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Model-to-model Transformation with ATL

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Agenda

- Introduction
  - Model-To-Model transformation in the MDE field
  - M2M vs. M2T
- ATL Overview
  - Available resources: wiki, zoo, newsgroup, use cases, etc.
  - ATL language description
- First exercise: **Ecore-To-UML2.1**
- Architecture
  - Overview
  - The new virtual machine: EMF-VM
- Second exercise: **GMF Diagram Refactoring**
- Third exercise: **Public-To-Private**

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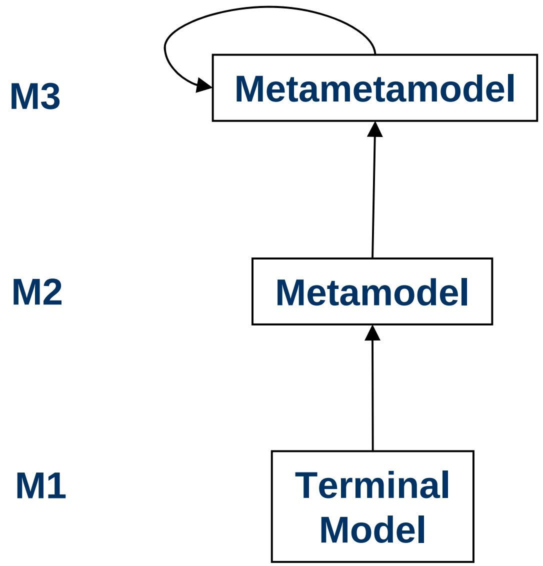
ATL - Description

- ATL : ATLAS Transformation Language
- ATL is a language and a virtual machine dedicated to model transformation
- ATL is an Eclipse Model-to-Model (M2M) component, inside of the Eclipse Modeling Project (EMP)

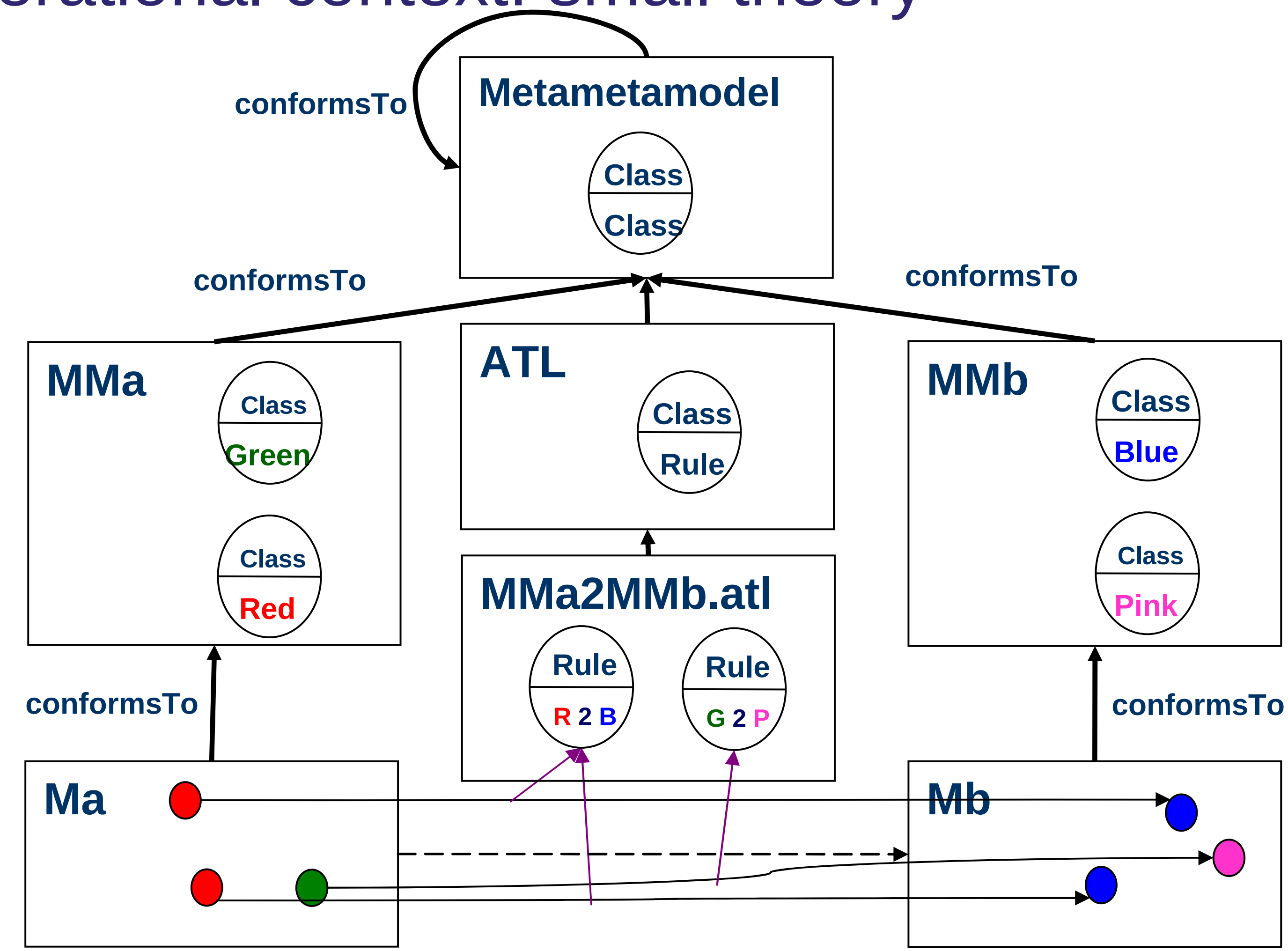
Definitions

- A model transformation is the automatic creation of target models from source models.

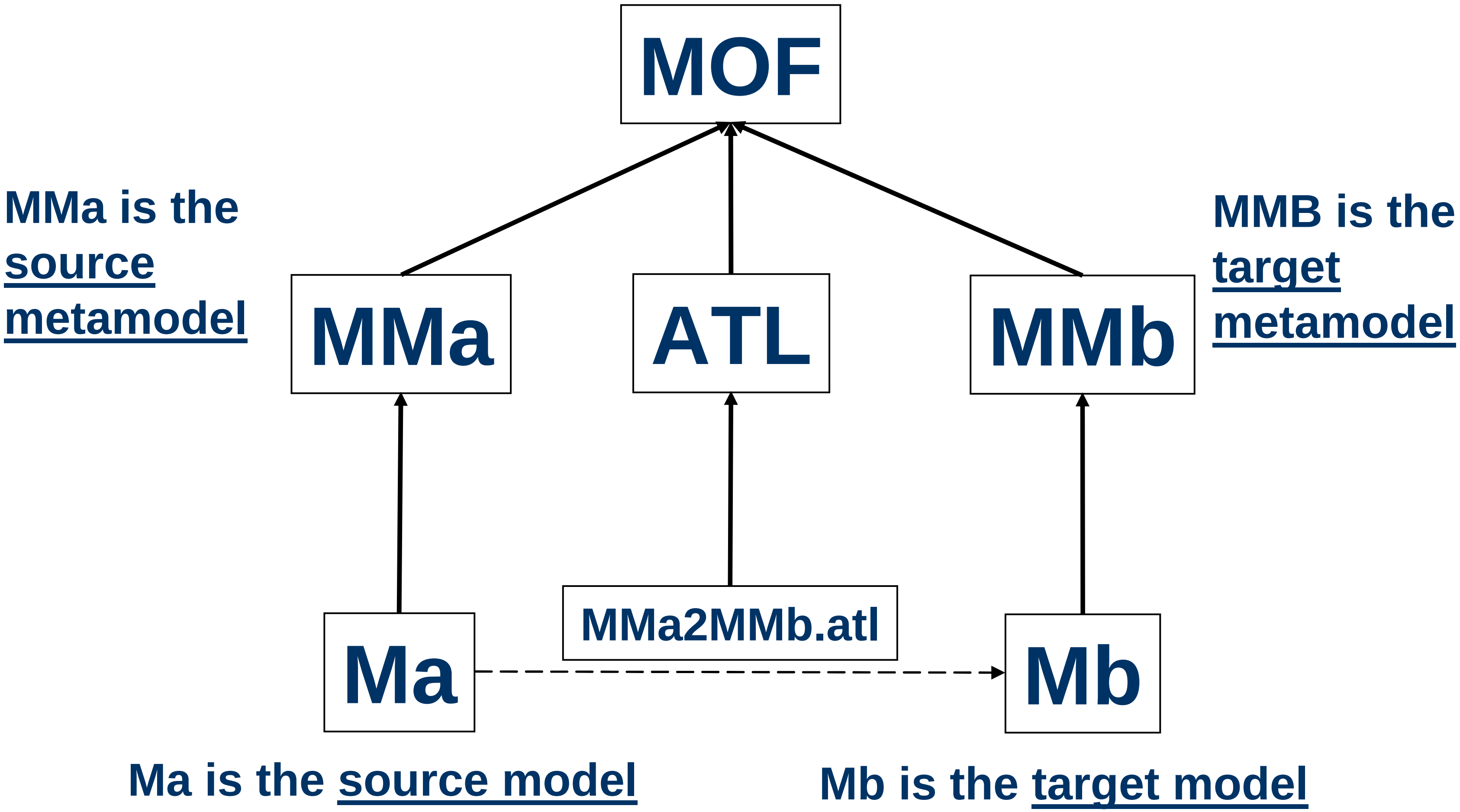
- Model transformation is not only about M1 to M1 transformations:
  - M1 to M2: promotion,
  - M2 to M1: demotion,
  - M3 to M1, M3 to M2, etc.



