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Transformation of Protégé Ontologies into the Eclipse Modeling Framework

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Division of Biomedical Informatics

Mayo Clinic

Outline

- Motivation
- Eclipse Modeling Framework (EMF)
- EMF at work
- LexGrid Model & FMA Mapping
- FMA Transformation Example
- Conclusion

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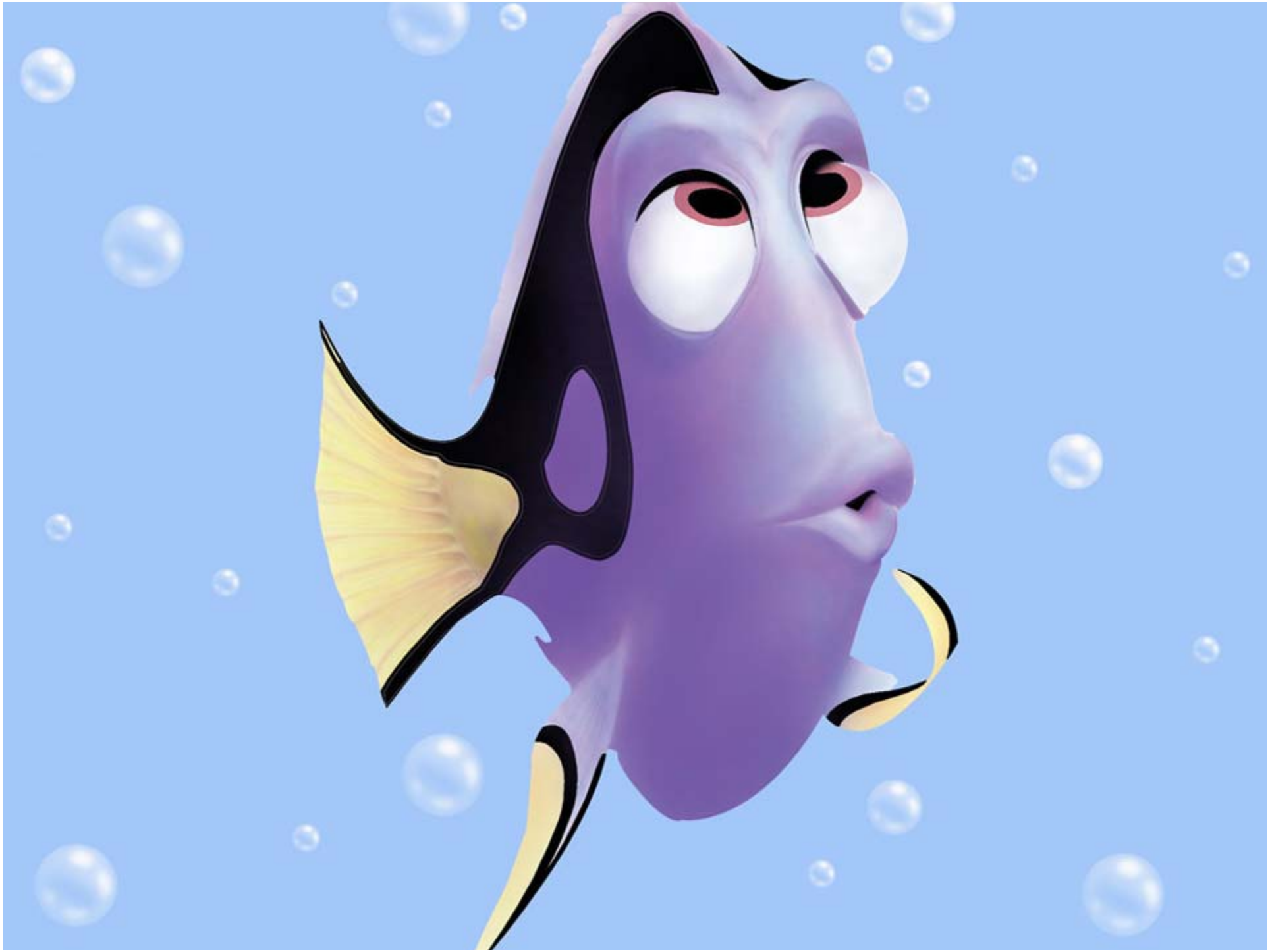
Outline

Lots of things to talk about in short time ☹



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Motivation

Why do a transformation?

- Native form of FMA cannot be readily integrated into grid, databases and other terminologies
- Need to transform content into a format and structure that is readily accessible via:
  - Standard API's
  - SQL
  - …
- The Mayo LexGrid model is one such candidate

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Motivation

Why EMF ?

- Easy & Simple to:
  - Use EMF Transformation
  - Integrate EMF with Protégé
  - Use EMF as a hub
- Successful FMA transformation

What is EMF ?

Eclipse Modeling Framework

- Framework & Code Generation tool
- Available with Eclipse
- Modeling ← EMF → Programming

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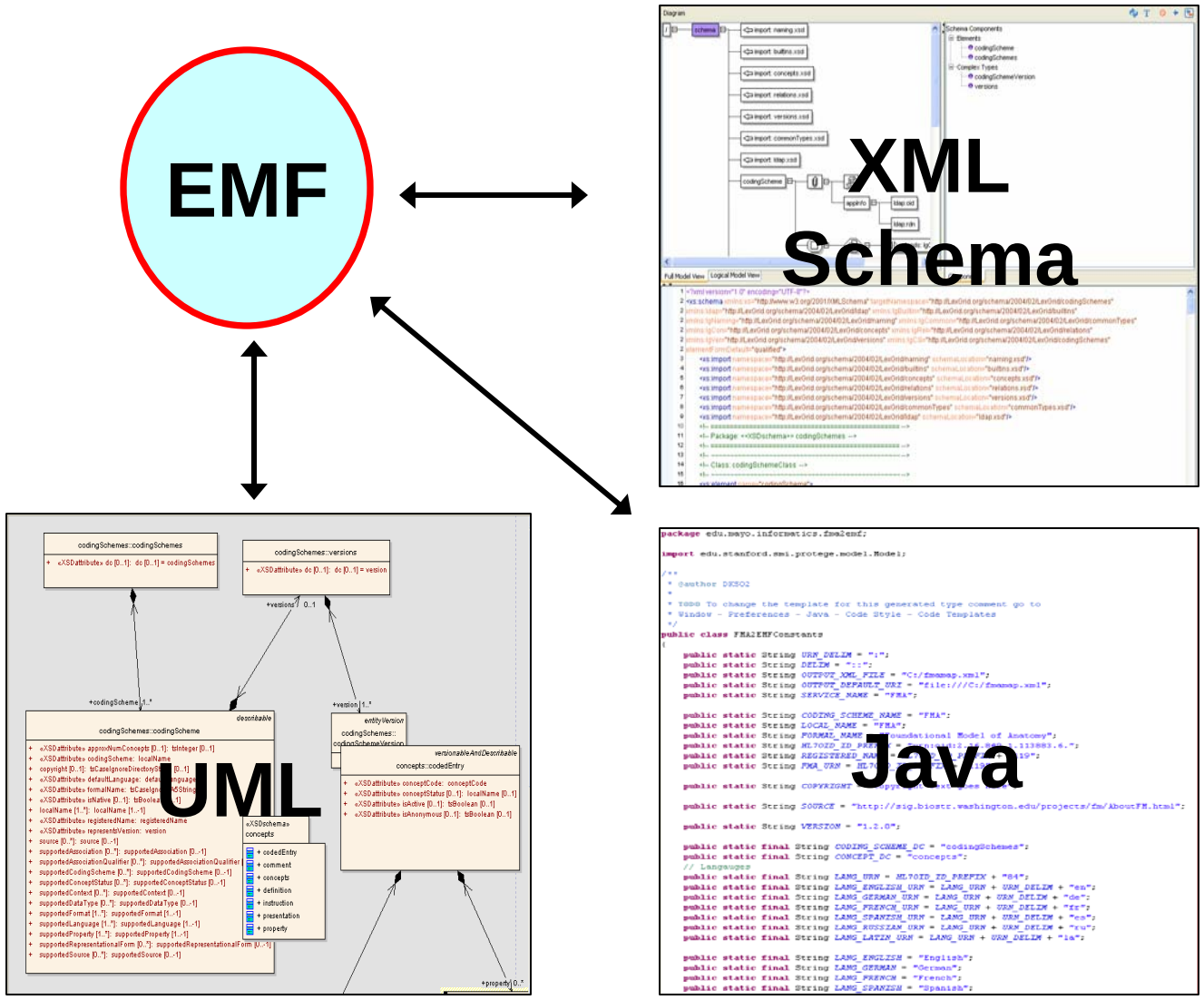
Eclipse Modeling Framework



Eclipse Modeling Framework

- Model in XMI (XML Metadata Interchange) format
- EMF Project
  - ECORE
  - GENMODEL
- Generated Code can be customized
- Easy to Update & Regenerate

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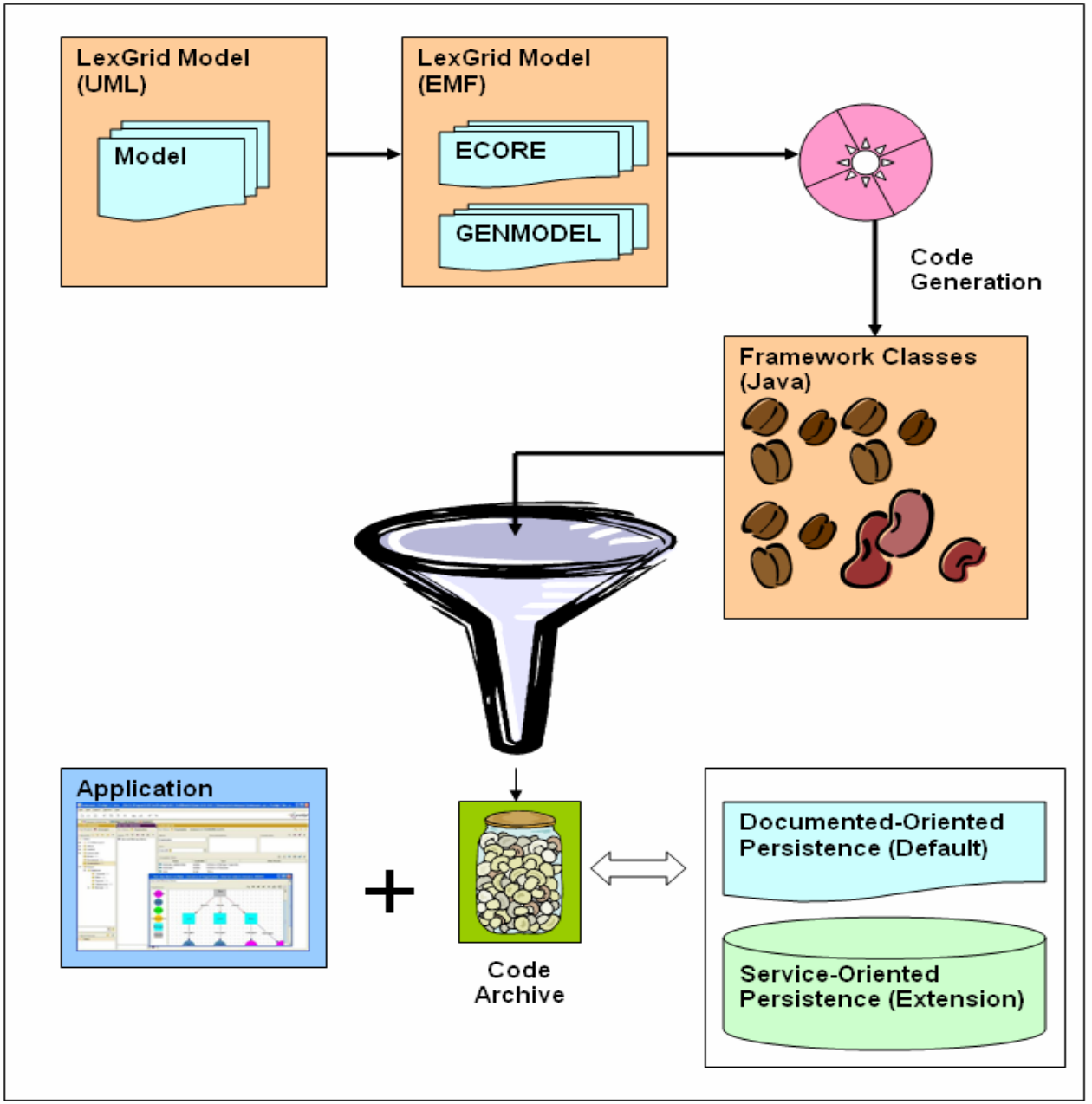
EMF



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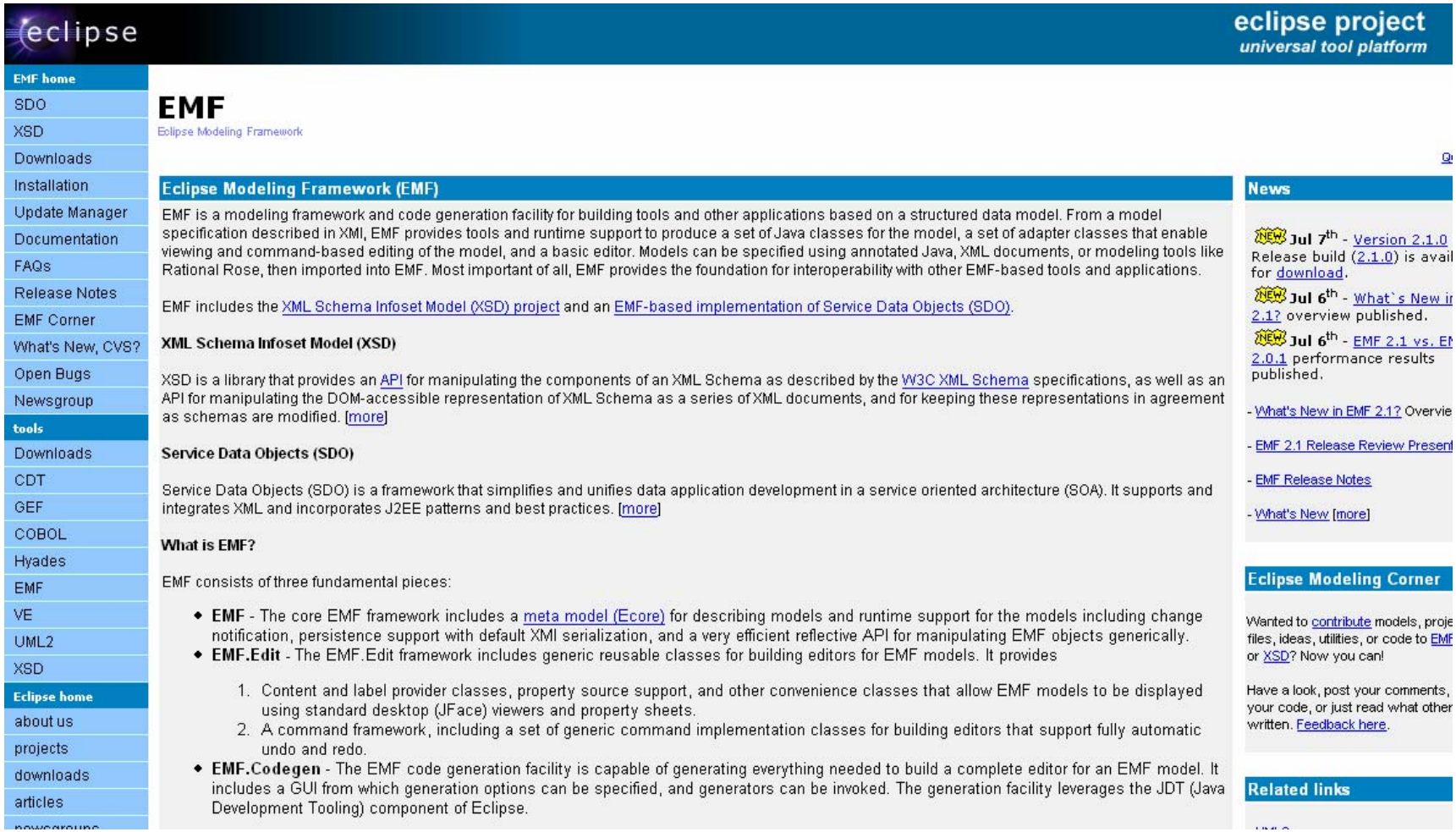
Eclipse Modeling Framework

http://www.eclipse.org/emf/



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EMF at work

- **Model & Representation**
- **Protégé Content**
- **Mapping**
- **Output**

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EMF at work

- **Model & Representation** → **LexGrid Model in XML Schema**
- **Protégé Content** → **FMA**
- **Mapping** → **FMA to LexGrid Model**
- **Output** → **LexGrid XML Document**

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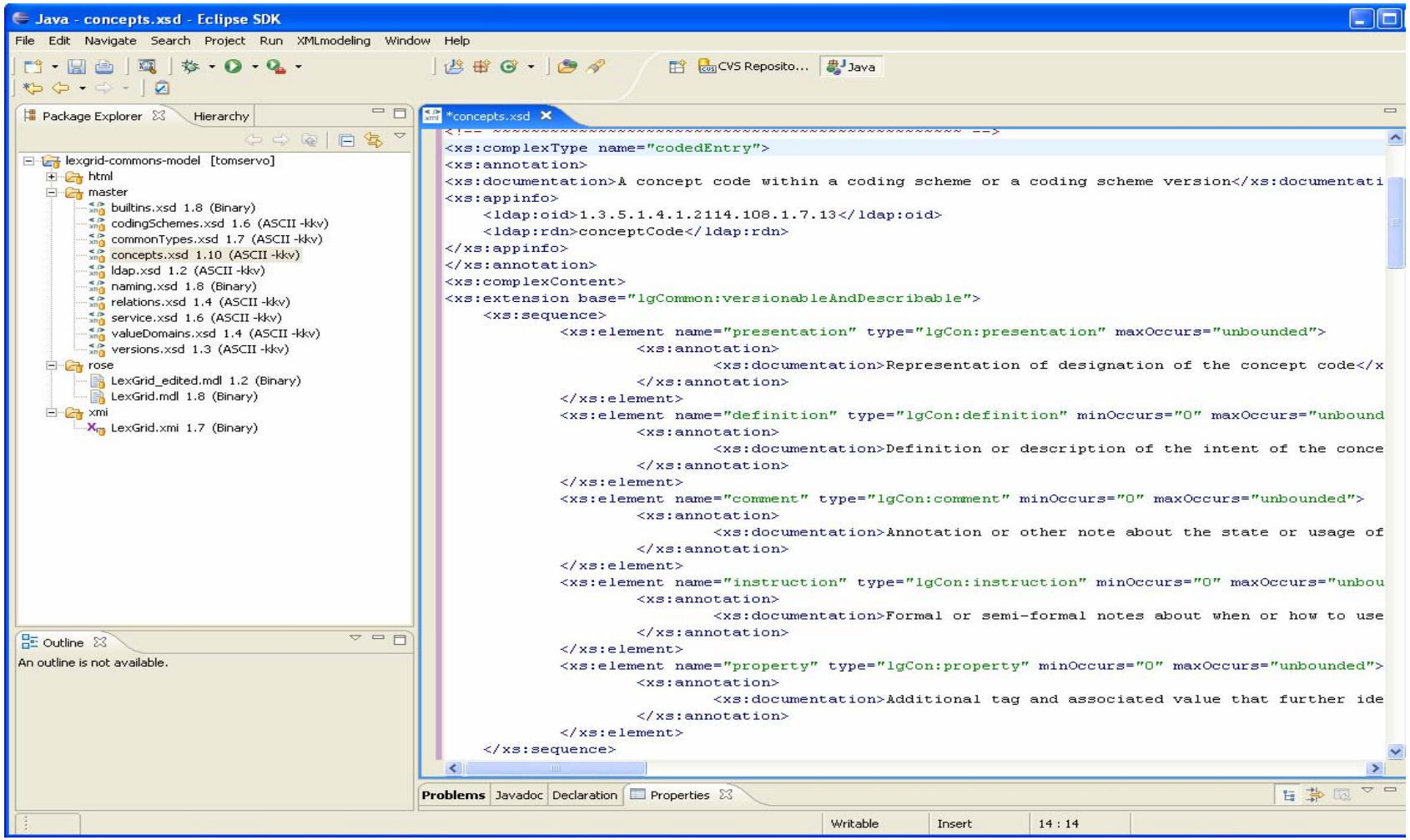
EMF at work
Model Representation



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EMF at work
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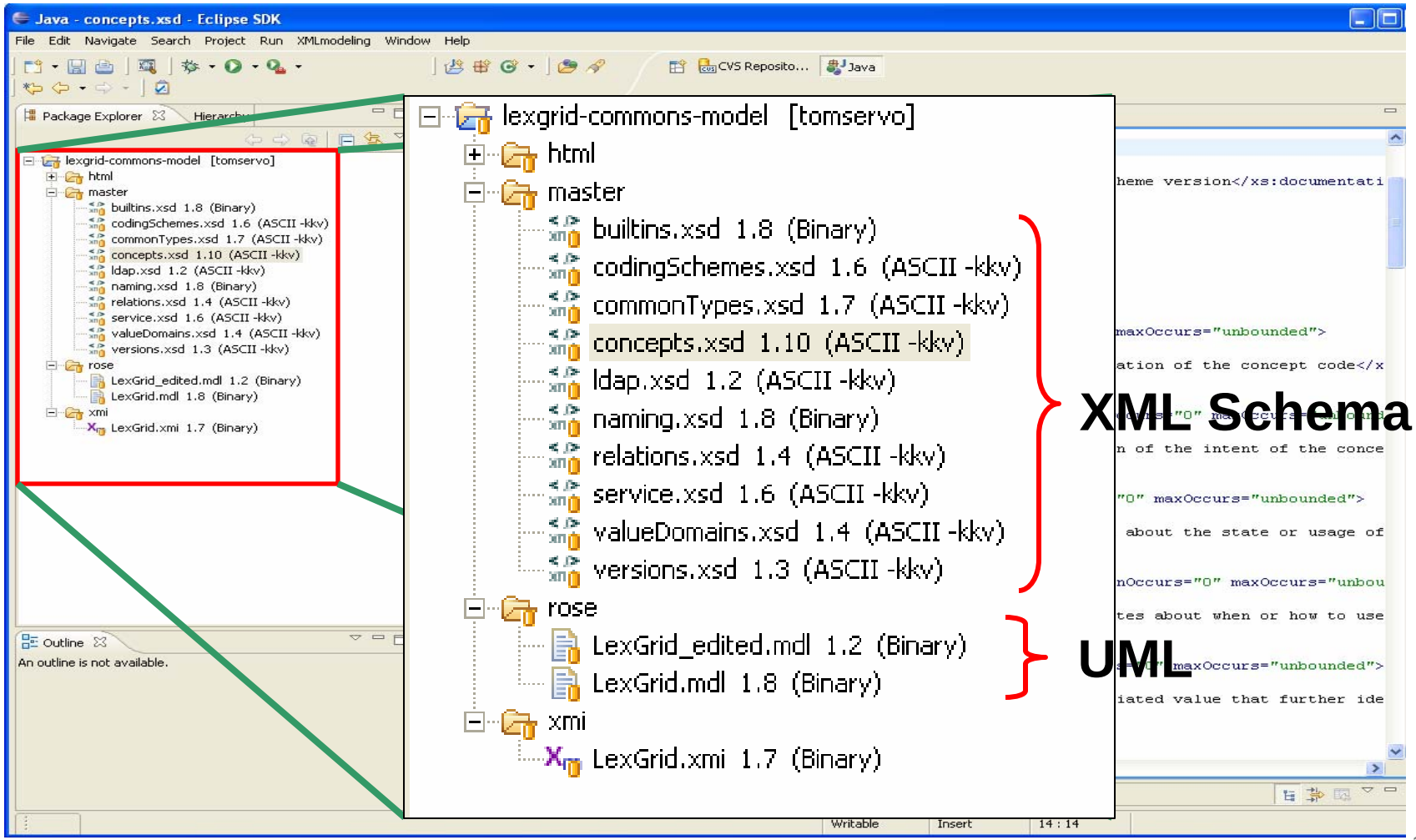

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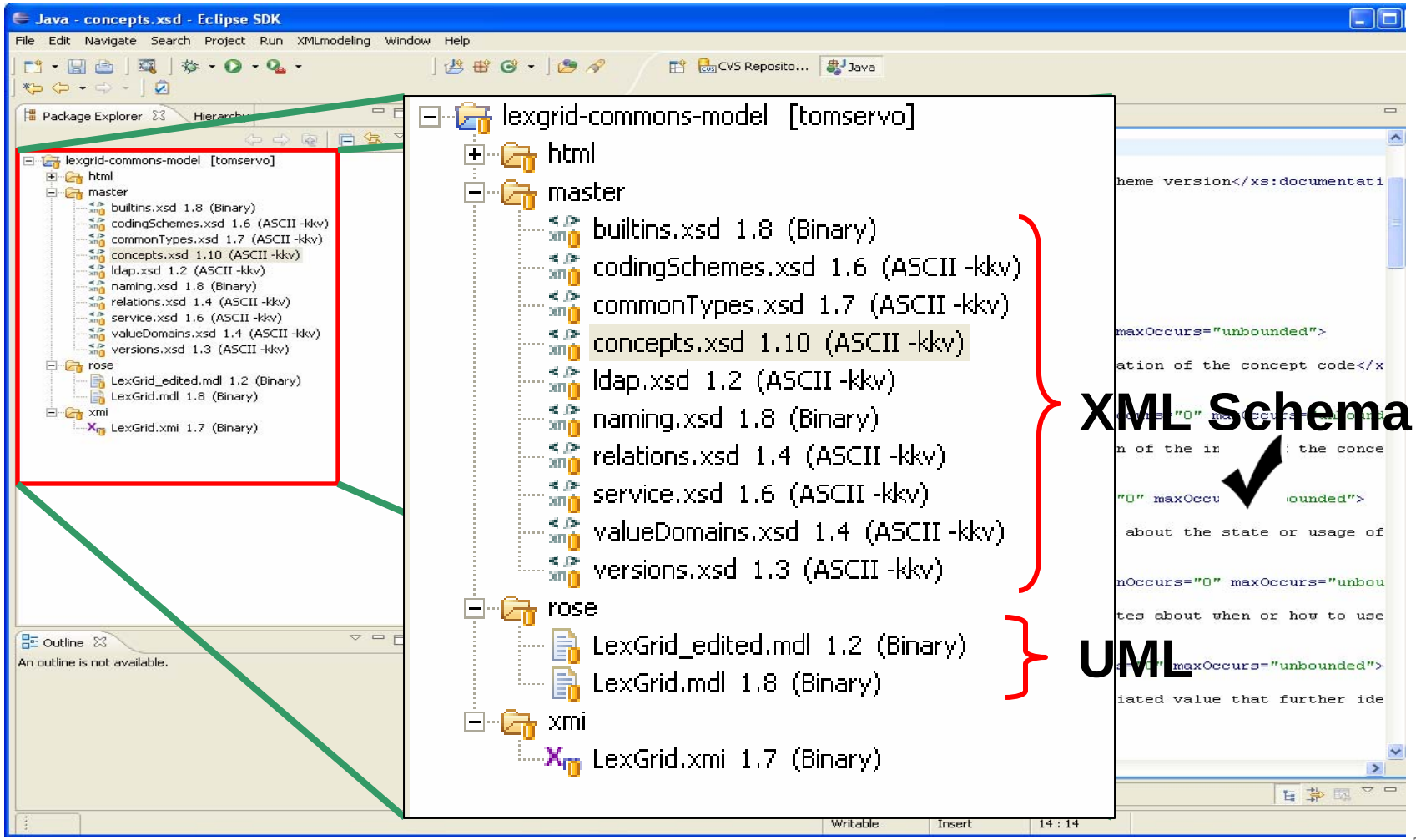

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EMF at work
Model Representation (XSD)

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<xs:annotation>
<xs:documentation>A concept code within a coding scheme or a coding scheme version</xs:documentati
<xs:appinfo>
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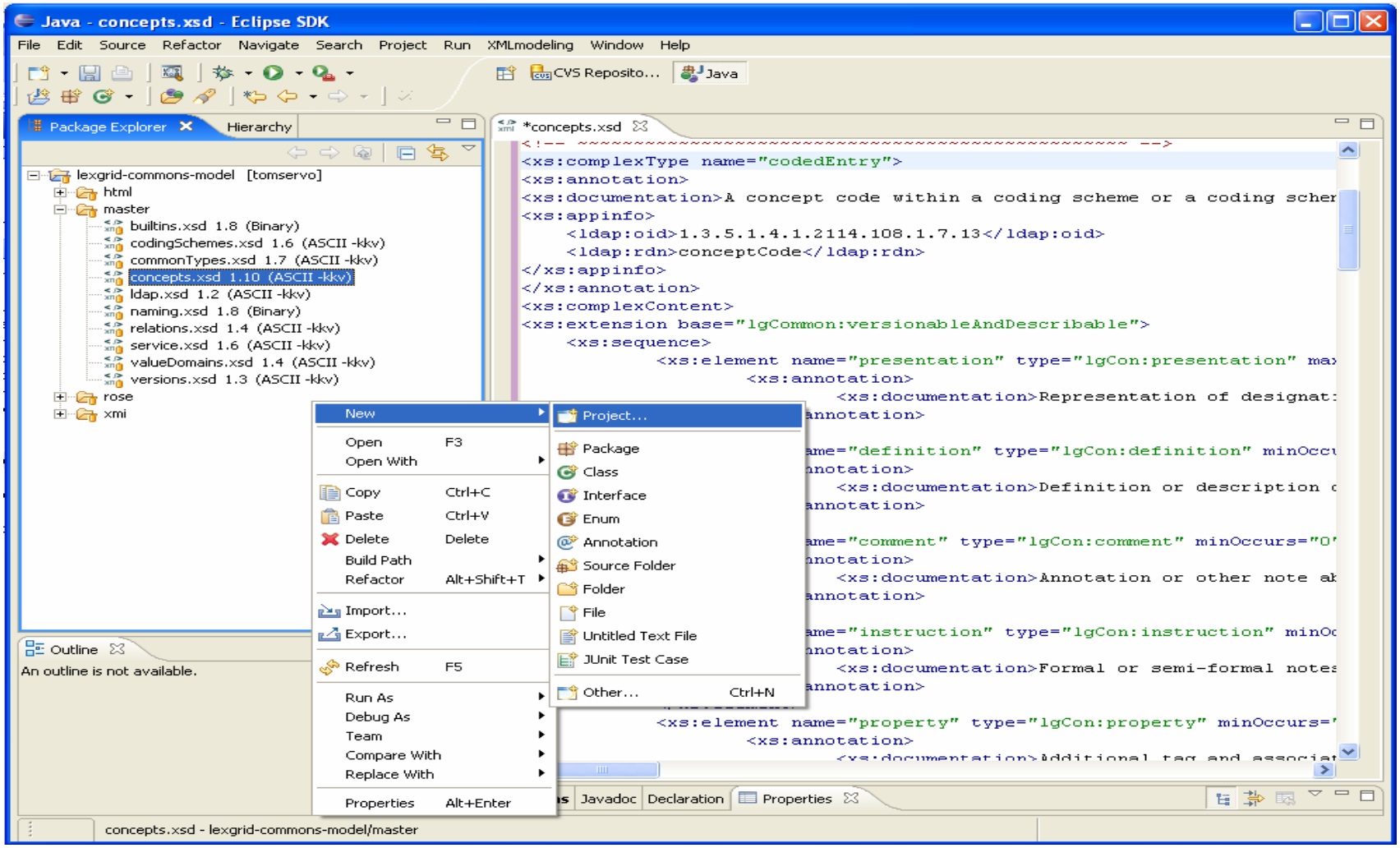
EMF at work
Create an EMF Project



