="text" value="Netlib"/> <input type="button" value="Go!"/>	Metadata Directory <input type="text" value="Dublin Core"/> <input type="button" value="Go!"/>
Title <input type="text" value="Netlib Repository"/>	Title <input type="text" value="The Dublin Core Metadata Initiative"/>
Site Contents <input type="text" value="Netlib is a collection of mathematical software, papers, and databases."/>	Site Contents <input type="text" value="DC metadata sets, Overview, Architecture"/>

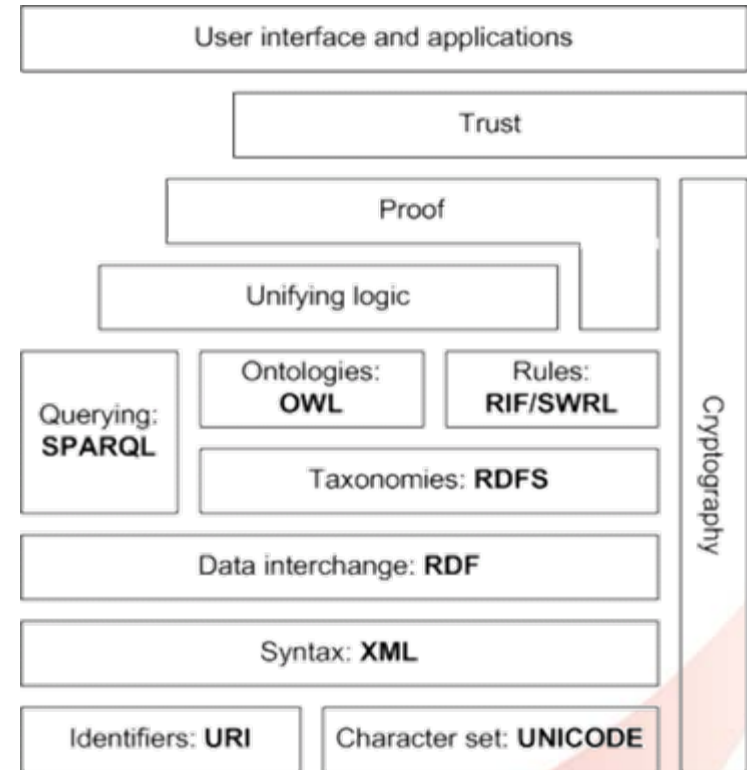
- Generic ontologies for program curriculum built upon standards: domain-specific such as IEEE/ACM Computing Curricula; Metadata; Content Packaging
- Ontology-based learning provides the connection between topics in different courses
 - Similar topics
 - More general topics
 - More specific topics
 - And others ...

Objectives

- Design an ontology for course content, structure with cross-course connections starting with the following selected courses
 - Data structures and Object-Oriented Programming
 - Algorithms
- Design queries to exploit the ontology capabilities

