

# Ontology-Based Representation Transformations

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# Representation Languages

- There are a great many ways to represent (express) a specification (some examples are in parentheses):
  - Natural language (English)
  - Controlled natural language (SBVR)
  - Logic Languages (CL)
  - Graphical language (UML)
  - OO programming language (Java, C#)
  - Data language (SQL, XML Schema, OData)
  - Ontology language (RDF, OWL, CL)
- The number of representation languages is large and increasing.

# Transformations

- There is a need to transform from one representation to another.
- Transformation frameworks and tools are increasing
  - Service-Oriented Architecture (SOA)
  - Model Driven Architecture (MDA and QVT)
  - Metamodel Framework for Interoperability (MFI)
  - Heterogeneous Tool Set (HeTS) for logic languages
  - Industry-specific frameworks: telecommunications, medicine, government, public safety, military

# Rationale

- Why transform?
  - Main reason: Interoperability
  - Secondary reason: Flexibility and Adaptability
    - Provide new features without starting over
    - Increase applicability of services
- Why not use one universal representation?
  - Representations have different advantages and disadvantages.
  - Multiple representations increase robustness
    - More opportunities to find inconsistencies
    - Separation of concerns
  - Enriching specifications

# Experiences


- Extracting representations from OASIS standards documents.
- Representations include RDF/S, OWL, XSD, SQL, WSDL, REST, Java, semantic wikis, podcasts
- Procedural (behavioral) capabilities include persistence (with ORM), data representation transformers (such as XML to RDF), wiki forms, and web services (both SOAP and REST).
- Automated mappings improve accuracy compared with manual mappings.
- Once one has mapped to a formal representation, one can transform to other representations using existing tools.
- Multiple mappings allow one to use existing transformation tools for consistency checking and to enrich the semantics.

# Conceptual Levels

- Metalevels
  - M0: Data (Abox)
  - M1: Schema (Tbox)
  - M2: Language Metadata
  - M3: MetaObject Facility
- Transformations
  - Normally on one metalevel
  - Sometimes cross metalevels
- Directionality
  - One directional (may lose information)
  - Two directional (usually requires annotations)

# Example one-directional mapping


```
<xs:complexType name="node">
  <xs:sequence>
    <xs:element name="op1" type="node" minOccurs="0"/>
    <xs:element name="op2" type="node" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="code" type="OpCode" use="required"/>
  <xs:attribute name="id" type="xs:string"/>
</xs:complexType>
```



```
public class Node {
    protected Node op1;
    protected Node op2;
    protected OpCode code;
    protected String id;
}
```

# Example one-directional mapping

```
public class Node {  
    protected Node op1;  
    protected Node op2;  
    protected OpCode code;  
    protected String id;  
}
```



```
<xs:complexType name="node">  
    <xs:sequence>  
        <xs:element name="id" type="xs:string" minOccurs="0"/>  
        <xs:element name="op2" type="node" minOccurs="0"/>  
        <xs:element name="code" type="OpCode"/>  
        <xs:element name="op1" type="node" minOccurs="0"/>  
    </xs:sequence>  
</xs:complexType>
```



