Archetype Modeling Language (AML)

Presentation to HL7/OMG Joint Working Group

Outline

- CIMI and AML
- AML – Purpose and Goals
- OMG, UML, and UML Profiles
- AML Submission overview
- State of current submission

CIMI AND AML

CLINICAL INFORMATION MODELING INITIATIVE (CIMI)

Clinical Information Modeling Initiative **Mission**

Improve the interoperability of healthcare systems through shared implementable clinical information models.

(A single curated collection.)

Clinical Information Modeling Initiative **Goals**

- Shared repository of detailed clinical information models
- Using a single formalism
- Based on a common set of base data types
- With formal bindings of the models to standard coded terminologies
- Repository is open and models are free for use at no cost

Clinical Information Modeling Initiative

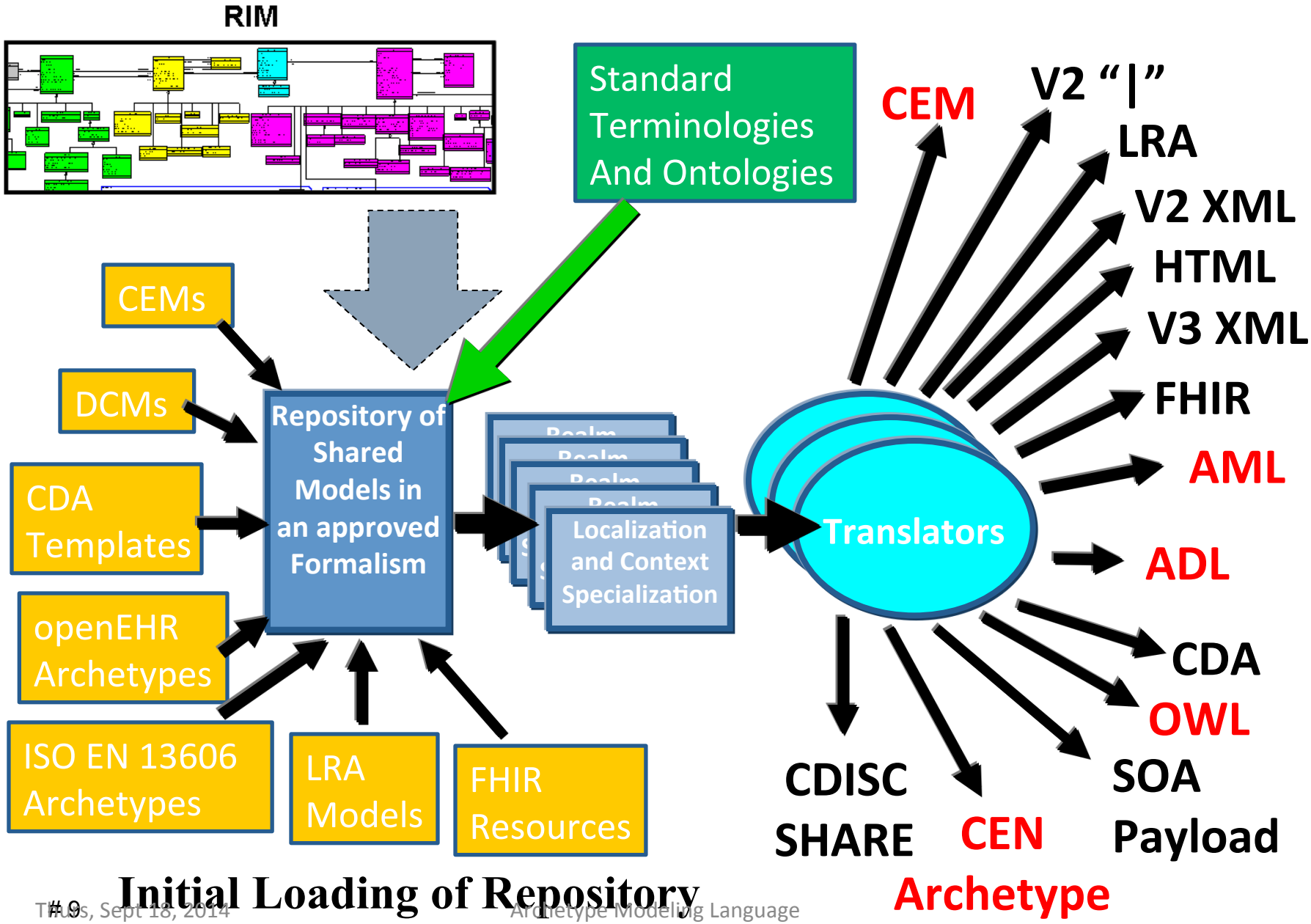
Models that support multiple contexts

- EHR data storage
- Message payload and service payload
- Decision logic (queries of EHR data)
- Clinical trials data (clinical research)
- Quality measures
- Normalization of data for secondary use
- Creation of data entry screens (like SDC)
- Capture of coding output from NLP

Strategic Goal

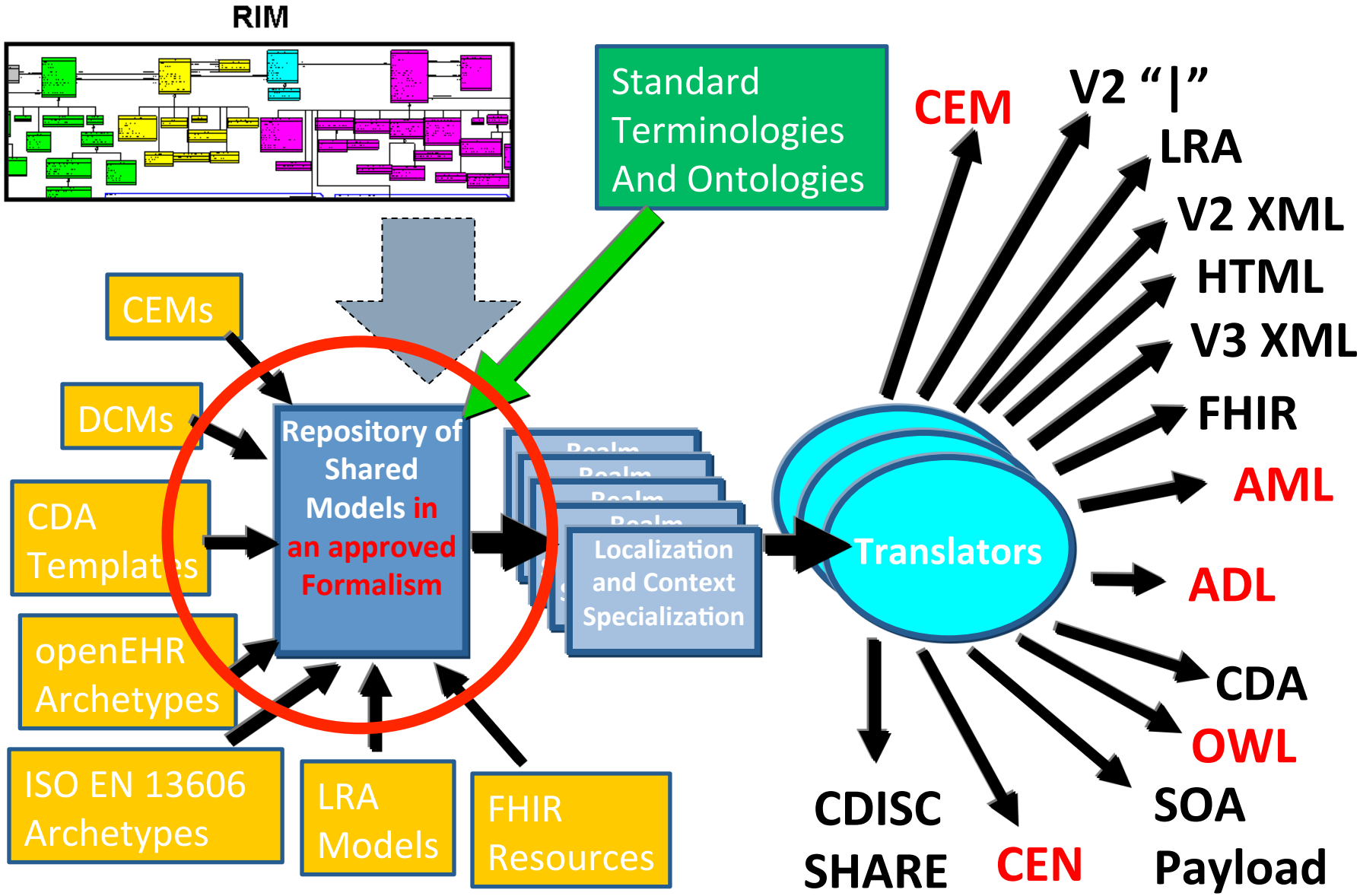
- Be able to share data, applications, reports, alerts, protocols, and decision support modules with anyone in the WORLD
- Goal is “plug-n-play” interoperability

CIMI Repository



Initial Loading of Repository

CIMI Repository



Initial Loading of Repository

SELECTED CIMI POLICIES, DECISIONS, AND MILESTONES

London, Dec 1, 2011

- ADL 1.5 as the initial formalism, including the Archetype Object Model
- **A CIMI UML profile (Archetype Modelling Language, AML) will be developed concurrently as a set of UML stereotypes, XMI specifications and transformations**

Terminology

- **SNOMED CT is the primary reference terminology**
- **LOINC is also approved as a reference terminology**
  - In the event of overlap, SNOMED CT will be the preferred source
- CIMI will propose extensions to the reference terminologies when needed concepts do not exist
  - CIMI will have a place to keep needed concepts that are not a part of any standard terminology
- CIMI has obtained a SNOMED extension identifier
- CIMI will adhere to IHTSDO Affiliate's Agreement for referencing SNOMED codes in models
  - Copyright notice in models, SNOMED license for all production implementations
- CIMI will create a Terminology Authority to review and submit concepts to IHTSDO as appropriate

Terminology (cont)

- The primary version of models will only contain references (pointers) to value sets
- We will create tools that read the terminology tables and create versions of the models that contain enumerated value sets (as in the current ADL 1.5 specification)

The Ultimate Value Proposition of CIMI

- Interoperable sharing of:
  - Data
  - Information
  - Applications
  - Decision logic
  - Reports
  - Knowledge

AML PURPOSE AND GOALS

Archetype Modeling Language RFC (AML)

Goal:

"Create a standard for modeling Archetype Models (AMs) using UML, to support the representation of Clinical Information Modeling Initiative (CIMI) artifacts in UML. "

AML Profiles
Profiles Called for in RFP

- **Reference Model Profile(RMP)** - enable the specification of reference models, upon which archetypes can be based
- **Constraint Model Profile(CMP)** - support the specification of constraints on a given reference model, to enable the development of archetypes, including Clinical Information Models (CIMs)
- **Terminology Binding Profile (TBP)** - support the binding of information models to terminology, with optional support for binding to CTS2.

AML Profiles

Additional Profiles Described in Submission

- **Archetype Profile** – Archetype Library, Archetypes and Archetype Versions
- **Rules Profile** – define a common constraint profile, compatible with a subset of OMG Object Constraint Language (OCL) and covering ADL Rules..
- **Identification and Designation** – Link to ISO 11179
- **Metadata Profile** – description and state of model artifacts. Who, what, why, where, when…

Initial Submission

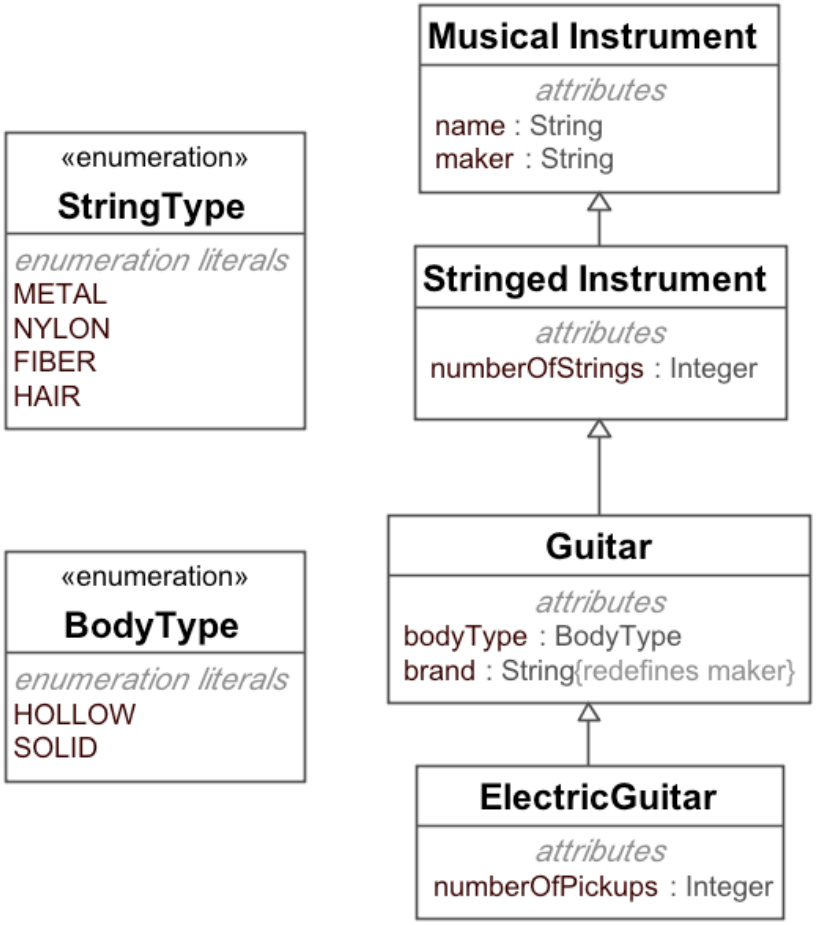
- Addresses **archetype, reference model**, **constraint model, terminology binding profile identification and designation** and **metadata profile**
- Rules (OCL) out of scope for current submission
  - Rules is is a not-insignificant task
  - Harmonization may be an issue

WHAT ARE “ARCHETYPES”?