Background

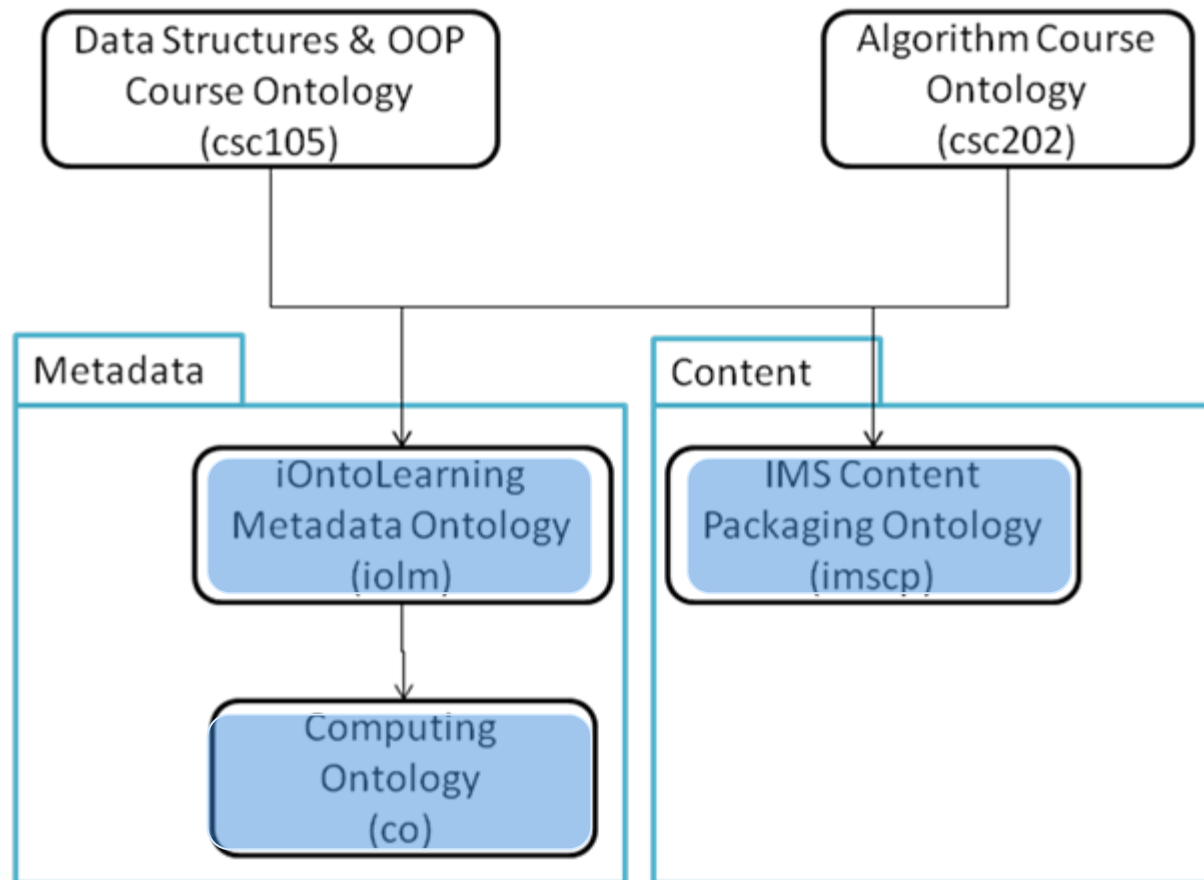
Ontology provides a shared and common understanding of a domain (in this case, curriculum and e-learning metadata) that can be communicated between people and across application systems



Background

- ACM Computing Ontology
 - Supported by ACM and US National Science Foundation
 - Attempts to cover the whole computing field
 - show all interrelationships among topic areas
 - identify the relevant areas for each sub disciplines
 - is an ongoing project

Ontology design



ACM Computing Ontology

- Classes: areas, subareas, topics, subtopics
- Relationships: Instance, PartOf, Uses
- Current version by ACM group:
 - contains instances for Algorithm discipline,
 - lacks of instances for Data Structure and OOP
 - no relationships

Computing Ontology (CO)

- Modifications to address above shortcomings
- E.g. added a subarea called “Fundamental Data Structures”
 - Primitive Types
 - Reference Types
- For Object-Oriented Programming
 - Add subtopic “Object-Oriented Design” under “Language Design”
 - Add subtopic “Object-Oriented Features” under “Language Features”