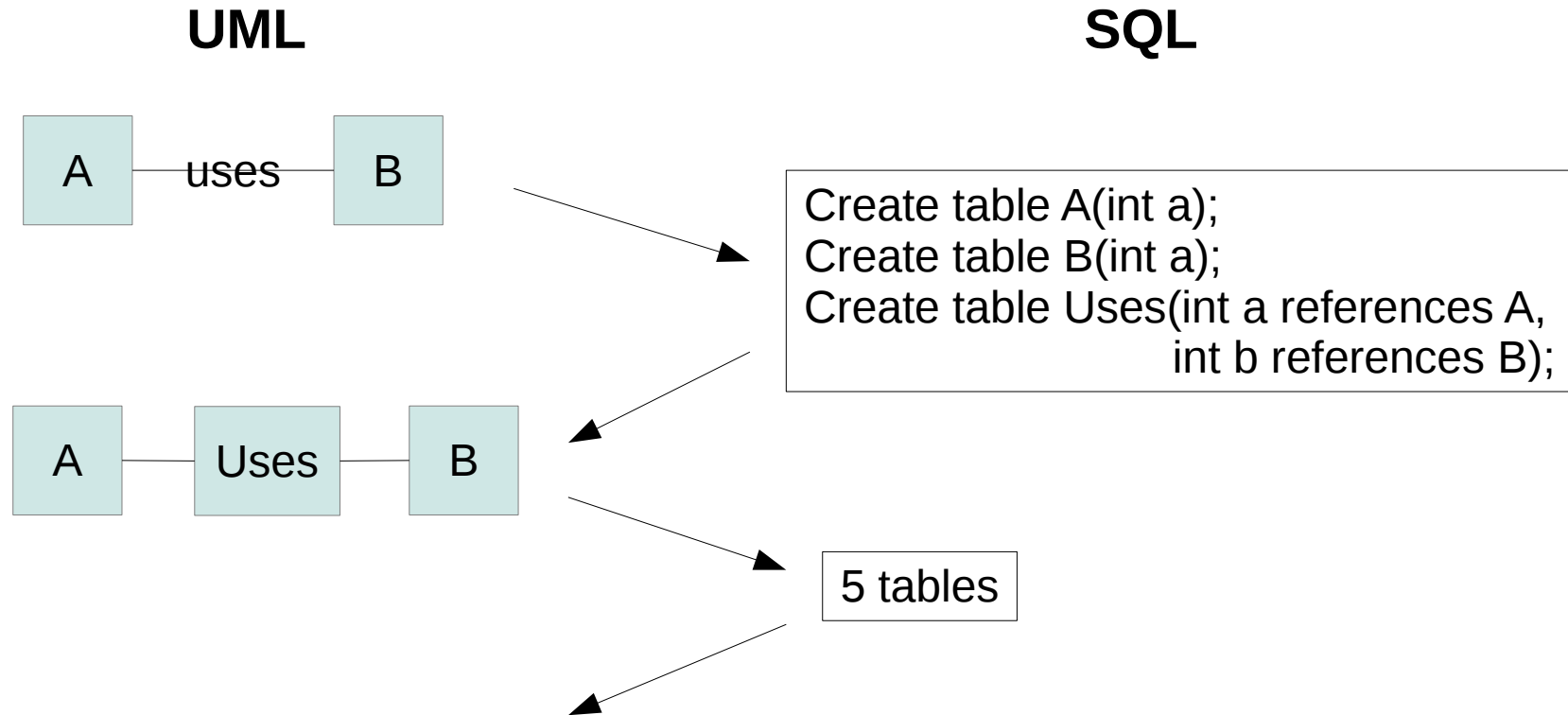
# Example bidirectional mapping

```
<xs:complexType name="node">
  <xs:sequence>
    <xs:element name="op1" type="node" minOccurs="0"/>
    <xs:element name="op2" type="node" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="code" type="OpCode" use="required"/>
  <xs:attribute name="id" type="xs:string"/>
</xs:complexType>
```



