Engenharia de Domínio

Mestrado em Engenharia Informática

PL 8

Model to Text Transformations

Exercise 4: Generating Java Source Code

Alexandre Bragança, Isabel Azevedo
atb@isep.ipp.pt, ifp@isep.ipp.pt

Dep. de Engenharia Informática – ISEP

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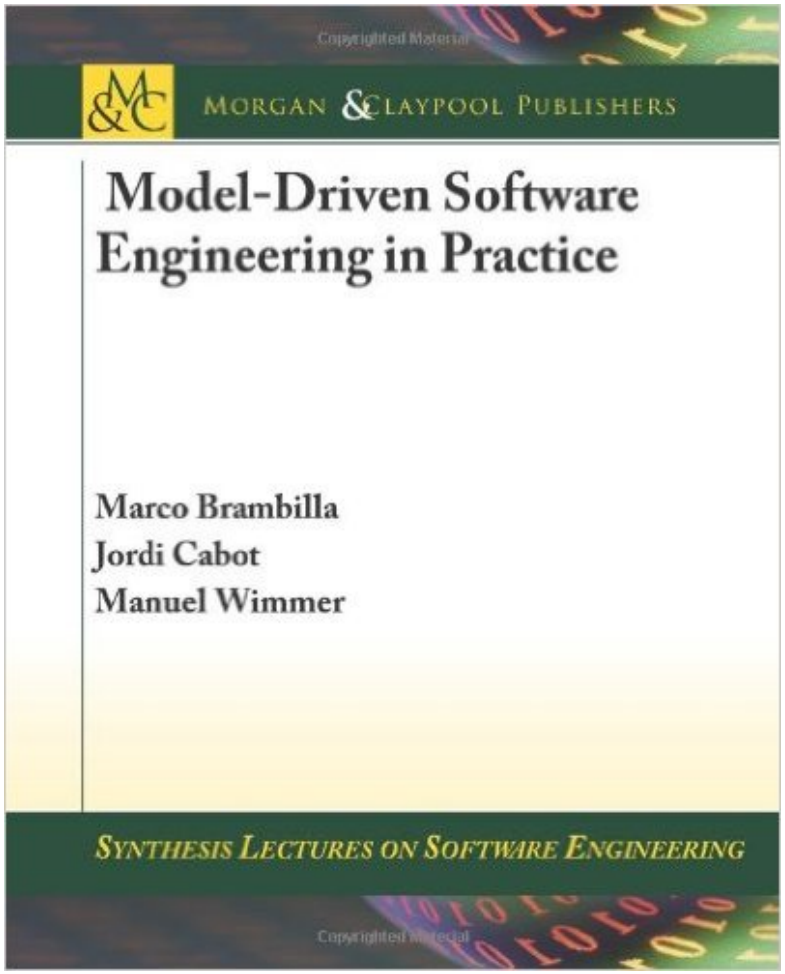
Acknowledgement



This lecture is mainly based on the contents of the following book (chapter 8):

"Model-Driven Software Engineering in Practice", Brambilla, Marco; Cabot, Jordi; Wimmer, Morgan & Claypool Publishers, 2012

but also on chapter 6 of [4].

Outline

- Model-to-Text Transformations
- Acceleo
- Setup of the Acceleo Tools
- Exercise 4

Model-to-Text transformations

- Model-to-Text (**M2T**) transformations imply the **derivation of text from models**.
- Model-to-Text transformations have been used for automating several software engineering tasks such as **code-generation** (code representing the system to develop derived from the models, but also other forms of code such as test cases, deployment scripts, etc.), but also **generation of documentation** and task lists, among others. [2].

Model-to-Text transformation - example

Ecore-based metamodel and the generated Java code (shown as UML Class Diagram):

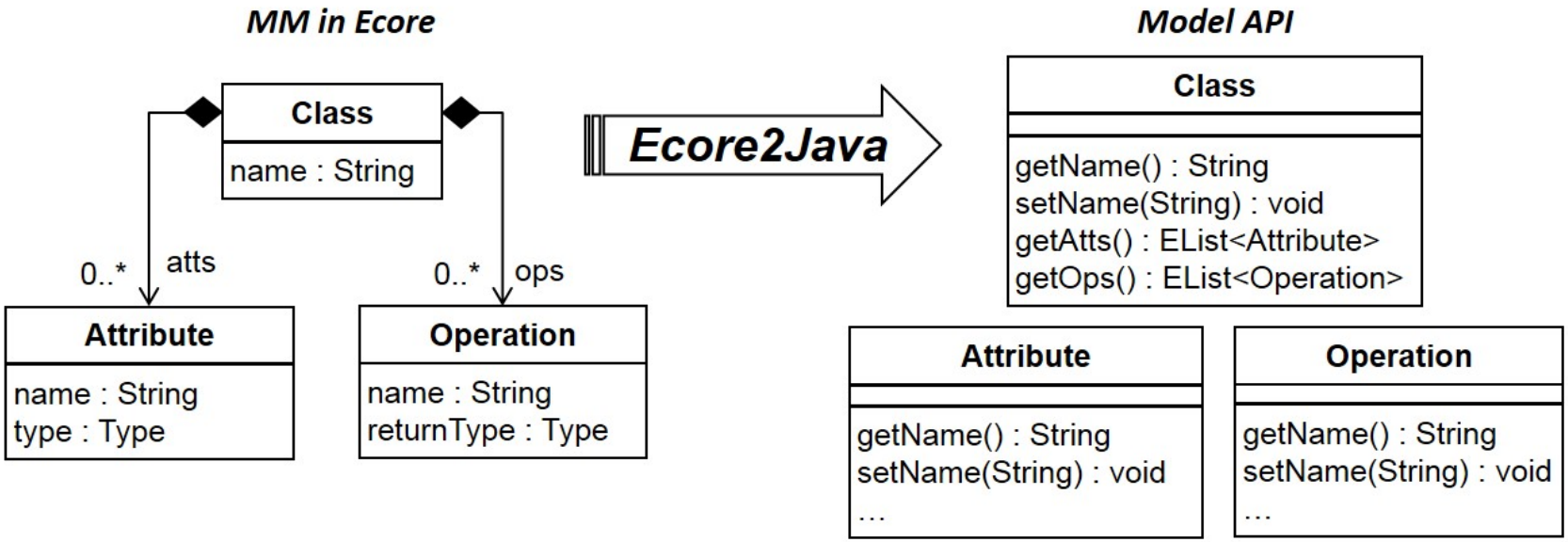


Figure 1: M2T transformation - an example

Using programming languages to generate code

Phases of code generation:

- Load models
  - Load XMI file into memory
- Process models and produce code
  - Process models by traversing the model structure
  - Use model information to produce code
  - Save code into String variable
- Write code
  - Persist String variable to a file using streams

Weighing up the pros and cons of using programming languages

Advantages

- No new languages have to be learned
- No additional tool dependencies

Disadvantages

- Intermingled static/dynamic code
- Non-graspable output structure
- Lack of declarative query language
- Non-graspable output structure

Model-to-Text transformations languages

M2T Transformation Languages are template based.

A bunch of template languages for M2T transformation available:

- JET, JET2
- XPAND
- MOFScript
- Acceleo
- XSLT
- ...

Templates

Templates are a well-established technique in software engineering.

Many application domains:

- Text processing
- Web Engineering
- ...