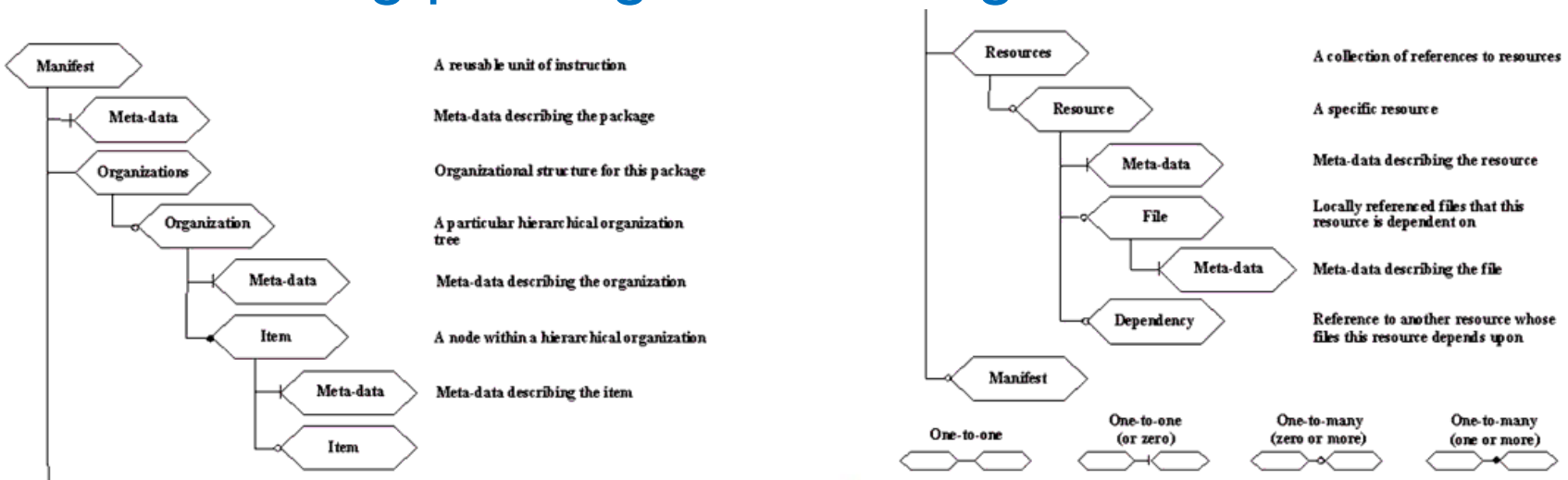
iOntoLearning Metadata Ontology

- Contains only one class called FileMetadata and eight data-type properties: *level*, *language*, *format*, *size*, *href*, *learningResourceType*, *title*, and *creator*
- Contains 4 properties that link with Computing Ontology:
 - isA
 - partOf
 - uses
 - isClassifiedAs



IMS Content Packaging Ontology

- IMS Content Packaging is a standard for structuring content of a course, it captures
 - Physical structure
 - Content structure
- IMS CP standard is adopted by many popular e-learning packages including BlackBoard



Course Ontologies

- The previous ontologies form the framework for courses: class FileMetadata of Metadata Ontology become a subclass of class Metadata in IMS CP Ontology
- A specific Course Ontology contains instances of the classes introduced in Metadata and IMS CP Ontology.
- Two courses ontologies are constructed: Algorithms, Data Structures and Object-Oriented Programming