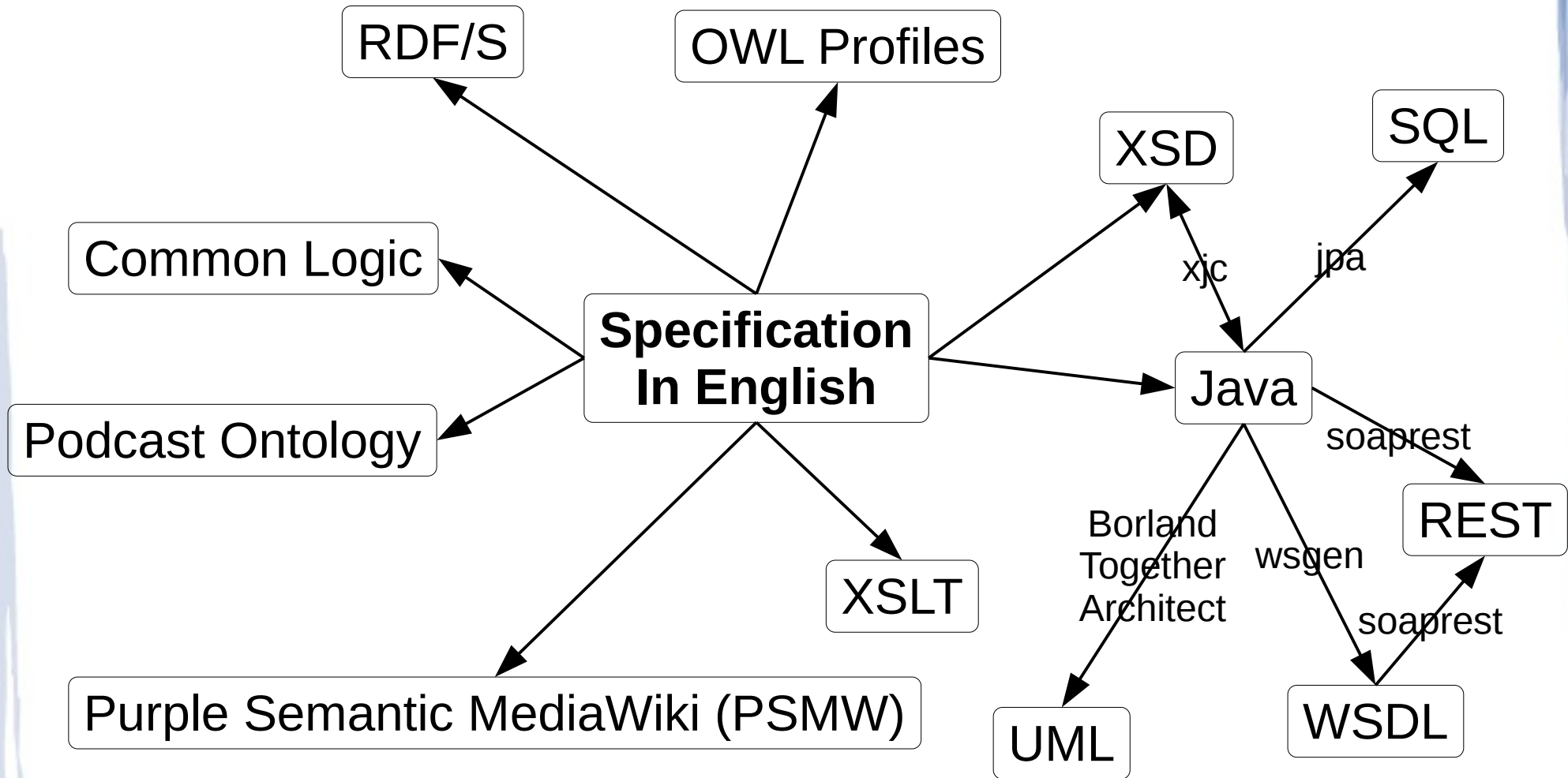
```
@XmlAccessorType(XmlAccessType.FIELD)
@XmlType(name = "node", propOrder = { "op1", "op2" })
public class Node {
    protected Node op1;
    protected Node op2;
    @XmlAttribute(required = true)
    protected OpCode code;
    @XmlAttribute
    protected String id;
}
```

# Unbounded bidirectional mapping

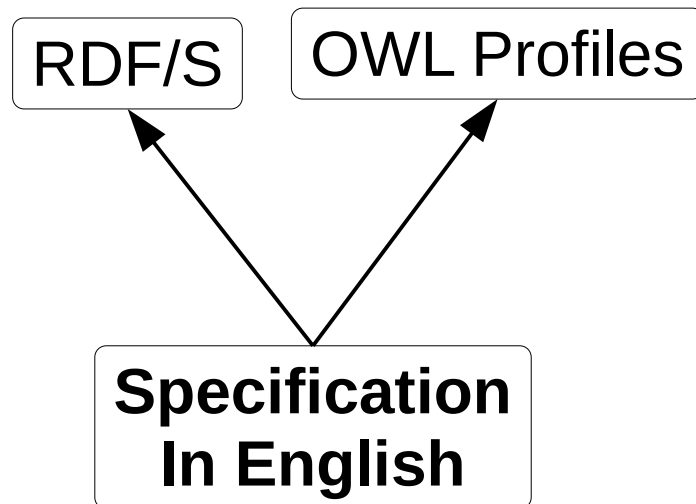


Naïve mappings can result in an unbounded bidirectional mapping.