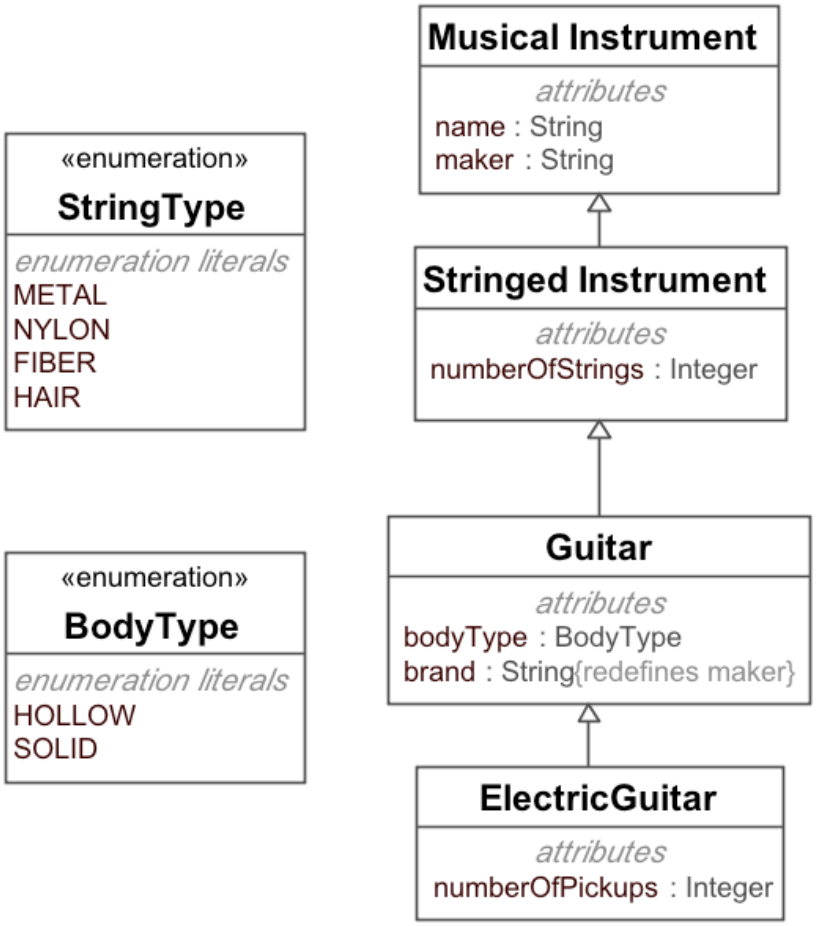
“Top Down” Modeling

- Additive
  - Start with most abstract
  - Specialize adding properties and relationships
- Instances only valid at selected level up

“Top Down” Modeling

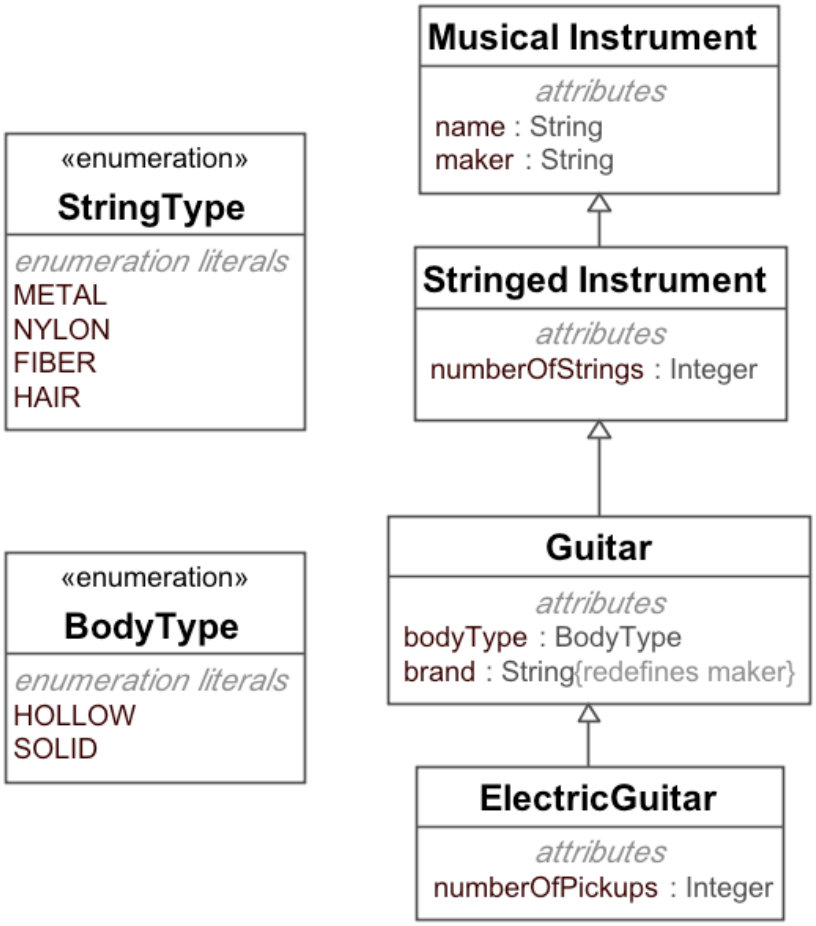


“Top Down” Modeling



<MusicalInstrument name=“Guitar”
maker=“Gibson/>

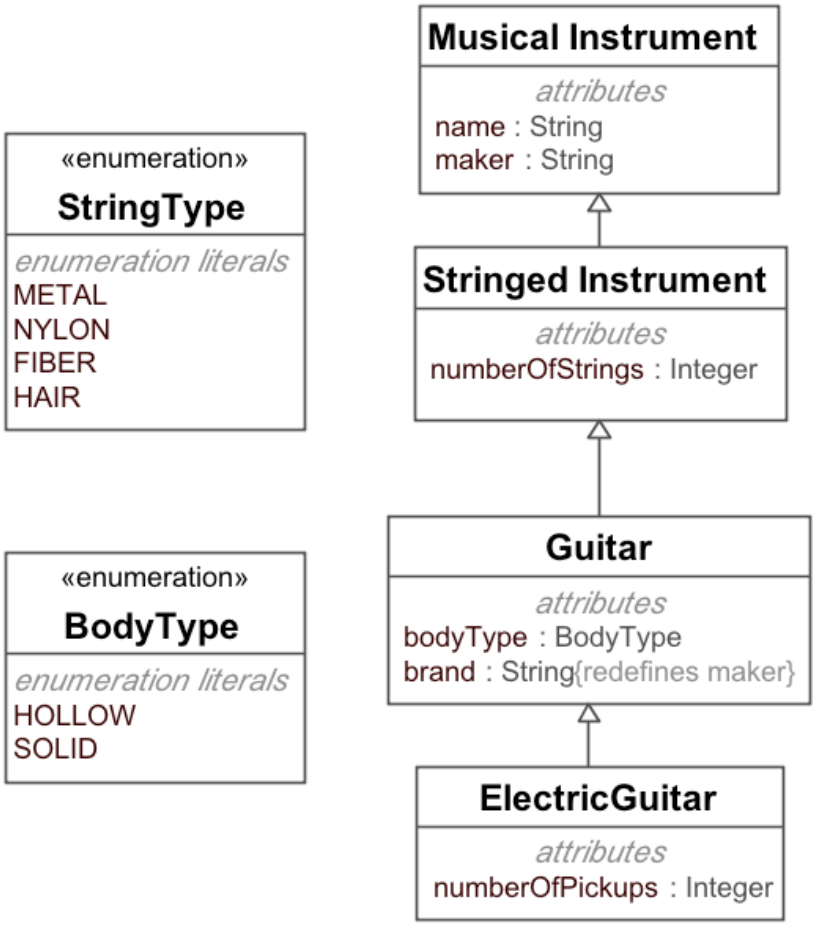
“Top Down” Modeling



<MusicalInstrument name=“Guitar”
maker=“Gibson/>

<StringedInstrument name=“Guitar”
maker=“Gibson
numberOfStrings=“6”/>

“Top Down” Modeling



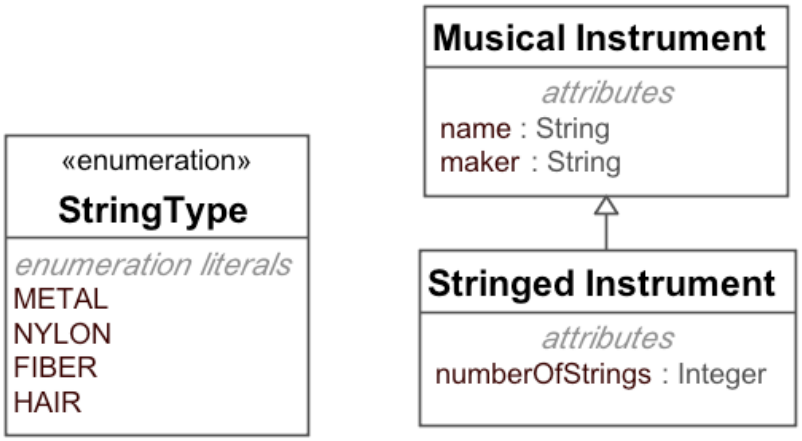
<MusicalInstrument name=“Guitar”
maker=“Gibson/>

<StringedInstrument name=“Guitar”
maker=“Gibson
numberOfStrings=“6”/>

<Guitar name=“Guitar”
brand=“Gibson
numberOfStrings=“6”/>

<ElectricGuitar name=“Guitar”
brand=“Gibson
numberOfStrings=“6”
numberOfPickups=“3”/>

“Top Down” Modeling



← If this is my model …

```
<ElectricGuitar name=“Guitar”
        brand=“Gibson
        numberOfStrings=“6”
         numberOfPickups=“3”/>
```

← … this makes no sense!

Constraint or "Bottom Up" Modeling

- Start with general model
  - Becomes the most abstract level of exchange
- Specialize by restriction
  - Cardinality
  - Value and value ranges
  - Optional → mandatory / prohibited
  - Enumeration subsets
  - Renaming

Constraint Based Models

- Start with UML "Reference Model" that defines the most abstract level of exchange
- Add constraints (restrictions) on reference model
  - Can serve as detailed type checking for input
  - Can serve as a generic grammar (!)
  - Can function as a query language

Constraints as a Grammar

- Without
  - Abnormal HCT == lab result with code '1234-5', abnormal flag set? Result > specified value?
  - Information is coded *in applications*(!)
    - Brittle
    - Rigid
- With
  - Abnormal HCT == {set of constraints}
  - Applications *reference* model

Constraints

- Need a grammar/interchange format
  - ADL 1.5.1 suites the bill well
  - UML XML (once AML is complete)
- Tooling
  - ADL Workbench / Clinical Knowledge Manager
  - UML Tools (once AML is complete)
- Representational forms
  - ADL WB / Mindmaps / JSON / XML / …
  - UML Profile / Model tools

OMG, UML, AND UML PROFILES

Object Management Group (OMG)

- Standards *consortium*
- Home to UML and Model Driven Architecture (MDA)
- "No Shelf-ware" policy – standards must be accompanied by implementations
- Platform Technical Committees – architecture, tools, middleware
- Domain Technical Committees – "vertical" domains (Healthcare, Manufacturing, Robotics, Space, …)

UML

A standard for representing and exchanging *models*

- A model *of* models (a "metamodel")
  - "Class", "Property", "Generalization", "Association"
- Representation for elements (An *instance* of a "Class" is represented as a box with separate slots…"
- Model of model exchange

Model of “Class”

11.4.2 Abstract Syntax

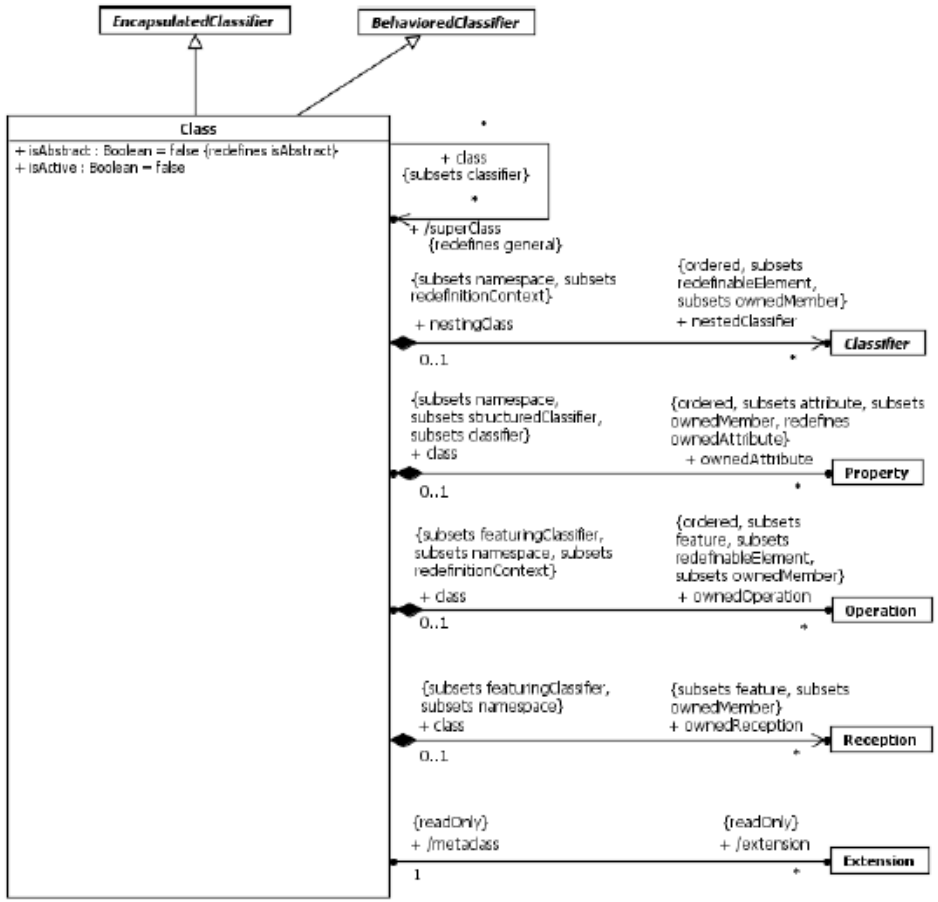


Figure 11.15 Classes

Representation of “Class”