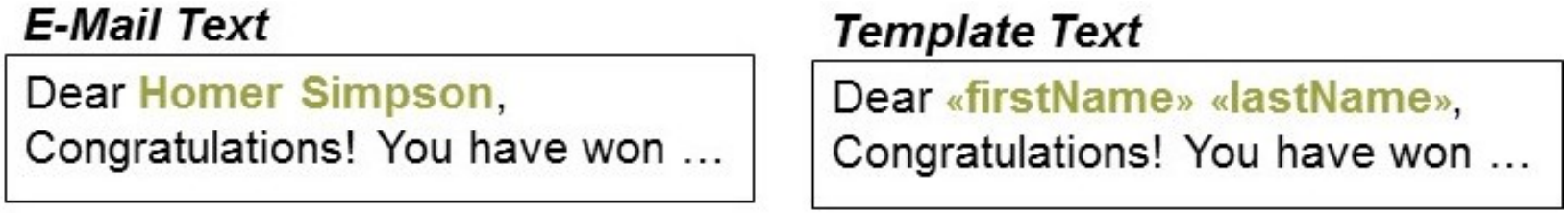


Figure 2: Using templates - an example

Components of a template-based approach

The main components of a template-based approach are:

- **Templates**
  - Text fragments and embedded meta-markers
- **Meta-Markers query an additional data source**
  - Have to be interpreted and evaluated in contrast to normal text fragments
  - Declarative model query: Query languages (OCL, XPath, SQL)
  - Imperative model query: Programming languages (Java, C#)
- **Template Engine**
  - Replaces meta-markers with data at runtime and produces output files

- Template-based Approach at a Glance

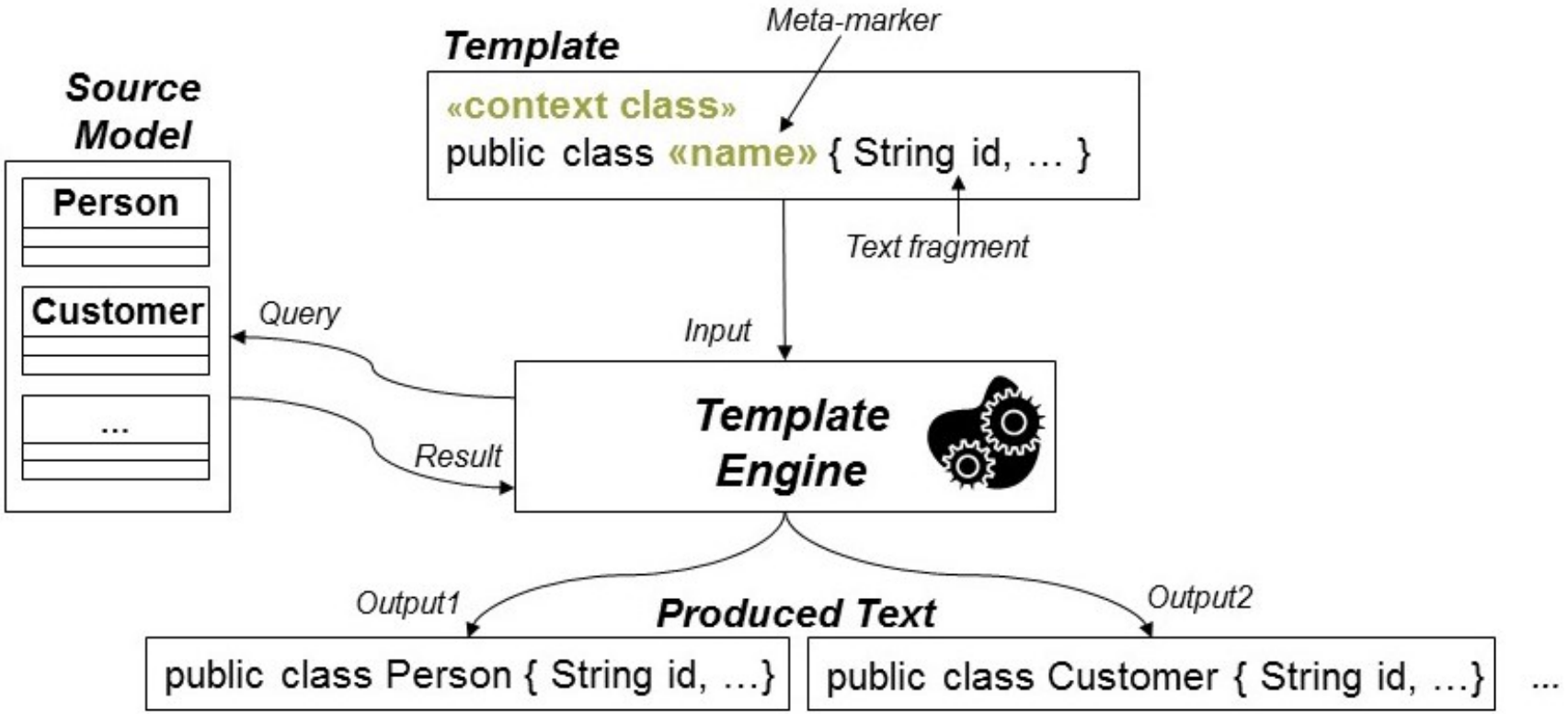


Figure 3: Use of templates by M2T languages

M2T Transformation Languages - advantages

- **Separated static/dynamic code**
  - Templates separate static code, i.e., normal text, from dynamic code that is described by meta-markers
- **Explicit output structure**
  - Primary structure of the template is the output structure
  - Computation logic is embedded in this structure
- **Declarative query language**
  - OCL is employed to query the input models
- **Reusable base functionality**
  - Support for reading in models, serialize text to files, ...

Acceleo

- **Acceleo is a mature implementation of the OMG M2T transformation standard**
  - Acceleo website: `http://www.eclipse.org/acceleo/`
  - M2T Transformation standard: `http://www.omg.org/spec/MOFM2T`
- **Template-based language**
  - Several meta-markers for useful for code generation available
- **Powerful API supporting**
  - OCL
  - String manipulation functions
  - ...
- **Powerful tooling supporting**
  - Editor, debugger, profiler, traceability between model and code, ...

Acceleo - language concepts

- **Module concept is provided**
  - Imports the metamodels for the input models
  - Act as container for templates
- **A template is always defined for a particular meta-class**
  - Plus an optional pre-condition to filter instances
  - Templates may call each other
  - Templates may extended each other
  - Templates contain text and provided meta-markers

Templates in Acceleo

Templates are the Acceleo structures used to generate code.

Listing 1: Basic signature of an Acceleo module with one template

```
[module moduleName('http://www.eclipse.org/emf/2002/Ecore')/]
[template public genMyTemplate(aEClass: EClass)]
[/template]
```