Operational context: small theory



Operational context of ATL



M2M vs. M2T

- M2M: Model To Model transformation
  - Abstract syntax to abstract syntax
  - Languages: ATL, QVT Operational, QVT Relations
- M2T: Model To Text transformation
  - Abstract syntax to concrete syntax
  - Languages: JET, xPand
- TMF: Textual Modeling Framework
  - Abstract syntax to <u>and</u> from concrete syntax
  - Languages: TCS, xText
- This tutorial is focused on M2M

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ATL history

- ***1990*** : first works on model transformation
- ***1998*** : initial publication for a Ph.D. thesis at the University of Nantes
- ***1998 - 2004*** : Implementation
  - CARROLL/MOTOR project (CEA, Thales, INRIA)
  - Collaborative projects : ModelWare, ModelPlex, OpenEmbeDD
- ***2004*** : Eclipse GMT integration
- ***2006*** : Industrial solution inside of the Eclipse M2M project

ATL community

- Active community
  - Newsgroup: news://news.eclipse.org/eclipse.modeling.m2m
  - Wiki: http://wiki.eclipse.org/ATL
  - Bugzilla
  - Use cases: http://www.eclipse.org/m2m/atl/usecases/
  - Transformations zoo (i.e., a library): http://www.eclipse.org/m2m/atl/atlTransformations/
- Other links :
  - Project page: http://www.eclipse.org/m2m/atl/

ATL transformation zoo

ATL Transformations

There are currently 101 model transformations scenarios in this zoo.

ATL Transformations list

- Ant to Maven: Documentation, Source files
- AssertionModification: Documentation, Source files
- ATL to BindingDebugger: Documentation, Source files
- ATL to Problem: Documentation, Source files
- ATL to Tracer: Documentation, Source files
- BibTeXML to DocBook: Documentation, Source files
- Book to Publication: Documentation, Source files
- CatalogueModelTransformations: Documentation, Source files
- Class to Relational: Documentation, Source files
- Code Clone Tools to SVG: Documentation, Source files
- CPL to SPL: Documentation, Source files
- Disaggregation: Documentation, Source files
- DSL to EMF: Documentation, Source files
- EliminateRedundantInheritance: Documentation, Source files

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★☆☆ **Specification Only** ★★☆ **Partially Implemented** ★★★ **Reaching Completion**

List of use cases

DSLs coordination for Telephony	This work presents a case study of implementing two telephony languages: SPL and CPL. They are partially based on similar vocabularies. However they are very different and have been designed to be used by different people. The use case shows how M2M transformations may be used to map programs conforming to SPL or CPL at different abstraction levels.	★★★
Models Validation through Petri nets	This work presents a use case of model transformation using ATL rules to validate MDD's models. This use case considers a simplified process description language, SimplePDL. It then presents a property-driven approach in which SimplePDL process models are translated into Petri nets. SimplePDL behavioral properties are expressed on corresponding Petri nets in LTL (*Linear Temporal Logic*). The Tina toolkit and, in particular, its model-checker, are used to validate process models by checking the expressed properties. This use case has been done by **Benoit Combemale** (**IRIT**). This is a collaboration between **IRIT** and **LAAS** labs in Toulouse, France.	★★★
Sharing Rules Between OCL/UML and SWRL/OWL	This work presents an implementation of sharing rules between two rule languages from different domains: OCL (Object Constraint Language) together with UML and SWRL (Semantic Web Rule Language) together with OWL. For this integration we used the R2ML (REWERSE I1 Rule Markup Language) metamodel as pivotal metamodel. The R2ML is a general Web rule markup language and it can represent different rule types: integrity, reaction, derivation and production. This work has been done by **Milan Milanovic** in collaboration between the **GOOD OLD AI Laboratory** at **University of Belgrade**, **School of Interactive Arts and Technology** at **Simon Fraser University Surrey** in Canada and **Chair of Internet Technology** at **Brandenburg University of Technology at Cottbus** in Germany.	★★★

ATL overview

- Source models and target models are distinct:
  - Source models are read-only (they can only be navigated, not modified),
  - Target models are write-only (they cannot be navigated).
- The language is a declarative-imperative hybrid:
  - Declarative part:
    - Matched rules with automatic traceability support,
    - Side-effect free navigation (and query) language: OCL 2.0
  - Imperative part:
    - Called rules,
    - Action blocks.
- Recommended programming style: declarative

ATL overview (continued)

- A declarative rule specifies:
  - a source pattern to be matched in the source models,
  - a target pattern to be created in the target models for each match during rule application.
- An imperative rule is basically a procedure:
  - It is called by its name,
  - It may take arguments,
  - It can contain:
    - A declarative target pattern,
    - An action block (i.e. a sequence of statements),
    - Both.

ATL overview (continued)

- Applying a declarative rule means:
  - Creating the specified target elements,
  - Initializing the properties of the newly created elements.
- There are three types of declarative rules:
  - Standard rules that are applied once for each match,
    - A given set of elements may only be matched by one standard rule,
  - Lazy rules that are applied as many times for each match as it is referred to from other rules (possibly never for some matches),
  - Unique lazy rules that are applied at most once for each match and only if it is referred to from other rules.

Declarative rules: source pattern

- The source pattern is composed of:
  - A labeled set of types coming from the source metamodels,
  - A guard (Boolean expression) used to filter matches.
- A match corresponds to a set of elements coming from the source models that:
  - Are of the types specified in the source pattern (one element for each type),
  - Satisfy the guard.

Declarative rules: target pattern

- The target pattern is composed of:
  - A labeled set of types coming from the target metamodels,
  - For each element of this set, a set of bindings.
  - A binding specifies the initialization of a property of a target element using an expression.
- For each match, the target pattern is applied:
  - Elements are created in the target models (one for each type of the target pattern),
  - Target elements are initialized by executing the bindings:
    - First evaluating their value,
    - Then assigning this value to the corresponding property.

Execution order of declarative rules

- Declarative ATL frees the developer from specifying execution order:
  - The order in which rules are matched and applied is not specified.
    - Remark: the match of a lazy or unique lazy rules must be referred to before the rule is applied.
  - The order in which bindings are applied is not specified.
- The execution of declarative rules can however be kept deterministic:
  - The execution of a rule cannot change source models
    - ➔ It cannot change a match,
  - Target elements are not navigable
    - ➔ The execution of a binding cannot change the value of another.

Example: Class to Relational - Overview

- The source metamodel *Class* is a simplification of class diagrams.
- The target metamodel *Relational* is a simplification of the relational model.

➔ ATL declaration of the transformation:

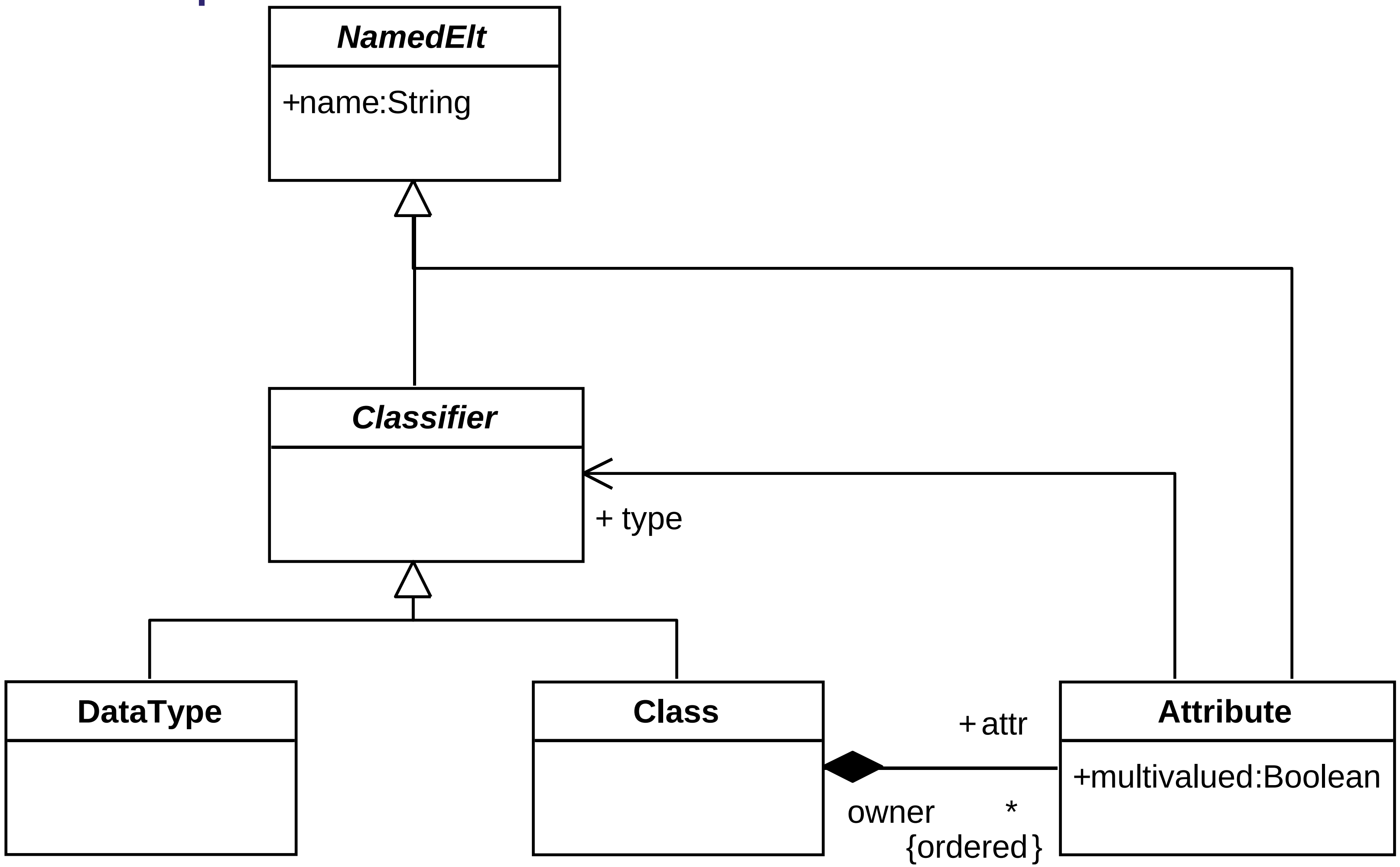
module Class2Relational;

create Mout : Relational **from** Min : Class;

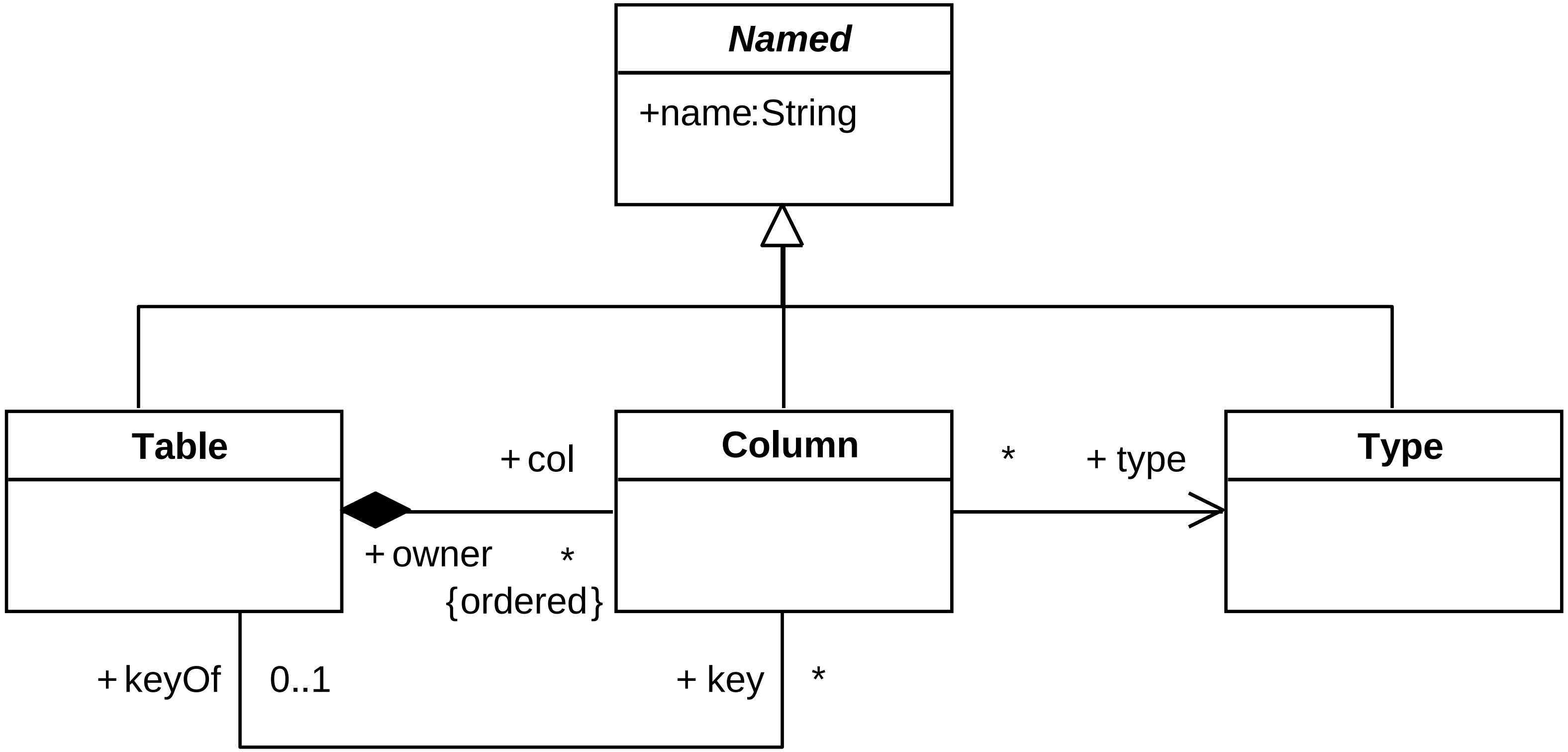
- The transformation excerpts used in this presentation come from:

http://www.eclipse.org/m2m/atl/atlTransformations/#Class2Relational

Example: Class to Relational - Source Metamodel



Example: Class to Relational – Target Metamodel



Example: Class to Relational, overview

- Informal description of rules
  - Class2Table:
    - A table is created from each class,
    - The columns of the table correspond to the single-valued attributes of the class,
    - A column corresponding to the key of the table is created.
  - SingleValuedAttribute2Column:
    - A column is created from each single-valued attribute.
  - MultiValuedAttribute2Column:
    - A table with two columns is created from each multi-valued attribute,
    - One column refers to the key of the table created from the owner class of the attribute,
    - The second column contains the value of the attribute.

Example: Class to Relational - Rule Class2Table (1 Of 4)

- For each Class, create a Table :

```
rule Class2Table {
    from                    -- source pattern
        c : Class!Class
    to                      -- target pattern
        t : Relational!Table
}
```

Example: Class to Relational - Rule Class2Table (2 Of 4)

- The name of the Table is the name of the Class:

```
rule Class2Table {
    from
        c : Class!Class
    to
        t : Relational!Table (
            name <- c.name      -- a simple binding
        )
}
```

Example: Class to Relational - Rule Class2Table (3 Of 4)

- The columns of the table correspond to the single-valued attributes of the class:

```
rule Class2Table {
   from
      c : Class!Class
   to
      t : Relational!Table (
         name <- c.name,
         col <- c.attr->select(e |             -- a binding
                  not e.multiValued            -- using
   complex                     )                  --
   navigation
   )
}
```

- Remark: attributes are automatically resolved into columns by automatic traceability support.