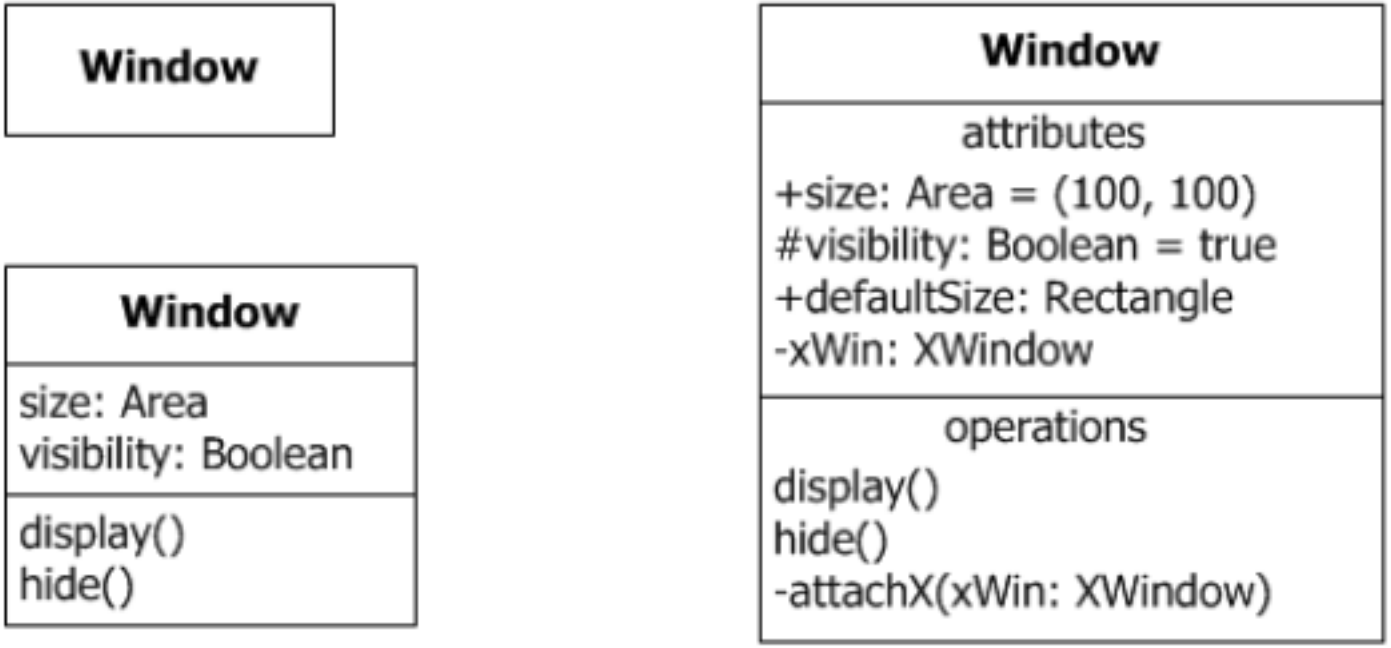
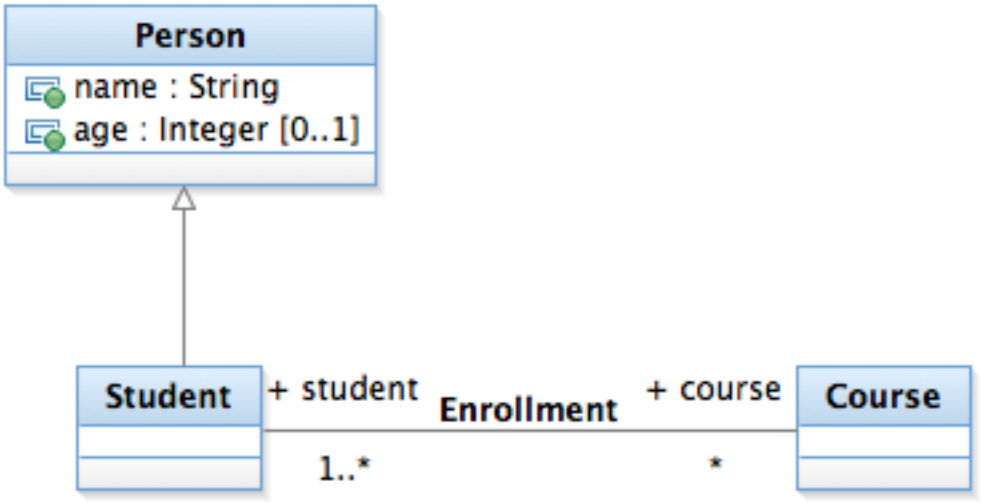


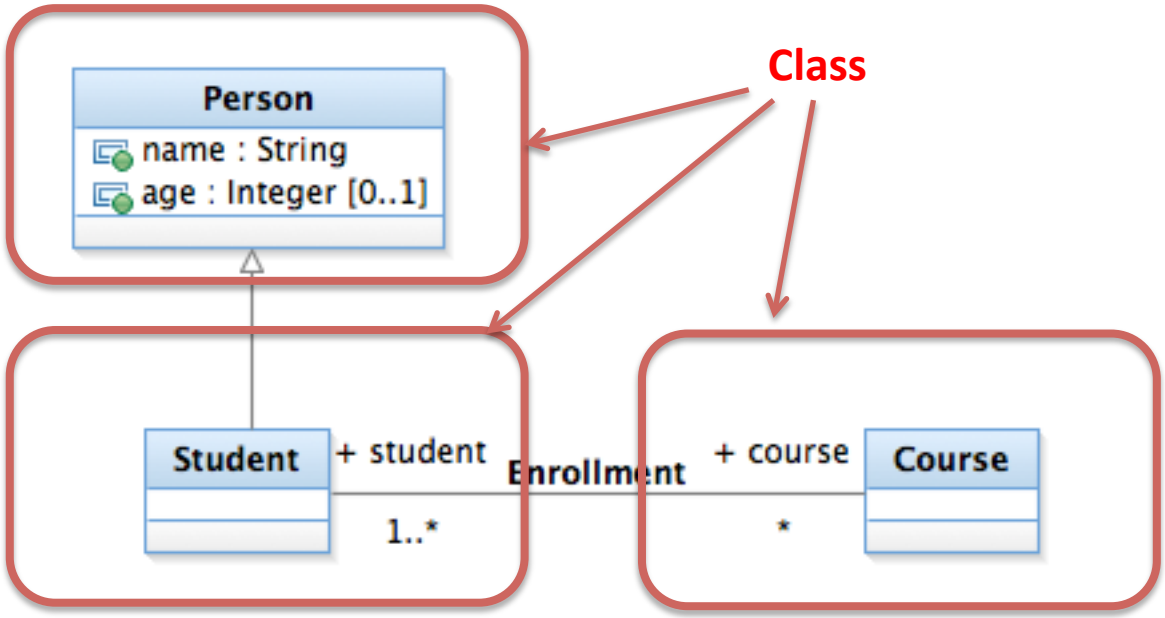
Figure 11.16 Class notation variants

Figure 11.17 shows the visibility grouping option (see 9.2.4) applied to the attribu
Window.

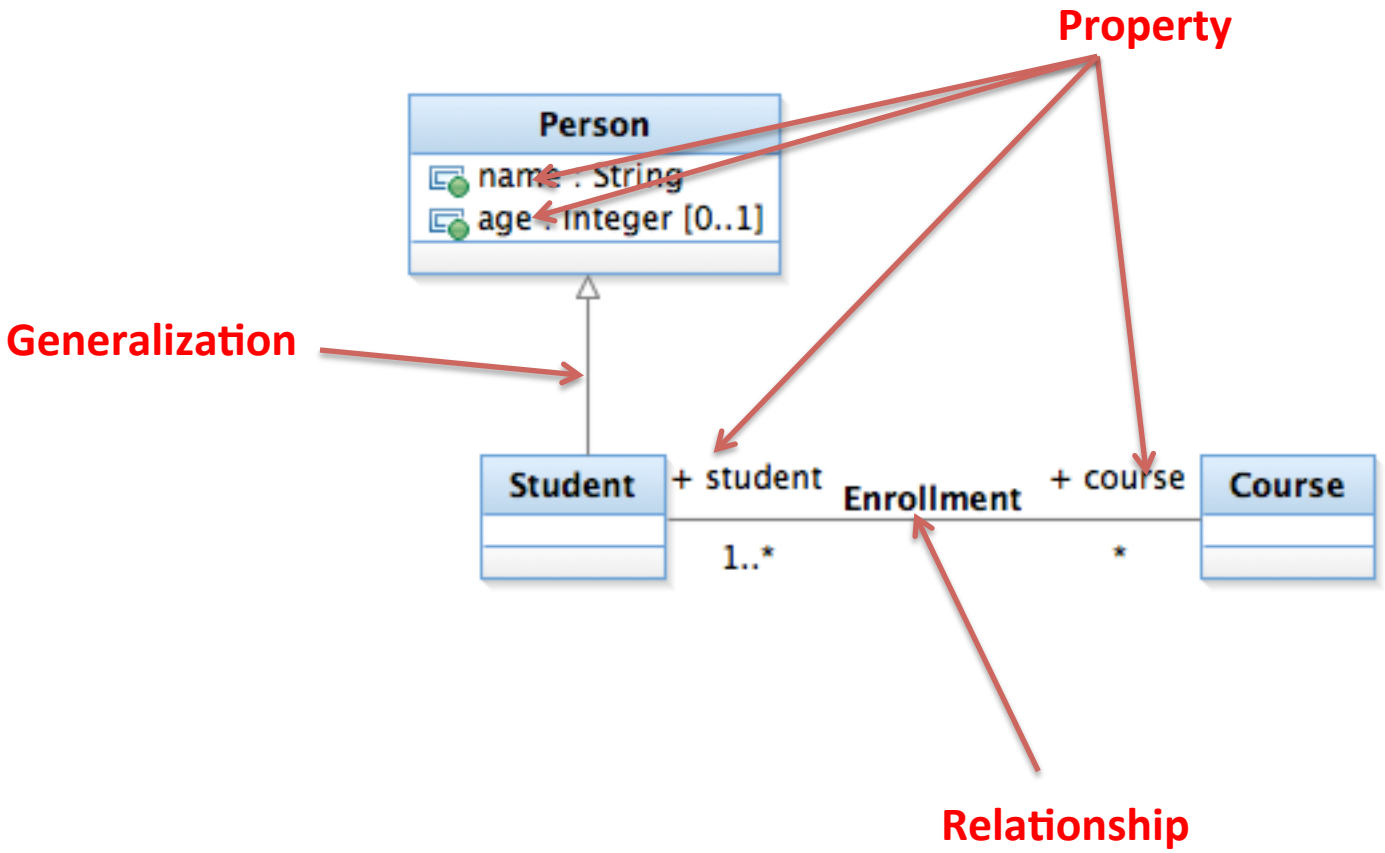
UML Model *Instance*



UML Model *Instance*



Instances


Property
Person
name : String
age : Integer [0..1]
Generalization
Student
+ student
Enrollment
+ course
Course
1..*
*
Relationship

Model Interchange

```
<?xml version="1.0" encoding="UTF-8"?>
<uml:Package xmi:version="2.1" xmlns:xmi="http://schema.omg.org/spec/XMI/2.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:ecore="http://www.eclipse.org/emf/2002/Ecore"
  xmlns:uml="http://schema.omg.org/spec/UML/2.2"
  xsi:schemaLocation="http://schema.omg.org/spec/UML/2.2 http://www.eclipse.org/uml2/3.0.0/UML"
  xmi:id="_PCoU8J_YEeO0_ccVLTZGDA" name="UML Sample">
  <packageImport xmi:type="uml:PackageImport" xmi:id="_PCoU85_YEeO0_ccVLTZGDA">
    <importedPackage xmi:type="uml:Model" href="pathmap://UML_LIBRARIES/UMLPrimitiveTypes.library.uml#_0"/>
  </packageImport>
  <packagedElement xmi:type="uml:Package" xmi:id="_VdF28J_YEeO0_ccVLTZGDA" name="PersonPackage">
    <packagedElement xmi:type="uml:Class" xmi:id="_Ydyn0J_YEeO0_ccVLTZGDA" name="Student">
      <generalization xmi:type="uml:Generalization" xmi:id="_B1-w0KABEeO0_ccVLTZGDA" general="_8ML2wKAAEeO0_ccVLTZGDA"/>
      <ownedAttribute xmi:type="uml:Property" xmi:id="_hWMXkKC3EeO0_ccVLTZGDA" name="course" visibility="public"
        type="_uapgsJ_YEeO0_ccVLTZGDA" association="_hWLJcKC3EeO0_ccVLTZGDA">
        <upperValue xmi:type="uml:LiteralUnlimitedNatural" xmi:id="_hWNlsaC3EeO0_ccVLTZGDA" value="*"/>
        <lowerValue xmi:type="uml:LiteralInteger" xmi:id="_hWNlsKC3EeO0_ccVLTZGDA"/>
      </ownedAttribute>
```