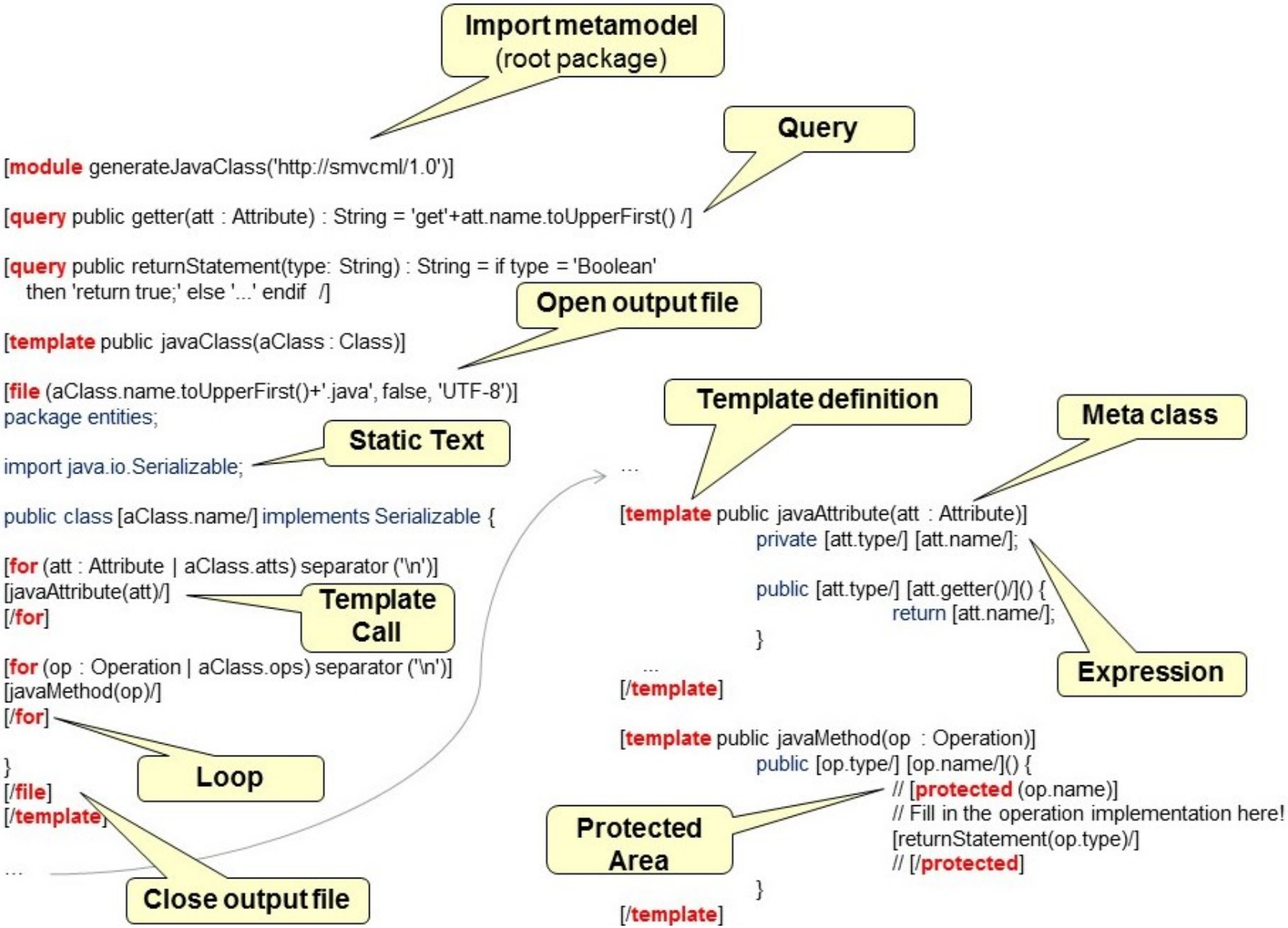
Note the visibility specification, the name of the template and its parameters. The parameters are declared following this convention "**name: type**". It is recommended to name them with the following convention "**a<Type>**"(where **Type** is the name of the parameter type). The type of the parameter must be one of the following:

- Types provided by the meta-model (ex: Class, Property, Operation... for UML)
- Default types from OCL like Boolean, String, Integer, OclAny (common super-type of all concepts)

Acceleo - more concepts

- Several meta-markers (called **tags**) are supported
  - **File** tag: To open and close files in which code is generated
  - **For/If** tag: Control constructs for defining loops and conditions
  - **Query** tag: Reusable helper functions
  - **Expression** tag: Compute values that are embedded in the output
  - **Protected** tag: Define areas that are not overridden by future generation runs