Example: Class to Relational - Rule Class2Table (4 Of 4)

- Each Table owns a key containing a unique identifier:

```
rule Class2Table {
    from
        c : Class!Class
    to
        t : Relational!Table (
            name <- c.name,
            col <- c.attr->select(e | not e.multiValued
            )->union(Sequence {key}),
            key <- Set {key}
        ),
        key : Relational!Column (     -- another target
            name <- 'Id'              -- pattern element
        )                             -- for the key
}
```

Example: Class to Relational - Rule SingleValuedAttribute2Column

- For each single-valued Attribute create a Column:

```
rule SingleValuedAttribute2Column {
    from  -- the guard is used for selection
       a : Class!Attribute (not a.multiValued)
    to
       c : Relational!Column (
            name <- a.name
       )
}
```

Example: Class to Relational - Rule MultiValuedAttribute2Column

- For each multi-valued Attribute create a Table, which contains two columns:
  - The identifier of the table created from the class owner of the Attribute
  - The value.

```
rule MultiValuedAttribute2Column {
  from
      a : Class!Attribute (a.multiValued)
  to
      t : Relational!Table (
            name <- a.owner.name + '_' + a.name,
            col <- Sequence {id, value}
      ),
      id : Relational!Column (
            name <- 'Id'
      ),
      value : Relational!Column (
            name <- a.name
      )
}
```

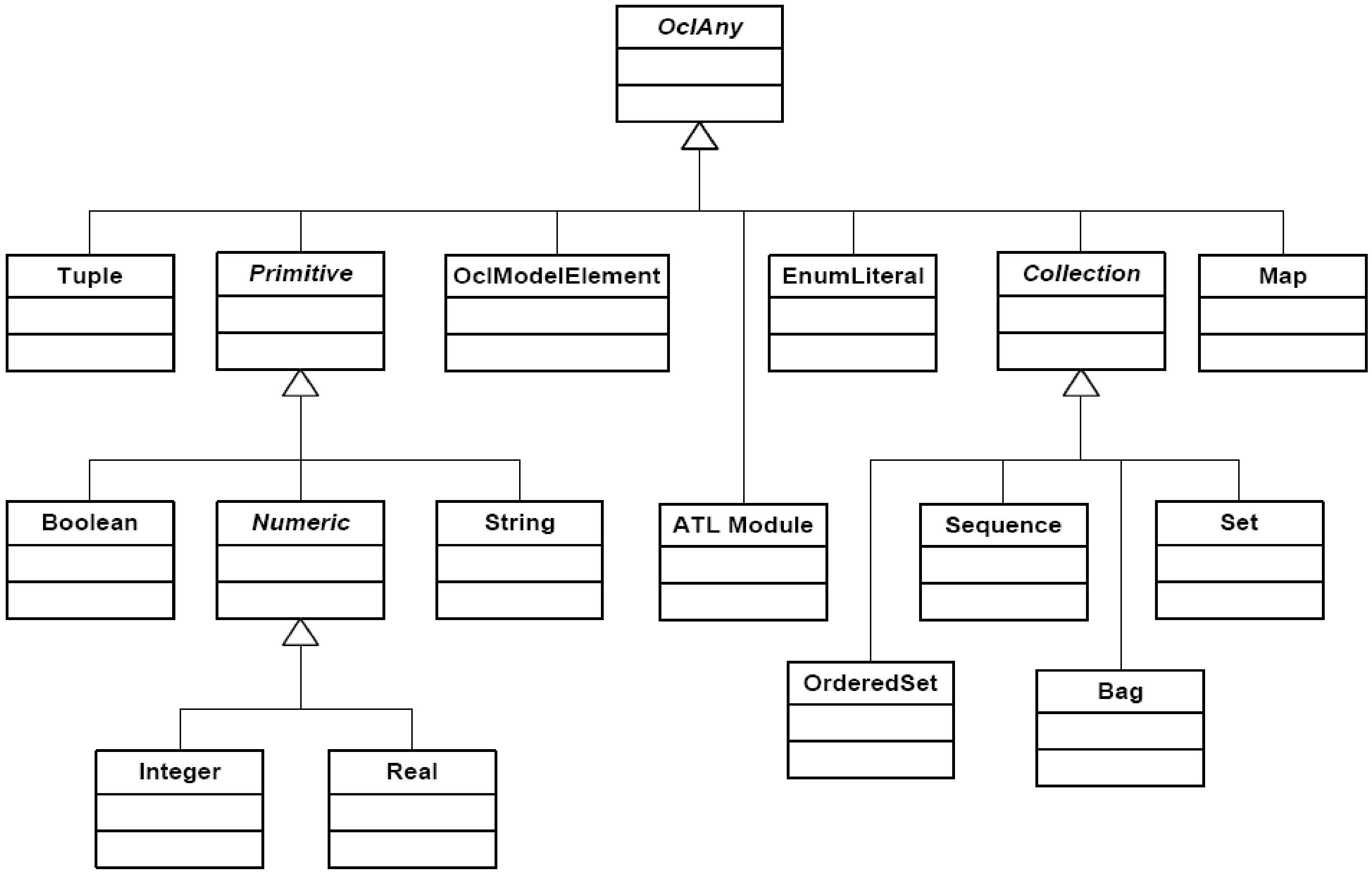
Object Constraint Language (OCL)

- Originally intended to express constraints over UML models, for instance:

  context Person inv: self.age > 0
- Extended to query any model
- Used in several transformation languages (e.g., ATL, QVT) to compute values from the source models
- Specification:
  - The version on which ATL is based is available from:

    http://www.omg.org/docs/ptc/03-10-14.pdf
  - Section 7: language overview
  - Section 11: standard library
    - Section 11.8: iterator expressions

ATL types hierarchy



Other ATL features: rule inheritance

- Rule inheritance, to help structure transformations and reuse rules and patterns:
  - A child rule matches a subset of what its parent rule matches,
    - ➔ All the bindings of the parent still make sense for the child,
  - A child rule specializes target elements of its parent rule:
    - Initialization of existing elements may be improved or changed,
    - New elements may be created,
  - Syntax:

```
abstract rule R1 {
  -- ...
}
rule R2 extends R1 {
  -- ...
}
```

Copy class inheritance without rule inheritance

```
-- Source metamodel: MMA
class A1 { attribute v1 : String; }
class A2 extends A1 {
    attribute v2 : String;
}
```

```
-- Target metamodel: MMB
class B1 { attribute v1 : String; }
class B2 extends B1 {
    attribute v2 : String;
}
```

```
module MMAtoMMB;
create OUT : MMB from IN : MMA;
rule A1toB1 {
  from
    s : MMA!A1
  to
    t : MMB!B1 (
      v1 <- s.v1
    )
}
```

```
rule A2toB2 {
  from
    s : MMA!A2
  to
    t : MMB!B2 (
      v1 <- s.v1,
      v2 <- s.v2
    )
}
```

Copy class inheritance with rule inheritance

```
-- Source metamodel: MMA
class A1 { attribute v1 : String; }
class A2 extends A1 {
   attribute v2 : String;
}
```

```
-- Target metamodel: MMB
class B1 { attribute v1 : String; }
class B2 extends B1 {
   attribute v2 : String;
}
```

```
module MMAtoMMB;
create OUT : MMB from IN : MMA;
rule A1toB1 {
  from
    s : MMA!A1
  to
    t : MMB!B1 (
      v1 <- s.v1
    )
}
```

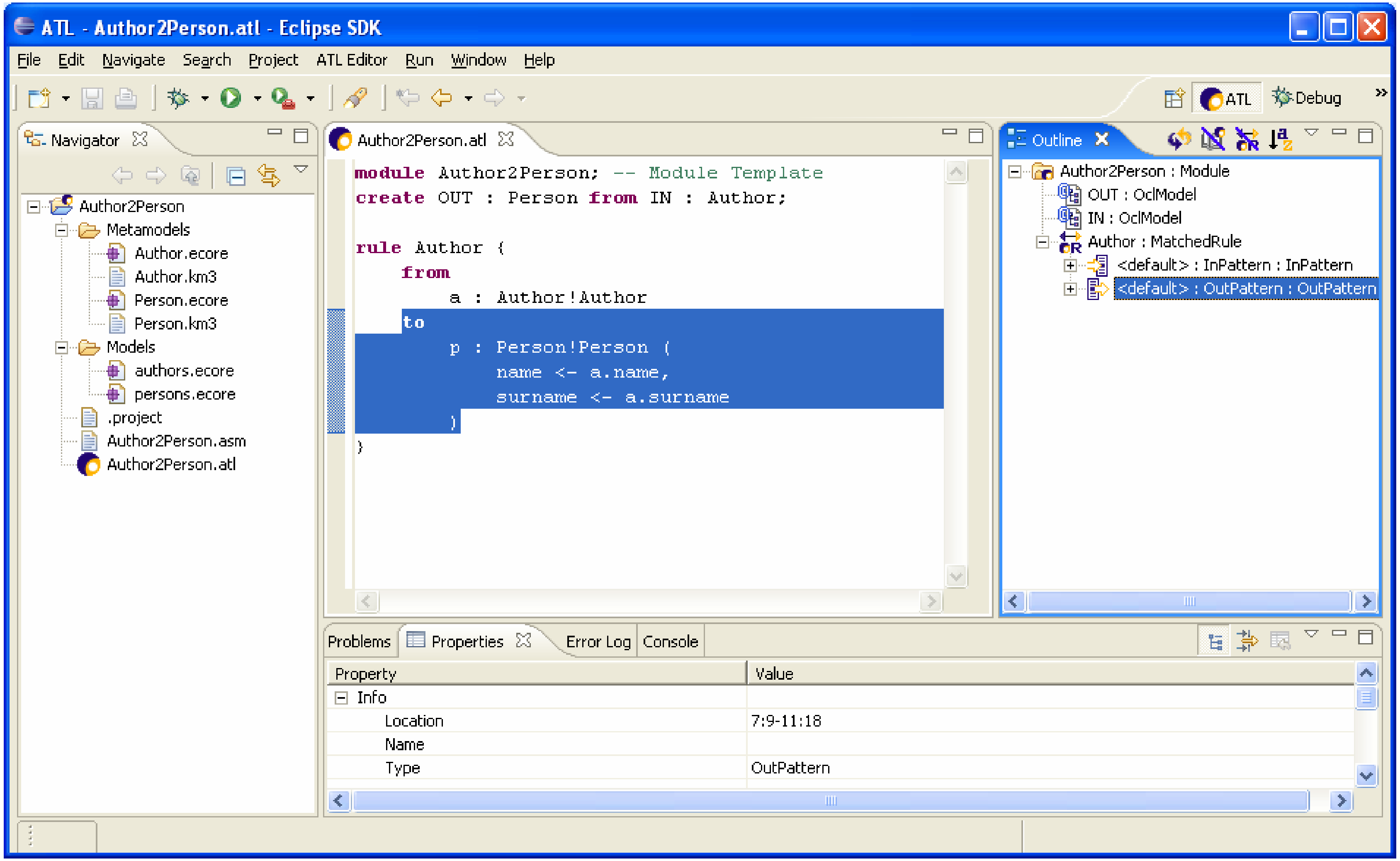
```
rule A2toB2 extends A1toB1 {
  from
    s : MMA!A2
  to
    t : MMB!B2 (
      v2 <- s.v2
    )
}
```