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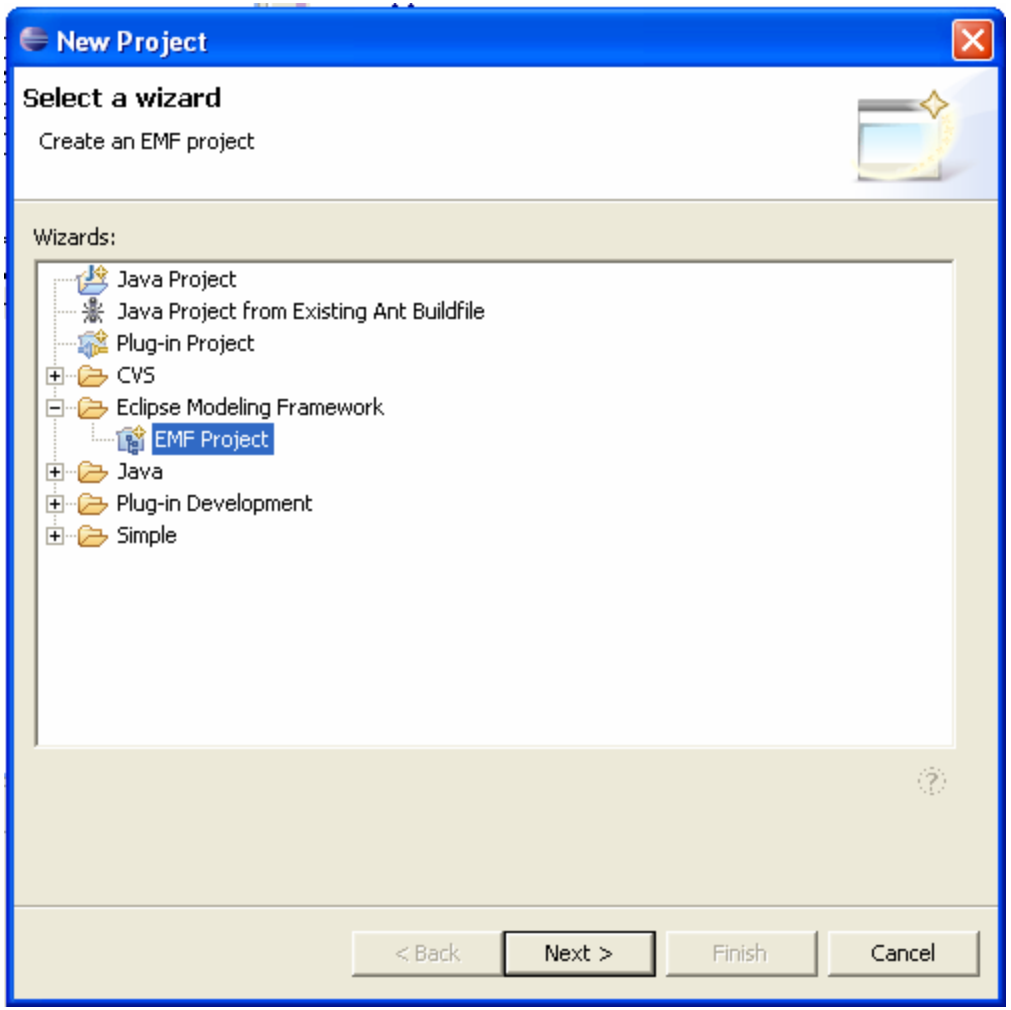

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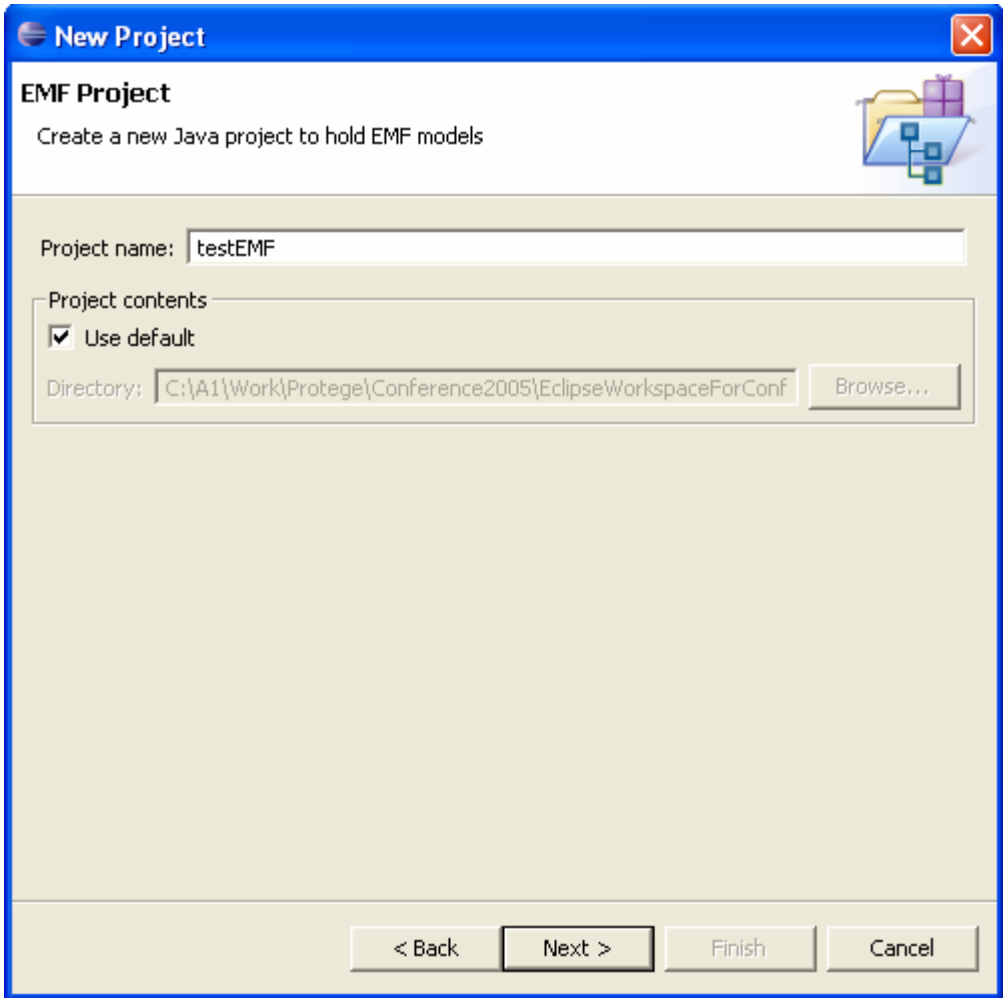

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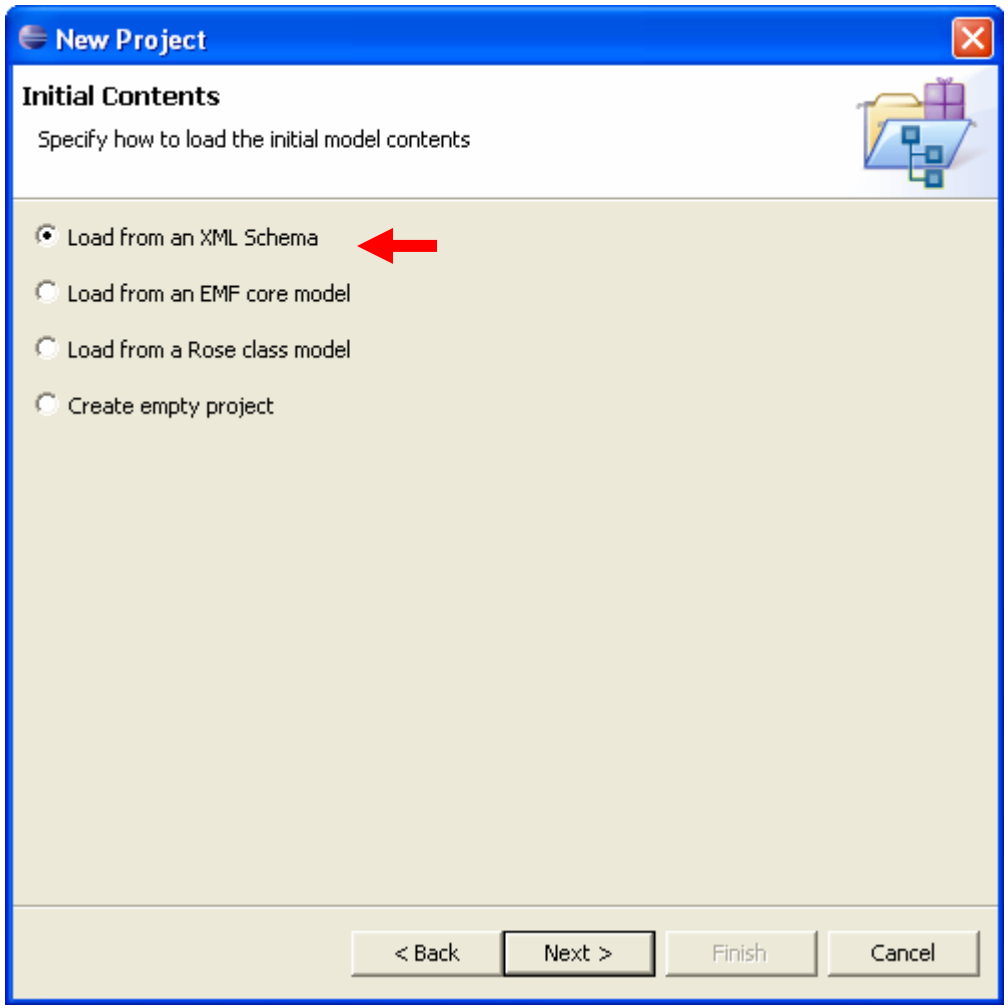

EMF at work
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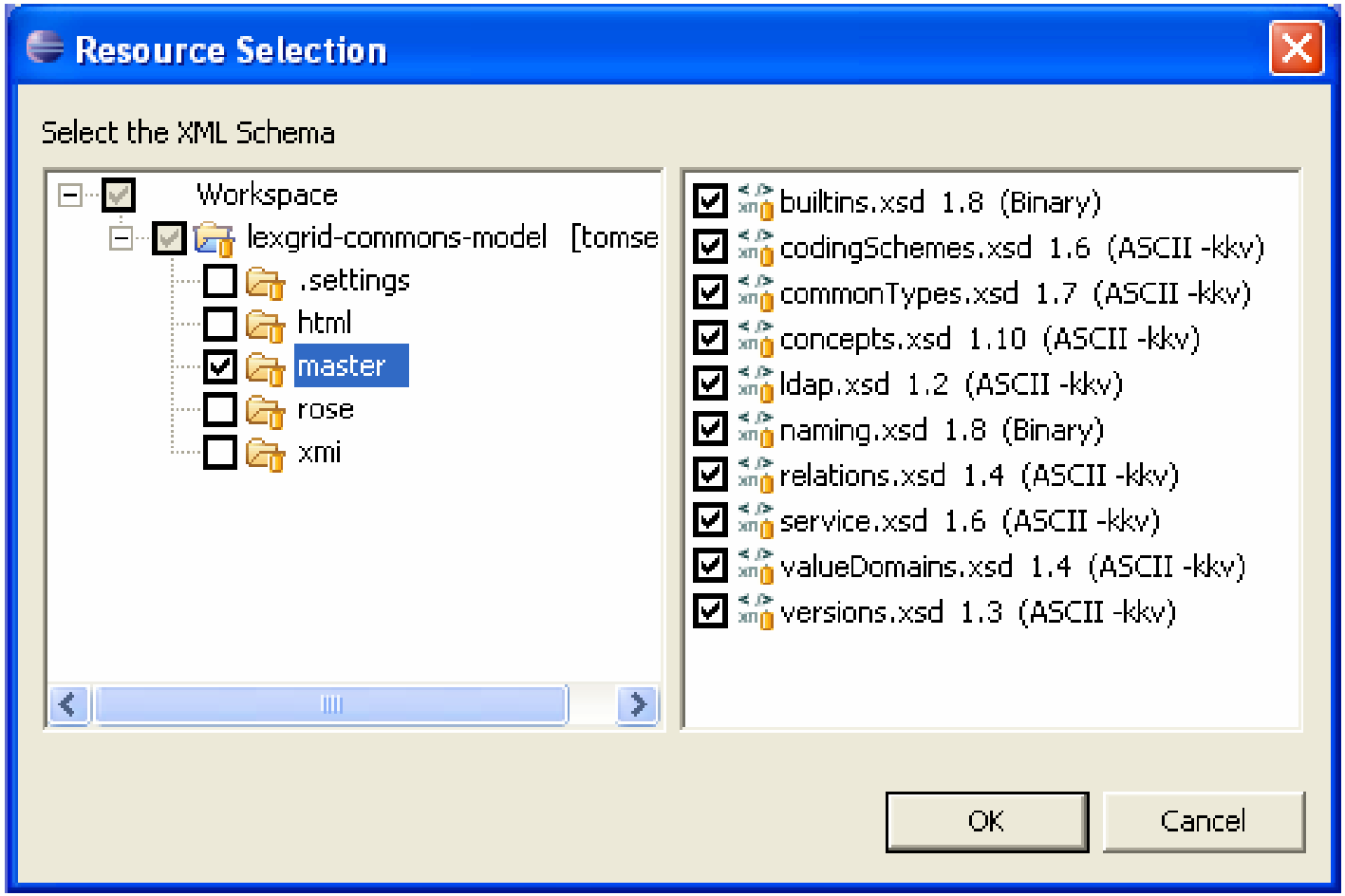

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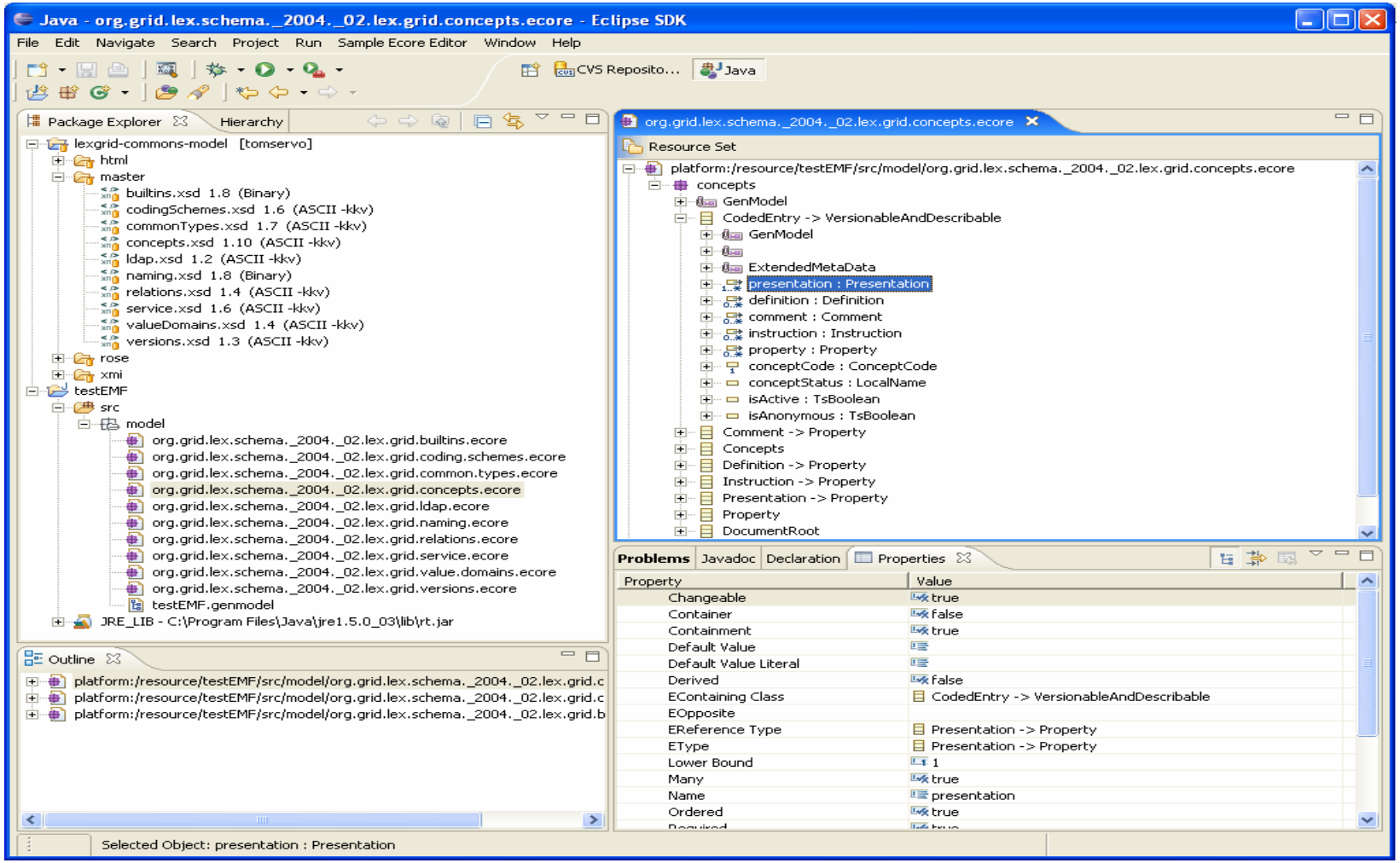
EMF at work
EMF Project Components



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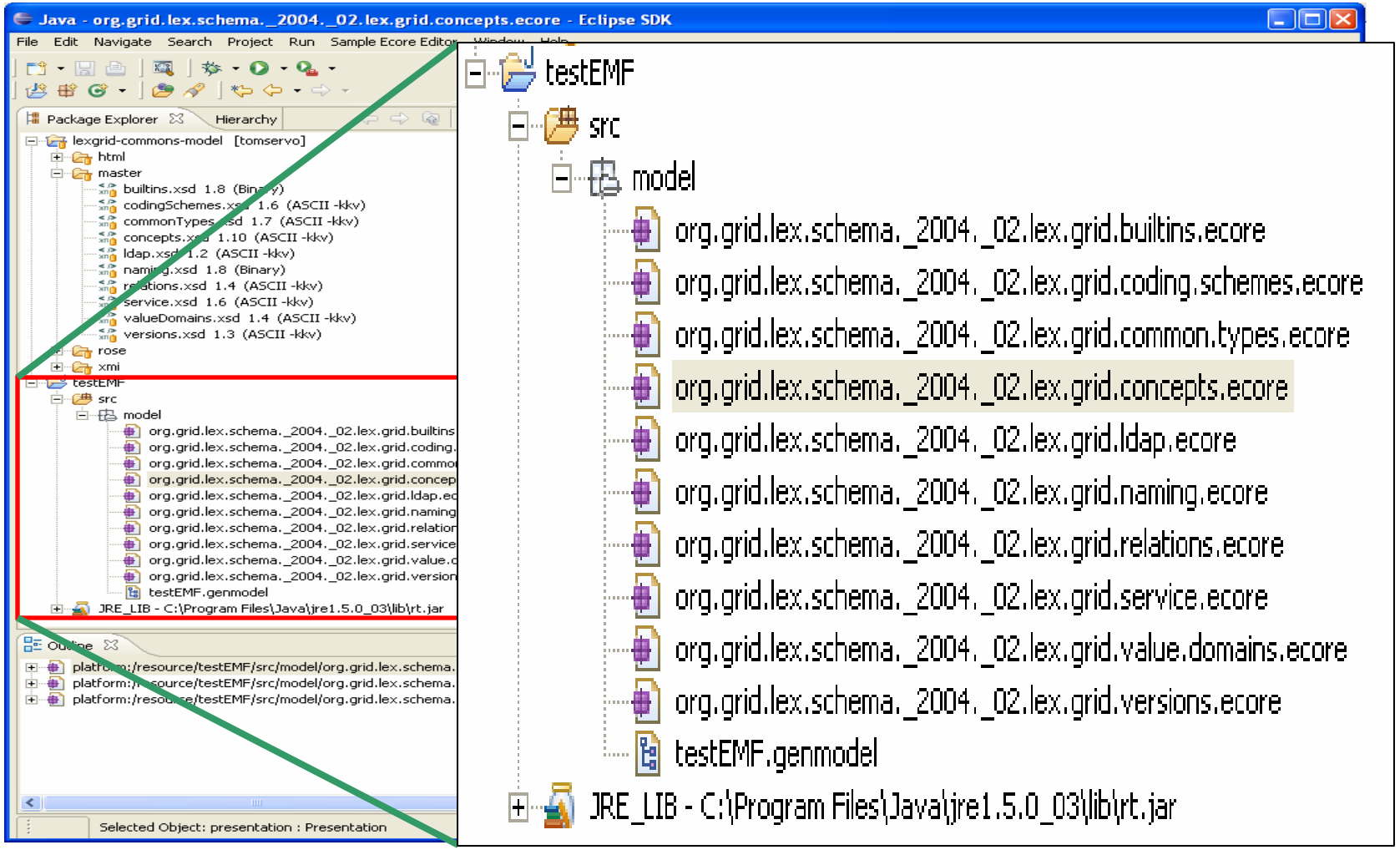

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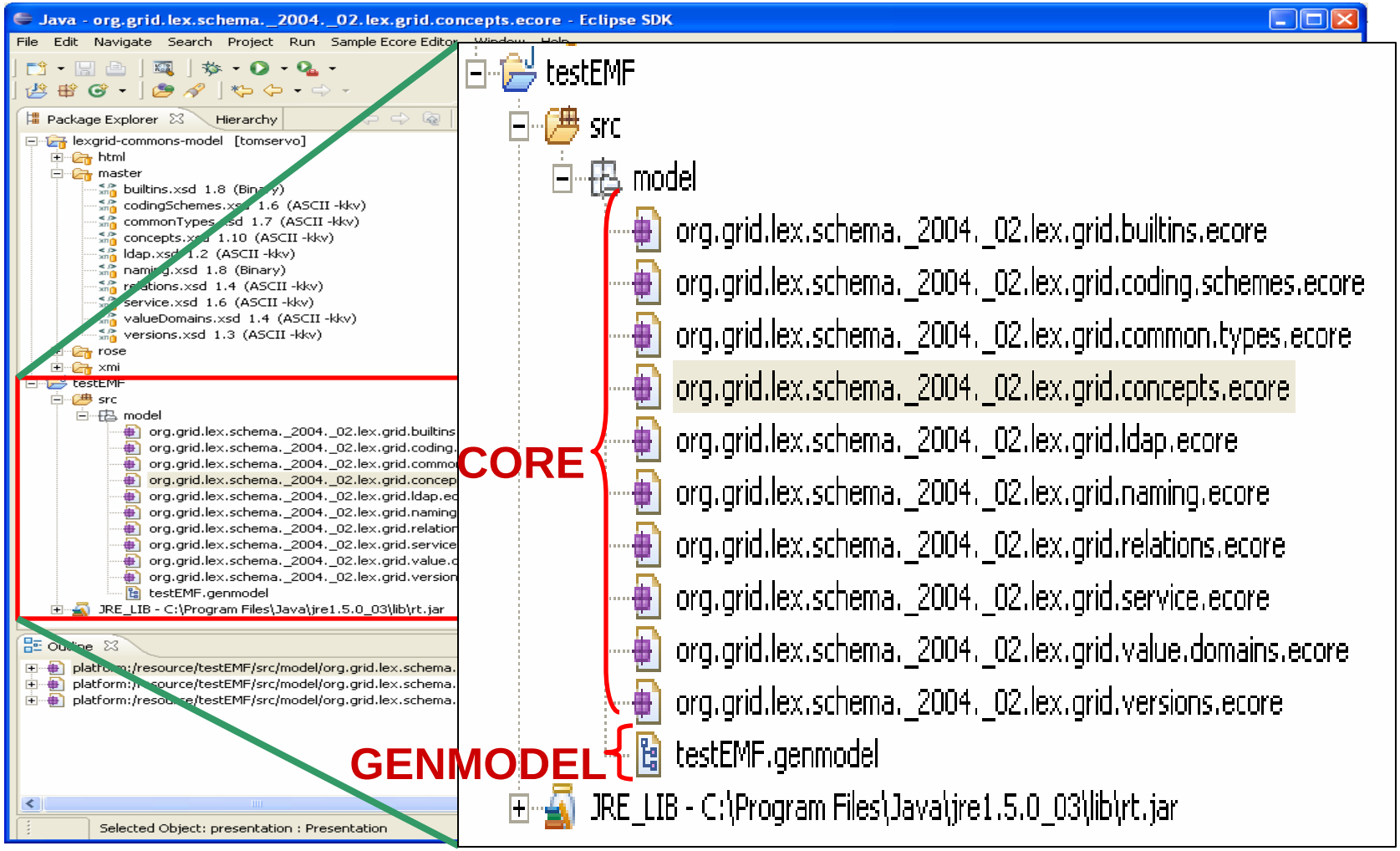

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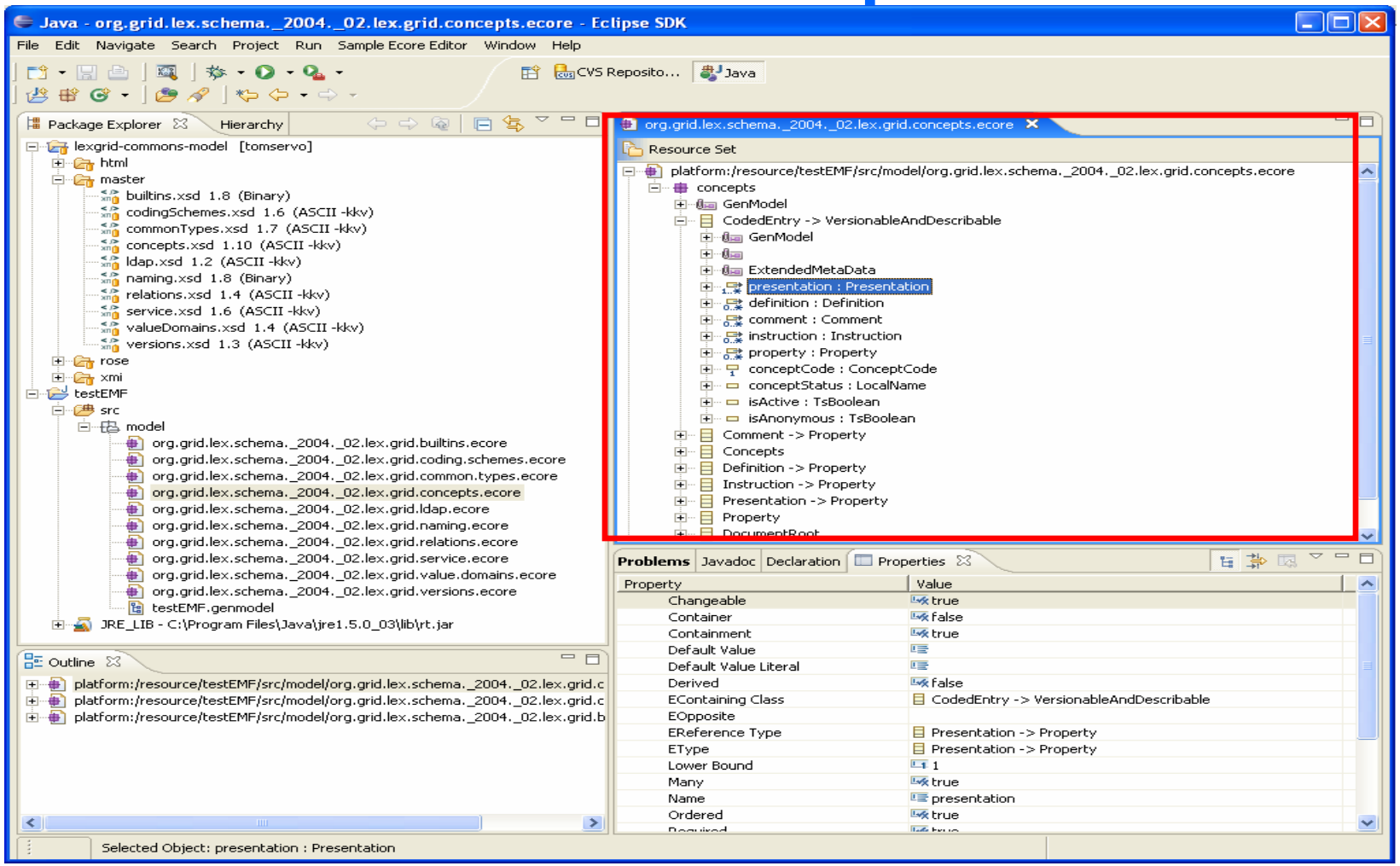
EMF at work
EMF CORE Component