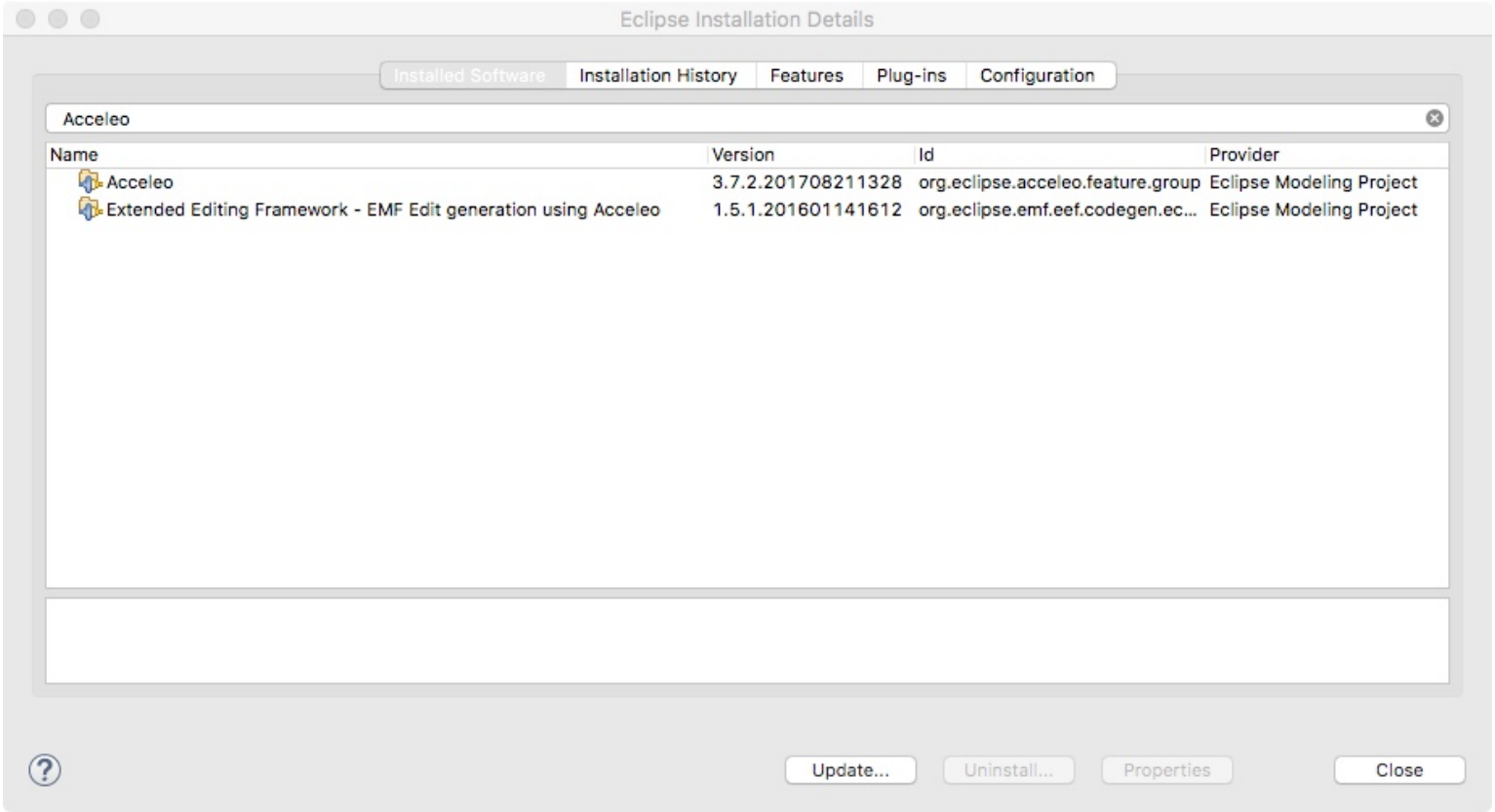
Acceleo example



Setup of The Acceleo Tools

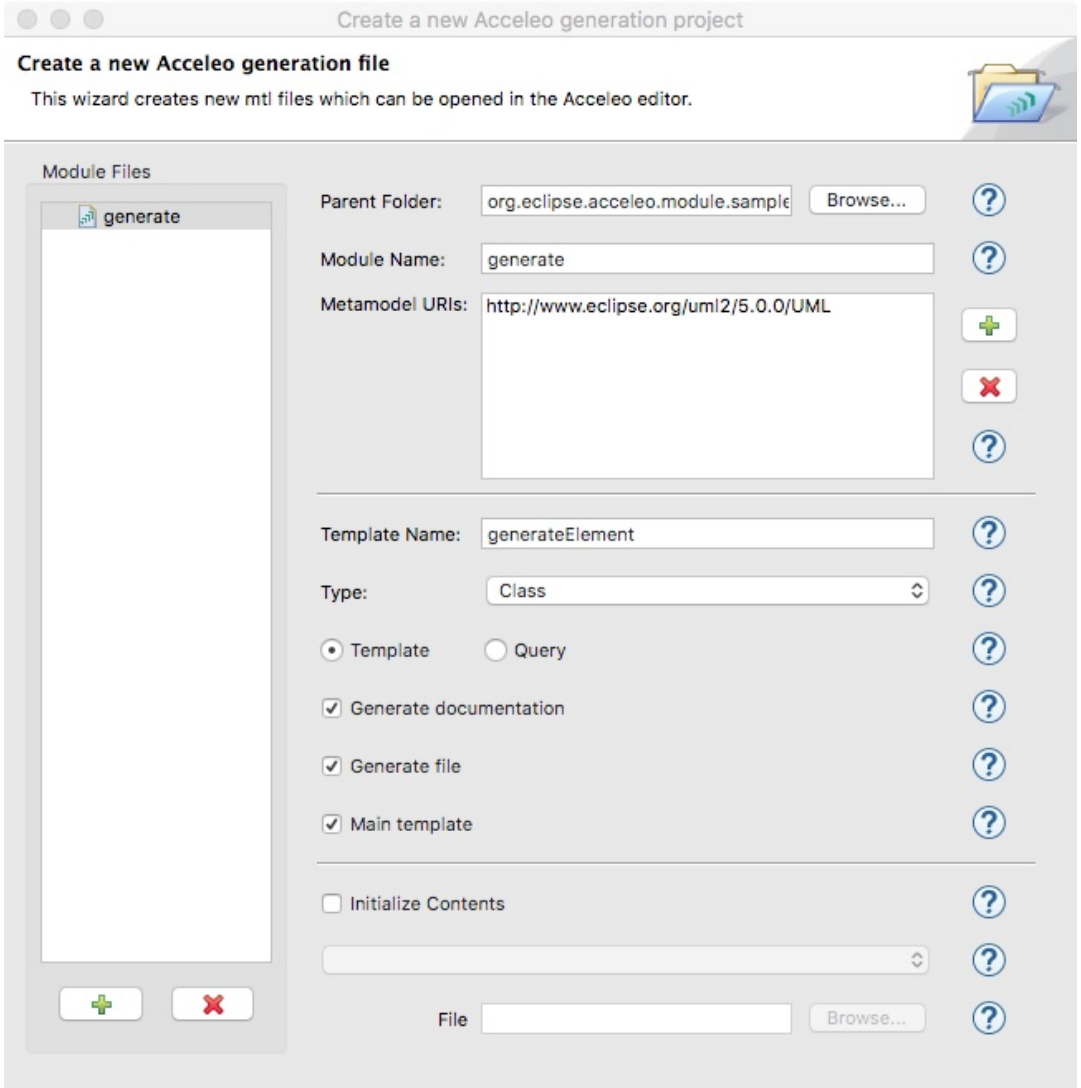
Acceleo installation

In Eclipse select "About" and then "Installation Details" and check if the Acceleo plugin is installed. If it is not installed, click on "Help"/"Eclipse Marketplace..." and then search and install **Acceleo**.



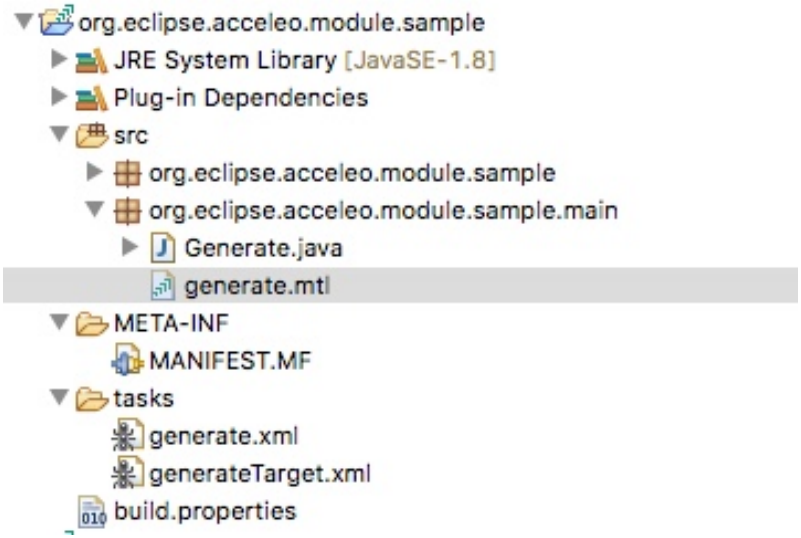
How to Create an Acceleo Project (1/8)

- To create an ATL project just select "File"/"New" and then select "Acceleo Project". Fill the fields of the wizard as presented in the Figure. **Do not forget to select the UML metamodel!**



How to Create an Acceleo Project (2/8)

- Your new project should have the following structure.
- The **mtl** file is the most important. It contains the M2T (model-to-text) transformation using the Acceleo syntax.
- The **tasks** folder includes ant build files that can be used to execute our transformations (inside or outside Eclipse).
- The java code is for the plugin project and for running the transformation but we shouldn't need to worry about that for the moment.



How to Create an Acceleo Project (3/8)

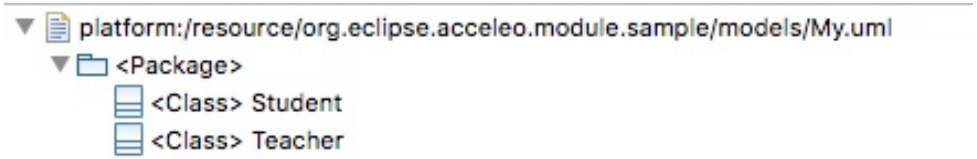
- The **mtl** file should contain a very simple template, like the one presented in the Figure.
- Note line 5 that references the UML metamodel, since in the wizard we selected this metamodel as the source of the transformation.
- The file only includes a template that generates a simple file for each **Class** element that exists in the source model.
- We need a source model (i.e., a UML model) to be able to run this Acceleo transformation.

```
1  [comment encoding = UTF-8 /]
2  [**
3   * The documentation of the module generate.
4   */]
5  [module generate('http://www.eclipse.org/uml2/5.0.0/UML')]
6
7
8  [**
9   * The documentation of the template generateElement.
10  * @param aClass
11  */]
12 [template public generateElement(aClass : Class)]
13 [comment @main/]
14 [file (aClass.name, false, 'UTF-8')]
15
16 [/file]
17 [/template]
18
```

How to Create an Acceleo Project (4/8)