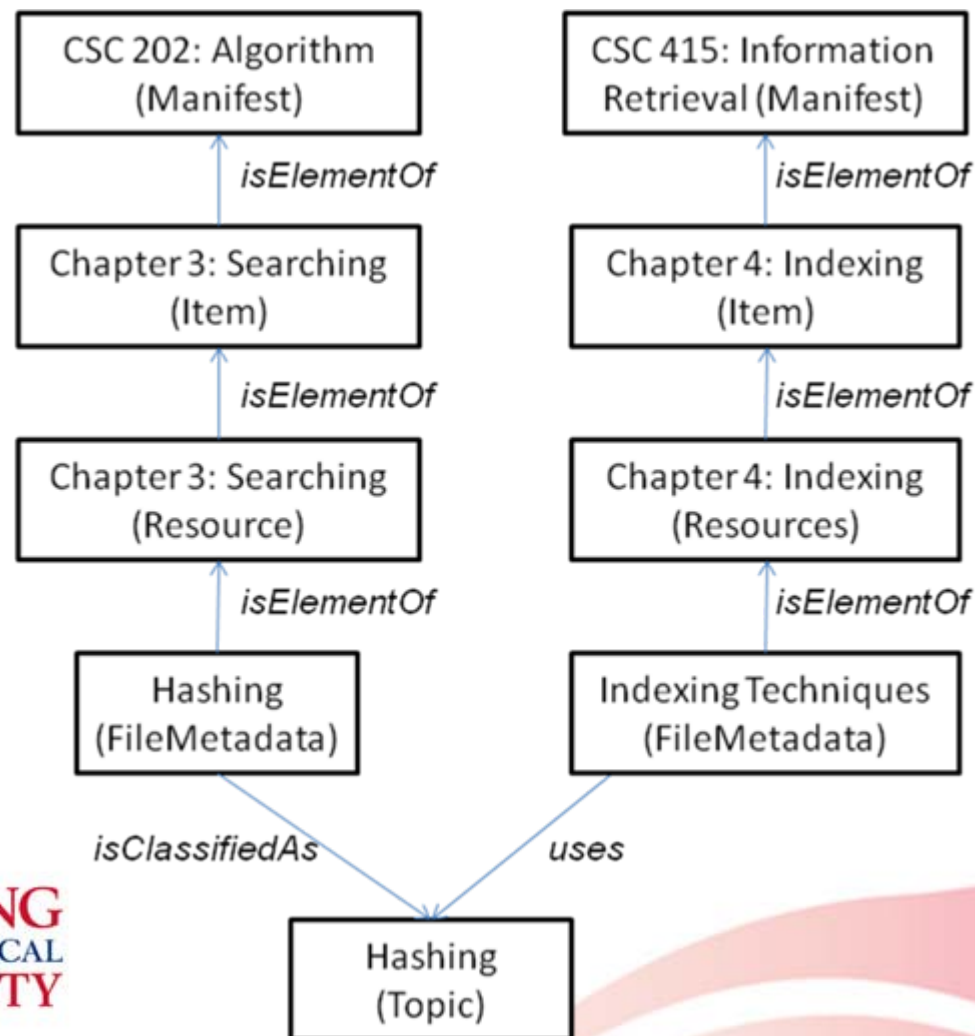


Discovering relationships between resources

- Implicit relationships between learning units can be discovered.
- Learning units have associated metadata which may have a relationship with a topic in the Computing Ontology
- Two learning units that relate to a same topic in the Computing Ontology has a relationship



Discovering relationships between resources



Queries

- We use nRQL (new RacerPro Query Language) which provides powerful capabilities to extract information from ontology
- Queries can be sent to a separate RacerPro server
- Queries can be used by application using RacerPro's client library

Content Structure Queries

- Queries can be applied to IMS CP Ontology to show content structures
- Queries can be applied to Metadata Ontology to show metadata information of a physical file
- Some queries:
 - List all courses available in the curriculum
 - List all chapters of a course
 - Show the location of the file corresponding to a lesson
 - Show the size and format of a particular file

Content Structure Queries

- A query to list all available courses

```
(retrieve
  (
    ?element
    (datatype-fillers (!imscp:title ?element))
  )
  (?element !imscp:Organization)
)
```

User doesn't
need to know or
see the queries

- Result

```
(((!element !:NTU_CSC105_Organization_2)
  (:datatype-fillers (!imscp:title ?element))
  ("Data Structures and Object-Oriented Programming")))
((?element !:csc202:NTU_CSC202_Organization_1)
  (:datatype-fillers (!imscp:title ?element)) ("Algorithm"))))
```

Content Structure Queries

The screenshot shows the iOntoLearning application window. On the left is a hierarchical tree of course content. The right pane displays details for the selected item, 'Graph Algorithms Part I: Graph Traversal'. Below this, there are two tabs: 'View' and 'Uses'. The 'View' tab is active, showing a list of related items. Three blue boxes with white text are overlaid on the image: 'Area A' points to the 'Lectures' folder in the tree; 'Area B' points to the details pane; 'Area C' points to the 'Uses' tab and its list of related items.