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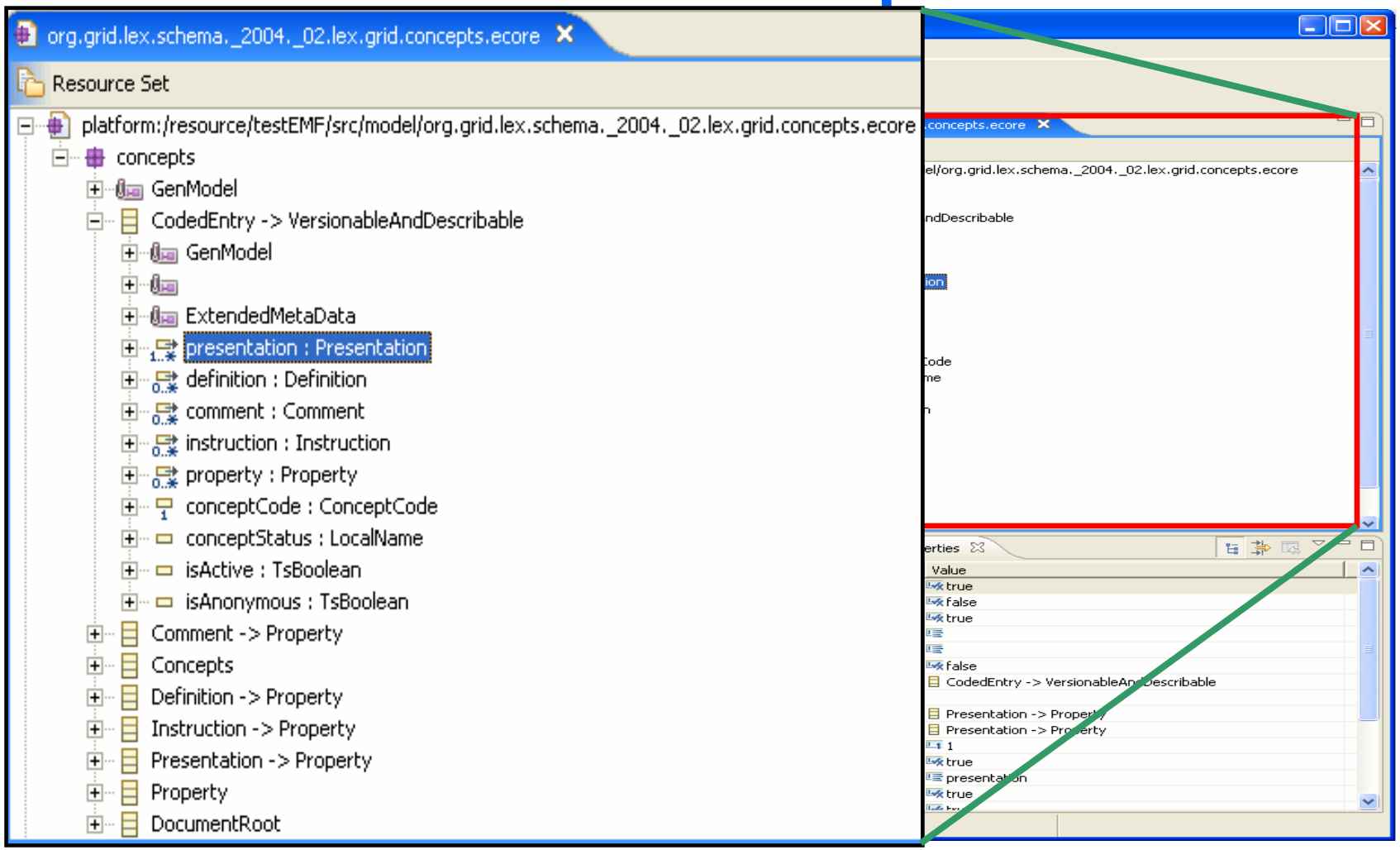

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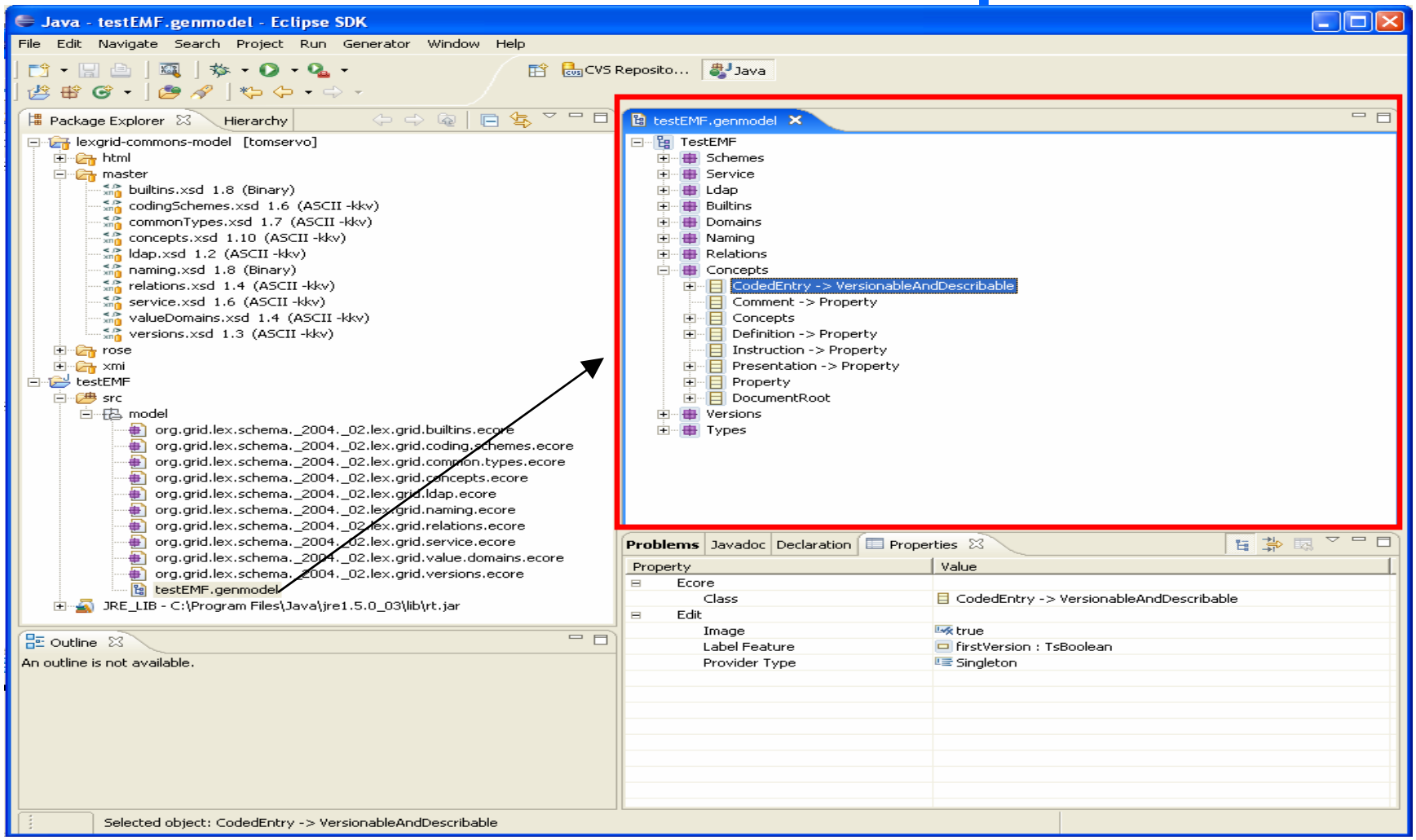
EMF at work
EMF GENMODEL Component



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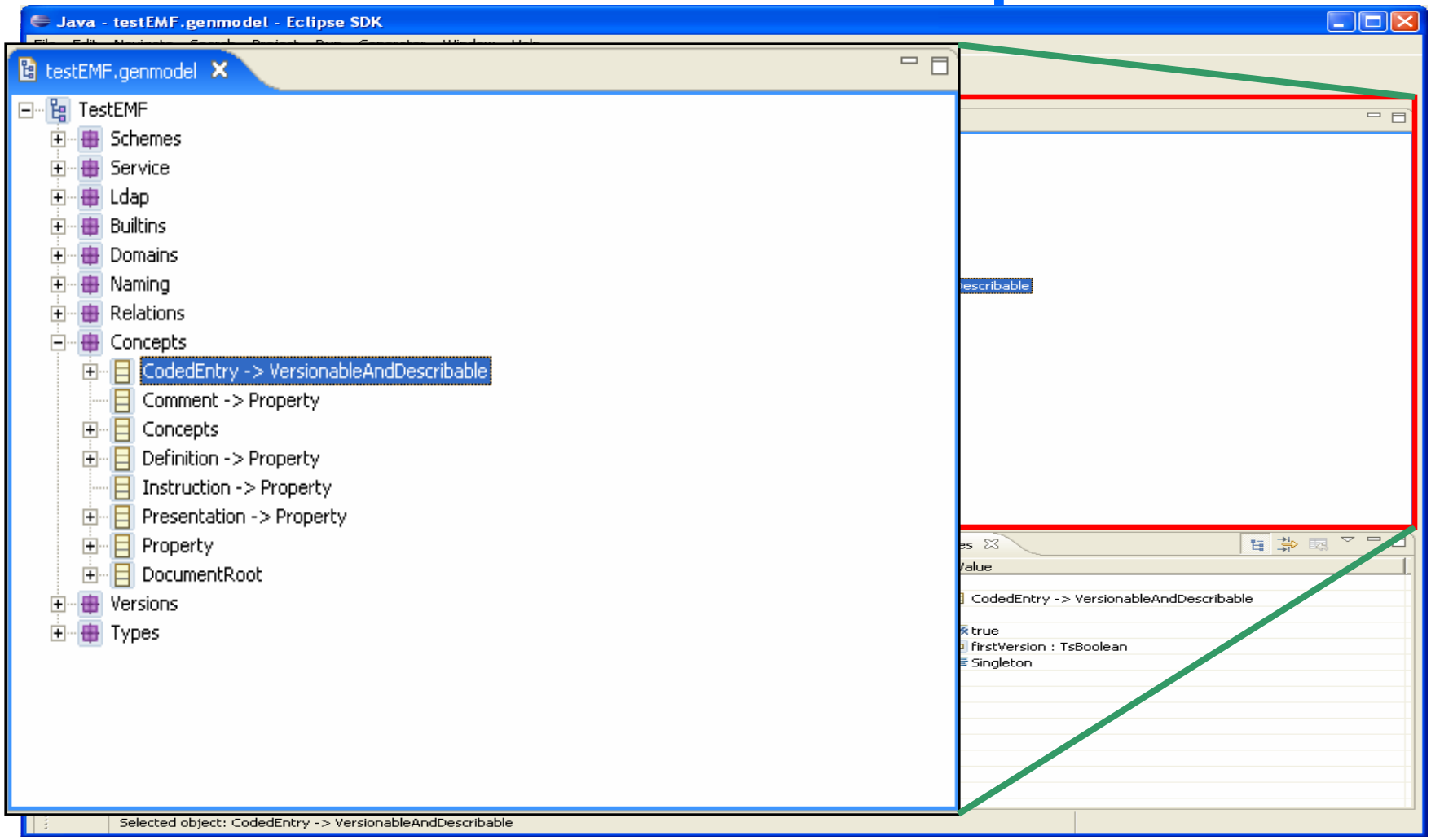

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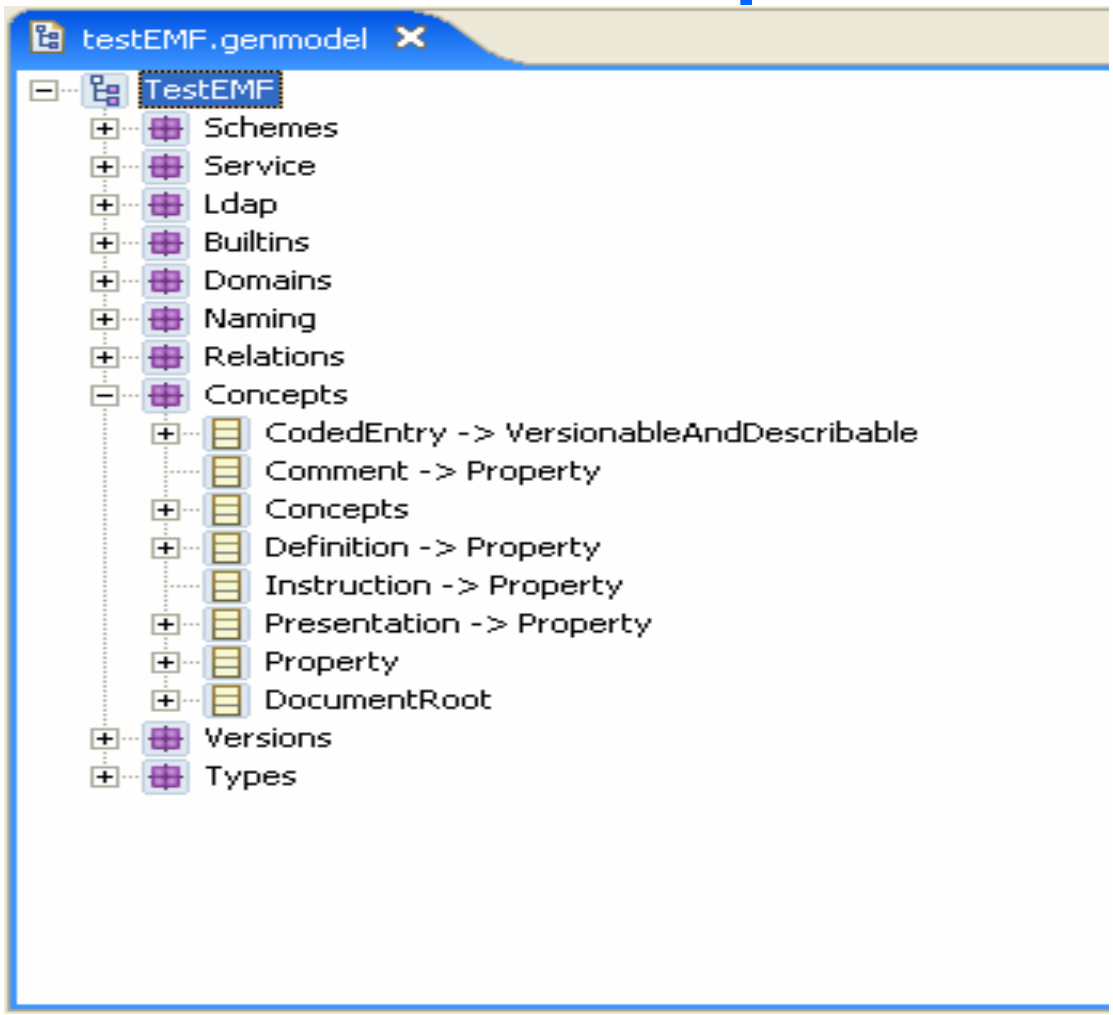
EMF at work
Generate Implementation



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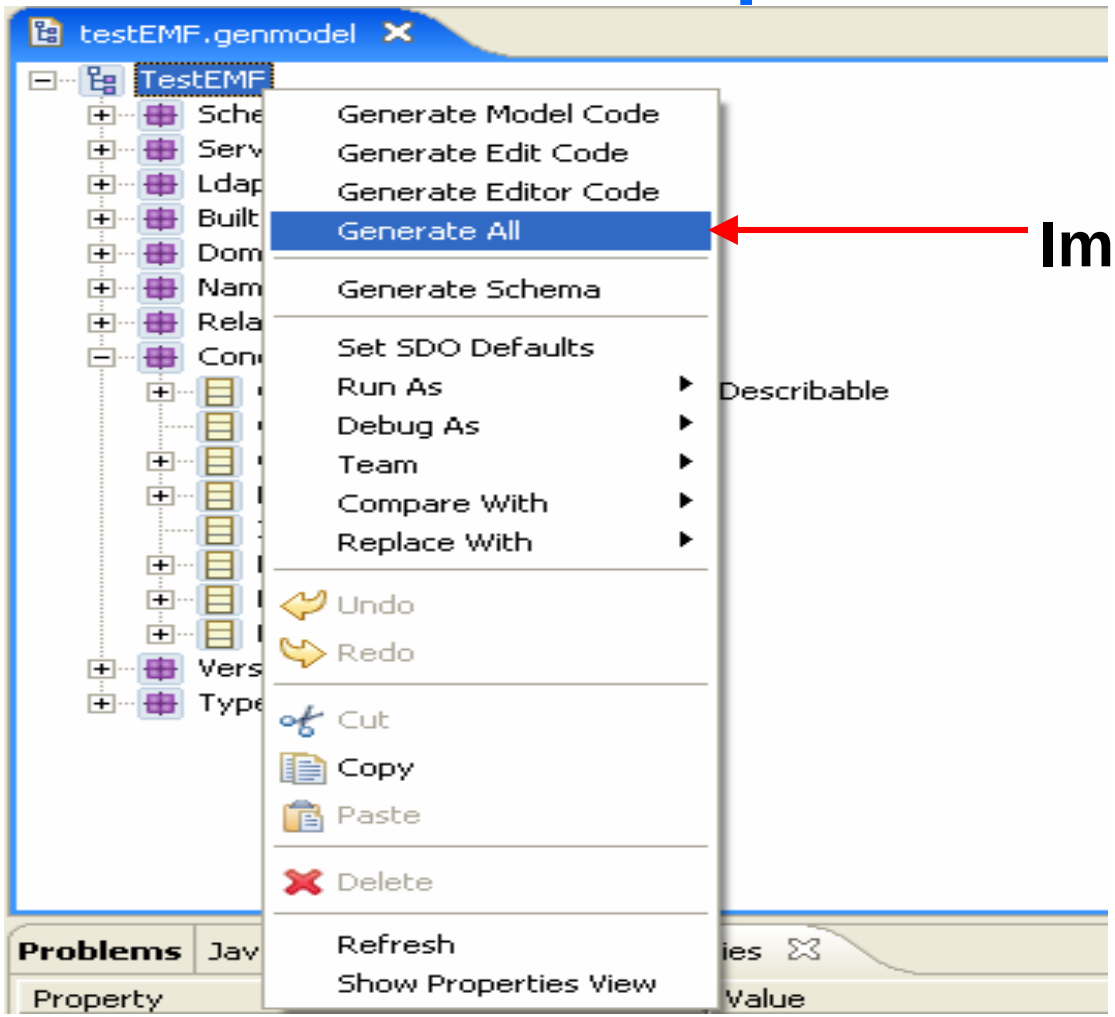

Generates Implementation

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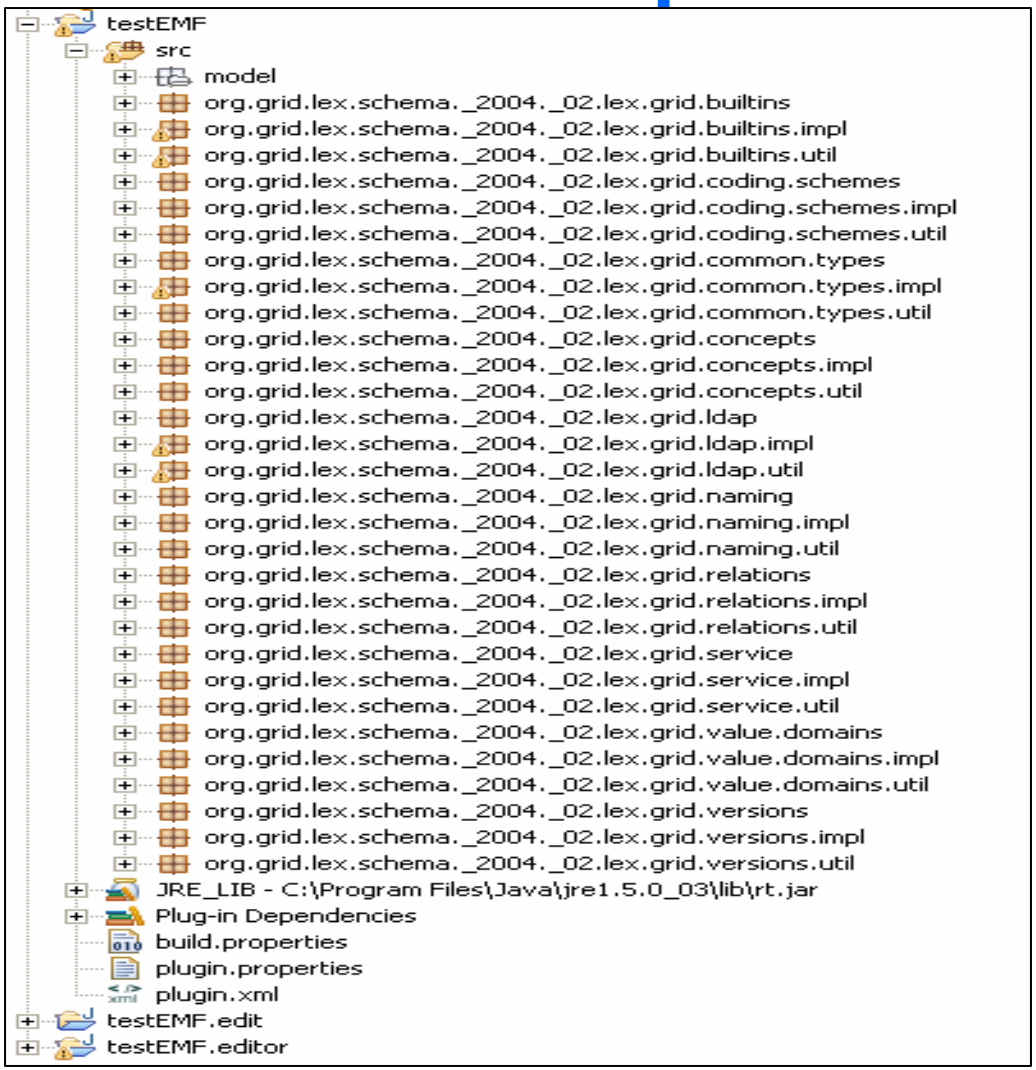
EMF at work
Implementation



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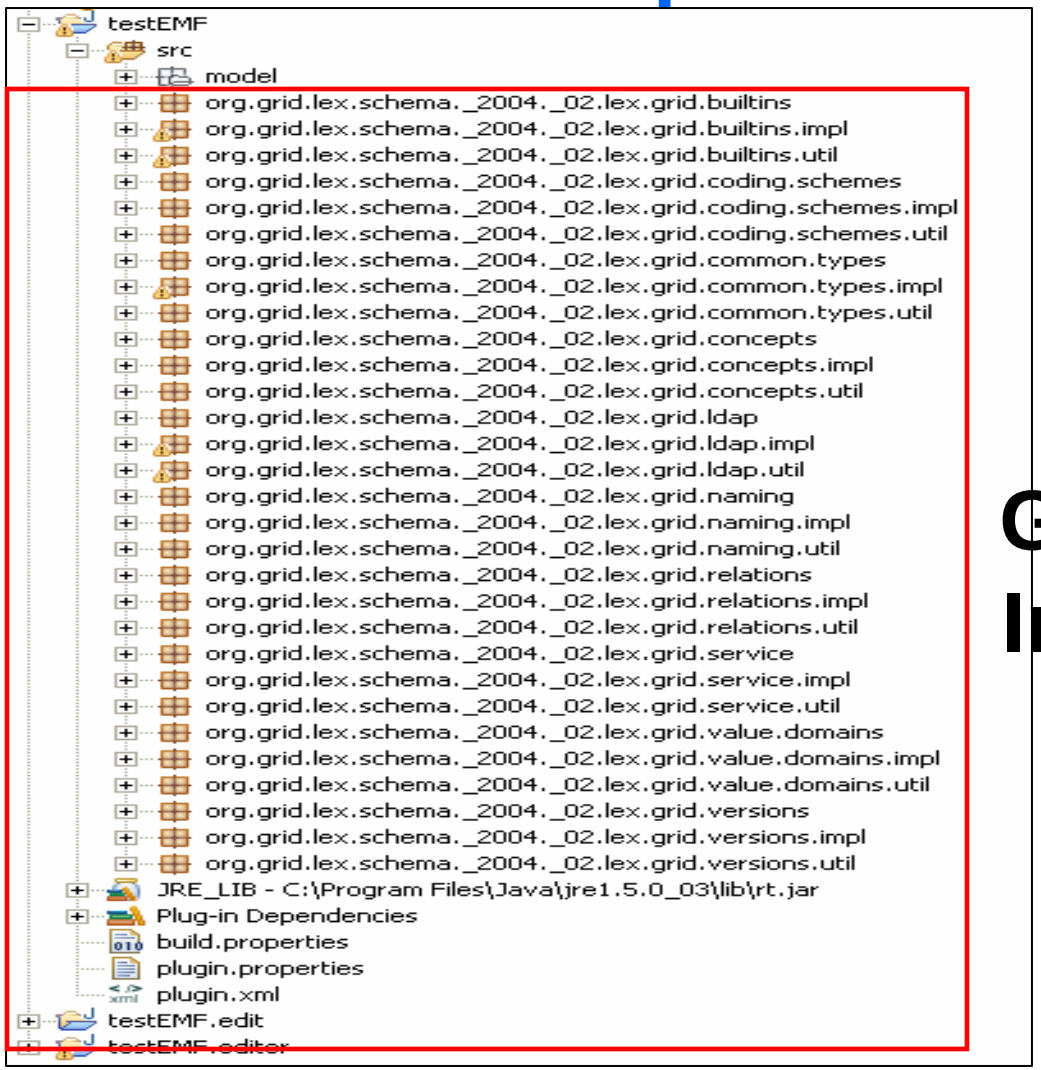

Generated Implementation

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EMF at work
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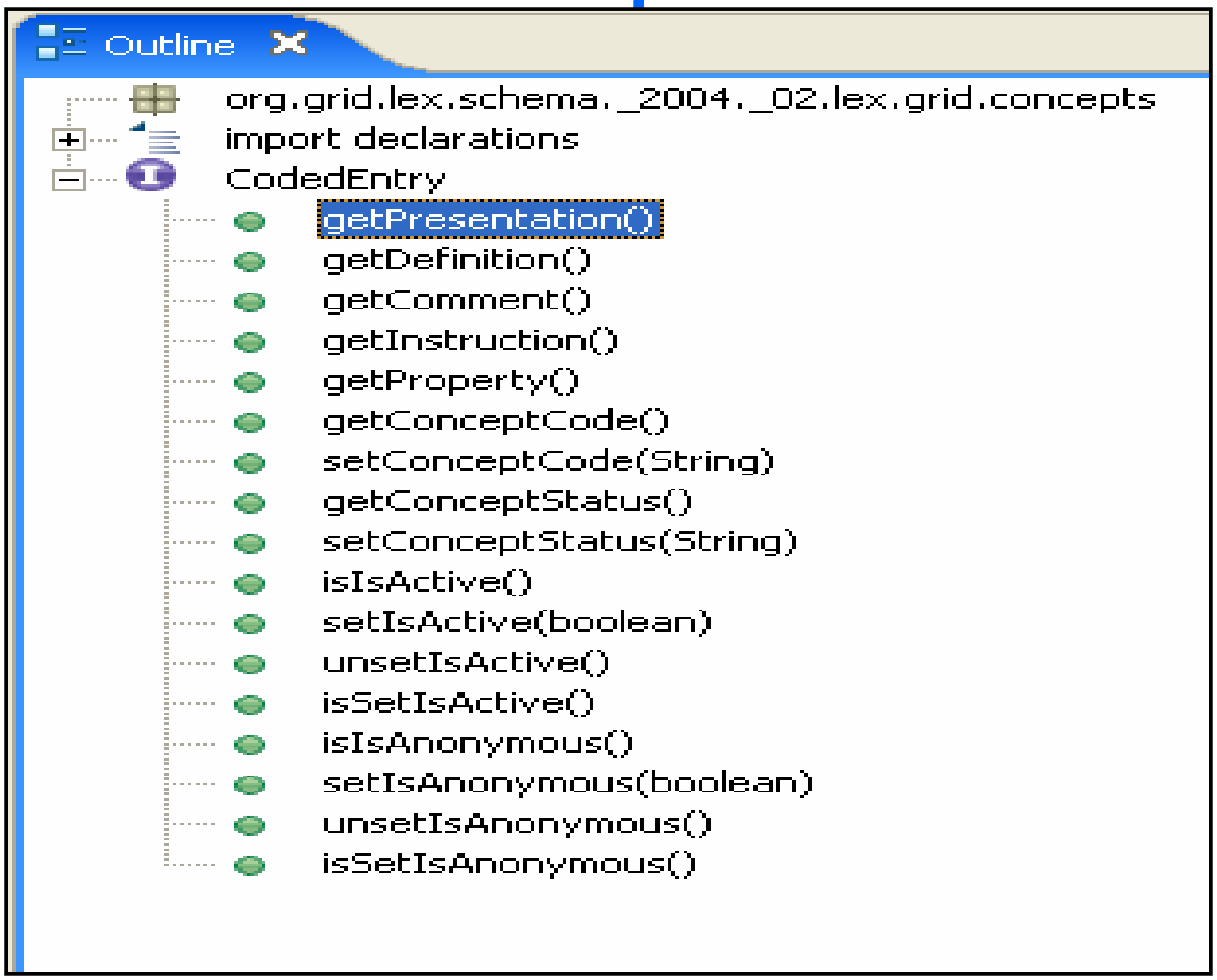