Other ATL features: refining mode

- Refining mode for transformations that need to modify only a small part of a model:
  - Since source models are read-only target models must be created from scratch,
  - This can be done by writing copy rules for each elements that are not transformed,
    - ➔ This is not very elegant,
  - In refining mode, the ATL engine automatically copies unmatched elements.
- The developer only specifies what changes.
- ATL semantics is respected: source models are still read-only.
  - ➔ An (optimized) engine may modify source models in-place but only commit the changes in the end.
- Syntax: replace **`from`** by **`refining`**

```
module A2A; create OUT : MMA refining IN : MMA;
```

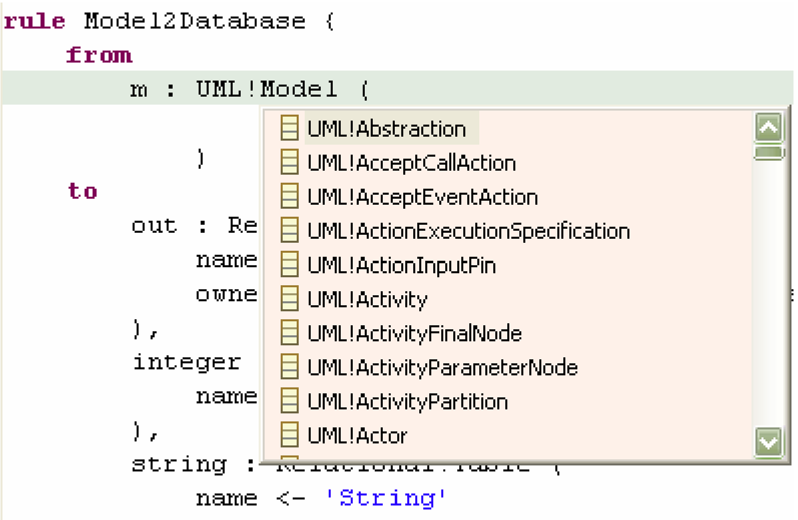
ATL editor

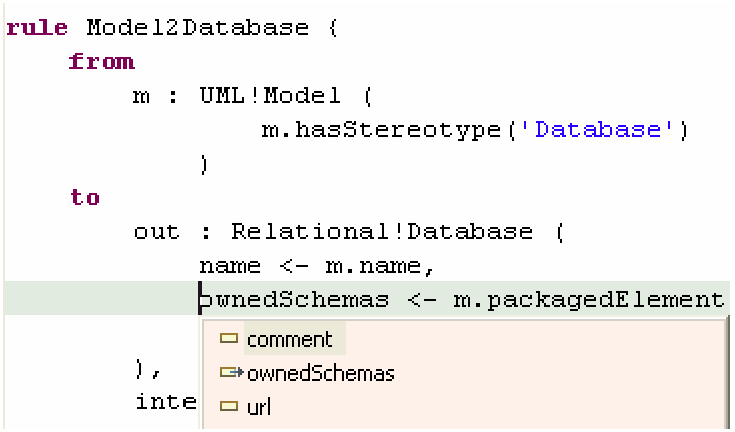


ATL - Author2Person.atl - Eclipse SDK
File Edit Navigate Search Project ATL Editor Run Window Help
ATL
Debug
Navigator
Author2Person
Metamodels
Author.ecore
Author.km3
Person.ecore
Person.km3
Models
authors.ecore
persons.ecore
.project
Author2Person.asm
Author2Person.atl
module Author2Person; -- Module Template
create OUT : Person from IN : Author;
rule Author {
from
a : Author!Author
to
p : Person!Person (
name <- a.name,
surname <- a.surname
)
}
Outline
Author2Person : Module
OUT : OclModel
IN : OclModel
Author : MatchedRule
<default> : InPattern : InPattern
<default> : OutPattern : OutPattern
Problems
Properties
Error Log
Console
Property
Value
Info
Location
7:9-11:18
Name
Type
OutPattern

ATL content assist

- ADT (ATL Development Tools) has recently been improved with basic content assist
  - Type completion
  - Left-side bindings completion
  - Basic code templates





Launching ATL using ANT

```
<project name="Families2Persons" default="main">
     <property name="input" value="sample-Families.ecore"/>
     <property name="output" value="sample-Persons.ecore"/>

     <target name="main" depends="loadModels">

          <am3.loadModel modelHandler="EMF"
               name="myFamilies" metamodel="Families"
               path="${input}"/>

          <am3.atl path="Families2Persons.atl">
           <inmodel name="Families" model="Families"/>
           <inmodel name="IN" model="myFamilies"/>
           <inmodel name="Persons" model="Persons"/>
           <outmodel name="OUT" model="myPersons" metamodel="Persons"/>
          </am3.atl>

          <am3.saveModel model="myPersons" path="${output}"/>

     </target>

     <target name="loadModels">
          <am3.loadModel modelHandler="EMF"
               name="Families" metamodel="%EMF"
               path="Families.ecore"/>
          <am3.loadModel modelHandler="EMF"
               name="Persons" metamodel="%EMF"
               path="Persons.ecore" />
     </target>
</project>
```

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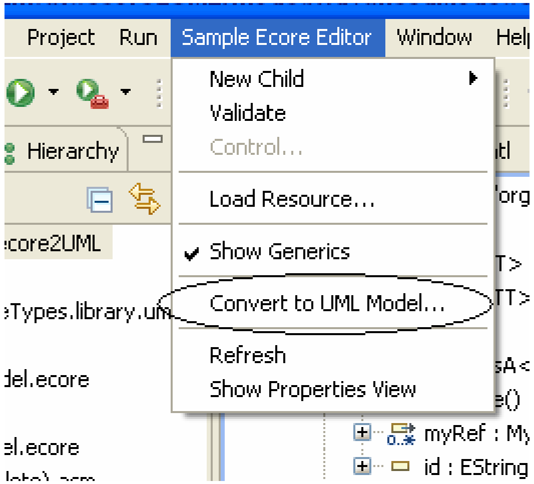
First exercise: Ecore-To-UML2.1

- In Java
  - Already implemented by eclipse UML2 API.
  - Ecore2UMLConverter.java
    - ~2330 code lines



- In ATL
  - Ecore2UML.atl
    - ~230 code lines

First exercise: Quick overview

- **Java**

```
public Object caseETypedElement(ETypedElement eTypedElement) {
        Object element =
    eModelElementToElementMap.get(eTypedElement);
        if (element != null) {
            if (element instanceof TypedElement) {
            ((TypedElement) element).setType(getType(eTypedElement));
        }
        …
        return element;
}
public Object caseEAttribute(EAttribute eAttribute) {
        EClass eContainingClass = eAttribute.getEContainingClass();
        if (eContainingClass != null) {
        Property property = UMLFactory.eINSTANCE.createProperty();
            eModelElementToElementMap.put(eAttribute, property);
            Classifier classifier = (Classifier)
            doSwitch(eContainingClass);
            getOwnedAttributes(classifier).add(property);
            property.setName(eAttribute.getName());
            property.setIsReadOnly(!eAttribute.isChangeable());
            property.setIsDerived(eAttribute.isDerived());
            property.setVisibility(VisibilityKind.PUBLIC_LITERAL);

            caseETypedElement(eAttribute);

            defaultCase(eAttribute);

            return property;
        }
        return super.caseEAttribute(eAttribute);
}
```