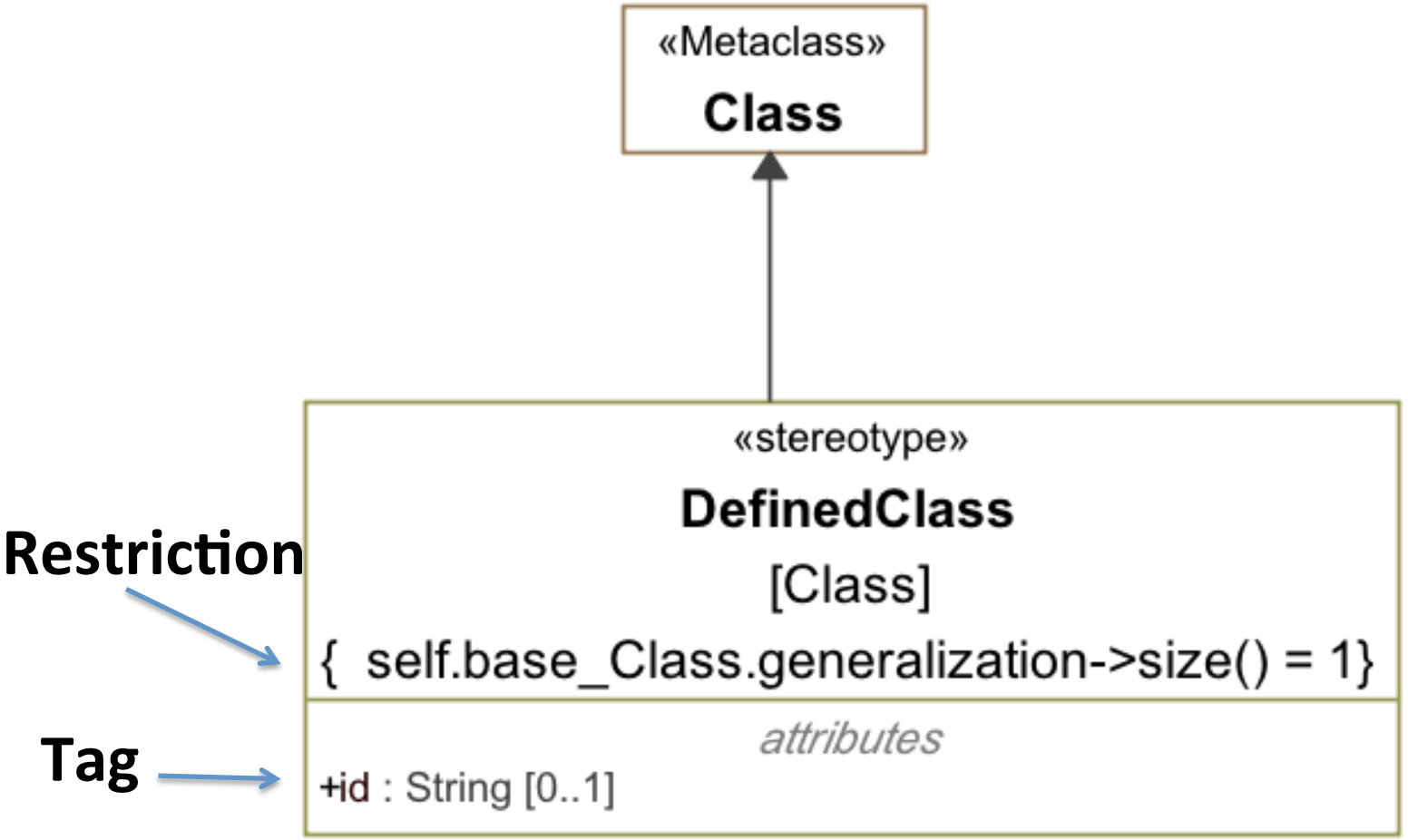
UML

- Good at general, “extensible” models
- NOT so good at “constraint” models
- *Extensible* – elements the metamodel itself can be extended as a “Profile”

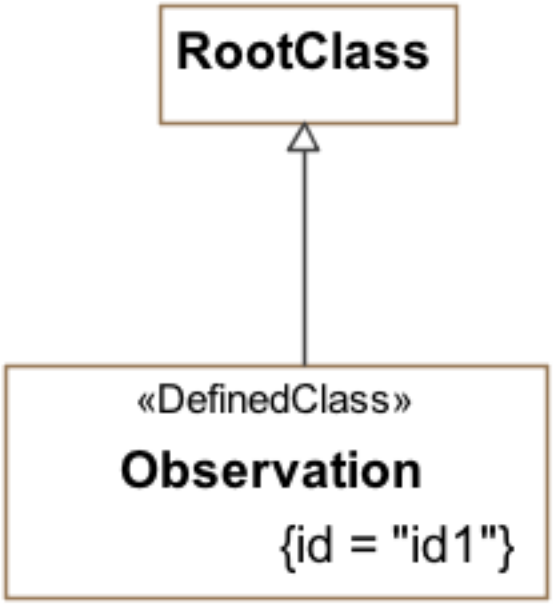
Extension

'Particularization' of UML by specializing some of its elements, imposing new restrictions on them but respecting the UML metamodel, and without modifying the original semantics of the UML elements (i.e., the properties of the UML classes, associations, attributes, etc., will remain the same, but new constraints will be added to their original definitions and relationships).

Extension


«Metaclass»
Class
«stereotype»
DefinedClass
[Class]
{ self.base_Class.generalization->size() = 1}
attributes
+id : String [0..1]
Restriction
Tag

Using a Stereotype (extension)



Profile

- Collections of Stereotypes and Classes
- Semantics of the above
- *Suggestions* for representation and use

The (or "A") GOAL is to have UML model vendors incorporate profiles as first class items into their tools…

OMG STANDARDS PROCESS

OMG RFP Process

Members Only

1) TC issues RFP – requirements document
2) Organizations submit responses
    1) Initial submission – draft responses shown, discussed.
    2) Final submission – (typically) one harmonized fesponse
3) Response(s) are balloted

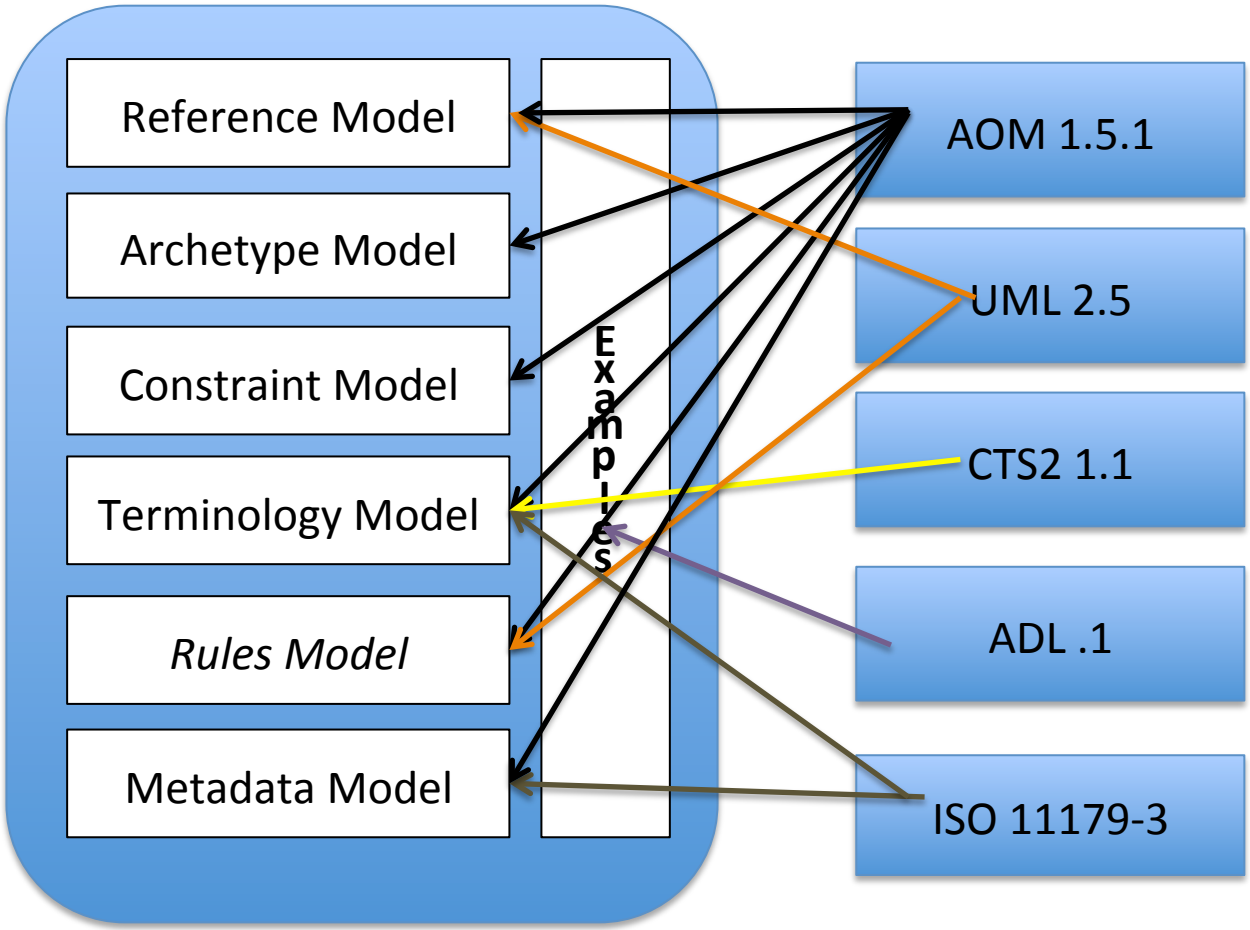
Public

4) Accepted response becomes a Beta Specification / Finalization Task Force formed
5) FTF report submitted and Beta Specification becomes a final specification.

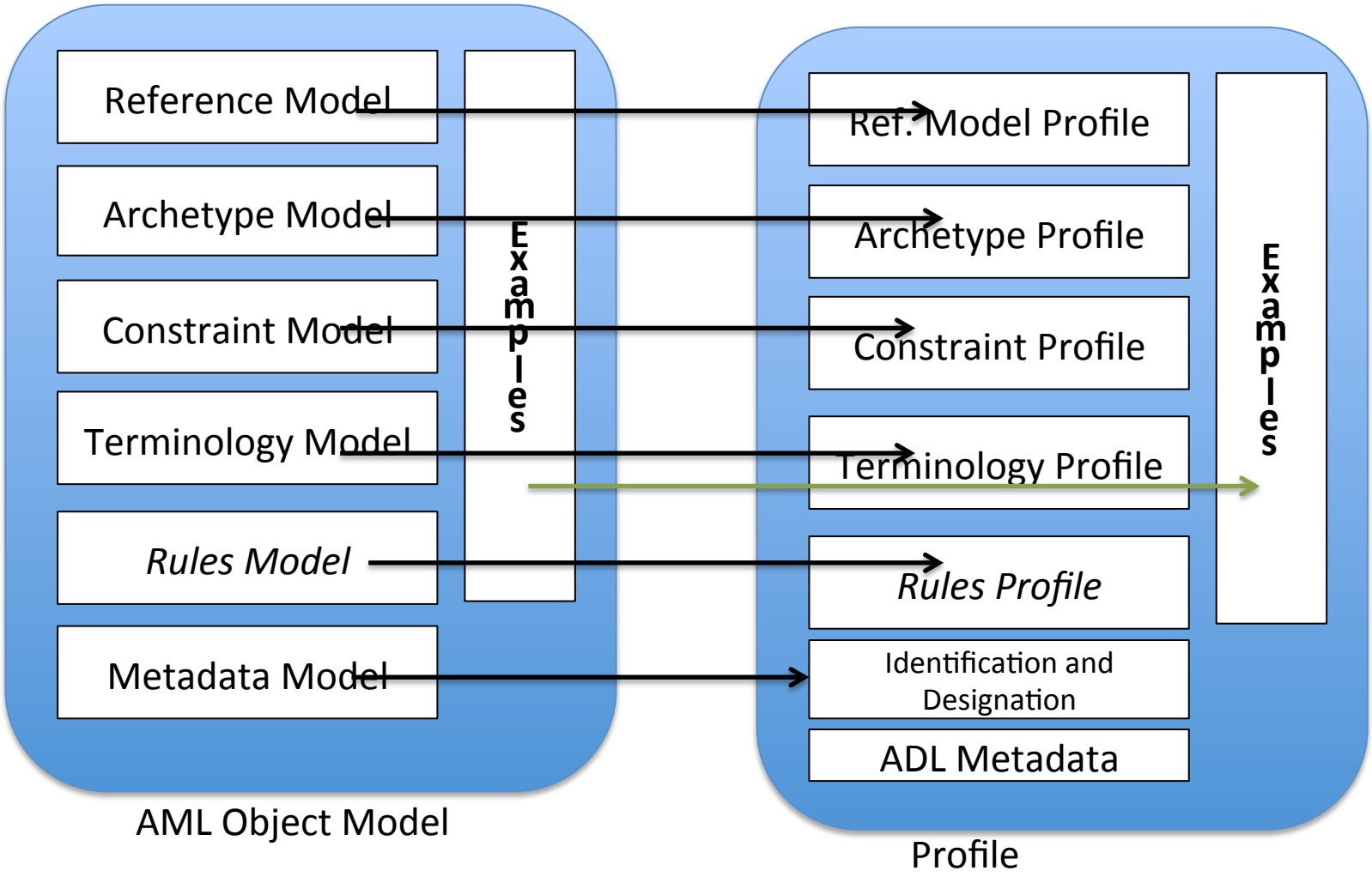
AML Submission

- Boilerplate (Chapters 1-7)
- Metamodel – (Chapter 8) *what* we are trying to do
- Profiles – (Chapter 9…) *how* we do it (profiles)