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EMF at work
Generated Implementation

```
 *
 * @generated
 */
public class CodedEntryImpl extends VersionableAndDescribableImpl implements CodedEntry {
    /**
     * The cached value of the '{@link #getPresentation() <em>Presentation</em>}' containment
     * <!-- begin-user-doc -->
     * <!-- end-user-doc -->
     * @see #getPresentation()
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     * @ordered
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    protected EList presentation = null;

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More implementation classes snapshots

Later in this presentation

EMF at work

- Customize the implementation
  - Before & After Generation
- Make EMF implementation available by either :
  - Create and include as an Archive
  - Application dependent on EMF implementation classes.

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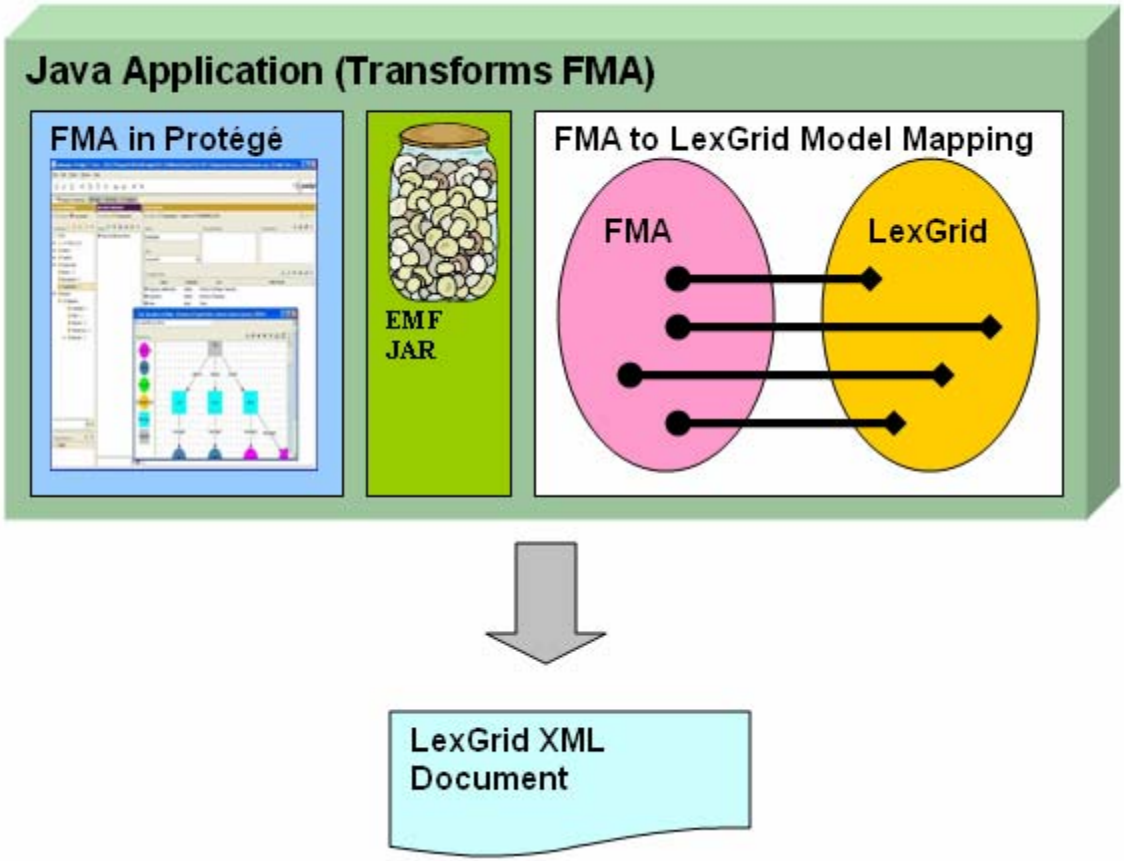

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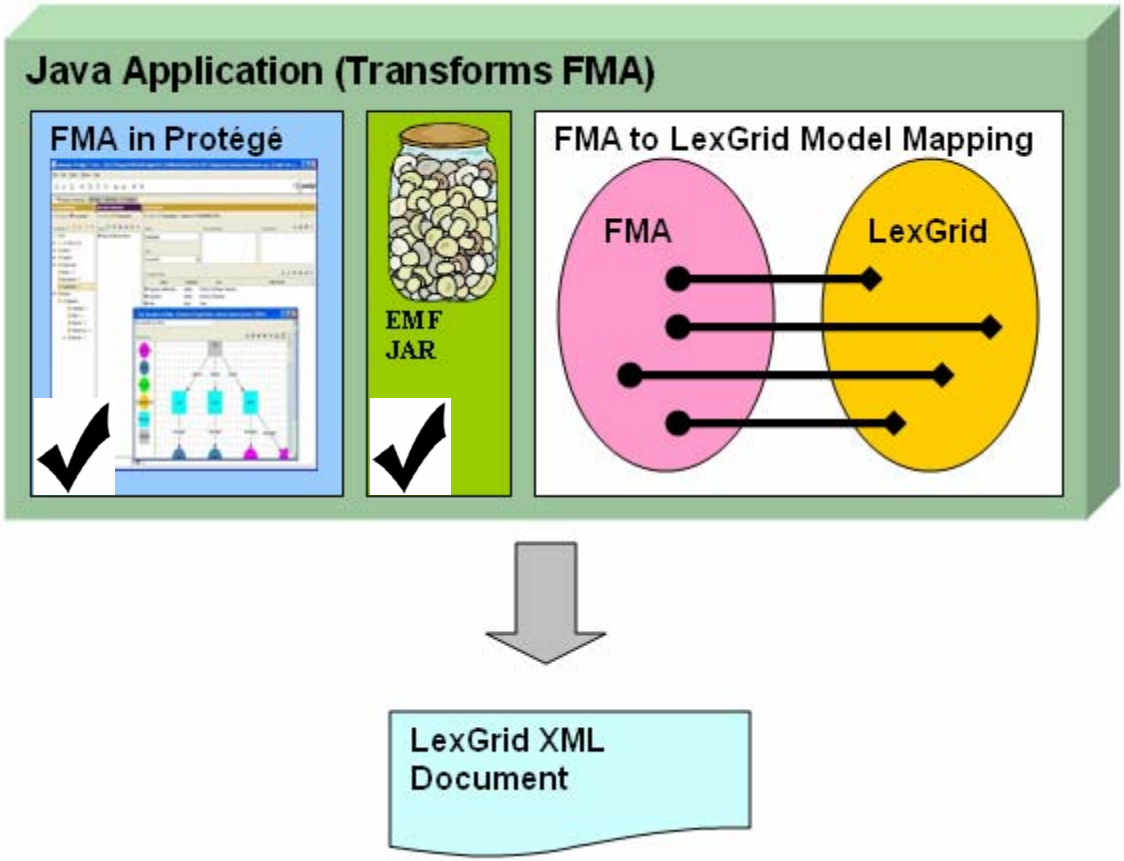

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LexGrid Model

- Developed by Mayo Biomedical Informatics Group
- Formal model of terminology
- Explicit definition of entities & objects used in LexGrid tooling
- Supports non-semantic entities (from the toolkit perspective) as name/value pair

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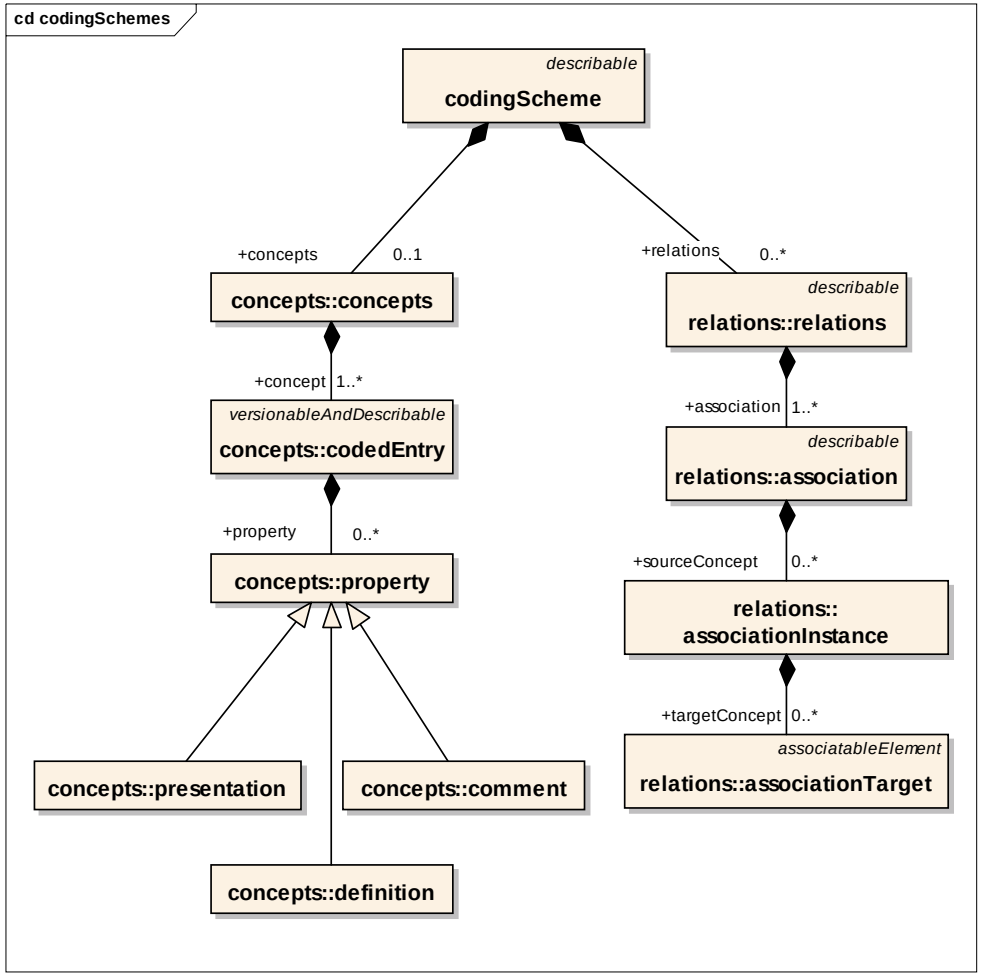
LexGrid Model
Information Model (partial)



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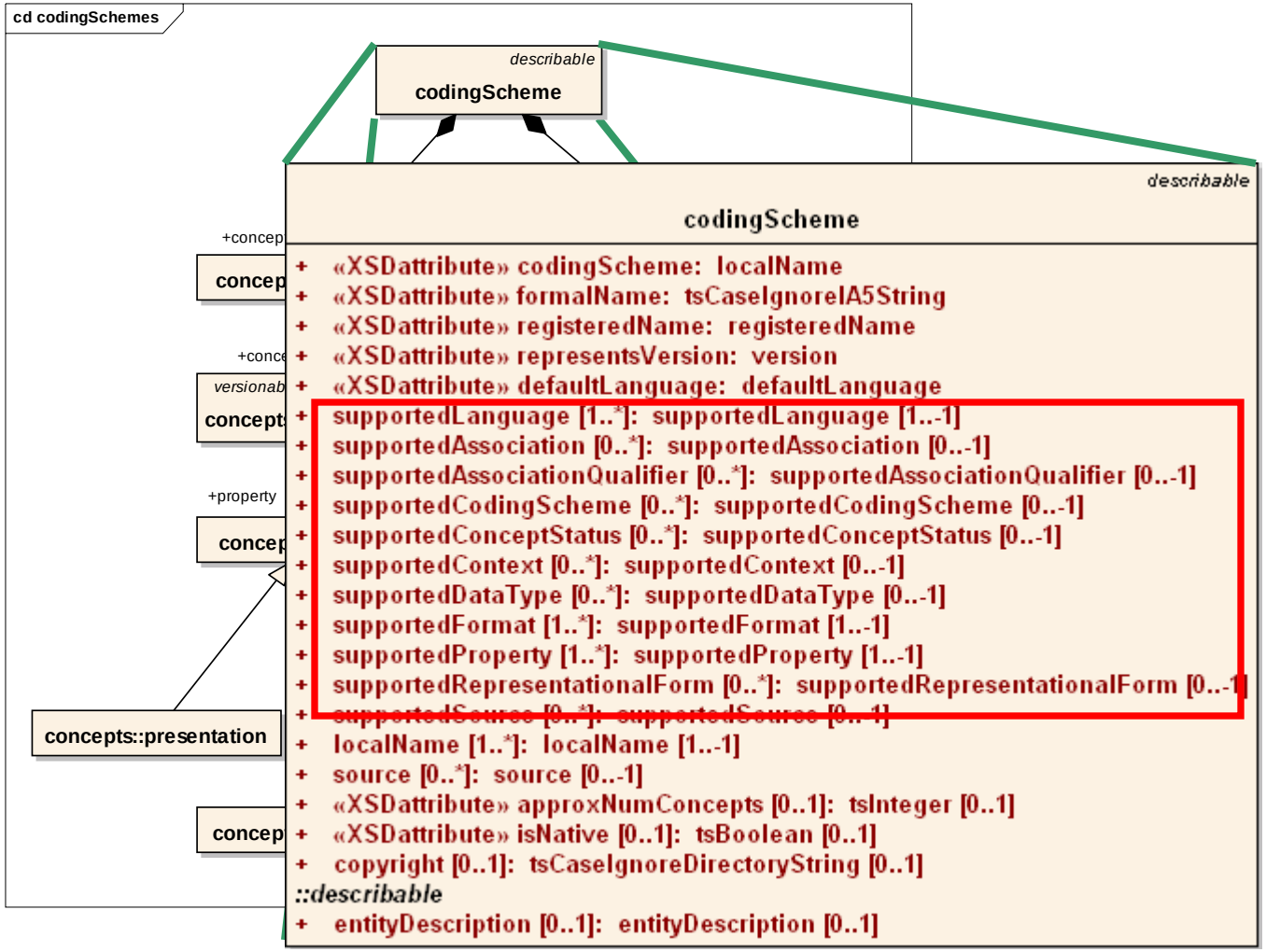
LexGrid Model
Coding Scheme Node



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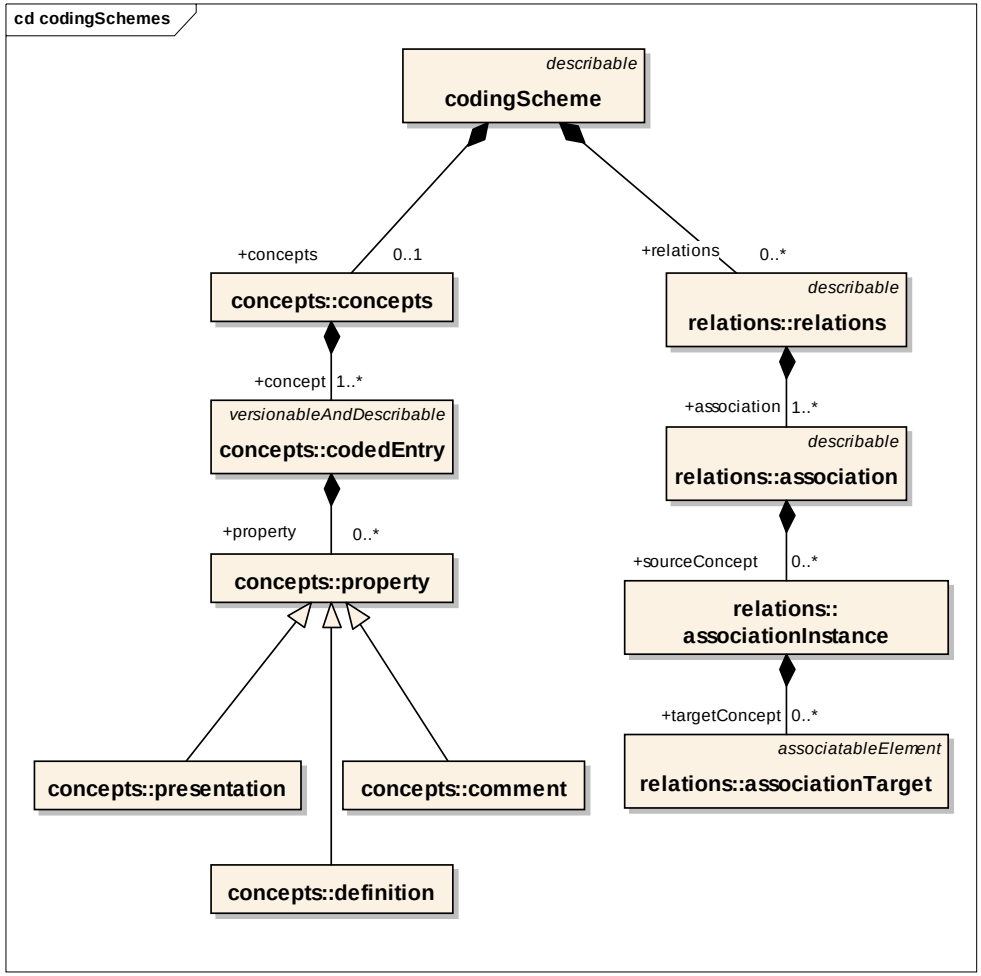

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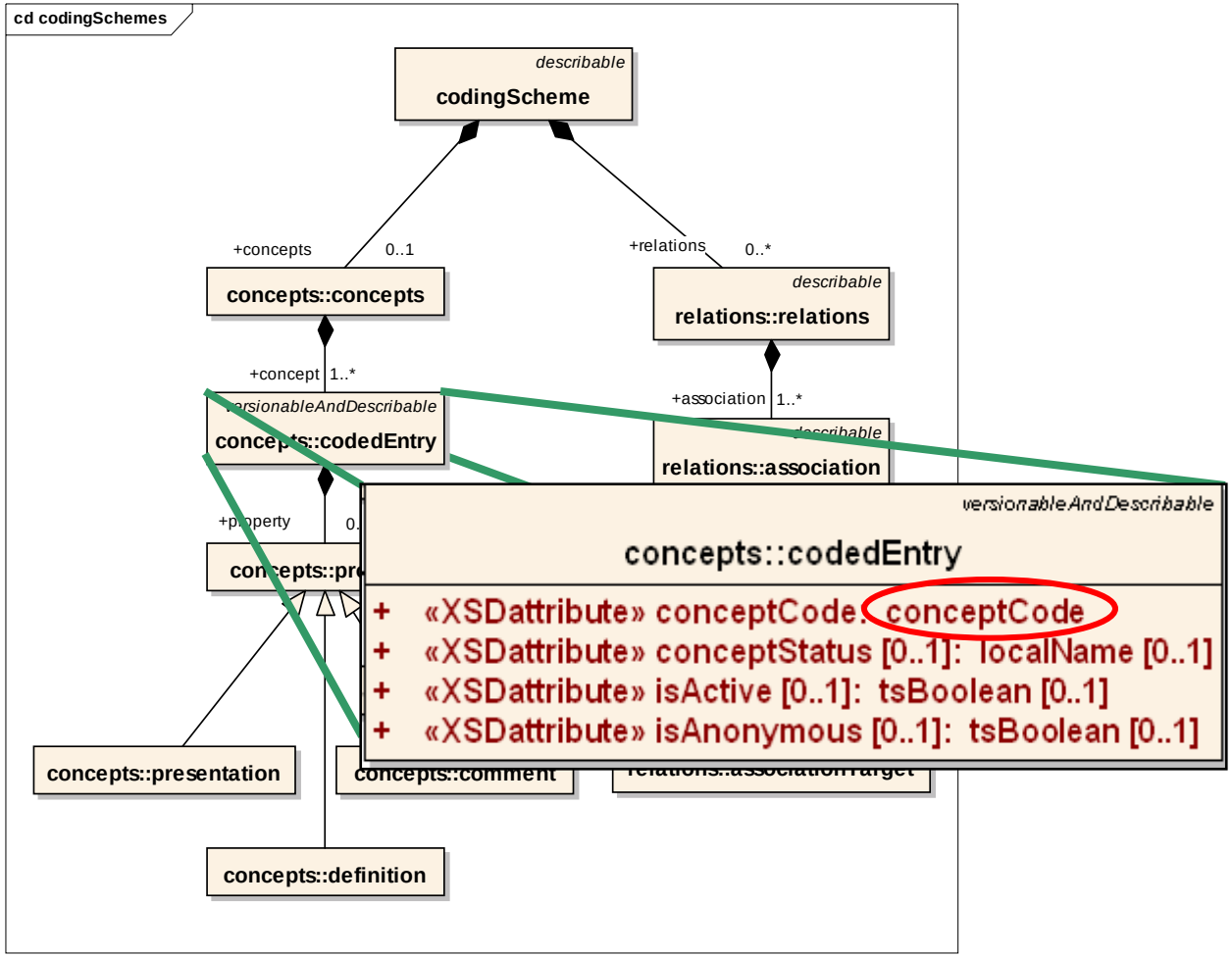
LexGrid Model
Coded Entry



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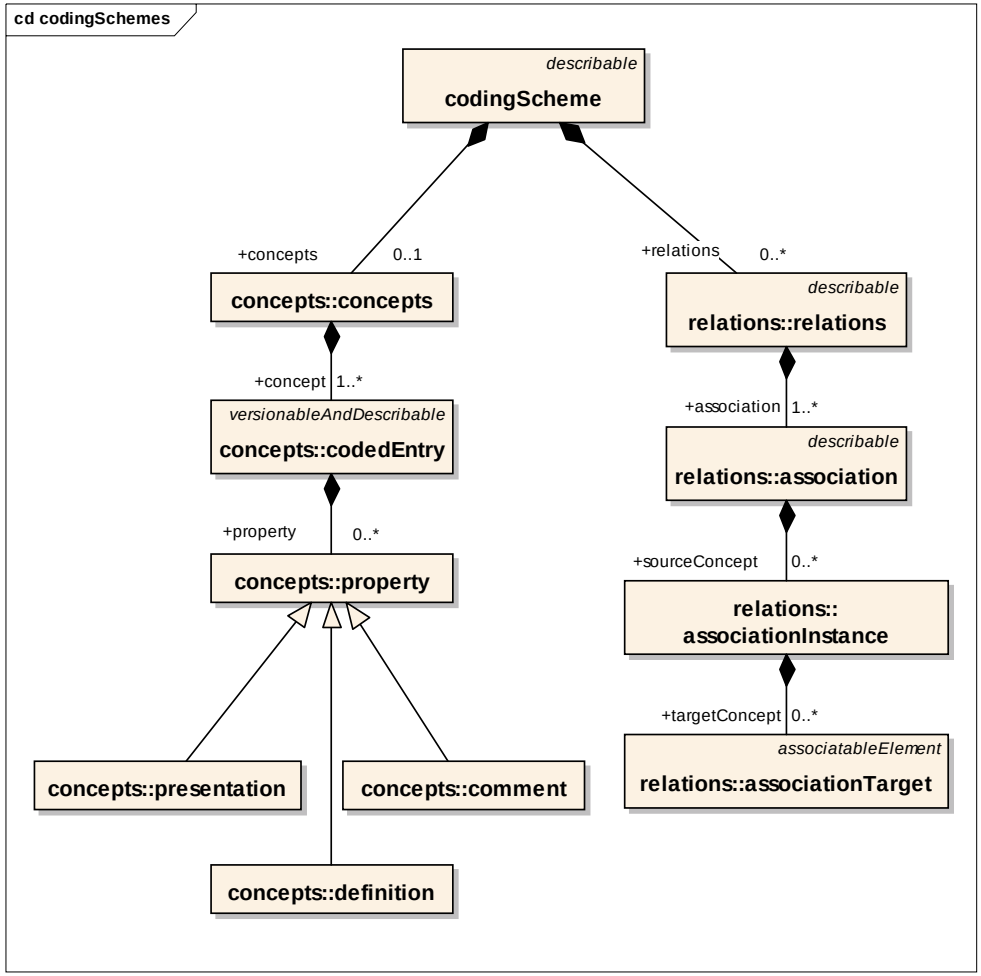

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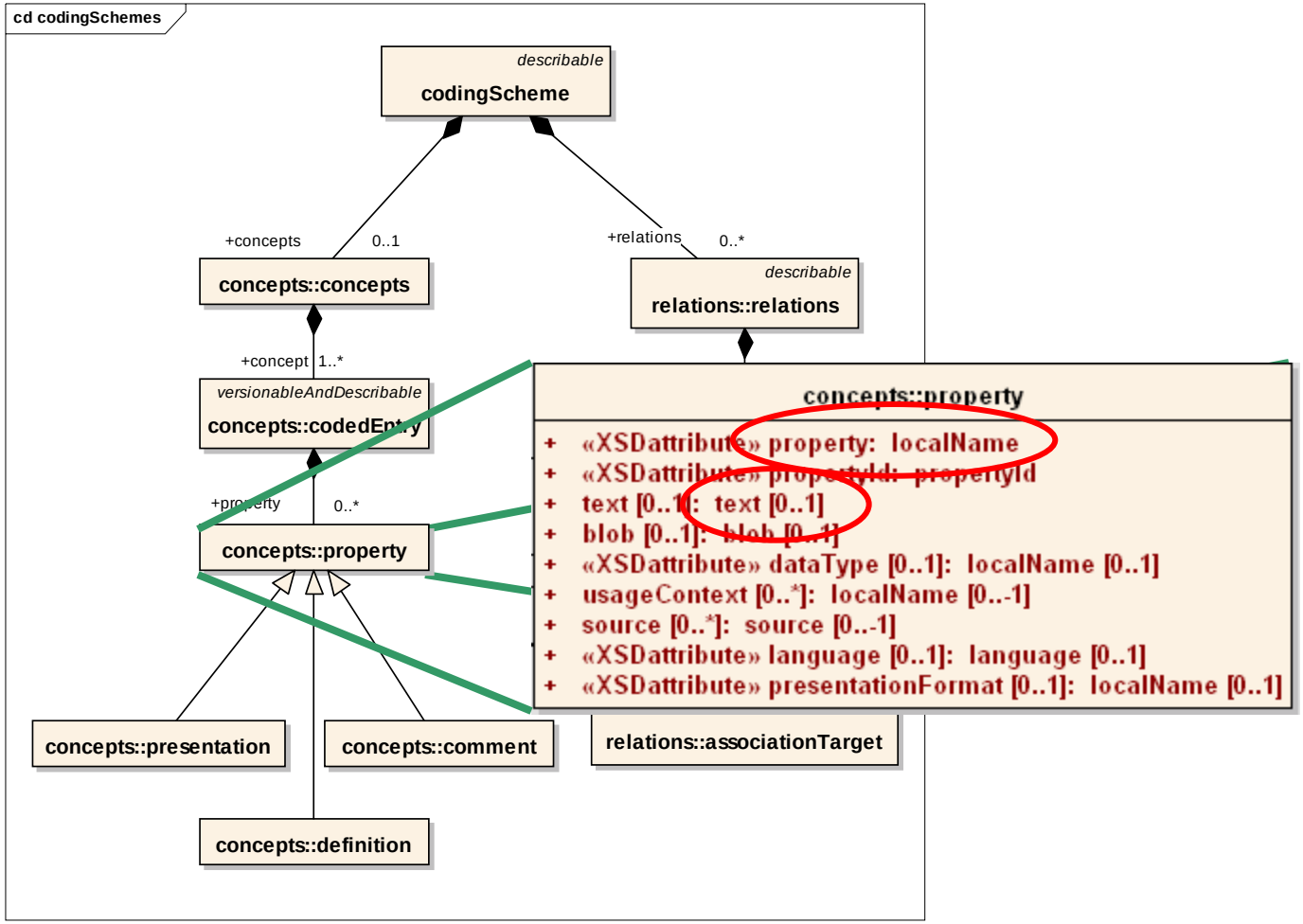
LexGrid Model
Concept Property



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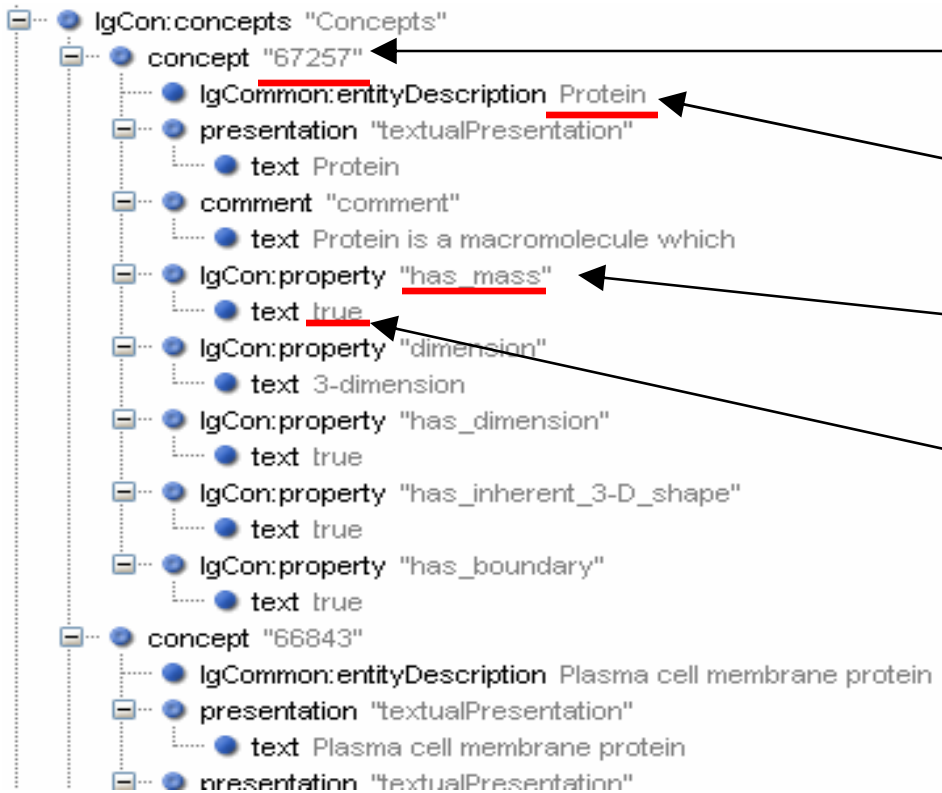
LexGrid Model
CodedEntry Node



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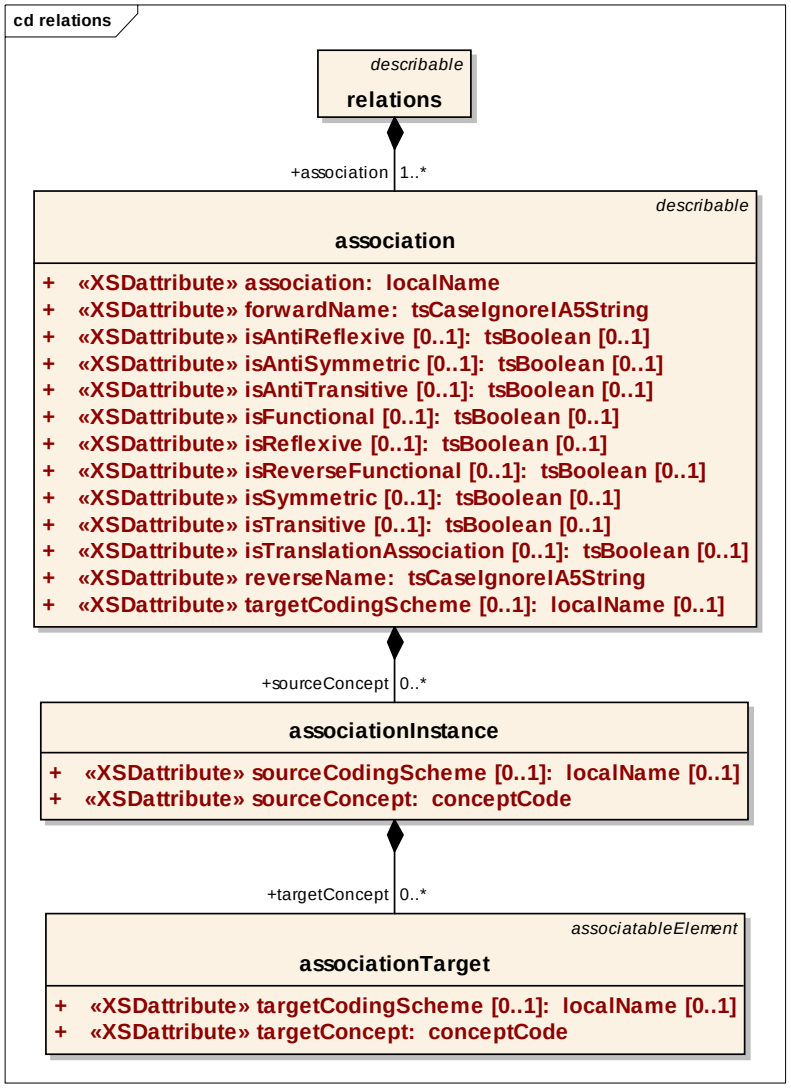
LexGrid Model
Association Node



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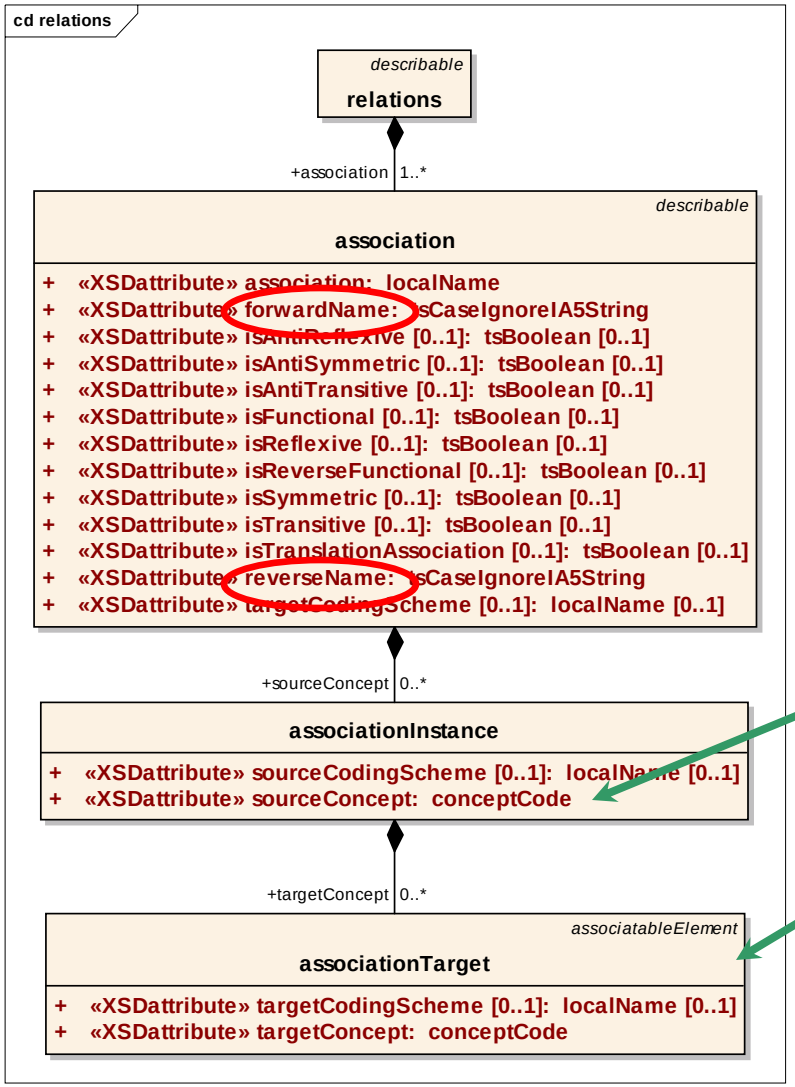
LexGrid Model
Association Node



Source concept

Target

(concept / Data)

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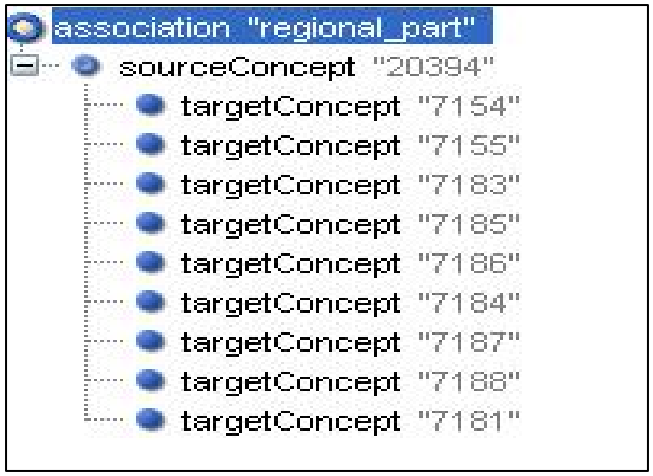
LexGrid Model
Association Node