# Some Schema (M1) Mappings



# Mapping to Ontology Languages



- Properties
  - First-class in ontologies
  - Scoped by classes in programming languages
- Inheritance
  - Multiple inheritance in ontologies
  - (Java) Single inheritance of classes, multiple inheritance of interfaces.
- Specifications often presume the programming language limitations.

# Mapping to Ontology Languages

- Many consistency checks were performed.
  - At least 25 checks so far.
- Inverse properties can be problematic because of property scopes.

Property	Domain	Range
assignedCommunity	Actor	Community
memberActor	Community, Group	Actor
assignedGroup	Actor, Group	Group
memberGroup	Group, Scope	Group
assignedScope	Group	Scope

- There are actually 8 properties (4 and their inverses)

# Mapping to Ontology Languages

- A property can have different ranges, on different domains.
  - OWL can specify these restrictions provided they do not cross the datatype/object boundary.
- Metalevel as scope for names
  - OWL2 allows the same name for both an instance and a class.
  - OWL1 does not allow this.
- Abstract classes
  - In some cases, the intention is that the abstract class is the union of its subclasses.

## 4.5.7 AccessControlList

# Example of an ICOM Class

### 4.5.7.1 Description

An access control list (ACL) is an object attached to an entity to specify a list of permissions to access the entity.

### 4.5.7.2 Class Definition

The AccessControlList class has attribute values:

#### localNamespace

Value: icom\_ac

#### localName

Value: AccessControlList

#### extendsFrom

Value:

#### stereotype

Value: primary

#### description

Value: An access control list (ACL) is an object attached to an entity to specify a list of permissions to access the entity.

This representation is based on the Content Management Interoperability Service (CMIS) standard.



# Examples of ICOM Properties

## 3.5.7.3 Property Definitions

The AccessControlList class MUST have the property definitions:

### icom\_ac:object

Description:	Associated object.
Required:	True
Inherited:	False
Property Type:	<u>icom_core:Entity</u>
Cardinality:	Single
Updatability:	On Create

### icom\_ac:accessControlEntry

Description:	One or more access control entries.
Required:	True
Inherited:	False
Property Type:	<u>icom_ac:AccessControlEntry</u>
Cardinality:	Multi
Updatability:	Read Write



```

<owl:Class xml:base='&icom_ac;#' rdf:ID='AccessControlList'>
  <icom_meta:categoryMetadata>
    <icom_meta:Category rdf:about='&icom_ac;#AccessControlListMetadata' />
  </icom_meta:categoryMetadata>
  <rdfs:label xml:lang='en'
    rdf:datatype='&xsd;#string'>AccessControlList</rdfs:label>
  <rdfs:comment xml:lang='en' rdf:datatype='&xsd;#string'>An
access control list (ACL) is an object attached to an entity to
specify a list of permissions to access the entity.</rdfs:comment>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource='&icom_ac;#accessControlEntry' />
      <owl:minCardinality
        rdf:datatype='&xsd;#integer'>1</owl:minCardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource='&icom_ac;#object' />
      <owl:cardinality
        rdf:datatype='&xsd;#integer'>1</owl:cardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
<icom_meta:Category xml:base='&icom_ac;#' rdf:ID='AccessControlListMetadata'>
  <icom_core:name xml:lang='en'
    rdf:datatype='&xsd;#string'>AccessControlList</icom_core:name>
  <icom_core:description xml:lang='en' rdf:datatype='&xsd;#string'>An
access control list (ACL) is an object attached to an entity to
specify a list of permissions to access the entity.</icom_core:description>