AML Submission
AML Object Model



AML Submission Profiles



AML SUBMISSION OVERVIEW

REFERENCE MODEL PROFILE

Reference Model Object Model

- Identify the subset of UML that will be recognized by AML
  - Class
  - Property (SingularProperty / CollectionProperty
  - DataType (UML Sense)
    - Enumeration
    - PrimitiveType
    - ConceptReference
  - Namespace / Package

Reference Model Profile

- Identify the "primitive" types that can be constrained
  - Boolean, String, Integer, Real
  - DateTime, Date, Time, Duration
- Provide stereotypes to identify components of the reference model that are constrained by the Profile primitive types
- Provide abstract types that need to be realized in any model
  - ArchetypeId, ArchetypeVersionId, ArchetypeMetadata

ARCHETYPE PROFILE

Archetype Profile

Archetype Library : a collection of archetypes that apply to the same reference model

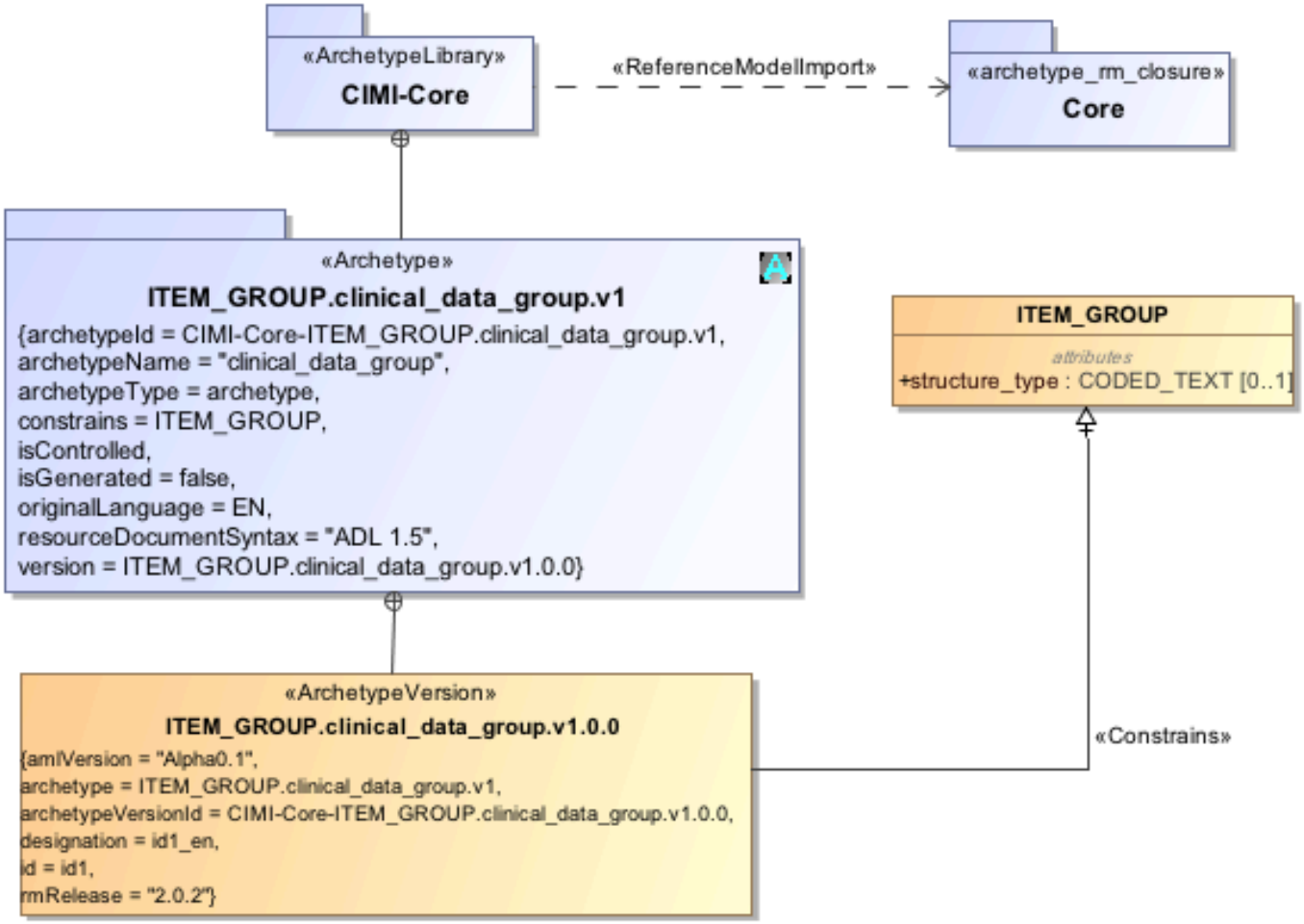
Archetype : a constraint applied to a specific class in a reference model

ArchetypeVersion : the state of a constraint at a point in time

ADL

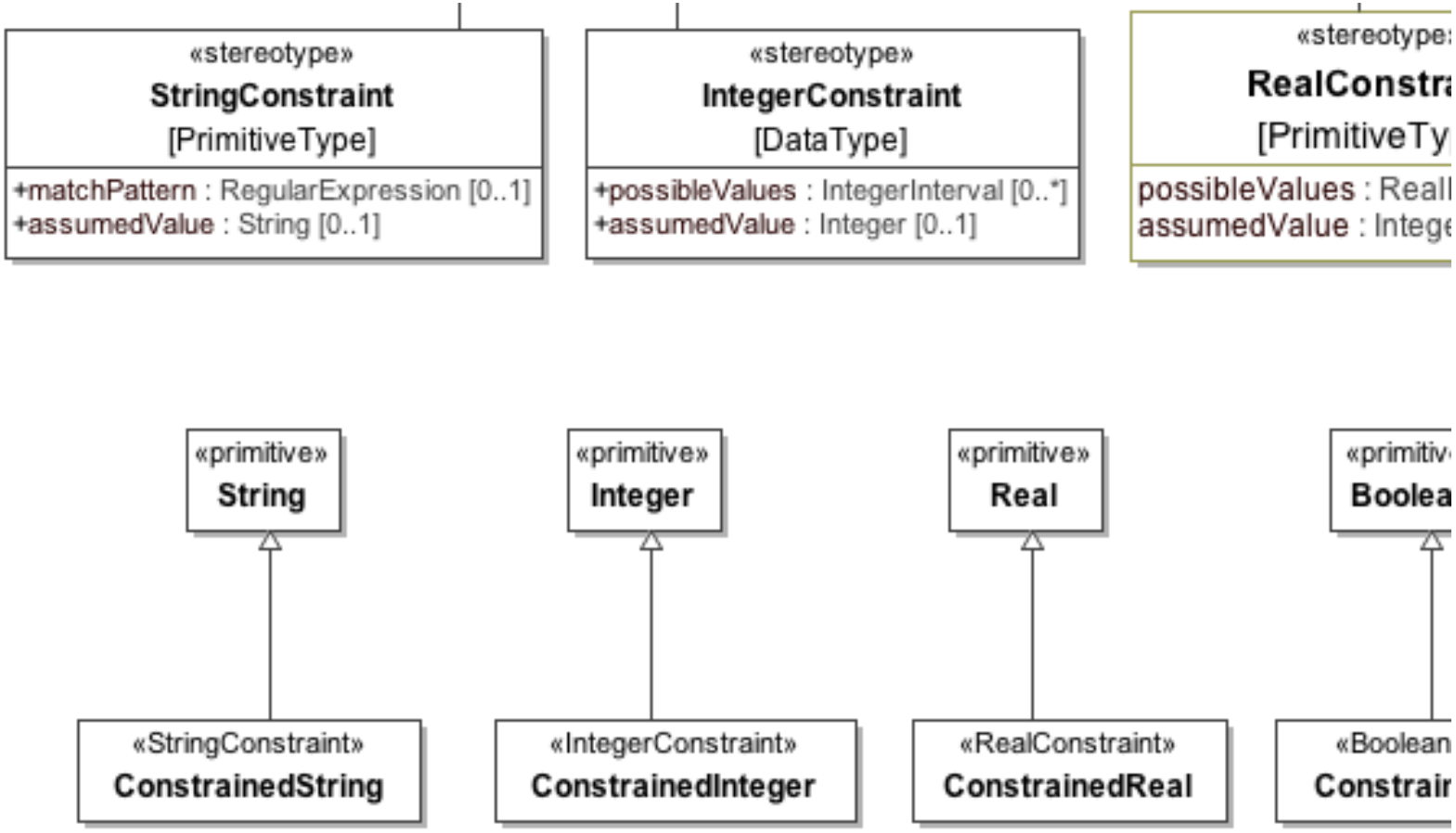
```
archetype (adl_version=1.5.1)
    CIMI-Core-ITEM_GROUP.clinical_data_group.v1.0.0

language
    original_language = <[ISO_639-1::en]>

description
    original_author = <
        ["name"] = <"Thomas Beale">
        ["organisation"] = <"Ocean Informatics">
        ["email"] = <"thomas.beale@oceaninformatics.com">
        ["date"] = <"10/04/2014">
    >
    details = <
        ["en"] = <
            language = <[ISO_639-1::en]>
            purpose = <"Pattern archetype for CIMI:CDG">
            keywords = <"Entry", ...>
            copyright = <"© 2014 CIMI">
        >
    >
    lifecycle_state = <"unmanaged">
    other_details = <
        ["model_level"] = <"reference">
    >

definition
    ITEM_GROUP[id1] -- CLINICAL_DATA_GROUP
```

AML

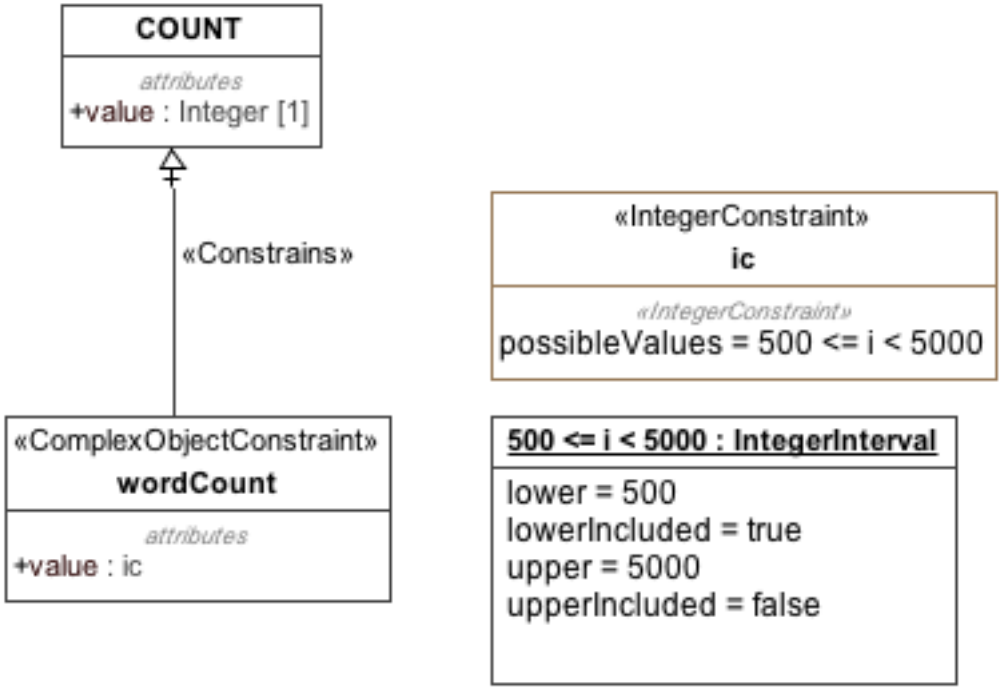

«ArchetypeLibrary»
CIMI-Core
«ReferenceModelImport»
«archetype_rm_closure»
Core
«Archetype»
ITEM_GROUP.clinical_data_group.v1
{archetypeId = CIMI-Core-ITEM_GROUP.clinical_data_group.v1,
archetypeName = "clinical_data_group",
archetypeType = archetype,
constrains = ITEM_GROUP,
isControlled,
isGenerated = false,
originalLanguage = EN,
resourceDocumentSyntax = "ADL 1.5",
version = ITEM_GROUP.clinical_data_group.v1.0.0}
ITEM_GROUP
attributes
+structure_type : CODED_TEXT [0..1]
«ArchetypeVersion»
ITEM_GROUP.clinical_data_group.v1.0.0
{amlVersion = "Alpha0.1",
archetype = ITEM_GROUP.clinical_data_group.v1,
archetypeVersionId = CIMI-Core-ITEM_GROUP.clinical_data_group.v1.0.0,
designation = id1_en,
id = id1,
rmRelease = "2.0.2"}
«Constrains»

CONSTRAINT PROFILE

“Primitive Type” Constraints



“Primitive Type” Example



Constraint Profile

- Root is *ObjectConstraint* – a class with:
  - Exactly one superclass (either reference model class or another *ObjectConstraint*)
  - No additional attributes
    - Can only “subset” or “redefine”