```
<association association="regional_part" forwardName="regional_part" reverseName="regional_part_of">
  <sourceConcept sourceConcept="20394">
    <targetConcept targetConcept="7154"/>
    <targetConcept targetConcept="7155"/>
    <targetConcept targetConcept="7183"/>
    <targetConcept targetConcept="7185"/>
    <targetConcept targetConcept="7186"/>
    <targetConcept targetConcept="7184"/>
    <targetConcept targetConcept="7187"/>
    <targetConcept targetConcept="7188"/>
    <targetConcept targetConcept="7181"/>
  </sourceConcept>

  <!-- SOME MORE ASSOCIATION INSTANCES HERE  -->

  </association>
```

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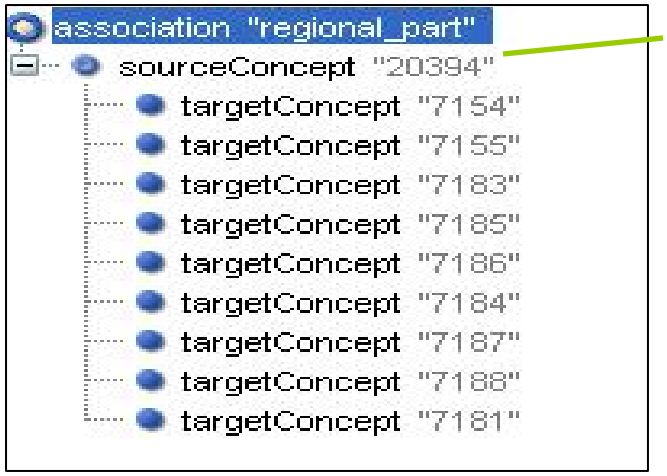
LexGrid Model
Association Node



Body *(has regional parts)*

Source

Head
Neck
Upper limb
Right Upper limb
Left Upper limb
Lower limb
Right Lower limb
Left Lower limb
Trunk

Targets

```
<association association="regional_part" forwardName="regional_part" reverseName="regional_part_of">
  <sourceConcept sourceConcept="20394">
    <targetConcept targetConcept="7154"/>
    <targetConcept targetConcept="7155"/>
    <targetConcept targetConcept="7183"/>
    <targetConcept targetConcept="7185"/>
    <targetConcept targetConcept="7186"/>
    <targetConcept targetConcept="7184"/>
    <targetConcept targetConcept="7187"/>
    <targetConcept targetConcept="7188"/>
    <targetConcept targetConcept="7181"/>
  </sourceConcept>

  <!-- SOME MORE ASSOCIATION INSTANCES HERE  -->

  </association>
```

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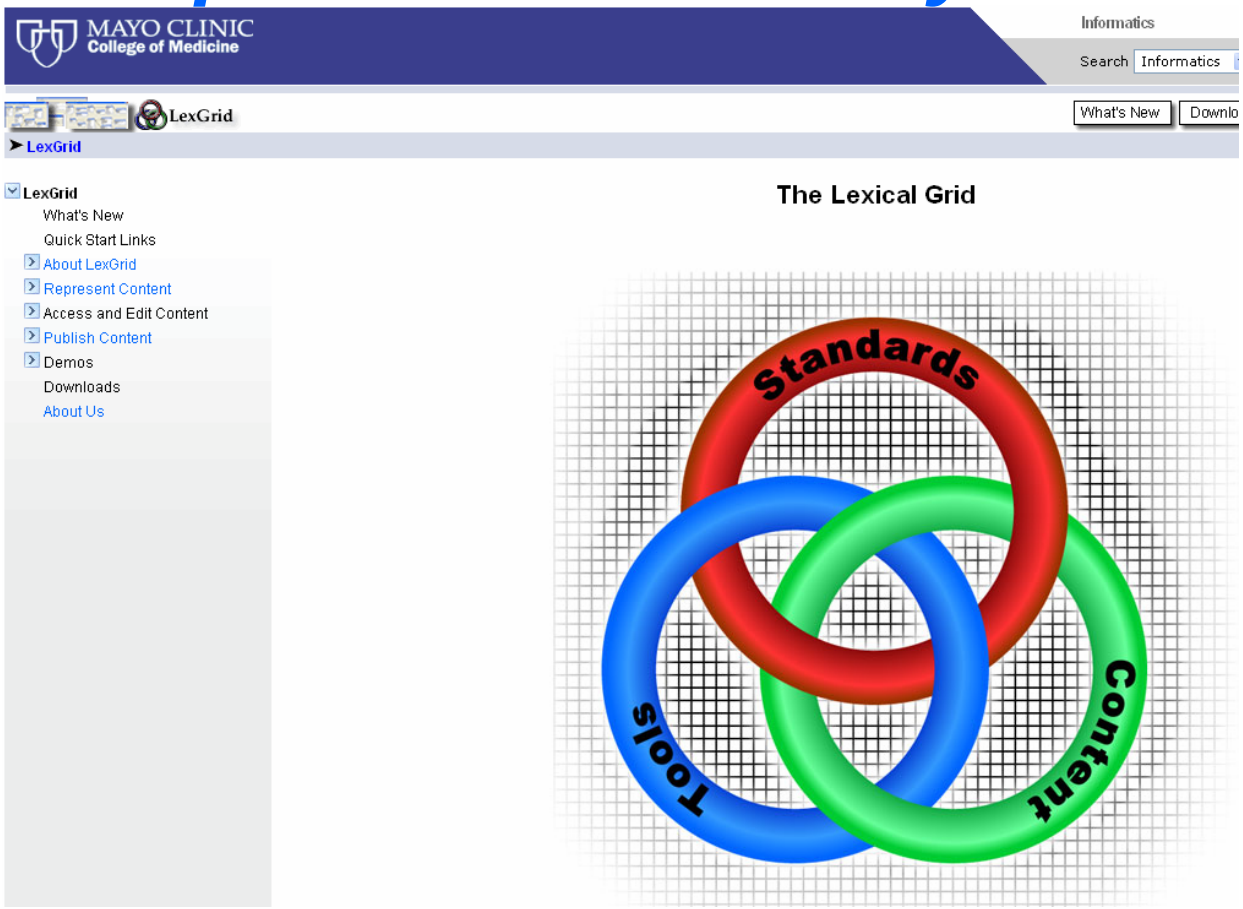
LexGrid Model

http://informatics.mayo.edu



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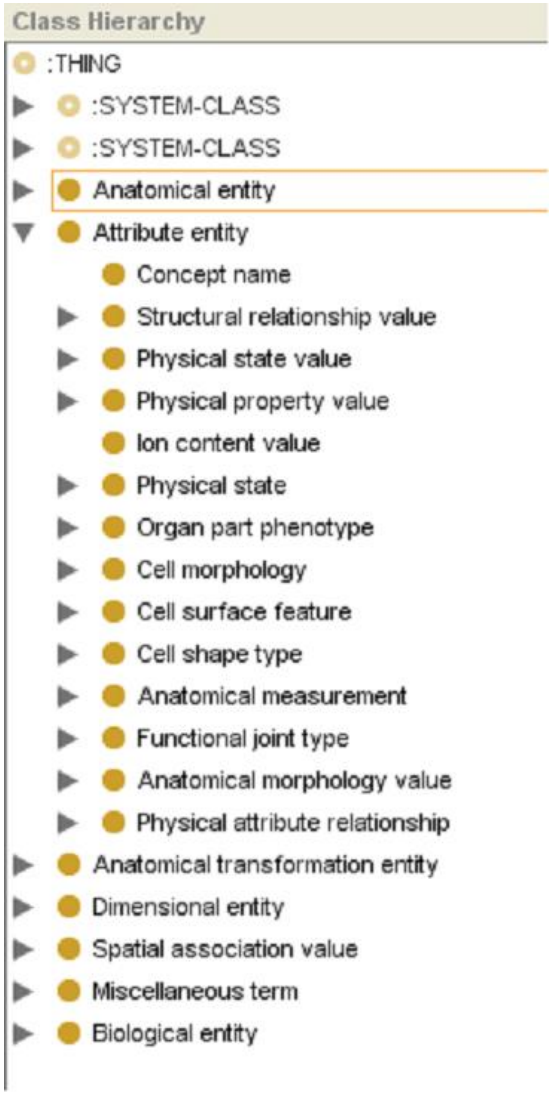
FMA (Protégé)



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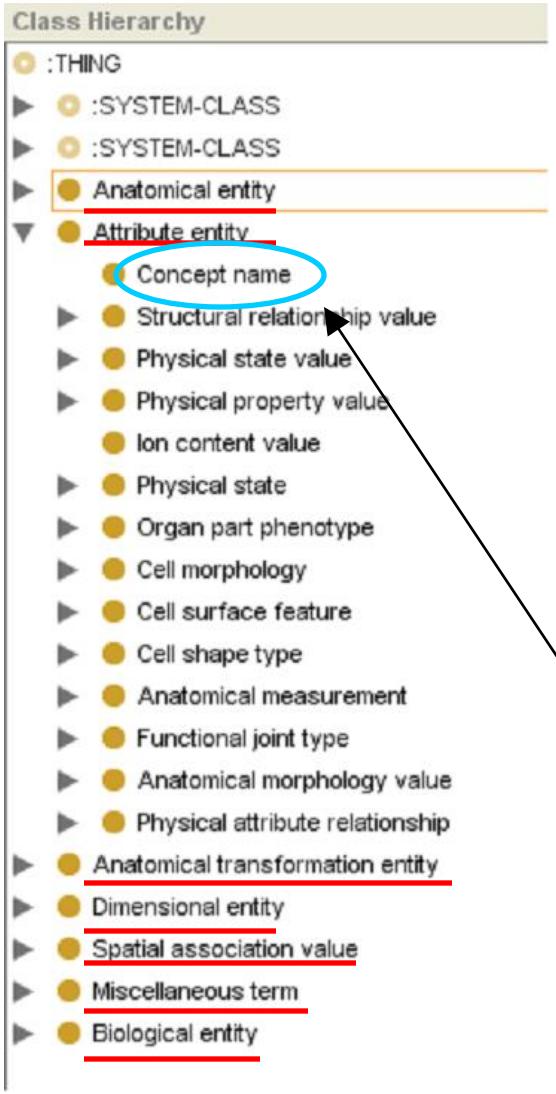
FMA (Protégé)



Root Nodes

- **Anatomical entity**
- **Attribute entity**
- **Anatomical transformation entity**
- **Dimensional entity**
- **Spatial association value**
- **Miscellaneous term**
- **Biological entity**

"Concept name"

Has > 130,000 instances correspond to FMA concept names & add more information to them

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FMA Mapping to LexGrid

- **Both Protégé CLS and Protégé Instance map to LexGrid Coded Entry**
  - **Meta-Class / CLS / Instance distinction in FMA model is pragmatic decision – not "ontological"**
  - **Most FMA classes are both**
  - **Exception is "Concept name", which is strictly descriptive**

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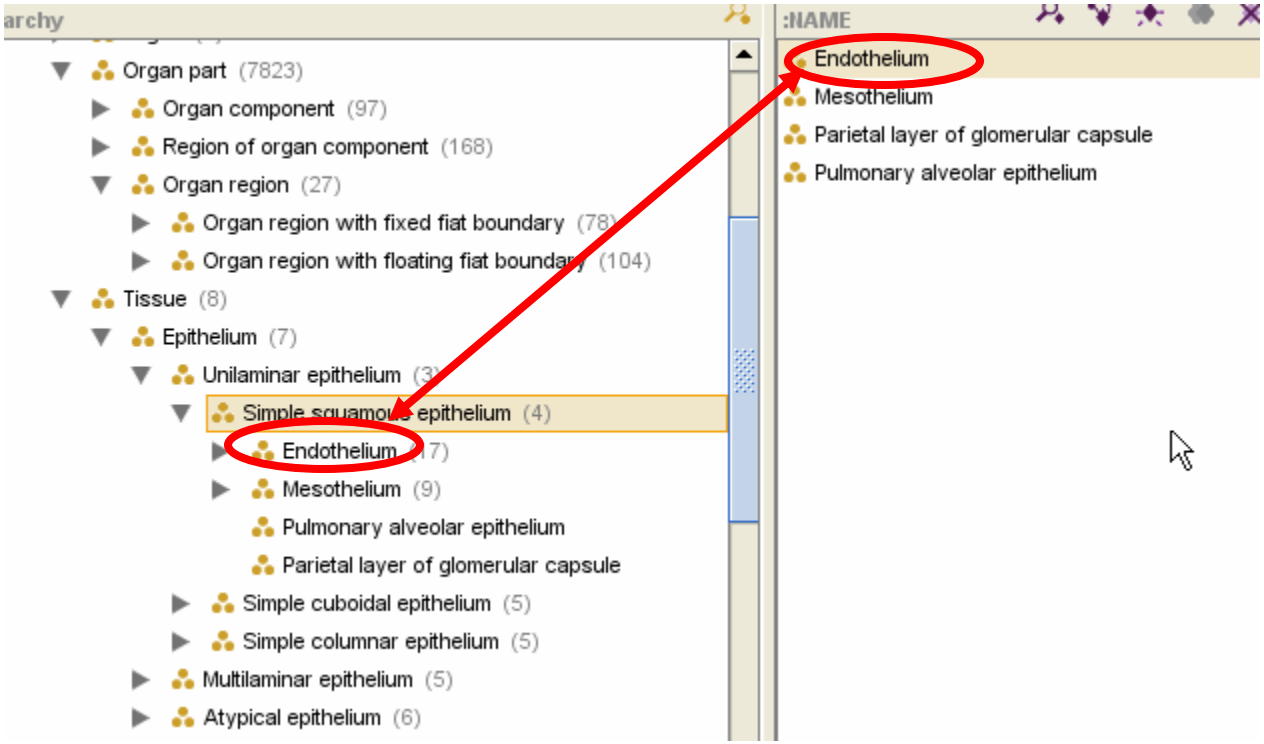
FMA Mapping
Classes and Instances



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FMA Mapping to LexGrid

Slot Type decides Category

Slot type in FMA	LexGrid
String with values "Preferred name", "name", "Synonyms", "Eng-Equivalent"	Presentation
String with other values	Property

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FMA Mapping to LexGrid

Slot Type decides Category

Slot type in FMA	LexGrid
“definition”	Definition
:Documentation	Comment
Protégé CLS or Instance	Association
Boolean	Property {true | false}
Other	Property

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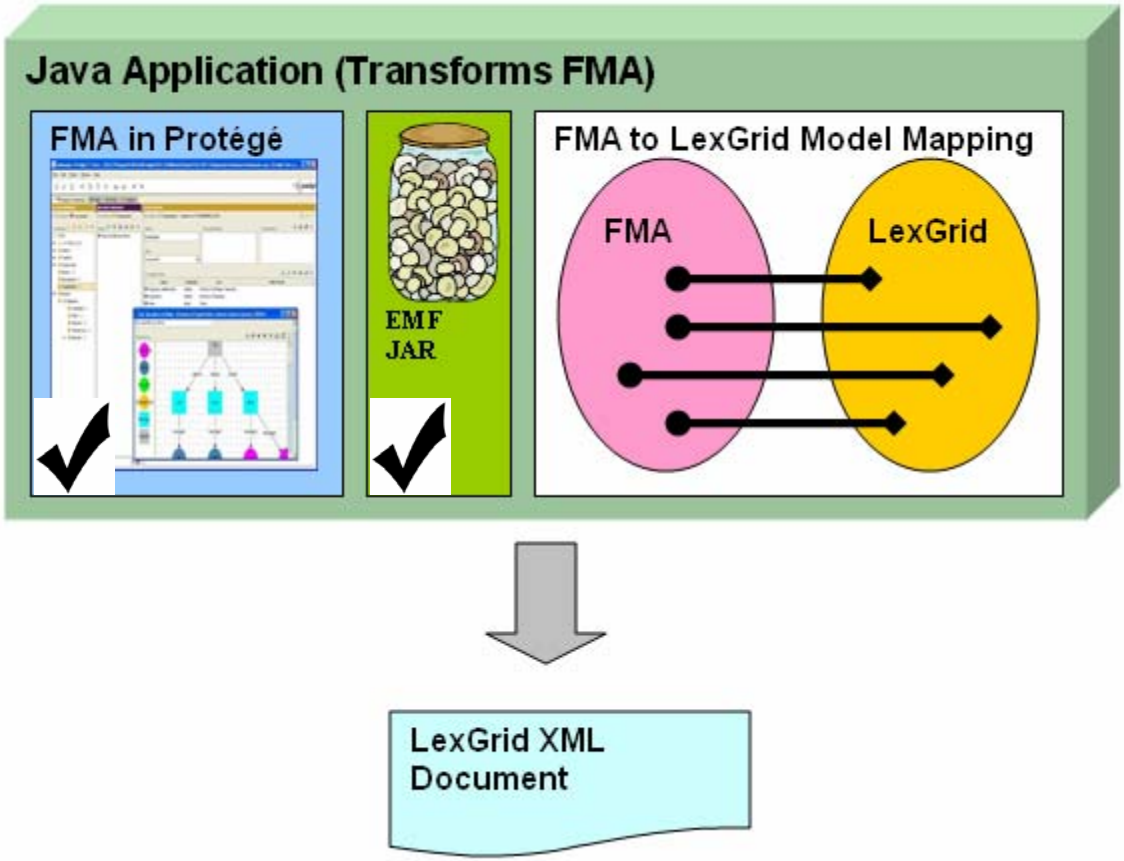
FMA Mapping to LexGrid

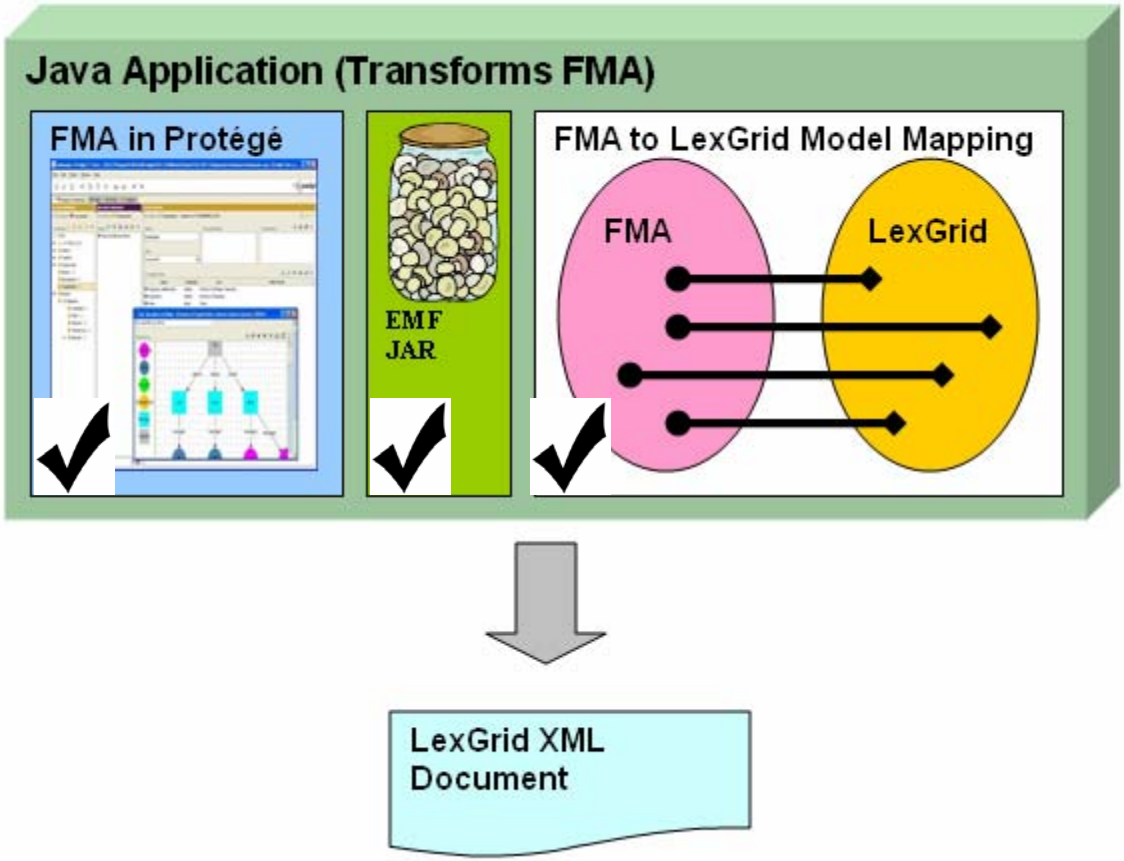
Slot Type decides Category

Slot type in FMA (Instances of 'Concept name')	LexGrid
"Authority" "Source" "Language" "TA ID" "Eponym", …	Presentation or its attributes

EMF at work


Java Application (Transforms FMA)
FMA in Protégé
EMF
JAR
FMA to LexGrid Model Mapping
FMA
LexGrid
LexGrid XML
Document

EMF at work


Java Application (Transforms FMA)
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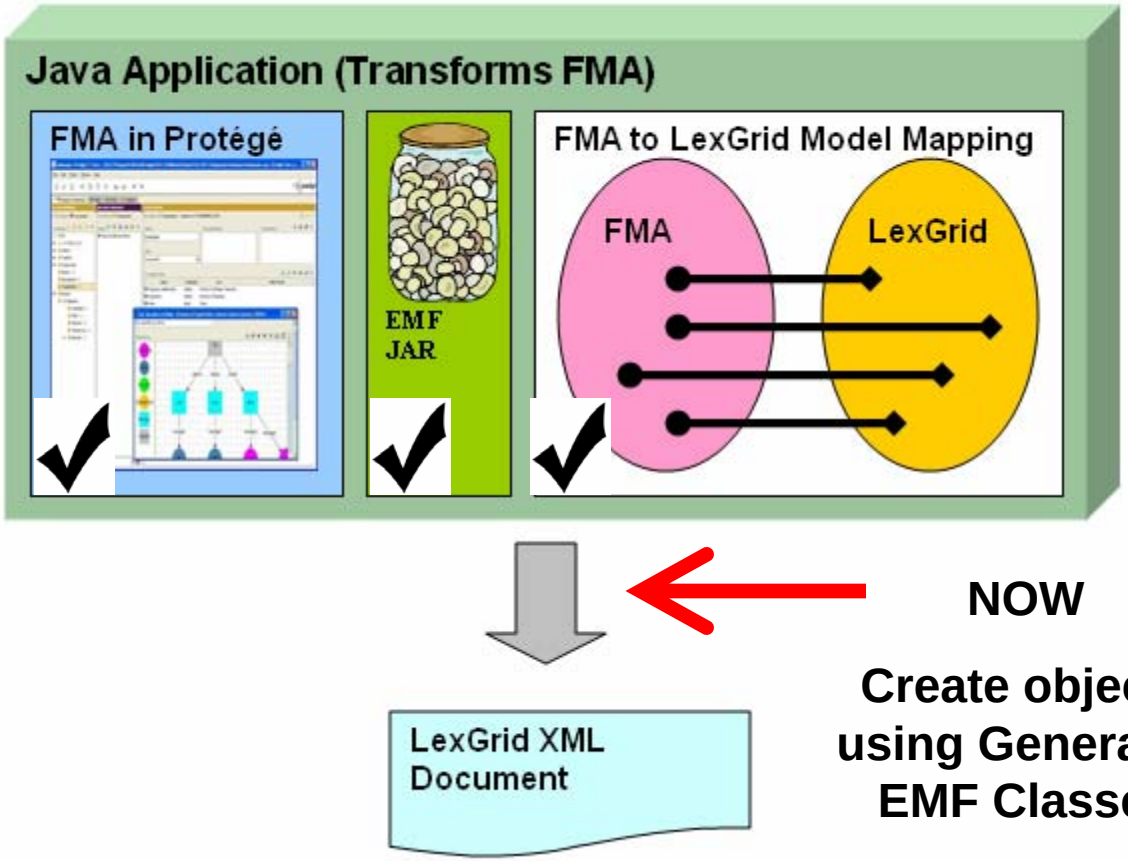
EMF at work



NOW

Create objects using Generated EMF Classes

AND

Generate XML output file

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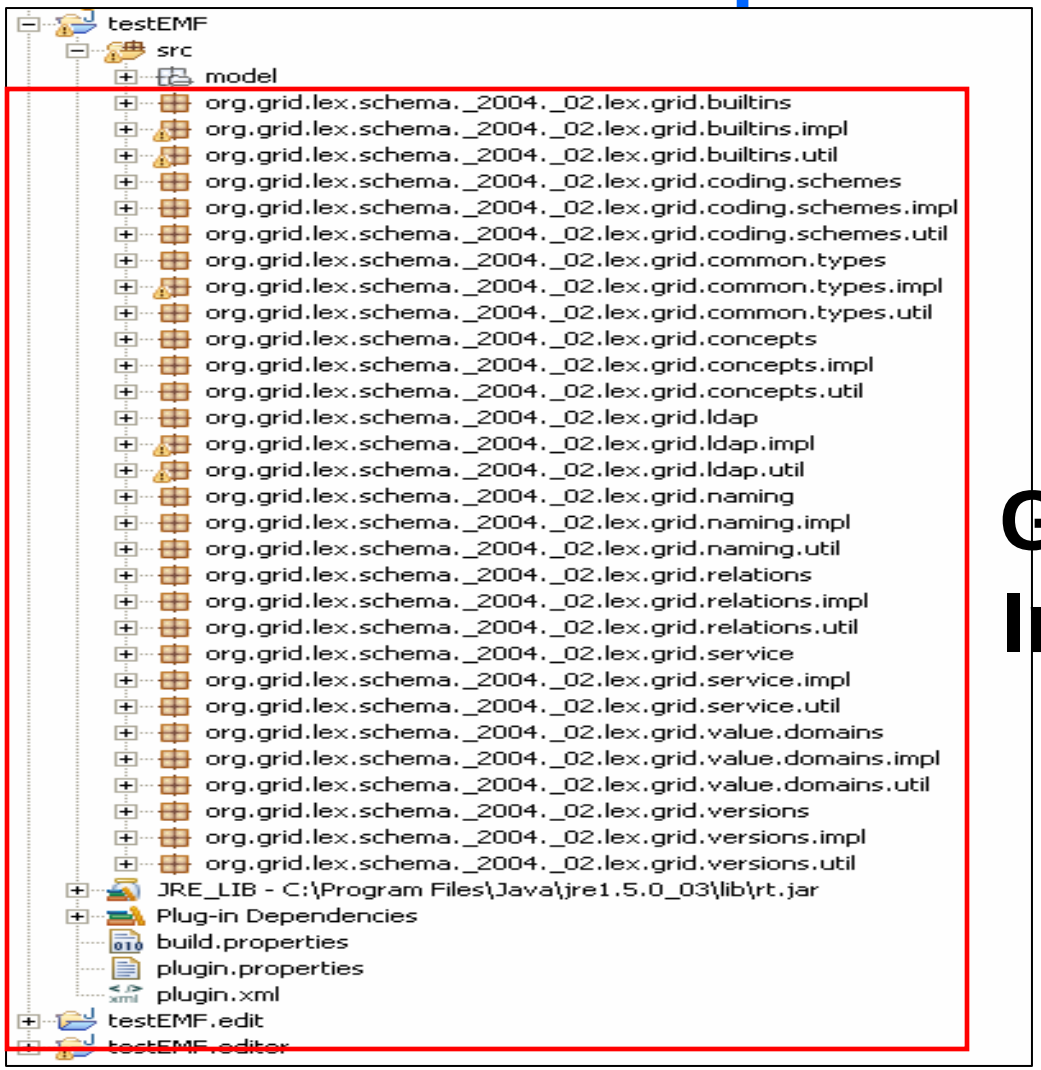
EMF at work
Generated Implementation Classes



Generated Implementation

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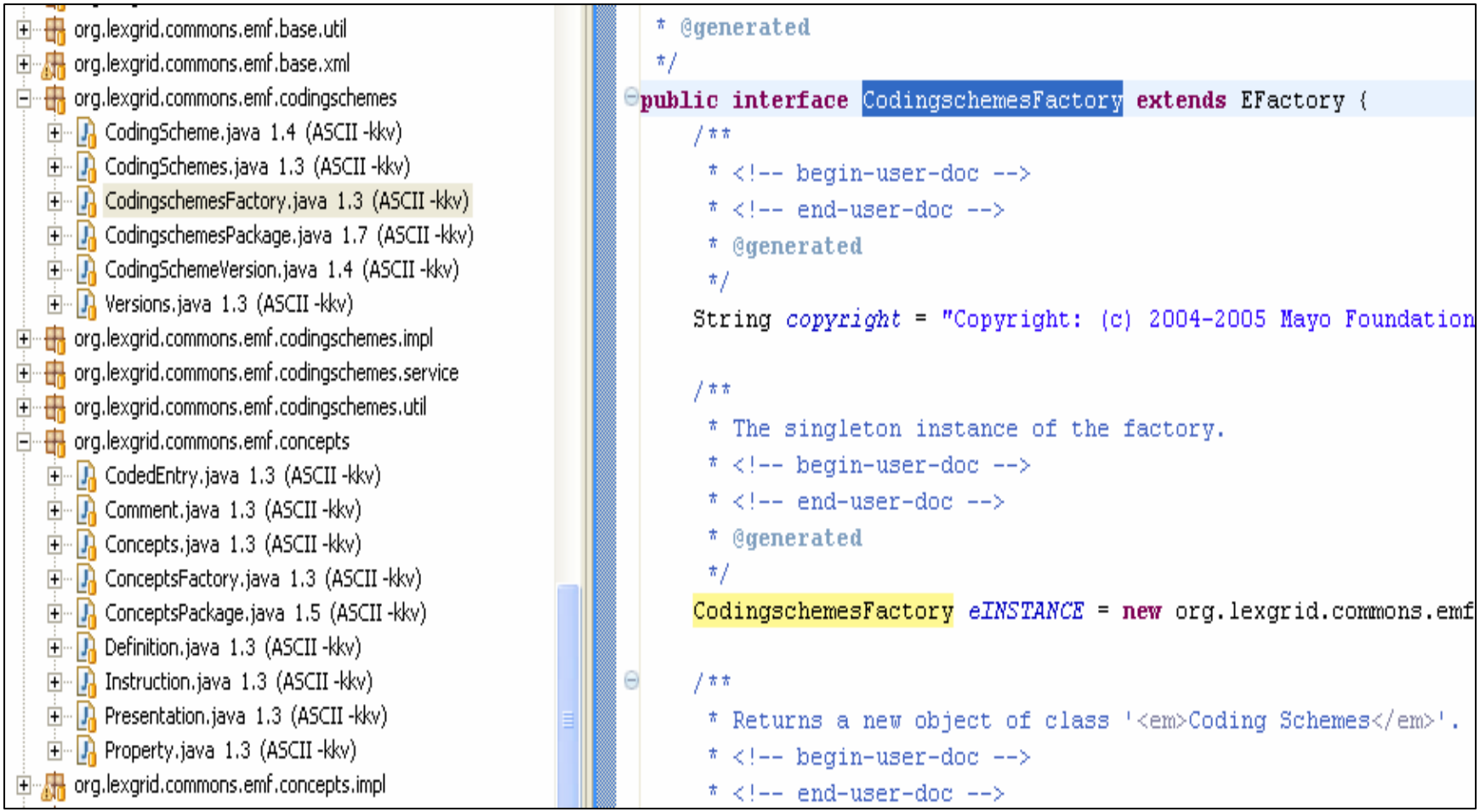
EMF at work
Generated Implementation Classes



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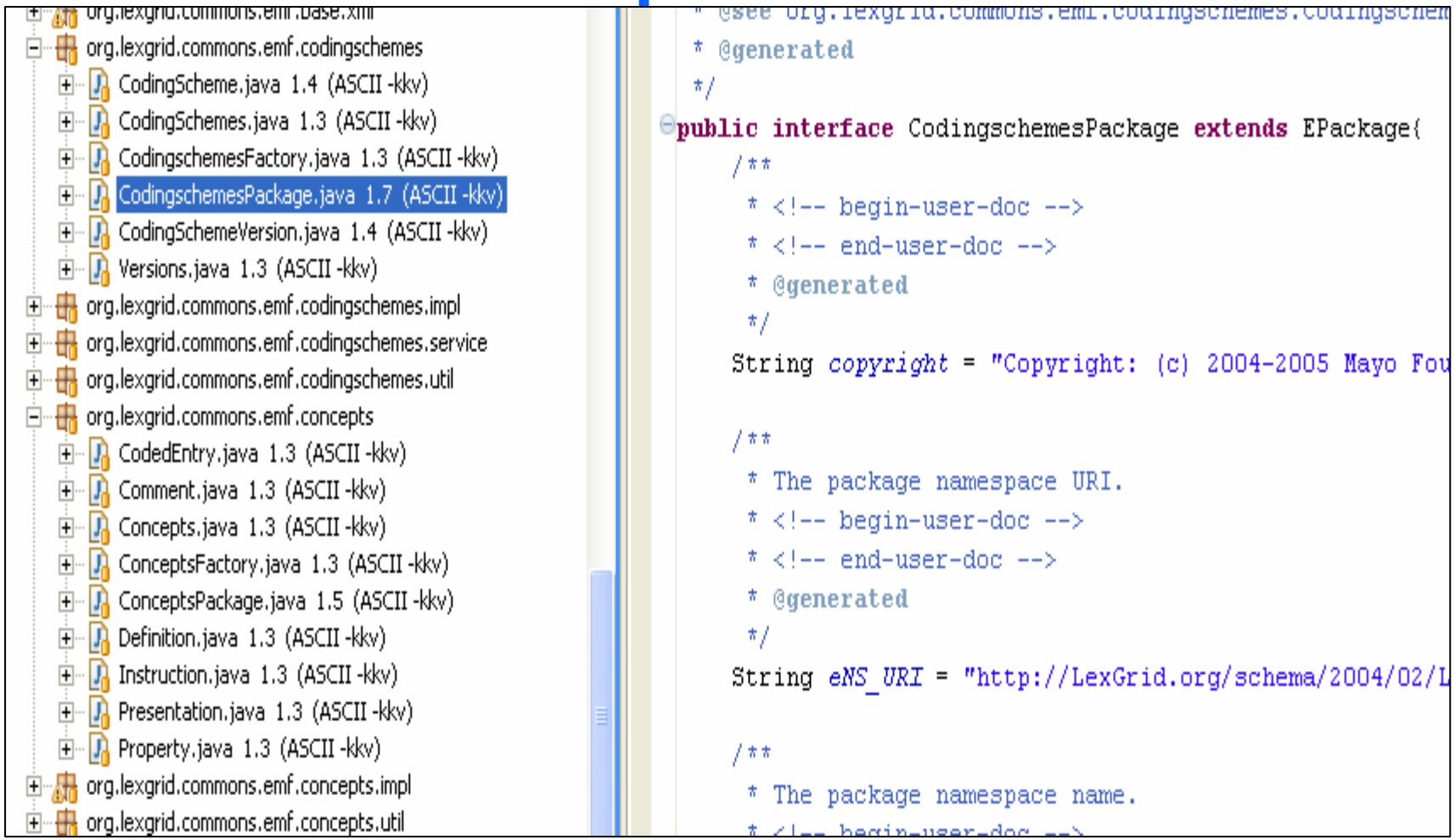
EMF at work
Generated Implementation Classes



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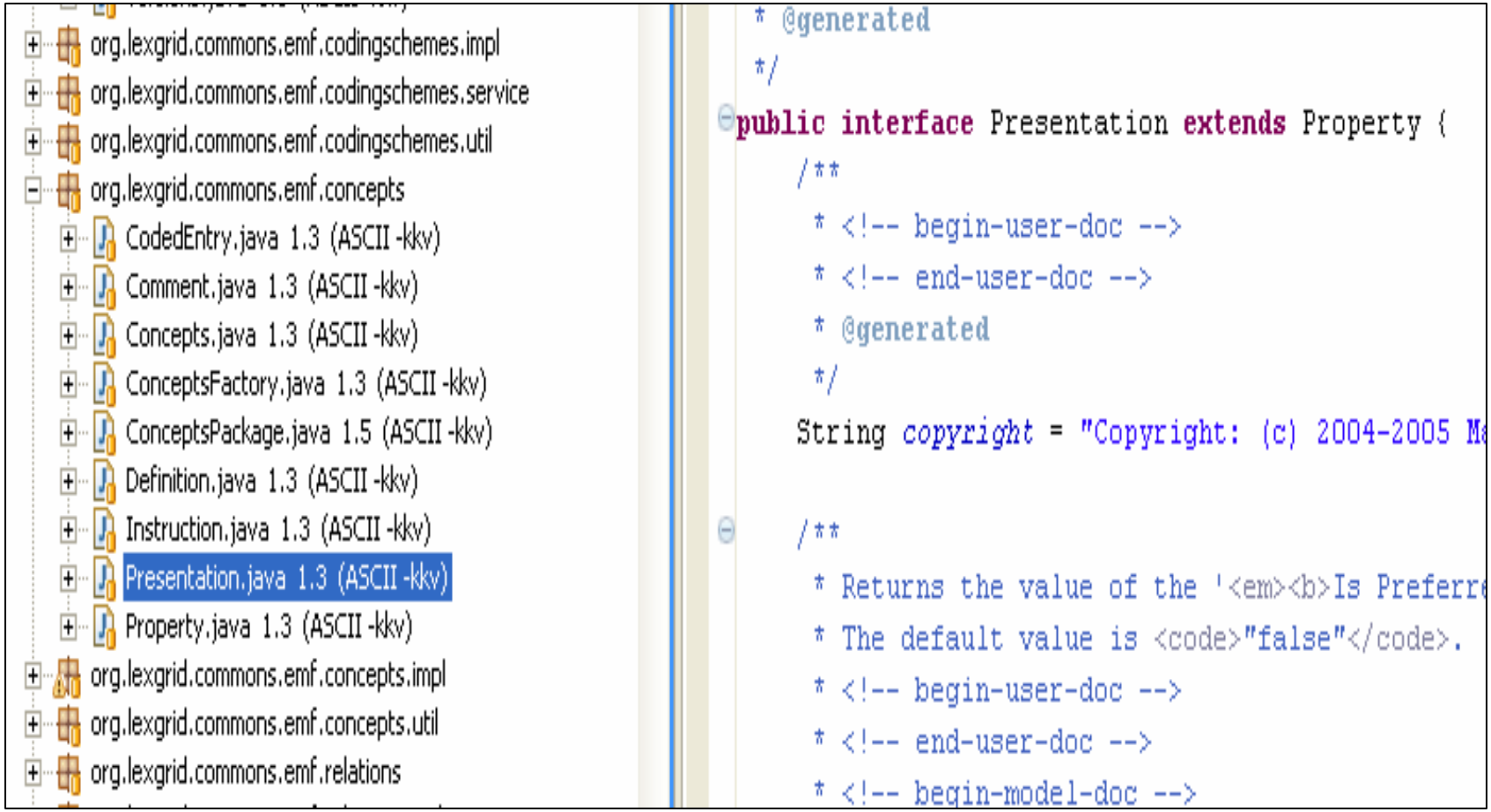
EMF at work
Generated Implementation Classes



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EMF at work
Factory Classes