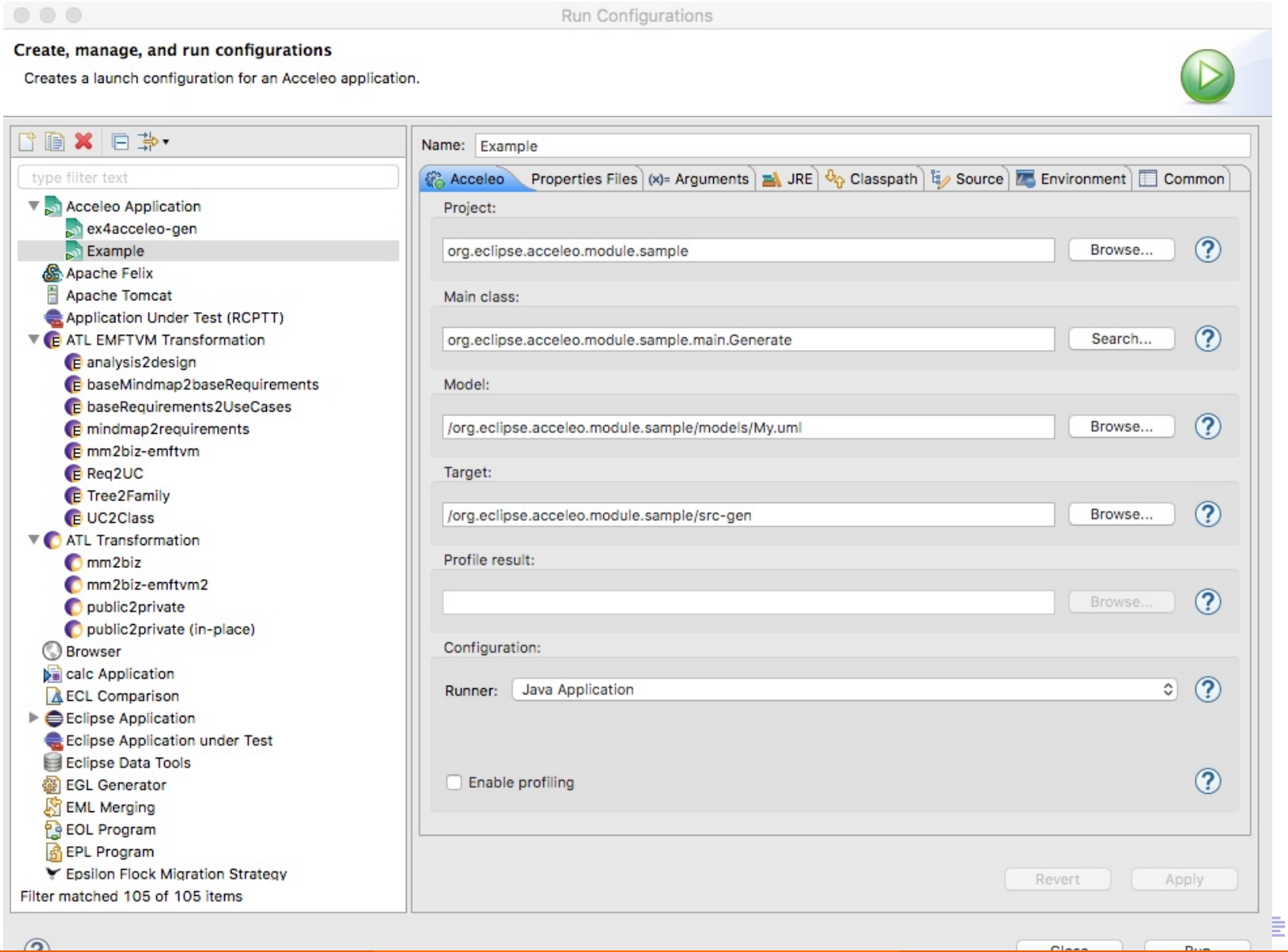
To create a UML source model:

- Create a new folder in the project and call it **models**
- Select "File/New" and then "UML Model". Call it "My.uml".
- Select as "Model Object": Package.
- Add some Class elements to the model (such as the ones presented in the Figure).



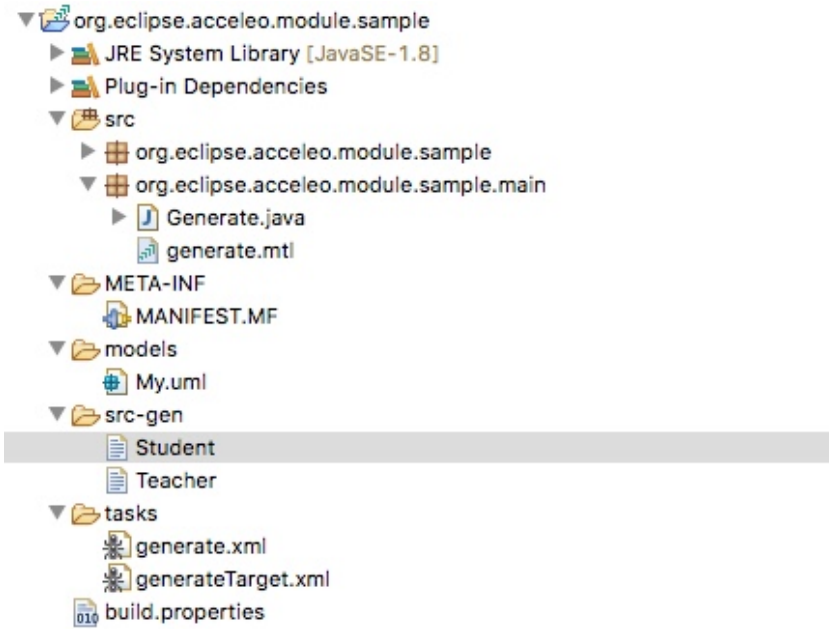
How to Create an Acceleo Project (5/8)

- We can now use the model in a new Acceleo Run Configuration.



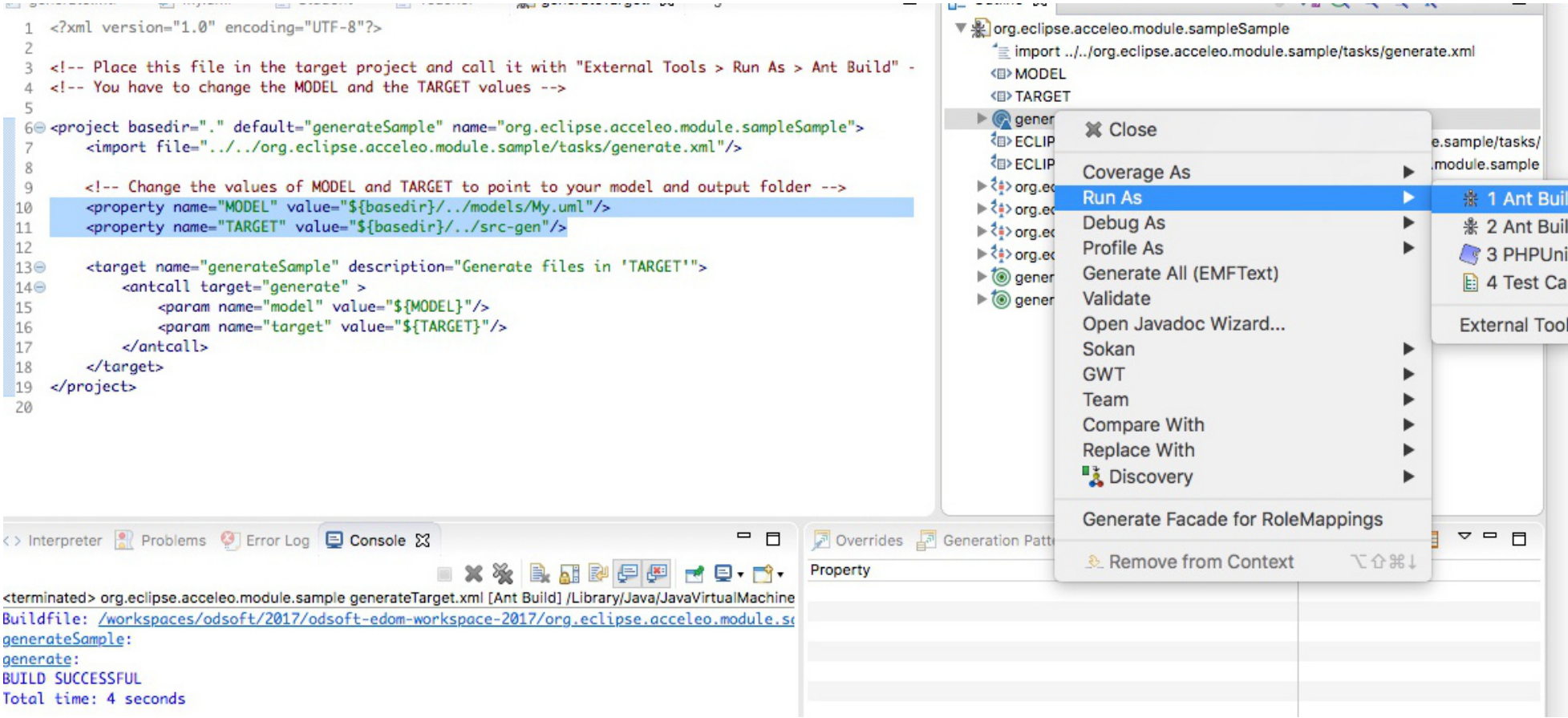
How to Create an Acceleo Project (6/8)

- The project should now have some new files...