```

An ICOM Class in OWL

# ICOM Properties in OWL

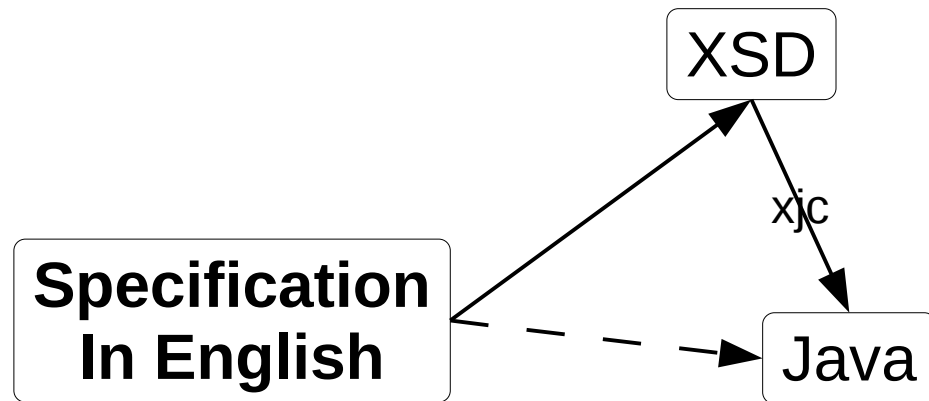
```
<owl:ObjectProperty xml:base='&icom_ac;#' rdf:ID='accessControlEntry'>
  <rdfs:label xml:lang='en'
    rdf:datatype='&xsd;#string'>accessControlEntry</rdfs:label>
  <rdfs:domain rdf:resource='&icom_ac;#AccessControlList' />
  <rdfs:range rdf:resource='&icom_ac;#AccessControlEntry' />
</owl:ObjectProperty>
```

```
<owl:ObjectProperty xml:base='&icom_ac;#' rdf:ID='object'>
  <rdfs:label xml:lang='en'
    rdf:datatype='&xsd;#string'>object</rdfs:label>
  <rdfs:domain rdf:resource='&icom_ac;#AccessControlList' />
  <rdfs:range rdf:resource='&icom_core;#Entity' />
</owl:ObjectProperty>
```

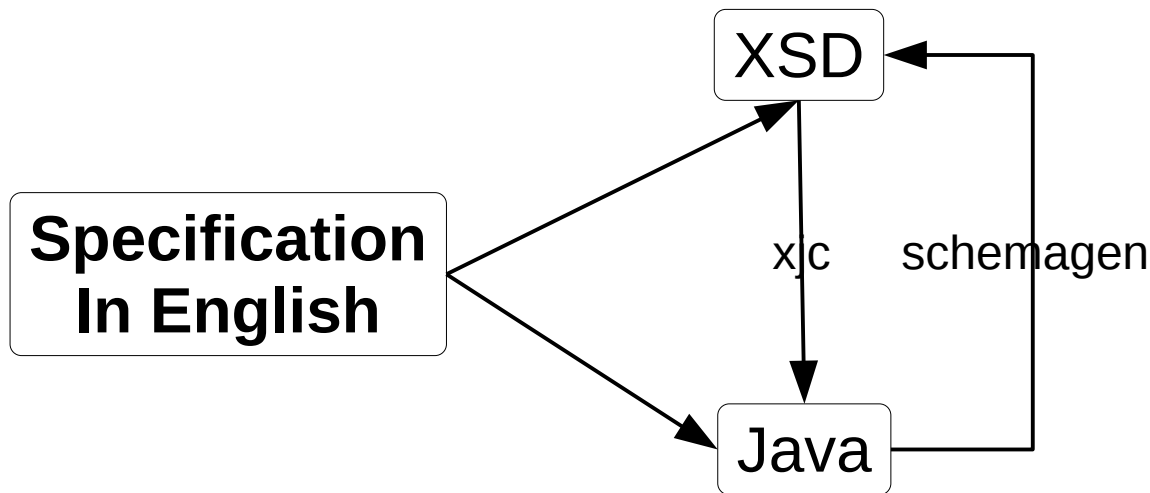
# Common Logic

- Planned mappings
  - My group is mapping from CMIS format
  - Elisa Kendall at OMG is mapping from SBVR
    - SBVR is an English-like syntax for logic
    - Potentially easier to understand than OWL
- Advantages
  - Richer notation than OWL
  - Basis for axiomatic systems in mathematics
- Disadvantage
  - Few implementations

# Mapping to XSD and Java



Mapping to XSD, and then using xjc, gives a mapping to Java



Mapping separately to XSD and Java allows xjc and schemagen to be used for checking consistency.

# JPA Annotations

assignedGroup on Actor is inverse of memberActor on Group.