```
private CodingschemesFactory csFactory = new CodingschemesFactoryImpl();
private RelationsFactory relationsFactory = new RelationsFactoryImpl();
private ConceptsFactory conceptFactory = new ConceptsFactoryImpl();
private NamingFactory nameFactory = new NamingFactoryImpl();
```

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EMF at work
Create Coding Scheme

Creates Coding Scheme

```
CodingScheme   csclass = null;
try
{
     init(kb);

     csclass = csFactory.createCodingScheme();
     csclass.setCodingScheme("FMA");
     csclass.setFormalName("Foundational Model of Anatomy");
     csclass.setRegisteredName("urn:oid:2.16.840.1.113883.6.119");
     csclass.setDefaultLanguage("English");
     csclass.setRepresentsVersion("1.2.0");
     csclass.getLocalName().add("FMA");
     EList supportedLanguages = csclass.getSupportedLanguage();

     SupportedLanguage lang = nameFactory.createSupportedLanguage();
     lang.setLocalName("English");
     lang.setUrn("urn:oid:2.16.840.1.113883.6.84:en");
     supportedLanguages.add(lang);

     lang = nameFactory.createSupportedLanguage();
     lang.setLocalName("Latin");
     lang.setUrn("urn:oid:2.16.840.1.113883.6.84:la");
     supportedLanguages.add(lang);

     EList supportedFormats = csclass.getSupportedFormat();
     prepareSupportedFormats(supportedFormats);

     EList supportedDataTypes = csclass.getSupportedDataType();
     prepareSupportedDataTypes(supportedDataTypes);
```

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EMF at work
Create Concept

```
CodedEntry con = conceptFactory.createCodedEntry();
con.setConceptCode(conceptCode);

String description = getEntityDescriptionFromObj(concept);
if (description != null)
    con.setEntityDescription(description);

Comment [] comments = getCommentsFromObj(concept);
if (comments != null)
    for(int i = 0; i < comments.length; i++)
        con.getProperty().add(comments[i]);

Definition [] definitions = getDefinitionsFromObj(concept);
if (definitions != null)
    for(int i = 0; i < definitions.length; i++)
        con.getProperty().add(definitions[i]);

processSlots(concept, con, false);
```

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EMF at work
Create Relation

```
// Relations
allRelations_ = relationsFactory.createRelations();
allRelations_.setDc("relations");

// Creating the relation instance
firstRelation_ = csclass.getRelations();
firstRelation_.add(allRelations_);
allAssociations_ = allRelations_.getAssociation();

// Add HasSubtype
hasSubTypeAssocClass_ = relationsFactory.createAssociation();
hasSubTypeAssocClass_.setAssociation("hasSubtype");
hasSubTypeAssocClass_.setForwardName("hasSubtype");
hasSubTypeAssocClass_.setReverseName("isA");
hasSubTypeAssocClass_.setIsTransitive(true);
hasSubTypeAssocClass_.setIsSymmetric(false);
hasSubTypeAssocClass_.setIsReflexive(true);
allAssociations_.add(hasSubTypeAssocClass_);

relations_.add(firstRelation_);
```

EMF at work
XML Serialization

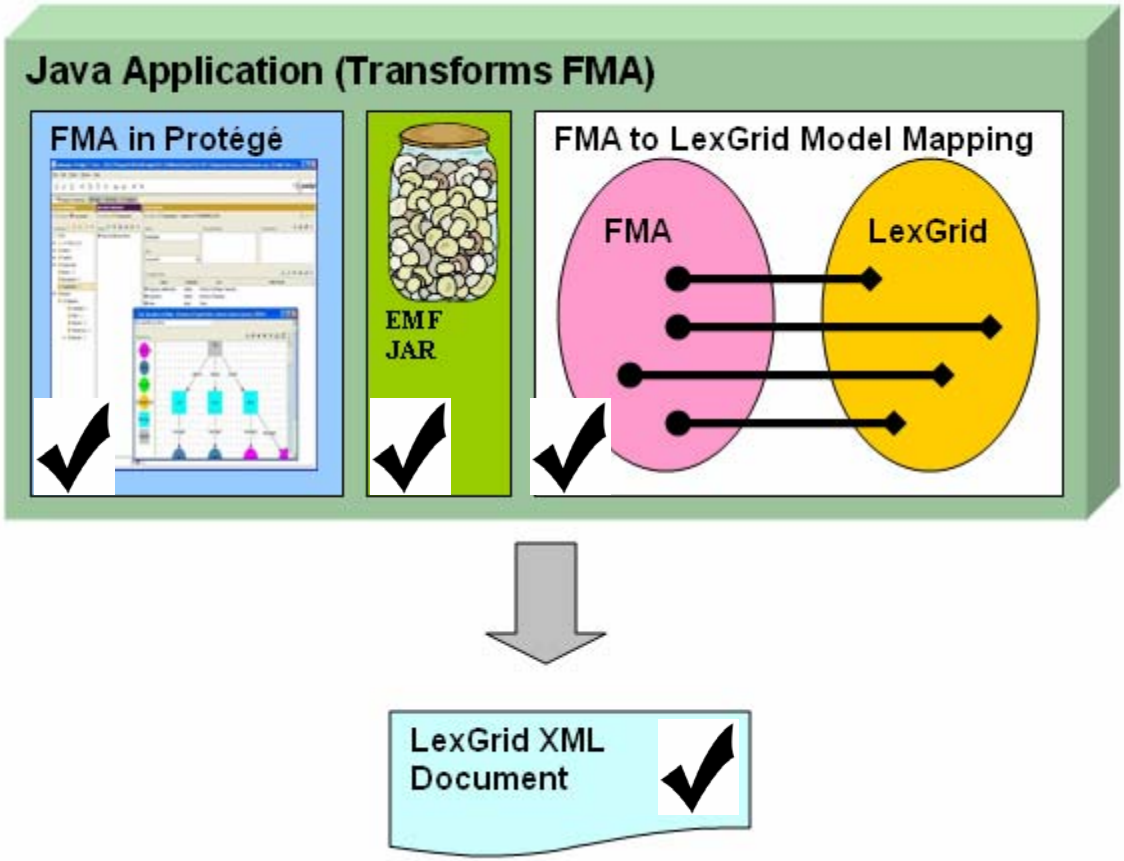
```
XMLResource xmlrsc = new XMLResourceImpl();
xmlrsc.getContents().add(csclass);

XMLMap mapping = getXMLMappings();

if (mapping != null)
{
    Map mp = new HashMap();
    //System.out.println("Got the mappings...");
    mp.put(XMLResource.OPTION_XML_MAP, mapping);
    xmlrsc.save(new FileOutputStream("testFMA.xml"), mp);
}
```

These classes are from ECORE framework
e.g.
package org.eclipse.emf.ecore.xmi.impl

EMF at work


Java Application (Transforms FMA)
FMA in Protégé
EMF
JAR
FMA to LexGrid Model Mapping
FMA
LexGrid
LexGrid XML
Document

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FMA (LexGrid XML Snapshot)


```
<?xml version="1.0" encoding="ASCII"?>
<codingScheme codingScheme="FMA" formalName="Foundational Model of Anatomy" registeredName="urn:oid:2.16.840.1.113883.6.119" defaultLangu
 <localName>FMA</localName>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:en">English</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:la">Latin</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:de">German</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:es">Spanish</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:fr">French</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:ru">Russian</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:Greek">Greek</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:Italian">Italian</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:Filipino">Filipino</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:Japanese">Japanese</supportedLanguage>
 <supportedLanguage urn="urn:oid:2.16.840.1.113883.6.84:Chinese">Chinese</supportedLanguage>
 <supportedFormat urn="urn:oid:2.16.840.1.113883.6.10:text_plain">text_plain</supportedFormat>
 <supportedProperty>comment</supportedProperty>
 <supportedProperty>definition</supportedProperty>
 <supportedProperty>instruction</supportedProperty>
 <supportedProperty>textualPresentation</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:slot_synonym">slot_synonym</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:dimension">dimension</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_dimension">has_dimension</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_boundary">has_boundary</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_mass">has_mass</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_inherent_3-D_shape">has_inherent_3-D_shape</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:physical_state">physical_state</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:polarity">polarity</supportedProperty>
 <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:state_of_determination">state_of_determination</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:cell_appendage_type">cell_appendage_type</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:contact_type">contact_type</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:coordinate">coordinate</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:laterality">laterality</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:adjacent">adjacent</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:anatomical_arbitrary">anatomical_arbitrary</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:partition">partition</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:shared_unshared">shared_unshared</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:view">view</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:percentage">percentage</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:number_of_pairs_per_nucleus">number_of_pairs_per_nucleus</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:ploidy">ploidy</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:state">state</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:cell_layer">cell_layer</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_trunk">has_trunk</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_branch">has_branch</supportedProperty>
  <supportedProperty urn="urn:oid:2.16.840.1.113883.6.119:has_shape_type">has_shape_type</supportedProperty>
  <supportedSource urn="urn:oid:2.16.840.1.113883.6.119:Alberts_94">Alberts_94</supportedSource>
  <supportedSource urn="urn:oid:2.16.840.1.113883.6.119:Bloom__Fawcett_94">Bloom__Fawcett_94</supportedSource>
  <supportedSource urn="urn:oid:2.16.840.1.113883.6.119:Fawcett_81">Fawcett_81</supportedSource>
  <supportedSource urn="urn:oid:2.16.840.1.113883.6.119:Grays_99">Grays_99</supportedSource>
  <supportedSource urn="urn:oid:2.16.840.1.113883.6.119:Gene_Ontology">Gene_Ontology</supportedSource>
  <supportedSource urn="urn:oid:2.16.840.1.113883.6.119:Cornelius_Rosse">Cornelius_Rosse</supportedSource>
```

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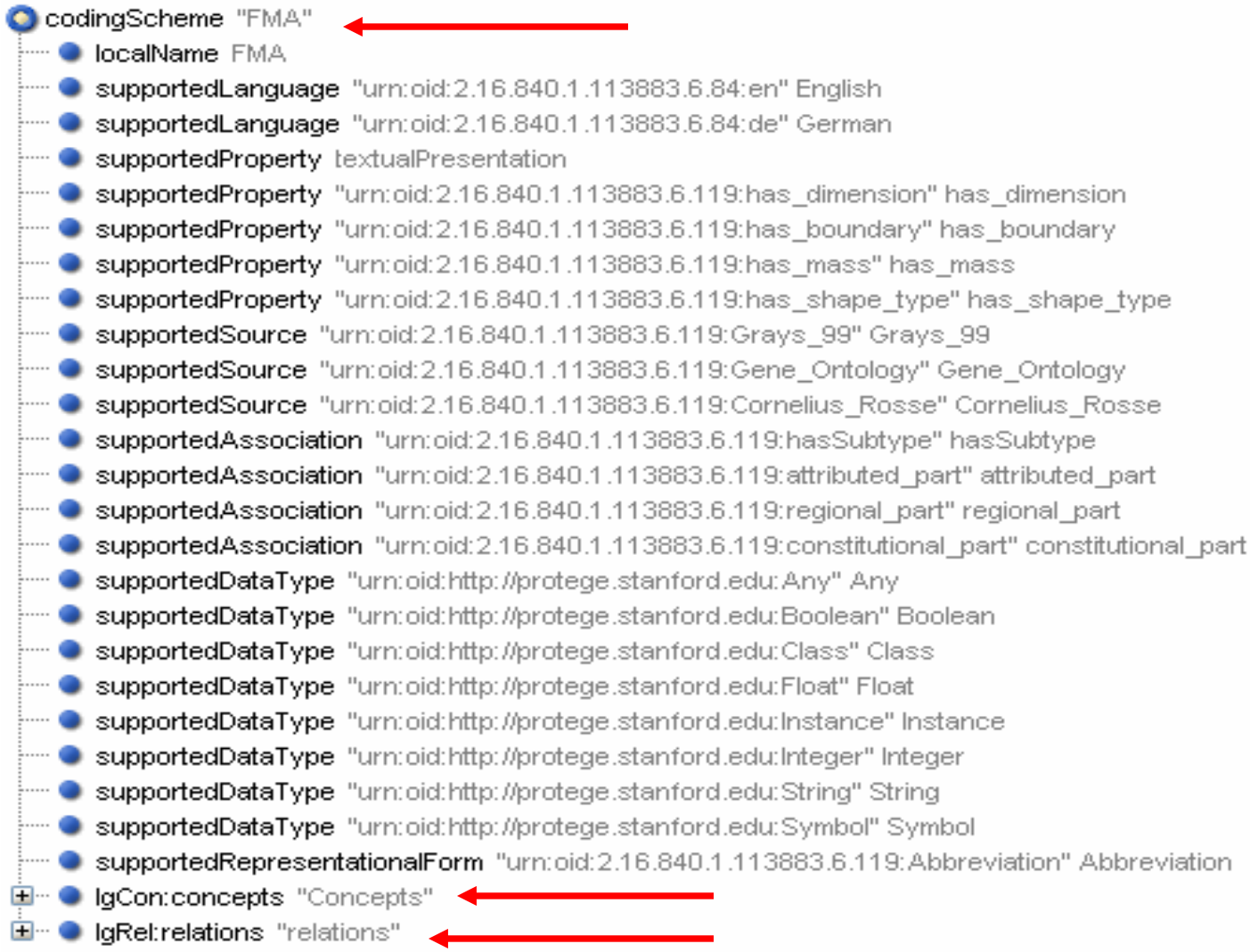
FMA (LexGrid XML Snapshot)



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Transformation Example

- Concept “Body”
- LexGrid Editor tool (Mayo)
- Observe Mappings:
  - FMA Content with Protégé
  - Transformed LexGrid content with LexGrid Editor

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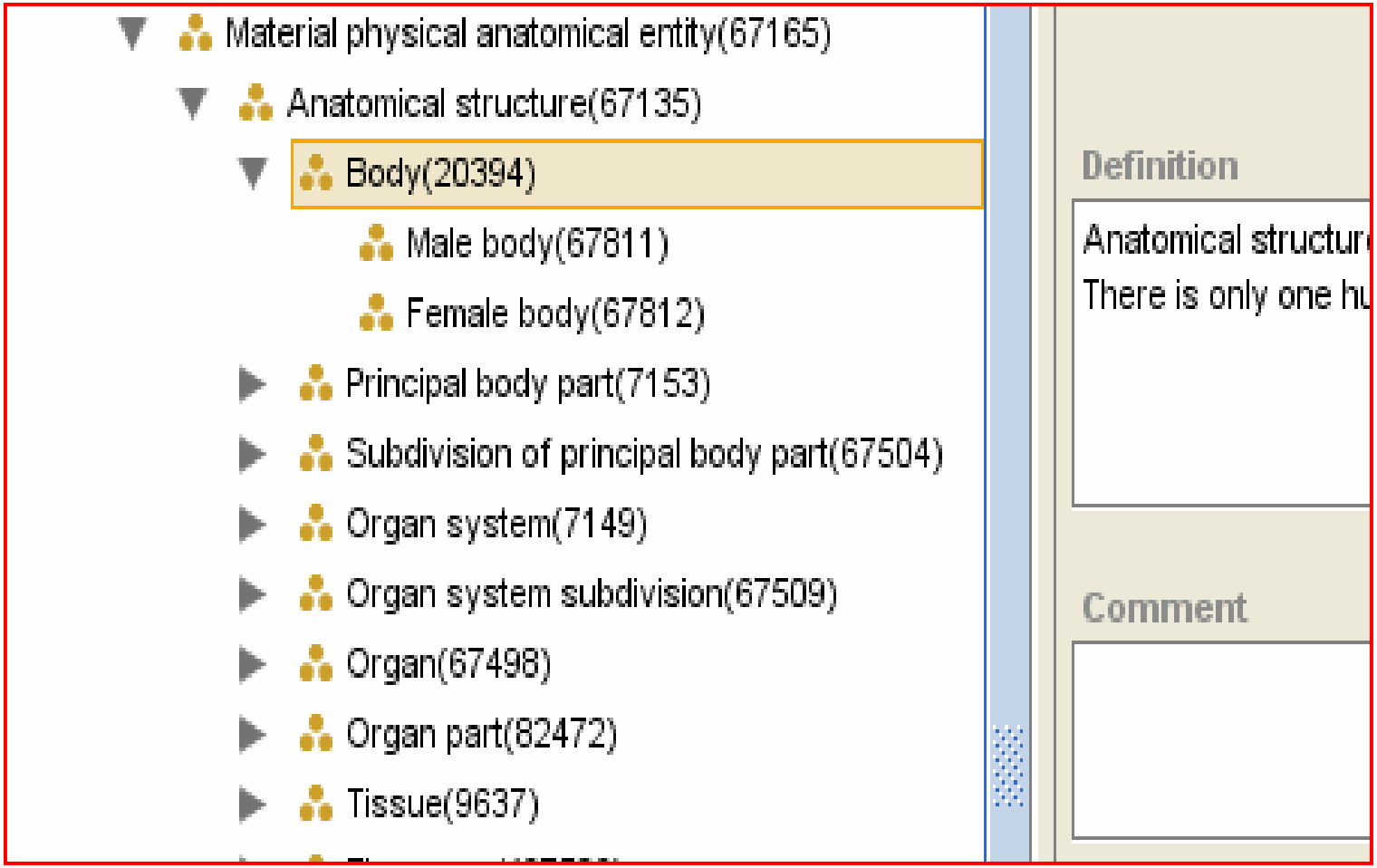
Concept “Body” (FMA)



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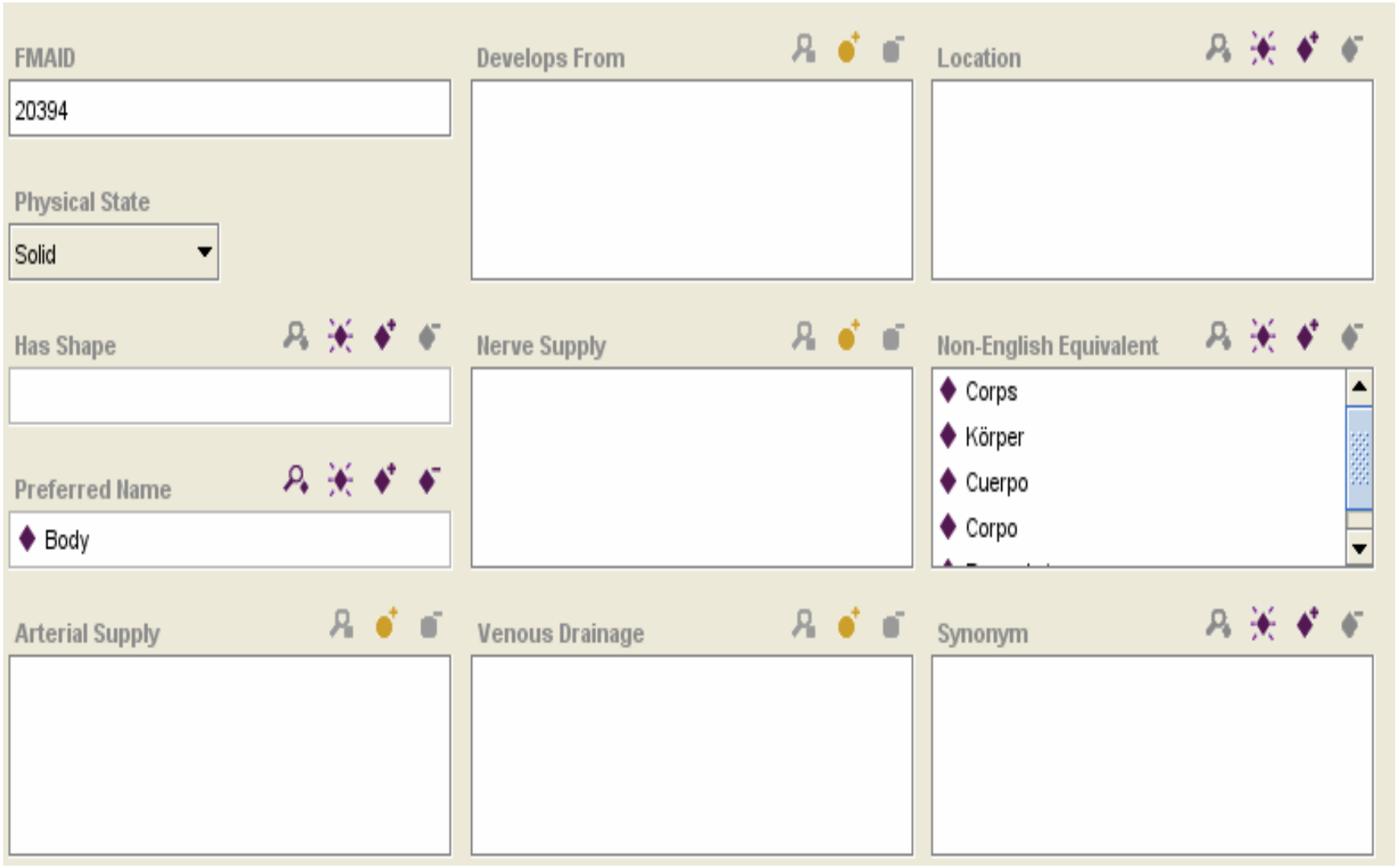
“Body” (FMA) - Attributes



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Concept “Body” (LexGrid)