Title	Type	Format	Href	Size	Language	Level
Graph Algorithms Part I: Graph Traversal	lecture slide	application/mspowerpoint	Part I - Graph Traversal.pps	417792	en	lesson

Area A

Area B

Area C



Queries to discover relationships between resources

- We define 5 relationship types between two learning units based on its relationship with the topic in the Computing Ontology
 - Similar
 - More general
 - More specific
 - Uses
 - Used by

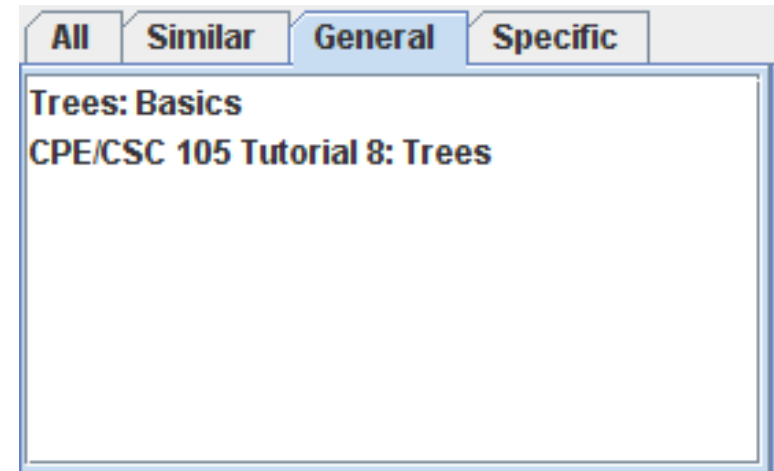
Queries to discover relationships between resources

- **Similar:** contains learning units that cover a related contents with the same level of granularity
 - *isClassifiedAs* (of the selected resource) and *isClassifiedAs*: two resources are classified as a same topic
 - *isA* and *isA*: two resources are instances of a same topic
 - *isPartOf* and *isPartOf*: two resources are part of a same topic
 - *isA* and *isPartOf*: resources that are part of a topic that the selected resource is an instance of
 - *isPartOf* and *isA*: resources that are instances of a topic that the selected resource is a part of

All	Similar	General	Specific
CPE/CSC 105 Tutorial 10: Graphs			
Graphs: Basics			
Graphs: Traversal			

Queries to discover relationships between resources

- **General:** contains learning units that cover a related contents with higher level of abstract
 - *isA* and *isClassifiedAs*
 - *isPartOf* and *isClassifiedAs*



General learning units for “Graph Algorithms: Minimum Spanning Tree”

Queries to discover relationships between resources

- **Specific:** contains learning units that cover a related contents which is more specific
 - *isClassifiedAs* and *isA*
 - *isClassifiedAs* and *isPartOf*

Queries to discover relationships between resources

- **Uses:** contains learning units that cover a related contents which the selected learning unit may require
 - *uses* and *isClassifiedAs*
 - *uses* and *isA*
 - *uses* and *isPartOf*

All	Uses	Used by
CPE/CSC 105 Tutorial 10: Graphs		
Graphs: Basics		

Uses learning units for “Graph Algorithms: Minimum Spanning Tree”

Queries to discover relationships between resources

- **Used by:** contains learning units that may require the selected learning unit
 - *isClassifiedAs* and *uses*
 - *isA* and *uses*
 - *isPartOf* and *uses*



Used by learning units for
“Graph Algorithms: Minimum
Spanning Tree”

Future Work

- This is work-in-progress
- To demonstrate scalability, more courses need to be added
- GUI for authors to create course ontologies without knowledge of an ontology description language
- Automatic metadata extractions from files
- Integrate with existing e-learning system such as BlackBoard

Thank you

Questions?