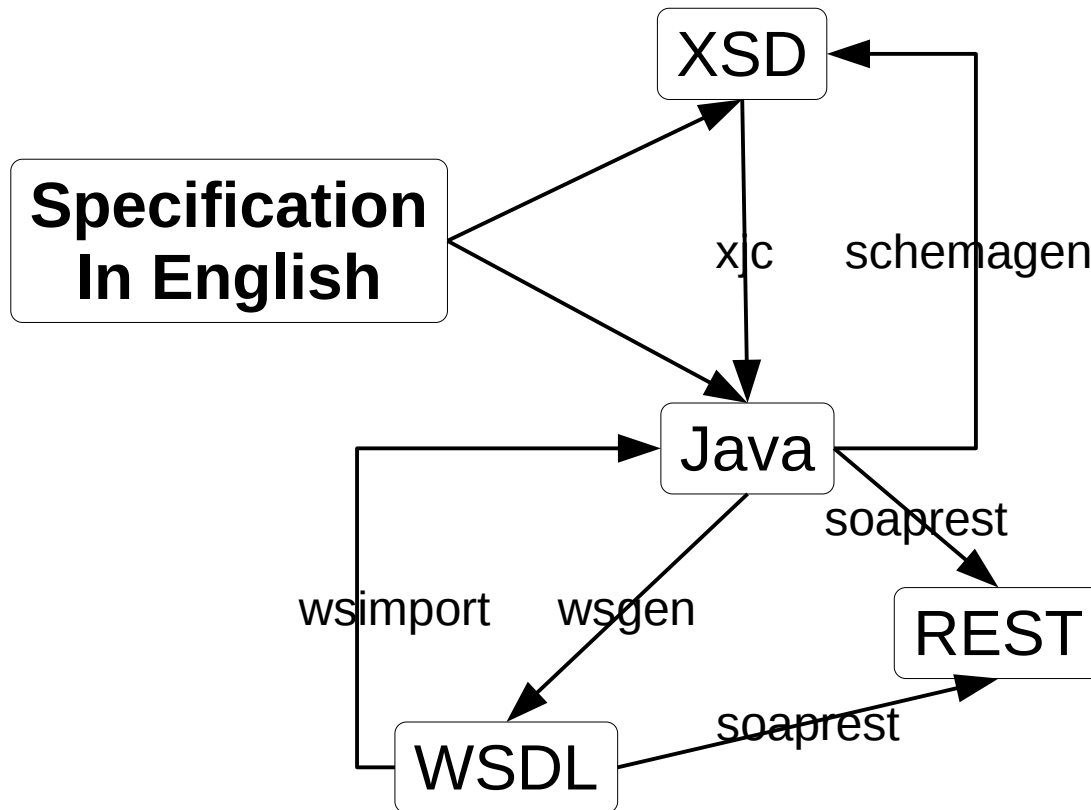
```
@ManyToMany(targetEntity=Actor.class,  
            mappedBy="assignedGroups")  
@DeferLoadOnAddRemove  
@XmlElement(name="memberActor")  
Set<Actor> memberActors;  
  
@ManyToMany(targetEntity=Group.class,  
            mappedBy="assignedGroups")  
@DeferLoadOnAddRemove  
@XmlElement(name="memberGroup")  
Set<Group> memberGroups;
```

assignedGroup on Group is inverse of memberActor on Group.

assignedGroup is the owner in both cases.

The associations are navigable in both directions.

# Web Services



## WSDL (SOAP)

- Derived from remote procedure call
- Considerable tool support
- Large collection of standards

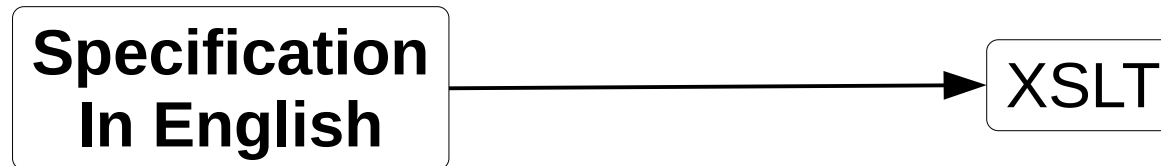
## REST

- Derived from HTTP
- Less tool support
- Fewer standards
- Growing in popularity