Constraint Types
Object Constraints

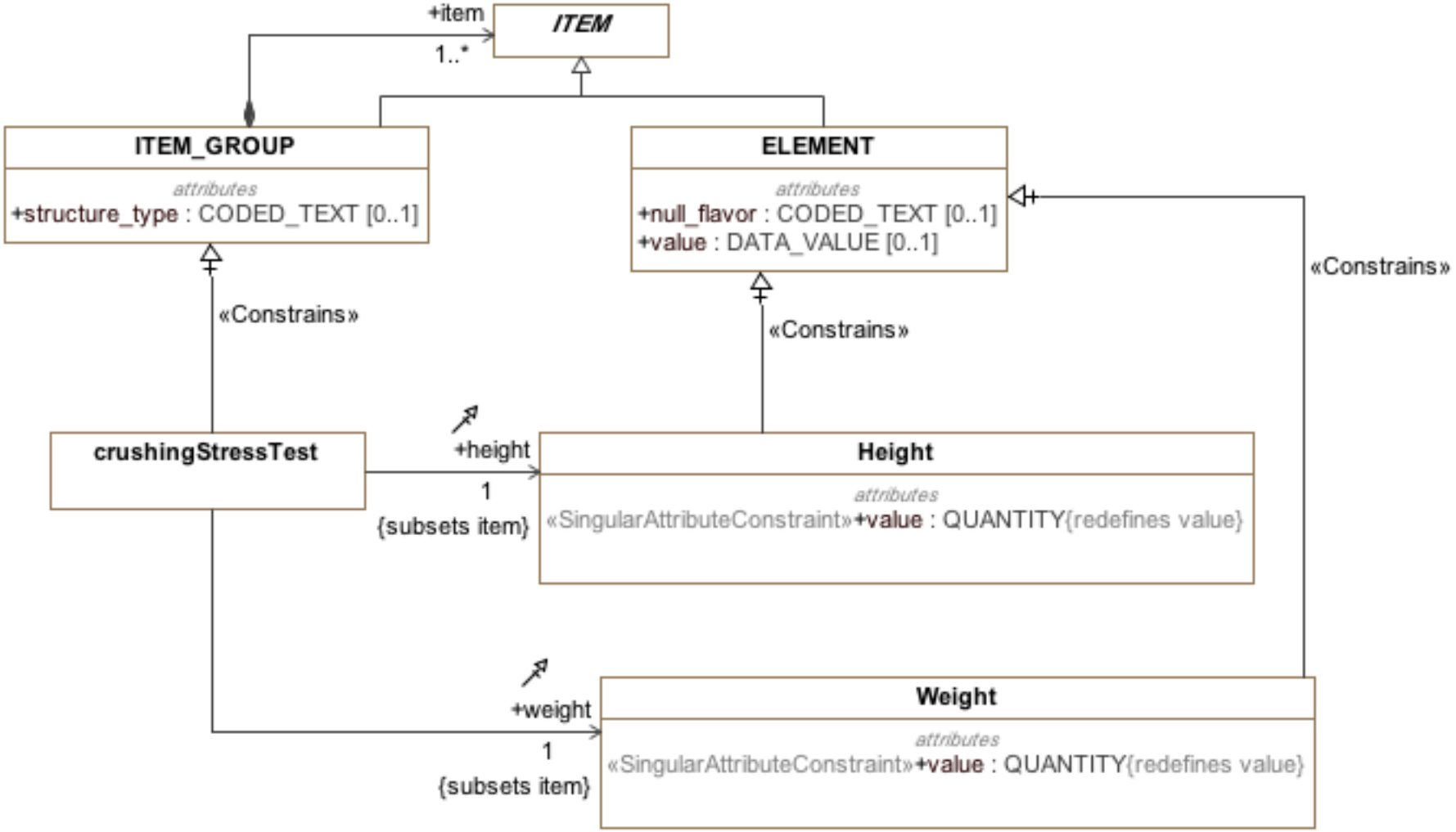
- **ComplexObject**: constrains class properties (i.e. attributes and relationship targets)
- **PrimitiveObject**: constrains ranges, content, sizes, etc. of data types
- **Enumeration**: constrains members of enumerations
- **Slot**: constrains types of 'imported' constraints
- **Proxy**: references to external constraint

Constraint Types
Attribute Constraints

Constraints on UML *properties*

- **SingularAttributeConstraint** ([0..1],[1..1])
  - Alternative
  - Presence (required / prohibited)
- **AttributeCollectionConstraint([x..*])**
  - Cardinality: total # of instances
  - Subsets: n..m instances of type A, n..m of B, etc.

Constraint Example



IDENTIFICATION AND DESIGNATION PROFILE

Identification and Designation

Advised by ISO 11179-3

- IdentifiableItem
  - Namespace + id
- DesignatableItem
  - Language + sign + [description]
- Namespaces
- “meaning” linkage from Class

11179-3 Identification

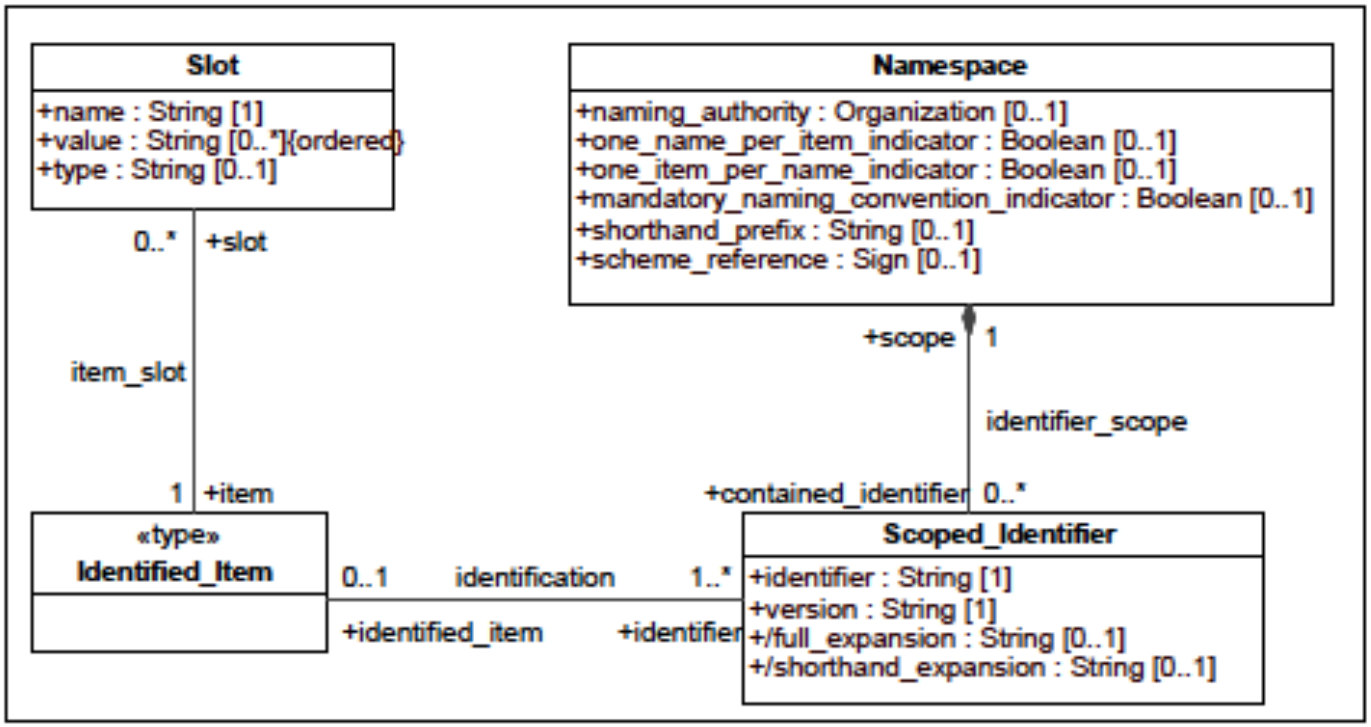


Figure 5 — Identification metamodel region

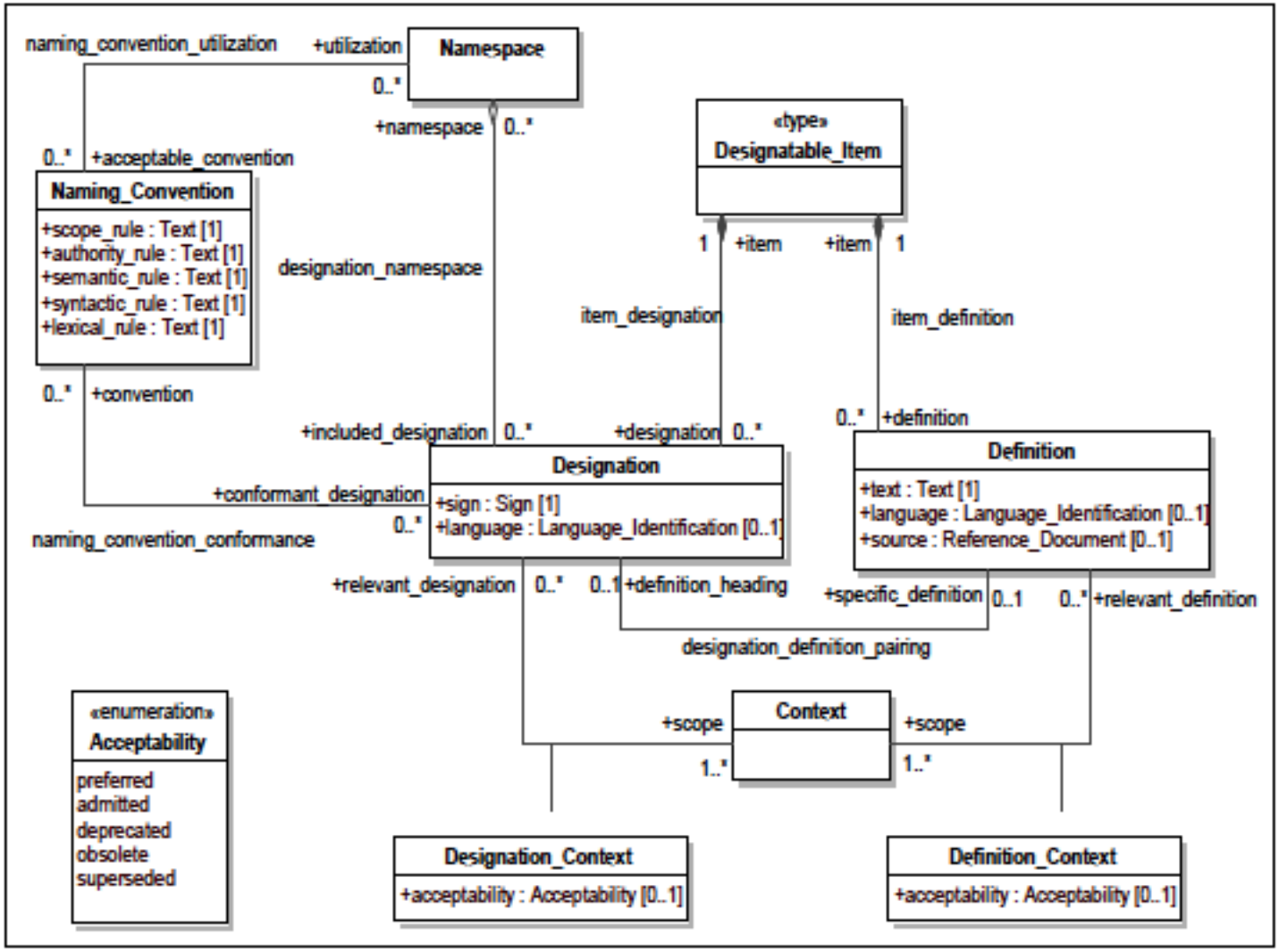
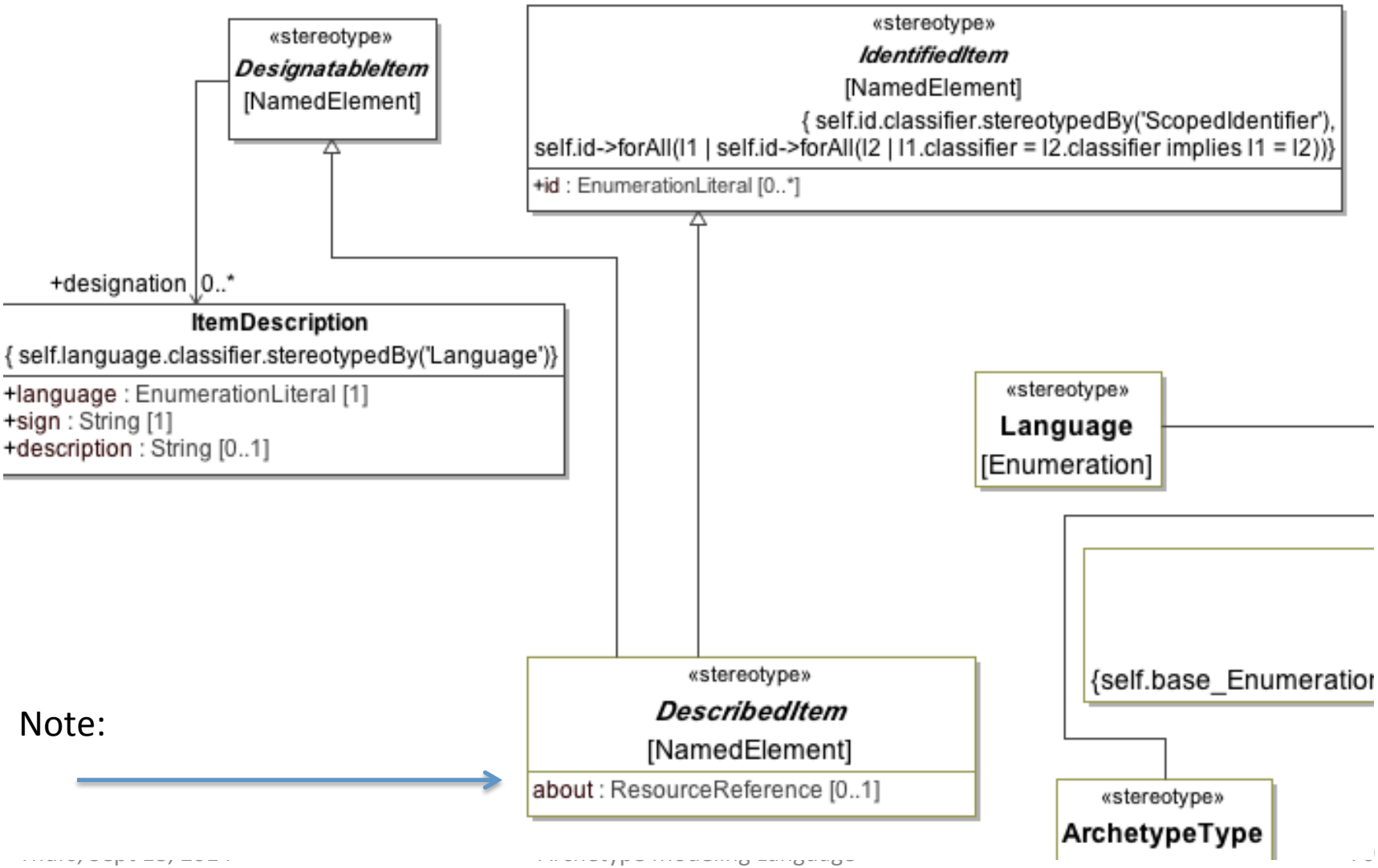
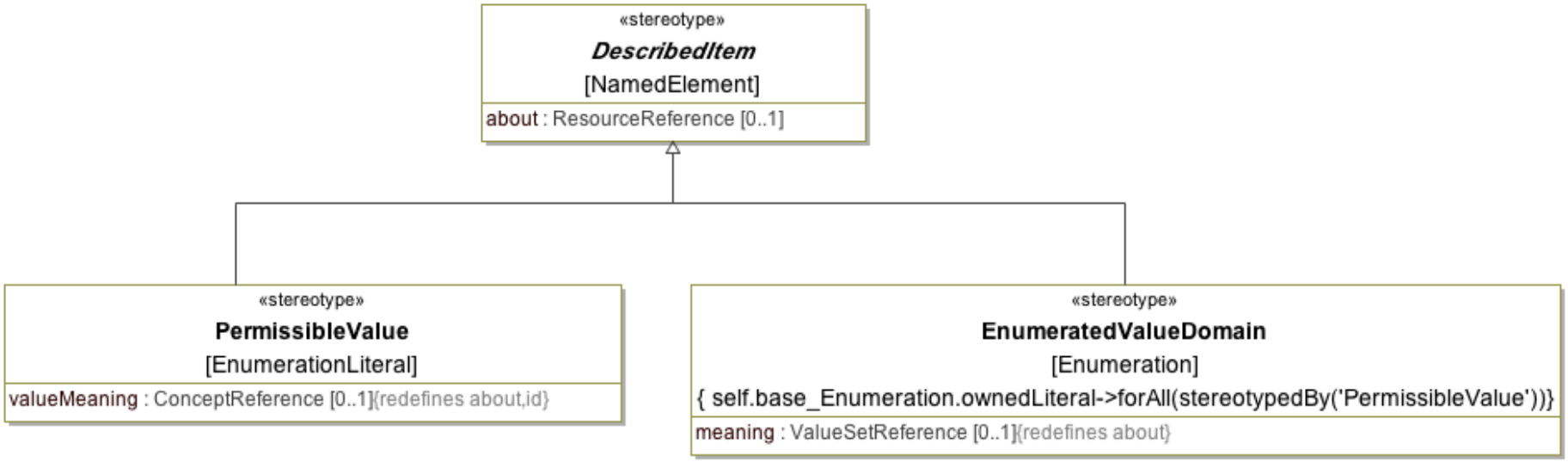