```
<concept conceptCode="20394">
  <lgCommon:entityDescription>Body</lgCommon:entityDescription>
  <presentation property="textualPresentation" propertyId="P8" isPreferred="true">
    <text>Body</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language38355" language="Filipino">
    <text>Buong katawan</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language37742" language="Spanish">
    <text>Cuerpo</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="authority32777" language="French">
    <source>Robert_Baud_PhD</source>
    <text>Corps</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language38164" language="Filipino">
    <text>Corpo</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language37437" language="German">
    <text>Körper</text>
  </presentation>
  <definition property="definition" propertyId="P1">
    <text>Anatomical structure, which is the maximal aggregate manifestation
    of an individual member of the species Homo sapiens;
    it is completely surrounded by skin. Examples: There is only one human body.</text>
  </definition>
  <lgCon:property property="physical_state" propertyId="P4" dataType="Symbol">
    <text>Solid</text>
  </lgCon:property>
  <lgCon:property property="has_boundary" propertyId="P7" dataType="Boolean">
    <text>true</text>
  </lgCon:property>
  <lgCon:property property="has_inherent_3-D_shape" propertyId="P2" dataType="Boolean">
    <text>true</text>
  </lgCon:property>
  <lgCon:property property="has_dimension" propertyId="P6" dataType="Boolean">
    <text>true</text>
  </lgCon:property>
  <lgCon:property property="has_mass" propertyId="P3" dataType="Boolean">
    <text>true</text>
  </lgCon:property>
  <lgCon:property property="dimension" propertyId="P5" dataType="Symbol">
    <text>3-dimension</text>
  </lgCon:property>
</concept>
```

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Concept “Body” (LexGrid)