## Soaprest Package

- Supports both SOAP and REST
- Both SOAP and REST accepted by the same server
- Best of both SOAP and REST

# Data Transformations



- Data transformations can also be generated from the specification.
  - Normally requires that the source and target schemas (M1 metalevel) be generated.
- Basis for web services (where it is called serialization or marshaling)

# Collaboration Tools

**Specification  
In English**

Purple Semantic MediaWiki (PSMW)

- Wikis were introduced as a way to use web browsers for collaboration.
- MediaWiki is the wiki used by Wikipedia
  - Most popular wiki software
- Semantic wikis add semantic annotation and query capabilities to wikis
- Purple wikis add fine-grained access to a wiki
  - Introduced by Doug Engelbart



# Purple Semantic MediaWiki (PSMW)

- A bundle of MediaWiki plugins that support semantic and fine-grained access.
- Mapping ontologies to PSMW:
  - Classes map to **Categories**
  - Properties are specified with **Templates**
  - **Forms** use one or more templates for data entry and display
  - Applications use **SPARQL** queries

# Generated PSMW Pages

- These were generated for the AccessControlList class:
  - The accessControlEntry property is a set of AccessControlEntry objects
  - The object property is an Entity object.
  - Style information was omitted for clarity.

Template:AccessControlList

```
{|-  
! accessControlEntry  
| {{#arraymap:{{{AccessControlEntry|}}}|,|x|[[AccessControlEntry::x]]}}  
|-  
! object  
| [[Entity:{{{Entity|}}}]]  
|}
```

# Generated PSMW Pages

## Form:AccessControlList

```
{{{for template|AccessControlList}}}
{| class="formtable"
! accessControlEntry:
| {{{field|AccessControlEntry}}}
|-
! object:
| {{{field|Entity}}}
|}
{{{end template}}}
```

## Category:AccessControlList

An access control list (ACL) is an object attached to an entity to specify a list of permissions to access the entity.

```
[[Create a new access control list::AccessControlList]]
```

# Generated Data Entry Form

 [Ken](#) [My talk](#) [My preferences](#) [My watchlist](#) [My contributions](#) [Log out](#)

Special page

Go

Search

## Create AccessControlList: Acl1

**accessControlEntry:**

**object:**

Summary:

This is a minor edit  Watch this page

Save page

Show preview

Show changes

Cancel

[Privacy policy](#) [About PSMW](#) [Calendar](#) [Disclaimers](#)



# Semantic Wiki Issues

- Semantic wiki resources are only whole pages.
  - Unlike general web and wiki pages that allow links to *anchors* marking locations on each page.
- Namespaces are problematic
  - There is a notion of namespace but it is not compatible with the XML notion.

Go

Search

# PSMW Calendar

Sparql query:

```

{[#ask:
  [[Category:Occurrence]]
  [[StartDate::>Oct 01 2012]]
  |? StartDate
  |format=calendar
}}

```

## October 2012

◀ Today ▶

October 2012

Go to month

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
30	1	2	3	4	5	6	
7	8	9	10	11	12	13	
14	15	16	17	18	19	20	
21	PSMW Special call 2012 10 22	22 PSMW meeting call 2012 10 23	23	24	25	26	27
28	29	30	31	1	2	3	

# Provenance of Specifications

- Can be regarded as metadata at the M2 level
- The metadata for over 1400 OASIS standards documents were extracted to XML and will be mapped to various provenance ontologies
  - Dublin Core
  - Ontology Metadata Vocabulary (OMV)
  - ISO 11179 (and ISO 19763)
  - PROV
- Important for consistency checking, search and reports.