Figure 6 — Designation and Definition metamodel region

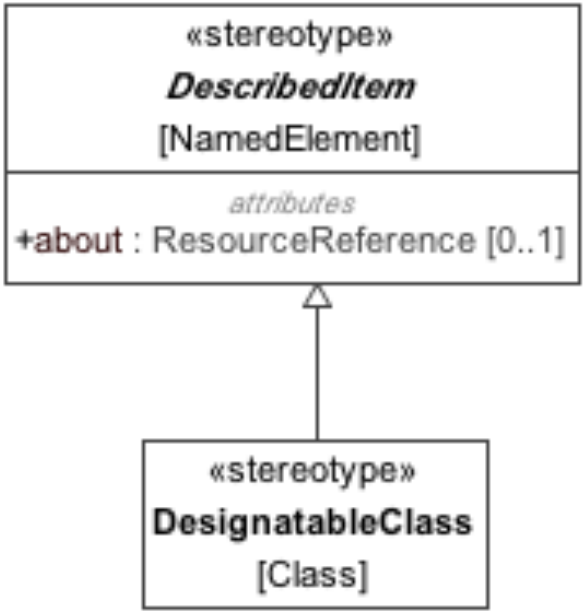
Designatable/Identified/Described



EnumeratedValueDomain and PermissibleValue

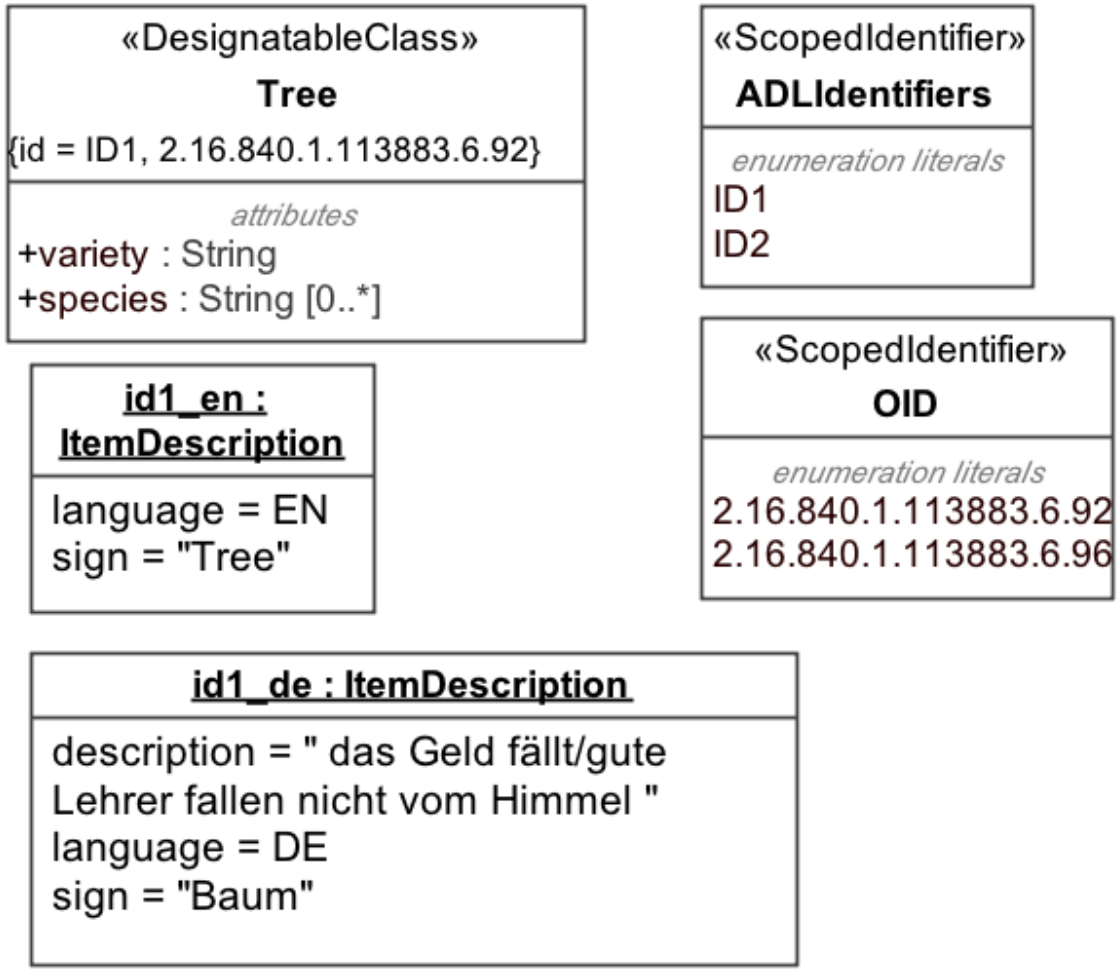


Identification and Designation in Action



Any UML NamedElement can
Be marked as “Described”

Identification and Designation in Action



TERMINOLOGY BINDING PROFILE

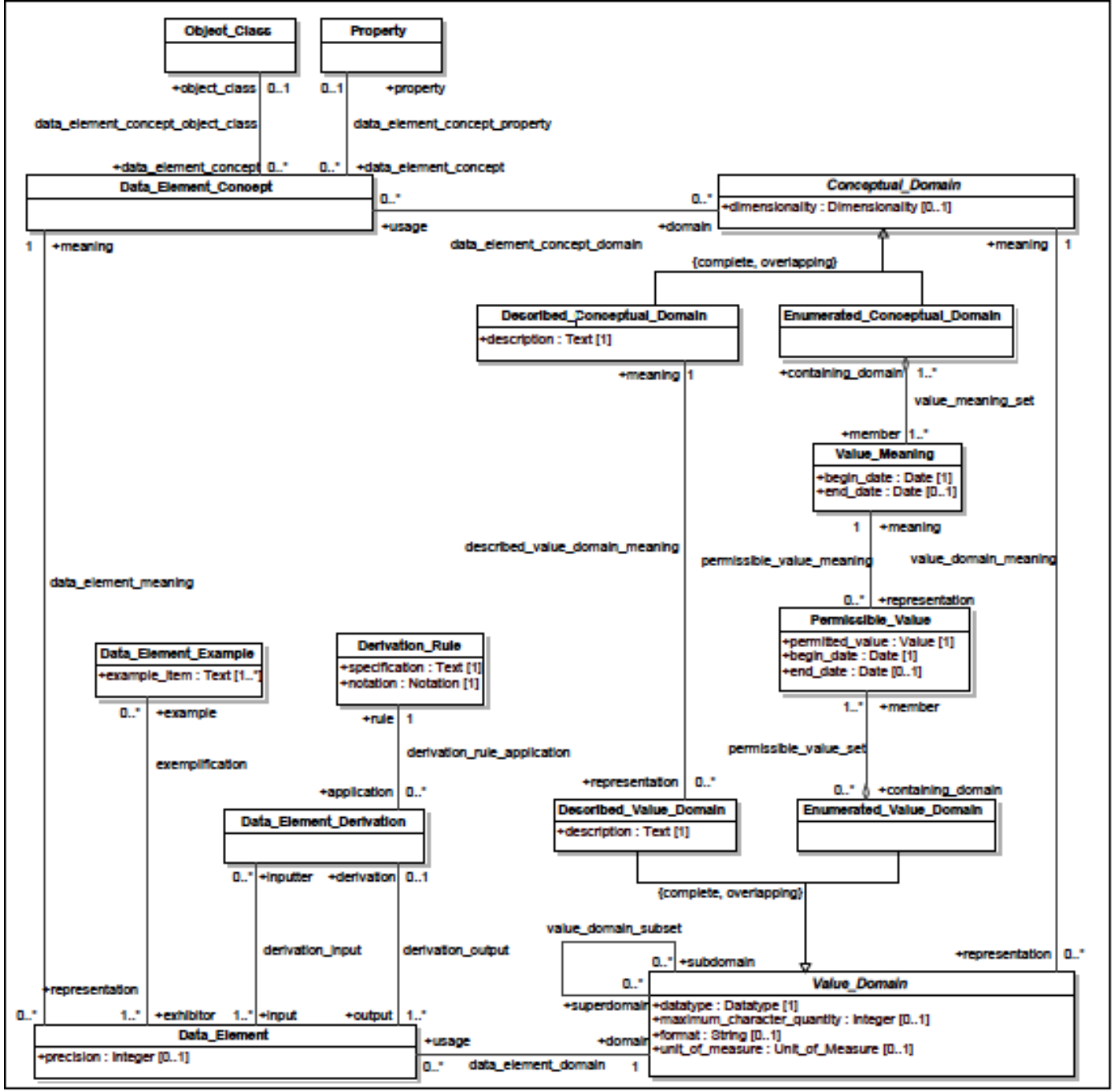
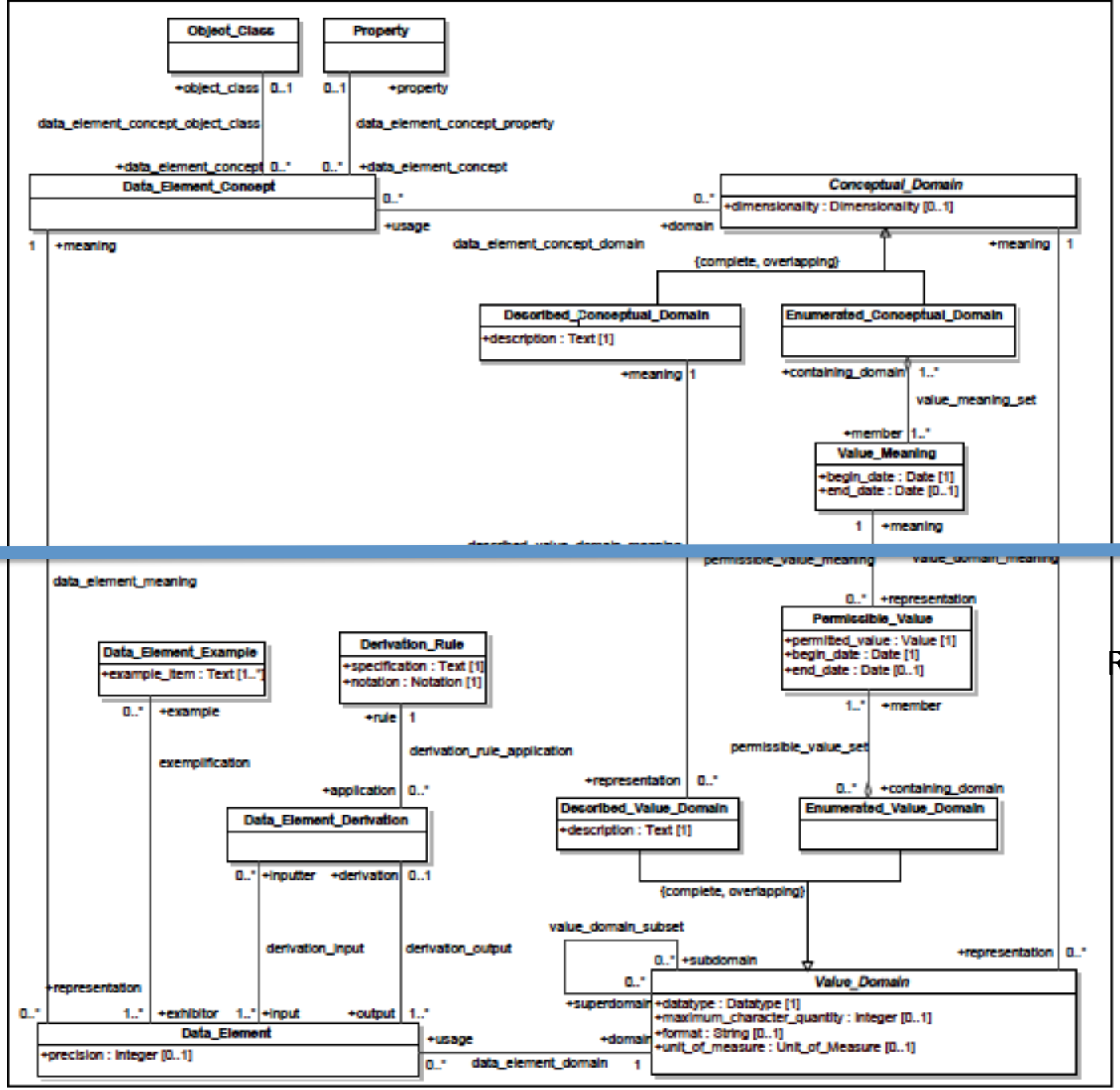