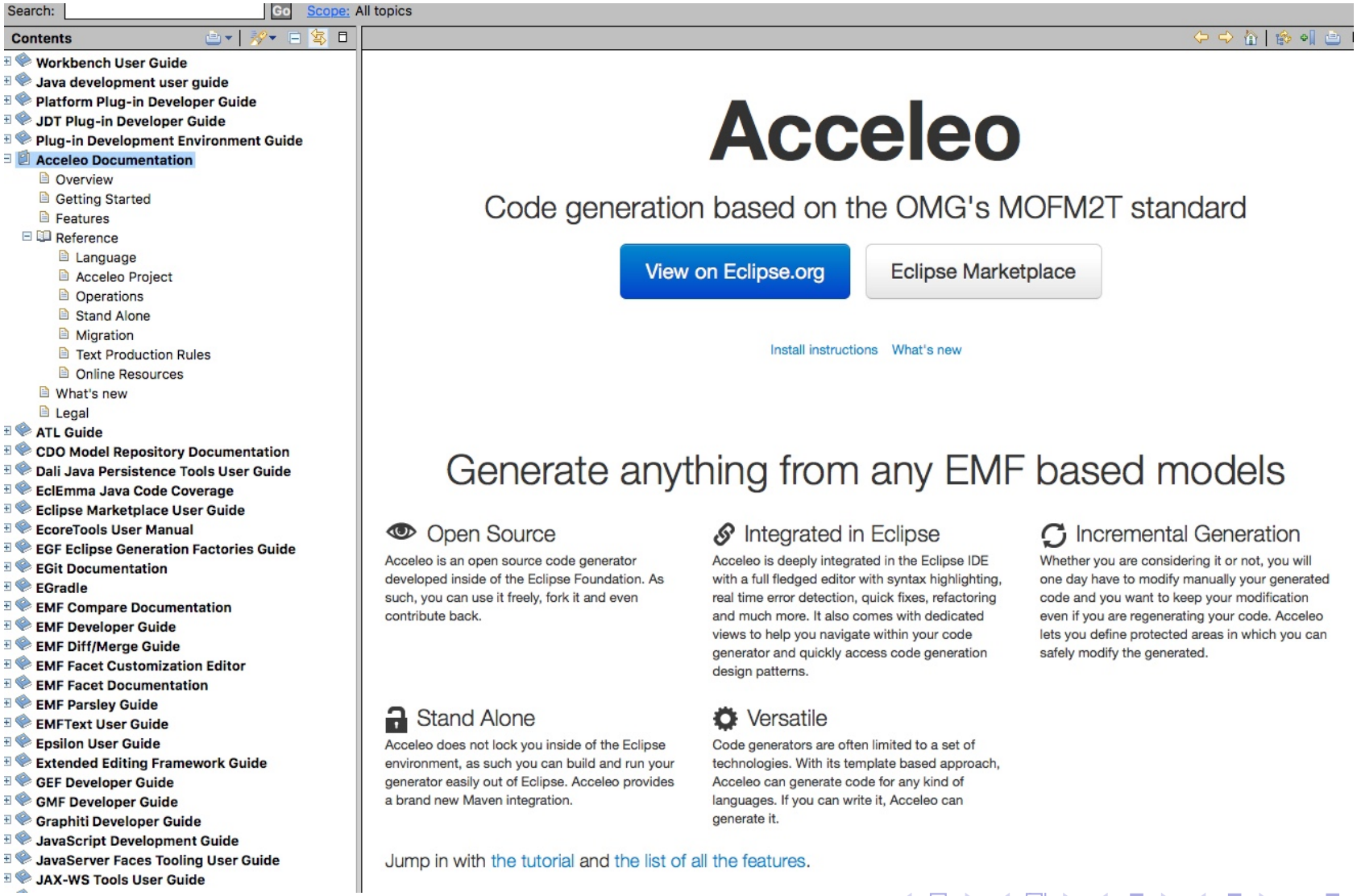
How to Create an Acceleo Project (7/8)

- We can also use the ant files to execute the transformation.
- In the file **generateTarget.xml** you need to update the properties **MODEL** and **TARGET** to reflect your configuration options.



How to Create an Acceleo Project (8/8)

- For more information on Acceleo and the language please refer to the Acceleo Documentation in the Help of Eclipse.



Exercise 4

Exercise 4: Context

Context for this Exercise:

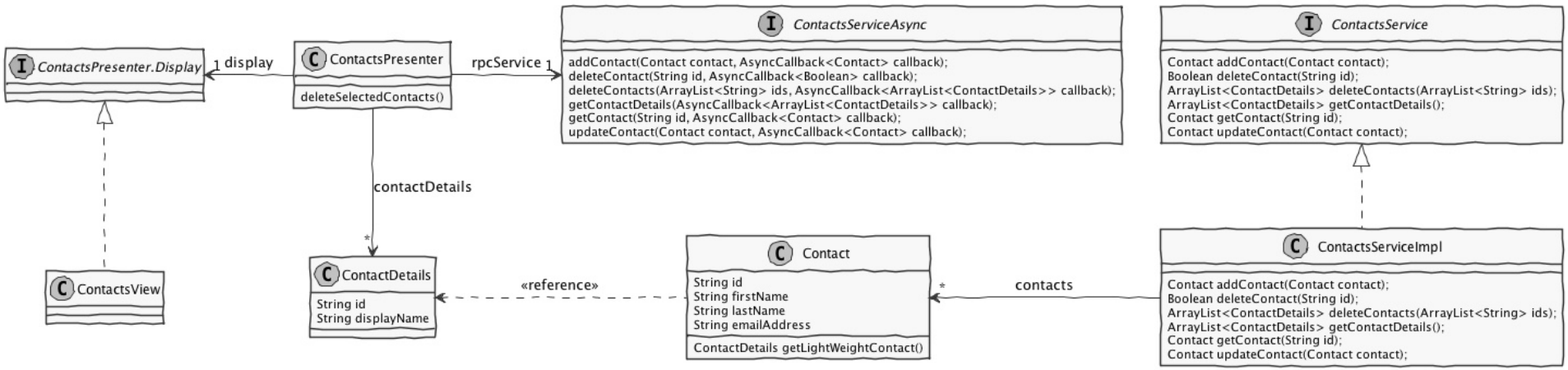
- In this exercise we will continue from where we left in exercise 3.
- In exercise 3 we end up with a UML Use Case model that reflected the functional requirements of our applications.

In exercise 4 we will:

- Complement the use case model with more information. We will call it **analysis model**.
- Generate Java code for implementing the functional requirements by using two approaches:
  1. Generate a new **design model** from the analysis model and then generate the implementation from this new design model.
     - First an ATL transformation (UML analysis to UML design)
     - Then an Acceleo transformation (UML design to Java Code)
  2. Generate the implementation (i.e., java code) directly from the analysis model.
     - This will use an Acceleo transformation (UML to Java Code).
- The target will be new functionality in the GWT sample application: College Management System.