```
<concept conceptCode="20394">
  <lgCommon:entityDescription>Body</lgCommon:entityDescription>
  <presentation property="textualPresentation" propertyId="P8" isPreferred="true">
    <text>Body</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language38355" language="Filipino">
    <text>Buong katawan</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language37742" language="Spanish">
    <text>Cuerpo</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="authority32777" language="French">
    <source>Robert_Baud_PhD</source>
    <text>Corps</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language38164" language="Filipino">
    <text>Corpo</text>
  </presentation>
  <presentation property="textualPresentation" propertyId="Language37437" language="German">
    <text>Körper</text>
  </presentation>
  <definition property="definition" propertyId="P1">
    <text>Anatomical structure, which is the maximal aggregate manifestation
    of an individual member of the species Homo sapiens;
    it is completely surrounded by skin. Examples: There is only one human body.</text>
  </definition>
  <lgCon:property property="physical_state" propertyId="P4" dataType="Symbol">
    <text>Solid</text>
  </lgCon:property>
  <lgCon:property property="has_boundary" propertyId="P7" dataType="Boolean">
    <text>true</text>
  </lgCon:property>
  <lgCon:property property="has_inherent_3-D_shape" propertyId="P2" dataType="Boolean">
    <text>true</text>
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  <lgCon:property property="has_dimension" propertyId="P6" dataType="Boolean">
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  </lgCon:property>
  <lgCon:property property="has_mass" propertyId="P3" dataType="Boolean">
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</concept>
```

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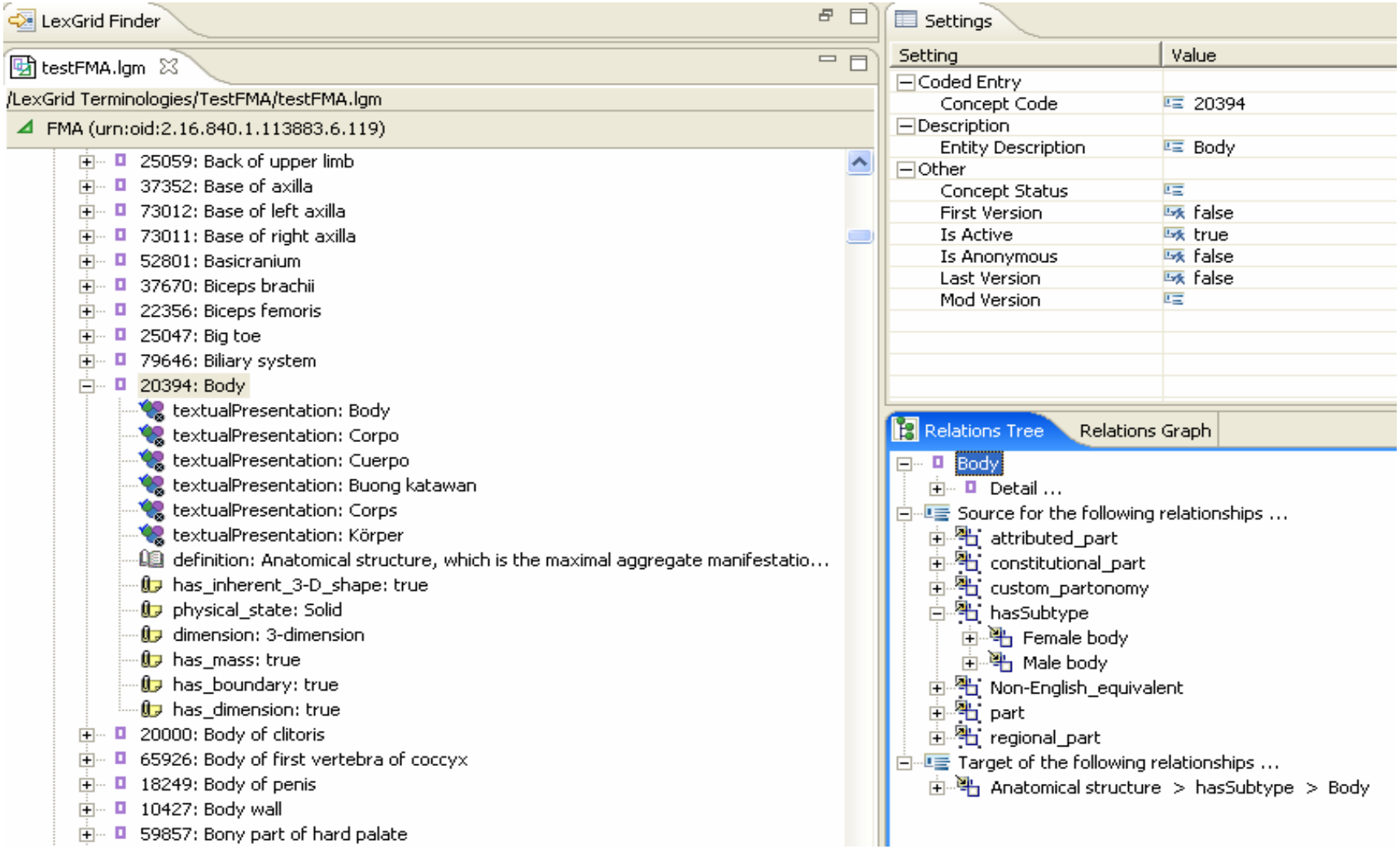
Concept “Body” (LexGrid)



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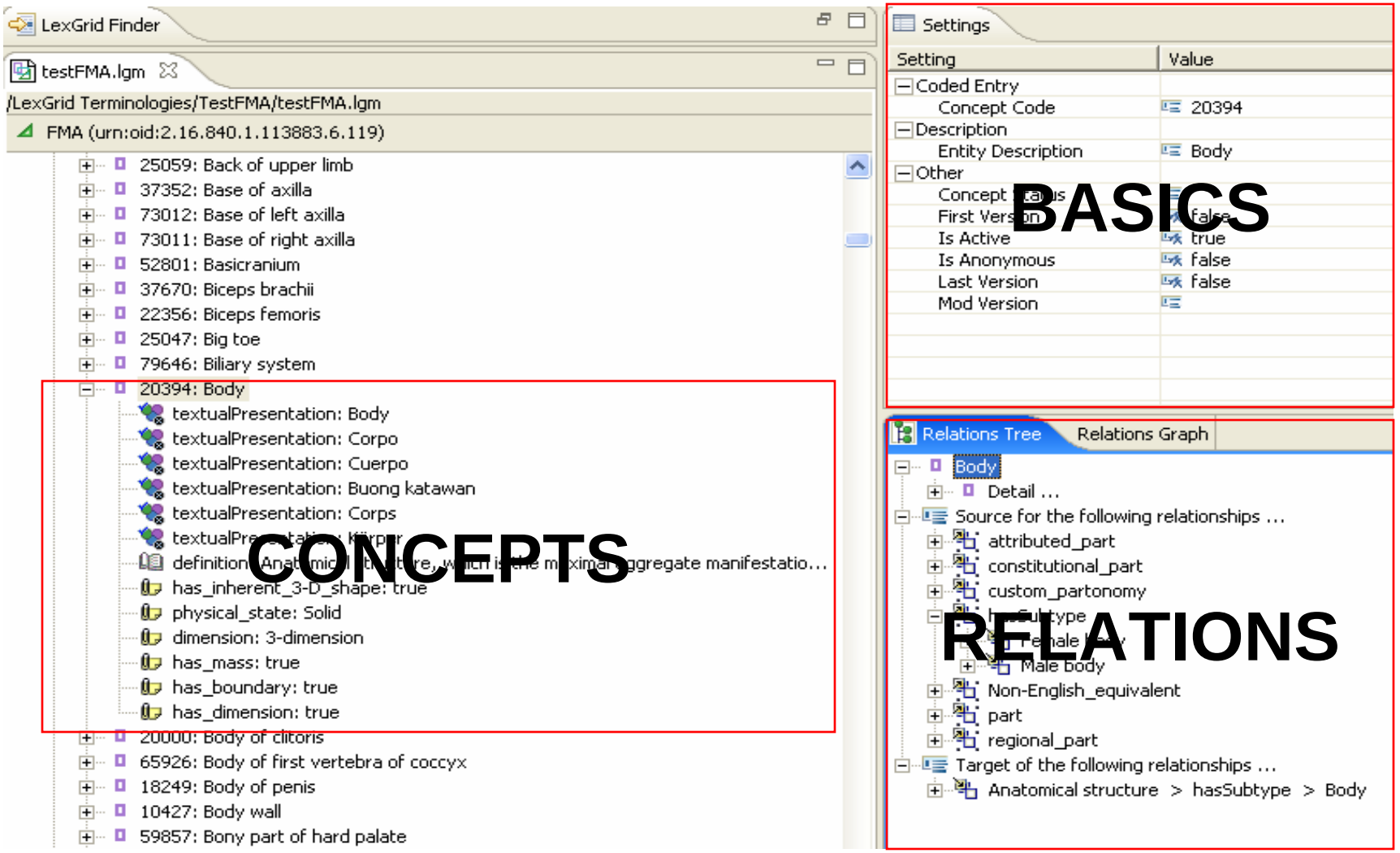
Concept “Body” (LexGrid)



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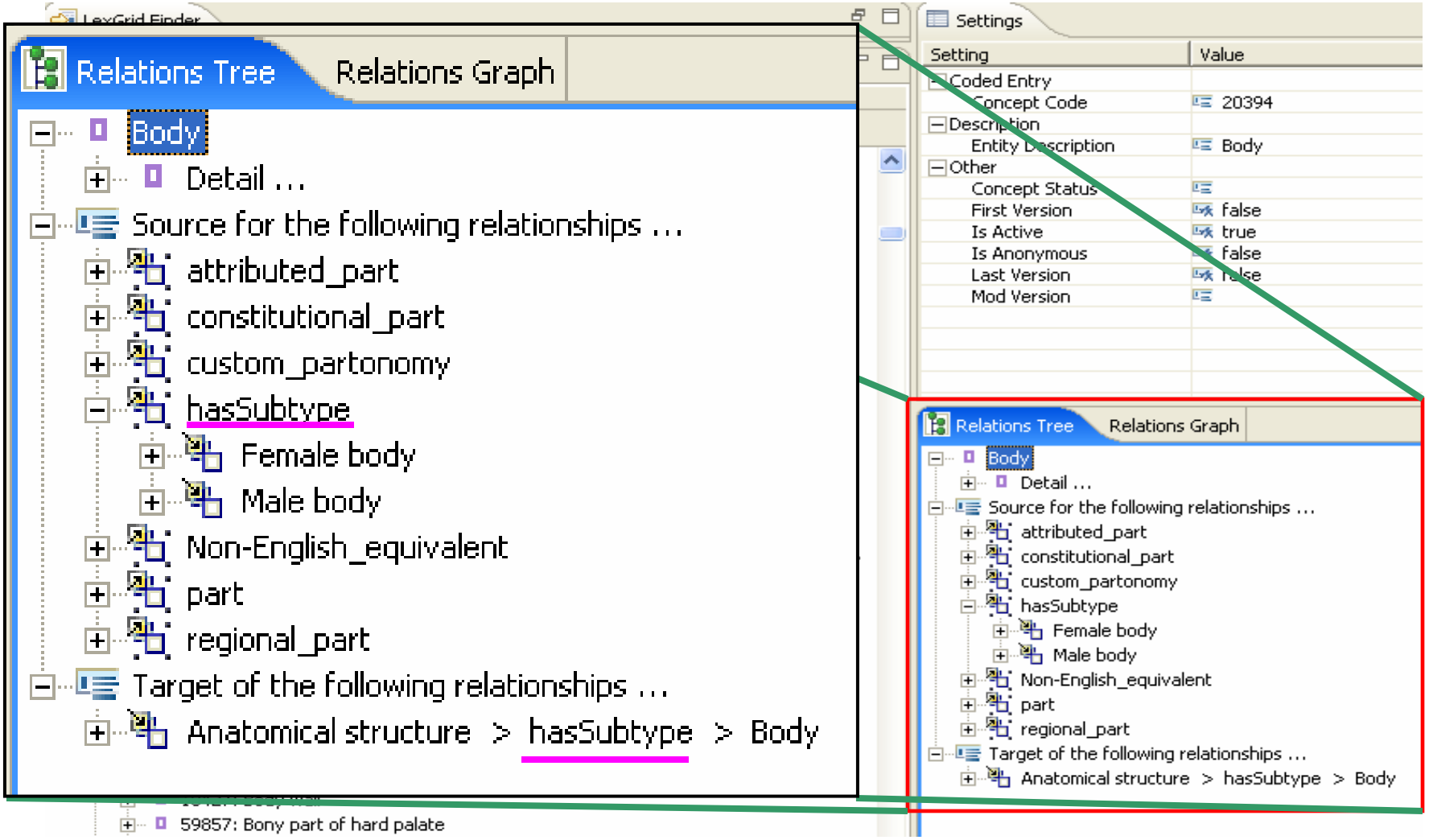
Concept “Body” (LexGrid)



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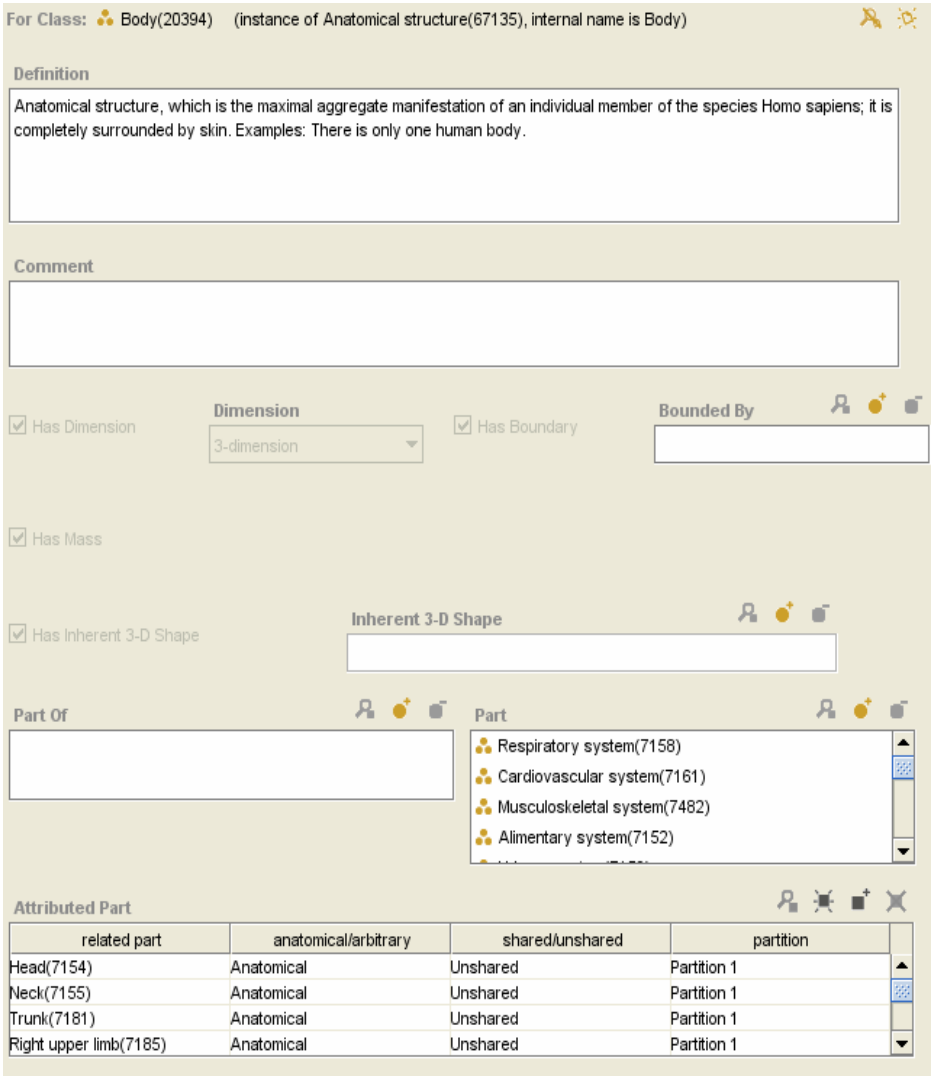
“Body” (FMA) - Attributes



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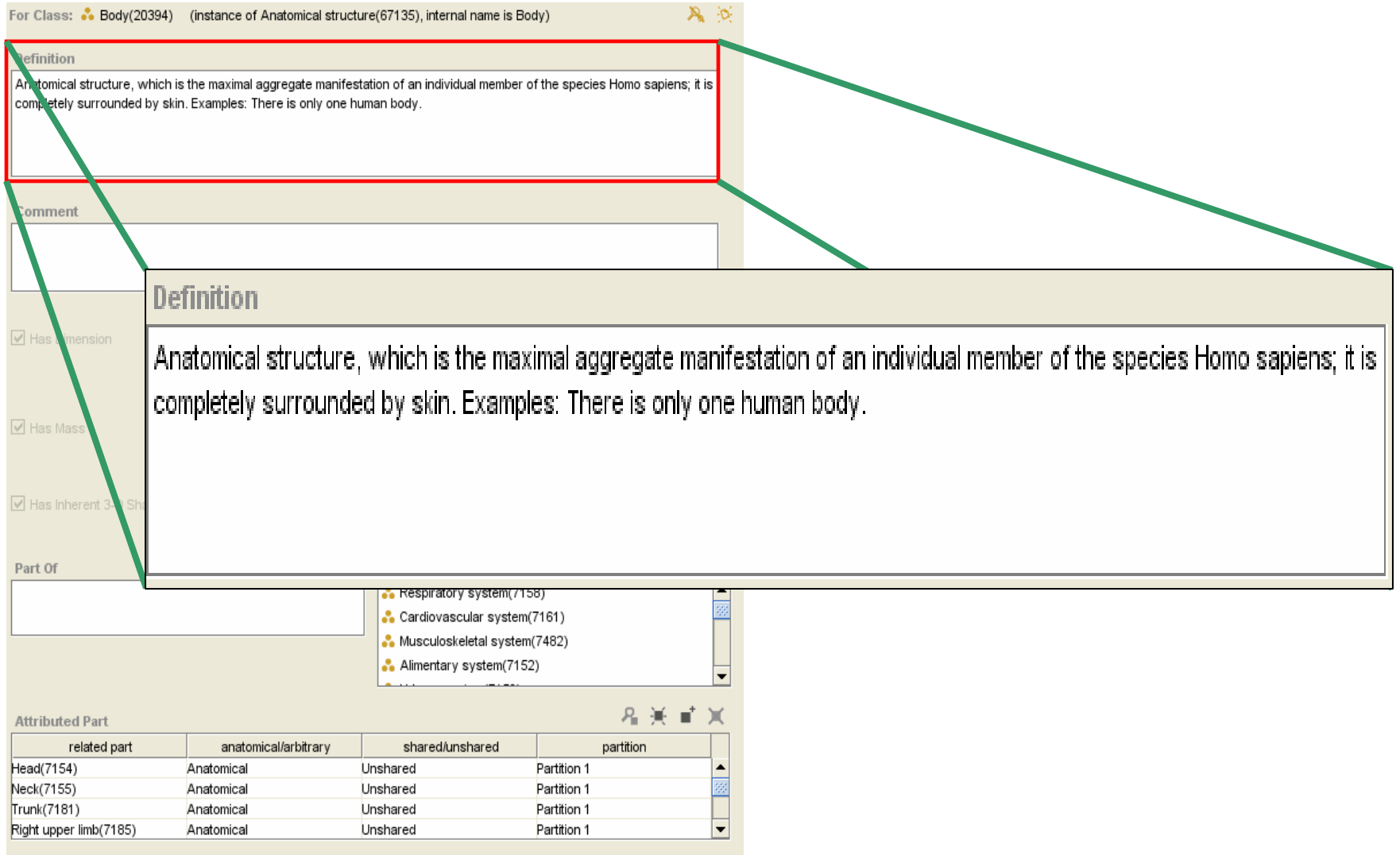
“Body” (FMA) - Attributes



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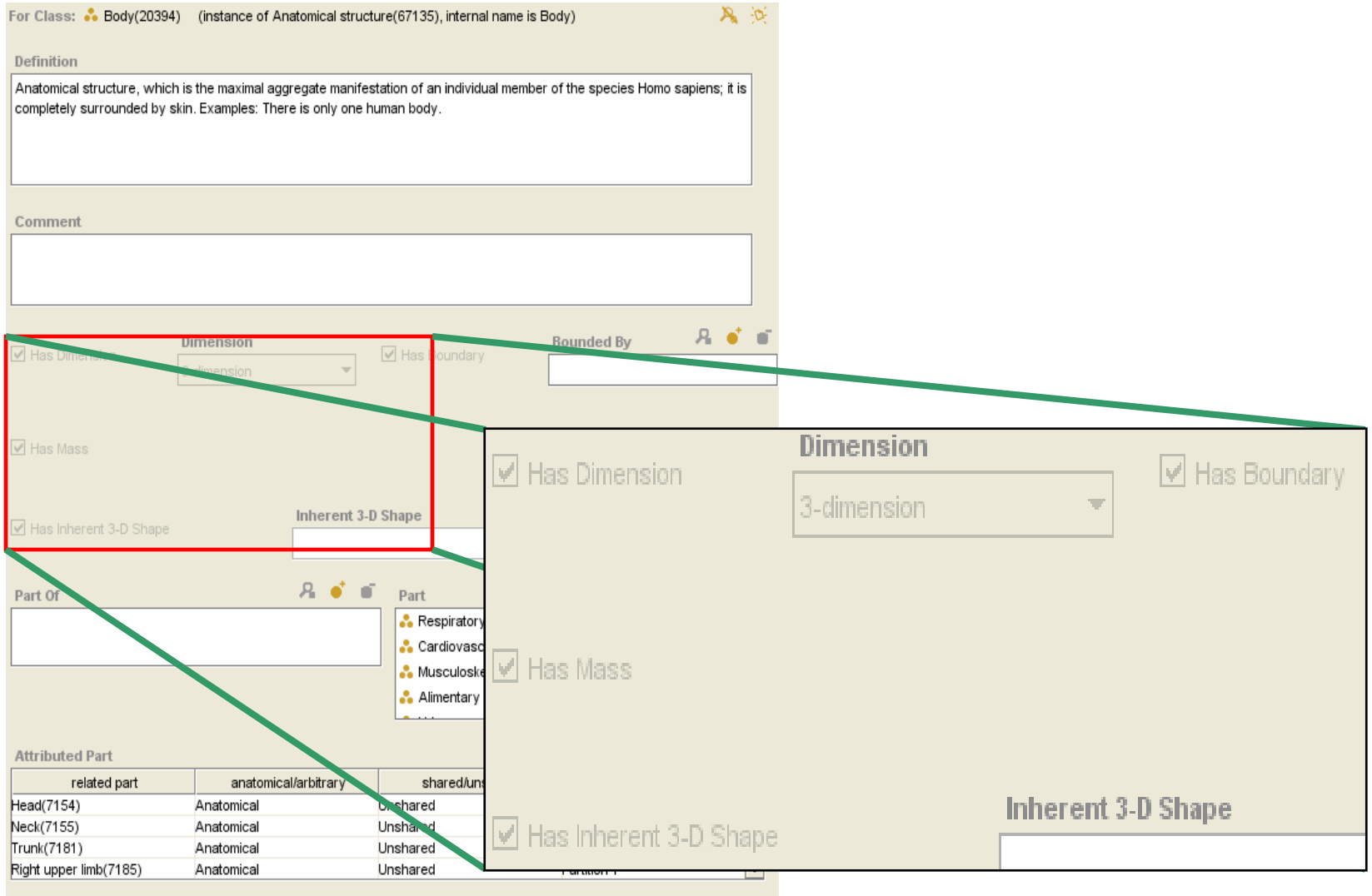
“Body” (FMA) - Attributes



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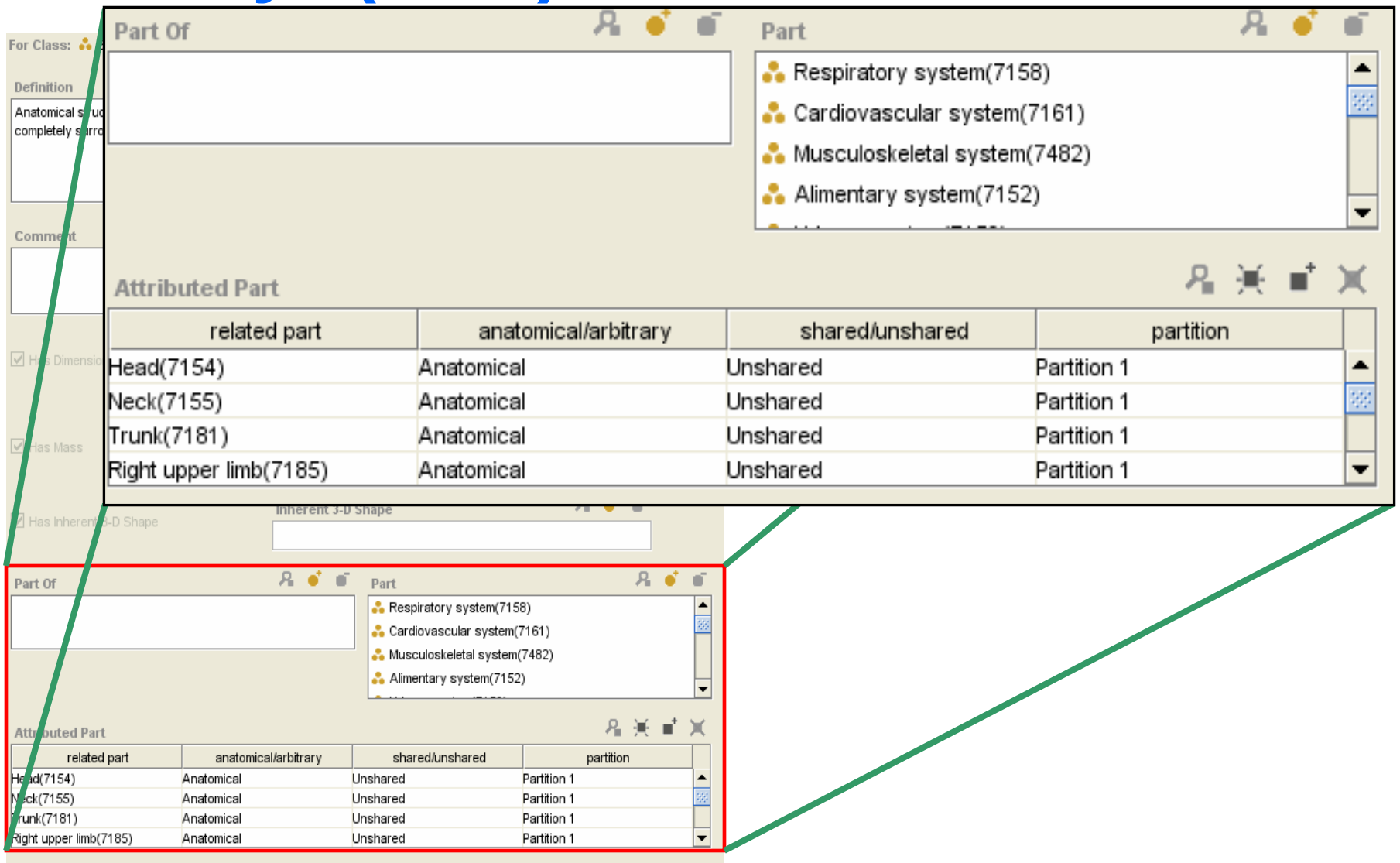
"Body" (FMA) - Attributes



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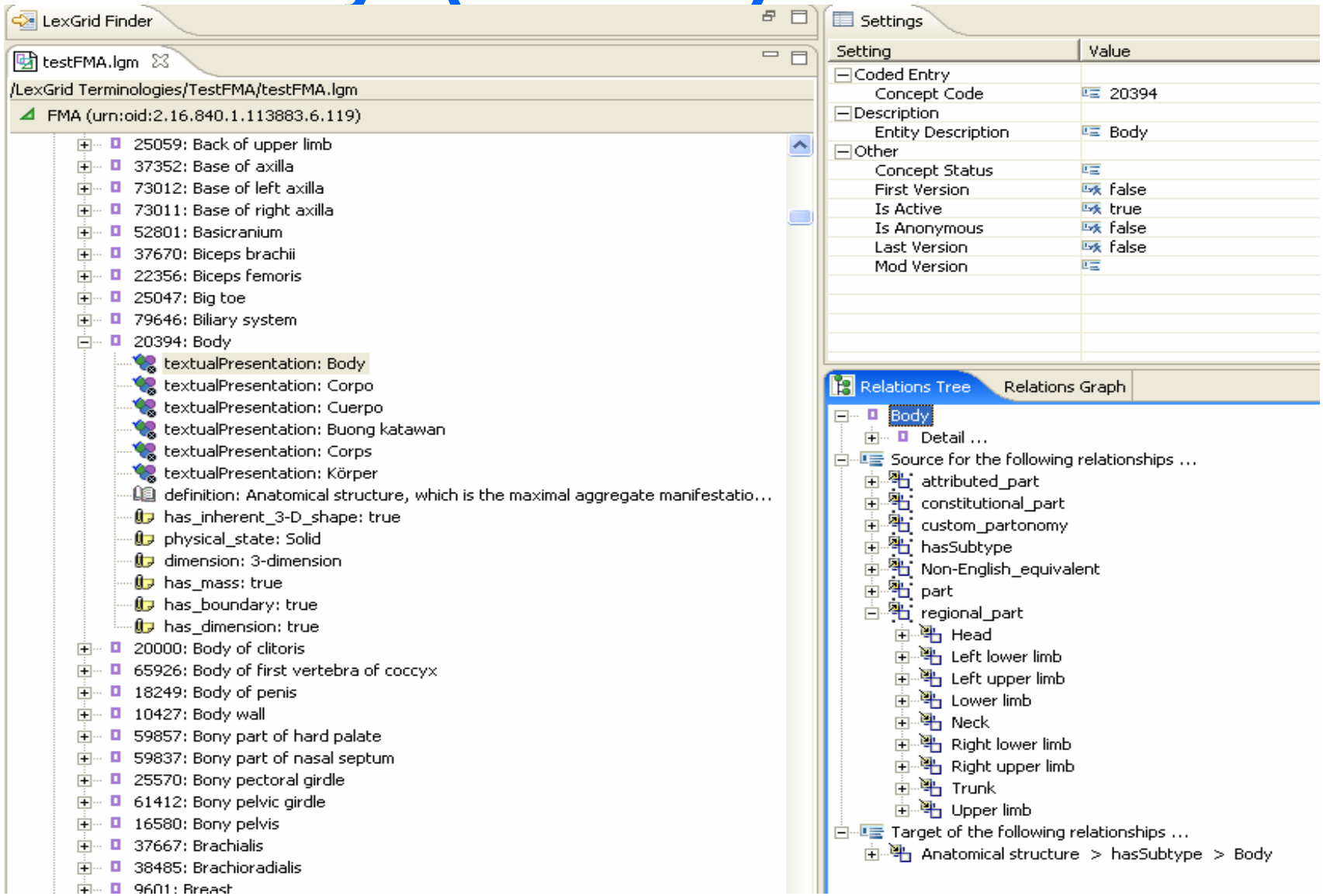
“Body” (LexGrid) - Attributes



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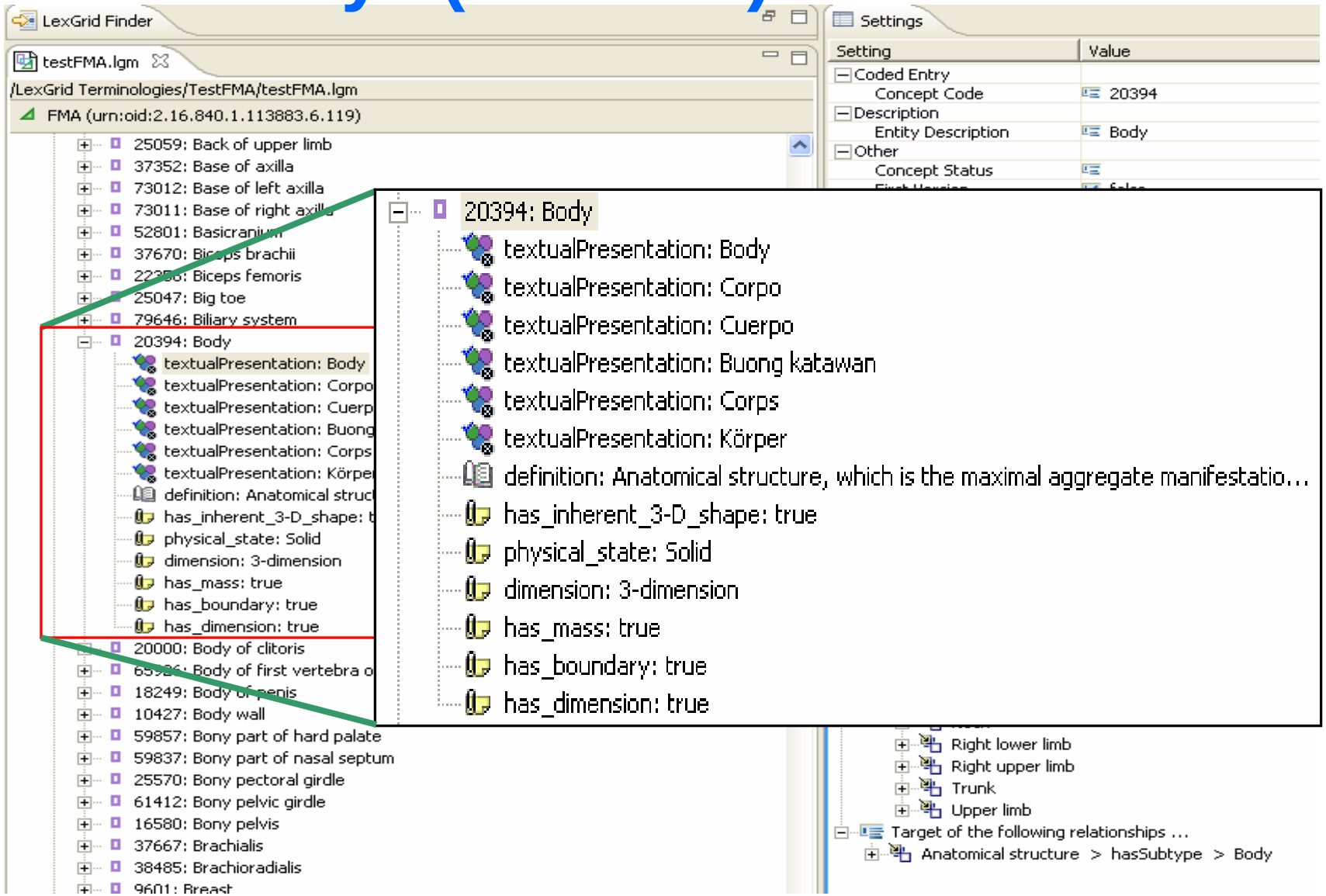
“Body” (LexGrid) - Attributes



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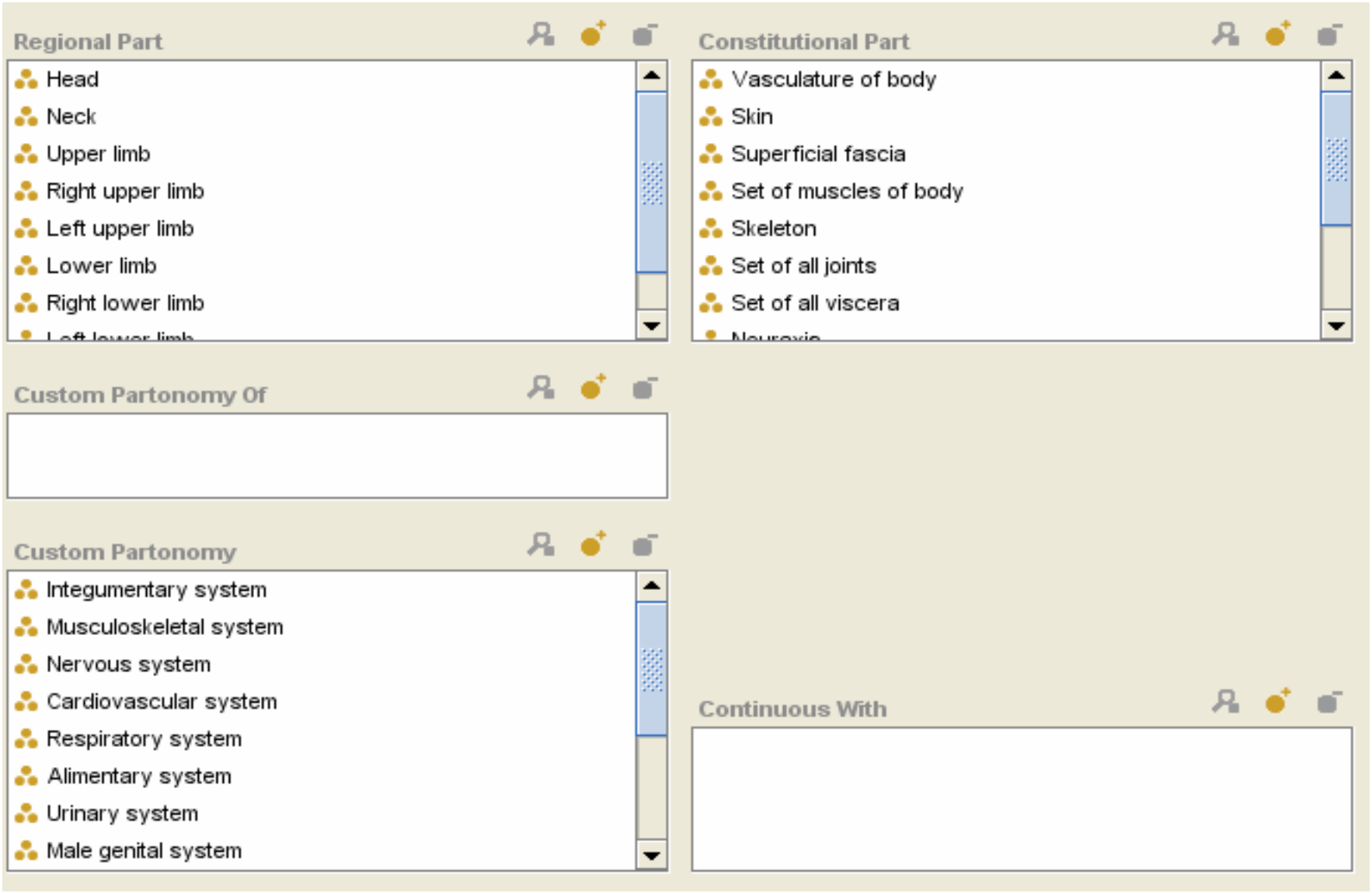
“Body” (FMA) - Relations



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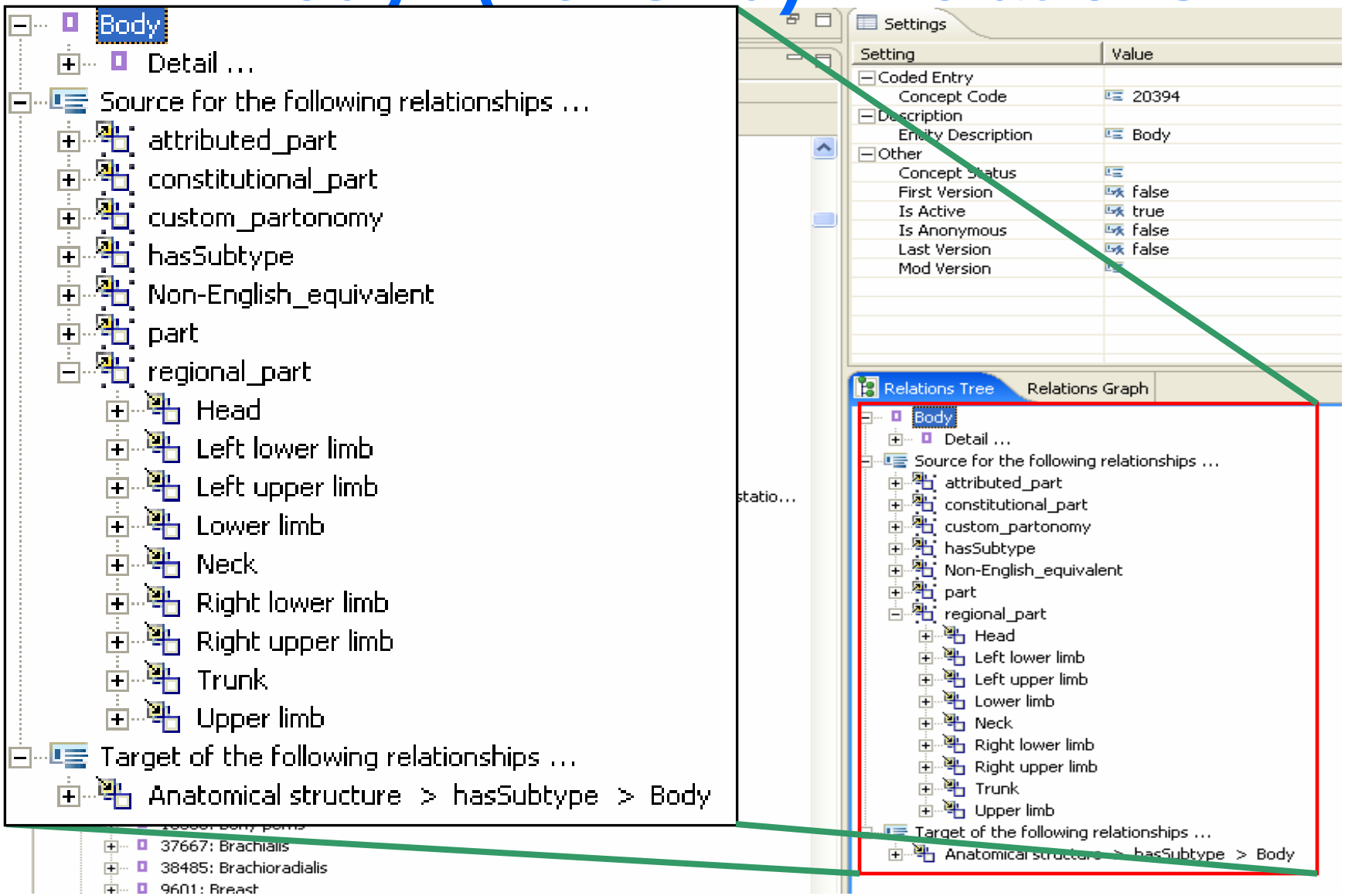
"Body" (LexGrid) - Relations



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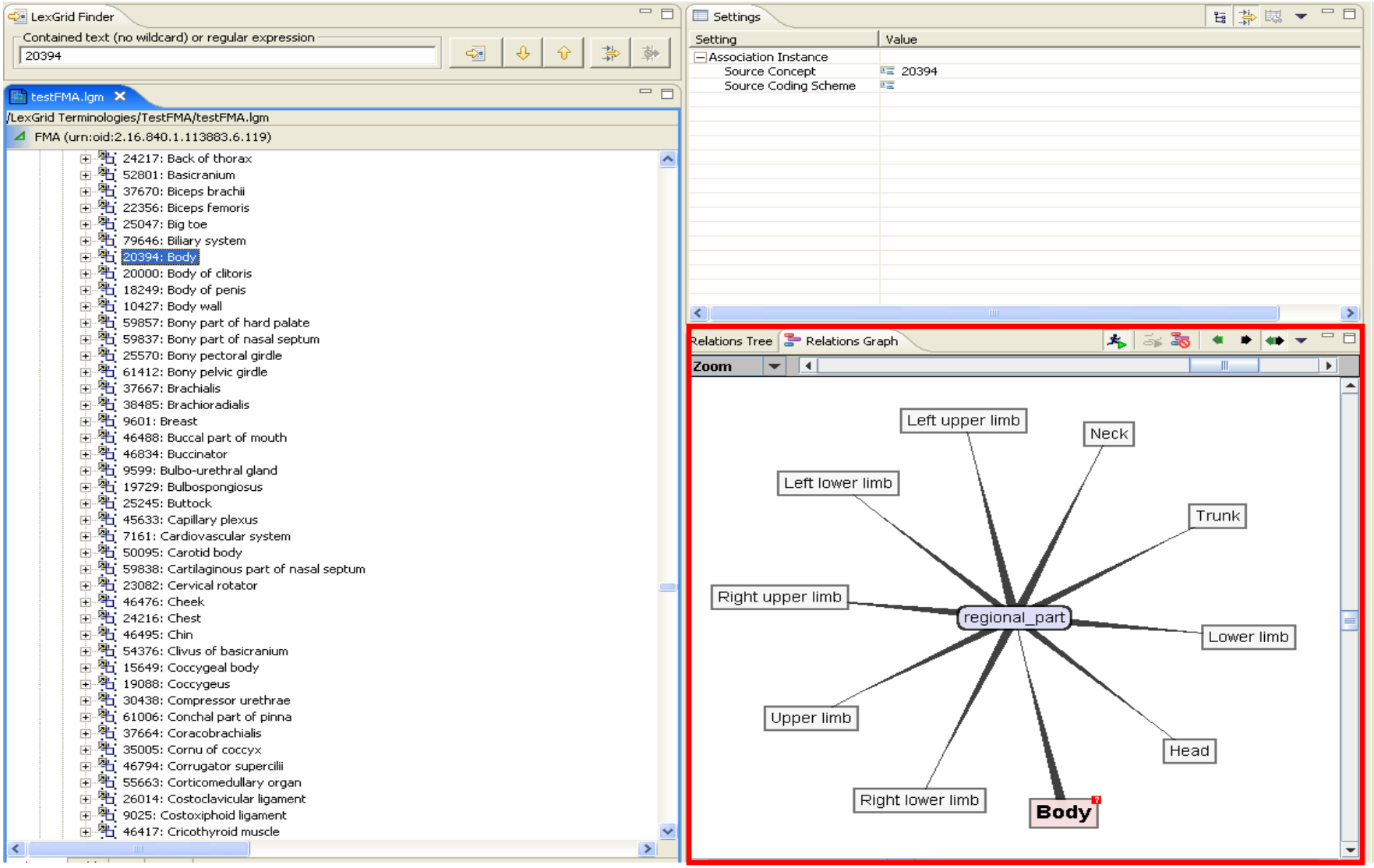
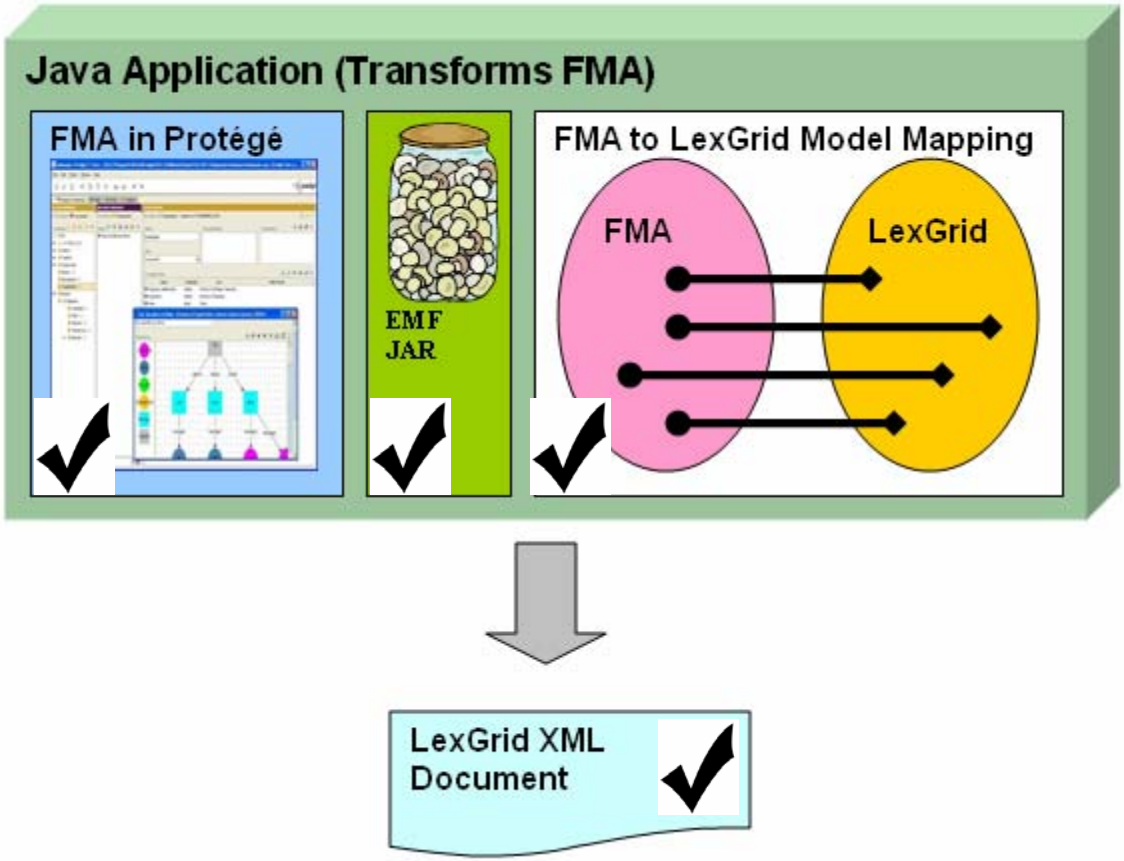
“Body” (LexGrid) - Relations



Current Status

- Transformation tool is a Java application
- Possible to make a Protégé plug-in
- Need to Isolate “Mapping to LexGrid Model” from EMF implementation

EMF at work


Java Application (Transforms FMA)
FMA in Protégé
EMF
JAR
FMA to LexGrid Model Mapping
FMA
LexGrid
LexGrid XML
Document

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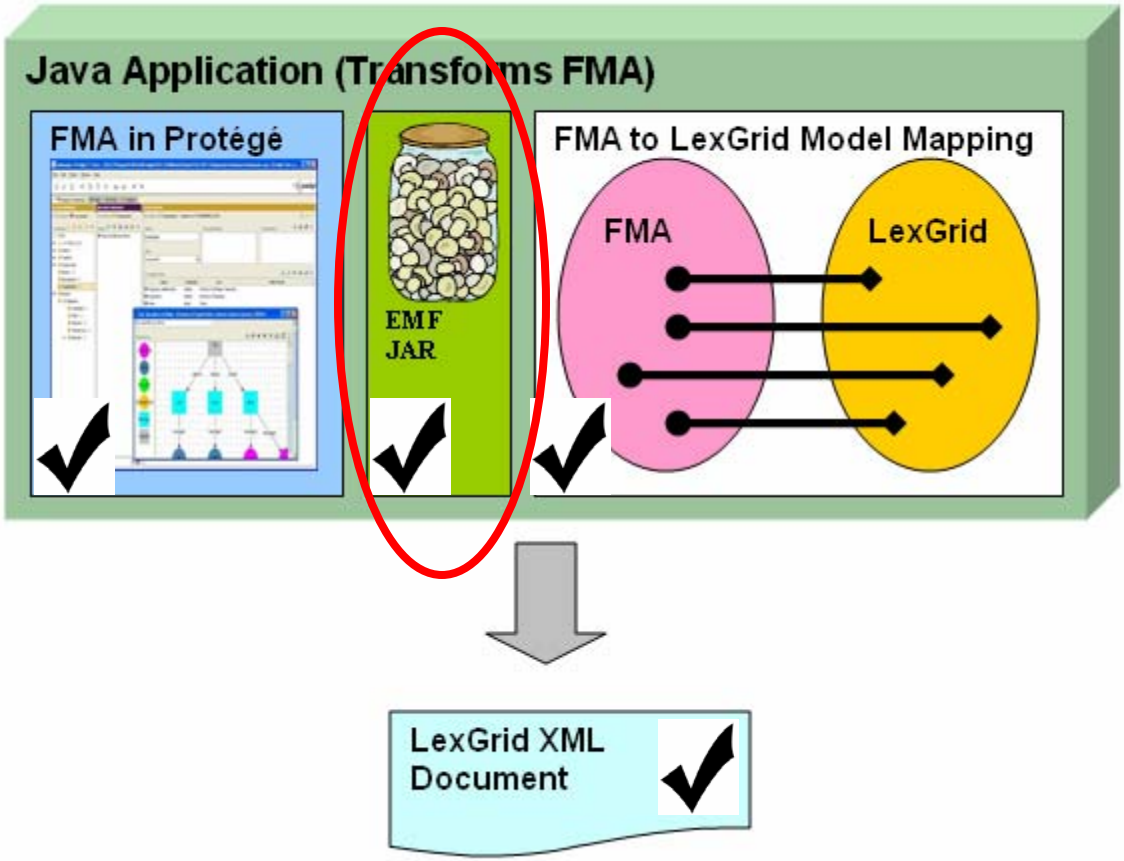
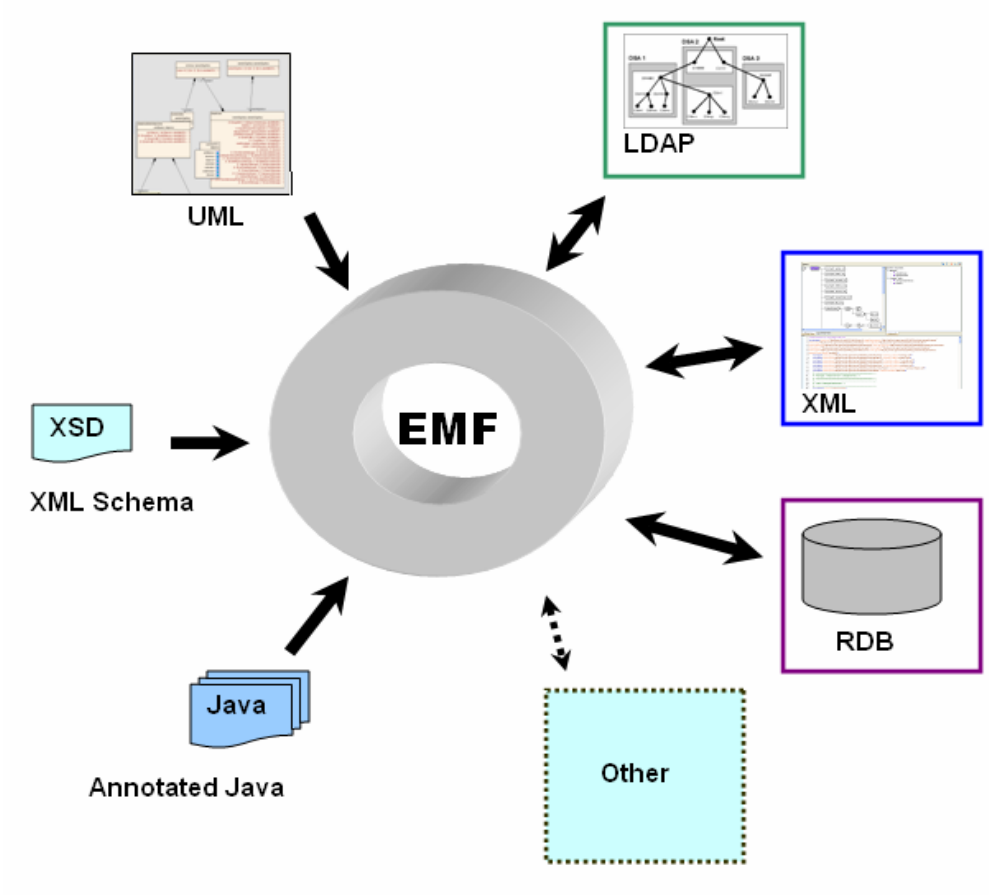
EMF at work



Current Status
EMF as a Hub



Available at
http://informatics.mayo.edu

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Conclusion

- Easily used EMF to work with user model and generate code
- Successfully
  - Converted FMA content to LexGrid Model
  - Used EMF to create LexGrid XML output document
- EMF as a hub

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Thanks!

- **Harold Solbrig**
- **Thomas Johnson**
- **Dr. Christopher Chute**

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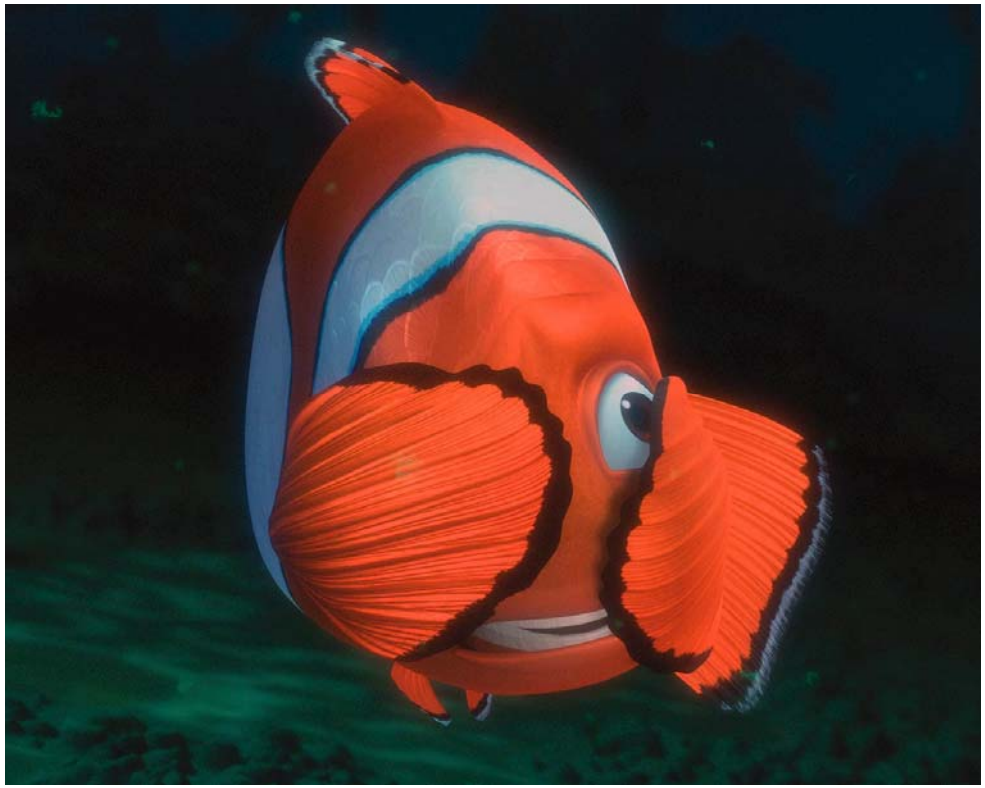
Thanks!

Protégé Conference Organizers

Questions ?



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Questions ?

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