Figure 16 — Consolidated Data Description metamodel



Meaning

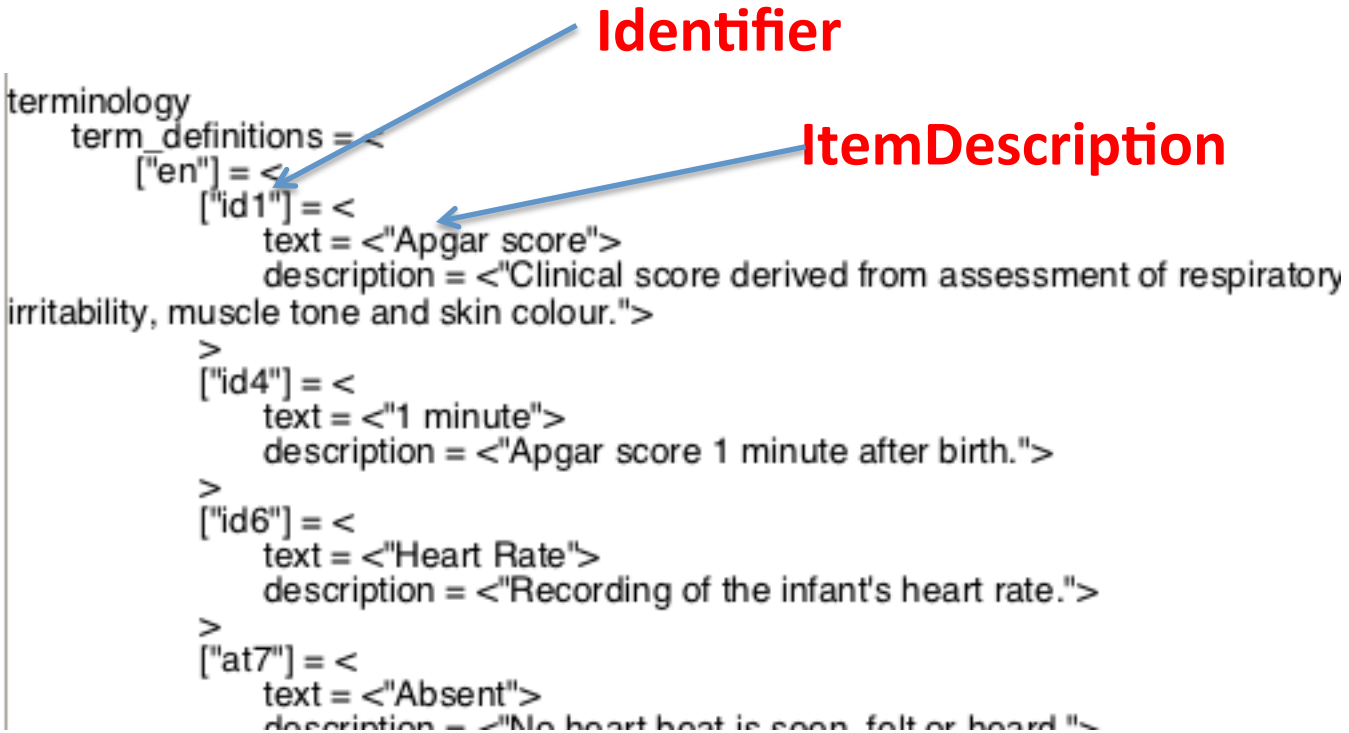
Representation

Figure 16 — Consolidated Data Description metamodel

ADL Terminology

- Term Definitions Section
  - Covered in Identification and Designation
- Term Bindings Section
  - Covered in Identification and Designation *about* item (see note earlier)
- Value Sets Section

ADL Terminology
Term Definitions



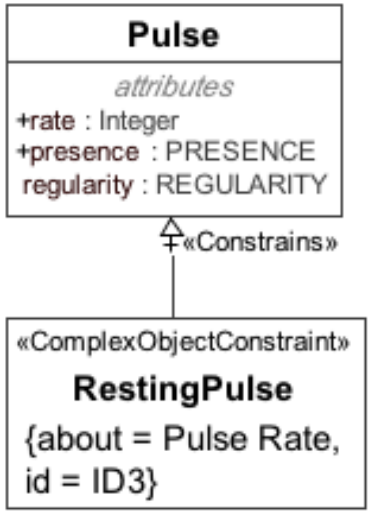
ADL Terminology
Term Bindings

```
term_bindings = <
    ["openehr"] = <
        ["at1046"] = <http://openehr.org/id/382>
        ["at1047"] = <http://openehr.org/id/144>
    >
    ["snomedct"] = <
        ["id3"] = <http://snomed.info/id/78564009>
        ["ac2"] = <http://snomed.info/id/12394009>
        ["ac3"] = <http://snomed.info/id/12394015>
    >
>
value_sets = <
```

ADL Terminology
Term Bindings

```
term_bindings = <
    ["openehr"] = <
        ["at1046"] = <http://openehr.org/id/382>
        ["at1047"] = <http://openehr.org/id/144>
    >
    ["snomedct"] = <
        ["id3"] = <http://snomed.info/id/78564009>
        ["ac2"] = <http://snomed.info/id/12394009>
        ["ac3"] = <http://snomed.info/id/12394015>
    >
>
value_sets = <
```

Term Bindings Example



Pulse Rate : ConceptReference

describingCodeSystem = SNOMED_CT_INTL_20140731
description = 78564009_en
id = 78564009
uri = "http://snomed.info/id/78564009"

20140731 : CodeSystemVersionReference

uri = "http://snomed.info/sct/900000000000207008/version/20140731"

SNOMED_CT_INTL_20140731 : CodeSystemReference

uri = "http://snomed.info/sct/900000000000207008"
version = 20140731

78564009_en : ItemDescription

language = EN
sign = "Pulse Rate"

Value Sets

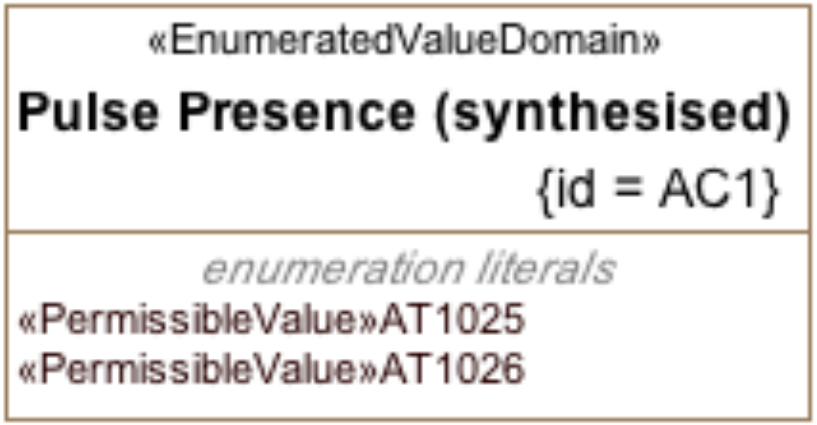
Three Flavors

- Local – Equivalent to UML Enumeration
- External – Reference to Externally Defined Value Set
- Mapped Value Set
  - Local Permissible Values (enumeration)
  - External “value meaning”

ADL Terminology
Local Value Sets

```
term_bindings = <
    ["openehr"] = <
        ["at1046"] = <http://openehr.org/id/382>
        ["at1047"] = <http://openehr.org/id/144>
    >
    ["snomedct"] = <
        ["ac2"] = <http://snomed.info/id/12394009>
        ["ac3"] = <http://snomed.info/id/12394015>
    >
>
value_sets = <
    ["ac1"] = <
        id = <"ac1">
        members = <"at1025", "at1026">
    >
    ["ac3"] = <
        id = <"ac3">
        members = <"at7", "at1029", "at8", "at9">
    >
```

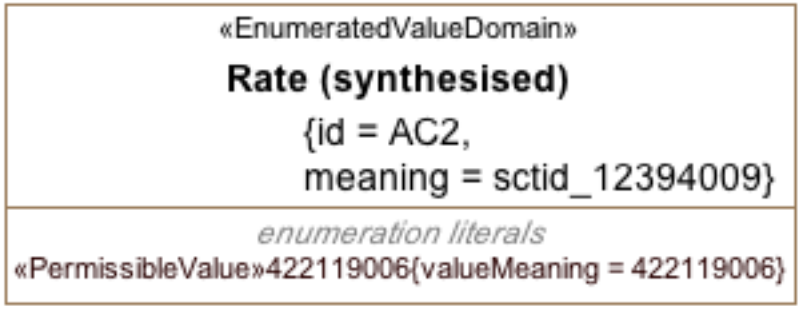
Local Value Set

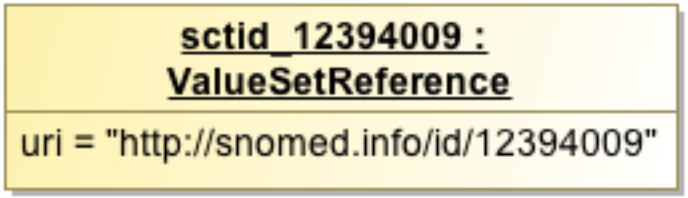


ADL Terminology
External Value Set

```
term_bindings = <
    ["openehr"] = <
        ["at1046"] = <http://openehr.org/id/382>
        ["at1047"] = <http://openehr.org/id/144>
    >
    ["snomedct"] = <
        ["ac2"] = <http://snomed.info/id/12394009>
        ["ac3"] = <http://snomed.info/id/123940015>
    >
>
value_sets = <
    ["ac1"] = <
        id = <"ac1">
        members = <"at1025", "at1026">
    >
    ["ac3"] = <
        id = <"ac3">
        members = <"at7", "at1029", "at8", "at9">
    >
```

External Value Set





ADL Terminology
Mapped Value Set

```
term_bindings = <
    ["openehr"] = <
        ["at1046"] = <http://openehr.org/id/382>
        ["at1047"] = <http://openehr.org/id/144>
    >
    ["snomedct"] = <
        ["ac2"] = <http://snomed.info/id/12394009>
        ["ac3"] = <http://snomed.info/id/12394015>
    >
>
value_sets = <
    ["ac1"] = <
        id = <"ac1">
        members = <"at1025", "at1026">
    >
    ["ac3"] = <
        id = <"ac3">
        members = <"at7", "at1029", "at8", "at9">
    >
```

Mapped Value Set

- What do we use for ‘permissible value’?
  - Local identifier
  - Concept identifier
- How does this evolve?
- More to come when we examine instance data

STATE OF CURRENT SUBMISSION

OMG Process

1) TC issues RFP – requirements document
2) Organizations submit responses
   1) Initial submission – draft responses shown, discussed.
   2) Final submission – (typically) one harmonized response
3) Response(s) are balloted
4) Accepted response becomes a Beta Specification / Finalization Task Force formed
5) FTF report submitted and Beta Specification becomes a final specification.

Members Only

Public

Where we are

1) AML RFP Issued – June 2012
2) LOI Deadline – January 14, 2014
    1) VA, Mayo, SemantX, The Software Revolution, Visumpoint
3) Initial submission – Feb 24, 2014
    1) One joint submission received
4) Submission presented to OMG – March 27, 2014
5) ~~Revised submission – May 19, 2014~~ (*missed*)
   Revised submission – Nov 8, 2014

AML

References

RFP
http://www.omg.org/techprocess/meetings/schedule/AML_RFP.html

Initial Submission
http://www.omg.org/cgi-bin/doc?health/14-02-01

ADL 1.5
https://github.com/openEHR/specifications/blob/master/publishing/architecture/am/adl1.5.pdf

AOM 1.5
https://github.com/openEHR/specifications/blob/master/publishing/architecture/am/aom1.5.pdf

UML 2.5
http://www.omg.org/cgi-bin/doc?ptc/13-09-05.pdf

GIT Repository
https://github.com/opencimi/AML