Exercise 4: Goal

Whatever the approach of the previous slide the goal is to have generated Java code similar to the one presented in the Figure for **each of the CRUD Use Cases**.



Exercise 4: Context / CRUD Use Cases and Domain Model

The Context:

- From exercise 3, the final transformation, produces a Use Case Model.
- This Use Case Model specifies the functionality of an application. For instance, we can have a use case called "Manage Contact", that represents the CRUD[1] operations over the entity "Contact".

The Problems:

- Although this is the **intention** of the model, there is nothing that unambiguously states that and we also do not know the details of the "Contact" entity. Therefore, we need to:
  - State that some Use Cases represent CRUD functionality;
  - Specify the details of entities.

The Solution:

- **Problem:** State that some Use Cases represent CRUD functionality.
  - **Solution:** Use annotations to mark such use cases.
- **Problem:** Specify the details of entities.
  - **Solution:** Use a domain model to model entities.

[1] See `https://en.wikipedia.org/wiki/Create,_read,_update_and_delete`

Exercise 4: Disclaimer

Notice:

- This is an academic exercise!
- We do not state that all use cases represent CRUD functionality.
- The presented approaches are only to illustrate the used technologies and the MDE approach.
- Other approaches could have been taken.

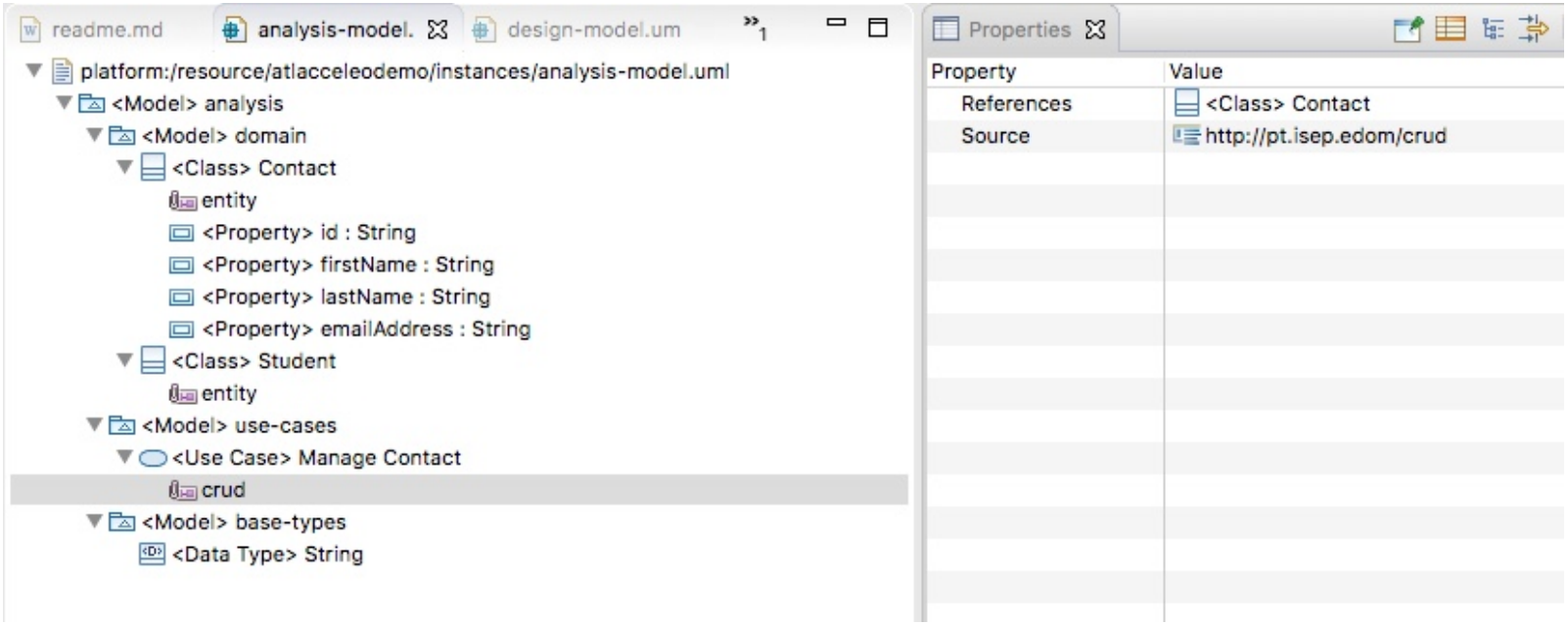
Exercise 4: Startup Sample Project

- For this exercise there is a sample project that you should use as a starting point.
- Please, use the following url to get the project:
  `https://bitbucket.org/mei-isep/atlacceleodemo`
- This is an Eclipse project that you can import into Eclipse.
- This project contains a partial solution for the overall exercise.

Exercise 4: Startup Sample Project / Analysis Model

In this figure we illustrate an analysis model that should be the starting point for this exercise. It includes:

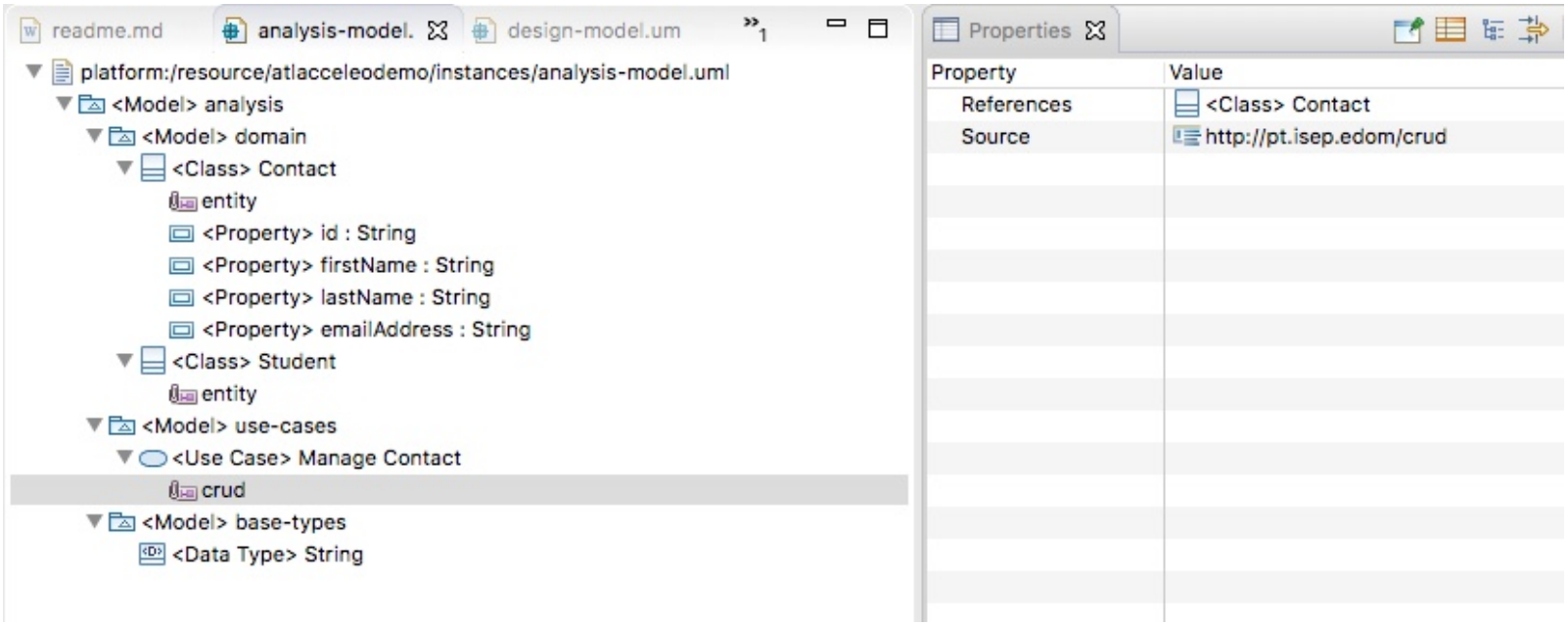
- **use-cases** This is the use case model that resulted from the previous exercise.
- **domain** This is a domain model that should contain the specification of the entities of the application that are "referenced" by the use cases. This domain model must be edited manually!
- **base-types** This include some base types that arre required for the domain model.