- **ATL**

```
abstract rule ETypedElement2TypedElement{
        from
                et: Ecore!ETypedElement
        to
                f: UML!TypedElement(
                        name<-et.name,
                        type<-thisModule.getMappingType(et),
                        lower<-et.lowerBound,
                        upper<-et.upperBound
                )
}
rule EAttribute2Property  extends

        ETypedElement2TypedElement {
        from
                et: Ecore!EAttribute
        to
                f: UML!Property(
                        isReadOnly<- not et.changeable,
                        isDerived<- et.derived
                )
}
```

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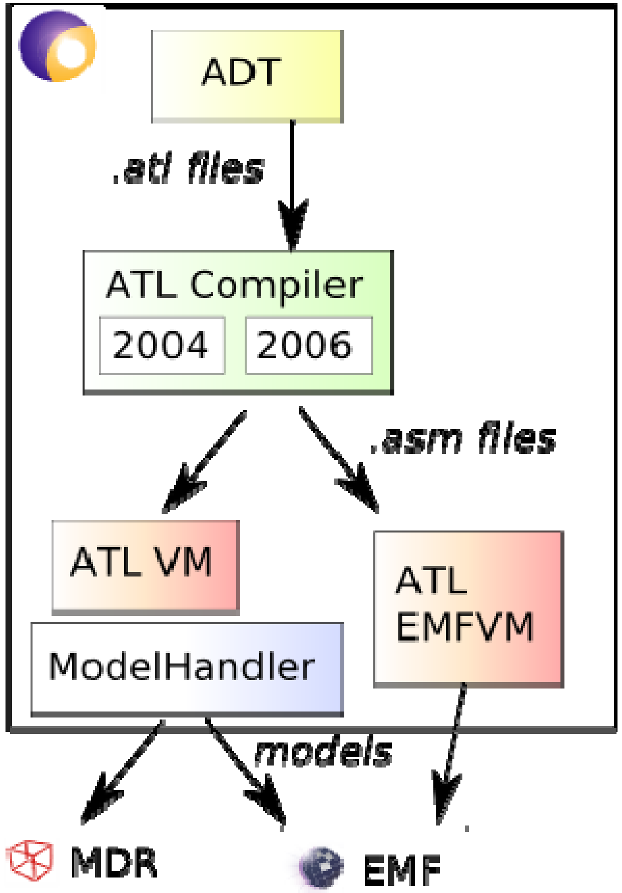
ATL main plugins organization

- ATL Developement Tools → **Eclipse ui integration**
  - org.eclipse.m2m.atl.adt.builder
  - org.eclipse.m2m.atl.adt.debug
  - org.eclipse.m2m.atl.adt.editor
  - org.eclipse.m2m.atl.adt.perspective
  - org.eclipse.m2m.atl.adt.wizard
- ATL Engine → **ATL core**
  - org.antlr.runtime 3.0.0
  - org.eclipse.m2m.atl.compilers.atl2006
  - org.eclipse.m2m.atl.engine
- ATL VM → **ATL Regular VM (with drivers)**
  - org.eclipse.m2m.atl.drivers.emf4atl
  - org.eclipse.m2m.atl.drivers.mdr4atl
  - org.eclipse.m2m.atl.drivers.uml24atl
  - org.eclipse.m2m.atl.engine.vm
- ATL EMFVM → **New ATL VM EMF-dedicated**
  - org.eclipse.m2m.atl.engine.emfvm

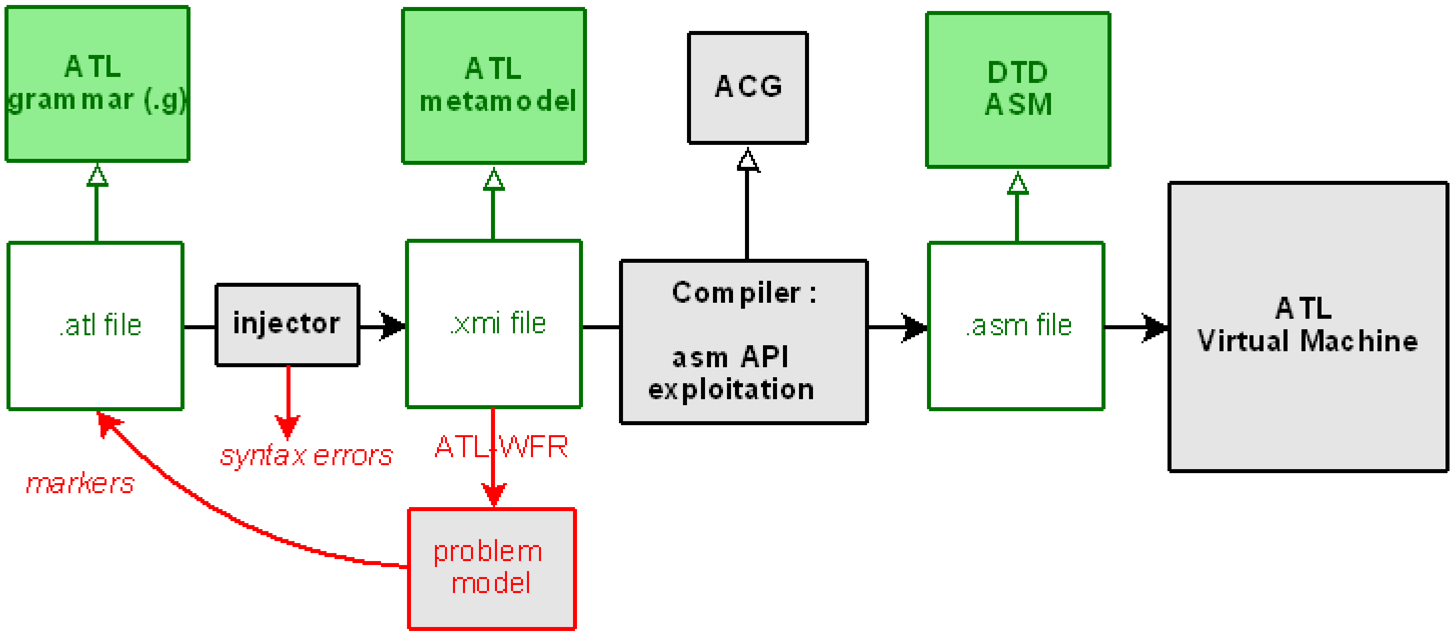
ATL architecture

- Intermediate file format : ASM
- Modular VM dedicated to M2M support
  - A complete specification describes the VM (http://www.eclipse.org/m2m/atl/doc/)
  - Can be implemented on different platforms (Java, .Net)



ATL execution process

- 2 steps
  - Compilation
  - Execution



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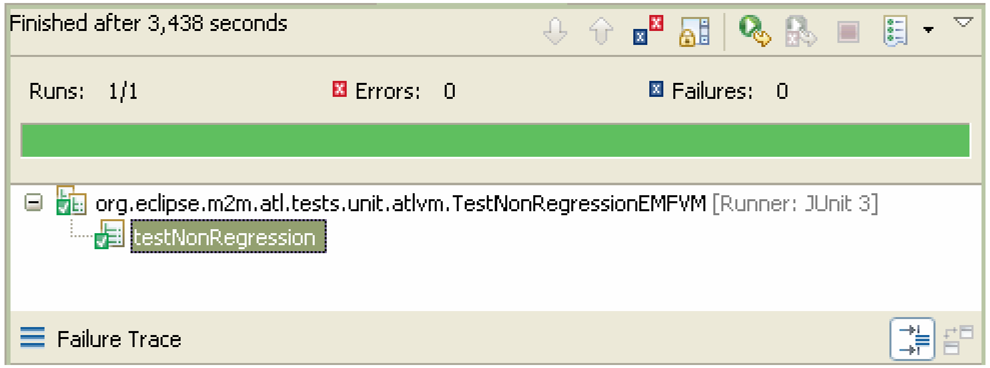
EMF-VM

- A new ATL Virtual Machine is now available
  - Increased performance
  - EMF-only (no wrapping of EObjects)
- At this time...
  - Some missing features (decreasing in number quickly)
  - No UML profile support
- Non-regression evaluated with a new test plugin



Non regression wiki page

Test case	Status	Time		Comments
		emfvm	Regular VM	
Trace2PerformanceMetrics	PASS	0.015s.	0.0s.	
BibTeX2DocBook	PASS	0.031s.	0.047s.	
FlattenTest	PASS	0.047s.	0.032s.	Collections implementation completed on 12/12/2007.
XML2Book	PASS	0.0s.	0.016s.	
Families2Persons	PASS	0.0s.	0.0s.	
Ecore2Class	PASS	0.0s.	0.016s.	
DSL2KM3	PASS	0.032s.	0.031s.	
Book2Publication	PASS	0.016s.	0.015s.	
Class2Relational	PASS	0.0s.	0.0s.	
UML2Relational	FAIL		0.046s.	Unsupported model elements containing "::".
DSL2XML	PASS	0.094s.	0.156s.	
AssertionModification	PASS	0.078s.	0.063s.	
XML2DSLModel	PASS	0.938s.	10.203s.	
XML2Ant	PASS	0.25s.	2.063s.	
DSLModel2KM2	PASS	0.016s.	0.031s.	
Ant2Maven	PASS	0.015s.	0.031s.	
KM32DSL	PASS	0.032s.	0.031s.	
Maven2XML	PASS	0.031s.	0.047s.	
ATL2Problem	PASS	0.046s.	0.078s.	EnumLiteral support added on 25/01/2008.
XML2DSL	PASS	0.078s.	0.453s.	
SpreadsheetMLSimplified2Trace	FAIL		0.015s.	Transformation fails without errors.