## **Integrated Collaboration Object Model (ICOM) for Interoperable Collaboration Services Version 1.0**

**Committee Specification Draft 04 /  
Public Review Draft 04**

**26 June 2012**

**Specification URIs**

**This version:**

<http://docs.oasis-open.org/icom/icom-ics/v1.0/csprd03/icom-ics-v1.0-csprd03.doc>

(Authoritative)

<http://docs.oasis-open.org/icom/icom-ics/v1.0/csprd03/icom-ics-v1.0-csprd03.html>

<http://docs.oasis-open.org/icom/icom-ics/v1.0/csprd03/icom-ics-v1.0-csprd03.pdf>

**Previous version:**

<http://www.oasis-open.org/committees/download.php/44405/icom-ics-v1.0-csprd02.zip>

**Latest version:**

<http://docs.oasis-open.org/icom/icom-ics/v1.0/icom-ics-v1.0.doc> (Authoritative)

<http://docs.oasis-open.org/icom/icom-ics/v1.0/icom-ics-v1.0.html>

<http://docs.oasis-open.org/icom/icom-ics/v1.0/icom-ics-v1.0.pdf>

**Technical Committee:**

[OASIS Integrated Collaboration Object Model for Interoperable Collaboration Services  
\(ICOM\) TC](#)

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Patrick Durusau, ([patrick@durusau.net](mailto:patrick@durusau.net)), [Individual](#)



# ICOM Metadata in XML format

```
<standard>
  <title>Integrated Collaboration Object Model (ICOM) for Interoperable Collaboration Services Version 1.0</title>
  <version>Committee Specification Draft 04 /Public Review Draft 04</version>
  <url>http://docs.oasis-open.org/icom/icom-ics/v1.0/csd04/icom-ics-v1.0-csd04.html</url>
  <date>26 June 2012</date>
  <abstract>The Integrated Collaboration Object Model (ICOM) for Interoperable Collaboration Services defines a framework for integrati
The framework is not intended to prescribe how applications or services conforming to its model implement, store, or transport the data
The model integrates a broad range of collaboration activities, by encompassing and improving on a range of models which are part of ex
  <chair>Eric S. Chan (eric.s.chan@oracle.com), Oracle</chair>
  <chair>Kenneth P. Baclawski (ken@ccs.neu.edu), Northeastern University</chair>
  <citeAs>[ICOM-ics-v1.0]
Integrated Collaboration Object Model (ICOM) for Interoperable Collaboration Services Version 1.0. 28 March 2012. OASIS Committee Speci
  <editor>Eric S. Chan (eric.s.chan@oracle.com), Oracle</editor>
  <editor>Patrick Durusau, (patrick@durusau.net), Individual</editor>
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  <namespace>http://docs.oasis-open.org/ns/icom/forum/201008</namespace>
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  <status>This document was last revised or approved by the OASIS Integrated Collaboration Object Model for Interoperable Collaborator
Technical Committee members should send comments on this specification to the Technical Committee's email list. Others should send comm
For information on whether any patents have been disclosed that may be essential to implementing this specification, and any offers of
  <technicalCommitteeMember>OASIS Integrated Collaboration Object Model for Interoperable Collaboration Services (ICOM) TC</technicalCc
  <thisVersion>http://docs.oasis-open.org/icom/icom-ics/v1.0/csprd03/icom-ics-v1.0-csprd03.html</thisVersion>
  <thisVersion>http://docs.oasis-open.org/icom/icom-ics/v1.0/csprd03/icom-ics-v1.0-csprd03.pdf</thisVersion>
  <thisVersionAuthoritative>http://docs.oasis-open.org/icom/icom-ics/v1.0/csprd03/icom-ics-v1.0-csprd03.doc</thisVersionAuthoritative>
</standard>
```

# Other Applications

- Ontolog Forum
  - An open, international, virtual community of practice devoted to advancing the field of ontology, ontological engineering and semantic technology
  - Example of a very large (> 1000 members), long-term (10 year) collaborative group activity based on a wiki.
- Podcasts
  - Ontology is the basis for annotation and search.
  - Import/export of annotations from other platforms such as wikis

# Acknowledgements

- The PSMW mapping and calendar application are joint work with Yuwang Yin.
- The Podcast Ontology and import/export are being developed by Sumit Purohit.
- The transformations were developed for the OASIS ICOM standard in collaboration with Eric S. Chan.
- The ICOM standard was developed by the ICOM TC.

# Links

- Ontolog Forum: <http://ontolog.cim3.net>
- For documentation and a demo of the PSMW Calendar see: [PMMW Calendar](#)
- PSMW Home Page: [PSMW Project](#)