Exercise 4: Startup Sample Project / Analysis Model

Use cases that represent CRUD operations should be annotated. The annotation should:

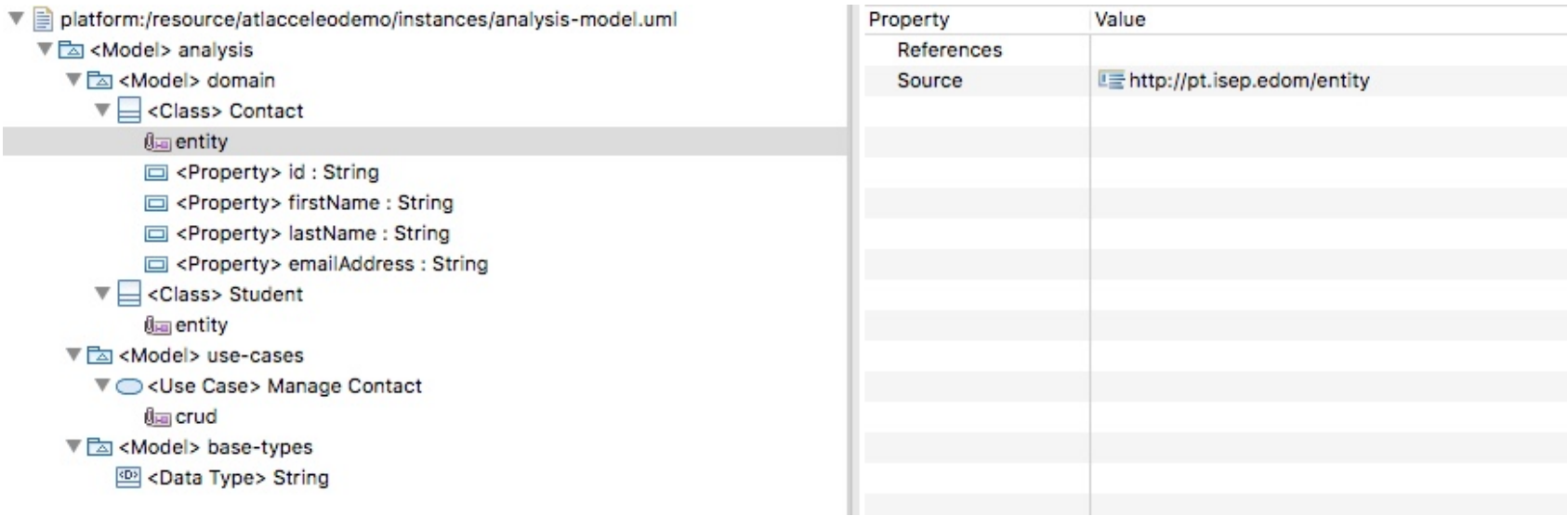
- Have as **Source**: http://pt.isep.edom/crud
- Have as **References**: the entity from the domain model that is the focus of the CRUD operations of the use case



Exercise 4: Startup Sample Project / Analysis Model

Elements of the Domain Model that represent "Entities" should be annotated. The annotation should:

- Have as **Source**: http://pt.isep.edom/entity



Exercise 4: Startup Sample Project / Analysis Model to Design Model

In the project you will find a very incomplete ATL transformation that generates a design model from the analysis model described previously. Right click on the file "analysis2design2.launch" and select "Run As".

```
-- @atlcompiler emftvm

-- @path Analysis=http://www.eclipse.org/uml2/5.0.0/UML
-- @path Design=http://www.eclipse.org/uml2/5.0.0/UML

module Analysis2Design;
create OUT : Design from IN : Analysis;

helper context Analysis!Model def : referencedInCRUDUseCase() : Set( Analysis!Class ) = Analysis!Class.allInstances()->select( c |
            not c.eAnnotations->select(a | a.source = 'http://pt.isep.edom/entity')->asSet()->isEmpty()   -- must be annotated as entity
            and Analysis!UseCase.allInstances()->select( uc |
                uc.eAnnotations->select( anot |
                    anot.source = 'http://pt.isep.edom/crud' and anot.references->includes(c)
                )->asSet()->notEmpty()
            )->asSet()->notEmpty() )->asSet();

rule Model2Model {
    from
        sm: Analysis!Model (sm.name = 'domain')
    to
        tm: Design!Model (
            name <- 'design-model'
        , packagedElement <- sm.referencedInCRUDUseCase()
        )
}

rule Entity2Class {
    from
        sm : Analysis!Class (
            not sm.eAnnotations->select(a | a.source = 'http://pt.isep.edom/entity')->asSet()->isEmpty()  -- must be annotated as entity
            and Analysis!UseCase.allInstances()->select(
                uc | uc.eAnnotations->select(
                    a | a.source = 'http://pt.isep.edom/crud' and a.references->includes(sm)
                    )->asSet()->notEmpty()
                )->asSet()->notEmpty()              -- must be referenced by a CRUD use case
            )
    to
        tm : Design!Class (
            name <- sm.name
        ),
        tmDetails :  Design!Class (
            name <- sm.name + 'Details'
        ),
        tmPresenter :  Design!Class (
            name <- sm.name + 'sPresenter'
        )
}
```

Exercise 4: Startup Sample Project / Design Model to Java Code

In the project you will find a very incomplete Acceleo transformation that generates java code from the previous design model. You can use "tasks-nogen/design2code.xml" to run this Acceleo transformation with Ant. You can also create a Run Configuration as described in slide 24.

```
1  [comment encoding = UTF-8 /]
2  [module generate('http://www.eclipse.org/uml2/5.0.0/UML')]
3
4  [template public generateElement(aClass : Class)]
5  [comment @main /]
6  [file (aClass.name+'.java', false, 'UTF-8')]
7  // This is a test
8  public class [aClass.name/] {
9
10    [for (p: Property | aClass.attribute) separator('\n')]
11      private [p.type.name/] [p.name/];
12    [/for]
13
14    [for (o: Operation | aClass.ownedOperation) separator('\n')]
15      public [if (o.type->isEmpty())]void[else] [o.type.name/][/if]  [o.name/]() {
16          // [protected(o.name)]
17        // TODO should be implemented
18          // [/protected]
19      }
20    [/for]
21
22 }
23 [/file]
24 [/template]
```

Exercise 4: Requirements

- Generate Java code for implementing the functional requirements by using two approaches:
  1. **Base Solution**: Generate a new **design model** from the analysis model and then generate the implementation (i.e., **java code**) from this new design model.
     - First an ATL transformation (UML analysis to UML design)
     - Then an Acceleo transformation (UML design to Java Code)
  2. **Alternative Solution**: Generate the implementation (i.e., **java code**) directly from the analysis model (i.e., do not generate an intermediate design model).
     - This will use an Acceleo transformation (UML to Java Code).
- The target will be new functionality in the GWT sample application: College Management System. Both solutions should try to generate code **as much as possible similar** to the one in the GWT CMS application and **in accordance with the diagram from slide 30**. It is not required to generate complete functional code but the code should be correct.
- **Review** Your review should focus on how both solutions compare.

Further Reading

Eclipse community
Acceleo/Getting Started.
https://wiki.eclipse.org/Acceleo/Getting_Started.

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