EMF-VM Benchmarks

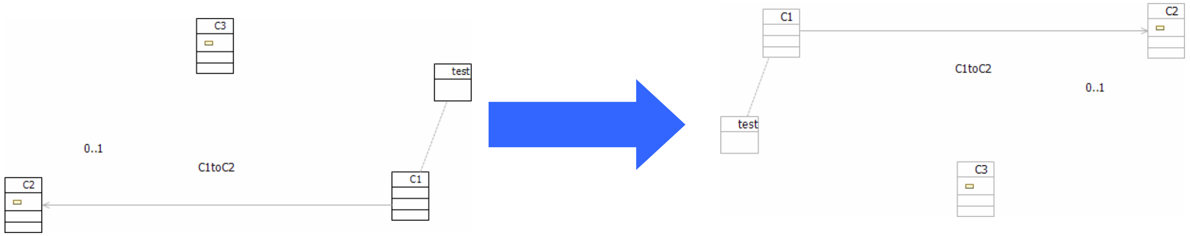
Benchmarks	ATL	
	Regular VM	emfvm
RSM to TOPCASED	v0: 45 min	v0: 75 s
	v1: ? min	v1: 45 s
UML2 API to Platform Ontologies	v0: 92 min 37 sec	v0: 29 min 53 sec
	v1: ?min	v1: ?min

Agenda

- **Introduction**
  - **Model-To-Model transformation in the MDE field**
  - **M2M vs. M2T**
- **ATL Overview**
  - **Available resources: wiki, zoo, newsgroup, use cases, etc.**
  - **ATL language description**
- **First exercise: Ecore-To-UML2.1**
- **Architecture**
  - **Overview**
  - **The new virtual machine: EMF-VM**
- **Second exercise: GMF Diagram Refactoring**
- Third exercise: **Public-To-Private**

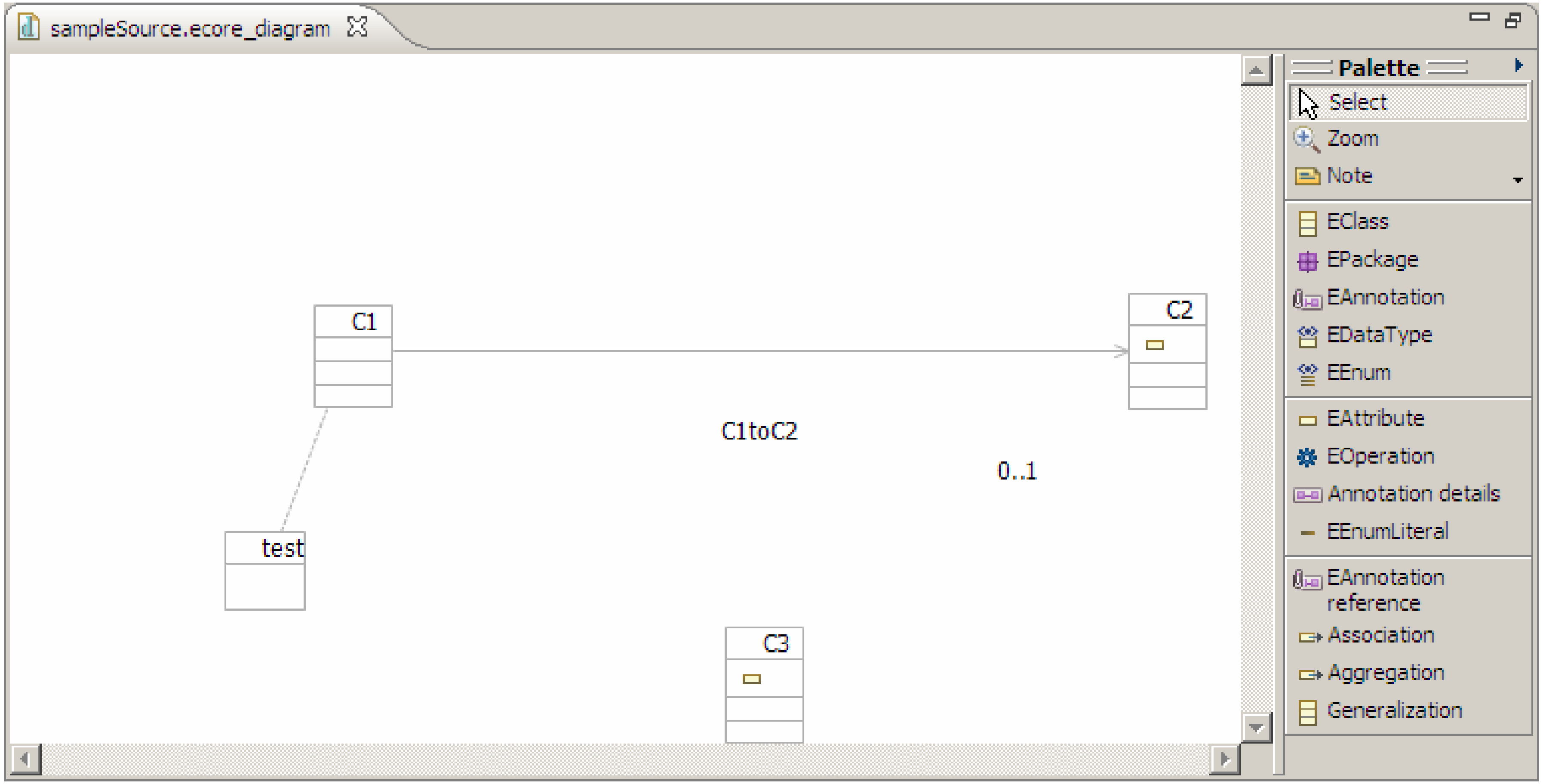
Second Exercise: GMF Diagram Refactoring

- Context:
  - GMF (Graphical Modeling Framework) enables graphical concrete syntaxes for models
  - Graphical properties (e.g., position, size, color) are stored in a separate *Notation* model, for instance:
    - default.uml conforming to the *UML* metamodel
    - default.umlclass_diagram conforming the *Notation* metamodel
- Objective:
  - Mirroring a *Notation* model horizontally and vertically

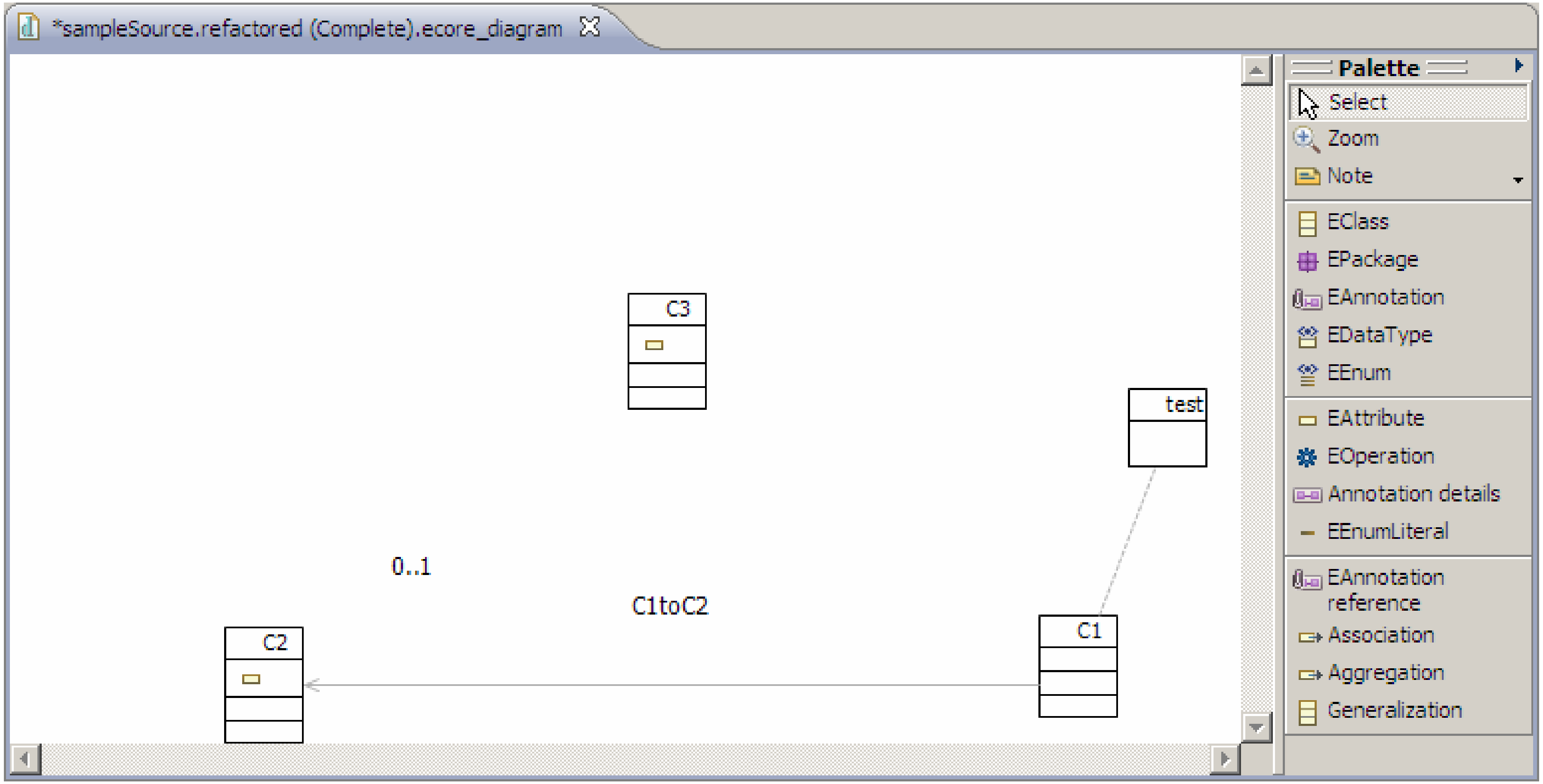


- Approach:
  - Using an ATL transformation from *Notation* to *Notation*

GMF Diagram Refactoring: Sample Source



GMF Diagram Refactoring: Sample Target



GMF Diagram Refactoring

- Possible extensions:
  - Bendpoints for edges
  - Styles (e.g., so that lines appear in the same shade of gray)
  - Other kinds of refactorings

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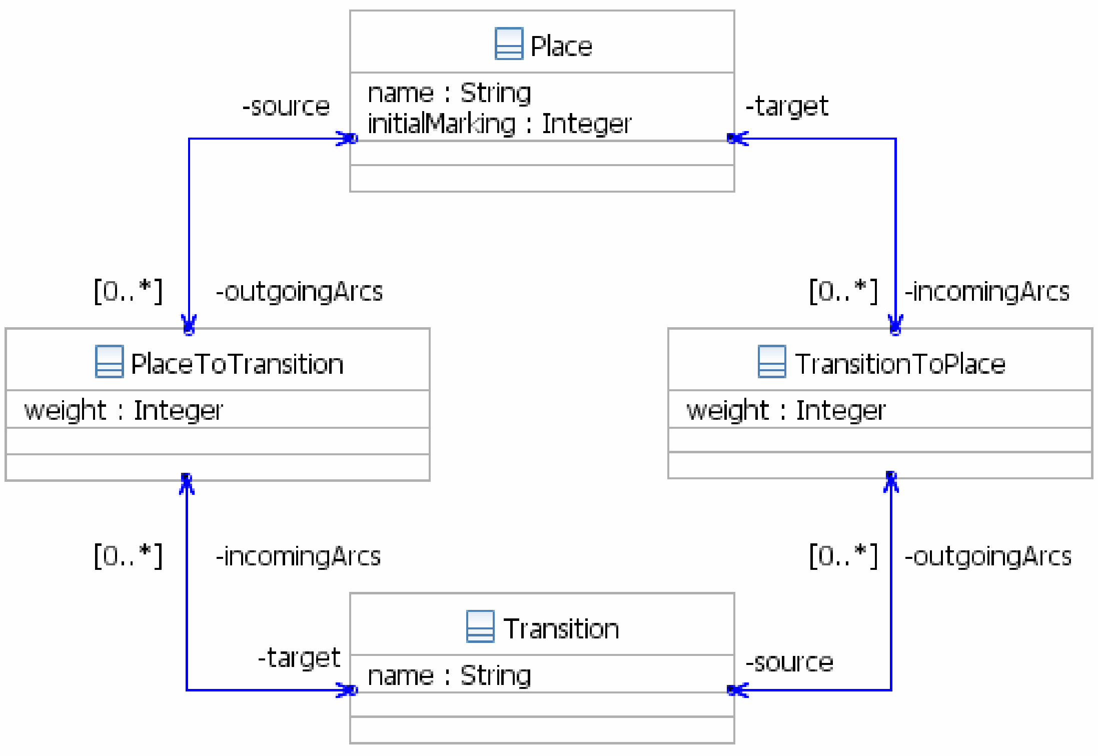
Third exercise : Public To Private

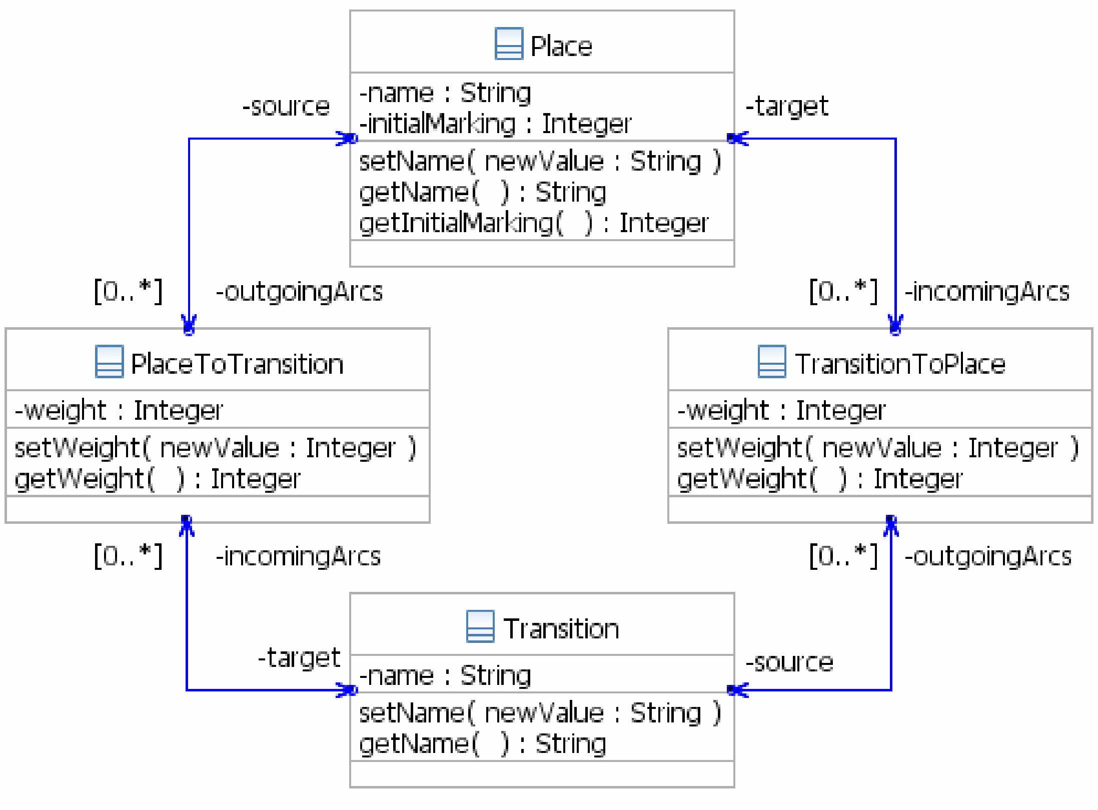
- Context
  - Simplified Java metamodel: classes, fields, methods
  - Sample Java model: PetriNet
- Objective
  - Convert public fields into:
    - Private fields
    - A getter method
    - A setter method (if the attribute is changeable, i.e. non-final)
- Sample
  - A classic PetriNet model encoded using the simplified Java metamodel

Input model (with public fields)



 |

Output model (privatized)



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- Questions or Comments?